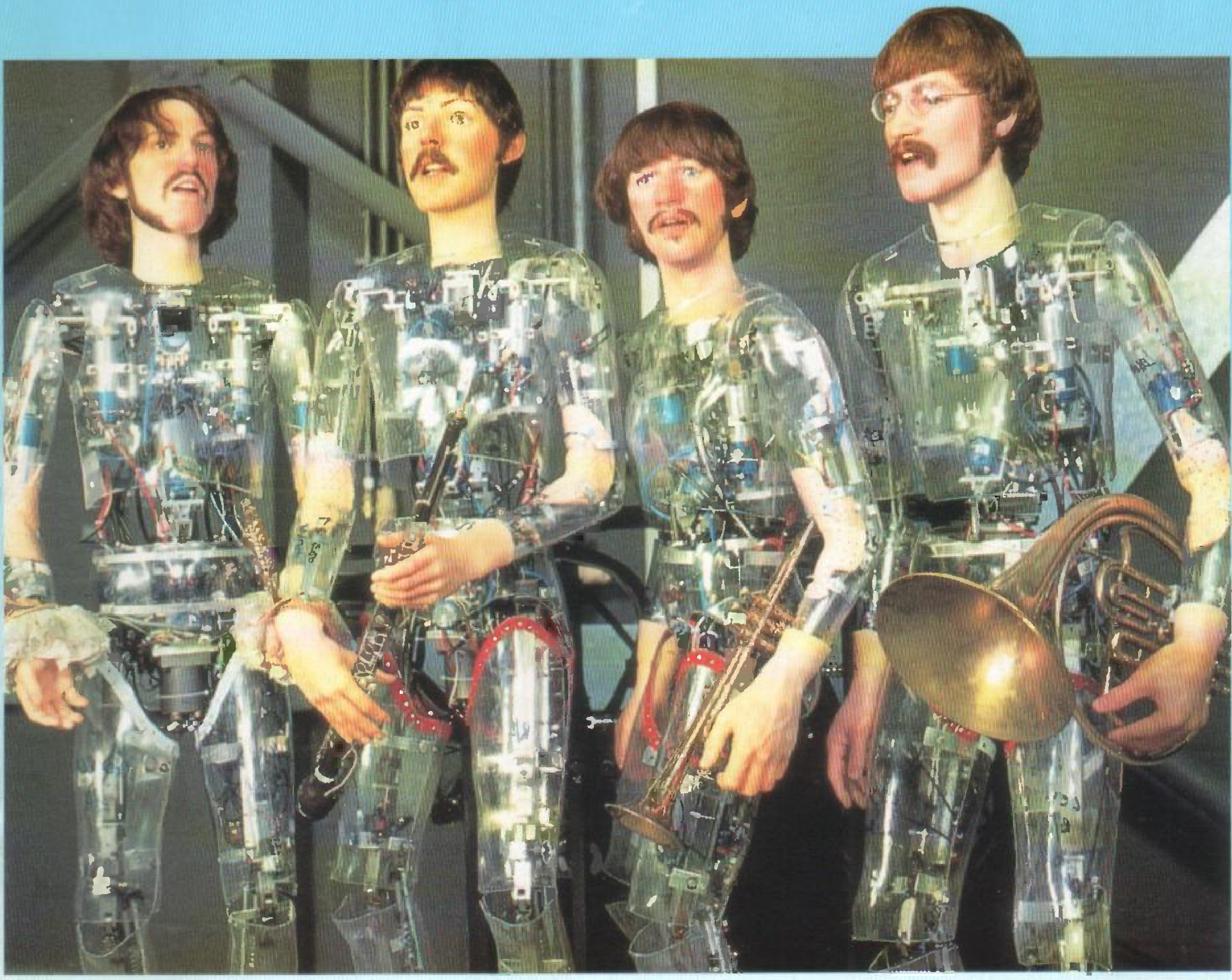
ETI

ELECTRONICS TODAY INTERNATIONAL

TOMORROW'S TECHNOLOGY TODAY

6 PROJECTS FOR YOU TO BUILD

THE ART OF ANIMATRONICS
THE SCIENCE OF ROBOTICS



May 1994 £1.95

BUILD THE PALESAVER SPEAKER ATTENUATOR

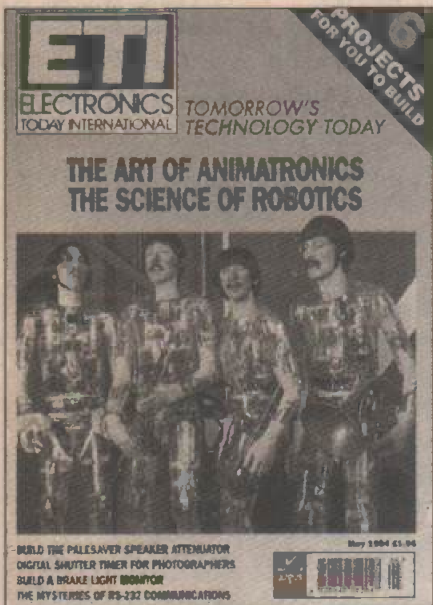
DIGITAL SHUTTER TIMER FOR PHOTOGRAPHERS

BUILD A BRAKE LIGHT MONITOR

THE MYSTERIES OF RS-232 COMMUNICATIONS

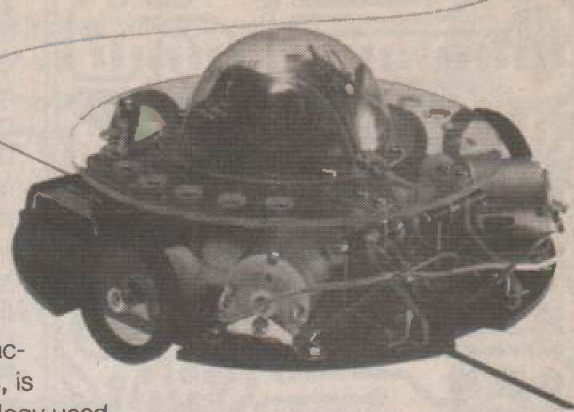
9 770142 722047 05

Contents



Volume 23 No.5
May 1994

Features & Projects



Animatronics Today - Robotics Tomorrow? 14

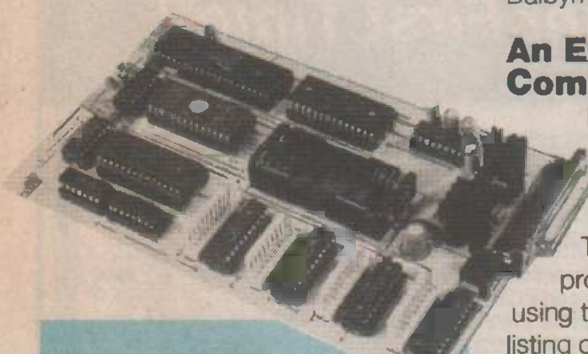
A look at how the technology used to create sophisticated moving characters, for use in theme parks, is converging with the technology used in building the next generations of free moving robots

Brake Light Monitor 18

Are your brake lights working properly? This project from Terry Balbyrnie makes testing them easy

An Experimenter's Computer 22

Part 2 of Jim Spence's project to build a Z-80 based computer, especially designed for experimenters. This month we look at programming the computer using the Forth language and a full listing of the more common Forth commands and their use



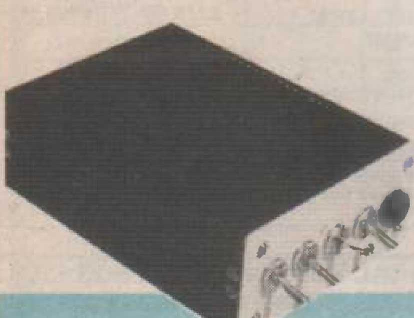
Project
An Experimenter's Computer
42

Digital Shutter Timer 34

A useful little circuit, from Robert Penfold, to enable photographers to generate accurate timed exposures

Palesaver Load/Attenuator 42

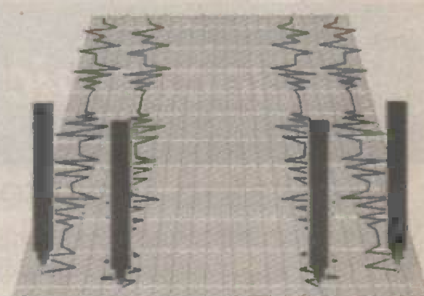
This useful little unit, designed by Dave Bradshaw, acts as a flexible loudspeaker attenuator and as an accurate 8 ohm load



Project
Palesaver Load/Attenuator
42

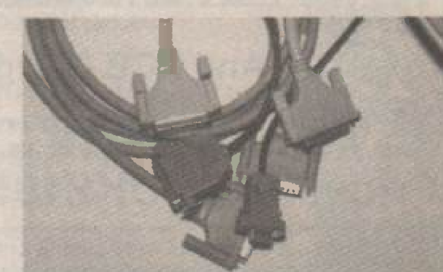
Turning a PC into a Chart Recorder 46

In Part 2 of Keith Garwell's project to turn a PC into a virtual chart, recorder we look at the control software



Computer Communications and RS232 52

A detailed look at parallel and serial data communications between a microprocessor and a peripheral, with particular emphasis on serial RS232C communications. Also, a special section on how to make your own computer cables

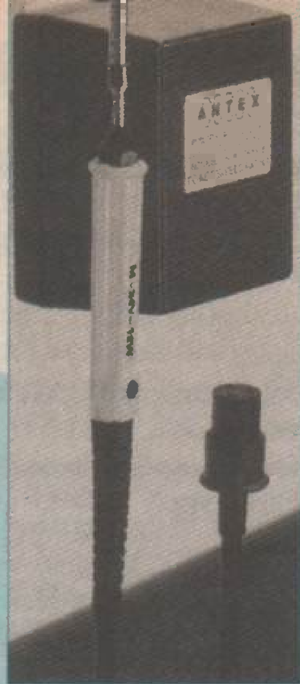


Regulars

News	6
PCB Foils	63
Open Forum	66

ETI NEWS

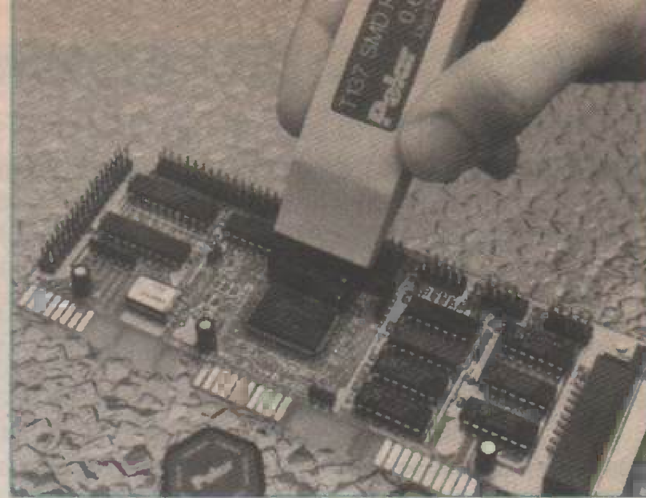
New 24V plug in power supply for soldering irons



Many soldering iron users require 24V power supply for operator safety. Now, any 24V soldering iron (up to 25W) can be used with the new Antex low cost plug in power supply. It is a 24V power supply which simply plugs into a standard mains socket, saving valuable bench space and avoiding trailing leads to a transformer.

