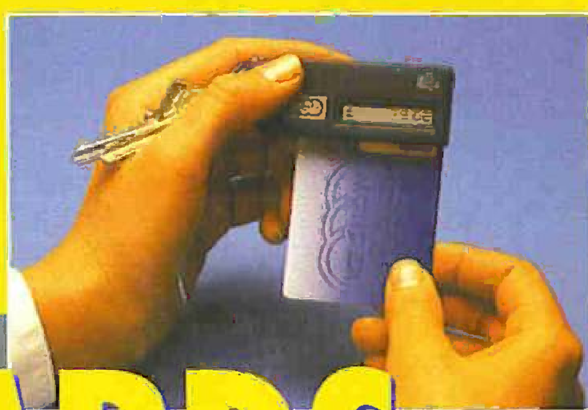
ETI
ELECTRONICS TODAY INTERNATIONAL

FEBRUARY 1997 £2.35

Peaceful Waves Biofeedback



SMART CARDS BY THE MILLION

PCB Shake'n'etch

PLUS

- *New Series!* Experimenting with Video
- ETI Remote Data Logger
- Cupid's Arrow!

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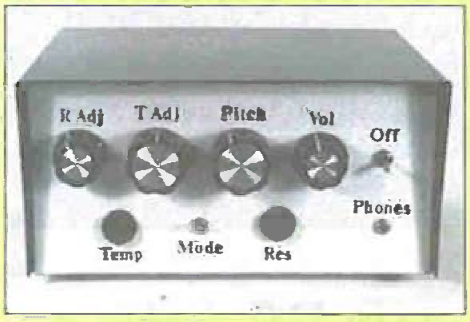
FOR ENTHUSIASTS BY ENTHUSIASTS
NEXUS
VOLUME 26 No. 1

Contents

Volume 26 No.1

& Features Projects



Regulars

ETI ELECTRONICS TODAY INTERNATIONAL News...

New low-cost PIC training

Kanda Systems - who are also the sponsors of the Kanda/ETI Design Competition (see last month) - have added a new, low cost PIC training system to their catalogue, the Kanda PIC Explorer. "Imagine being able to lift the lid off the processor and see what happens inside as it responds to your code", is how they describe the new package. "The system contains everything you need to fully explore the workings of the chip, you just need to add a PC and a bit of grey matter."

The software includes a full-function editor, an assembler (which links to the editor to highlight errors) and the Explorer screen. The Explorer screen allows you to see exactly what is happening inside the processor as it shows all the register values and the code as it is being run.

The hardware features switches for setting input bits plus a push-button switch for creating interrupts (the unit can also generate timer and change on port B' interrupts). Changing the switch values will immediately change the port register values, and pressing interrupt will make the code jump to the interrupt vector address. The output is displayed on either LEDs (arranged in the familiar traffic light pattern) or on a seven-segment display. The reference manual explains the functions of the PIC family in plain English, and the training (based around the GNVQ Microelectronics syllabus) allows you to understand how to use the device, from binary numbering through to complex interrupt functions.

Operation is either by single-step (where you see the effect of each line of code being reflected in both the hardware the on the Explorer screen) or run, which runs the code in real time (processor dependent) so that you can see exactly how your code runs at speed.

Designed as a dedicated introduction to the PIC processor family (and processors in general), the PIC Explorer costs £99 plus VAT and is available now.

Contact Kanda Systems Ltd. for more details. Tel 01974 282670 Fax 01974 282356 email Info@Kanda-Systems.com

Turn your PC into a digital oscilloscope

Pico Technology's new ADC 200 converter plugs into the parallel port of a PC laptop or desktop, to operate the computer as a 50 MSPS dual channel storage oscilloscope, a 25 MHz spectrum analyser or a multimeter for less than £500.

The PicoScope software has recently gone into a Windows version, with full on-line help, and offers advanced features such as the simul-taneous display of multiple views of the same signal. Data such as the waveform itself, its frequency components, AC voltage and frequency can be displayed on-screen at the same time. As well as oscilloscope features, the ADC 200 provides FFT spectrum analysis, wave form storage and printing facilities normally found on Dual Storage Oscilloscopes costing well into four figures. There is also an advanced triggering mode that mkes it possible to capture infrequent one-off events.

The 50 MSPS ADC 200 is prices at £459. There is a 20 MSPS unit available at £359.

For information and sales contact Pico Technology Ltd., Broadway House, 149-151 St Neots Road, Hardwick, Cambridge CB3 7QJ Tel 01954 211716 Fax 01954 211880 email post@picotech.co.uk

10 GHz amateur band to go in April '97

The Radiocommunications Agency has announced the date for the withdrawal of part of the represent 10GHz amateur band from amateur use. The frequency allocation 10.15 to 10.30 GHz will be withdrawn from the 1st April 1997.

The reason given for the withdrawal, which was announced some time ago, is the continuing demands on the radio spectrum for existing and new radio services. The allocation of new amateur bands in spectrum under less pressure of demand is being explored constantly, with the recent introduction of a new Low Frequency amateur band allocation as an example of this shift.

DIFFERENTIAL THERMOSTAT KIT Perfect for heat recovery, solar systems, boiler efficiency etc. Two sensors will operate a relay when a temp difference (adjustable) is detected. All components and pcb. £29 ref LOT93

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

RADIO METERS - REMEMBER THESE? Glass bulb on a display stand that contains four vanes that rotate when exposed to sunlight, scientific novelty for £8.99 ref SC120

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

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

DC TO DC CONVERTERS
DRM56 input 10-40vdc output 5v 6A £15 DRM126 input 17-40vdc output 12v 6A £18 DRM158 input 20-40vdc output 15v 6A £18 DRM243 input 29-40vdc output 24v 6A £12 DRS123 input 17-40vdc output 12v 3A £10 DRS153 input 20-40vdc output 15v 3A £20 DRS243 input 29-40vdc output 24v 3A £8

INSTALL A COINBOX FOR LESS THAN £20 Convert any standard phone into a coinbox with this kit, some mods required plus hinges and a lock. £19 ref CBT1

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

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

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

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

JUMBO BI COLOUR LEDS PCB with 15 fitted also 5 giant seven segment displays (55mm) £6 ref JUM1

HOME DECK CLEARANCE These units must be cleared! leads, a infra red remote qwerty keyboard and receiver, a standard UHF modulator, a standard £200/75 BT approved modem and loads of chips, capacitors, diodes, resistors etc all for just £10 ref BAR33.

6.8MW HELIUM NEON LASERS New units, £55 ref LOT33

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

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

TELEKINETIC ENHANCER PLANS Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing phychic phenomenon. £4/set Ref F/TKE1

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

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

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

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commission of NEGEV in Israel. £10/set Ref F/CVL1

VOICE SCRAMBLER PLANS Miniature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/set Ref F/VS9

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

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

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

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

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

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

WOLVERHAMPTON ELECTRONICS STORE NOW OPEN IN WORCESTER ST TEL 01902 22039

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

LASER BOUNCE LISTENER SYSTEM PLANS Allows you to hear sounds from a premises without gaining access. £12/set Ref F/LLIST1

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

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

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

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

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

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

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

2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS Operates on 9-12vdc, many possible experiments. £10 Ref F/HVM7/TCL4

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

MOD TRANSMITTING VALVES 5J180E £80 ref LOT112

SWITCHED MODE PSU'S 244 watt, +5 32A, +12 6A, -5 0.2A, -12 0.2A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 d/drive connectors 1 m/board). £15 ref LOT135

Check out our WEBSITE full colour interactive 1997 catalogue

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

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

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

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

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

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

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

FM/AM SCANNER KIT Well not quite, you have to turn the knob your self but you will hear things on this radio that you would not hear on an ordinary radio (even TV). Covers 50-160mhz on both AM and FM. Built in 5 watt amplifier, inc speaker. £15 ref 1013

BULL ELECTRICAL

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

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3.50 P&P PLUS VAT.

24 HOUR SERVICE £4.50 PLUS VAT.

OVERSEAS ORDERS AT COST PLUS £3.50

PLEASE ALLOW 7-10 DAYS FOR DELIVERY PHONE ORDERS WELCOME (ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

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FAX 01273 323077

E-mail bull@pavilion.co.uk

3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £17 Ref 1014

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

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

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

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

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

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

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

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

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

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

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

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

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

HUMIDITY METER KIT Builds into a precision LCD humidity meter, 9 ic design, pcb, lcd display and all components included. £29

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

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GIR20

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

Minature adjustable timers, 4 pole c/o output 3A 240v,
HY1230S, 12vDC adjustable from 0-30 secs. £4.99
HY1260M, 12vDC adjustable from 0-60 mins. £4.99
HY2405S, 240v adjustable from 0-5 secs. £4.99
HY24060m, 240v adjustable from 0-60 mins. £6.99

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

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

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

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

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

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG5P12

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

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

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

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

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

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

COMPAQ POWER SUPPLIES WITH 12V DC FANS Ex equipment psu's, some ok some not but worth it for the fan alone! probably about 300 watt PC unit with IEC input. £3.50 each ref CO1

BALLON MANUFACTURING KIT British made, small blob blows into a large, longlasting balloon, hours of fun! £3.99 ref GI/E59R

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

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

SOLID STATE RELAYS
CMP-DC-200P 3-32vdc operation. 0-200vdc 1A £2.50
SMT2000/3 3-24vdc operation. 28-280vac 3A £4.50

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

VEGA RUSSIAN MULTIBAND World communications receiver, 9 wave bands, (5 short, 1 LW, 1FM, 1MW) internal ferrite and external telescopic aerials, mains or battery. Large, typically Russian radio! £45 ref VEGA

NEW LASER POINTERS <5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm £29 ref DEC49

MULTIBAND RADIO Compact general purpose radio receiver covering air, pb, tv, cb etc. Squelch vol and tuning £24 ref MB1

DIVINING RODS £3.99 a pair! ref EF111

MOONSHINE BIBLE 270 page book covering the production of alchohol from potatoes, rice, grains etc Drawings of simple home made stills right through to commercial systems. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of 800 metres or more and up to 100 hours use from a PP3 this will be popular! Bug measures less than 1" square! £28 Ref LOT102

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

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

TRACKING TRANSMITTER range 1.5-5 miles. 5,000 hours on AA batteries, also transmits info on car direction and motion!Works with any FM radio. 1.5" square. £65 ref LOT101

ELECTRIC DOOR LOCKS Complete lock with both Yale lock and 12v operated deadlock (keys included) £10 ref LOT99

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

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!)

GPS SATELLITE NAVIGATION SYSTEM Made by Garmin, the GPS38 is hand held, pocket sized, 255g, position, altitude, graphic compass, map builder etc £179 ref GPS1

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

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

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, krypton bulb, gives out powerful infrared light! 4 D cells required. £29 ref PB1.

MONO VGA MONITORS, Perfect condition, Compaq, 14", 3 months warranty £29 ref MVGA

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, 360 degree coverage, front and rear wave guides, may be illegal to use! 1.1"x2.7"x4.6" £149 ref RD2

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 alignment. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. 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. £199 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 LOW PRICED 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. £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

WIND UP FLYING PARROT! Genuine parrot that flaps its wings and flies for up to 50 meters £6 ref EF2

RADIO CONTROLLED CARS FROM £6 EACH!!!! All returns from famous manufacturer, single channel (left,right,forwards,backwards) £6 ref LOT1. Two channel with more features £12 ref LOT2.

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 electronics 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

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

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 information ref TAL-1, £249

SOLAR ENERGY/GENERATOR PLANS For your home, loads of info on designing systems etc £7 ref PV1

SOLAR COOKERS Comprehensive guide to building solar powered cookers, includes plans, recipes, cooking times etc £7 ref SSC1

WOLVERHAMPTON ELECTRONICS STORE NOW OPEN IN WORCESTER ST TEL 01902 22039

CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, D base, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £6 ref lot 97 3.5" disks

COLOUR CCTV VIDEO CAMERAS, BRAND NEW AND, CASED, £119.

PERFECT FOR SURVEILLANCE, INTERNET,VIDEOCONFERENCING, SECURITY, DOMESTIC VIDEO

Works with most modern video's, TV's, Composite monitors, video grabber cards etc

Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty, 10 or more £99 ea

MICRO RADIO It's tiny, just 3/8" thick, auto tunning, complete with headphones. FM £9.99 ref EP35

HANDHELD SCANNERS 10 channel, built in charger, LCD display £119 ref B110B. 100 channel model £229 ref B110E.

SMOKE MACHINE 42.3 cubic metres a min from this mains operated machine £299 ref G002B, smoke fluid £25 (5 litres) gives about 2.5 hours use. ref GOO2AA

Check out our WEB SITE full colour interactive 1997 catalogue

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

IBM PS2 MODEL 150Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. £9.95 ref EP57

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

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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 (01342-326009 try before you buy!) SALE PRICE £9.95 ref SA12. SAVE £120!!!

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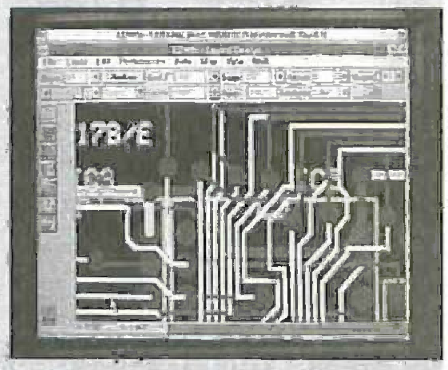
Edwin NC - professional EDA software for non-commercial use

Visionics UK have announced the launch of EDWin NC, a new non-commercial licenced version of their Windows-based electronic design software, EDWin. The con-commercial version is available at a fraction of the cost of the professional system, but includes all the features that have made EDWin a success worldwide.



EDWin's easy-to-use structure, running on Windows 3.1x, '95 or NT, along with its versatile, completely integrated database, have attracted engineers since it superceded Visionics' original EE Designer system.

MD Jonathan Hewer explained: "We've been led by the demands of potential customers. For years our EDA systems have been used not only in Industry but in the educational sector. Students and hobby users have requested the change to buy EDWin, but the cost, which is easily justifiable to a company which will profit from productivity gains, has been prohibitive for the amateur user. Now non-commercial users can enjoy the benefits of a professional system."

Visionics recently launched EDWin NC in Belgium and Holland, where EDWin was previously little known, to test user reaction. The result, which surprised even Visionics, was over 800 systems sold within the first three weeks.

Prices now range from £49 including VAT for the basic version, which included schematics, PCB layout, 500-device library, basic autorouter, full post-processing facilities and a limit of 100 components (normal price £1163) to the de luxe 3 version at £115, which includes unlimited database, professional libraries, mixed-mode simulation and the Arizona autorouter (normal price £3513). The system comes on CD-ROM, including comprehensive manuals. Visionics EDSpice simulator, and a thermal analysis module, are also available as plug-ins.

EDWin NC can be purchased from Visionics' UK dealer, Swift Designs of Stevenage, Tel 01438 310133 Fax 01438 722751.

Overseas Readers

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

Shorts

Hitachi has doubled its production capacity of insulated gate bipolar transistors (IGBTs) in Japan to 50,000 per month. This follows increasing demand for power components, particularly in Europe. The devices are used for high-power switching in applications such as large power supplies and motor drives and are a comparatively new breed of transistor. The newest devices have lower power dissipation and more compact packaging, and the Hitachi devices range from 600V to 1200V and from 50A to 400A load currents... **IBM** is investing $380 million in advances in disk drive technology, centring on magnetoresistive (MR) read heads. MR heads use changes in resistance to read magnetic data from the disk platter, instead of more conventional current-change, and have the potential to resolve smaller magnetic domains. IBM expects this innovation to make disk drives more reliable and less expensive to build, and hope to make further inroads into the commercial mass storage market... **Quantum Corporation** has announced 1,280 MB-per-disk versions of its Quantum Fireball TM series of 3.5-in high-performance disk drives. Offering capacities of 1.2GB (1 disk) 2.5GB (2 disks) and 3.2GB (3 disks), the drives are targeted at information-intensive commercial desktop applications. Quantum already offer Fireball drives in three 1080MB -per-disk format. The drives are designed to operate fast and provide a high level of error correction. Standard prices for the new line vary at time of writing from US $277 for the 1.2GB set-up to US $415 for the 3.8GB set-up. Enquiries 0171 835 1001.

You can't get enough... ...of a good thing!

Now you can have even more of your favourite magazine. As from this issue, *Electronics Today International* will be published on a four weekly cycle - which means that you get 13 instead of 12 in the calendar year.

This does mean that our normal 1st Friday publication date cannot apply throughout the year - so you will need to keep a close eye on the 'Next Month' column where the date will be prominently displayed. Furthermore, issues will not carry the 'month' of issue, but will display our Volume and Issue Number. This is Volume 26 No.1. The next issue, Volume 26 No.2 will publish on 31 January. Volume 26 No.3 will be on sale 28 February. Subscriptions continue to be for twelve issues.

TRANSISTORS

PART	PRICE	PART	PRICE	PART	PRICE	PART	PRICE
BU105	80P	BU408D	75P	BUT18AF	80P	MJ15024	400P
BU108	100P	BU409	85P	BUT39V	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
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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 APOLLO	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

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ORDER CODE; PACE9000 PRICE 800p

SERVICE AIDS

DESCRIPTION	VOLUME	CODE	PRICE
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VIDEO HEAD CLEANER	200 ML	SP27	250P
SWITCH CLEANER	176 ML	SP02	170P
SUPER 40	400 ML	SP15	250P
SILICONE GEASE	200 ML	SP03	210P
FREEZE IT	170 ML	SP04	300P
FREEZE IT	400 ML	SP16	600P
FOAM CLEANER	400 ML	SP05	160P
ANTI STATIC	150 ML	SP06	190P
AEROKLEANE	200 ML	SP07	220P
AERO DUSTER	150 ML	SP08	310P
AERO DUSTER	400 ML	SP17	550P
PLASTIC SEAL	200 ML	SP09	250P
GLASS CLEANER	250 ML	SP10	160P
COLDKLENE	250 ML	SP13	230P
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	220P
TUBE SILICON SEALANT WHITE	75ML	SP22	280P
TUBE SILICON SEALANT CLEAR	75 ML	SP23	260P
TUBE HEAT SINK COMPOUND	25 GRAMMES	SP12	150p
DRIVE CLEANER	200ML	SP24	150p
SCREEN CLEANER	200 ML	SP25	150P
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FUSES

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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	60P

CERAMIC PLUG TOP

CURRENT RATING	ORDER CODE	PRICE
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5A	FUSE34	100B
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
10A	FUSE48	825P

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DESCRIPTION	CODE	PRICE
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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
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SOLDER MOP 1.2mm x 10 METRE	SI13	400P
DESOLDERING PUMP	SI05	320P
SPARE NOZZLE	SI06	60P

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Electronics Industry survey confirms Engineering shortage

The Federation of the Electronics Industry (FEI) set up a task force in 1996 to address the issues of education and training in the electronics industry, from the point of view of those businesses that employ school leavers, graduates and indeed anyone with Electronics qualifications and/or experience.

The FEI, in consultation with the DTI (which provided some of the financing) commissioned a survey of 250 FEI member companies with two main objectives:

- to gather information on the education, training and skills perspectives of FEI members and other employers within the UK electronics industry, and
- to clarify FEI members' priorities in this area, in order to refine the focus of attention of the Federation's Education and Training Task Force.

In order to do this, a questionnaire was sent to FEI members. The findings were then analysed, and also compared with other recent surveys.

The questionnaire covered three main subject areas: information about the main activities of each company, and the money they allocate to training; how aware the companies are of government schemes available to help with training, and what problems the companies had with obtaining trained staff and extra training for their staff. A fourth section, requested by the DTI, asked for information on how many engineers the companies needed, and what specific classes of engineer were needed.

The questionnaire was refined in consultation with the DTI, as well as other interested bodies and a leading market research company, before being sent out to 250 member companies.

In the event, replies were received from 39 companies by the deadline. This response, of only 15%, caused a certain amount of concern, so much so that a section of the report was dedicated to examining the possible reasons.

Notwithstanding the limited statistical value of the survey's findings, the responses of genuine companies active in the electronics industry cannot fail to be of some interest to anyone working in electronics.

Firstly, nearly all the respondents are providing some training or re-training to their employees. Whether this is representative across the industry, or whether this applies only to businesses most concerned with staff training, is not known. The other side of this coin is that the majority of training seems to be either "induction training" (getting new recruits "up to speed" on the job) or product knowledge training (specific to the individual business, and not readily transferable). 21 of the 39 companies offer management training (although there is no detailed analysis of this), and 17 of the 39 offer technical training (again, without a clear distinction between "technical" and "induction/product" training, which is of necessity technical in this field). All companies were reluctant to estimate their financial input to training.

It was interesting to read that, for new recruits (including school and college leavers), the greatest need for better skills was in the area of literacy and communications, closely followed by initiative, problem solving, teamwork and "improving performance". There was far less dissatisfaction with numeracy and calculating, despite the recent publicity about poor maths results in UK schools, and concern about "other core skills" are almost non-existent.

None of these concerns is new to the 1990s, but it is significant to see them coming so squarely from within the electronics industry. There is no doubt that a sound basis in maths is important to engineering competence. There has long been a perception that technicians and engineers are to be kept in the back room and not required to communicate. Whether the new attention to literacy and communication means that managements are genuinely endeavouring to improve teamwork, or whether they are simply wishing that engineers should be easier to extract reports from is not reported by the survey. Historically, of course, engineers have always felt that it is Management needs to improve its communication and listening skills.

There is also more concern about the shortfall in non-technical skills than there is in technical skills (although only by a narrow margin), despite the fact that the most serious need for personnel is for engineers.

In recruitment, the real difficulty emerges: finding technical employees is top of the list of employers' main concerns. The industry shortfall of trained engineers and technicians is clearly reflected in the survey's results. In the category of "hard-to-fill vacancies", "Engineers" - Sales, Design, Electrical, Field, etc. - elicited 29 responses, around 75 per cent. The next category - test technicians - elicited only seven responses, and the next one after that - sales reps - only five.

In the category of Engineers, the need for Design engineers - engineers actually able to devise new equipment and new means of carrying out operations - is paramount.

"Technical Recruitment Difficulties represent the greatest need" is the conclusion of this section. In plain terms, this should mean that there are jobs there, waiting for people to fill them, at this time when there is still high unemployment throughout the UK.

The replies to many other sections are presented as comments rather than statistics, as they were felt to be to individual to analyses into classes. The underlying themes, though, are pretty clear. "Providing design and applications training that bridges the gap between graduation and being effective in a commercial environment" "More vocational courses with transferable skills" "Support on development projects" "More trained engineers" "More IT training" "Higher basic educational standards" "Higher status to technical disciplines" "Competence development" "Tax incentives for individuals funding their own education" and so on.

Basically, industry is looking for people who know how to do the job, and those who understand it well enough to further develop their own skills on the job. It is felt that schools and colleges should provide basic skills, especially the "three Rs", and that government should provide more incentive to people trying to improve and extend the skill-base, whether their own of their employees'. They want more understanding of industry passed on to students in schools and universities, and more access to management skills as well as technical skills, as teamwork, time- and resource-management is necessary for everyone above the level of junior technician.

MODSMODSMODSMODSMODSMODS

Phoney Phone (November 1996)

IC1 appeared as a 7555. It should be the dual 7556, also available from Maplin.

Camplight (October 1996)

The correct wire width for winding the custom transformer is 0.20 mm insulated copper wire. This information and some extra part suggestions also appeared on page 20 of the December issue of ETI.

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

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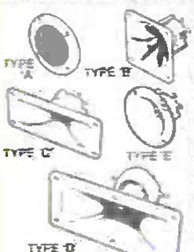

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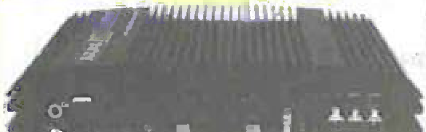

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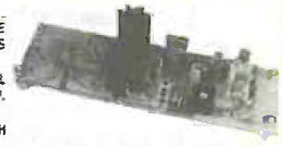

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Smart Cards by the Million

Nick Hampshire takes a look at how smart cards are developing and examines some of the problems facing this technology in the future.

If you open the Sunday papers, or one of the more heavyweight dailies, you can almost guarantee to find an article about some new application for smart cards, those credit card sized plastic cards containing an embedded integrated circuit. They are rapidly becoming another one of those technological products that we all accept as being a part of everyday life.

We use them to make phone calls, to access restricted areas, to pay for goods and services, to travel on a bus or train, and in the near future we will even be using them to prove that we are who we claim to be. Not bad for a concept which, however obvious it may seem today, is only a little over ten years old and encountered much scepticism in its early days. It is one of those products which was conceived by several people in different parts of the world at around the same time, in the early 1980s. However, most of the pioneering work, including nearly all the early commercial applications took place in France.

It was the adoption of smart card technology by French Telecom as the basis of their phone card technology which gave smart cards the initial boost. British Telecom opted for what they regarded as the more reliable, and cheaper, holographic card technology which is only just being obsolesced. Other users opted for the magnetic stripe backed card, like the familiar credit card.

Both mag strip and smart card technologies were at that time also being used for applications such as access control, and of course magnetic stripe cards were widely used in finance in the form of credit cards and charge cards. Both of the widely used phone card technologies performed the same function. They stored a preset number relating to phone units which could be used; this number was then decremented as the card was used. When it reached zero the card was simply thrown away and a new one bought.

British Telecom phone smartcard

In the holographic cards the value was stored as an optical bar with a length equal to the number of units, as each unit was used the bar was shortened by one unit length by fusing the plastic at that point with a heater. In the smart card version, the PROM chip in the card had a fusible link blown for each unit used. Both card technologies performed the same function, both were used once and then disposed of, so why is the smart card replacing the holographic card in phone boxes across the UK?

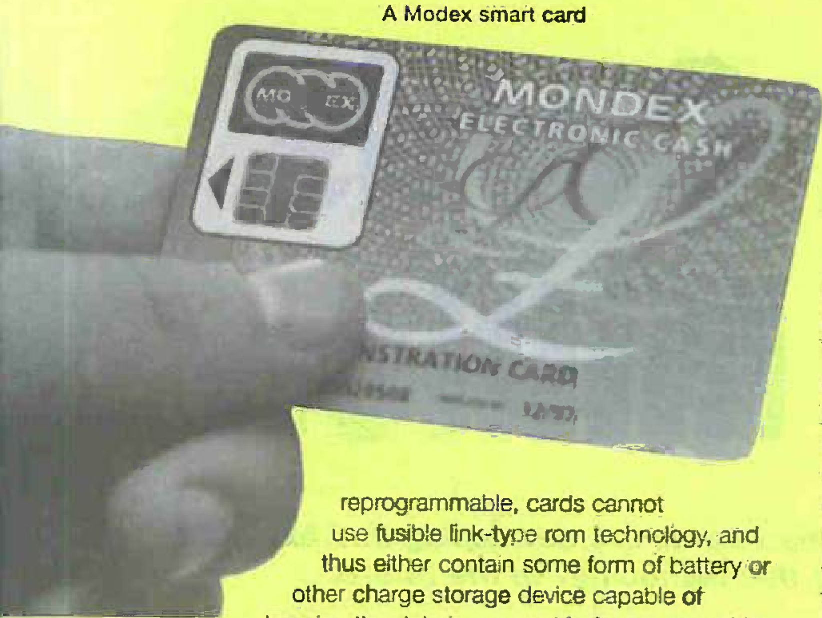
The answer is that smart card technology has advanced to a point where it can be used for much more than simply paying for phone usage. They are no longer necessarily a disposable one-function item, but as a key part of the financial system of the future.

Smart card technology

There are three common types of smart card currently in use. The simplest is the preset stored value card such as phone cards. These cards are simply thrown away when all the stored value is used up. Then there is the rechargeable stored value card, such as those used as utility payment cards, where the card can be reused by putting new value into it using a special terminal. Finally there is the intelligent card, such as those being used in some advanced electronic purse systems, where a microprocessor built into the card is used to give added security and additional features.

There are two types of card design, those with contacts and those without. The commonest types of smartcard simply consist of an ic mounted in a credit card sized piece of plastic sheet with a set of gold plated contacts in a fixed position on one side of the card. In most such cards the ic is basically a one-time programmable Read Only Memory, which can either be pre-programmed to output a particular numeric value or can have the stored value decremented by the card reader as is the case with phone cards. Simple rechargeable, or

A Modex smart card



reprogrammable, cards cannot use fusible link-type rom technology, and thus either contain some form of battery or other charge storage device capable of keeping the data in a ram chip for a reasonable period, or in an eeprom. Such cards are commonly used in access control systems to contain additional data about the authorised user and permitted access areas.

The intelligent cards may look no different, but they are infinitely more sophisticated and the reason why there is a current explosion in applications for smart card technology. Intelligent cards usually contain a fast embedded microprocessor and large memory capacity as well as some form of charge storage to ensure continuing functioning of the processor over very long periods. The embedded processor means that such cards can use advanced encryption techniques which allow them to be used in financial applications, such as the new electronic purse systems, that must be secure against fraudulent use.

The smart cards of the future will be even more sophisticated. In the high tech battle against fraud they will have sufficient embedded intelligence to recognise the owneris retinal pattern or palm print. Within the next couple of years we will see the development of smart cards containing several Mbytes of memory and high speed 64bit RISC processors.

Contactless cards are favoured by the utilities, in particular the transport companies, since the card does not need to be inserted into the card reader, but only come close to it. This is important for two main reasons; firstly it allows the card checking time to be reduced to an absolute minimum, very important when faced with large numbers of commuters eager to get home. Secondly, it is more reliable, since there is no problem with contact wear on the card reader due to heavy usage.

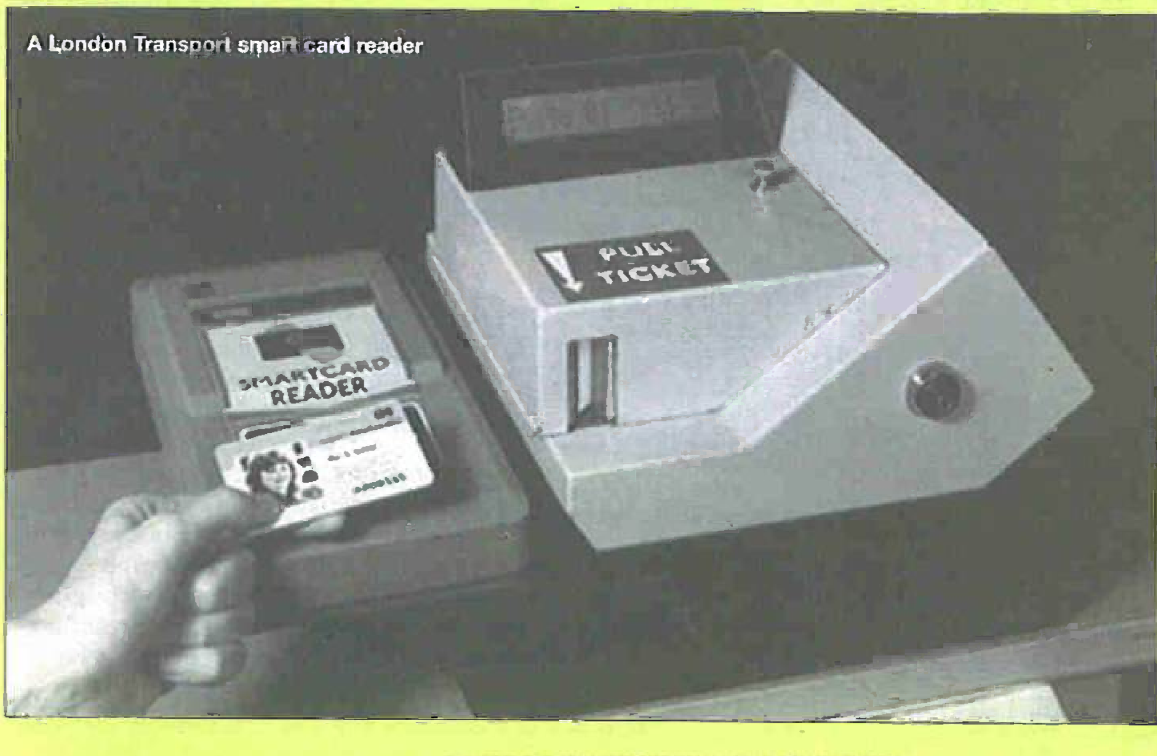
Mitsubishi are a major designer of contactless smartcards. Those seen so far employ electromagnetic coupling to transfer data between the card and a transceiver unit at up to 25.6kbps and at a distance of up to 80cms, and an updated design is expected in 1997. The cards incorporate an 8-bit microcontroller with on-chip rom and ram, and have been designed to form part of an integrated system with transceiver units linked via a network to a host controller. Contactless cards tend to be much thicker, since they incorporate a transmitter and receiver with aerial coil, in addition to a charge storage device. Most contactless cards are of the rechargeable intelligent variety; this is because the card's extra electronics makes them too expensive to be disposable.