Even if your work bench has a 24V power supply already installed, this new single plug-in unit allows much greater user flexibility.

For further information contact Antex, of Tavistock, on 0822 613565.



Simplifying service testing

A major advance in fault diagnostics technology for service testing has been launched by Polar Instruments. The company's new T4000 family of analogue signature analysers (ASAs) utilise PC technology to automate V/I trace signature capture, storage and comparison. These new instruments put automated ASAs within the reach of all, thanks to the incorporation of cost effective, software based, virtual instrument techniques which dispense with conventional front panel electronics.

Using a friendly PC interface, signature files can be learnt and stored quickly for auto comparison at any future point. This eliminates the need for expert knowledge of the circuit under test and speeds component level diagnostics, allowing companies to implement far more cost effective maintenance and repair strategies.

ASA is based on impedance signatures, which are the response of circuit nodes to current limited AC stimuli. They provide an accurate guide to in-circuit behaviour, suitable for establishing the functionality of passive and active devices, including digital, analogue and mixed signal ICs, in rework/repair applications. IC complexity is immaterial - the technique is as relevant to complex ASICS and VLSIs as it is to analogue voltage regulators. Moreover, because ASA does not require boards to be powered up, it is intrinsically safe and easy to use.

For more information contact Polar Instruments Ltd, of Guernsey, on 0481 53081.

Low cost micro-controller design kit

NEC Electronics has reduced the cost of designing embedded systems twentyfold with the introduction of a starter kit for just £300. The low cost starter kit contains everything an engineer needs to design systems based on NEC's popular 78K0 range of 8-bit microcontrollers, at a fraction of the price of the full design kit.

It is intended for use by small engineering firms, design consultancies in development projects and by larger firms that wish to evaluate the devices. It includes an assembler and debugger (for use on an IBM compatible PC), an evaluation board with 32k of RAM, a programmer for UV and one time programmable (OTP) devices, a UV erasable 78K0 microcontroller and all the necessary cables and power supplies.

The designer can therefore write code and perform three levels of prototyping. Firstly, the code can be downloaded into the RAM on a stand-alone evaluation board. The evaluation board can also be connected to the target hardware, enabling users to debug code in a fully functional prototyping system. The full screen debugger allows real time execution, single step operation, multiple break points and watching and modifying memory.

When testing is complete, the UV erasable device can be programmed and plugged directly into the prototype system, for example for field testing. Any bugs detected at this stage can be modified and the new code blown into the erased UV device. The programmer board can also be used to program OTP devices, which can then be used for short production runs, perhaps to produce prototypes for key customers.

The only equipment the user of this development system requires is a PC and a UV eraser.

For further information contact NEC Electronics UK Ltd at Cygnus House, Linford Wood Business Centre, Sunrise Parkway, Linford Wood, Milton Keynes MK14 6NP.

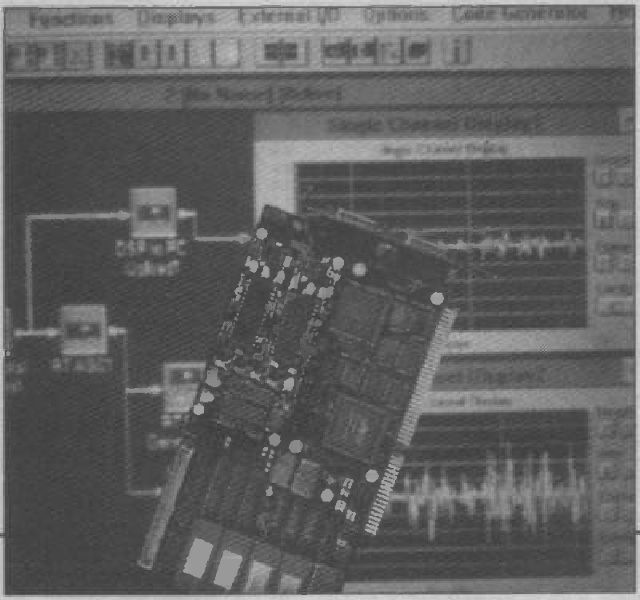
Home theatre speakers

The new Cerwin-Vega **HTE-10** SenSurround! (tm) Home Theatre System brings the impact of 'Cinema Sound' into the home. Although relatively compact, the system is said to have tremendous dynamic punch and awesome bass. The speakers use the technology that added heightened reality to such blockbuster movies as Earthquake and Midway. The HTE-10 system consists of four identical compact surround speakers, one 'point source' centre channel and a dual voice-coil 10in sub-woofer. With the sub-woofer behind the sofa and the other speakers tucked away, the system can be very unobtrusive.

To generate the cinema type sound, the speaker system needs to deliver high volume (when required), deep bass, strong dynamics and an enveloping sound-field. The HTE-10 does all this and the design allows owners of modestly powered mid-price AV receivers and amplifiers to get the dynamic sound that is normally the sole province of powerful expensive amplification.

The **HTE-10** is designed to be part of a Dolby Pro-Logic set up. Each speaker has a high sensitivity of 91dB (sub-woofer 93dB) at 8 ohms. The four satellites and the centre channel are voiced to produce consistent vocal clarity, are overload protected and are fully magnetically shielded. The elliptical source point driver in the centre channel offers coherency in the critical mid-band. All the tweeters are Ferro-fluid cooled dome designs and the sub-woofer uses a dual voice-coil driver with a cast alloy frame, tuned to 40Hz for a deep powerful bass. All the speakers use quality 4mm cable connectors.

The HTE-10 system has a recommended retail price of £499. For further details contact Cerwyn Vega on 0423 359054.

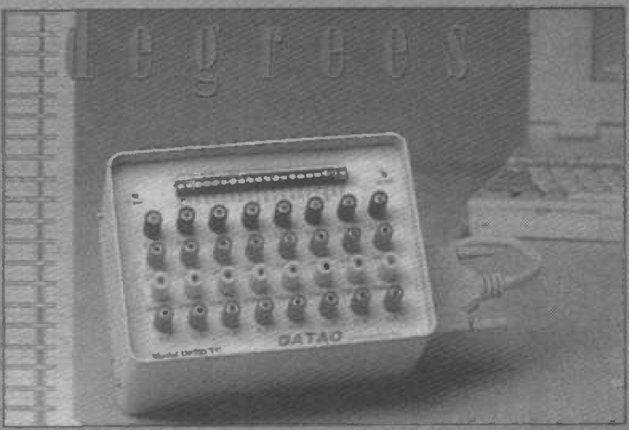


World's first 40MHz TMS320C31 PC board

Loughborough Sound Images has launched the world's first PC board based on the Texas Instruments' TMS320C31 digital signal processor, running at 40MHz. This plug in PC board combines 40MFLOPS of 32-bit real time processing power with high level development support and flexible I/O options. These features mean that, in addition to its role as a development system, it will be used in OEM applications as a target system.

Designers working in applications areas such as telecomms., embedded control, noise and vibration, digital audio and aerospace could benefit from the board's real time performance. It can interface with a wide variety of external signals, via LSI's existing daughter modules, including A/D and D/A conversion, at a range of speeds and resolutions, as well as an industry standard AES/EBU interface for digital audio applications.

For further details contact Loughborough Sound Images on 0509 231843.



Portable data acquisition

Keithley Instruments has introduced a 12-bit, 16-channel portable data acquisition system that is particularly well suited for thermocouple based temperature measurement, as well as any other type of analogue signal input.

The new DI-221TC allows users to connect up to 16 grounded thermocouples or other analogue inputs, in any desired combination, via a built in signal I/O panel. A sensor, attached to the signal termination receptacles on the DI-221TC's printed circuit board, provides cold junction compensation.

This unit linearises thermocouple signals in real time, with DSP based 10th order polynomial calculation software. Thermocouple voltage signals are automatically converted to temperature measurements in the user's choice of ranges - +/-1200C or +/-120C. This polynomial calculation software also allows users to linearise signals from other types of non-linear transducers.

The DI-221TC can be plugged into the parallel (printer) port of any PC compatible computer, be it a portable or a desktop machine. An internal battery means that it does not draw any power from the computer, an important consideration when using a portable PC.

For further information, contact Keithley Instruments Ltd, of Reading, on 0734 575666.

VIEWDATA RETURNS £6 made by Tandata, Includes 1200.75 modem, k/bd, RGB and comp o/p, printer port. No PSU £6 MAG6P7

IBM PC CASE AND PSU Ideal base for building your own PC. Ex equipment but OK. £14.00 each REF: MAG14P2

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit just £5.99 REF: MAG6P8

SOLID STATE RELAYS Will switch 25A mains. Input 3.5-26v DC 57x43x21mm with terminal screws £3.99 REF MAG4P10

300DPI A4 DTP MONITOR Brand new, TTL/ECL inputs, 15" landscape, 1200x1664 pixel complete with circuit diag to help you interface with your projects. JUST £24.99. REF MAG25P1

ULTRAMINI BUG MIC 6mmx3.5mm made by AKG, .5-12v electret condenser. Cost £12 ea. Our? four for £9.99 REF MAG10P2

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. £99 each REF MAG99P1

GX4000 GAMES MACHINES returns so ok for spares or repair £9 each (no games). REF MAG9P1

C64 COMPUTERS Returns, so ok for spares etc £9 ref MAG9P2

FUSELAGE LIGHTS 3 foot by 4" panel 1/8" thick with 3 panels that glow green when a voltage is applied. Good for night lights, front panels, signs, disco etc. 50-100v per strip. £25 ref MAG25P2

ANSWER PHONES Returns with 2 faults, we give you the bits for 1 fault, you have to find the other yourself. BT Response 200's £18 ea REF MAG18P1, BT Response 400's £25 ea REF MAG25P3 Suitable power supply £5 REF MAG5P12

SWITCHED MODE PSU ex equip, 60w +5v @5A, -5v@.5A, +12v@2A, -12v@.5A 120/220v cased 245x88x55mm IEC input socket £6.99 REF MAG7P1

PLUG IN PSU 9V 200mA DC £2.99 each REF MAG3P9

PLUG IN ACORN PSU 19v AC 14w, £2.99 REF MAG3P10

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

ACORN ARCHIMEDES PSU +5v @ 4.4A on/off sw uncased, selectable mains input, 145x100x45mm £7 REF MAG7P2

GEIGER COUNTER KIT Low cost professional twin tube, complete with PCB and components. £29 REF MAG29P1

SINCLAIR C5 13" wheels complete with tube, tyre and cycle style bearing £6 ea REF MAG6P10

AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex equip, 55x32x32mm. £3 a pack. REF MAG3P11

13.8V 1.9A psu cased with leads. Just £9.99 REF MAG10P3

360K 5.25 brand new half height floppy drives IBM compatible industry standard. Just £6.99 REF MAG7P3

PPC MODEM CARDS These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud dial up unit complete with leads. Clearance price is £5 REF: MAG5P1

INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 REF: MAG2

TOWERS INTERNATIONAL TRANSISTOR GUIDE. A very useful book for finding equivalent transistors, leadouts, specs etc. £20 REF: MAG20P1

SINCLAIR C5 MOTORS We have a few left without gearboxes. These are 12v DC 3,300 rpm 6"x4", 1/4" OP shaft. £25 REF: MAG25

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the above motor but suitable for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 REF: MAG15P1

LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair REF: MAG 8P1 2 x PP3 req'd.

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2 kilometres in open country. Units measure 22x52x155mm. Complete with cases and earpieces. 2xPP3 req'd. £30.00 pair REF: MAG30.

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc etc in fact everything bar the case and electronics, a good stripper! £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

SPEAKERWIRE Brown 2 core 100 foot hank £2 REF: MAG2P1

LED PACK of 100 standard red 5m leds £5 REF MAG5P4

JUG KETTLE ELEMENT good general purpose heating element (about 2kw) Ideal for heating projects. 2 for £3 REF: MAG3

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF: MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

***FM TRANSMITTER** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £26 REF: MAG26 Transmits to any FM radio.

***FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5 REF: MAG5P5

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert and ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 REF: MAG3P1

100 WATT MOSFET PAIR Same spec as 2SK343 and 2SJ413 (8A, 140v, 100w) 1 N channel, 1 P channel, £3 a pair REF: MAG3P2

VELCRO 1 metre length of each side 20mm wide (quick way of fixing for temporary jobs etc) £2 REF: MAG2P3

MAGNETIC AGITATORS Consisting of a cased mains motor with lead. The motor has two magnets fixed to a rotor that spin round inside. There are also 2 plastic covered magnets supplied. Made for remotely stirring liquids! you may have a use? £3 each REF: MAG3P3

BULL'S BULLETIN BOARD

100MHZ DUAL TRACE OSCILLOSCOPES JUST £259 RING FOR DETAILS

MASSIVE

WAREHOUSE CLEARANCE

FANTASTIC **£20.00** REDUCTION

REFURBISHED PC BASE UNITS COMPLETE WITH KEYBOARD

FROM ONLY **£29.00**

AMSTRAD 1512 BASE UNITS

GUARANTEED

PERFECT WORKING ORDER.

A LOW COST INTRODUCTION TO THE HOME COMPUTER MARKET.

AMSTRAD 1512SD

1512 BASE UNIT, 5.25" FLOPPY DRIVE AND KEYBOARD. ALL YOU NEED IS A MONITOR AND POWER SUPPLY. WAS £49.00

NOW ONLY £29.00

REF: MAG29

AMSTRAD 1512DD

1512 BASE UNIT AND KEYBOARD AND TWO 5.25" 360K DRIVES. ALL YOU NEED IS A MONITOR AND POWER SUPPLY WAS £69.00

NOW ONLY £39.00

REF: MAG39

SOLAR POWER PANELS

3FT X 1FT 10WATT GLASS PANELS

14.5v/700mA

NOW AVAILABLE BY MAIL ORDER

£33.95

(PLUS £2.00 SPECIAL PACKAGING CHARGE)

TOP QUALITY AMORPHOUS SILICON CELLS HAVE ALMOST A TIMELESS LIFESPAN WITH AN INFINITE NUMBER OF POSSIBLE APPLICATIONS, SOME OF WHICH MAY BE CAR BATTERY CHARGING, FOR USE ON BOATS OR CARAVANS, OR ANYWHERE A PORTABLE 12V SUPPLY IS REQUIRED. REF: MAG34

FREE SOFTWARE!

Brand new, UNUSED top quality *Famous brand* licensed software discs. Available in 5.25" DSDD or 5.25" HD only. You buy the disk and it comes with free BRAND NEW UNUSED SOFTWARE. We are actually selling you the floppy disc for your own "MEGA CHEAP" storage facilities, If you happen to get software that you want/need/like as well........ you get a "MEGA BARGAIN" too!

DSDD PKT10 £2.99 REF: MAG3P7 PKT100 £16.00 REF: MAG16

££££££WE BUY SURPLUS STOCK££££££

TURN YOUR SURPLUS STOCK INTO CASH.
IMMEDIATE SETTLEMENT. WE WILL ALSO QUOTE FOR COMPLETE FACTORY CLEARANCE.

1994 CATALOGUE.

PLEASE SEND 45P, A4 SIZED SAE FOR YOUR FREE COPY.

MINIMUM GOODS ORDER £5.00. TRADE ORDERS FROM GOVERNMENT, SCHOOLS, UNIVERSITIES, & LOCAL AUTHORITIES WELCOME. ALL GOODS SUPPLIED SUBJECT TO OUR CONDITIONS OF SALE AND UNLESS OTHERWISE STATED GUARANTEED FOR 30 DAYS. RIGHTS RESERVED TO CHANGE PRICES & SPECIFICATIONS WITHOUT PRIOR NOTICE. ORDERS SUBJECT TO STOCK. QUOTATIONS WILLINGLY GIVEN FOR QUANTITIES HIGHER THAN THOSE STATED.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX BN3 5QT

MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.

PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY

TELEPHONE ORDERS WELCOME

TEL: 0273 203500

FAX: 0273 323077

TOP QUALITY SPEAKERS Made for HI FI televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality general purpose speaker. £2 each REF: MAG2P4 or 4 for £6 REF: MAG6P2

TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 REF: MAG2P5 or 4 for £3 REF: MAG3P4

AT KEYBOARDS Made by Apricot these quality keyboards need just a small modification to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 REF: MAG6P3

XT KEYBOARDS Mixed types, some returns, some good, some foreign etc but all good for spares! Price is £2 each REF: MAG2P6 or 4 for £6 REF: MAG6P4

PC CASES Again mixed types so you take a chance next one off the pile £12 REF: MAG12 or two the same for £20 REF: MAG20P4

COMMODORE MICRODRIVE SYSTEM mini storage device for C64's 4 times faster than disc drives, 10 times faster than tapes. Complete unit just £12 REF: MAG12P1

SCHOOL STRIPPERS We have quite a few of the above units which are 'returns' as they are quite comprehensive units they could be used for other projects etc. Let us know how many you need at just 50p a unit (minimum 10).

HEADPHONES 15P These are ex Virgin Atlantic. You can have 8 pairs for £2 REF: MAG2P8

PROXIMITY SENSORS These are small PCB's with what look like a source and sensor LED on one end and lots of components on the rest of the PCB. Complete with fly leads. Pack of 5 £3 REF: MAG: 3P5 or 20 for £8 REF: MAG8P4

SNOOPERS EAR? Original made to clip over the earpiece of telephone to amplify the sound-it also works quite well on the cable running along the wall! Price is £5 REF: MAG5P7

DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 REF: MAG5P8 Worth it just for the very comprehensive manual! 5.25" only.

DOS PACK Microsoft version 5 Original software but no manuals hence only £3 REF: MAG3P6 5.25" only.

FOREIGN DOS 3.3-German, French, Italian etc £2 a pack with manual. 5.25" only. REF: MAG2P9

CTM644 COLOUR MONITOR Made to work with the CPC464 home computer. Standard RGB input so will work with other machines. Refurbished £59.00 REF: MAG59

PIR DETECTOR Made by famous UK alarm manufacturer these are hi spec, long range internal units. 12v operation. Slight marks on case and unboxed (although brand new) £8 REF: MAG8P5

WINDUP SOLAR POWERED RADIO AM/FM radio complete with hand charger and solar panel! £14 REF: MAG14P1

COMMODORE 64 TAPE DRIVES Customer returns at £4 REF: MAG4P9 Fully tested and working units are £12 REF: MAG12P5

COMPUTER TERMINALS complete with screen, keyboard and RS232 input/output. Ex equipment. Price is £27 REF: MAG27

MAINS CABLES These are 2 core standard black 2 metre mains cables fitted with a 13A plug on one end, cable the other. Ideal for projects, low cost manufacturing etc. Pack of 10 for £3 REF: MAG3P8 Pack of 100 £20 REF: MAG20P5

SURFACE MOUNT STRIPPER Originally made as some form of high frequency amplifier (main chip is a TSA5511T 1.3GHz synthasiser) but good stripper value, an excellent way to play with surface mount components £1.00 REF: MAG1P1.

MICROWAVE TIMER Electronic timer with relay output suitable to make enlarger timer etc £4 REF: MAG4P4

MOBILE CAR PHONE £5.99 Well almost! complete in car phone excluding the box of electronics normally hidden under seat. Can be made to illuminate with 12v also has built in light sensor so display only illuminates when dark. Totally convincing! REF: MAG6P6

ALARM BEACONS Zenon strobe made to mount on an external bell box but could be used for caravans etc. 12v operation. Just connect up and it flashes regularly) £5 REF: MAG5P11

FIRE ALARM CONTROL PANEL High quality metal cased alarm panel 350x165x80mm. With key. Comes with electronics but no information. sale price 7.99 REF: MAG8P6

SUPER SIZE HEATSINK Superb quality aluminium heatsink. 365 x 183 x 61mm, 15 fins enable high heat dissipation. No holes! sale price £5.99 REF: MAG6P11

REMOTE CONTROL PCB These are receiver boards for garage door opening systems. You may have another use? £4 ea REF: MAG4P5

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

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

LOPTX Line output transformers believed to be for hi res colour monitors but useful for getting high voltages from low ones! £2 each REF: MAG2P12 bumper pack of 10 for £12 REF: MAG12P3.

SHOP OPEN 9-5.30 SIX DAYS A WEEK

PORTABLE RADIATION DETECTOR

£49.99

A Hand held personal Gamma and X Ray detector. This unit contains two Geiger Tubes, has a 4 digit LCD display with a Piezo speaker, giving an audio visual indication. The unit detects high energy electromagnetic quanta with an energy from 30K eV to over 1.2M eV and a measuring range of 5-9999 UR/h or 10-99990 Nr/h. Supplied complete with handbook.