Smart card applications

The development of the smart phone card over ten years ago demonstrated that the technology could be economically used as a replacement for cash. Not only does it demonstrate that the technology could be used, but it also showed that there was widespread public acceptance for the idea. The development of the smart phone card also had the effect of developing all the techniques for very low cost mass production of such cards, together with the reader technology. This in turn has led to on-going research into smart cards, research which has resulted in both the advanced card technology now in use and the multitude of applications which we see around us today.

Rather than look at all the enormous number of different applications for smart cards we will examine just three types of application in some greater depth. These are: smart cards for access control; smart cards as a ticketing system in public transport; and smart cards as a means of transferring cash between individuals, retailers, banks, etc. These three types of application are perhaps the most important, because they will affect the lives of all of us within the next few years.

Anyone who works in a job where there is restricted access to certain areas, for safety or



A London Transport smart card reader

security reasons, will be familiar with the badge type systems which have been in use for many years. These credit-card sized plastic badges usually bear a photo of the individual, and some text giving name, job title, access authorisation etc. These cards usually carry a mag stripe on the back which us used together with a PIN number to gain access to restricted areas by means of a card reader and keypad controlled door lock.

The smart card version is essentially exactly the same, except that there is no mag stripe. Instead the card is a contactless smart card which can be read by the door lock system without the owner having to swipe it through a reader. So, what is the advantage of the smart card system over the mag stripe system?

One advantage is that it is more robust, mag stripes are easily damaged, and the data can be destroyed by coming in contact with a magnetic field. It is also easier to use because there is no need to physically swipe the card through the reader. However, perhaps the biggest advantage is the one that is least obvious to any user. A contactless smart card with a reasonable sensitivity across a range of several metres cannot only be used to open doors, it can also be used to track the location of the person carrying the card. In fact, card readers can be placed anywhere to provide virtually unlimited security control.

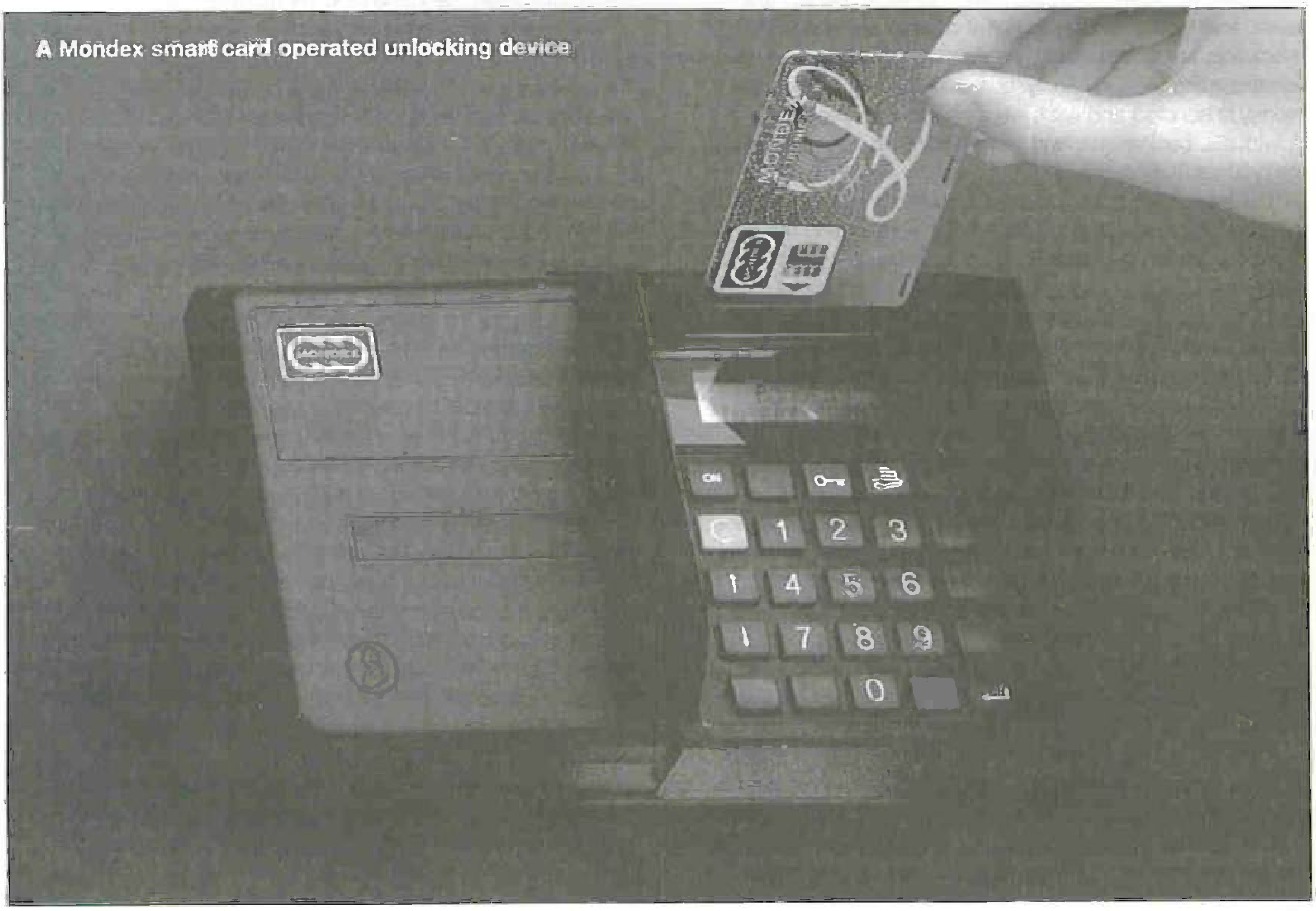
Smart card ticketing systems are basically another type of access control system, and once again basically replace the widely used mag stripe cards that are used for season tickets. The public transport operators, such as the railways, underground, and bus companies see smart cards as a replacement for the existing paper tickets which can offer the operators greater flexibility and information feedback than is otherwise possible.

Probably the biggest smart card ticketing scheme in Europe is about to be launched by London Transport. It will involve contactless cards being issued to all London Transport season ticket holders. The cards will be read by terminals on every underground station access gate, and on every bus. All terminals will be linked to a central computer systems that will give the operators an instant picture of passenger movement across the city.

The use of smart cards gives LT an increased number of ticketing options in addition to the existing one day and season travel cards. For example it will allow travellers to have pre-paid cards which will be decremented in value as they are used, in much the same way as a phone card. The LT cards will be rechargeable and passengers will be able to recharge their cards as required at terminals located in underground stations, as well as local shops, post offices, etc. London Transport see enormous advantages in such a smart card ticketing system, advantages which well outweigh the enormous cost of implementing it.

The main advantage is that will allow them to build up a very detailed analysis of exactly how passengers use the public transport network. This data will allow them to optimise scheduling to cater for the changing pattern of usage. Smart fare cards also have the advantage of reducing the need to handle large quantities of cash, something which will both reduce the enormous expenses involved. Smart cards will also help reduce ticket fraud and theft. Because the system will be able to track the position of any smart card carrying passenger on the network, it will be possible to automatically notify the police of the illegal use of a card and have the illegal user apprehended at the next stop. Also, because all records will be stored on the central control computer it will be possible to compensate the owner for any illegal use.

A Mondex smart card operated unlocking device



The electronic purse

It is the ability to securely store monetary value within a smart card which has attracted the most interest in the last few years, and led to the development of what are known as 'electronic purse' systems. The development of this technology will according to many analysts revolutionise the way that money is handled and will have an enormous impact on individuals, businesses, and governments in the early part of the next century.

The 'electronic purse' system is based around a smart card that has stored within it a digital value representing the amount of money which has been put in the electronic purse. The card, the size of a standard credit card, locks into a special electronic wallet which makes it useless to anyone but the owner. The wallet, which looks like a small calculator with keypad and display, is accessed by a security PIN code.

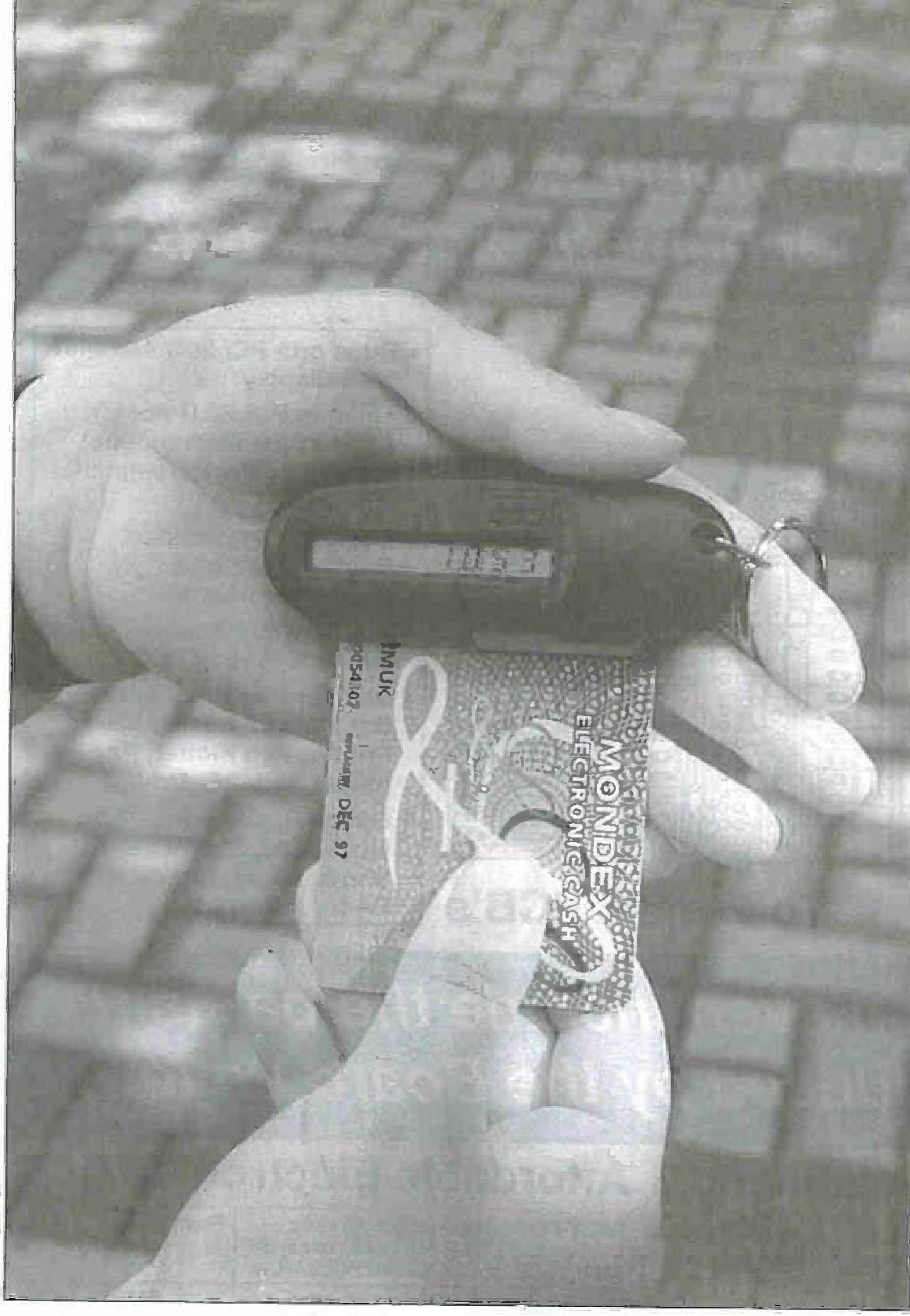
Probably the most advanced 'electronic purse' system in the world is run by Mondex, a consortium of National Westminster Bank, Midland Bank, British Telecom, plus 17 other banks, and now 51% owned by the Mastercard international credit card consortium. A rival system is Visacash, from Visa, the other main international credit card consortium. This card, which was given a test launch at the Atlanta Olympics this year, is expected to be in operation in Leeds and a couple of other UK cities within the next year. Since the middle of 1995 the Mondex system has been undergoing a large scale public test in Swindon (population 190,000). In this trial over 12,000 people were issued with Mondex cards, and over 700 retailers supplied with terminals capable of taking Mondex cards. In addition, the Mondex card can be used in many Swindon telephone boxes and via bank ATM machines.

The test has proved very successful, with customers able to use the card for buying everything from an evening paper from a street news-vendor, to a drink in the local pub. The test has now come to an end, and Mondex are planning a UK national launch of some time in the next six months.

The survey associated with the test has shown that over 21% of the member bank's customers have taken up Mondex, this equates to a UK national figure of 2.5million people. The average user has been loading between L25 and L30 into the Mondex card, and the majority of purchases are for less than L5, with fast food, newspapers, bus fares, confectionery, and car parking tickets, being the most frequently purchased items. Supermarkets accounted for the largest value purchases and were the biggest users in terms of value, followed by department stores and petrol stations.

According to the survey, cash was previously the preferred payment method for 98% of sales in a newsagent, with Mondex card holders this has dropped to 32%, with 66% using their cards as the preferred payment method. Interestingly, 77% of users felt that the Mondex card was safer than cash, and 90% found it very easy to use. The great advantage of the Mondex system, unlike the competing VisaCash system, is its complete anonymity. It has been designed to be exactly like cash; the transactions are not logged on some central computer, the card value is simply incremented or decremented. Cash can be loaded into the card from another card, via the wallet, or from a bank ATM machine, and even a phone box can be used to transfer cash between individuals, and between an individual and the bank.

The 'electronic purse' technology is seen by the major banks of over 26 countries, including most EU member states, as the key component in a long term goal to abolish 'cash'. The abolition of cash is seen by both banks and retailers as a very important goal. Handling cash is expensive, and in the UK alone is estimated to add over £4.5billion per annum to overall



business costs. Currently about 90% of all transactions in the world are made using cash. Mondex have set a goal of taking over 40% of these.

The credit card companies are also becoming involved in the use of smart cards which they see as a technology which will allow them to beat card fraud as well as offering additional services. As part of the EMV and APACS projects both Visa and Mastercard have developed smart card versions of their credit cards. Starting next year the banks involved will be converting all credit cards and credit card terminals to use smart cards as opposed to conventional mag stripe cards, a process which they estimate will take between five and ten years, with hybrid cards being used in the transition period.

Uniquely in the UK, debit cards are also being converted to smart cards. This move is being paralleled by big retailers rapidly expanding their loyalty card schemes into the financial services sector, such as Tesco's Club Card scheme and Sainsbury's recent acquisition of a banking licence. As yet none of the big supermarket chains have come up with a smart loyalty card, although Shell have produced a multi vendor smart loyalty card which may well be a pointer to the future in this area.

Too many cards and not enough standards

The rush to use smart card technology for a wide range of different applications is good from the standpoint of the technology developers and suppliers, but for the end user it spells chaos. This potential chaos will arise from the lack of any degree of standardisation apart from the actual card size. Take a half dozen different smart cards and you will find the contacts positioned in slightly different places, and the contact layout slightly different.

In many ways this is probably a deliberate policy. Card issuers do not, for example, want users to try using a Shell loyalty card in a BT phone box. However, do we, the users, want to end up with a wallet or purse stuffed with assorted smart cards? The trouble is that too many incompatible smart cards could end up destroying the potential offered by smart card technology, particularly as a means of electronic cash payment. If they are to replace old fashioned money as the preferred means of paying for low cost items then they need to be universally acceptable, just as conventional cash is within a specified country's borders.

For the technology to be of any value, the user of, say, a Mondex electronic purse card needs to be able to use it in the same terminals as a VisaCash card, or use it in a BT phone box, or even use it to pay for a ticket on London Transport. Otherwise we end up with the same infuriating situation that exists with credit cards - to be sure of being able to pay for something wherever you are you need to carry a card from all three big card groups, Mastercard, Visa, and American Express. If you do not then the odds are that you will be greeted with 'I am sorry but we do not take that card'.

This page shows two types of Mondex keyfob smartcard reader

A Mondex telephone terminal

The fact that all the main credit card groups are independently developing smart card based electronic cash technology means that we can look forward to a perpetuation of the existing credit card system. Retailers will be forced to have two or three terminals, one for each type of smart card, in addition to terminals for their own loyalty cards. It is difficult to see a street newspaper vendor investing in the means of accepting payment from two or three different electronic purse systems, and if someone like that does not accept all the competing cards then electronic cash will not be a reality. Some sort of standardisation will probably evolve over time but only after some very expensive 'terminal wars' have been fought by the main electronic purse providers.

The spectre of Big Brother?

Like a great deal of information technology the smart card has the potential to be extremely beneficial to society in general, but at the same time could also be perverted to the detriment of both individuals and society as a whole. Smart card technology gives both governments and big companies the ability to pry into our everyday lives, to check what we buy in the shops, to see where we go, to know exactly what we spend our money on, what papers we buy, what meals we eat, what films we see.

The spectre of Big Brother can easily be conjured up by the improper use of smart cards. However, we must accept that gathering data on customers is now a key element in both marketing and management. Such data allows companies to tailor their services to the needs of the customer, while at the same time maximising profitability. Indeed such data is rapidly becoming the most important asset of many companies, and it is thus hardly surprising that they are prepared to invest heavily in any technology which will increase the value of that asset.

Smart cards fall into this category, since they will allow the information gathered on each customer to be drawn from a much wider area. Although it is important that as a society we carefully look at how new technologies such as smart cards are both applied and used, so as to prevent any usage which will have a negative impact on us as individuals and the community in general, it is also important that we look at the positive side. While smart cards may make gathering data easier, they could also be used to give back to the individual control over the data relating to that individual.

Smart cards could in the future be used, for example, to store an individual's complete medical records, data which could only be accessed via some form of security technique such as retinal scanning. A use of the technology which would be far preferable to storing all such data on a centralised computer system that could potentially be accessed by any inquisitive individual.

The future for smart cards

All around the world there are now groups of engineers developing the smart card technologies of tomorrow. They are working at building more and more intelligence into a card as well as increasing the memory capacity of cards. Indeed it is probably fair to assume that by the end of the century we will see smart cards that have a processing power equal to that of a mid range PC of today, and come complete with a megabyte or two of memory.

One of the principle security related aims for all this extra processing power is to allow smart cards to both carry and analyse biometric data. This means being able to recognise voice commands, palm prints, or retinal patterns, in addition to a conventional signature. The extra memory capacity will also be used to allow smart cards to act as personal information storage ystems, containing perhaps, the owner's complete medical records.

However, as smart-cards become more intelligent so the concept of a smart card as a credit card sized piece of plastic may start to give way to the increasingly talked about concept of the 'wearable computer' - rather than carrying a smart card in a wallet or purse it may become something we wear, like a watch, and in the light of recent IBM research we will then communicate with each other via subcutaneous signals transferred by a handshake.

A Mitsubishi contactless Melcard

A Modex wallet Terminal

Are smart cards really secure?

The smart card, a credit card sized plastic card which contains electronic circuitry capable of storing several kilobytes of data, are increasingly being viewed by banks and other financial institutions as the solution to credit card fraud. They also see smart cards as a means of generating new forms of revenue from applications such as electronic cash.

Smart cards are viewed as being immune to fraud. This is because the large memory capacity plus the incorporation of a small processor in the card's circuitry means that it can have an unique identity, an individual and totally unique electronic signature. Unfortunately, however, recent research at France Telecom, a world leader in smart card development, has shown that this may not necessarily be true.

The common card specification drawn up by the major credit card companies and known as EMV uses the RSA encryption algorithm. This algorithm relies on two keys consisting of 155 digit numbers, one public, and the other hidden in the card's memory. These keys are used to generate another number which is then used to code and decode the data stored on the card. The flaw lies in the fact that in order to either create or verify such an electronic signature requires a lot of processing, and thus a long time.

According to security experts it takes about 30 seconds for the card's RSA keys to be generated, this is deemed too long for both everyday use and card manufacture. In both cases between 1 and 2 seconds is the target. The result of this time problem is that card manufacturers are considering replacing the unique signature with one of 10.000 preset signatures. This will of course mean that no card will be unique, indeed, there could be thousands of identical cards in circulation, a situation which lays smart cards wide open to fraudulent use.

However good the encryption techniques may be, yet further questions about smart card security have been raised by a group working at the University of Cambridge. Using a variety of different techniques these researchers claim to have broken the security of every smart card they have seen, a claim which is causing some serious redesign work to be done by smart card developers across the world.

The research group, led by Dr Ross Anderson, a lecturer at the university's computer laboratory and an expert on computer security, were able to penetrate even the most secure chips and have shown how fraud could be committed on an industrial scale. In a paper recently published on the Internet the group have outlined the techniques for cracking one of the most widely used microprocessor chips, the Dallas Semiconductor's 5002, a device which is used in about 1million POS terminals.

The manufacturers of equipment incorporating the Dallas Semiconductror device, as well as Dallas themselves, are now working on measures to overcome the weakness identified by Dr Anderson. However, what Dr Anderson's team have shown is that any security technique can be broken, and that the developers of secure smart card systems will have to continually develop new and better security techniques if they are to stay one step ahead of the fraudsters.

New series

Experimenting

THE SYNC SEPARATOR

In the first part of his new series, Robin Abbott introduces video signals and constructs a sync separator module that can be incorporated into other circuits, for example a multi-function fader-wiper.

In recent years, with the increasing affordability of camcorders and other video sources, the operation and construction of electronic projects involving video signals has been of greater interest to electronics constructors.

Virtually all video recorders, camcorders and increasingly computer systems and video games are equipped with composite video outputs, and sometimes input connectors. In this series we shall look at the operation of the composite video signal and how it may be manipulated. We will look at some techniques for manipulating the signal, some typical video building blocks, and how to construct faders, wipers, mixers, and test equipment.

The composite video signal

The composite video signal is so named because it is a single analogue signal which contains the brightness (known as luminosity), colour, and synchronisation information necessary to display a complete colour picture. On a TV broadcast it also contains teletext signals, which are not normally visible. It is sometimes described as a baseband video signal. The signal has a bandwidth of approximately 4MHz for black and white (monochrome), and approximately 6MHz for colour. The signal has a DC content which, as we will see, can cause us some problems.

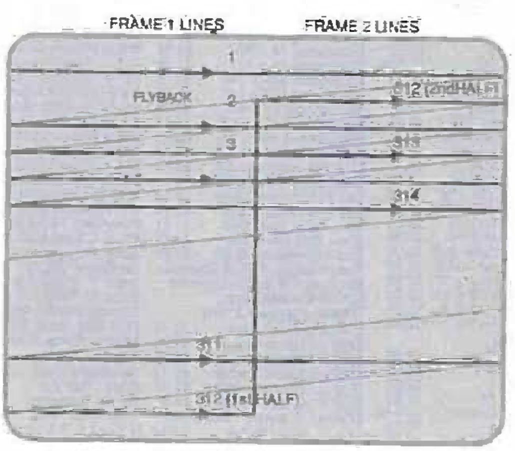


Figure 1: frame displayed on CRT

A frame is a complete picture displayed on a monitor or a television receiver. In this series we will look only at standard TV frames in the UK video system (although foreign systems are similar, but with differing details such as number of lines, frame rate, and method of colour encoding). A complete frame is included in the composite video signal once in every 40 milliseconds, resulting in 25 frames (or cycles) per second. If we were to view a TV picture at this frame rate, however, it would flicker unpleasantly. To overcome this problem the picture frame is split into two halves, and one half is sent every 20ms to result in a 50Hz display rate.

The two frame halves are split such that one half displays odd lines of the frame, and one the even lines of the frame. The persistence of the cathode ray tube (CRT) is such that the two halves appear to come together to make a single frame at the 50Hz rate. A frame half is referred to as a field.

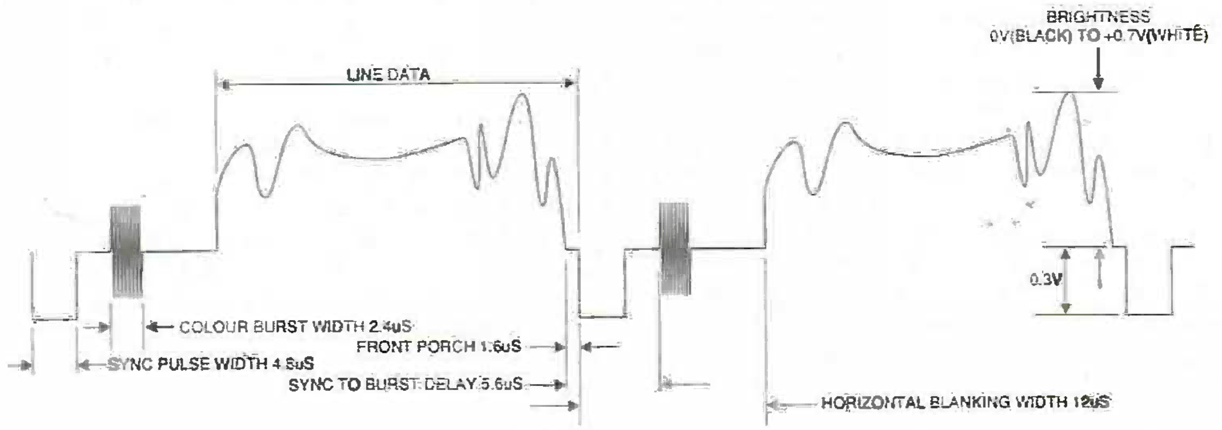
The frame is made up of 625 lines, and each field includes 312.5 lines. Figure 1 shows the composition of a single frame on a CRT. Each line takes 64us.

The composite video signal must include information to signal to the monitor the start of each line, the start of each field, and whether a field forms the odd or even half of the frame. These signals are the synchronising (or sync) signals. The lowest level of the signal defines the black signal, and a signal level below the black level can be used to define the start of each line, and the start of each field. The level of the signal drops to -0.3V to indicate sync information. We will consider the black level to be 0V (in practice as we shall see this is usually not the case, although in the designs that follow the video signal is adjusted to ensure this). Figure 2 shows two complete lines of video information.

Note that the signal drops to the black level (0V) at the end of each line for 1us. This is called the front porch. It then drops to -0.3V for a period of 4us to allow the monitor circuits to return the electron beam to the start of the next line. There then follows a period when the signal is at the black level, defining black for the following line for the receiver. This period (called the back porch) lasts for 7us, and then the line information starts. During the back porch, for a 2us period a

With Video PART 1

Figure 2: lines of picture information



burst of the colour subcarrier is sent, which is used to lock the internal oscillator of the monitor to the colour signal and to allow the colour signals to be demodulated.

Thus the 64us line time contains video information, and then 12us to define the end of line, the black level, and to send the colour synchronising signal. This 12us period is described as the line blanking interval - no information is displayed on the screen during this period.

The video information is carried as a simple brightness (or luminosity) signal, with colour modulated onto this basic signal. The luminosity signal varies from 0V (which is black), to 0.7V which represents white, with shades of grey in between. The electron beam in the receiver sweeps from the left hand side of the CRT to the right, so the information sent immediately after the back porch is the information on the left of the screen. If you have an oscilloscope and a camcorder it is possible to test this, and careful adjustment of the trigger level can allow a reasonable display of a line. Point the camcorder at a piece of white paper and place a black card half way across the lens. The difference in the signal should be clearly visible.

Colour information is sent as a subcarrier at 4.33MHz. The composition and use of the colour signal is beyond the scope of this first article, but it is important to note its presence, and in particular it is very important to maintain the amplitude and phase of the colour burst during the back porch to ensure a stable colour picture.

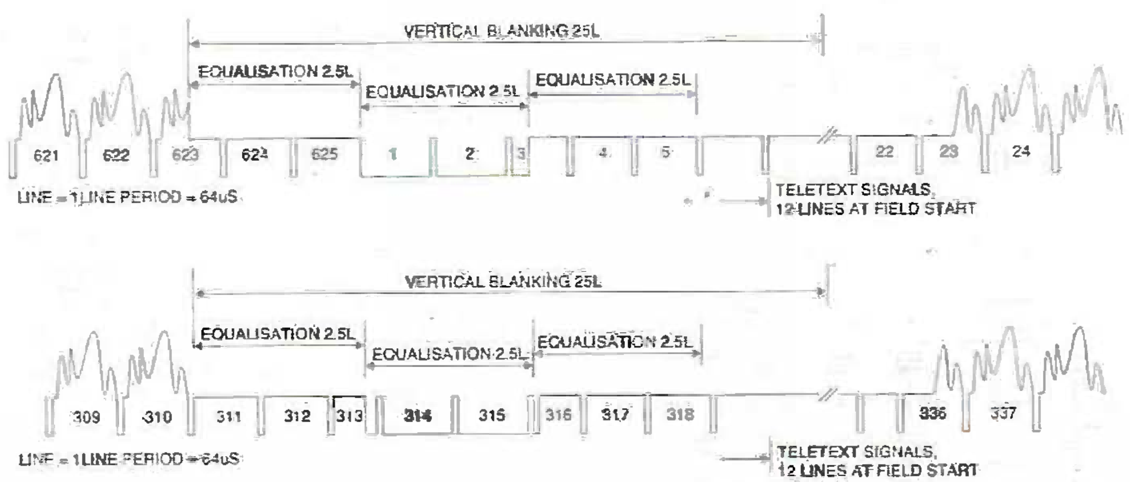


Figure 3: field synchronisation signals (for clarity, equalisation pulses are not shown)

Frame synchronisation

Frame synchronisation is complex. A full understanding of frame synchronisation is not essential to experiment with video, but an explanation is presented here for completeness. Figure 3 shows the end of a frame. For a period of 25 lines the field information is blanked to allow the monitor to return the electron beam to the top of the CRT. During the latter part of this period (when there is no opportunity for the monitor to display any information) the TV transmission authorities superimpose teletext data on the signal during the line.