REF: MAG50

Wafer contamination

Particle formation resulting from chemical and physical processes inside CVD reactors is a primary source of contamination in semi-conductor manufacture. Researchers from NIST's Chemical Science and Technology Laboratory estimate that more than 80% of total contaminant particles come from chemical processing steps and the mechanical movement of equipment.

Moreover, as much as 75% of the yield loss in chips with sub-micron feature sizes can be attributed to particle contamination of the wafer.

The NIST team tackled the problem by running a numerical simulation of particle dynamics in a vertical rotating-disk CVD reactor. They focused on identifying the factors influencing particle contamination of the deposition substrate, concluding that spin rate, disk temperature and particle size influence how close an individual particle gets to the disk.

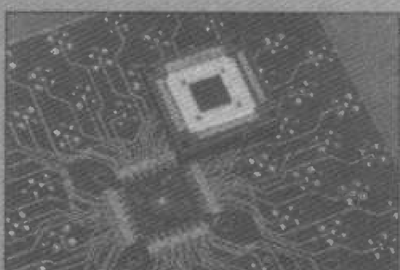
Inverting the reactor, so that gas and heat flowed up instead of down, eliminated contamination in both rotating and non-rotating disks.

According to the NIST researchers, contaminant particles approaching the spinning disk tend to be flung away from the wafer surface by a combination of centrifugal and thermal forces. The researchers' computer model charts the predicted trajectory of particles based upon the particles' size and the temperature and speed of the rotating CVD disk. In most cases, the disk spun at a rate of 1000 rpm.

The smooth axisymetric flows of heat and CVD gases across the surface of a rotating wafer lend themselves to numerical modelling. Nonetheless, the CVD reactor operating conditions had to be carefully selected to obtain the best flows. For example, the researchers found that a downward flow against a heated, non-rotating disk often results in the formation of what they call unstable buoyant recirculation zones, above the substrate. The deposition process is destroyed by the zones.

A rotating disk usually overcomes the problem by creating a suction, that pulls the gas towards the disk, spinning it out radially. The technique eliminates recirculation zones, resulting in uniform deposition layers.

Digital gallium arsenide ASICs take on silicon



Digital gallium arsenide technology is now making significant inroads into commercial markets, particularly when high speed and low power are required.

With GaAs device manufacturers now showing density levels as high as 350,000 gates, and device features as small as 0.4 micron, the speed and low power consumption of digital GaAs, as well as reduced prices, are attracting designers in such growing commercial markets as telecommunications, test equipment and high performance workstations.

According to vice president Jerry Worchel, of market research firm InStat Inc. of Scottsdale, Arizona, "recent times have seen the cost of GaAs gate arrays decline below that of high performance ECL (emitter coupled logic) bipolar gate arrays, and GaAs arrays are approaching parity with BiCMOS gate arrays, across a wide spectrum of product families."

Now that applications such as digital telecommunications and data communications have moved to higher frequencies - where the cost performance of GaAs is competitive, or even superior to silicon - digital GaAs is moving into the mainstream. In fact, it has already put a crimp into the growth of ECL and is taking on BiCMOS in applications at 100MHz and higher.

The two most common logic schemes used in digital GaAs are direct coupled FET logic (DCFL) and source coupled FET logic. CDFL is close to silicon NMOS in topology and uses NOR structures instead of the usual NAND gate structures of CMOS. SFCL resembles ECL, in that it is a current switched logic. It therefore tends to dissipate more power than DCFL but is still lower than CMOS in applications that involve a lot of switching.

The transistor structure in both technologies is a metal semiconductor FET (MESFET), in which the metal gate resides directly on the substrate. Rockwell International Corp. of Newbury Park, California, uses a bipolar structure called the heterojunction bipolar transistor, which permits considerably faster operation than either of the FET types of logic.

Diary...

April 2nd, 9th, 16th, 23rd, and 30th -
The Computer Fair Central Club, 16/22 Great Russell Street, London. Telephone 0985 844360.

April 2nd -
Northern Computer Markets Manchester. Telephone 061 681 0569.

April 2nd -
Country Wide Computer Fairs Slough. Telephone 0225 868100.

April 3rd -
UK Computer Fairs Peterborough. Telephone 0533 402206.

April 4th -
Centre of England Computer, Satellite and Ham Radio Show Coventry. Telephone 0952 598173.

April 9th -
All Formats Computer Fair Brentwood Centre, Essex. Telephone 081 856 8478.

April 9th -
Traderdesk Auctions Motorcycle Museum, Birmingham. Telephone 021 445 1794.

April 9th -
Northern Computer Markets Bradford. Telephone 061 681 0569.

April 10th -
All formats Computer Fair University Union, Park Place, Cardiff. Telephone 081 856 8478.

April 10th-12th -
ECTS Business Design Centre, Islington, London. Telephone 081 742 2828.

April 10th -
Northern Computer Markets Birmingham. Telephone 061 681 0569.

April 10th -
UK Computer Fairs Ryton on Dunsmore. Telephone 0533 402206.

April 10th -
Northern Computer Markets Manchester. Telephone 061 6810569.

FM Radio Smaller than a 50p Piece

A tiny FM radio, built using state of the art miniaturisation, is now available from Maplin Electronics. The auto tuning, FM radio receiver produces a quality of reception that is normally only expected from radios many times its size.

The little radio is provided with an on/off switch, 'seek' button and a 'reset' button, plus a pair of earphones attached to 800mm of cord, that also doubles as an aerial. To operate, the 'reset' button is pressed once for each station that is automatically tuned in to, until the desired station is found. However, if the user has a favourite station, then tuning is not required every time the radio is switched on, as the last station selected is always remembered when the power is switched off.

Ideal for commuters, cyclists, walkers, etc., this little radio costs just £9.95 and is available from any Maplin store or direct by phoning 0702 554161.

New High Sensitivity Electronic Voltmeter

The Kenwood VT176 is a two channel electronic analogue voltmeter with a large display, providing AC RMS measurements from 0.3mV to 100V (full scale) over 12 ranges (-90db to +45db).

The AC impedance is 10m ohm 45pf and the frequency response is 5Hz to 1MHz. An AC amplifier provides a gain of 70db. Linked and independent input are switch selected.

The VT176 is priced at £399 and complements Kenwood's existing range of meters. For more information contact Trio-Kenwood UK Ltd, of Watford, on 0923 816444.

April 11th -
Cable and Satellite 94
London. Telephone
021 705 6707.

April 16th -
All Formats Computer Fair
Haydock Park
Racecourse.
Telephone 081 856 8478.

April 16th -
Spring all Micro Show
Bingley Hall,
Stafford.
Telephone
0473 272002.

April 16th -
Traderdesk Auctions
Reading. Telephone
021 445 1794.

April 17th -
All Formats
Computer Fair
Ulster hall,
Bedford Street,
Belfast. Telephone
081 856 8478.

April 17th -
Countrywide Computer Fairs
Brighton.
Telephone
0225 868100.

April 22nd -
Midi and Electronic Music
Wembley, London.
Telephone 0222 512128.

April 23rd -
All Formats Computer Fair
Northumbria Centre,
Washington.
Telephone 081 856 8478.

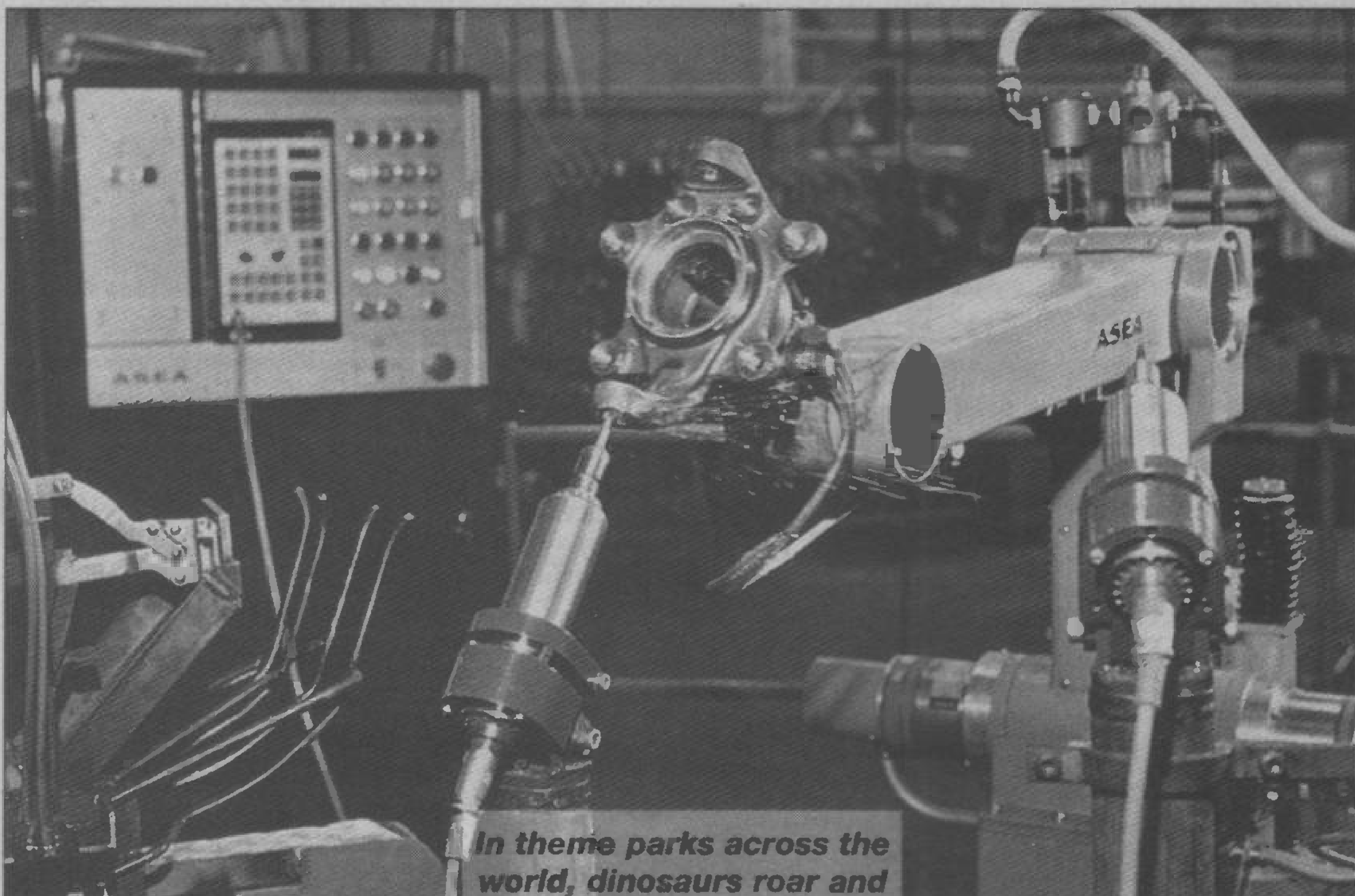
April 23rd -
MCD Auctions
Surrey.
Telephone
0932 571911

April 24th -
All Formats Computer Fair
National Motorcycle
Museum, Birmingham.
Telephone 081 856 8478.

June 26th - 27th
Longleat Amateur Radio Rally
- Bristol Group RSGB
Longleat Park, Warminster,
Wiltshire. Telephone
0272 860442.

If you are organising an event of any description which would be of interest to ETI readers and would like to have it included in this diary section then please send details to: ***Event Diary, ETI, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST.***

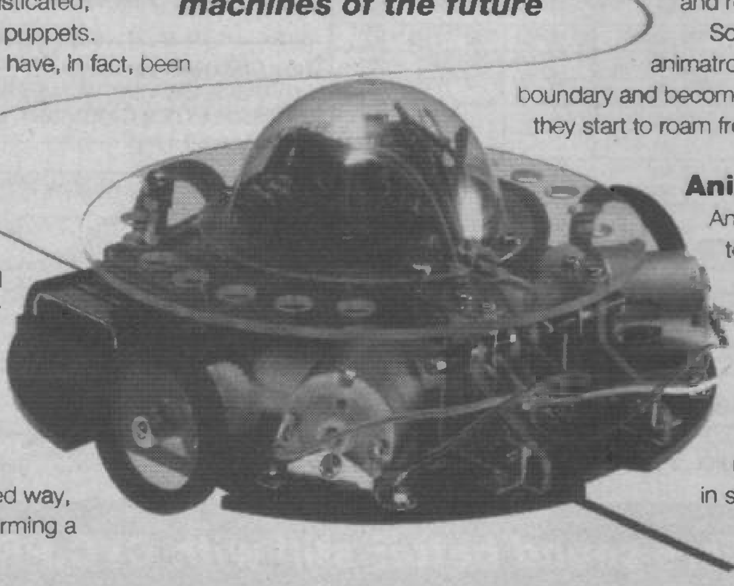
Animatronics today, robotics tomorrow?



In theme parks across the world, dinosaurs roar and gnash their teeth, familiar looking pop musicians play familiar sounding songs. Are they real? They may look it, but they are robots, the first generation of the machines of the future

In many ways it is perhaps incorrect to describe these moving creatures as robots. They perform a fixed repetitive routine and have few, if any, in-built sensors which allow them to interact with the outside world. In many ways it is easier to think of them as sophisticated, stringless, computer controlled puppets.

The makers of such systems have, in fact, been very careful to avoid using the word 'robot' when describing these 'creatures'. Instead, they have coined the word 'animatronics' to describe the technology, a word you will probably not find in your dictionary, it is too new, but it is a word which rather descriptively owes its origin to a fusion of 'animation' and 'electronics'.



Obviously a 'creature' which can move in a carefully controlled way, even though tethered and performing a repetitive sequence of movements under computer control, is only a step away from being a robot. All it needs is the added ability to react to the world around it, to have sensory input and to use that input to modify and control its movements and reactions.

So when and how will the animatronic dinosaurs step over the boundary and become robotic dinosaurs? When will they start to roam free in a robotic Jurassic Park?

Animatronics Today

Animatronics is a big business today in most of the technologically advanced nations, with dozens of companies producing and using animatronic products, ranging from sophisticated talking 'people' to the simple moving characters often used in shop window displays.

True animatronics, as

opposed to simple mechanical automatons, can be defined as mechanical moving characters which work under computer control. The earliest such systems first appeared about fifteen years ago and were primarily the result of work by Disney and the University of Utah. These animatronic characters were used in Disney World and were an immediate hit with the public.

The characters used pneumatic actuators operating under computer control. Pneumatics were used primarily because they were easy to implement using off the shelf components. They are quiet and, unlike electrical actuators, free from jerky movements. They are also safe, a factor which turned users against hydraulic systems. There is a story that the entire board of directors of one major animatronics company went to look at the first such product created by their R&D people. It was a hydraulic system and half way through the demonstration a hydraulic hose came loose and drenched the directors in warm oil. From that day forth pneumatics were used.

The success of animatronics at Disney World has led to their being developed and used in a wide range of different theme park, entertainment and even museum environments around the world. One of the world's leaders in animatronics, and apart from Disney probably the largest operator of such systems in Europe, is Madam Tussauds.

This company's most sophisticated animatronics set up is Rock Circus in the London Pavilion on London's Picadilly Circus. Here, on the largest revolving stage in Europe, visitors can see 'live' performances by animatronic versions of some of the world's bets known rock and pop legends.

The animatronic figures used at Rock Circus move naturally and have fully animated faces. Unless you look at them very closely and critically, you could be mistaken for almost thinking that they were real. The naturalism comes from a combination of technological sophistication in their design and construction and in Tussauds traditional skills in creating lifelike copies of famous people.

Inside an Animatronic Figure

The animatronic characters at Tussauds are all made and designed by the company at their workshops in north London. The work with the aid of electronically controlled pneumatic actuators, with each character having dozens of different actuators, rotary ones, linear ones, big ones and small ones. A blinking eyelid has its own actuator, the moving eyeball another, others control movement of the mouth, the hands, neck, arms, etc.

Each animatronic character is thus a very sophisticated pneumatic and mechanical structure and, at about £150,000, is also very expensive. They are designed to be robust and as maintenance free as possible. The shows go on seven days a week and operate continuously for over twelve hours per day so, for example, the eyelid actuator on a character will operate about 18,000 times a day and some of the characters have been operating continuously for over 87,000 shows - that is a lot of eye blinks.

For reliability, the systems are very well engineered, they have robust steel 'skeletons' and use high grade miniature pneumatic actuators, with steel rods providing the mechanical linkage. The actuators are controlled by high precision and, most importantly in this type of application, very quiet electronic valves and pressure controllers (the system works on air pressure of 130psi from a large central compressor).

Very few positional sensors are used, it is mainly switches and the odd potentiometer based rotational position sensor. In most cases, current generation of animatronics uses simple open loop control systems, with limit switches to stop any malfunction tearing the system apart by having actuators

Robots and the Amateur

Building and developing your own robots is not only practical, but a great challenge and an enormous amount of fun. Robotics brings together a wide range of different engineering and technological skills, mechanics, electronics, computer programming and, if you are feeling really ambitious, pneumatics and hydraulics. This means that robots are ideal as educational and club projects, where people with different skills and ideas can be brought together.

Robotics is also one of the few areas of technology where an amateur can produce original work, do something that no one has managed to do before. Be at the cutting edge of new technology. It is an area where ingenuity and imagination can count for as much as knowledge, and where high budgets are not necessary. Indeed many university research projects on robotics are very poorly funded and have relied on surplus and scrap materials to build their systems.

There is also the aspect that many potential applications for robotic systems are being commercially ignored because the perceived market is too small, in comparison to manufacturing and development costs. This need not deter the amateur robot builder. For example, how about a robot lawn mower, or a robot cleaner trained to pick up pieces of litter? Both ideas would be possible using off the shelf technology and there are many more potential applications like those two!

In future issues of ETI we will be looking at different aspects of electronics which will be of use to robot builders, such as motor and actuator control, a more detailed look at subsumption architecture, microcontrollers and servo loop systems. Indeed, we will be going even further and promoting a series of amateur robot competitions, to discover the most ingenious systems and those best able to perform a specific task. Watch out for more details in future issues of ETI.

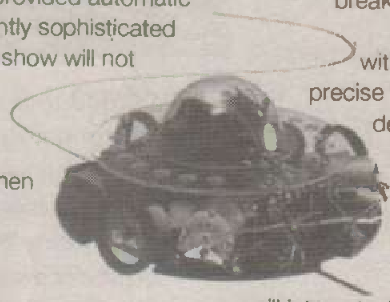
working against their limits or against each other. However, the next generation of animatronics, currently being introduced by Disney, makes extensive use of closed loop control systems to create some quite spectacular performances.

The systems all rely on a hierarchy of electronic control. At the lowest level, the movement of an individual joint is controlled by a local control circuit, which uses an EPROM programmed to generate the exact sequence of actuator movements necessary to move the limb smoothly and naturally from its current position to a new designated position. These local control circuits are the same for a wide range of different limbs and compound movements, the EPROM will be tailored exactly to produce the necessary movements required of the particular application.

The data stored in the EPROM of the local control circuit is generated when the system is first created and it allows complex movements to be executed, using just a simple command to move from one set of co-ordinates to another. This frees the higher levels of control hierarchy from any need to perform a lot of repetitive actions and the modularity inherent in this approach also makes the system easier to design and maintain.

At Rock Circus, the higher level control is performed by a special dedicated computer system from ElectroSonics, In fact, three such computer systems are used, each one having the control data sequences, as well as sound output, lighting and stage elevation controls, stored on massive optical disk systems.

At all stages in the system's integration, from individual limbs to the complete show, the designers have provided automatic safety features and cut-outs. This is sufficiently sophisticated that if a portion of the system fails, then the show will not stop but will simply compensate for that failure. With long opening hours, there is very little time to repair and maintain the system. You cannot shut down the show when there are five hundred enthusiastic French youngsters waiting outside!



Animatronics Tomorrow

Rock Circus contains some of the most sophisticated animatronics currently in use, the main constraints at the moment being size and freedom of movement. Even using the smallest available actuators, it is very difficult, if not impossible, to create an animatronic 'person' the size of a child, or a large dog. It is a question of trying to pack the mechanics, pneumatics and control electronics into a small space. The problems associated with size are one reason why dinosaurs have been a popular type of 'creature' with animatronic designers.

Freedom of movement is the other main constraint. Once again, size is an important consideration - with an animatronic 'creature' the size of an elephant or a tyrannosaurus rex, one could pack pneumatic/hydraulic pumps, power supply and computer inside and thus have something that was self contained and free moving. But with anything smaller, this could prove extremely difficult, if not impossible. Such self contained large animatronic systems suffer from the weight/power ratio vicious circle; the more weight the more power, but the more power the more weight.

There has, however, been one recent success in free moving self contained animatronics and that was the animatronic killer whale used in certain sequences in the film 'Free Willy'. At a cost of reputedly £1/2million, the makers of this film produced an exact copy of the real whale, which was able to swim and move in a natural looking manner without being visibly attached. Here the unit was large enough to be self contained and thanks to the buoyancy of sea water did not require the power and structural strength of a land based system.