At the end of each field a field sync pulse is sent which lasts 2.5 lines (160us). As for the line synchronisation signals this pulse is at a level of -0.3V. However the monitor must still detect the start of each line during this period to start the lines correctly when the field sync pulse is complete. For this reason the field sync pulse is temporarily removed just before the line sync pulse so that the signal level is 0V instead of -0.3V just preceding the line sync pulse. This means that the falling edge of the sync pulse is in the same place as before, and that there is what looks like an inverted line sync pulse before the line sync period. Monitors and TVs operate on the falling edge of the pulse, so that they continue to detect line pulses correctly.

TVs and monitors usually generate the timing signals for lines using analogue circuitry. One field ends half way through a line, while the other field ends at the normal end of a line. Thus the field sync pulse arrives in one field closer to the last line sync pulse than in the other. The analogue circuitry for the frame sync detection is upset by this disparity, so "equalising pulses" are included in the lines before, during and after the frame sync pulse. These pulses sent halfway through each line, they ensure that prior to the field blanking interval there are the same number of transitions below the black level, and correct the frame sync problem. It is necessary to be aware of these signals when counting lines as some line sync detectors will trigger on the equalising pulses as well as line sync pulses.

Driving a composite video signal is straightforward. Virtually all devices with a composite video signal input terminate it with a 75ohm resistor, so any device driving a video input should provide an output of double amplitude with a 75ohm resistor in series with the output. Similarly inputs should be terminated with a 75 ohm resistor (unless they are intended to be used in parallel with other devices).

Video signals are quite frequently provided on phono sockets, and phono leads can be used to connect devices together. Most recent equipment also includes a SCART socket. This type of socket is multi-function and amongst other signals carries composite video signal inputs and outputs, as well as stereo and mono audio information. All the projects that we will look at can make use of the SCART socket or phono sockets. The latest high band video equipment (Hi-8 and SVHS) provides output on an S-Video connector. These are described below.

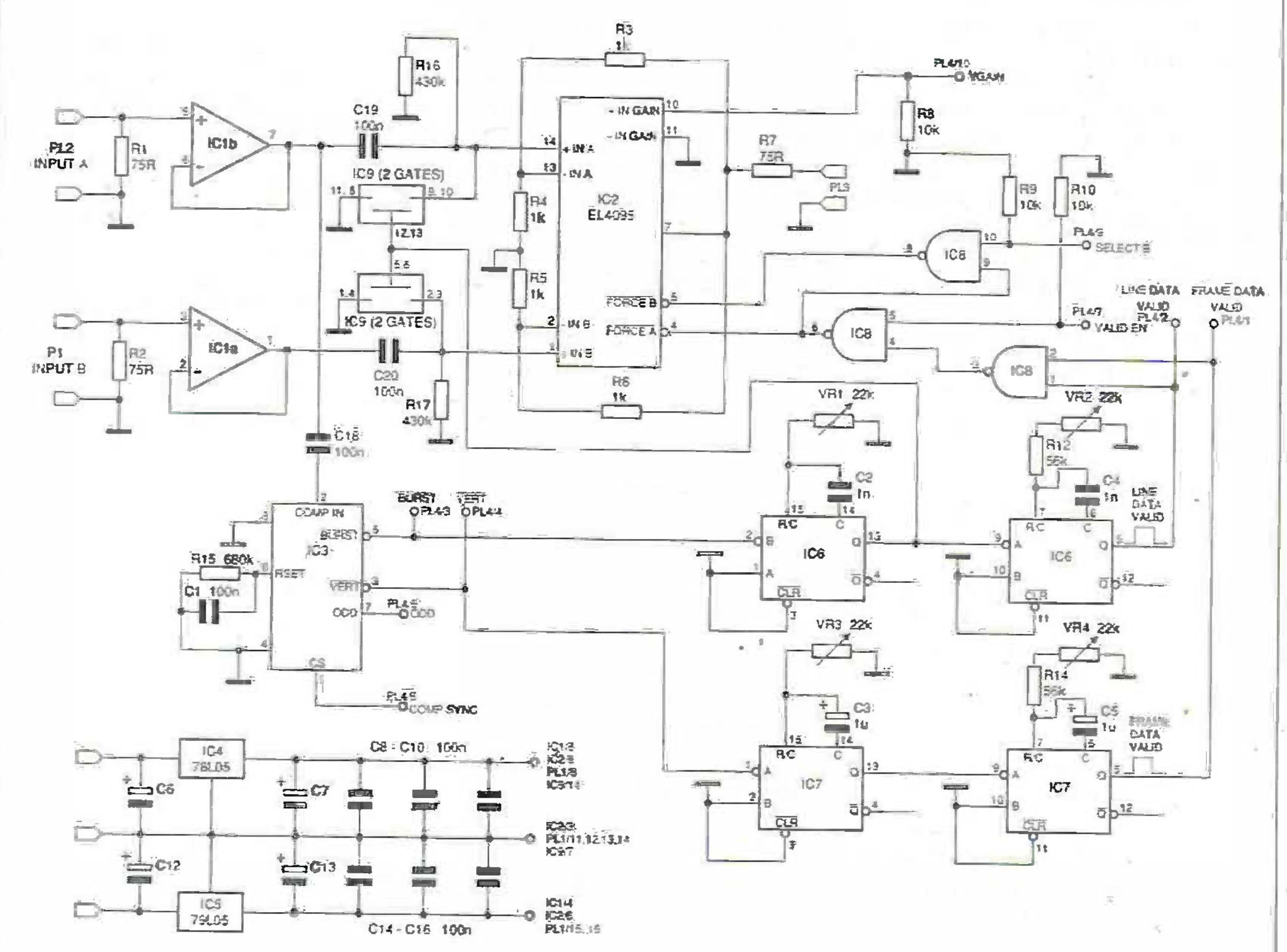


Figure 4: circuit diagram: sync separator, video buffer and variable gain sync regenerator

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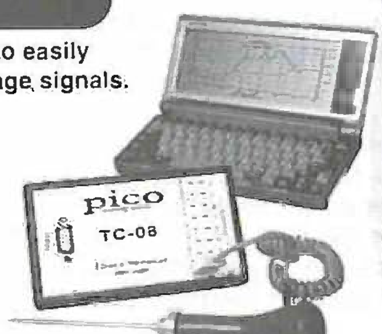

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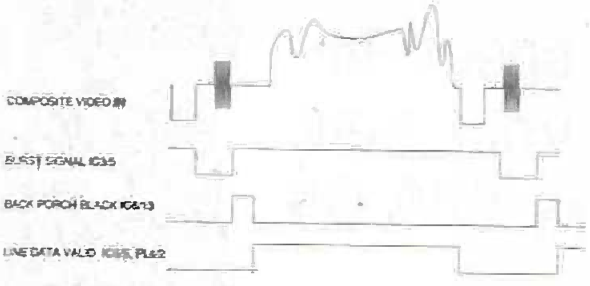
Figure 5a: waveforms from different parts of the sync separator circuit



The sync separator

In this article we shall look at the design and construction of a general purpose video buffer, sync separator and regenerator. This is an essential building block of any project which is to modify the composite video signal. The sync separator provides the following functions:

Input buffer for two video signals.
DC restoration for each signal (see below).
Voltage controlled mixer to control gain of each channel and mix the channels to a common output channel. This provides fading or mixing.
Output buffer.
Synchronisation signal detection.
Line and frame valid signals which may be used to control mixing and wiping - however we manipulate the video signal we must ensure that the line and frame sync pulses are maintained because any operation which affected these sync signals would destroy the ability of a monitor to display the frames, and this function is provided on this board.
Fast switch to restore original sync signals.
We shall also look at how the circuit may be used at the heart of a fairly sophisticated multi function fader/wiper. In the next article we shall extend this to a full video mixer/fader/wiper which is digitally controlled and, apart from keyboard operation, may be controlled over a serial link from a PC or other computer to provide pre-programmed effects.

The circuit

Fortunately many useful video functions have been provided in integrated form. In this project we will be using the ELANTEC series of video buffers and control blocks.

Figure 4 shows the circuit diagram of the sync separator and regenerator. IC1a and IC1b provide unity gain buffering for the input signals. These are wide band op-amps which have a unity gain bandwidth which extends into tens of megahertz. The inputs are terminated with 75ohm resistors. If there is no signal on the B input then fading and wiping to channel B will fade and wipe to black.

From the output of IC1b (which is the buffered output from channel A), the sync circuit determines the line and frame synchronisation signals. This is achieved by IC3. This universal sync separator chip derives 4 output signals which are logic compatible. The burst signal goes low during the colour burst on each line. The vert signal goes low during the vertical sync period, and is generated on the first serration during the vertical sync period. The ODD output is high during odd fields and low in even fields. The composite sync output reproduces all the video input pulses.

Monostables

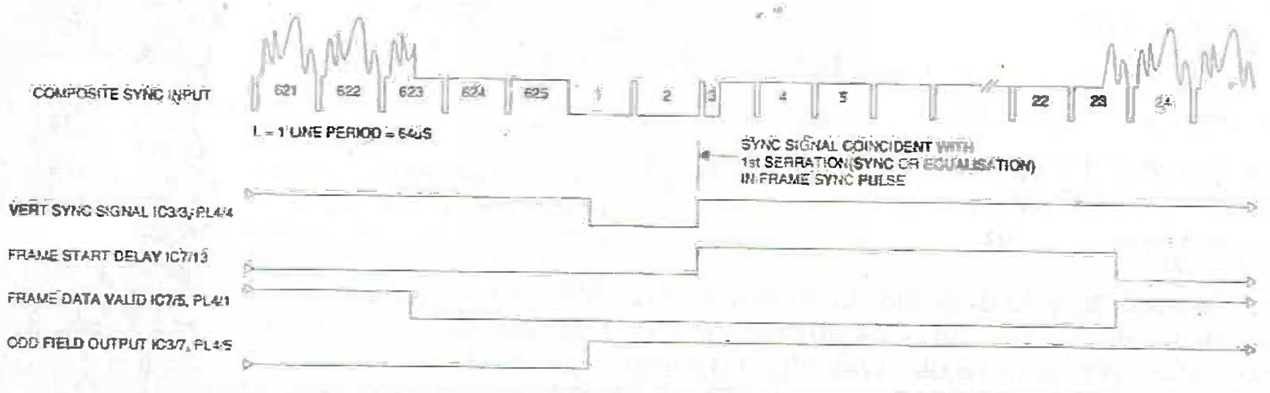
IC6 and IC7 are monostables used to derive useful signals for the rest of the circuit. IC6a is driven by the rising edge of the burst signal. It is timed to produce a pulse of about 4us which is active during the period of the back porch following the colour burst. This is used in DC restoration (see below). The falling edge of this pulse defines the beginning of the line. IC6b is triggered by the falling edge of IC6b and is set to produce a pulse of about 50us which is the same length as the data in the line. Thus the output of IC6b is a signal which is high during the line data, and low for the entire line blanking period. This is used to switch the Input signal directly to the output signal during line sync data.

In similar fashion IC7 provides a signal which is high for the entire period of the field when there is no synchronisation data in the input signal. This is used to switch the input signal directly to the output signal during field sync data.

Figure 5 shows the timing of signals around this circuit.

C19 and C20 provide ac coupling from the input buffers into the next stage. Here we find the DC restoration circuit. The biggest problem with fading a video signal is that the average DC value of the composite video signal varies with the brightness of the signal. A white field will produce a video signal which has a DC level which is several hundred millivolts above the DC level of a black field. The result of this is that the black level varies with the type of picture being displayed. Any attempt to fade or wipe this signal to black (or white) will result in a blank field which will vary in shade of grey depending on the signal which is being faded. To overcome this it is

Figure 5b: waveforms from different parts of the sync separator circuit



necessary to bring the DC value of the black level back to a fixed level, in this case we choose ground so that an unused input appears as black.

DC restoration is traditionally accomplished using a diode clamp, however this does not guarantee restoration to ground. during the back porch (recall that the back porch defines the black level). The post burst pulse from IC6 is used to define this period and an analogue switch is used to short the signal to ground. R16 and R17 serve to pull up the signal during the period when the signal is not being clamped, and serve to make the black "blacker" which gives a better fade or wipe.

Integrated fader/mixer

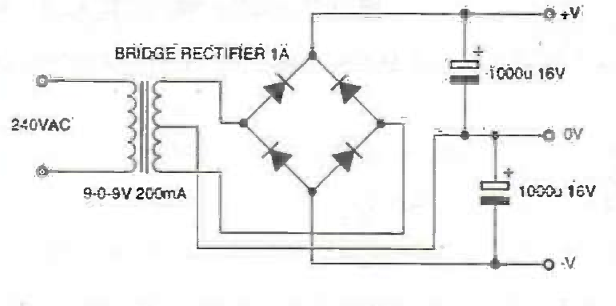
IC2 is an integrated 2-channel fader/mixer IC. It has two inputs, A and B, and a gain control which defines the gain on each channel. The gain control should vary from -0.5V to +0.5V. When it is at the lowest voltage then channel B has full gain, and channel A has zero gain. When at the highest voltage then channel B has zero gain, and channel A has full gain. Thus the gain input may be used to fade the signal between channels, or when there is only one channel, to fade to black. Please note that the input impedance of the gain control is very low within IC2 (about 5K), and therefore should always be driven from a buffer.

IC2 also has an output amplifier, this is set to have a gain of +2 by R3,R4, R5 and R6 so that the output signal level (which is driven by a 75 ohm resistor) is at the right level when it is terminated correctly.

IC2 also has two inputs which force the gain to full gain on one channel and zero gain on the other. These are the force A and force B inputs. These inputs are used to force the output to channel A during sync periods by the line data valid and frame data valid signals. Whenever these signals are low (during sync periods) channel A is forced to full gain, so that sync signals are passed directly through without modification.

To achieve wiping functions, channel A is turned off and full gain is given to channel B. This is achieved by IC8. Whenever the Select B input (pin 10 of IC8) is grounded then channel B is placed to full gain, and with no input signal to channel B, the output of the circuit will be at the black level. However IC8 also ensures that during sync periods the output of the circuit is forced back to channel A.

Figure 7: simple power supply circuit



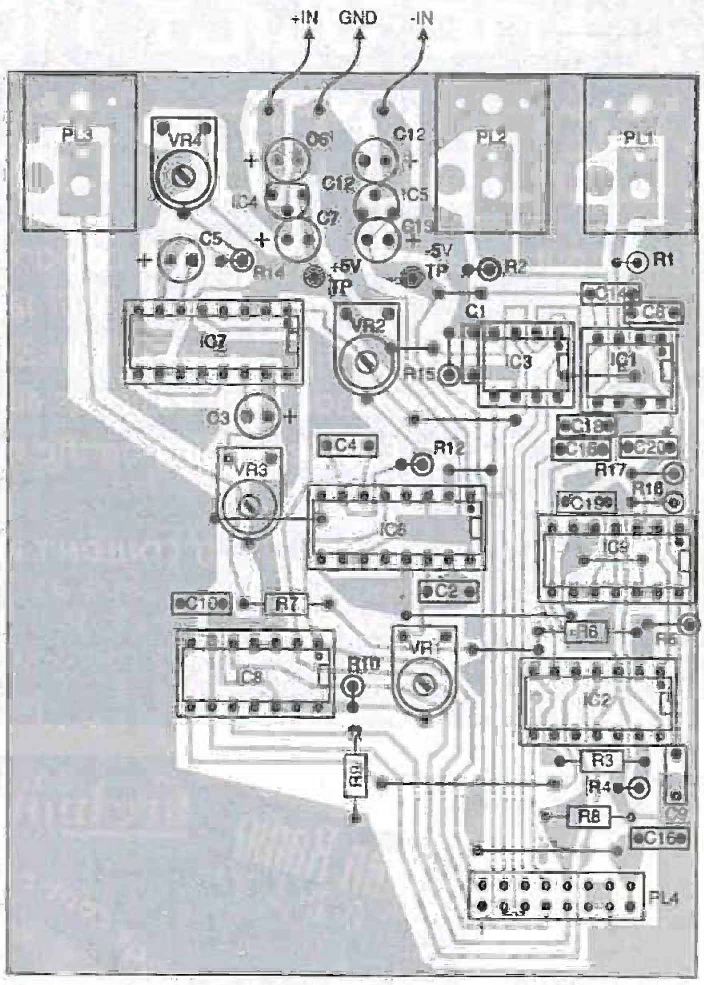


Figure 6: the component layout

There is a 16 way control connector provided on the board. This provides the following signals:

Burst, vertical, odd and composite sync outputs from IC3.
Line data valid from IC6.
Field data valid from IC6.
Input to force the output to take its input from input A or input B directly.
The gain input to fade between channels A and B.
Power supplies at -5V and +5V at about 50mA drive capacity.

Construction and setting up

A PCB has been designed for this project. However, layout is not critical as most of the signals are at a high level and low impedance, and stripboard techniques could be used for the construction of this circuit. Close decoupling of the power supplies to the video chips IC1 and IC2 is very important whatever technique is used for construction. Figure 6 shows the component layout for the board.

Fit the 11 wire links first - some of these run under other components, so stripped hook up wire is recommended. Next, in order, fit the ic sockets, the resistors, the capacitors (watch for polarity here), and the remaining components. The board mounted phono sockets are sold by Maplin, other phono sockets may require a different board layout. Do not fit the ics into their sockets yet.

The board requires a power supply at +/- 9V. Figure 8 shows a suitable circuit. To set the board up, connect the power supply and check the power supply pins of the IC sockets which should be at +/-5V as shown on the circuit diagram. Power down, insert the IC into their sockets, and power up again. Connect a composite video signal to PL2 (the A input), and monitor the output from PL3. The output can be connected directly into a TV set via a phono or SCART socket, or through a video recorder or modulator. At this point the display will be at half brightness, and will probably be rolling.

If you have a dual trace oscilloscope, trigger it from IC5 pin 7, connect channel 1 to the input on one end of R2, and channel 2 to pin 13 of IC6. Finally set the trigger delay to examine a line about 5ms into the field. Now adjust VR1 so that the output on pin 13 ends just before the line data, connect channel 2 on pin 5 of IC6, and adjust VR2 so that the signal ends just before the front porch. Now increase the timebase and monitor the outputs of IC7 to adjust VR3 and VR4.

If you do not have an oscilloscope then connect pin 10 of IC8 to +5v (connect to one end of R9 - make sure it is the signal end !). Now the display on the monitor should be blank, although the picture may show around the edges. Adjust VR1 to bring the picture onto the left of the display slowly, back off until the picture disappears and is stable. Now adjust VR2 so that the picture just disappears on the right hand side. In similar fashion use VR3 to adjust the top of the picture, followed by VR4 to make the entire screen black, and stable.

Using the sync board for a multi-function fader/wiper

In this section we will look briefly at a simple application of the sync circuit. With just two further ics and a handful of other components we can make a fader/wiper with the following functions:

Fade picture out
Wipe picture to left or right of screen
Wipe picture to top or bottom of screen
Direct switch of picture to black
Fade, switch or wipe (effects 1-4) to black, white or any shade of grey

Any of these functions may be combined, for example the picture can be wiped off to any corner of the screen by combining the two wipe effects.

In addition any of the fade or wipe functions can fade or wipe to the picture on input B. Note that this input must be synchronised with the input on Input A. Typically this may be the output of a character or caption generator, although these devices often include their own wiper/fader functions.

Figure 8 shows the extra components needed to make the fader/wiper. This circuit can be constructed on strip board. Do not fit PL4 on the sync board, simply wire the circuits of figure 8 directly to the holes for PL4. As much or as little of this circuit can be constructed depending which functions are required. The potentiometer controls in this circuit should be slide devices.

Fade input A

Figure 8a shows the circuit for the variable gain control which can be used to fade the video input to black, white or any shade between. The potentiometer and resistors are chosen to provide a voltage from -0.6V to +0.6V to control the gain input of IC2. The unity gain buffer matches the to the low input impedance of the gain input of IC2.

The SCART socket

The SCART socket (also known as a Peritel socket), is now widely supported on video equipment, particularly in Europe. The diagram shows the layout looking down into the socket. The socket is normally 21-pin, although the final pin is usually formed from the body of the connector which forms a safety ground. All the projects in this series can be interfaced via a SCART connector, although for convenience they are all shown with phono sockets.

The pinout depends on the specific functions implemented, however certain pins such as audio and composite video are present in all implementations. For any project in this series with most videos and TV sets pins 1,2,3,4 and 6 will provide audio in and out, and pins 17,19, and 20 will provide video input and output.

The table below shows the SCART pinouts, note that where a pin is not designated as input or output (eg Blue) then it is usually an output on one device, and an input on another. Where a pin has more than one function dependant on function then these are shown in the description column. The most common function is shown first in each case

SCART connector pinout

Pin	Signal level	Impedance	Description
1	0.5V	less than 1K	Audio mono out
			Audio right out
2	0.5V	more than 10K	Audio mono in
			Audio right in
3	0.5V	less than 1K	Audio mono out
			Audio left out
4	0V	more than 10K	Audio ground
5	0V		Blue ground
6	0.5V	more than 10K	Audio mono in
			Audio left in
7	0.7V	75R	Blue in/out
8	Digital		Function select
			HD status in/out
9	Ground		Green ground
10	Digital		Data (2)
11	0.7V	75R	Green in/out
12	Digital		Data (1)
			HD vsync in/out
13	0V		Red ground
14	0V		Data ground
15	0.7V	75R	Red in/out
			Chrominance video in/out
16	Digital		RGB Control
			(High=RGB
			Low=Composite)
			HD hsync in/out
17	0V		Video ground
18	0V		RGB control ground
19	1V	75R	Composite video out
20	1V	75R	Composite video in
			Luminance video in/out
21	0V		Safety ground

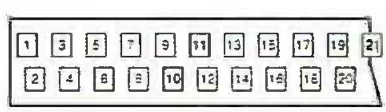


Figure 9: the SCART socket

The S-Video Connector

This type of connector is a 4 pin mini DIN plug. The composite video signal comprises the brightness signal (luminance) with the colour signals (chrominance) modulated on a 4.33 MHz sub carrier. The operation of modulating the colour signal onto the composite video signal, and then demodulating introduces noise. In addition to this high frequency variations in the brightness signal can create false colour signals (the effect can commonly be seen on small checked jackets on TV pictures).

To carry high quality video signals such as those recorded on hi-band camcorders the S video connector is used. On this type of connector the Y signal contains the brightness information with no colour burst, and no colour information, the C signal contains the colour information. This also allows the Y signal to have a higher bandwidth than in a composite video signal, and more detail is available. It is notable that the eye can detect detail in the brightness domain with greater detail than colour, therefore increasing bandwidth of the Y signal only give the illusion of overall increase in bandwidth.

The pinout of the S-Video connector:

Pin	Function
1	Luminance Ground
2	Chrominance Ground
3	Luminance (Y)
4	Chrominance (C)

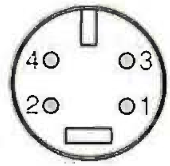


Figure 10: the Video connector

Fade/wipe shade control

Figure 8b shows a simple control to force the wipe or fade shade to any brightness between black and white. The potentiometer and resistor are chosen to produce a luminosity voltage between 0V and +0.7V which is buffered by the op-amp. As the B input is AC coupled this DC voltage cannot be directly used into input B, but must be connected to a point where DC restoration has been used, in this case the junction of R17 and IC2/1. Note that if fading or wiping to input B is to be used, then this circuit cannot be used.

An interesting effect is to set the fade control to half, and the shade to white, this gives the effect of peering through fog, although the usefulness of this function may be questioned.

Sideways wipe

Figure 8c is a sideways wiper. This operates by using a monostable triggered from the rising edge of the line data valid signal to produce a pulse which switches off the video signal during the line. The period of the monostable is controlled by the potentiometer, and the output of the monostable drives the

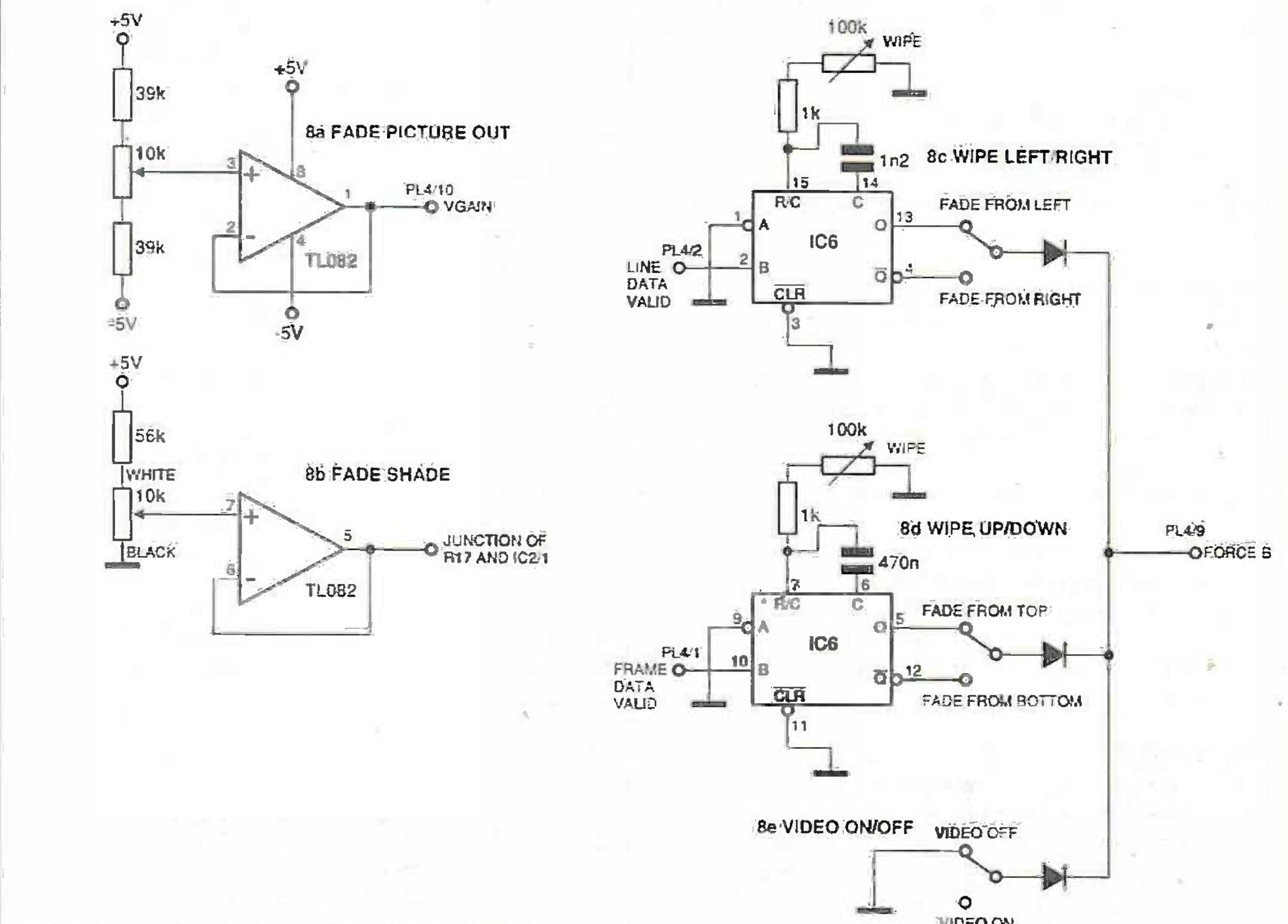


Figure 8: using the Sync separator board in a multi-function fader/wiper

force B input of the sync board. By using either the true or inverted output the wipe can be forced from the left or the right of the screen.

Note that the functions of figure 8c, 8d and 8e all drive the force B input to switch the video signal. To achieve this a simple diode OR circuit is used.

Up/down wipe

Figure 8d is the up/down wiper control which operates in the same way as Figure 8c, however it operates from the field data valid signal, and has a time constant which is much longer than the sideways wiper of frame length. Note that the on/off signal may occur during a line, and therefore the vertical fader may switch during a line causing a partial line to be displayed at the boundary of the wiped area. This is very unlikely to be noticed, but if it is thought to be a problem then the output should be retimed by a flip flop (eg HC74) triggered by the line data valid signal to ensure that switching only occurs at the beginning of a line. The full function digitally controlled mixer to be presented in the next article uses this technique.

Video on/off

This simple switch function provides a direct on/off control for the video.

Next month

In the next article we will look at using the sync board in a full function digitally controlled fader/wiper which can be controlled from a PC, or from a keypad.

PARTS LIST

Resistors All 1% 0.25 watt

R1,2,7	75R
R3,4,5,6	1K
R8,9,10	10K
R12	56K
R14	39K
R15	680K
R16,17	430K
VR1,2,3,4	22K horizontal preset

Capacitors

C1,8-10,14-16,18-20	0.1uF disc ceramic
C2,4	1nF disc ceramic
C3,5	1uF 10V radial electro
C6,7,12,13	10uF 25V radial electro

Semiconductors

IC1	EL2244
IC2	EL4095
IC3	EL4581
IC4	78L05
IC5	79L05
IC6,7	74HC123
IC8	74HC00
IC9	74HC4066

Miscellaneous

PL1,2,3 PCB mounted phono sockets
PL4 16 way 0.1in IDC header
Veropins, 2 x DIL 8 pin ic sockets, 3 x DIL 4 pin ic sockets, 2 x DIL 16 pin ic sockets
All parts are available from Maplin and other regular suppliers.

Peaceful Waves

BIOFEEDBACK

There is nothing so relaxing as the sound of surf on faraway sands. With a bit of imagination, and Robert Penfold's biofeedback monitor, you too could drift away from it all

In many ways Harold Macmillan was right when he said that most of us have "never had it so good", but modern life does have its down-side. Stress levels certainly seem to be on the rise, and means of combatting stress are not only of interest to high-powered executives. High tension (not the electrical kind) and anxiety now seem to trouble a substantial percentage of the population. This subject may seem to be outside the realm of electronics, but an electronic means of easing tension has been in existence for many years. The process is known as biofeedback.

Strain gauges

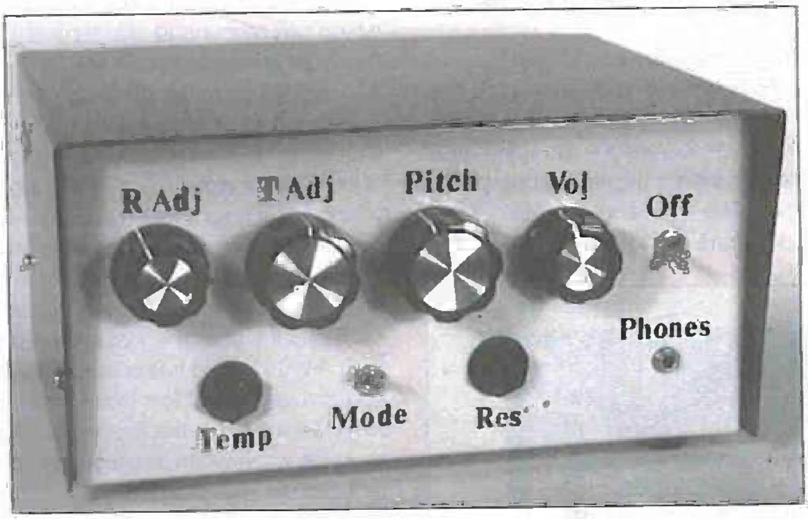
At one time biofeedback was not taken entirely seriously, and had a slightly zany image. However, over the years it has proved to be beneficial to most of the people that have tried it, and it can often be very effective indeed. Biofeedback is certainly taken more seriously these days, aided by the fact that it does not involve the use of any drugs which could be addictive or potentially harmful.