The animatronic whale used in Free Willy was capable of looking and moving just like the real thing. However, the naturalness of the movements was really due to the skill of the operators, since it was in fact simply a large radio controlled puppet. The movements were all dictated by human operators, rather than by a control computer.

What About Robotics?

All the animatronic systems we have looked at so far have all been designed to either perform repeated sequences of movements or have been, in essence, sophisticated puppets. Thus, the animatronic Beatles will go through a performing sequence of movements lasting several minutes, then at the next show they will repeat the same performance. At no time will they be called upon to interact with their environment.

This is the difference between a robot and an animatronic system. The robot can interact with its environment. Even a simple Industrial arm robot will have sensors that allow it to modify its actions in relation to a change in its environment. Such a robot arm equipped with a gripper will have sensors in the gripper which allow it to pick and place an object as delicate and variable in size and weight as an egg, or a standard 10kg block of metal. The sensors will tell the robot's control system when the object has been gripped sufficiently tightly to allow it to be picked up without, in the case of an egg, breaking it.

Similarly, an industrial robot needs to be equipped with sensors which will ensure that it moves in a very precise manner - animatronic devices do not need a great deal of positional accuracy. This means that an animatronic system can function with a simple system which has no positional feedback, while every actuator on a robot will be equipped with a full servo loop positional feedback system.

It is this question of how to design systems that will interact with the world around them that is exercising the minds of researchers in robotics all around the world. If you stop and think about how many senses we are all using at any one time and how we feel lost if we are deprived of any single one of them, you can get an idea of the enormity of the problem.

We use complex interactions of our senses all the time. As I type this article I am using touch to feel the keys, sight to look at the screen and hearing to confirm that the key has been pressed. We can make a robot see, hear and in a rudimentary way feel, but we are still a long way from making systems which can smell and taste more than a few chemical compounds. We are even further away from making a robot which can fully utilise all such sensory input.

The Robotics Researchers

There are thus several key areas of research in robotics and the associated discipline of artificial intelligence, which are currently exercising some of the world's finest brains. These are the development of suitable sensors, the interpretation of the data coming from these sensors, especially the area of machine vision, the creation of a knowledge base of the world in which the robot lives with respect to this sensory input, a knowledge of and interpretation of natural language, so that it can communicate with its developers and the ability to reason and plan, so that it can perform tasks and overcome problems without human assistance.

The ultimate goal of all the researchers at work in these areas today is to build not just 'smart' computers, but electro/mechanical 'creatures', which could function independently in the world. In other words, a free roaming device which demonstrates some degree of intelligent behaviour.

This is, of course, the image that we all have in the back of our mind when we talk about robots, the image of the metal men of Hollywood movies and science fiction novels. Ten years ago, researchers in AI and robotics may have shared that image and sought to create human like intelligent systems. Today, in the face of the enormous problems involved, such researchers are more likely to be thinking more in terms of a mechanical ant than a mechanical man.

By and large, this is an approach which is generating a considerable degree of success and the lessons learnt will enable more complex systems to be built in the future. This is still a very controversial area, but much of the success has tended to indicate that a lot of the traditional approaches have been based upon the wrong premises and are not what is needed for building machines designed to live in the real world.

Many researchers are now arguing that complex behaviour is not derived from some knowledge representation system but from the interaction of simple behaviours. The traditional approach to the design of a robotic 'brain' has been an analytical one, where the engineer first decides what the robot will sense, then decides how it will analyse that input and finally decides what it will do in response to that input. A process that can be extremely complex even for a simple robot.

The new approach has been pioneered by Rodney Brooks of MIT and is a robot architecture called subsumption. Subsumption relies on a network of processors and hardware, each demonstrating simple behaviour patterns, such as moving a leg, to create a system showing much more complex behavioural patterns. Thus subsumption architecture relies on the behavioural pattern developing in response to the nature of the world in which the robot lives, rather than a sophisticated analysis of that world by the robot's designer.

Rodney Brooks argues that if a robot encounters an obstacle, the important thing is that it can find its way around that obstacle, not that it can analyse the object and its position. A knowledge of the world in which it lives is not really necessary, but an ability to survive in that world and react appropriately to it is. This way, it is possible to circumvent the thorny AI problem of constructing and maintaining a logical model of the outside world and making a correspondence between that model and reality.

To test the theory of subsumption, Brooks' team at MIT has created a range of artificial creatures, which have been designed to wander around and avoid obstacles. These creatures use legs for movement and have been dubbed 'insectoids'.

One of these insectoid robots, called Ghengis, clearly demonstrates how subsumption works. This foot long robot consists of six legs and sensors consisting of two whiskers and six infra-red 'eyes'. Each of the six legs has two electric motors, one, the Alpha motor, moving the leg backwards and forwards, the other, the Beta motor, lifting the leg up and down. Each leg has its own microcontroller which controls the movement of that leg and monitors the sensors associated with it, using a system of augmented finite state machines within the software.

The processor on each leg spends most of its time checking the leg's position and maintaining the correct attitude to keep the robot standing. All the leg processors work independently and the robot will walk or run in response to a signal from a high level processor. This processor will send a 'walk' command to each of the legs, but does not actually co-ordinate them.

Co-ordination is achieved by interaction between the various 'leg' processors and the system learning to walk in the most efficient manner. To do this, each leg experiments with a set of basic behaviours to see what the neighbouring legs were doing and whether, as a result, the body fell down or not. With this learning system Ghengis learnt how to walk with a proper alternating tripod like gait, in about one and a half minutes.

This shows how a properly designed subsumption system can acquire complex behaviour patterns, without any need to have those patterns pre-programmed into the system. A simple insectoid like Ghengis uses just two levels of processor hierarchy, but there is no reason why much more complex systems should not be built which use many more layers.

This is a concept which runs contrary to the popular 'folk psychology' concept of a centralised, all powerful, all- controlling, conscious mind. Instead, subsumption sees intelligence as a distributed hierarchical structure. Indeed, subsumption architecture systems have already been built which incorporate 'beliefs' and 'motivations'. However, a lot of researchers believe that, at higher levels, more traditional approaches will be found more appropriate.

It should always be remembered that AI and robotics are littered with intellectual minefields. The big success story of today might turn out to be a forgotten technique tomorrow, although it has to be admitted that we have come a long way since Shakey, the first mobile robot, wondered around a lab at Stanford University over twenty years ago.

Where Animatronics meets Robotics

In this article, I have briefly looked at some of the current technical developments in both animatronics and robotics. It is true that animatronics is only a high tech form of puppetry and, as such, is dismissed by many in robotics, but the development of animatronics performs several valuable functions. It acts as a test bed for the complex mechanical and actuator systems which will be needed by future generations of robots. It is a test bed with the emphasis on reliability and safety, two very important factors in future robot development. The other valuable function performed by animatronics is a public relations role. They remove the often irrational fear so often associated with the word 'robot'.

In the future, of course, animatronic systems will incorporate many of the advances being made in robotics. Work in the area of subsumption should be of particular interest to animatronic system developers and it is probably only a matter of time before free roaming animatronic/robotic systems are being produced. I am sure that at this very moment someone, somewhere, is thinking about the practicality of producing a robotic Jurassic Park.

PROJECT

BRAKE LIGHT MONITOR

Stay within the law with Terry Balbirnie's light checking circuit

The problem with filament lamps is that they eventually fail. Car bulbs are especially vulnerable due to the bumping and vibration which they experience during the normal course of driving. The ability of these bulbs to survive in such a hostile environment has improved over the years, but they still rank as one of the most unreliable components in the car's electrical system.

The law requires that all lights be kept in good working order and the annual UK MOT test will be failed if a lamp does not work properly. In theory, all lights should be checked before the start of a journey. However, there will be difficulty testing the brake lights, unless an assistant is available to press the pedal. Many readers will therefore find the Brake Light Monitor makes a worthwhile and inexpensive add-on unit. It detects filament failure when it happens and provides an audible signal in the form of a high-pitched bleep each time the brake pedal is pressed. If the driver carries a spare bulb, the problem can be corrected before any significant danger or inconvenience has been caused to other road users. Note that the warning does not indicate which of the brake lights has failed - only that one of them has done so. This is not thought to be a problem, as the faulty one will soon be located once the signal has been given.

The Brake Light Monitor is simple to construct. It does not involve breaking any wires to insert components and will not cause the lamps to go off if the unit itself fails for some reason. It imposes no drain on the battery while the car is left parked because it draws current only while the brake pedal is pressed. Any small plastic box of sufficient size may be used as an enclosure and this may be sited under the dashboard in an inconspicuous position. The specified internal buzzer will sound clearly above engine and other noises.

It is likely that the circuit could be used to monitor other car lamps, such as side and tail light bulbs, but this has not been tried and readers would possibly need to experiment to obtain reliable operation.

Before constructing this circuit, it would be wise to check that the unit will be easy to fit to the car. Access is needed to the foot brake switch wires and to the wiring at either stop light at the rear. On most cars, the foot brake switch is located above the brake pedal itself and easy to find. It will be necessary to run a wire from this position and from the brake light to the main unit. Check that it will be possible to route these wires unobtrusively.

Basic Theory

Operation of the Brake Light Monitor relies on the voltage developed across a resistor when it carries current. This is referred to as the voltage drop. Figure 1a shows a 12V battery, bulb and resistor connected in series. In this example, the resistance of the lamp filament is 11Ω and that of the resistor, 1Ω. A total resistance of 12Ω is therefore connected across the 12V supply. Ignoring the internal resistance of the battery and the small resistance of the connecting wires, the current can be predicted by Ohm's Law which states:

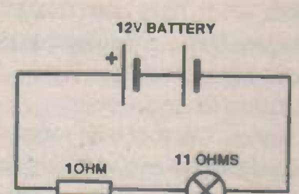


Fig. 1a Brake Light Monitor.

$$I = V/R$$

Where I is the current, V is the supply voltage and R is the resistance. The current (flowing through both the lamp and resistor) is therefore 1A. Ohm's Law can be applied again but this time to the lamp alone, using the re-arranged version of Ohm's Law:

$$V = I \times R$$

This calculates the voltage developed across the bulb to be 11V and there will be 1V appearing across the resistor. Assuming the bulb is designed to operate from a 12V supply, it would be dimmed somewhat. Now consider Figure 1b, which shows an automotive circuit in which a 12V lamp operates through a length of wire from the supply. The car chassis (metal bodywork) forms the return connection to the negative battery terminal. Here, the resistor in Figure 1a is replaced by the resistance of the connecting wire itself. Although small, this is significant - typically around 20 milliohms (0.02 ohms) per metre (3ft approximately) depending on its thickness. Over a run of 3m of wire (a typical length), a resistance of 60mW could therefore be expected.

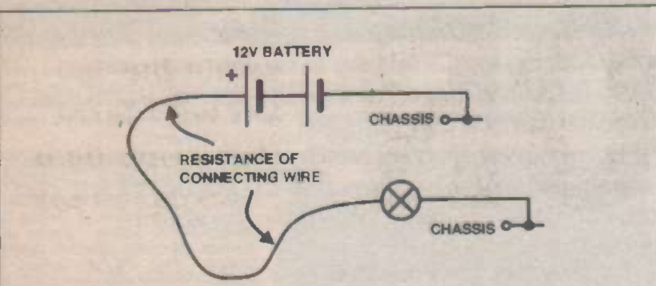


Fig. 1b Brake Light Monitor.

A standard brake light bulb rated at 21W requires a current of 1.75A - that is, 3.5A for the pair. Using V = I x R again, a voltage drop of some 200mV may therefore be expected over 3m of wire. This will be halved to around 100mV when one of the lamps fails, since the current is halved. The voltage across the bulb(s) will therefore be nominally 11.8V with both operating and 11.9V with only one. The dimming effect here is negligible which is important in practice. With a monitoring circuit adjusted to trigger above about 11.85V it will remain off with two lamps illuminated but will operate when there is only one.

In the circuit to be described, the operating voltage threshold is adjusted to suit the length of wire over which monitoring takes place. As long as the monitoring points are close to the brake light switch and one of the brake lights, there will be sufficient voltage drop for correct operation.

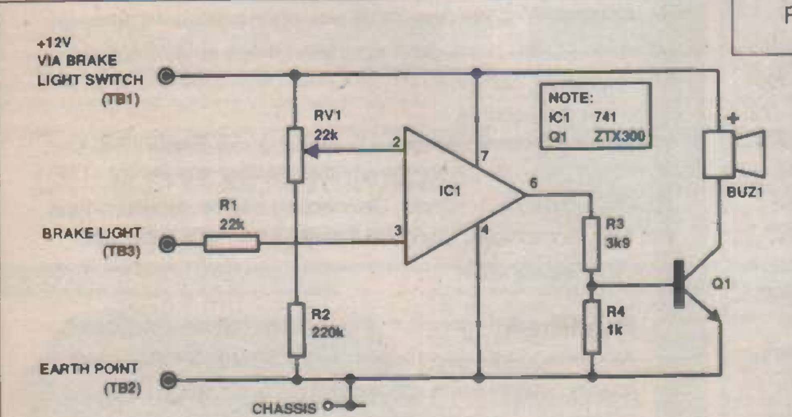


Fig. 2 Circuit diagram.

Circuit Description

The circuit is shown in Figure 2 and this uses IC1 as its main component. This is an operational amplifier used as a voltage comparator. Although various general purpose op-amps could be used here, the inexpensive and robust 741 type works perfectly well. When the non-inverting (+) input voltage exceeds the inverting (-) one, the output (pin 6) is high. Otherwise, it will be low. In this circuit, the inverting input (pin 2) voltage is determined by the setting of preset potentiometer, VR1. Fixed resistor, R2, limits VR1 operating range and, with the values stated, this can be adjusted between nominal limits of 11 and 12V. The non-inverting input (pin 3) voltage is that existing across the brake light bulbs. R1 has virtually no effect and is included simply to prevent an excessive current flowing in the event of some catastrophic failure. VR1 will be adjusted to provide the correct threshold voltage at the inverting input. Thus, the inverting input voltage will exceed the non-inverting one (output off) when both lamps are operating, but when a filament fails, the conditions will reverse and the output will become high. While high, current enters the base of transistor, Q1, through R3 and buzzer, BUZ1 operates. With the 741 op-amp, the output is about 2V when the device is nominally off. Fixed resistors R3 and R4 form a potential divider which scales down this output voltage so that the transistor is not turned on under these conditions. Note that the circuit receives its feed and therefore draws current only while the brake pedal is pressed.

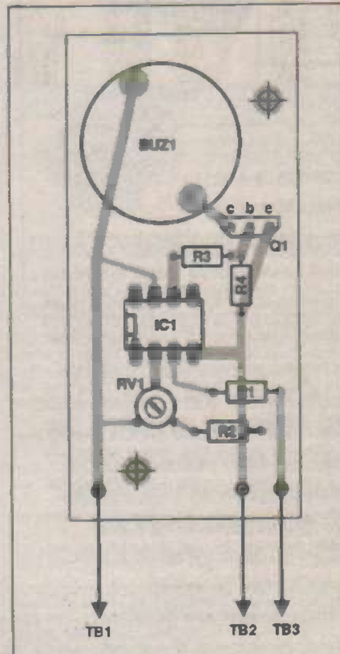


Fig. 3 Component Layout.

In the normal course of operation, the supply voltage will vary between around 10.5V and 14V, but this will not affect correct operation. This is because the voltages applied to the op-amp inputs are effectively derived from potential dividers connected across the supply, so as this varies, the input voltages will rise and fall in sympathy. Thus, the operating conditions will remain virtually the same.

Construction

All the components for the Brake Light Monitor are mounted on a single-sided printed circuit board apart from the 3-way piece of screw terminal block which is used for the external connections. Figure 3 shows the component view (parts placement diagram) for the PCB.

Begin by drilling the two mounting holes as indicated. Solder the components in the following order. Firstly, the IC. socket, then the preset and all fixed

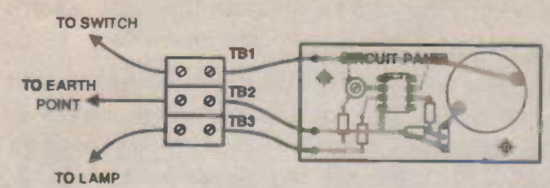


Fig. 4 Wiring Up diagram.

resistors, flat with the board. Add the transistor and buzzer, observing the polarity. Solder 5cm pieces of light-duty stranded connecting wire to the three pads for terminal block connections, as indicated.

Prepare the box by drilling holes in the base to correspond with those already made in the circuit panel and for terminal

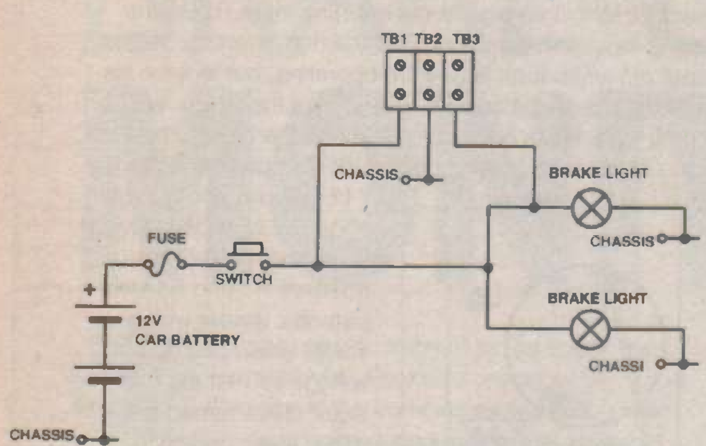


Fig. 5 Layout for typical brake system.

block mounting on the side. Drill a hole for the wires passing through the box to the terminal block. Mount the panel on short plastic stand-off insulators and attach the terminal block using small fixings. Pass the wires through the hole in the box and, shortening them as necessary, connect them as indicated in Figure 4. Drill a hole in the lid above BUZ1 position for the sound to pass through. Insert the IC into its socket. Adjust VR1 to approximately mid-track position. Do not fit the lid yet.

It would be wise to disconnect the car battery positive terminal as a precaution against short-circuits. If a security coded radio is fitted it may be more appropriate to simply remove the fuse feeding the brake lights. This is because if one of these radios is left without a supply, it 'loses' its code number and this would have to be re-entered when the supply was connected again. Refer to Figure 5 which shows the layout of a typical brake light system. Locate the brake light switch and identify the wires leading to it. You will need to make a connection to the wire which runs to the brake lights. Similarly, find a suitable place to make a connection to the wire leading to the live side of either brake light. Alternatively, this could be done at the existing connector where the wires divide to feed the individual lamps. The important point is that monitoring should take place over as long a distance as possible and with both lights being fed through most of the wire. Decide on the final position of the unit and measure the two pieces of wire needed to reach between these positions and the terminal block. Automotive-type wire must be used, although it can be of any light-duty type since only very small currents flow in it. Make the actual connections using Scotchloks. These are available from any car accessory store and allow permanent connections to be made to existing wiring without actually breaking into it. Connect the wires to the terminal block - TB1 to the switch wire and TB3 to the lamp. Connect TB2 to an existing earth point. If no such earth point can be found, drill a small hole in a metal part and use a solder tag secured with a self-tapping screw.

Testing

Testing is simply a matter of adjusting VR1 for correct operation. Removing a bulb will simulate failure of its filament. With both lamps in position, re-connect the supply and press the brake pedal (it may be necessary to switch on the ignition). The buzzer will probably sound. Rotate VR1 wiper clockwise (as viewed from IC1 position) until it just fails to do so. If when the brake pedal is pressed the buzzer fails to sound, rotate VR1 anti-clockwise until it does, then clockwise until it just stops. When correctly adjusted and with both bulbs intact, the buzzer will not sound. With one bulb removed, it should sound when the brake pedal is pressed. Check operation several times and with the engine running. Make any small adjustments as necessary. Fit the lid. With the engine running, the buzzer may give a slightly warbling tone. This is due to the unsmooth charging system output and may be ignored. The box may be mounted behind the dashboard and forgotten.

Failure of a filament is signalled by a continuous tone when the brake pedal is pressed. Intermittent operation indicates poor connections such as those due to loose connectors or corroded lamp holders.

PARTS LIST

Resistors

R1	22k
R2	220k
R3	3k9
R4	1k0
VR1	22k

Semiconductors

IC1	LM741CN
Q1	ZTX300

Miscellaneous

BUZZ1 Solid state PCB mounting buzzer - 12V operation 23mm diam. 5mA operation. Frequency 3.5kHz. (Maplin KU58N)
8-pin d.i.l. socket
3A screw terminal block - 3 sections required
Plastic box 75 x 50 x 25mm (Maplin FK73Q)
Printed circuit materials. Connecting wire, automotive-type wire, Scotchloks, stand-off insulators, small fixings, etc.

Buylines

All components used in the Brake Light Monitor are readily available and were obtained from Maplin for the prototype. Any bipolar 741-type op-amp should be suitable. The buzzer should have 17-18mm spaced pins to fit the PCB.