The basic idea is to have an electronic monitoring device that indicates how relaxed or stressed you are. You then try to relax while looking for any changes from the monitoring device. If you do something that relaxes you, the reduction in stress will be indicated by the biofeedback monitor, and you continue to do whatever it was that produced the improvement. If you lapse, and do something that causes an increase in stress, such as thinking about problems at work, the increased tension will be indicated by the monitor. You then act on the information from the biofeedback monitor, and think about something more relaxing again.

The feedback comes in the form of a signal (the type of signal that is displayed is decided by the biofeedback unit - it could be sound, or light, or a trace signal, for example) derived from the user's state of tension by the unit. The monitor relays the signal, and as the user responds to the information on the monitor, it is to be hoped that the signal will change in the direction of showing greater relaxation. The user is then part of a negative feedback circuit, steadily reducing tension, if the system has the desired effect.

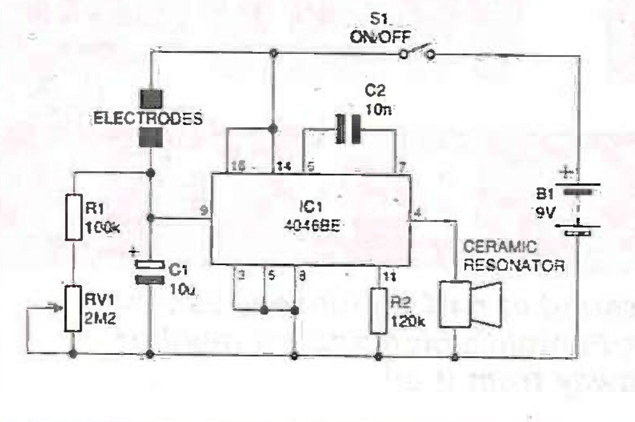
A biofeedback monitor can be surprisingly basic. There are three common methods of monitoring the subject's state of relaxation. These are heart rate, skin resistance, and skin temperature. Heart rate tends to reduce if someone becomes more relaxed, or increase if they become more stressed. Skin resistance varies with the degree of perspiration, and we tend to perspire more when stressed. The more the subject sweats, the lower his or her skin resistance becomes. Therefore, the higher the user's skin resistance, the greater the degree of relaxation.

There may seem to be no obvious link between skin temperature and tension, but stress can cause reduced blood flow to the extremities, and reduced skin temperature. This is the opposite of what one might expect, since tension also causes increased heart rate. Apparently, stress results in less efficient circulation despite the increased heart rate. Hence someone under a lot of tension usually ends up with cold but sweaty palms.



The heart rate monitoring method is perhaps the best, because heart rate changes relatively rapidly with changes in stress level. Its drawback is that it is relatively difficult to produce a heart rate monitor that is inexpensive, easy to use, and gives reliable results. Monitoring skin resistance is usually quite effective, has a reasonably rapid response time, and requires only the most basic of circuitry. The skin temperature method is also very simple and inexpensive, since it is only relative temperature that is of interest. A very basic temperature

Figure 1: the circuit diagram for a minimalist biofeedback monitor which responds to changes such as skin resistance.

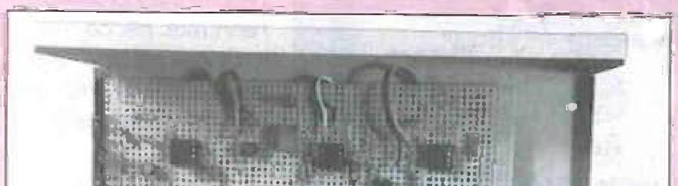


sensor such as a thermistor is perfectly satisfactory. In my experience the skin temperature method has the drawback of a relatively slow response time, and it is perhaps a little less reliable than the other two systems.

Toning it down

A biofeedback unit can be extremely basic, and anything that indicates the user's stress level can be used. Most units use a meter or some form of audio signal to indicate the user's stress level. The circuit of figure 1 is for a minimalist biofeedback monitor which can be built for a few pounds, and uses the skin resistance method. It is basically a CMOS 4046BE (IC1) used as a low frequency vco (voltage controlled oscillator). The output of the oscillator drives a ceramic resonator which produces a low frequency audio tone. The control voltage for IC1 is generated by a potential divider which has the resistance across the electrodes (in effect, the user's skin resistance) as for the upper arm, and the series resistance of R1 and VR1 as for the lower arm. C1 filters out any mains hum or other electrical noise which could otherwise produce erratic results from the circuit.

VR1 is adjusted for an output frequency that is somewhere in the middle of IC1's frequency range. If the user's skin resistance reduces, the control voltage to IC1 also reduces, and the pitch of the audio tone becomes lower. A decrease in the user's skin resistance has the opposite effect, with a higher control voltage and audio tone being produced. The user therefore tries to obtain the lowest possible audio tone from the monitor.



The modern trend is to use a more sophisticated form of signal to the user. This makes the system more interesting to use, and can actually aid relaxation. At its most advanced the system can have computer sound and graphics, with the onscreen action getting more pleasant if the user becomes more relaxed, or more unpleasant if the stress level increases. To some of us this seems more threatening than promising! At a less sophisticated level, the feedback could be in the form of a change in the colour of the room lighting, or via a more complex audio signal than a simple tone generator.

I suppose there is a potential flaw in any system which uses complex feedback. This is simply that the feedback which aids relaxation when things are going well could increase stress if things start to go wrong. In practice this does not seem to be a significant problem, provided a bit of common sense is used when designing the exact form of the feedback. This simply means that the feedback must not provide any sudden noises, flashing lights, or include anything which is seriously unpleasant.

Wave goodbye to stress

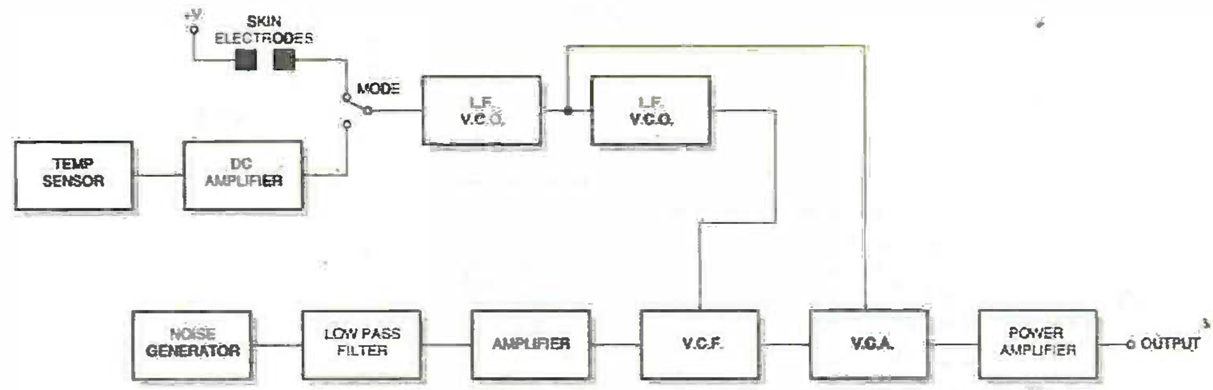
My experiments with various forms of feedback signal produced quite good results, and they were more fun to use than simple tone generators and meters. In general their effectiveness was not substantially better than more simple forms of feedback, but there were one or two exceptions. Some forms of sound feedback certainly seem to be above average in their efficacy. This unit, as finally developed, uses filtered noise which gives a synthesised breaking wave sound. The more relaxed the user becomes, the slower and more gentle the wave sound becomes. The sound of waves splashing onto the beach seems to have a relaxing effect on its own without any feedback element, and it is presumably this factor which aids the efficiency of the system. Sounds based on white noise tend to mask noises in the environment, and cut you off from the outside world. This possibly further accounts for the effectiveness of noise based sounds in this application.

Figure 2 shows the block diagram for the biofeedback unit, which can respond to skin temperature or skin resistance. A noise generator produces the basic "white" noise "hiss" signal. A substantial amount of signal processing is needed in order to mould this into the required breaking wave sound. Envelope shaping is needed in order to give suitable variations in the volume of the signal. The sound must build up quite rapidly in volume as the synthesised wave crashes down onto the beach, and then fall back in volume much more slowly. The pitch of the sound falls as the volume increases, and then rises again as the volume gradually falls away.

The first stage of signal processing is a simple low pass filter. "White" noise has a much stronger content at high frequencies than at low frequencies. This is the opposite of what we require in the final output signal, where the signal must be weak when it is high in pitch. The lowpass filtering reduces the high frequency content of the signal, so that it is easier for the envelope shaper to give the desired effect. The output signal from the noise generator is quite low, and it is reduced still further by the lowpass filtering. A high gain amplifier is used to boost the signal to a more useful level.

A vcf (voltage controlled filter) provides the changes in pitch, and a vca (voltage controlled amplifier) gives the required changes in the signal's volume. Both are controlled by a low frequency oscillator which provides a form of sawtooth waveform. The signal rises quite rapidly on its leading edge,

Figure 2: the block diagram for the biofeedback unit



and decays much more slowly on the trailing edge. It therefore provides the required volume shaping if it is fed direct to the control input of the vca. An inverted version of the waveform is fed to the control input of the vcf. This gives the desired effect with the pitch of the noise falling rapidly as the volume quickly reaches a peak, and then rising more slowly as the volume steadily dies away.

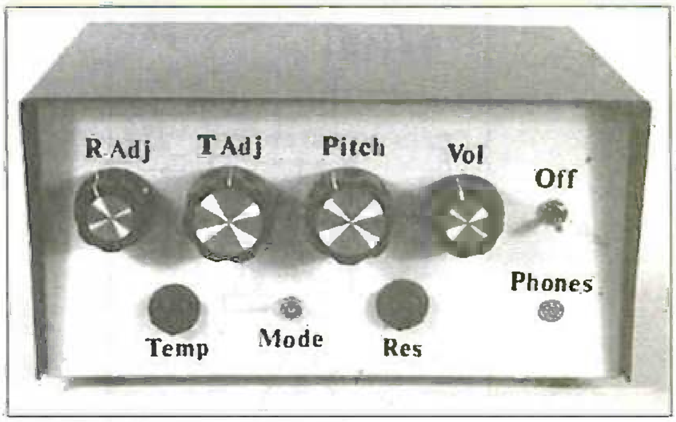
The low frequency oscillator is voltage controlled, and the rate at which the "waves" occur is governed by the input voltage to this stage. The mode switch enables the user to select either a skin temperature or a skin resistance sensor. The skin resistance sensor uses what is essentially the same setup as the one used in figure 1, and described previously. The skin temperature sensor uses a thermistor connected in a potential divider, but the small changes in temperature involved in this application produce only minute changes in the output voltage from the potential divider. A d.c. amplifier is used to boost the voltage changes to a high enough level to drive the low frequency vco properly.

The circuit

Figure 3 shows the full circuit diagram for the biofeedback monitor. The noise generator is based on TR1, which has its base-emitter junction reverse biased by R1. This results in the junction breaking down in zener diode fashion. Also like a zener diode, TR1 generates a useful amount of "white" noise. The noise level is substantially higher than that from a zener diode, but it is produced over a much narrower bandwidth. However, in this case it is only audio frequency noise that is required, and the noise bandwidth is more than adequate for this application. Note that no connection is made to the collector terminal of TR1. TR2 operates as a common emitter amplifier which boosts the noise signal. C3 provides the lowpass filtering.

The vcf is based on IC1, which is a dual transconductance amplifier. It is used in a form of state-variable filter, giving a bandpass output from IC1a, and a lowpass output from IC1b. In this case it is bandpass filtering that gives the best results, and it is therefore the output from IC1a that is utilised. R4, R5, and C4 provide a mid-supply bias voltage for the vcf and vca circuits. The disparate values of R4 and R5 take into account the loading on the bias circuit. Strictly speaking, the filter circuit is current rather than voltage controlled. R17 has been added in series with the control inputs of IC1, and this effectively converts the circuit from voltage to current control.

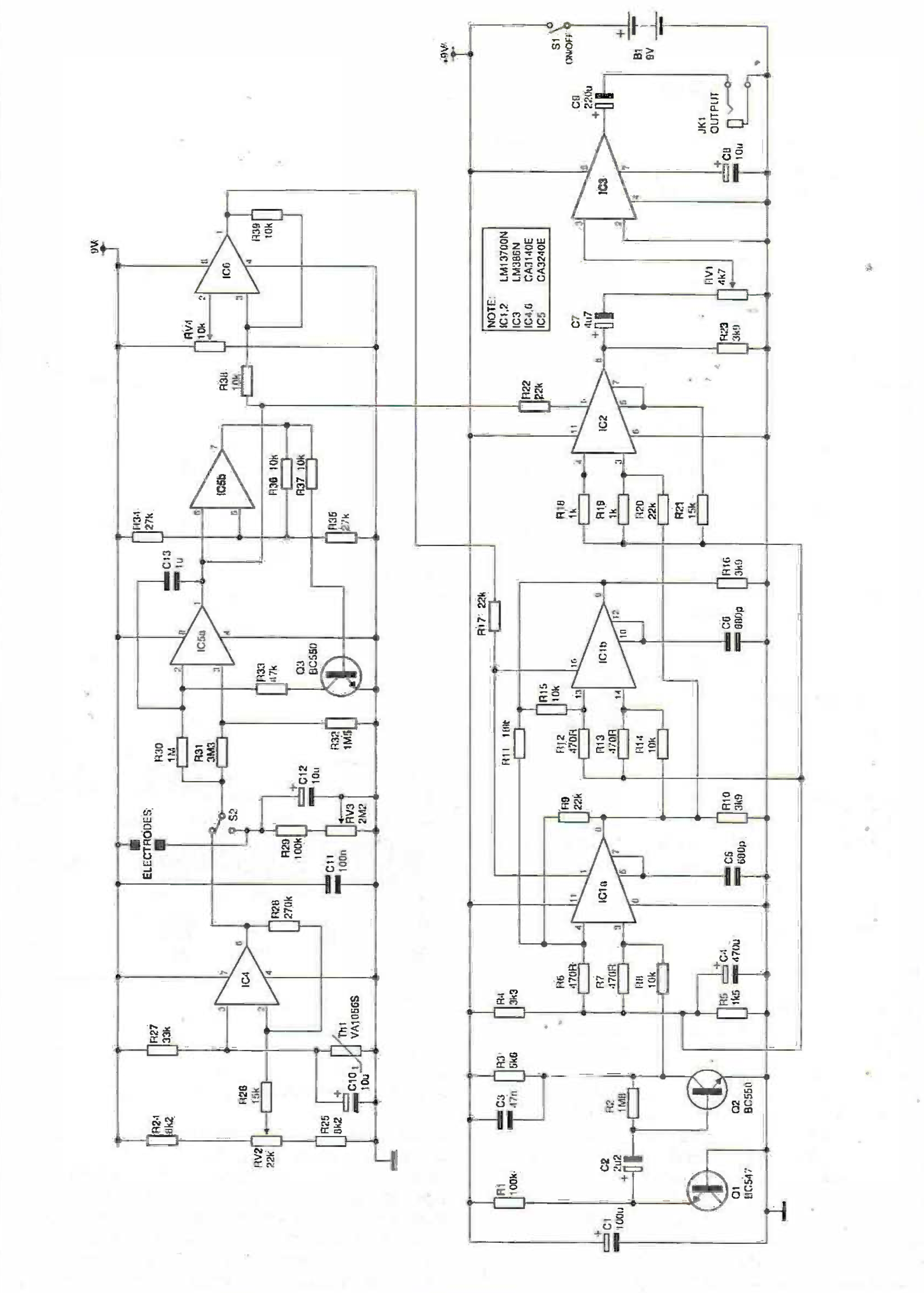
IC2 is used in the v.c.a., and this is another dual transconductance amplifier. Only one section of IC2 is required, and no connections are made to the other section. R22 is used in series with the control input of IC2 so that voltage rather than current control is obtained. The output from IC2 is coupled to a small audio power amplifier (IC3) via the volume control (VR1). IC3 provides a certain amount of voltage gain, but it is included primarily as a buffer amplifier to provide the relatively high output currents required by some headphones. The circuit was designed for use with personal stereo style headphones with the two earphones wired in series. The circuit will drive practically any headphones though, and it will even give reasonable volume if used with an eight ohm impedance loudspeaker.



Under no circumstances should the output of the unit be coupled to a mains powered audio amplifier or any mains powered equipment.

A completely different and more stringent set of safety rules apply to a device such as this, which connects to the user via electrodes. A severe electric shock could be delivered via the electrodes if a fault should occur, and it would be very difficult for the user to remove the electrodes. It is only acceptable to use the unit with mains powered equipment if there is an

Figure 3: the full circuit diagram for the biofeedback monitor

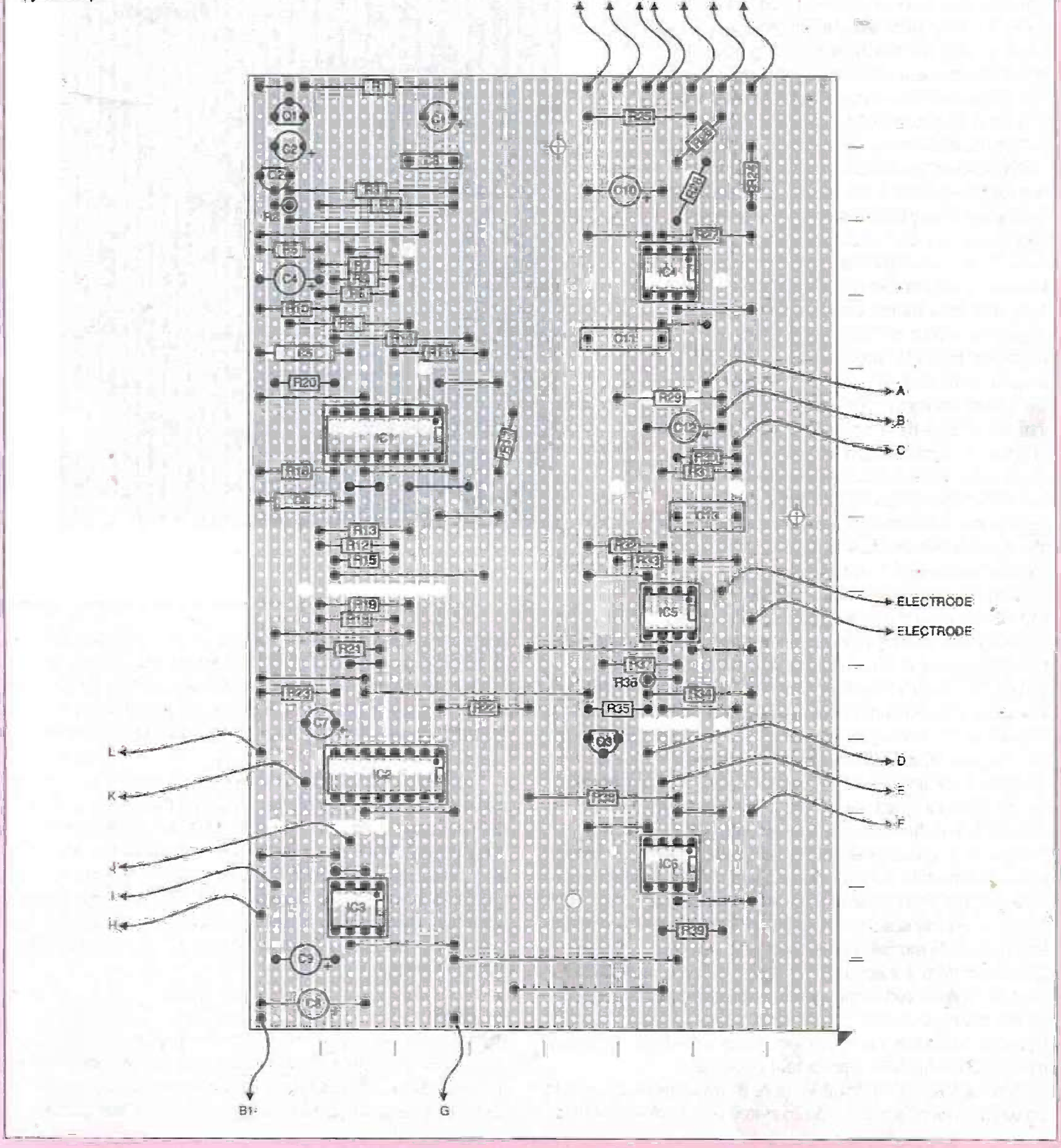


extra stage of isolation somewhere in the system (for example, to connect the audio output of the biofeedback unit to a hi-fi amplifier via a suitable opto-isolator circuit). Using battery power and headphones gives excellent results, and avoids complications.

The inverter stage uses IC6 as a standard inverting mode voltage follower circuit. VR4 enables the bias level at the non-inverting input of IC6 to be adjusted, and this provides control over the pitch range of the vcf. It is simply set for the pitch range that gives the most convincing wave effect. IC5 is used in a simple vco circuit which would normally provide a squarewave output from IC5b, and a triangular waveform from IC5a. The ratios of the resistors at the input of the circuit have been deliberately distorted from their normal figures in order to produce a suitable sawtooth waveform at the output of IC5a.

S2 enables the user to select either the skin resistance or the skin temperature sensor. The skin resistance sensor is a potential divider circuit, as used in the simple biofeedback circuit of Figure 1. The temperature sensor has thermistor Th1 connected in a potential divider circuit, and IC4 as the dc amplifier. IC4 is used as a non-inverting amplifier which has a closed-loop voltage gain of around ten times. VR2 provides an adjustable bias level to IC4, and it is adjusted to give a roughly mid-supply output voltage. C10 provides filtering of any mains hum or

Figure 4: the stripboard layout. The board measures 64 holes by 39 strips



other electrical noise picked up in Th1's connecting cable.

The quiescent current consumption of the circuit is approximately 25 milliamps, but the current drain can be substantially higher than this if the unit is used at high volume levels. A high capacity nine volt battery is required, such as six HP7 size cells in a plastic holder. For the reasons explained previously, this unit must not be powered from a mains power supply.

Construction

Details of the stripboard component layout are provided in figure 4, and the underside view of the board is shown in figure 5. A board having 64 holes by 39 copper strips is required, and this can conveniently be a piece cut from a standard 300mm x 100mm board. After trimming the board to size, drill the three mounting holes and make the necessary breaks in the copper strips. The breaks can be made using the special tool, or a hand-held twist drill bit of about five millimetres in diameter will do the job quite well.

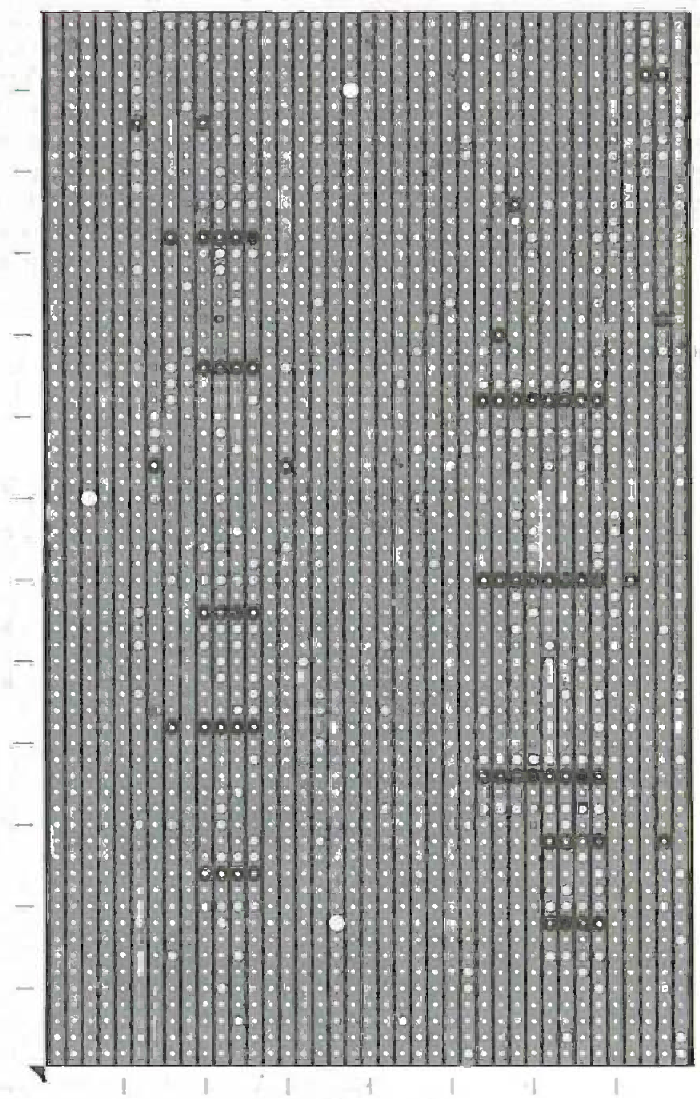
The CA3140E and CA3240E integrated circuits have PMOS input stages, and require the normal anti-static handling precautions. Both devices are operational amplifiers that will operate properly in single supply dc amplifier circuits. Most other operational amplifiers (741C, LF351N, TL071CP, etc.) will not work properly in this circuit. The circuit will work using either LM13700Ns or LM13600Ns for IC1 and IC2, or a mixture of the two. TR1 can be virtually any silicon npn transistor. There is a slight problem in that the reverse base-emitter breakdown voltage of some transistors might be a little high. This could result in the noise signal cutting off as soon as the battery voltage drops slightly due to ageing. It is probably worth experimenting with a few devices from the spares box to find one that has a low breakdown voltage.

With a large stripboard such as this I generally find things easier if the integrated circuit holders are fitted first, as they then act as markers which make it easier to navigate your way around the board. I then work my way across the board from left to right, adding the components and link-wires. I would certainly urge the use of methodical working, and not simply adding components here and there at random, which is usually a recipe for disaster. Be careful to fit the electrolytic capacitor with the correct polarity. To complete the board, fit single-sided solder pins at the points where connections to the controls, sockets, etc. will be made.

An instrument case about 200mm wide and 150mm deep will accommodate the circuit board and battery. Mount the board on the base panel of the case using 6BA or metric M3 fixings, including spacers about six to 12mm long. Position the board towards the rear of the case, and well over to the left (as viewed from the front). This keeps the board clear of the front panel mounted components, and leaves sufficient space for the battery pack to the right of the board. The front panel layout is not critical, but try to avoid long wires from the board to volume control VR1, and output socket JK1.

The hard wiring is shown in figure 6, which must be used in conjunction with fgiure 4. 3.5mm stereo jack sockets seem to vary considerably in shape and size. On the prototype JK1 is a switched type, and it is this type of socket that is shown in figure 6. If you use a different type the wiring must be changed to suit. The earth tag is left unconnected, and the connections are made to the other two tags so that the phones are driven in series.

Figure 5: the underside of the component panel showing strip cuts

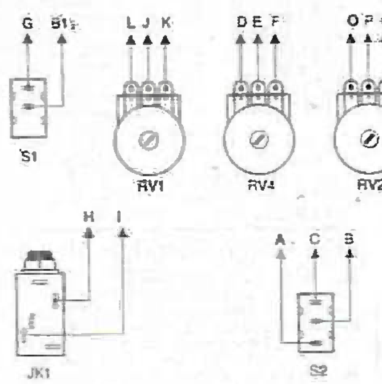


Thermistor Th1 and the skin electrodes can be wired direct to the circuit board, but on the prototype these connections are via standard jack plugs and sockets. It is not essential to use screened leads to make the connections to Th1 and the electrodes, since the circuit has built-in "hum" filtering. No problems were experienced when using non-screened leads about two metres or so in length. I used a VA1056S thermistor for Th1, but the circuit should work equally well using a 47k bead thermistor.

In use

Start with S2 set to the temperature mode. With Th1 in free air, adjust VR2 for a plausible wave rate, and then adjust VR4 for the best effect. The best wave sound is produced with VR4 set for a low sweep range, but not so low that the filter actually

Figure 6: details of the hard wiring (use in conjunction with figure 4)



cuts off at the low frequency end of the sweep. If the temperature sensor is functioning correctly, touching Th1 should reduce the wave rate, and may bring it to a halt (a permanent wave?). In use the thermistor is simply taped to a finger, making sure that the user does not come into electrical contact with the thermistors leads.

The skin resistance electrodes can be virtually any small pieces of sheet metal. A size of about 10mm square will suffice. It is difficult to make reliable soldered connections direct to aluminium and some other metals, but where necessary the connections can be made via solder tags bolted to the electrodes. This tends to produce rather chunky electrodes that can be difficult to use, so the direct connection method is the better one to use where it is possible. Small pieces of copper peeled from a scrap of copper laminate board are quite effective, and can be connected direct to the leads. Whatever you use for the electrodes, they must be kept reasonably clean and free from corrosion.

Good results seem to be obtained with the electrodes taped to finger tips or the palms of the hands. Another possibility is to have one electrode on the palm of a hand, and the other on the back of the same hand. Use the smallest amount of tape that will suffice, as there is otherwise a likelihood that the user will sweat a lot under the tape, rendering the results invalid. A fabric tape is the best type to use as it enables sweat to evaporate. Clipping the electrodes in place might be a better way of handling things. Simply holding the electrodes is ineffective, because the resistance between the electrodes varies enormously depending on how hard they are gripped.

The unit will usually respond quite rapidly if the user becomes more tense, but it takes longer to respond to a reduction in stress - just like reality, in effect. This is simply because you tend to sweat almost immediately when tension increases, but it takes time for skin moisture to evaporate. With any biofeedback system you should not be in any hurry, and must be prepared to give things time to work. Also, it is not just a matter of connecting everything up, switching on, and waiting to become more relaxed. You the user are an active part of the system, and must try to relax. This sounds like a contradiction, but it is the whole point of the exercise - once you have learned how to "become" more relaxed with the help of biofeedback, and learned what it feels like, you should be able to do it anywhere. Some things which people find help them are breathing deeply - not straining to breathe more deeply, but slowly and gently; or thinking of a place where you had a relaxing holiday and imagining how it felt to be there - not doing anything too exciting, of course. Perhaps of more importance, you must try not to think about things that produce increased stress. Biofeedback seems to work for most people, if it is given a fair chance.

PARTS LIST for Biofeedback

Resistors (all 0.25 watt 5% carbon film)

R1	100k
R2	1M8
R3	5k6
R4	3k3
R5	1k5
R6,7,12,13	470R (4 off)
R8,14,15,29,36-39	100k (8 off)
R9,17,20,22	22k (4 off)
R10,16,23	3k9 (3 off)
R11	18k
R18,19	1k (2 off)
R21,26	15k (2 off)
R24,25	8k2 (2 off)
R27	33k
R28	270k
R30	1M
R31	3M3
R32	1M5
R33	47k
R34,35	27k (2 off)

Potentiometers

VR1	4k7 log carbon
VR2	22k lin carbon
VR3	2M2 lin carbon
VR4	10k lin carbon

Capacitors

C1	100u 10V radial elect
C2	2u2 50V radial elect
C3	47n polyester (7.5mm lead spacing)
C4	470u 10V radial elect
C5,6	680p polystyrene (2 off)
C7	4u7 50V radial elect
C8,10,12	10u 25V radial elect (3 off)
C9	220u 10V radial elect
C11	100n ceramic
C13	1u polyester (10mm lead spacing)

Semiconductors

IC1,2	LM13600N or LM13700N (2 off)
IC3	LM386N
IC4,6	CA3140E (2 off)
IC5	CA3240E
TR1	BC547 (see text)
TR2,3	BC550 (2 off)

Miscellaneous

S1	spst min toggle
S2	spdt min toggle
JK1	3.5mm stereo jack socket
B1	9 volt (6 x HP7 size cells in holder)
Th1	VA1056S or similar thermistor

Case about 200 x 150 x 100mm, 0.1 inch pitch stripboard measuring 64 holes by 39 copper strips, 8-pin dil holder (3 off), 16- pin dil holder (2 off), control knob (4 off), battery connector (PP3 type), wire, solder, leads and electrodes (see text), fixings, etc.

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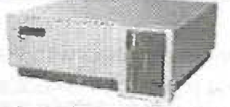

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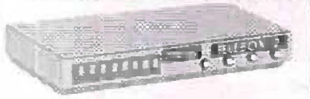

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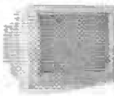

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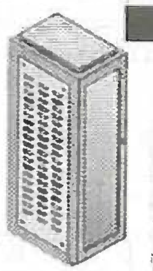

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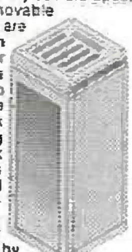

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ETI Remote Data Logger

Richard Grodzik has designed a PIC-driven low-voltage portable data logger that uploads to your PC.

This portable data logger has many features, including:

3 volt (lithium 'button' cell) operation
1 second or 1 minute sample intervals
Samples stored in eeprom non-volatile memory
Uploads at home-base to PC via 300 baud serial link
Continuous logging mode operation when docked with a PC, enabling unlimited sampling period
Protocol converter for importing into Lotus/Excel spreadsheets
8 bit +/- 0.5 bit conversion

The 5 volt Vcc power supply has been the standard for most microprocessor ics, peripherals and logic chips for many years, however, recent years have seen the introduction of Intel processors and memory operating on 3.3 volts. The advantages are obvious for portable computers - lower power expenditure with an associated reduction in heat produce a more reliable machine with a consequent extension of the primary or secondary battery life. If we take this one step further and reduce the clock frequency to a low level - kHz as opposed to MHz - power consumption by the ics is reduced to a very low level.

This is the principle of operation adopted by Microchip's low power PIC - the PIC16C54LP. Operating down to 2 volts, and with a 32.768 kHz clock, the current consumption barely reaches 10 microamps. Try measuring that with your multimeter!

Three parts, low power

The remote data logger consists of three parts.

The first section is the low power PIC with serial RS232 output, two input switches to control operations, an LED indicator and a simple jumper (J1) to select between second and minute sample times. No electrolytic capacitors are to be seen, since these capacitors have a leakage current and the object of the design was to keep current consumption down to the minimum. The power-on reset circuitry connected to the MCLR line consists of a high value resistor/diode network which provides the necessary logic low reset on switch on and consumes little current. The LED is a low current type, and with a 2k series resistor just allows a visual indication when a sample has been taken. Similarly high value (22k) pull-up resistors for the two input switches and the jumper link further reduce current consumption.

The second section is a serial A to D converter - the TLC5491P - with 8 bit resolution and a low power consumption of 6 milliwatts, operating on a wide supply range of between 3 and 6 volts. A reference voltage of 2.5 volts is provided by a REF25Z voltage reference device and with a 2:1 100K resistor divider network allows a 0 to 5 volt analogue input voltage range, even though the Vcc supply to the ic is only 3 volts.

The third section is a serial non-volatile eeprom 255 byte memory type 93LC56, which stores the logged data until it is retrieved by uploading via the PIC's serial link to the PC. Again, this is a low voltage device operating at voltages down to 2 volts and with a current consumption of mere microamps.

How it works

As with any embedded processor project the chip count is minimal - here only three ics are used, but the drastically reduced hardware count is at the expense of considerable expenditure in time and effort in constructing the firmware for the PIC. Let us first consider programming the ADC: for data logging, a sample is taken at a precise interval of time, in this case either every minute or every second. The conversion cycle for the TLC5491P is initiated with the 8th I/O clock pulse, so in order for a 'strobed' operation where conversion is necessary at a specific point in time, a 'dummy' conversion takes place (procedure 'RECEIVE') whereby 8 clock pulses are used to bring the hold function (of the analogue voltage) to the point in time where a conversion is required. Subsequent 8 clock input pulses (procedure 'CONV')will then clock out the conversions result starting with the MSB of the 8 bit conversion. If the dummy pulses were removed, the resulting conversion would provide data from the previous conversion,

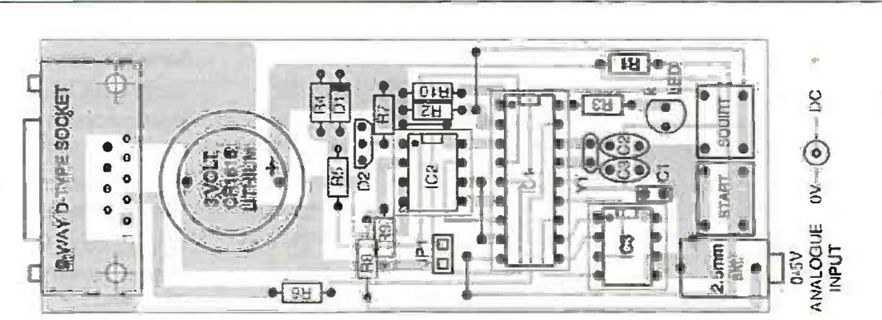
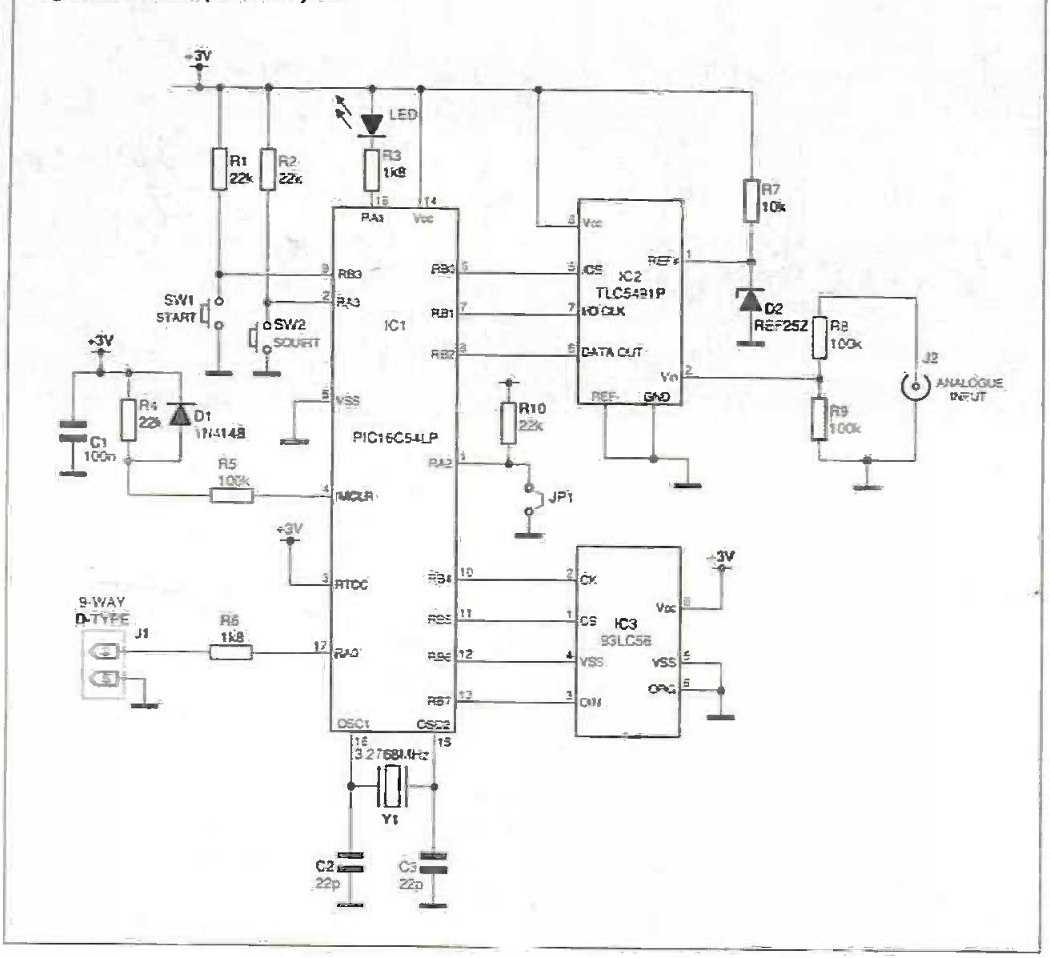


Figure 1: the circuit of the Remote Data Logger

Figure 2: the component layout



that is, a second or minute earlier in time. As each bit is clocked out the serial data is presented to port line RB2 and shifted left-wise into buffer register 0AH.

The next part of the operation is to write this 8 bit conversion result to the eeprom. However configuring the eeprom and writing or reading data is a complex operation since the 93CLC56 is a programmable memory device. I will therefore try to explain in stages the operation of the eeprom here.

Before any writing or reading of the eeprom is possible the 'EWEN' erase/write enable and disable instruction must be sent serially to the eeprom via the Din line. This instruction has the following format:

Start bit	Opcode	Address
1	00	1 1 X X X X X X X

Twelve clock cycle are therefore needed to clock in this information - (procedure 'EWEN').

To write data into the eeprom, the 8 bit data held in the BUFFER register is shifted out to the Din line, using register COUNTER to count the 8 data bits. The instruction to write data has the following format:

Start bit	Opcode	Address	Data
1	01	X A7 A6 A5 A4 A3 A2 A1 A0	D7-D0

Since the address (contained in register BHIGH) is clocked in serially to the eeprom Din line using the RLF BHIGH instruction, once eight address bits have been clocked in, a further RLF instruction will restore the original address, to be decremented by 1 for the next write operation.

Eight data bits are then clocked into the Din line from the BUFFER register, starting with the MSB (bit 7) of the data. A 10 millisecond delay routine (DELAYEE) then allows the self timed automatic erase and write cycle by the eeprom.

When 255 conversions have taken place, the logged data is stored safely in the eeprom whose contents will be preserved (for approximately 40 years) even if the battery supply is removed. By connecting the logger to the serial port (COM1) of a PC and pressing the 'SQUIRT' switch, procedure 'FLUSH' is executed:

This consists of three sub-routines: 'READ' 'INVERT' and 'TRANSMIT'. Again, an instruction must be sent to the eeprom in order for the stored data to be read. The format is as follows:

Start bit	Opcode	Address	Data
1	10	X A7 A6 A5 A4 A3 A2 A1 A0	D7-D0

Procedure 'READ' shifts in the start bit, Opcode and 8 bit address into the Din pin of the eeprom. A further 8 clock pulses are then applied to the CK clock input of the eeprom to shift out the 8 data bits on the Dout line to the data register BUFFER. Procedure 'INVERT' then logically inverts the data to satisfy RS232 logic protocol. Procedure 'Transmit' shifts each data byte to the RA1 pin of the PIC for serial transmission. Note that the bits are now shifted out using the 'RRF' (shift right) instruction since the previous writing and reading of data from the eeprom had caused a reversal of bits, that is, bit 0 occupying bit 7 position and so on. Transmission of serial data at 300 baud required a bit 'cell' period of 3333.3 microseconds. Since each instruction takes 122.07 microseconds to be executed by the PIC using a 32.768 kHz crystal, the software overhead time in shifting and counting the transmitted bits is quite considerable and has to be accounted for when computing the 3333.3 microseconds delay between each data bit. It was therefore decided to use simple NOP instructions to add to the software overhead time to define an accurate 'cell' delay period.

In association with writing and reading the serial data to and from the eeprom, both the CS (Chip select) and CK (Clock) signals have to occur at precise times and in the correct order. A close examination of the firmware will show how this is done.

Construction

A 90 degree 9 way D type PCB socket allows for the unit to be connected directly to the serial port of the PC. If necessary, an extension lead can be fabricated as follows:

9 way D type plug (to Logger) 9 way D type socket (to PC)

pin 2 .... pin 2
pin 5 .... pin 5

A battery holder is used to retain the lithium cell. This can be obtained from Electromail, Order No. 430-669. The 93LC56B ic is also available from the same source, Order No. 831-769. The other components are available from most component suppliers. Note that the press to make miniature switches have commoned connections and the 'squirt' switch must be oriented correctly to provide a 0 volt line continuity on the PCB.

Testing the unit is quite simple since the PIC software, if executing, will light the LED for an instant when the battery is inserted into its holder. A voltage check on pin 1 of the TLC549P ADC ic should be exactly 2.5 volts.

Data presentation and graphics software

The data 'squirted' from the data logger is in a binary format and has to be scaled and converted into an ascii format in order to produce a meaningful representation of the captured data. Pascal source program '3DISC' shown below converts the binary data, scales it and writes each sample, together with a sample number in ascii to disk to produce a file which can then be printed out or presented as a graphical XY plot using either Lotus or Excel spreadsheets. Since the ADC produces a 0 to 255 bit output for an input analogue voltage range of 0 to 5 volts a scaling factor of 51 will give a true indication of the actual voltage. An executable file, together with a real time data logging software package (VGA3) is available free of charge from the author with each pre-programmed PIC.

Continuous mode

A facility is available in the firmware so that if the data logger is docked with the PC ie connected to the serial port, continuous logging of data takes place at 1 second or 1 minute intervals. This together with PC driver 'VGA3' produces a real time graph of logged data.

```
PROGRAM 3DISC(INPUT,OUTPUT);
{$f+}
{$I-}

USES dos,crt;

VAR
sample:REAL;
r:real;
RO:STRING[5];
WO:STRING[20];
s:string[20];
TXT:TEXT;
BUF:ARRAY[1..5000]OF REAL;
BUFSAMPLE:ARRAY[6000..10000]OF REAL;

A:REAL;

X,Y:INTEGER;
LABEL
FINI;

PROCEDURE RECORDNAME;

VAR
NUM:INTEGER;

BEGIN
CLRSCR;
NUM:=0;

REPEAT
WRITE('ENTER  FILENAME: ');
READLN(WO);
NUM:=LENGTH(WO);
clrscr;
UNTIL NUM>0;

ASSIGN (TXT,WO);
REWRITE(TXT);
END;

PROCEDURE LETTERS;
VAR
CODE:INTEGER;

BEGIN
repeat
WRITE('SCALING FACTOR ? :');
READLN(r0);
VAL(r0,R,CODE);
clrscr;
UNTIL CODE=0 ;
if r=0 then
r:=1;
END;

PROCEDURE WRITETEXT;

BEGIN
CLRSCR;
BUF[X]:=A;
X:=X+1;

BUFSAMPLE[Y]:=SAMPLE;
Y:=Y+1;
WRITE('                    ','Receiving
Data. . . .        ',SAMPLE:2:0);

END;

PROCEDURE COM;
BEGIN
INLINE($B0);
INLINE($43);
INLINE($B4);
INLINE($00);
INLINE($BA);
INLINE($00);        (* com1 *)
INLINE($00);
INLINE($CD);
INLINE($14);
END;

PROCEDURE DATA;

VAR
POLL:WORD;
hex:WORD;
realdata:real;
CODE:INTEGER;

BEGIN

REPEAT
POLL:=PORT[$3FD];         (* com1 *)
POLL:=POLL AND 1;
UNTIL POLL=1;
HEX:=PORT[$3F8];          (* com1 *)
A:=HEX/R;
sample:=sample+1;
END;

BEGIN
X:=1;
Y:=6000;
COM;
SAMPLE:=0;
RECORDNAME;
LETTERS;
WRITELN('          ','Waiting for Data. . . .');

REPEAT
BEGIN
DATA;
WRITETEXT;
IF SAMPLE>254 THEN GOTO FINI;
END;
UNTIL KEYPRESSED;
READLN;

FINI:
X:=1;
Y:=6000;
```

Operating instructions

1. Insert battery. Note this must be Lithium type CR1616, 3 volts.
2. Insert jumper J1.
3. Press the start switch.
4. Data will now be logged at 1 second intervals. Every time a sample is taken, the LED will light briefly. Once 255 samples have been taken, the LED will remain off. Connect in the data logger to the COM1 serial port of the PC. Run either 3DISC.exe or VGA3.exe . (VGA3_2.exe for COM2 serial port.)
5. Press the squirt switch. 255 bytes of data will now be transferred from the logger to the PC. For a 1 sample/minute interval to be selected, simply remove the jumper.

To invoke continuous logging, insert the battery while keeping the start button pressed.

PARTS LIST

Resistors

R1,R2,R4,R10	22k
R3,R6	1k8
R5,R8,R9	100k
R7	10k

Capacitors

C1	100n
C2,C3	22p

Semiconductors

IC1	PIC16C54LP
IC2	TLC5491P
IC3	93LC5 (eg Electromail O/N 831-769)
D1	1N4148
D2	REF25Z
LED1	Low current LED (eg Electromail 590-547)

Miscellaneous

Y1	32.768 kHz crystal
J1	90 degree 9-way Dtype socket
J2	2.5mm PCB-mounting jack socket
JP1	2.5mm jumper

3V CR1616 lithium button cell battery; battery holder (eg Electromail O/N 430-669); 2 x press-to-make miniature switches; 2.5mm socket; jumper leads and wire links

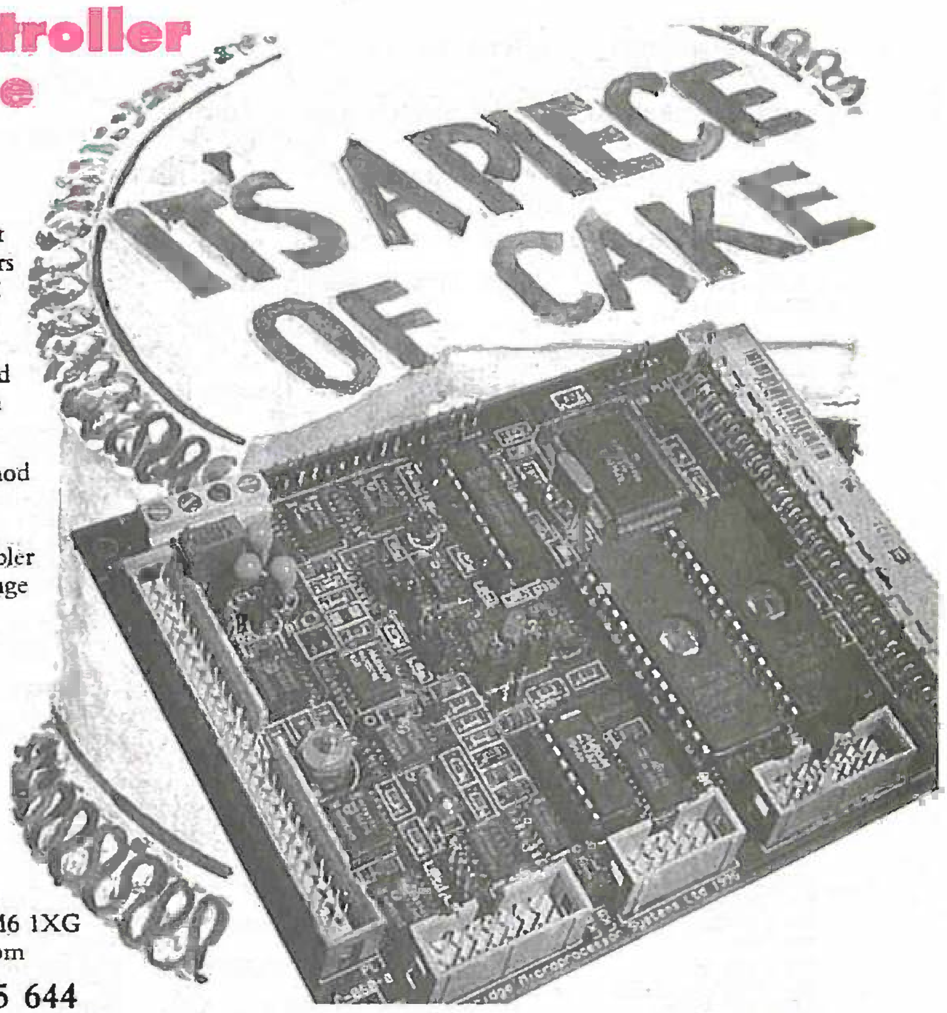
PLEASE CHECK that your jack socket and miniature switch pin-outs match the PCB layout - if you use a different layout, you need to alter the position of the pin holes on your PCB foil print to fit.

```
SAMPLE:=0;
REPEAT

WRITE(TXT,BUF[X]:9:2);
X:=X+1;
write(txt,'  ');

WRITELN(TXT,BUFSAMPLE[Y]:2:0);
SAMPLE:=SAMPLE+1;
Y:=Y+1;

UNTIL SAMPLE=255;

delay(1000);

CLOSE(TXT);
CLRSCR;
WRITE('      ','Completed capture......');

END.
```

PIC FIRMWARE LISTING: 'REMOTE. ASM'

```
LIST          p=16C54    ; PIC16C54 is the target
processor

                         ; SC = 122. 0703 FOR XTAL
32. 768 KHZ

EE    EQU . 26           ;10 Millisecond EEPROM WRITE
TIME


TXD           EQU 0      ;RA0 TRANSMIT SERIAL RS232
GREENLED      EQU 1      ;RA1 LOW = ON
SELECT        EQU 2      ;RA2 LOW = 1 SEC, HIGH = 1
MIN
SQUIRT        EQU 3      ;RA3 SWITCH ,LOW = PURGE
EEPROM

CS_ADC        EQU 0      ;RB0CHIP SELECT ADC
CK_ADC        EQU 1      ;RB1I/O CLOCK FOR ADC
DATA_ADC      EQU 2      ;RB2 8 BIT SERIAL ADC DATA
START_1       EQU 3      ;RB3 START LOGGING SWITCH
CK_EE         EQU 4      ;RB4 I/O CLOCK FOR EEPROM
CS_EE         EQU 5      ;RB5 CHIP SELECT EEPROM
DOUT          EQU 6      ;RB6 SERIAL DATA O/P FOR
EEPROM
DIN           EQU 7      ;RB7 SERIAL DATAIN I/P FOR
EEPROM

RTCC          EQU 1      ;REAL TIME TIMER/COUNTER
PC            EQU 2      ;PROGRAM COUNTER
STATUS        EQU 3      ;STATUS REGISTER
PORT_A        EQU 5      ;PORT A
PORT_B        EQU 6      ;PORT B

THIRTYTWO     EQU 0FH    ;MODULUS 31 COUNTER

DLYCNT        EQU 8      ;TIMING LOOP COUNTER
COUNT         EQU 9      ;8 BIT SHIFT REGISTER
COUNTER
BUFFER        EQU 0AH    ;ADC CONVERSION BUFFER
COUNTR        EQU 0BH    ;TIMING COUNTER
INVERT        EQU 0DH    ;TTL TO RS232 LEVEL
BHIGH         EQU 011H   ;255 SAMPLE COUNTER
SIXTY         EQU 012H   ;1 MINUTE COUNTER
FLAG          EQU 013H
REG           EQU 014H   ;RTCC VALUE
              ORG 0
START
NOP
NOP

MOVLW 0CH       ;RA0SERIAL OUTPUT
                         ;RA1 LED
                         ;RA2 JUMPER
                         ;RA3 SQUIRT SWITCH
TRIS PORT_A
BCF PORT_A,TXD           ;RS232 START BIT LOW
BSF PORT_A,GREENLED      ;LED OFF

MOVLW 04C       ;RB0 CHIP SELECT ADC
                         ;RB1 I/O CLOCK ADC
                         ;RB2 DATA OUT ADC
                         ;RB3 START SWITCH
                         ;RB4 CLOCK EEPROM
                         ;RB5 CHIP SELECT EEPROM
                         ;RB6 DATA OUT EEPROM
                         ;RB7 DATA IN EEPROM
TRIS PORT_B

BSF PORT_B,CS_ADC        ;DISABLE ADC
BCF PORT_B,CK_ADC        ;START WITH CLOCK LOW
BCF PORT_B,CS_EE         ;DISABLE EEPROM
BCF PORT_B,CK_EE         ;START WITH CLOCK LOW
BCF PORT_B,DIN           ;AND DATA LOW

CALL EVEN       ;INITIALISE EEPROM

CYCLE
```

The Low Cost Controller That's Easy To Use



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The K-307 Module provides the features required for most embedded applications

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Cheques/POs payable to Forest Electronic Developments.

VISA Access

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```
MOVLW B'00000001'        ;RTCC PRESCALE VALUE
OPTION

BTFSS PORT_B,START_1     ;CONTINUEOUS MODE
GOTO AUTO

BCF PORT_A,GREENLED      ;TEST LED
CLRF RTCC
CALL UPLOAD              ;DELAY
BSF PORT_A,GREENLED      ;LED OFF

MOVLW 0FFH               ;255 BYTE ADDRESS COUNTER
MOVWF BHIGH

POLL
CLRWDT
BTFSS PORT_A,SQUIRT      ;IF SQUIRT SWITCH PRESSED
                         ;SQUIRT DATA
GOTO STOP_FLUSH
BTFSC PORT_B,START_1     ;WAIT FOR START SWITCH
GOTO POLL

 RELEASE                 ;WAIT FOR START SWITCH TO
 BE
                         ;RELEASE
                         ;INCLUDE DEBOUNCE TIME
 CLRF RTCC
 DEBOUNCE CLRWDT
 BTFSS RTCC,7
 GOTO DEBOUNCE
 BTFSS PORT_B,START_1
 GOTO RELEASE

;-------------------------
;ADC CONVERSION AND WRITE TO EEPROM
;-------------------------

CYCLE_ADC
CLRF RTCC                ;CLEAR TIMER
CLRWDT
BCF PORT_A,GREENLED      ;GREEN LED ON
CALL RECEIVE             ;PERFORM ADC CONVERSION
CLRWDT
CALL WRITE               ;WRITE CONVERSION TO EEPROM
BCF PORT_B,CS_EE
CALL DELAYEE             ;10 MILLISECOND DELAY
                         ;FOR SELF TIMED EEPROM WRITE
BSF PORT_A,GREENLED      ;GREEN LED OFF

DECFSZ BHIGH,1           ;NEXT EEPROM ADDRESS -1
GOTO CONT
GOTO POLL_1              ;255 SAMPLES TAKEN

CONT BTFSC PORT_X,SELECT ;MINUTE SELECTED BY J1?
GOTO HIGHA               ;1 MINUTE DELAY
CALL SECOND              ;1 SECOND DELAY
GOTO CYCLE_ADC           ;REPEAT FOR 255 SAMPLES

HIGHA CALL SECOND

MOVLW . 59               ;MINUTE COUNTER
MOVWF SIXTY
CALL MINUTE
GOTO CYCLE_ADC

POLL_1

BTFSC PORT_A,SQUIRT
GOTO POLL_1

STOP_FLUSH
BCF PORT_A,GREENLED
CALL UPLOAD
BSF PORT_A,GREENLED
MOVLW 0FFH
MOVWF BHIGH

FLUSH                    ;SQUIRT DATA AT 300 BAUD
                         ;FROM RA0
CALL READ
MOVF BUFFER,0
CALL CONVERT
CALL TRANSMIT

CALL UPLOAD

DECFSZ BHIGH,1
GOTO FLUSH

GOTO CYCLE

RECEIVE                  ;ADC CONVERSION
MOVLW 8                  ;8 DATA BITS
MOVWF COUNTR
CLRF BUFFER              ;CLEAR BUFFER

BCF PORT_B,CS_ADC        ;CS LOW

NEXT

BSF PORT_B,CK_ADC        ;CLOCK HIGH
BCF PORT_B,CK_ADC
DECFSZ COUNTR,1
GOTO NEXT

MOVLW 8                  ;8 DATA BITS
MOVWF COUNTR
BSF PORT_B,CS_ADC        ;CS HIGH

CONV
BSF PORT_B,CK_ADC        ;CLOCK HIGH
BCF PORT_B,CS_ADC        ;CS LOW

BCF STATUS,0
RLF BUFFER
BTFSC PORT_B,DATA_ADC
BSF BUFFER,0
BCF PORT_B,CK_ADC        ;CLOCK LOW

DECFSZ COUNTR,1
GOTO CONV

BSF PORT_B,CS_ADC        ;CS HIGH STOP
RETLW 0

READ      CALL SB        ;START BIT LOGIC 1
          CALL DI_1      ;OPCODE 10
          CALL DI_0

          CALL DI_0      ;ADDRESS A8 LOGIC X

MOVLW 8                  ;8 BITS
MOVWF COUNTR

NEXT_TB
RLF BHIGH                ;CLOCK IN 8 BIT ADDRESS
BTFSC STATUS,0
BSF PORT_B,DIN
BTFSS STATUS,0
BCF PORT_B,DIN

BSF PORT_B,CK_EE
BCF PORT_B,CK_EE

DECFSZ COUNTR
GOTO NEXT_TB

RLF BHIGH                ;RESTORE ADDRESS
MOVLW 8                  ;8 DATA BITS
MOVWF COUNTR
CLRF BUFFER              ;CLEAR DATA BUFFER

CON                      ;CLOCK OUT 8 DATA BITS
BSF PORT_B,CK_EE         ;INTO BUFFER REGISTER

BCF STATUS,0
RLF BUFFER

BTFSC PORT_B,DOUT
BSF BUFFER,0
BCF PORT_B,CK_EE
DECFSZ COUNTR,1
GOTO CON

BCF PORT_B,CS_EE
RETLW 0

WRITE     CALL SB        ;WRITE START BIT INTO EEPROM
          CALL DI_0      ;OPCODE 01
          CALL DI_1

          CALL DI_0      ;A8 (X) BIT ADDRESS

MOVLW 8                  ;8 DATA BITS
MOVWF COUNTR

NEXT_TA
CLRWDT
RLF BHIGH                ;8 BIT ADDRESS
BTFSC STATUS,0           ;SHIFT ADDRESS SERIALLY
BSF PORT_B,DIN           ;INTO Din
BTFSS STATUS,0
BCF PORT_B,DIN
```

```
BSF PORT_B,CK_EE          ;ISSUE CLOCK PULSE H&L
BCF PORT_B,CK_EE

DECFSZ COUNTR
GOTO NEXT_TA              ;ADDRESS SHIFTED IN

RLF BHIGH                 ;RESTORE ORIGINAL ADDRESS

MOVLW 8                   ;8 DATA BITS
MOVWF COUNTR              ;TO COUNT

NEXT_T
CLRWDT
RLF BUFFER                ;DATA IN BUFFER REGISTER
BTFSC STATUS,0            ;SHIFTED INTO Din
BSF PORT_B,DIN
BTFSS STATUS,0
BCF PORT_B,DIN

BSF PORT_B,CK_EE
BCF PORT_B,CK_EE

DECFSZ COUNTR
GOTO NEXT_T
RETLW 0

EWEN    CLRWDT
        CALL SB           ;LOGIC 1
        CALL DI_0         ;OPCODE 00
        CALL DI_0
        CALL DI_1         ;LOGIC 1
        CALL DI_1         ;LOGIC 1
        CALL DI_1         ;7 FURTHER BITS LOGIC X
        CALL DI_1
        CALL DI_1
        CALL DI_1
        CALL DI_1
        CALL DI_1
        CALL DI_1

BCF PORT_B,CS_EE
RETLW 0

SB      CLRWDT
BCF PORT_B,CK_EE          ;CLOCK LOW
BSF PORT_B,DIN            ;START BIT HIGH
BSF PORT_B,CS_EE          ;CHIP SELECT HIGH
NOP
BSF PORT_B,CK_EE          ;CLOCK HIGH
NOP
BCF PORT_B,CK_EE          ;CLOCK LOW
RETLW 0

DI_0  CLRWDT
BCF PORT_B,DIN            ;DATA IN LOGIC LOW
BSF PORT_B,CK_EE          ;CLOCK HIGH
BCF PORT_B,CK_EE          ;CLOCK LOW
RETLW 0

DI_1  CLRWDT
BSF PORT_B,DIN
BSF PORT_B,CK_EE
BCF PORT_B,CK_EE
RETLW 0

CONVERT
XORLW 0FFH                ;EXCLUSIVE-OR DATA WITH FFH
MOVWF BUFFER
MOVLW 8
MOVWF COUNTR              ;LOAD 8 BIT COUNTER
RETLW 0

TRANSMIT
CLRWDT
BSF PORT_A,TXD            ;SEND START BIT TXD LINE
HIGH
EXTT CALL DELAY_3         ;DELAY
RRF BUFFER                ;ROTATE BUFFER
BTFSC STATUS,0            ;TEST CARRY FLAG
BSF PORT_A,TXD
BTFSS STATUS,0            ;TEST AND TRANSMIT BIT
BCF PORT_A,TXD
DECFSZ COUNTR             ;UNTIL ALL 8 BITS
TRANSMITTED
GOTO NEXTT

CALL DELAY_3              ;1 CELL BIT PERIOD
BCF PORT_A,TXD            ;STOP BIT

CALL DELAY_3

RETLW 0

DELAY_3                           ;3333.3 us DELAY
SOFTWARE OVERHEAD
        NOP                       ;122.07 us DELAY
        NOP
        NOP
        NOP
        NOP
        NOP
        NOP
        CLRWDT
        NOP
        NOP
        NOP
        NOP
        NOP
        NOP
        NOP
        NOP
        NOP
        RETLW 0

DELAYEE         ;10 MILLISECONDS EEPROM WRITE
                ;DELAY
MOVLW EE
MOVWF DLYCNT
RDO DECFSZ DLYCNT,1
goto RDO
CLRWDT
retlw 0

UPLOAD     MOVLW 1
           MOVWF RTCC
UPL        CLRWDT
BTFSS RTCC,5
GOTO UPL
RETLW 0

MINUTE
MOVLW . 2
MOVWF RTCC
MIN
MOVLW . 15
MOVWF THIRTYTWO
CALL SHORT
NOP
NOP
NOP
DECFSZ SIXTY,1
GOTO MINUTE
RETLW 0

SECOND
MOVLW . 15
MOVWF THIRTYTWO

SHORT
CLRWDT
MOVF RTCC,0
MOVWF REG
BTFSS REG,7

GOTO SHORT
CLRF RTCC
DECFSZ THIRTYTWO,1
GOTO SHORT

MOVLW . 31
MOVWF RTCC
HO    CLRWDT
MOVF RTCC,0
MOVWF REG
BTFSS REG,7
GOTO HO
NOP
NOP
NOP
CLRWDT
RETLW 0

AUTO  CLRWDT
```

(Cont. from previous column)

```
MOVLW 1
MOVWF RTCC

BCF PORT_A,GREENLED
CALL RECEIVE
MOVF BUFFER,0
CALL CONVERT
CALL TRANSMIT
BSF PORT_A,GREENLED

BSF FLAG,0
NOP
NOP
CLRWDT

BTFSC PORT_A,SELECT
GOTO HIGH_B

BTFSS PORT_A,SQUIRT
GOTO CYCLE

CALL SECOND
GOTO AUTO

HIGH_B
CLRWDT
MOVLW . 60
MOVWF SIXTY
BTFSS FLAG,0
CALL MINUTE
MOVLW 06FH
MOVWF RTCC
BCF FLAG,0
CALL MIN

GOTO AUTO

org     01FFh
goto    START
END
```

A pre-programmed PIC is available from the author with free software protocol converter and real time data logging software. A pre-drilled PCB is included. Price £27.50 P&P inc. From: R. Grodzik (MICROS), 53 Chelmsford Road, Bradford, BD3 8QN.

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Hewlett Packard 4261A - L.C.R. Meter (Digital)	£500
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Racal Dana 9917 UHF frequency meter 560MHz	£175
Racal Dana 9302A R/F millivoltmeter (new version)	£375
Racal Dana 9082 Synthesised am/fm sig gen (520MHz)	£500
Racal 9085 Low Distortion Oscillator	£POA
Racal 9301A - True RMS R/F Millivoltmeter	£300
Racal 9921 - 3GHz Frequency Counter	£450
Rohde & Schwarz AMF 2 - TV Demodulator	£1250
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Cupid's Arrow

Watch out - Cupid's about!

by Terry Balbirnie

The Valentine's Day party is in full swing. A smoochy CD is playing. Suddenly laughter is heard - couples are taking it in turns to try each other with Cupid's Arrow - the modern way. There are no little arrows sticking in your clothing and your hair, but if you have the potential for passion this little light-emitting dart will surely go straight to your heart - or are you secretly aiming at someone else? Are you merely a lemon-coloured lover or a red hot Romeo? Whatever you prove to be, the gales of laughter will show that you are making someone happy!

Get the message?

On the front panel of the "arrow" is a row of ten LEDs aimed in a dead-straight line. The lowest three are green, followed by two yellow, two orange, two red and, finally, a flashing red. When the button is pressed for an instant, the "reading" on the display slowly rises from the green end towards the red. After several seconds it stops. The obvious message which the colour conveys is the subject of the laughter.

It may be a disappointment to learn that operation of Cupid's Arrow is entirely random, but isn't that always the way it works out? It is impossible to predict where the display will stop - just like one of those little darts A simpler circuit could

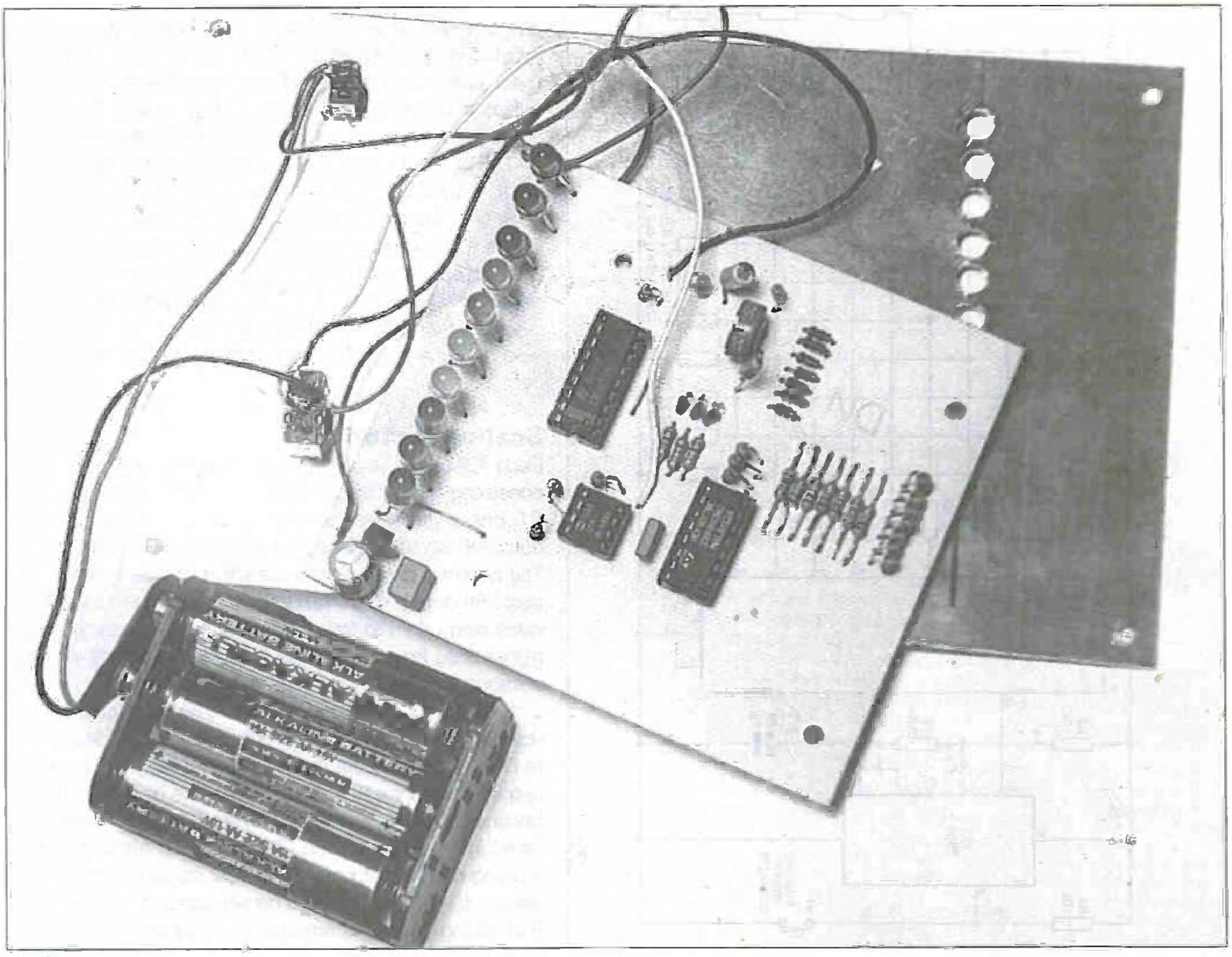
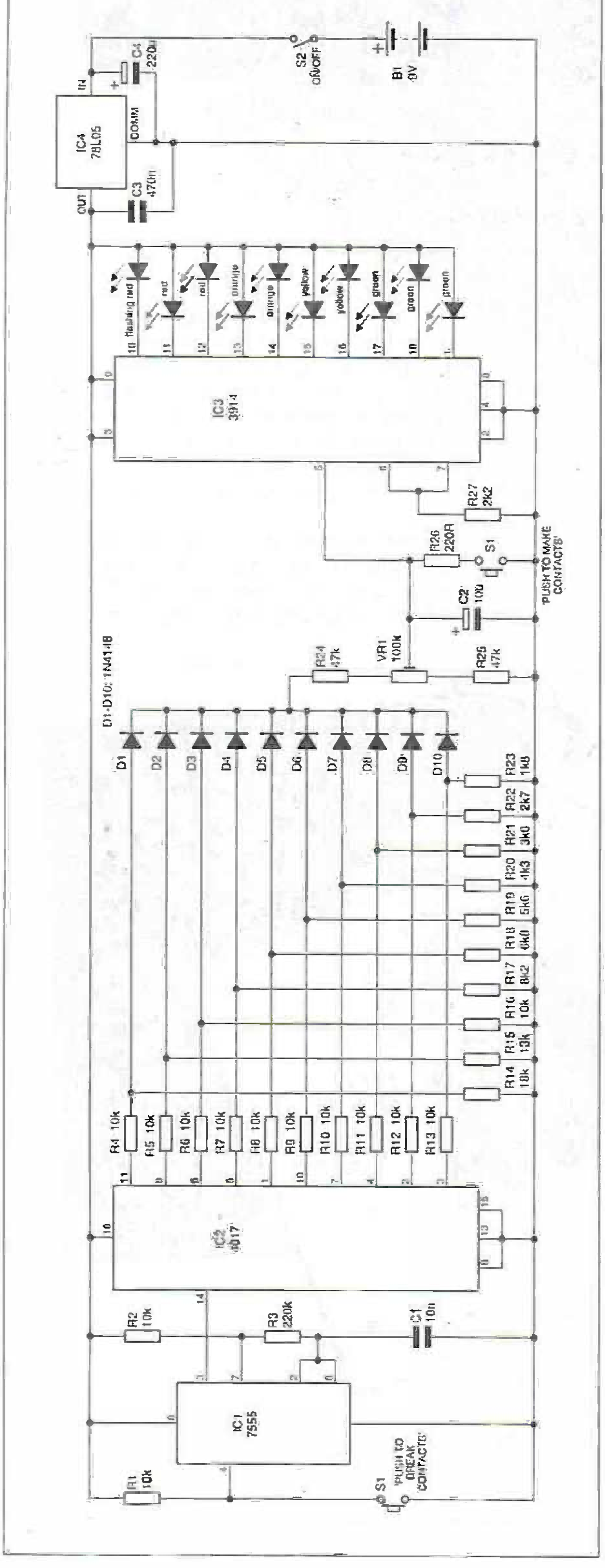


Figure 1: the circuit for Cupid's Arrow



have been devised if an instant readout was considered satisfactory. However, the gradual response of this design completes the suspense.

Circuit description

The circuit diagram for Cupid's Arrow is shown in figure 1. Power is derived from the 9V battery, B1. However, this cannot be taken directly because correct operation relies on absolute voltage levels. Since the supply voltage falls as the battery ages, some stabilisation is needed. This is the purpose of voltage regulator, IC4 which works in conjunction with capacitors C3 and C4. The regulator will maintain a constant 5V output for the rest of the circuit until the battery voltage falls below 7V approximately. A battery pack consisting of six alkaline AA cells was used for the prototype power supply and this may be expected to give about 50 hours of service.

The first section of the circuit is an astable based on IC1 and associated components. Providing the reset input - pin 4 - is high (positive supply voltage), the astable provides a train of pulses at its output, pin 3. The frequency of operation (number of pulses per second) is determined by the values of resistors, R2 and R3 in conjunction with capacitor, C1. With those specified, this will be several hundred pulses per second and since it is not critical, no adjustment is provided.

Push-to-go switch S1 is of the two-way type. In its released position, it maintains pin 4 in a low state through the push to break contacts and therefore no pulses are given. When S1 is pressed, pin 4 is made high via fixed resistor, R1 and pulses are produced until it is released. Even a momentary press will generate several tens of pulses due to the high frequency of operation. The exact number will therefore be completely unpredictable.

The pulses from the astable are applied to the clock input, pin 14, of decade counter, IC2. On the arrival of each one, the ten outputs, 0 to 9 (shown by the numbers in inverted commas), will go high in turn. On the next pulse, output 0 will go high again and the cycle will repeat until S1 is released. With a short press of S1, this cycle will therefore repeat several times. When the pulses stop, the one which happens to be high "freezes" (remains high).

Scaling factors

Each IC2 output is connected to a potential divider consisting of two fixed resistors. On each operation of S1, one of these will therefore be left active. For example, output 8 (pin 9) is connected to resistors R5 and R15. The potential dividers have the effect of scaling down the basic 5V output by certain known factors - the lowest value being derived from output "0" and increasingly higher ones from successive outputs. Table 1 shows the voltages provided by each potential divider.

With one of the potential dividers active, a certain voltage will appear at the common cathode of diodes D1 to D10. These prevent the low state of the other nine IC2 outputs interfering with the action of the high one. This is because the diodes prevent current flowing back to "sink" into the low outputs. The voltage is applied to the top end of a further potential divider consisting of fixed resistors, R24 and R25 and preset potentiometer, RV1. If RV1 sliding contact is adjusted to mid-track position, the voltage will be divided by two. It is then applied to capacitor, C2. This will charge slowly from zero taking several seconds to develop a steady voltage across it.

This increasing voltage is applied to the input, pin 5, of bargraph driver IC3. This responds to an analogue (smoothly changing) voltage and, according to its value, the ten outputs (labelled by the numbers in inverted commas) will go low respectively. The device is designed to respond in 0.125V increments with the corresponding output going low. When 0.125V is applied to pin 5, output "1" (pin 1), will go low. At 0.25V, output "2" (pin 18) will do so and so on. Thus, when 1.25V is reached, all ten outputs will be low. The device is configured in "bar" mode so that preceding outputs remain low as higher ones are reached.

Down the sink

The LEDs operate by allowing current to "sink" from the +5V line into the appropriate output. The first LEDs to light will therefore be the green "cold" ones followed by the "warmer" ones through yellow, orange, red and flashing red. Note that no conventional series resistors are needed for the LEDs since current limiting takes place within IC3.

Each operating voltage applied to IC3 pin 5 is calculated to exceed that required to switch on a particular LED but less than that needed to operate the next one in line. An example will help to make this clear. Suppose, when switch S1 is released, IC2 output 3 (pin 7) happens to be high. Note that this is actually the fourth output since the first one is output "0". The active potential divider will therefore be R10 and R20 and with the values specified, the voltage produced at their junction will be 1.5V approximately (see Table 1).

Table 1

IC2 Output	Voltage
0	0.76
1	1.06
2	1.32
3	1.50
4	1.79
5	2.02
6	2.25
7	2.50
8	2.83
9	3.21

Taking account of the 0.45V "lost" across diode D7, there will be 1.05V at the top end of the potential divider R24/VR1/R25. Note that the forward voltage drop of the diodes is much less than expected (usually taken to be 0.7V approximately). This is because they are operating under very low current conditions. If the sliding contact is at mid-track position, there will be equal values in the top and bottom arms. The voltage applied to capacitor C2 will therefore be one half of 1.05V - that is, 0.53V approximately. As the capacitor charges, the voltage applied to IC3 pin 5 will therefore rise from zero and gradually approach this value. Successive LEDs will light - the first one at 0.125V, the second at 0.25V the third and 0.375V and the fourth at 0.5V. The fifth one will not light because this would need 0.625V which is not available. The display will therefore stop at the fourth LED

Over the threshold

Preset potentiometer, RV1, provides an adjustment to the operating voltages. This will be used at the setting-up stage to provide correct operation. It is needed because the voltage levels may not be exactly as calculated.

Switch S1 is a single pole 2-way (SPDT) type. Its push to make contacts apply a virtual short circuit to capacitor C2 (since resistor R26 has a very low value) while the switch is pressed. This will ensure that it is completely discharged at the time it is released. The display will therefore rise from zero each time. Resistor R26 limits the discharge current which could possibly damage the switch contacts in time.

Construction

Begin by drilling the four mounting holes and soldering the three i.c. sockets in position. Follow with the two link wires then all diodes and resistors (including preset, RV1). Note that resistors R8, R12, R13, R11, R7, R6 and R10 are indicated using letters A to G for clarity. Take care to observe the polarity of the diodes. These are arranged in two sets. In the horizontal group of seven (D7, D3, D4, D8, D10, D9 and D5), the striped (cathode) end is to the right. In the vertical group of three (D2, D6 and D1), the cathode is at the bottom. Add the capacitors making sure to observe the polarity of electrolytic capacitors, C2 and C4. The slightly shorter end lead is the negative one in each case.

Solder the LEDs in position - the green ones are at the end closer to the regulator. All anode ends (those having the longer end lead) are soldered to the right-hand pads which are all connected together. Care must be taken to ensure that the LEDs stand equal distances above the panel and higher than any other component. In the prototype, the tips of the LEDs stood 20 mm above the panel. Add the regulator, again, taking care over its orientation. Using the specified component, the flat face is adjacent to the row of LEDs. Note that certain similar regulators have their outer pins interchanged. If necessary, refer to the supplier's data. Solder pieces of stranded connecting wires to the points labelled S1 "push to make contact", "push to break contact" and "common contact". Solder a similar piece of wire to the pad labelled "S2". Adjust RV1 to approximately mid-track position.

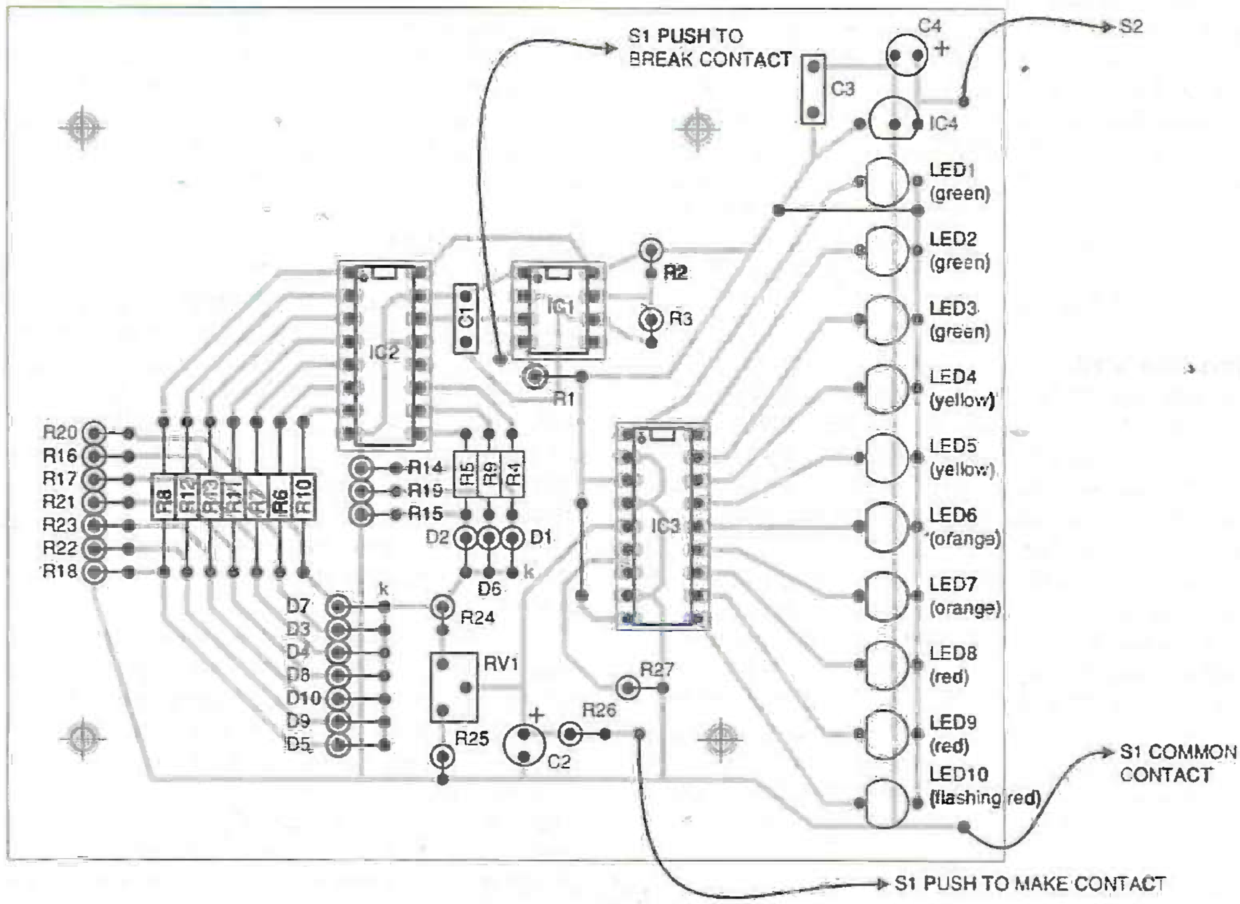
Insert the ics into their sockets with the correct orientation. Since these are CMOS devices, they are vulnerable to damage by static charge which might exist on the body. It would be a wise precaution to touch something which is earthed - such as a water tap - before handling the pins.

Just in case

The prototype unit was built in a plastic box with an aluminium lid. This gives a good appearance. However, any case style will do as long as it can accommodate the components. Everything, except the battery pack, is mounted on the top panel. The circuit panel will be attached so that the red LEDs are at the top of the display. Measure the positions for the LED holes and drill them to a diameter of 5mm and at 7.5mm centres. The final appearance of the device depends largely on the neatness of the row of LEDs so take great care to ensure that they are equally-spaced and in a perfect straight line. Drill holes for circuit panel mounting, for on-off switch S2 and push to go switch, S1. Mount the circuit panel using plastic stand-off insulators on the bolt shanks. Cut these to such a length that the LEDs protrude through their holes by about 3 mm.

Mount the switches and referring to figure 3, complete the wiring. Take care that S1 tags are correctly connected. With the component used in the prototype unit, the tag labelled "1" is the push to make one and the one labelled "3" the push to break. This marking will be found in small lettering next to the

Figure 2: the component layout



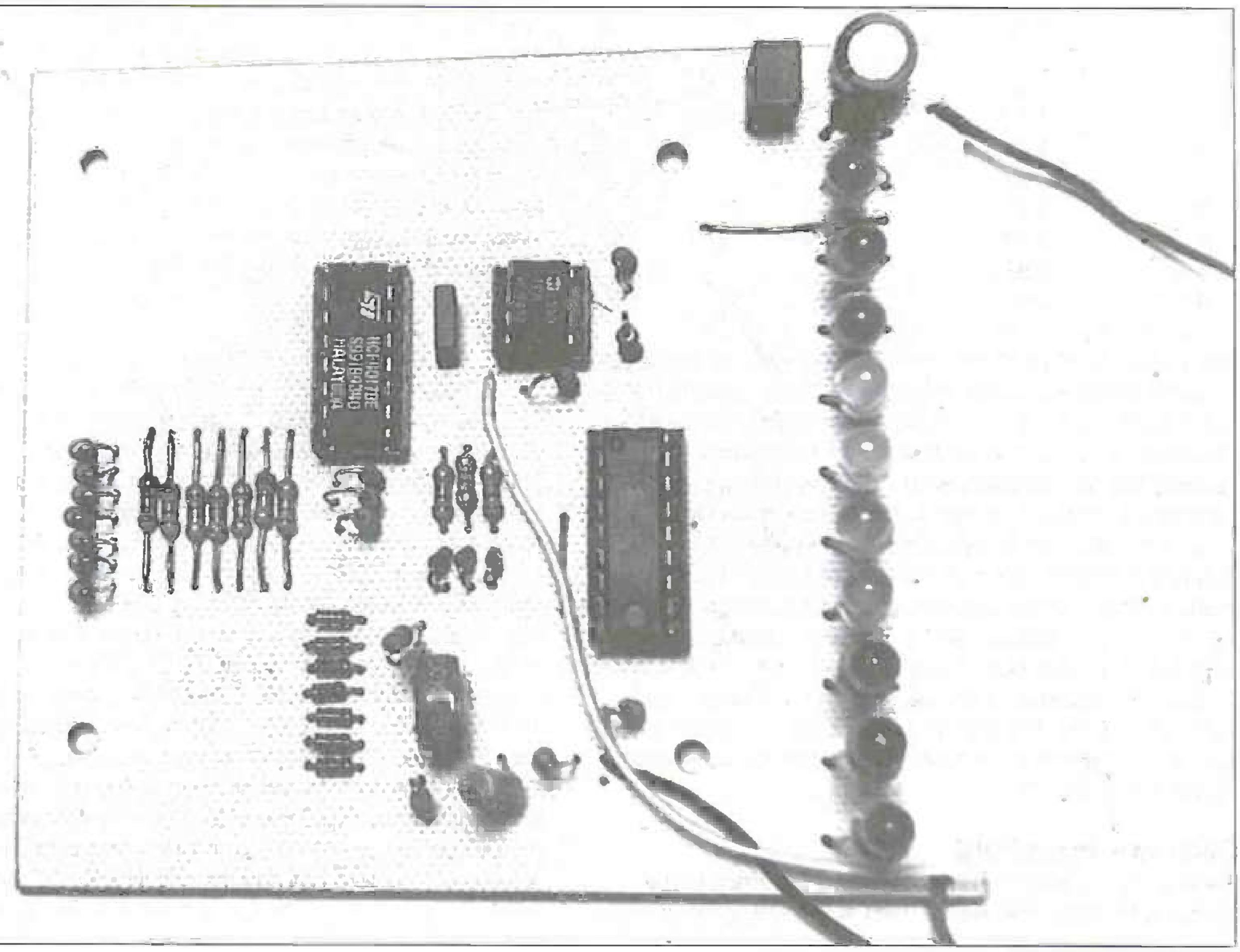
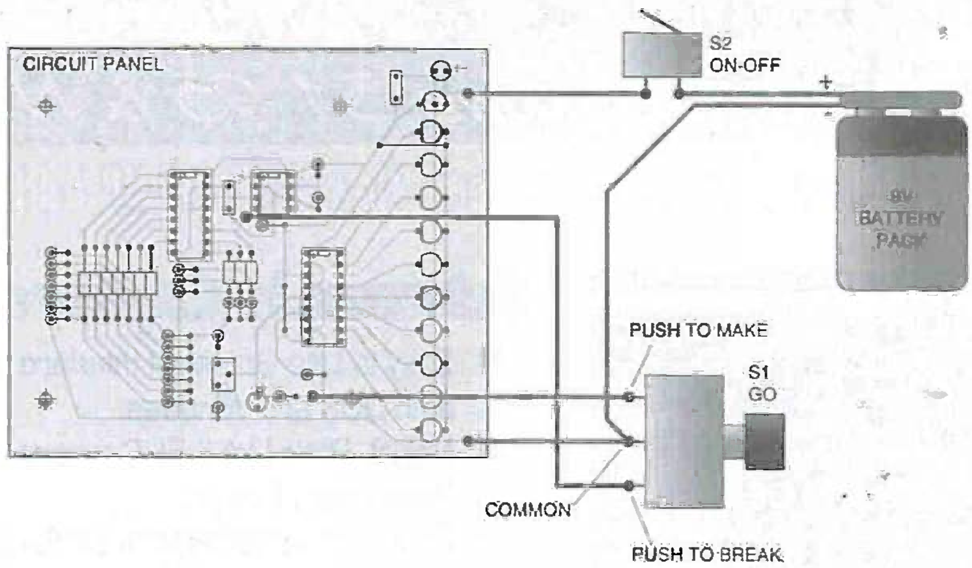


Figure 3: wiring up the arrow



terminals themselves. The centre tag is the common one and is connected to the negative battery snap wire together with the "S1 common contact" one leading from the circuit panel as shown.

With switch S2 off, insert the batteries, snap the connector in place and secure the battery holder using a small bracket or adhesive fixing pads. Fit the lid without the screws for the moment and switch on. Some of the LEDS will light to give a random display. Press S1 for a short time. Successive LEDs should light from the green end taking several seconds to reach the final outcome. Repeat a sufficient number of times to check that each LED has a chance to operate. If it is clear that the flashing red one never comes on and there is sometimes a result where no LED operates at all, the RV1 setting should be increased a little (by anti-clockwise rotation of the sliding contact as viewed from D8 position). If the first LED never comes on its own, the setting could be reduced. Once correctly adjusted, the preset should require no further attention and the lid may be secured. Note that the flashing red LED may not flash fully on and off. This is a consequence of the unusual way of driving it. The box may, of course, be decorated with a suitable heart motif.

The first sign that the batteries need replacing is when sometimes no LED comes on and no one ever gets the flashing red! We did warn you that this was true to life!

Press the button - you never know, you might be lucky in love!

PARTS LIST for Cupid

Resistors

R1, R2, R4 to R13, R16	10k
R3	220k
R14	18k
R15	13k
R17	8k2
R18	6k8
R19	5k6
R20	4k3
R21	3k6
R22	2k7
R23	1k8
R24, R25	47k
All fixed resistors 0.6W 1% metal film	
RV1	100k min vertical preset

Capacitors

C1	10n
C2	10m 16V electrolytic
C3	470n
C4	220m 16V electrolytic

Semiconductors

IC1	7555
IC2	4017
IC3	3914
IC4	LM78L05ACZ
LEDs	3 green; 2 yellow; 2 orange; 2 red; 1 flashing red. All 5mm.

Miscellaneous

S1	SPDT push-button switch (Maplin BK68Y); S2 SPST miniature toggle switch; printed circuit board; box; 8-pin dil socket; 16-pin dil socket; 18-pin dil socket; holder for 6 AA size cells; six alkaline AA cells; PP3-type connector for cell holder. All components for Cupid's Arrow were obtained from Maplin.

The Shake'n'Etch in operation - this shows the tilt of the tray and the approximate level (shallow) of the etching fluid.

PCB Shake'n'Etch

by Bob Noyes

Many of the messy complications of making your own PCBs at home or in a small workshop can be overcome with the help of this dedicated rocking tray for PCB etching solution.

This project was born out of total frustration: the frustration of waiting for a board to etch in an almost-cold PCB bath. When etching solution is fresh it is still hot from the hot water used to prepare it, but it soon loses its heat and takes longer and longer to work.

In the past I've used a PCB tank which has a heater and bubbles air through the solution to speed up the process, but you can't see what's happening and when the holder containing the board is withdrawn to examine the PCB it drops etching solution everywhere. Constant checks must be made to stop it from over-etching, especially when very thin tracks are used, and consequently a mess is made and ferric chloride is a devil of a chemical to clear up.

To keep a constant eye on proceedings you can't beat the good old fashioned etching trays, but these lose their heat very quickly because the layer of ferric chloride has to be very shallow (or you can't see the board). This shallow level also means that commercial heaters on the market can't be used as they require a fair depth of solution to radiate their heat.

After years of putting up with all these problems I finally decided to do something about it, so here's the finished project, the Shake 'n Etch; it has two distinct sections and either or both can be built.

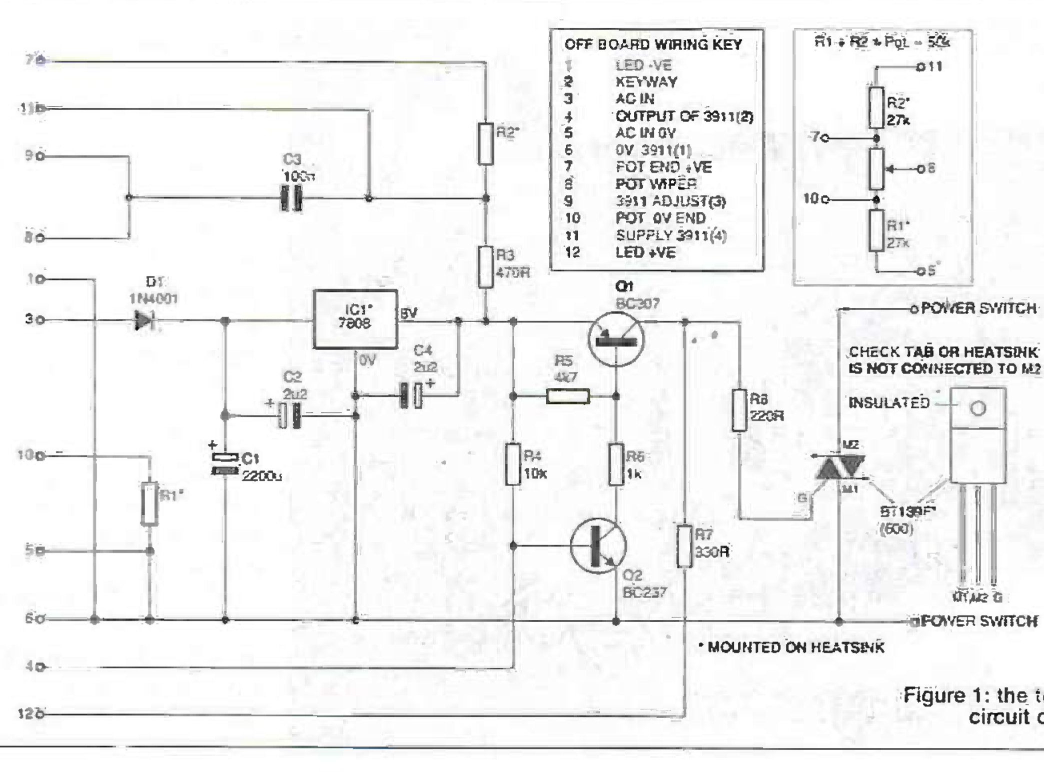


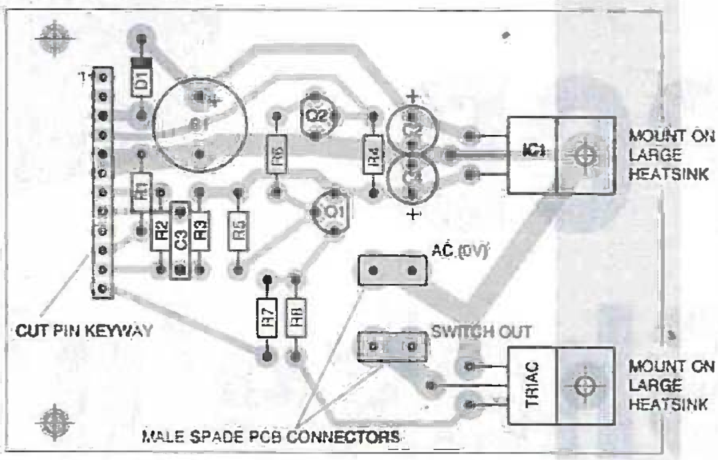
Figure 1: the temperature control circuit of the Shake'n'Etch

The heater

Because of the corrosive nature of ferric chloride it is not practicable to heat the solution directly, i.e. by putting the heater into the etching solution, so the only practical way is under floor heating - an idea borrowed from the Roman era of over a thousand years ago. In this case, it consists of a piece of aluminium at least 3mm thick, or two thinner pieces bolted together. The size is slightly larger than the PCB tray which is going to sit on it; the edges can be bent down for rigidity. A heater is bolted under the aluminium plate. The heater presented a problem at first until it struck me that large 100 watt power resistors are designed to dissipate heat to the surrounding heatsink, so two of these have been used to convert electricity directly into heat.

Now the problem was overheating; if the heaters can increase the temperature from ambient up to, say, 60 degrees C they can keep on going until either the plastic trays melt or the solution bubbles away. This problem was resolved by using an LM391 1 temperature sensor IC, also bolted directly to the underside of the tray plate and used to control the heaters via a small PCB using a triac to switch the power on and off. A variable control allows precise temperature setting of the temperature of the tray plate and hence the solution.

Figure 2: the component layout for the temperature control board



TRIAC BT139F SHOULD BE INSULATED ie. TAB SHOULD NOT BE CONNECTED TO MT2. IF TAB IS NOT INSULATED USE AN INSULATING MOUNTING KIT, MICA WASHER AND PLASTIC BUSH

The agitator

The second problem when using a PCB tray is that the board lies in a layer of black gunge, (although there is probably some fancy chemical name for it). In a PCB tank air is bubbled through the solution and the board sits up vertically so that the black gunge is bubbled away and drops to the bottom of the tank. This method is impractical in a PCB tray because the solution is only a fraction of an inch deep, so another approach was required. A way around this was to rock the tray slowly, producing a small wave; this washes over the board and removes the black gunge. When using both of these additions, the etching process is speeded up and a more even etch is achieved as well as making the solution last longer.

The heater in detail

For safety reasons a low voltage is used. Although this increases the current needed to produce the same amount of heat it is far safer; after all, a bath of liquid is going to sit on top of it when in operation. A supply of 12 volts AC was chosen as these transformers are readily available and reasonably priced. The value of the heating resistors is 4.7 ohms, 100 watts. So with no other losses the total heat generated is:

Two 4R7 resistors in parallel = 2.35R

Current = I = V/R =12/2.35 = 5/1 amps

Power (heat) = I x V = watts

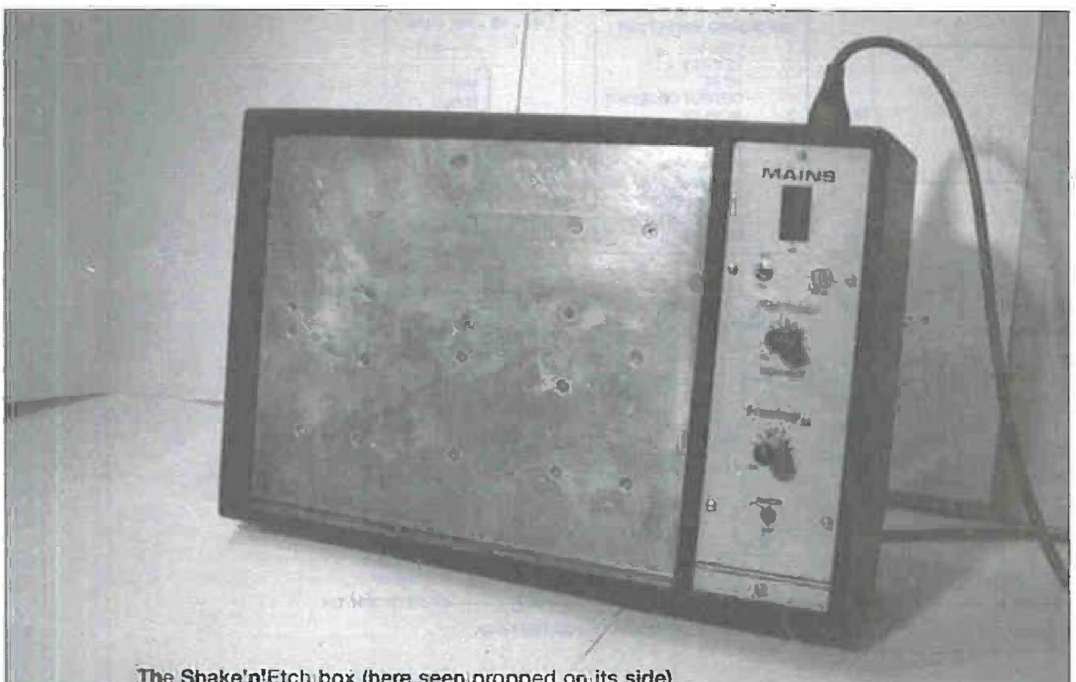
5.1A x 12V = 61.2 watts

or 30.6 watts in each resistor.

As can be seen from the above calculation, 50 watt power resistors can be used, but 100 watt ones are larger and dissipate the heat over a bigger area and as each one is only run at 30.6 watts they are being run well within their specification.

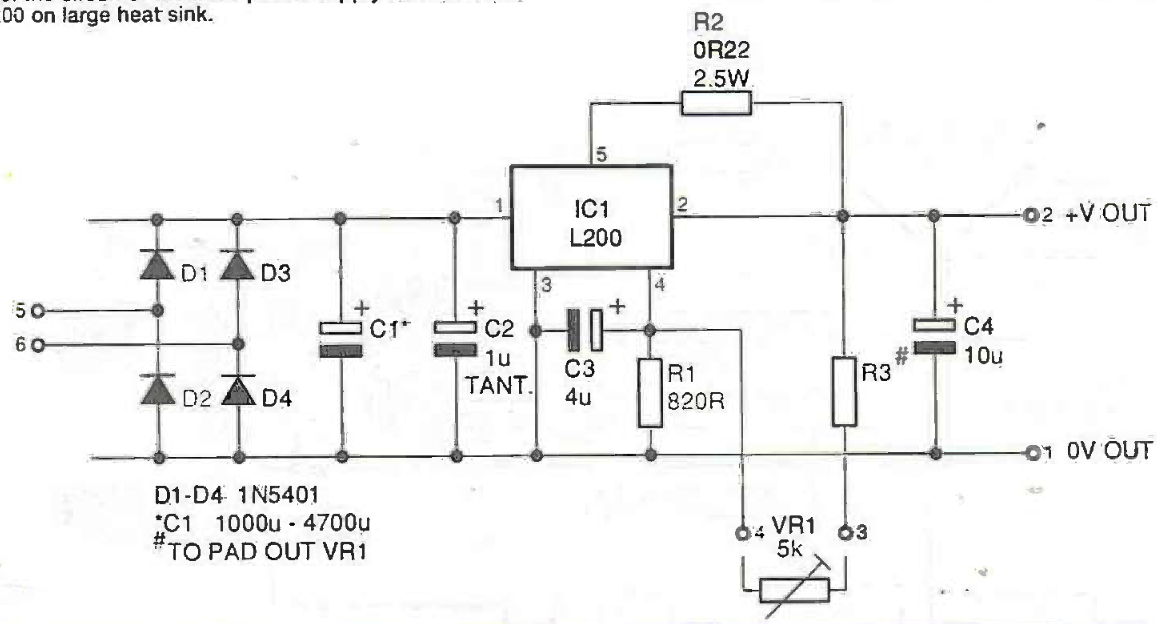
The total power of 61.2 watts is well within the rating of the 100 watt transformer even allowing a few watts for the motor drive in the agitator unit.

To control this 60 watts of heat, a LM391 I temperature control ic is used: this remarkable little ic is again reasonable in price and contains all the electronics to switch the heating



The Shake'n'Etch box (here seen propped on its side) showing the layout of the control panel and the rocking tray.

Figure 3: the circuit of the L200 power supply board. Mount IC1, L200 on large heat sink.



on and off digitally. Being a small DIL 8-pin device it requires an external power switch; this is because any high power switch produces heat and would interfere with the temperature being sensed by the internal thermistor. The pin out is as follows:

1. 0 volt
2. Output (open collector)
3. Temperature adjust input
4. + volts in: 6.8 volts internally regulated
5. 6, 7 and 8 not connected

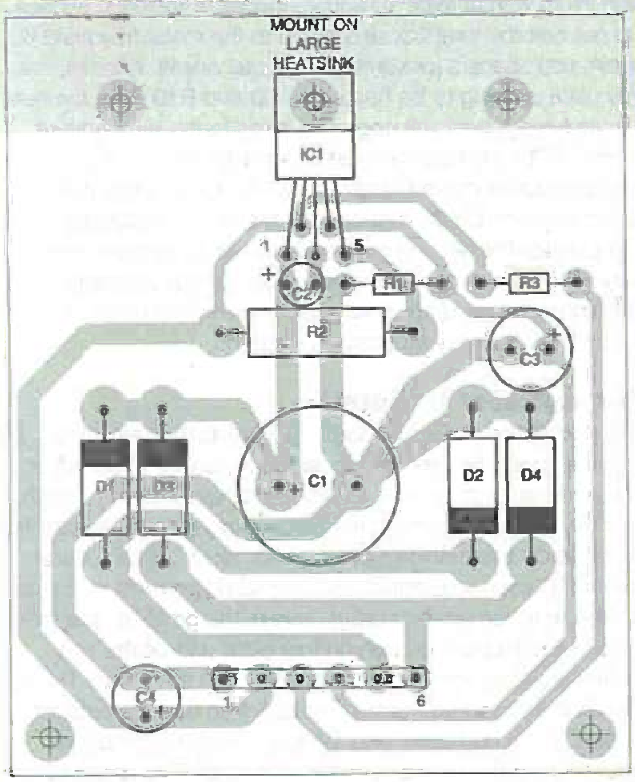


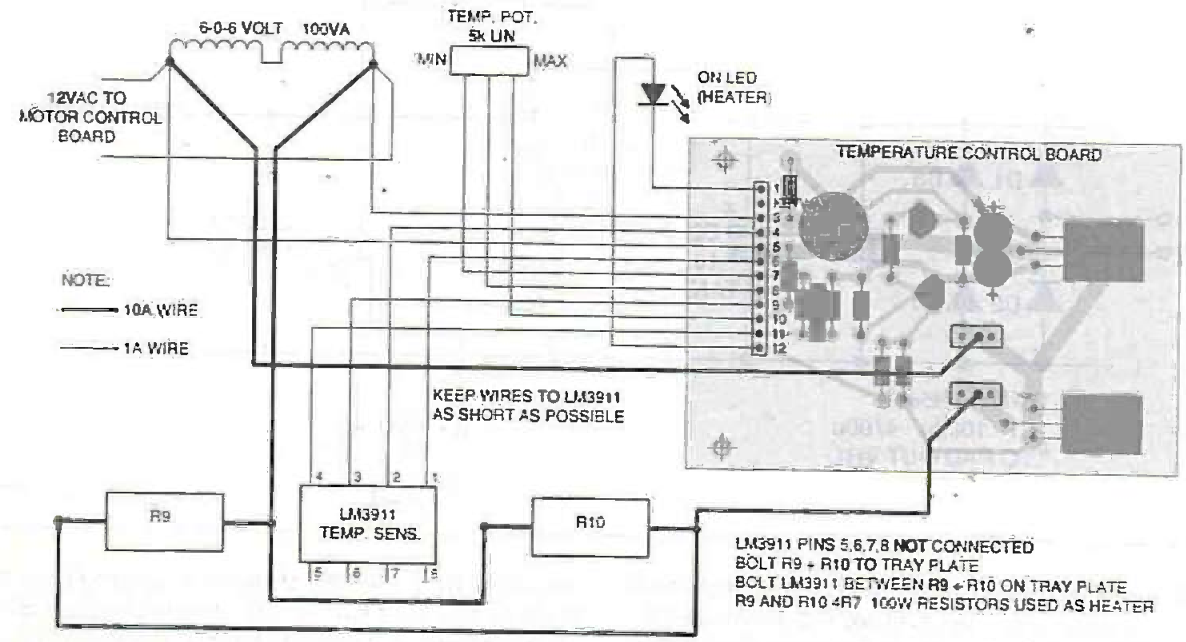
Figure 4: the component layout of the L200 power supply board. Pin 1 = 0V out; pin 2 = +V out; pin 3 = ext pot; pin 4 = ext pot; pin 5 AC in; pin 6 = AC in.

The output pin 2 takes the shape of an open collector output, so R4 is required to turn on TR2 when the temperature being sensed is lower than that set on pin 3. TR2 then turns on TR1 by drawing base current through it. TR1 then turns on the triac output device via R8 as well as a monitor LED via R7. The triac chosen, the BT139F, is a very high power device as, although in this circuit its RMS constant current is around 5 amps, its peak current is much higher. It has an insulated tab and can be mounted directly onto the heatsink without the need for an insulating set.

For correct operation the LM391 1 requires a stable supply although it has a built in zener regulator. The 12 volt AC will be higher off load, i.e. the heaters off and drop to 12 volts with the heaters on. To remove this voltage change IC1, a 7808 delivers a constant 8 volts to the dropper resistor R3. Because of the low current demand of the temperature circuit control, half wave rectification is used; this also allows a common connection for MT1 of the triac and the 0V of the supply, not the case if a diode bridge was used. When the temperature being sensed is the same as the temperature set on Pin 3 (the output), pin 2 goes low. This turns off TR2 which turns off TR1 which in turn switches off the triac and the monitor LED goes out indicating that the heaters are off.

Because of the spacing of the temperature sensor IC3 between the two heaters R9 and R10 there will be a thermal delay which is caused by the heat generated in R9, R10 taking time to reach the sensor. By the time the heat reaches it the heaters have slightly overheated, that is, gone above the preset temperature, so the sensor will turn off the heaters until the sensor detects a temperature lower than that set by VR1. Then the heaters will be switched on and stay on until the sensor detects the correct temperature, so that again the temperature will vary slightly, hovering around that set. Great care must be taken when calibrating the control VR1. The LM3911 does not respond to a setting of degrees centigrade but to a voltage on Pin3. This voltage sets the switching temperature. In both the models made here the correct maximum voltage on Pin 3 was 3.3 volts. The higher the voltage the lower the switching temperature and the lower the voltage the higher the temperature set. Because of the large number of variables no precise voltage can be given so it must be set by trial and

Figure 5: connections to the temperature control board



error. This should be set such that the tray plate is just touchable quickly but cannot be touched for more than an instant. The temperature of the solution will always be lower than that of the tray plate because the plastic tray acts as a kind of temperature insulator. The solution must be kept below 60 degrees C to minimise any vapour from being given off, as it has corrosive properties. Anything much above this could cause a health problem, as well as affecting the surroundings with tell-tale brown dots associated with ferric chloride.

The monitor LED will give an indication that the heaters are on. To test the circuit the base and emitter of TR2 can be shorted together, which should turn off the triac and the LED (this is simulating the effect of the temperature being sensed is above that set). If shorting these points fails to turn off the LED, re-check the circuit for errors to find out why.

As the set temperature approaches the monitor LED starts to glow less brightly; this is because the output Pin 2 of the LM3911 switches between off (high) and on (low). This is achieved by pulse width, that is, the output starts off high then pulses low with short low pulses. These pulses get wider and wider until it is low with short high pulses, and the last stage in the output goes low. This is done to provide a digital output. The triac is always hard on or hard off. This pulsing makes the use of a relay to do the power switching impractical, as the relay contacts chatter during this pulsing time. The chattering could cause the relay's contacts to pit due to the sparking of the contacts, as they would be switching the full 5.1 amps.

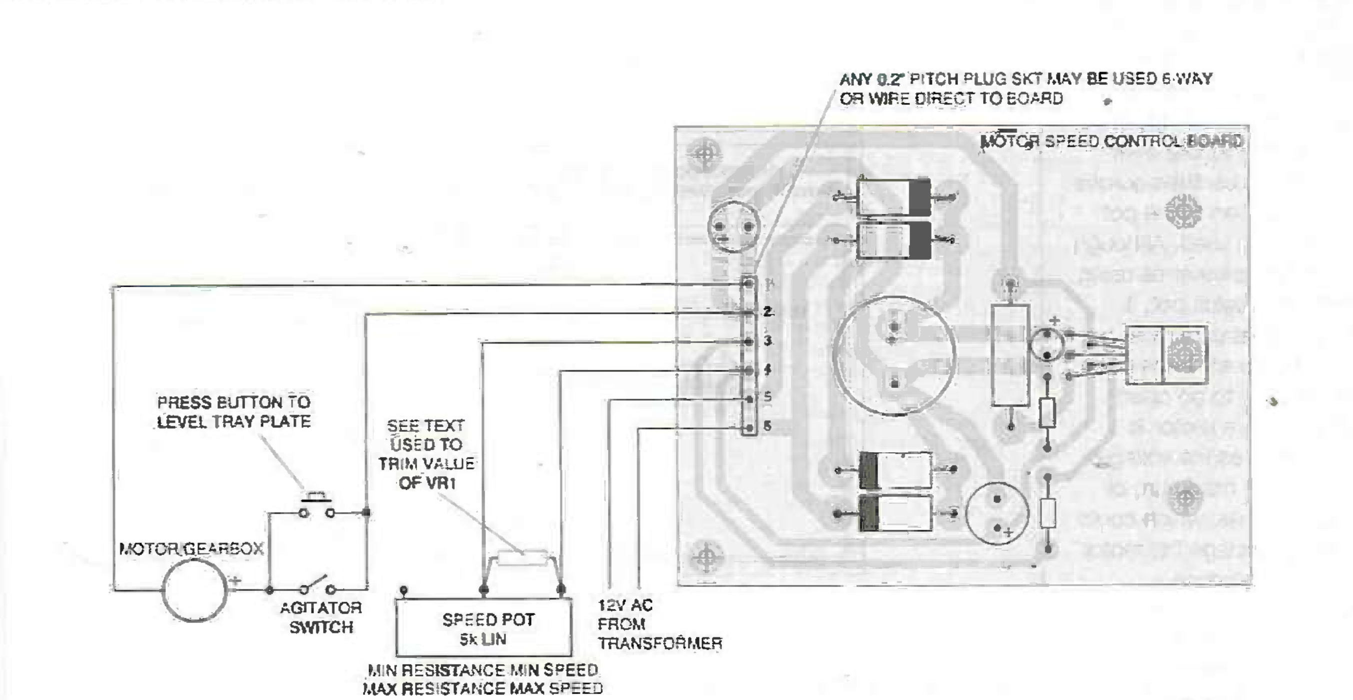
If the agitator section is not going to be built, the tray plate must be bolted to the box with four small-diameter bolts (3mm) and a gap of 3mm left between the metal tray plate and the external wooden box. This is to reduce the heat losses into the box as well as leave a path for any heat under the tray plate to escape. If you are going to build the agitator, only two mounting bolts are used, M4 type (4mm), and these will be used as the pivot points.

The leads from the sensor IC3 to the temperature control PCB should be as short as possible. The best way is to mount the PCB onto the underside of the tray plate with spacers; the leads then are only a few inches long. The heatsink with the 7808 and the triac mounted on it should be a piece of aluminium with at least 10 square inches of radiating surface. Do not bolt the heatsink directly on to the metal tray plate but, again, use spacers (preferably not metal ones!). After all, the tray plate is going to be heated by R9 and R10 - not the best way to keep a heatsink cool. The leads to the temperature control PCB and heaters must be long enough to allow the tray plate to be moved up and down by the agitator without straining them. Check that none of the wires actually touch the tray plate or the heating resistors, as over a period of time this may cause the insulation to melt, with obvious problems resulting. (Always keep wires away from hot surfaces, in any case.) See the suggested layout diagram.

The agitator in detail

This part of the project is more mechanical than electronic. The object is to slowly raise and lower one end of the tray plate about half an inch in order to produce a small wave to wash over the board to dislodge the black gunge not to cause a tidal wave. To do this a small electric motor fitted with a suitable gearbox is used to produce the up and down motion. A lever is fitted to a cog on the output drive of the gearbox, this lever is connected to one end of the tray plate and as the cog rotates the lever raises and lowers on each revolution. This is shown in the diagram; care must be taken that the outside surface of the cog is flat and the lever is not fouled by the mounting bush on the axle or the axle itself. The speed of the output of the gearbox should be in the range between 10 and 40 revs per minute. A little experimenting is required to get this right. The speed of the motor, a DC model motor or similar, is controlled by the motor speed control PCB. This is basically a

Figure 6: motor speed control connections



3-15 volt DC regulated supply. The motor gearbox used in the prototypes was bought as redundant stock from Greenweld but similar devices can be found from such firms as J. Bull, a frequent advertiser in ETI. The motor is basically a 12 volt DC motor and runs at 40 revs per minute at 12 volts but when the voltage is reduced it slows down.

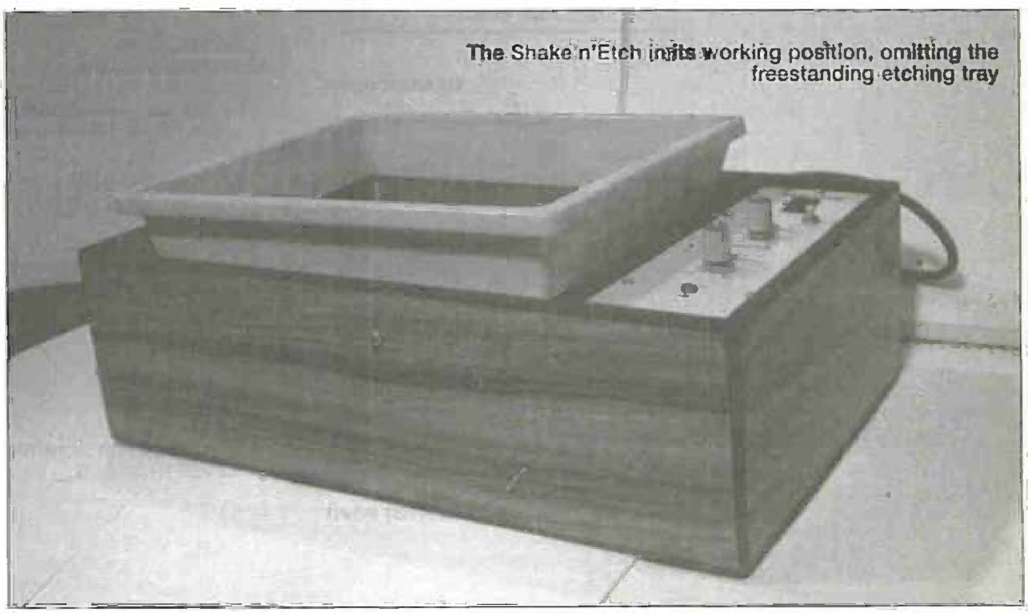
Because of the gearbox the torque is quite sufficient at this lower voltage to raise and lower the tray plate and tray of solution. It is advised to try out the design with a tray of water rather than solution and to use a plastic sheet over the tray plate. Needless to say, while these experiments are being carried out the heater unit should be disconnected.

The final design should produce a small wave, little more than a ripple, and even at the highest speed should not cause the solution to splash.

The motor control board can produce from 3 to around 15 volts, so care must be taken if a low voltage motor is used. The circuit is the standard L200 regulated supply almost out of the reference book. R2 is the current limit resistor which causes the supply to begin to shut down when the maximum set current is approached. For most small motors a 1R 2.5 watt resistor can be used, but if more current is required this can be reduced to 0R22 2.5 watt giving well over 1 amp of output. R3 has been added so as to increase the minimum voltage out of the supply its value can be anywhere from a short circuit, that is, a wire link to 2k2 . When a motor stalls due to lack of volts it draws more current than it should, albeit not enough to turn the motor but enough to damage it over a period of time, so by fitting a suitable resistor in R3's position the minimum voltage can be increased such that the speed control ,VR1, will run the motor even in the minimum speed setting. The choice of value depends on the minimum voltage required but it works out that a 330R resistor increases the minimum voltage by about 1 volt.

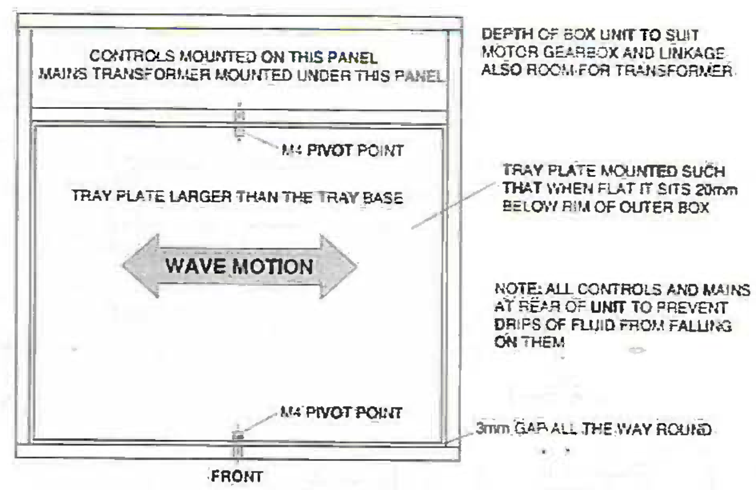
Once the correct voltage range has been found from experimenting say 6 -12 volts (example only). The minimum voltage has to be increased from 3 to 6 volts, that is, 3 volts at 330 ohms per volt works out to around a kilohm, so R3 is 1k.

From 6 volts to 12 volts maximum is 6 volts, so again at 330 ohms per volt 6 x 330R = 1,980 ohms (1k980), so the


The Shake'n'Etch in its working position, omitting the freestanding etching tray

nearest value is a 2k2 potentiometer. To give full range on the control VRI, a standard 5k pot can be used, and a resistor fitted in parallel. That is, to produce a value near to 2k2 a 4k7 resistor can be fitted across the connection of the pot that is being used. Although this is not as linear as using the correct value pot, it works. Great care must be taken not to allow the pot connections to go open circuit when a motor is connected, as the voltage will go to its maximum of about 15 volts, which could possibly damage the motor as well as produce a gigantic wave of corrosive etching fluid! Once everything has been sorted out, it should be run continuously for around half an hour without the tray in place to check everything is OK and the motor is not overheating. If bolts are used on the mechanical linkage as pivots, lock nuts must be used, or two nuts used with a shake proof washer between them, to prevent them working loose with prolonged use. Then run a final test with the tray in place, but with water in the tray instead of etching solution. Again, a full half an hour test should be carried out using the heaters and the agitator.

Figure 7: a guide to laying out the outer box



After all the testing the whole unit should be inspected for loose bolts, nuts etc. Only after these tests should solution be used. Care must be taken not to put too much liquid into the tray at once, so as to prevent splashes; also, the less fluid in the tray, the less the strain on the motor.

When in use the advantage of the press button on the agitator can be seen. It is much easier to level the tray plate with this rather than with the switch.

Figure 8: a guide to laying out LM3911, R9 and R10, and the PCB plate.

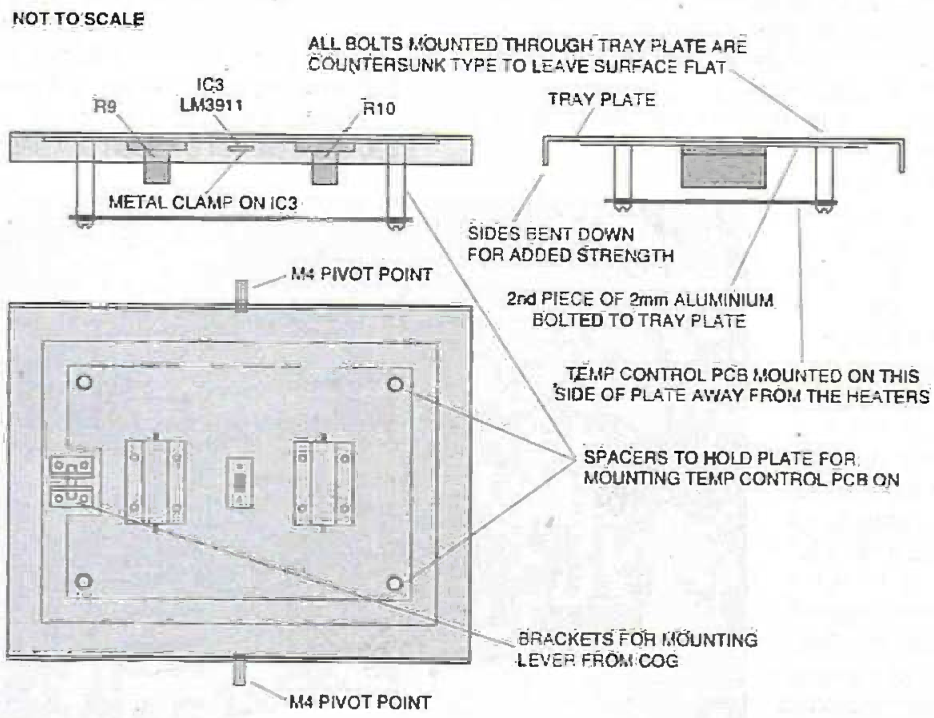
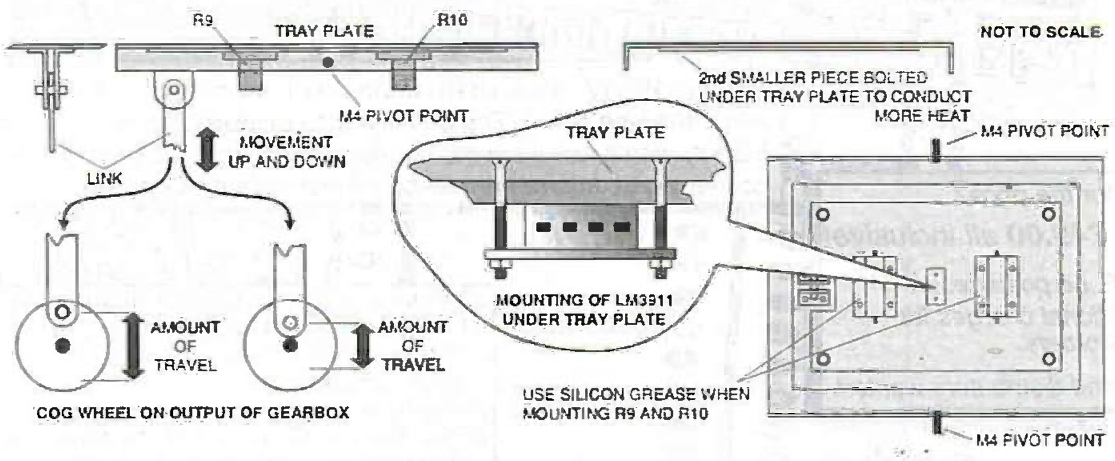


Figure 9: a guide to assembling the tray rocking plate



PARTS LIST For PCB Shake'n'etch

(1) The Heater

Resistors

*R1,*R2,*R3	22k
R4	10k
R5	4k7
R6	1k
R7	330R
R9,R10	4R7 100W (off board)
VR1	5k linear potentiometer

*Adjust to suit temperature range: see text.

Capacitors

C1	2200uF 16V radial
C2,C4	2u2 16V radial
C3	100n 16V disc

Semiconductors

IC1	7808 regulator
IC2	LM3911 temperature controller (off board)
Q1	BC307
Q2	BC237
D1	IN4001
TRIAC1	BT139F (Electromail 284949)
LED1	red 5mm 02 0.2in (off board)

Miscellaneous

T1 6-0-6 volt 100VA (e.g. Electromail 211351 torroidal; 207289 chassis mount; 805259 frame mount. The frame mount is suitable and cheapest.) Mains switch 2-pole on/off 3 amp; knob for temperature pot; 10amp wire for heaters; metalwork to suit (see text and diagrams); PCB.

(2) The Agitator

Resistors

R1	820R
R2	0.22R 2.5 watt for up to 1 amp from supply
R3	Link - see text

Capacitors

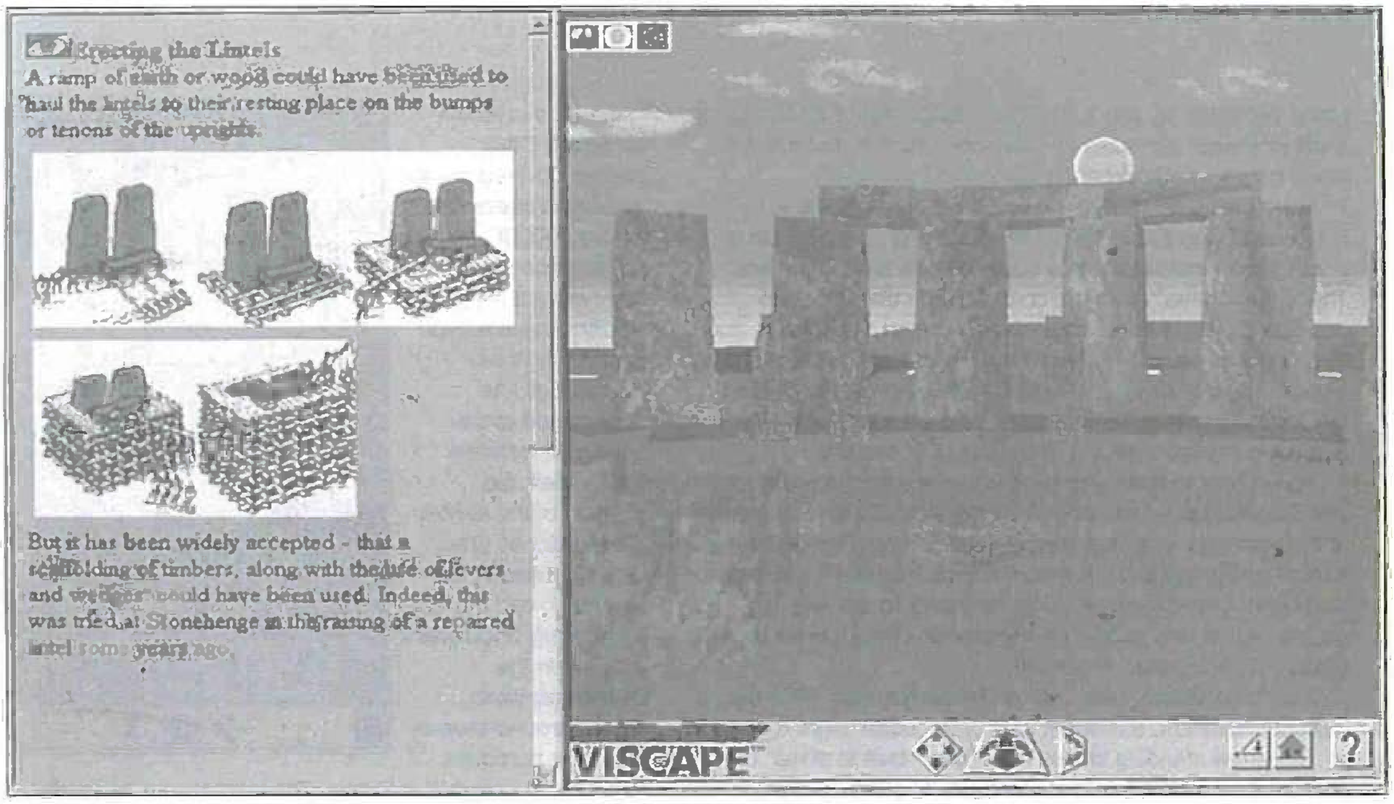
C1	4700uF 25V radial
C2	1uF 25V tantalum
C3	4u7 25V radial
C4	10u 25V radial

Semiconductors

IC1	L200 regulator
D1 - D4	IN5401 3 amp

Miscellaneous

Motor/gear box 3.12 volts DC motor and gearbox in the range of 10-40 revs on output. See text. (If all else fails, Maplin WC687 seems to have a suitable specification but has not been tested with the prototype.)
Speed control pot 5k linear
Knob for above
Switch - single pole on/off 1A
Switch - press-to-make 1A
Metalwork to suit; cog. etc. to fit output of gearbox cam-lever; Vero pins or 6-way x 0.2in pin plug (e.g. Maplin JY91Y); PCB.



A Heritage site on the World Wide Web

Virtual STONEHENGE

Electronics has brought one of the world's oldest scientific calculating machines - Stonehenge - into virtual reality, and made an interactive, real-time reconstruction of the site accessible through the Internet.

The ancient megalithic monument on Salisbury plain in England is famous for the large size of its stone structures, the "trilithons", in which accurately cut stone slabs weighing around 7 tons each are carefully fitted onto stone uprights weighing between 25 and 50 tons apiece to form a ring of square stone arches - and the mystery of its origins. The designers and builders of Stonehenge are lost to history, but the favoured interpretation of the stone circle's use is that it was a kind as astronomical compass, to assist priests (and farmers) of a long-gone age in predicting when sunrise and moonrise would fall at certain times of year so that seasonal religious ceremonies could be carried out at the proper time.

Stonehenge as we know it is in fact a series of stone circles built at different times. The oldest stones of Stonehenge are about 4,500 years old, dating back to around 2500 BC, but there are stoneworks and other traces in the vicinity of ritual activity going back to 4000 BC and beyond.

Virtual reality

The project has been developed by virtual reality specialists Superscape VR in collaboration with the modern monolith, semiconductor giants Intel, who regard it as a fine example of how semiconductors, virtual reality and the Internet can make a dramatised and educational presentation available to a worldwide audience.

The virtual reality model has been designed to provide "scaled performance" on the Internet, so that users with a fast Pentium processor-based PC computer based on one of the faster Pentium processors can get the maximum access to all the details, and a fast frame rate, but users with an older Processor can still get into the virtual environment.

The 3D Viscape software that runs the Stonehenge program runs at the moment with Netscape Navigator 2.0 and above on Intel-based PCs with a 486 processor (or higher) running Windows 3.1, Windows 95 and Windows NT. This demonstrates the amount of processing power needed to carry a moving VR image, even one that is limited to shifting a viewpoint, rather than moving figures around independently.

Using Windows 95 and a P150 processor, with a 28.8 modem, it still took over 5 minutes to download Viscape and the virtual world before the Stonehenge site could be viewed.

Superscape developed the virtual Stonehenge using their PC-based Superscape VRT, a VR authoring package, using photographs and illustrations taken from all around the site. The "viewing area" covers such a distance that it is quite possible to head for the mysterious grove on the horizon, and then find that you are not sure how to get back to the standing stones. You can move all round the site, and over it, gaining a full aerial view either from close to, or quite a long way up, giving a complete overview of the layout of the site.

Sometimes tourists who have come across the world to visit Stonehenge - perhaps expecting something on the scale of the pyramids - express surprise that it is not bigger. After all, it takes much longer to drive to the area from the nearest town - and park your car, buy a ticket, and walk to the wire enclosure that now surrounds the stones - than it does to walk around the immediate enclosure.

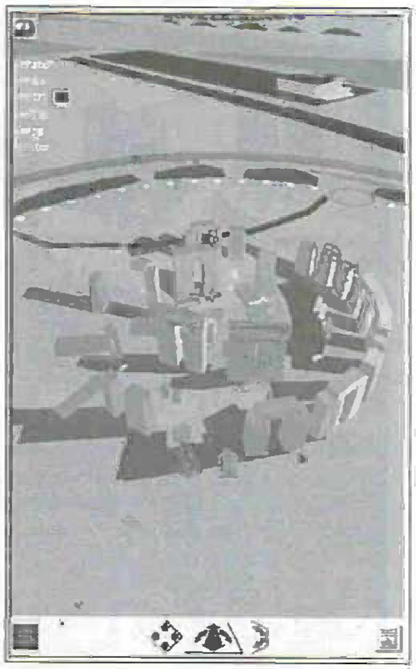
If visitors were to "walk" the entire site, perhaps from the nearest settlement, a different idea of the scale might emerge.

The virtual standing stones have been "built to scale" using photographs and photo-CD techniques to give a certain amount of texture to the stones as your viewpoint comes closer to them, and sharp showing to make the layout clearer. The display is split to give the virtual world on the right and an information display on the left, and a "Timeline" near the top of the screen allows you to scroll along and choose the age of the view that you want to explore.

Heritage

Superscape and Intel developed the Stonehenge project for English Heritage, the organisation that advises the UK Government on all matters concerning the conservation of the historic environment within England. The Chairman of English Heritage, Sir Jocelyn Stevens, has said that the project was "a fundamental part of our vision for increasing access to this mysterious monument and increasing our understanding of the enigma that is Stonehenge." Certainly "high-tech 'tourists'" will be able to "visit" the monument at any time, "day or night, present, past or future, from their own home or office".

The times that you can visit the site are split up into a series of "time bites" from various phases of the development of Stonehenge, from a speculative earliest phase when there were tall upright posts made of pine in the vicinity. One interpretation of these is that they may have been totem poles, not unlike those built by some native Americans and Canadians in recent centuries. Other phases covered are the woodland clearances before 4000BC and the appearance of long barrows and the Neolithic causewayed enclosure, Robin Hood's Ball, the appearance of the smaller Bluestones from Wales, the erection of the famous Sarsen stones (the largest stones in the structure), and the last phase, only 3500 years ago, when the Bluestones were moved around several times, for purposes that we can only guess at now. The most recent "redesign" seems to have remained unfinished. Perhaps this is a demonstration that even the most ambitious engineering projects must come to an end at some time.



Hypertext

Using the "intelligent links" feature of Viscape, the user can click on words in the text and "hot-link" to connected features in the virtual world, as well as related texts. This demonstrates one of the first public applications of 3D hypertext, say Superscape. The commentaries themselves are good potted histories of England's most famous ancient monument. The section under "Era 7: Phase 3: 2400-1600BC" describes how the main axis of the site is aligned to midsummer sunrise and midwinter sunset. Each time section is accompanied by a picture.

As an additional attraction, the software writers have built in the ability to observe the sunrise or moonrise over Stonehenge at each. The moonrise is a little disappointing, even on a fast processor - the full moon rises part of the way up the sky, but then seems to get stuck in the trees. The sunrise is more dramatic, with changing colours and shadows.

Virtual reality Stonehenge can be found at web site http://www.superscape.com.

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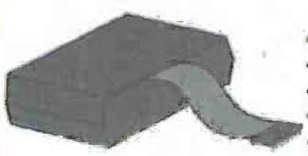

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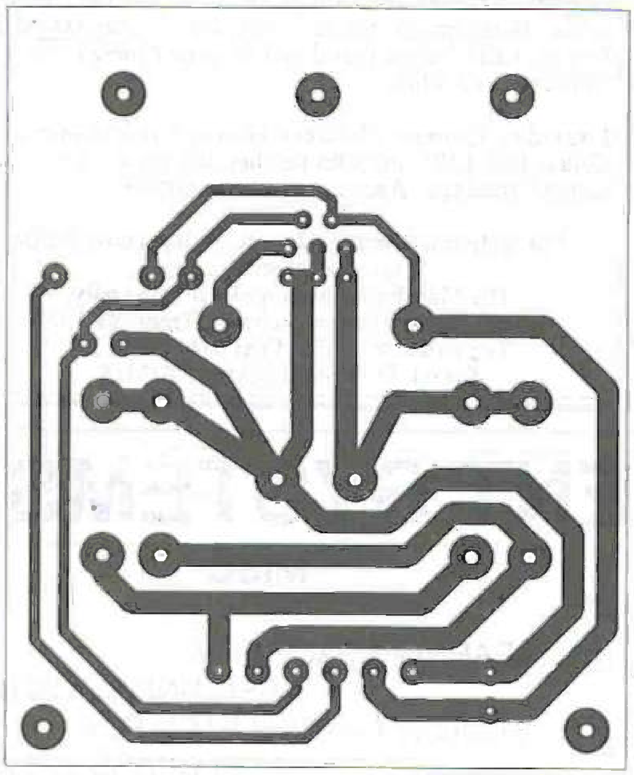
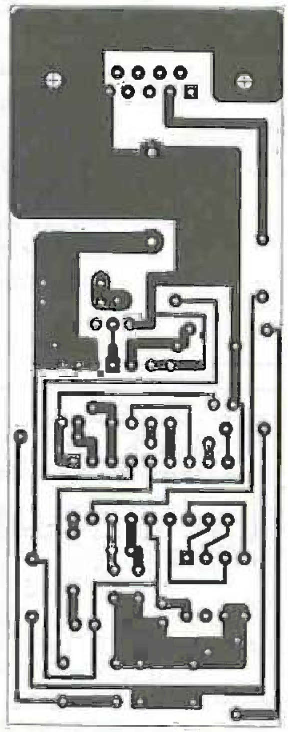


SHAKE 'N' ETCH POWER SUPPLY



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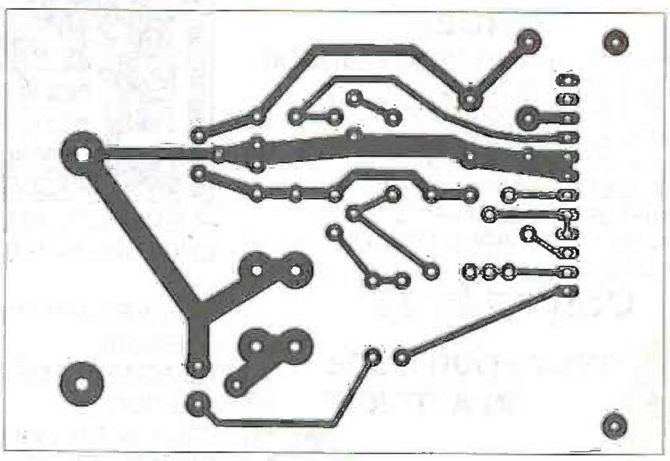

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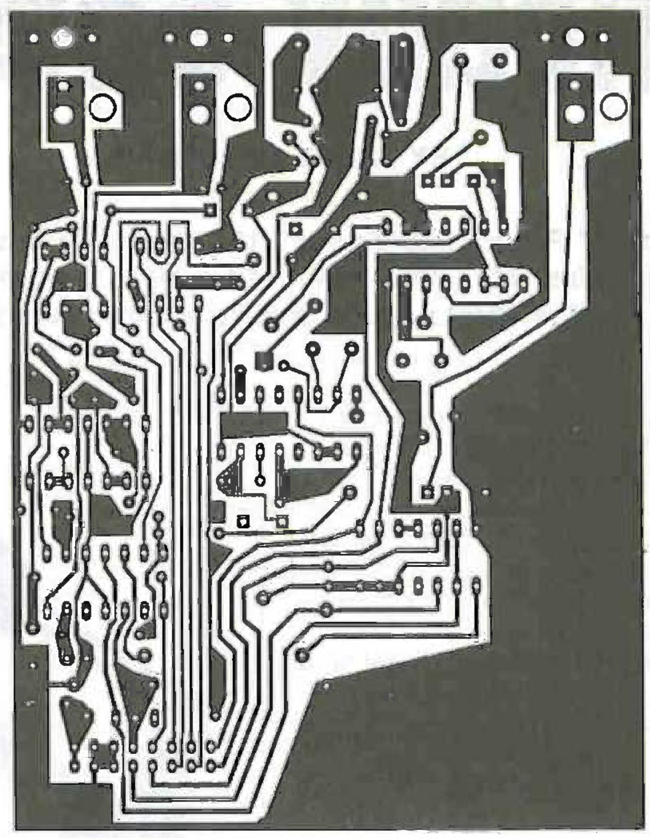

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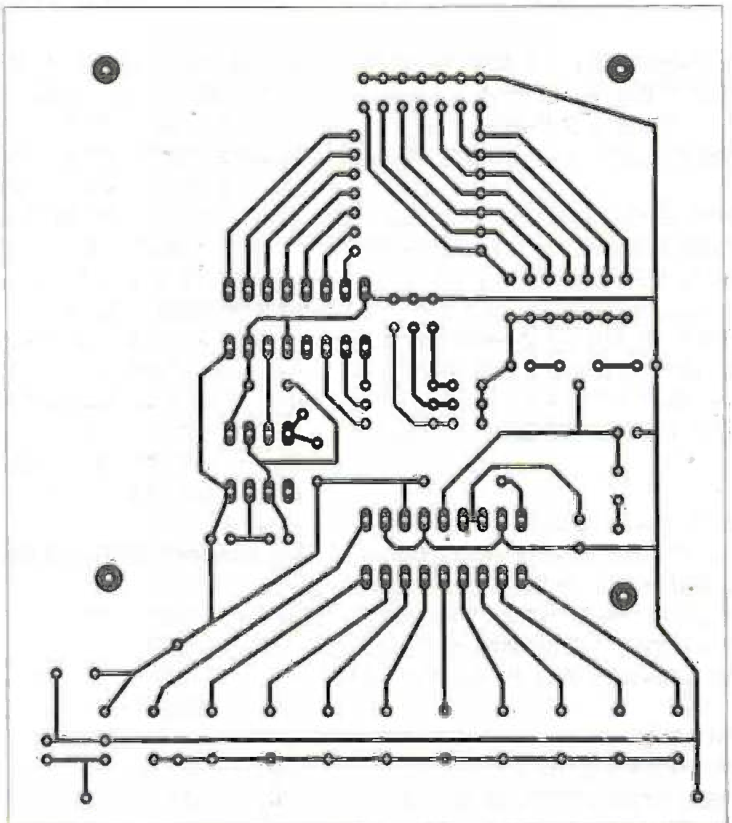


CUPID'S ARROW

Practically Speaking

BY TERRY BALBIRNIE

The last few months of Practically Speaking have been devoted to various aspects of connecting wire. This time we shall continue by looking at the way the thickness of a wire is expressed.

It would seem logical to specify the thickness of a wire as the diameter of its core. For example, a typical light-duty connecting wire may have a diameter of 0.6 mm. Remembering that the current-carrying capacity of a wire depends on the area of cross-section of its core, it might also seem to be a good idea to express it this way instead. For example, the 0.6 mm diameter wire above would have a cross-section area of about 0.28 square mm. Incidentally, this figure is obtained by regarding the cross-section of the wire as a circle of radius 0.3 mm. The formula for the area of a circle is then used:

$A = \pi R^2$ (where the constant π is approximately 3.14)

Illogical

However, life is not always as easy as that. A typical instruction for winding a tuning coil for a radio might read "wind 16 turns of 28 SWG enamelled copper wire on to a cardboard tube of diameter 20 mm". It is the "SWG" figure which often confuses newcomers.

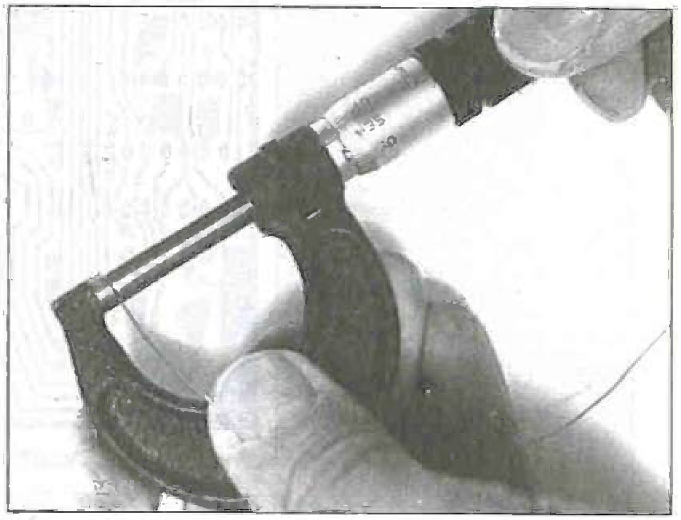
The SWG (standard wire gauge) relates the diameter of the wire to some arbitrary number (in this case, 28). The picture becomes less clear when we consider that there are four or five wire gauges used around the world, all with their particular idiosyncrasies!

In Britain, SWG is the most usual system used. American readers will note that they have their own similar American Wire Gauge (AWG). In both systems, the diameter corresponding with a given wire gauge is almost arbitrary (that is, it does not follow any particular plan). However, the rule to remember is that the lower the SWG, the thicker the wire will be. In the British system, 24 SWG wire has a diameter of 0.559 mm. In the American system, 24 AWG wire has a diameter of 0.510 mm.

Thick and thin

The thickest wire likely to be encountered by the amateur is 16 SWG and the thinnest, about 42 SWG although data tables often go as low as 10 SWG and as high as 50 SWG. Very thin wire becomes extremely difficult to handle without snapping it, so its use is really limited to automatic coil winding machines. On the other hand, very thick ones are better described as rod rather than wire.

Note that it is usual for wire to be used only in the even SWG sizes. For example, although it is possible to obtain 21 SWG wire, in practice it is usual for suppliers to list only 20 SWG and 22 SWG. The table below, therefore, only shows the even SWG sizes and how they are related to the diameter of the wire. Note that the SWG figure applies to wires made of materials other than copper. They are therefore often used to express the thickness of resistance wire, which will be the subject of the next Practically Speaking.



Using the micrometer to measure the diameter of a wire. Insulated wire must have the insulation stripped back first.

To find the SWG figure of an "unknown" wire, you will need to use a micrometer (see photograph). It is a simple matter to measure its diameter and compare this with the table. Note, however, that the diameter relates to the metal core only. With plastic insulated wire, it will be necessary to strip some of this off first. With enamelled wire, the insulation is very thin and it may be possible to make the measurement with the insulation in place. Although the diameter obtained will be slightly on the high side, when this is compared with the figures in the table, the correct SWG figure will still be found. There is a further point that the diameter of a wire is subject to a certain tolerance. Rarely will wire of a given SWG be found with its exact specified diameter.

The Standard Wire Gauge Table

SWG	Diam (mm)	SWG	Diam (mm)
16	1.63	30	0.315
18	1.22	32	0.274
20	0.914	34	0.234
22	0.711	36	0.193
24	0.559	38	0.152
26	0.457	40	0.122
28	0.376	42	0.102

That's all for this time. Next time we shall look at resistance wire.

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Around the Corner

At first sight, the news that the Federation of the Electronics Industry - the only trade association for the electronics industry recognised by the DTI - has compiled a survey of its members' opinions on education and training should be cause for rejoicing. A major Federation is acting upon a major concern - who can supply the excellent engineers that British industry needs?

But at once a note of scepticism comes leaping in. As one colleague put it, not long ago (he was, I must hasten to add, talking about a different survey): "Lots and lots of talking. What are they actually doing?" Old hands among you will have heard (or spoken) these words many, many times.

The note of scepticism is reinforced when we read that only 39 of the 250 companies canvassed actually returned a reply by the deadline. Is this apathy? Was the survey unreadable? Or is everyone just too busy doing electronics to spend time filling in surveys?

Let me now bring on the cheerleaders: 15 percent is not a bad response. It's quite common for surveys to return a response of 10% or even 2% to paper canvassing. And electronics companies really are too busy to fill in a yet another set of forms, unless they are very clear indeed about the advantage it will bring them. This is because prices have gone down, costs have gone up, and they cannot find all the technical staff they need. They tend to be understaffed. One of the values of this survey is that the shortage of good, trained people - that we are constantly hearing about anecdotally - is amply confirmed.

The second point of interest is the desire for employees with better "literacy and communications" skills. Clearly it is felt that technical people can do their maths up to the level required, but leave something to be desired when it comes to reading, writing and discussion. Now, by and large I do not find that the technicians and engineers I have worked with are inarticulate, or dislike reading. Of course, on ETI, most of our writers are highly self-expressive, but even outside the "tech writing" world, engineers may not spend their leisure hours writing poetry, but they usually have plenty to say and know how they want to say it.

What we do find, however, is that the finer arts of persuasion and diplomacy tend to be out-competed by the admirable tendency to call a spade a spade, and the appreciation of what the outside world finds fascinating about a product or project can become buried under the admirable art of numbered report-writing and the finer points of circuitry.

Well, the last thing we want to see is any endeavour to strangle the technical person's ability to be technical - this is after all what makes them valuable. But we also note the respondents' appeal for much more management training - significant in a technical field.

The schism between "the technical boys" and "management" has become almost axiomatic - how sales people promise new developments and fast delivery dates without consulting the engineers ... deadlines are rushed, customers (and therefore managers) are disappointed... projects linger for months and then have to be completed in a rush ... or work is suddenly shelved half way through because the management has changed its mind, leaving the technical departments dispirited and discontented.

Managers say that engineers don't understand how important it is to reach market before the competition. Engineers say that managers don't understand how difficult it is to develop a new process, or to test it sufficiently.

So it does seem that there is a crying need for engineers who understand management concerns, and management that thoroughly understands engineering. But is it the job of schools and colleges to bridge this gap? I'll come back to this next month.

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

This month I have to pass on a passionate cry from one of our colleagues: "PROBLEMS THAT ELECTRONICS HASN'T FIXED YET - why does my modem think it is sending stuff when it isn't?"

This is not the only modem that is sometimes economical with the truth about where the data has gone. Perhaps it needs a visit from a service engineer. Perhaps it needs to be monitored to find out where the connection breaks off. Perhaps the modem software isn't accurate enough in its send/receive reports. Or is it just possible that he needs to exploit the galloping pace of technical innovation and "fix it with a new one".

Next Month

In Volume 26, no. 2 of *Electronics Today International*, arriving at your newsagent in early February, Douglas Clarkeson Returns to Mars ... look out for Experimenting with Video (Part 2) ... Dr. Pei An has a Centronics Mini Data-Lab ready to operate ... Terry Balbirnie has been checking batteries quickly and neatly, and Robert Penfold has been seen checking out an RS232C port. Mike Rhodes has found a new way of not only counting his strides, but calculating exactly how far he has walked. And more ...

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