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

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

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

THOUSANDS PURCHASED BY PROFESSIONAL USERS

THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

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

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

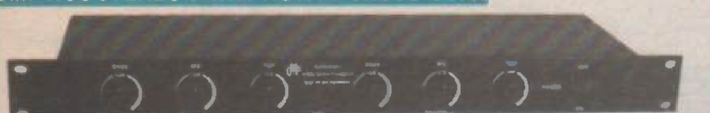
FEATURES: ★Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★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

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

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

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

OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER



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

Price £117.44 + £5.00 P&P

STEREO DISCO MIXER SDJ3400SE

★ ECHO & SOUND EFFECTS★

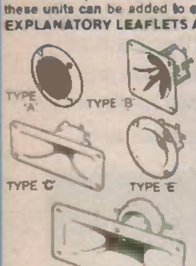
STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:-** Including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor, 8 Sound Effects. Useful combination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

Price £144.99 + £5.00 P&P

SIZE: 482 x 240 x 120mm

PIEZO ELECTRIC TWEETERS - MOTOROLA

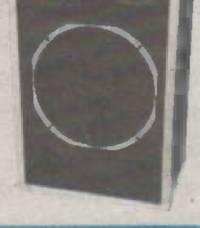
Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if two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



TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi speakers. Price £4.90 + 50p P&P.
TYPE 'B' (KSN1005A) 3½" super horn for general purpose speakers, disco and P.A. systems etc. Price £5.99 + 50p P&P.
TYPE 'C' (KSN1016A) 2"x5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. Price £6.99 + 50p P&P.
TYPE 'D' (KSN1025A) 2"x6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. Price £9.99 + 50p P&P.
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. Price £5.99 + 50p P&P.
LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. Price £4.10 + 50p P&P.

ibl FLIGHT CASED LOUDSPEAKERS

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



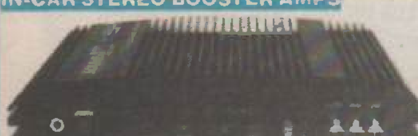
POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET
FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

ibl FC 12-100WATTS (100dB) PRICE £159.00 PER PAIR
ibl FC 12-200WATTS (100dB) PRICE £175.00 PER PAIR

SPECIALIST CARRIER DEL. £12.50 PER PAIR

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

IN-CAR STEREO BOOSTER AMPS



THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS
150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono
ALL POWERS INTO 4 OHMS
Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

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

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

BARCLAYCARD VISA

OMP MOS-FET POWER AMPLIFIER MODULES

SUPPLIED READY BUILT AND TESTED.

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

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

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

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

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

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

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

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

LOUDSPEAKERS

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

McKenzie and Fane Loudspeakers are also available.

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

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

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

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

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

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

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

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

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

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

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

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

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

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

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

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

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

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

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

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

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

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

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

TRANSMITTER HOBBY KITS

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

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

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

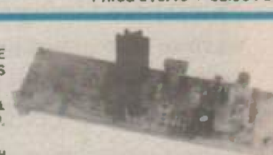


PHOTO: 3W FM TRANSMITTER

B.K. ELECTRONICS

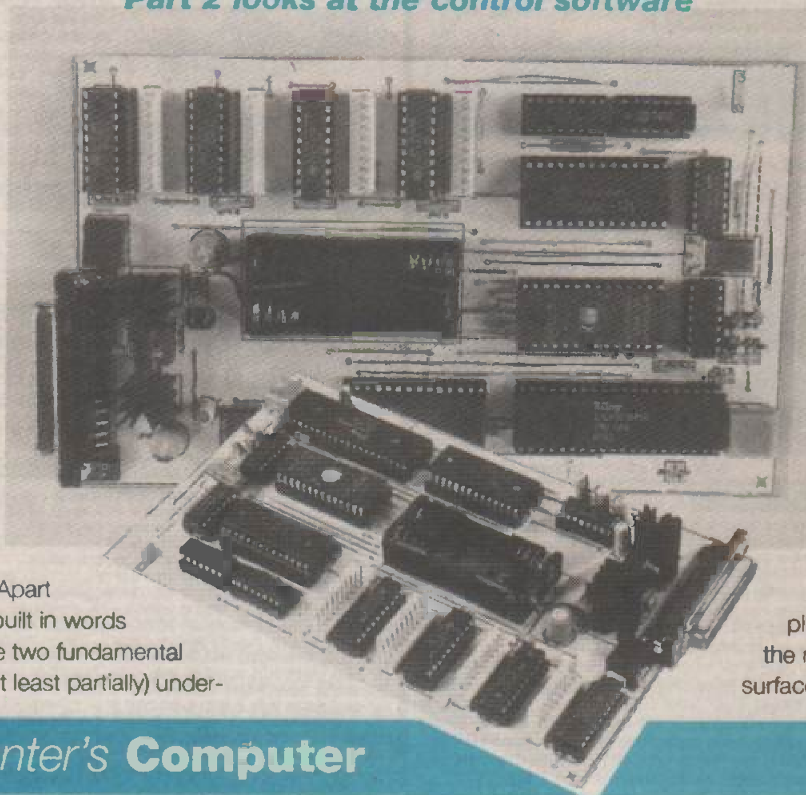
UNITS 1 & 5 COMET WAY, SOUTHEND-ON-SEA, ESSEX, SS2 6TR.
Tel.: 0702 - 527572 Fax.: 0702 - 420243

The *Experimenter's* Computer

Jim Spence's project to build a low cost FORTH control computer. Part 2 looks at the control software

FORTH is a complex language but fortunately, like all languages, programming or otherwise, you don't need to know every aspect of it to use it effectively. It is a language based on 'words', each word carrying out some low level function, and words can call other words to produce more complex functions.

Most of the words are built into the firmware. Using the board is simply a matter of defining your own words, to suit your needs. Apart from learning some of the built in words and what they do, there are two fundamental concepts which must be (at least partially) understood - the stack and post fix notation.



```
ok [H]
12  ok-1  [H]
20 30  ok-3  [H]
.S
top
  30
  20
  12
ok-3  [H]
```

The Stack

The most fundamental thing about the FORTH language is the stack. Think of this as the spring loaded plate holder at a self service restaurant. As you take a plate from the stack of plates, the others rise and the next one comes to the surface. If you put a plate onto

An *Experimenter's* Computer

As no doubt many readers will have realised, this project is a very versatile, low cost microprocessor system. If you shop around for the components and make your own PCB, then it should cost under £25 to build. This means that this system is an ideal building block for use in constructing a wide range of different microprocessor based applications, from the friendly robot to the intelligent home minder system.

For many such applications FORTH is an ideal programming language, especially Jim Spence's version with its in-built Z-80 assembler. FORTH may be a hard language to learn, but if you are prepared to take the time to do so, then I am sure you will find it well worth the effort.

If you do not want to use FORTH, then this is still a very useful board. Z-80 code can be written and assembled using the TASM assembler included on the free disk with the March issue of ETI. Or, of course, it could be assembled with the FORTH assembler. In either case, the code could be blown onto an EPROM, which would then be used in place of the FORTH EPROM used in this system.

It is the availability of good quality standard building blocks like this system which can make the design of an electronics system, especially one using a microprocessor, so much easier. In future issues, we will be showing how to construct other add-on components, such as a keyboard and an alphanumeric LCD display. Yet more valuable building blocks for the MPU user.

the stack, the other plates are pushed down. Instead of plates, we use numbers, 16 bit numbers to be precise and the first one in is the last one to come out.

To get a feel of this type 12 (greater than)ent(less than) ((greater than)ent(less than) is the enter or return key on your terminal). The board will respond with ok-1 [H], the 1 meaning there is one item on the stack and the [H] indicating that the numbering 'BASE' is set to HEX. Now type 20 (greater than)space(less than) 30 (greater than)ent(less than) and the response should be ok-3 [H], meaning there are three items on the stack. To verify the contents of the stack type .s (dot-s) - see Box 1

The .s (dot-s) prints out the stack contents and we can see that the top of the stack is 30, which was the last one in and the bottom of the stack is 12, which was the first one in. The basic unit of language in FORTH is the WORD and .s (dot-s) was one of these words. Most words consume one or more items of stack. Try . (dot). The function of this word is to print the number on top of the stack to the terminal. Notice now that you have only two items left on the stack.

Postfix Notation

I suppose this is what puts most people off even trying this language, but it is well worth the effort of getting to grips with. So what is it? Well, in normal algebra, we use the INFIX notation, i.e. 2 + 2 = 4. The bit that does the work, the '+' sign, is in-between the numbers, hence infix. PREFIX languages such as LISP have the operator in front of the number, i.e. + 2 2. The space between the 2s distinguish them from a twenty-two. As you may have guessed by now, in POSTFIX the operator comes after the numbers, i.e. 2 2 +. This notation does, believe it or not, have advantages over the infix notation, but readability is not one of them. The best way of looking at it is to say that the job of the '+' is to take two items from the stack, add them up and leave the result on the stack. You can try this by entering 2 (greater than)space(less than) 2 (greater than)ent(less than) OR 2 (greater than)ent(less than) 2 (greater than)ent(less than) which will put two 2s on the stack. Notice that either the enter key OR a space will act as a separator (delimiter) between items. Now type + and then . (dot) to view the result. As you can see the '+' did its job.

```
2 2  ok-2 [H]
+  ok-1 [H]
. 4  ok [H]
```

Input Output

Now to get to some real control stuff and test the board at the same time. Taking output first and referring to Table 1, we can see that IC8 is an 8 bit output port at address 0. The word for output is P! (p-store). This word expects two items on the stack, the first being the value you want to output and the second, or top item, the address where you want the first item to go. Incidentally, although the words are shown in upper case, this version of FORTH is not case sensitive.

Type 0 0 P! (greater than)ent(less than) and all the lines of the port should go low. Now type FF 0 p! and all the lines should go high. Check this with an LED, meter or logic probe.

The default number system of this board is HEX, but if you prefer to work in decimal, simply type DECIMAL and the above instructions would translate to 0 0 p! and 255 0 P! respectively. You can work in any numbering system you like, by altering the variable BASE. For example typing 2 BASE ! (two-base-store) will place the value 2 into the variable BASE - now you will be working in binary.

The word for input is P(at sign) (p-fetch). This requires the address of the port on the stack. P(at sign) will replace the address given on the stack with the contents of the address. IC7 has an address of 4, try 4 P(at sign) (greater than)ent(less than) and then print the contents out with . (dot). With nothing connected, this usually returns FF or 0. Try the same thing again, keeping one line held low and observe the results. Don't go overboard on this just yet, as adjacent lines tend to pick up each other values.

Writing Your Own Words

The real power of this language is being able to write your own words. We do this with the : (colon) and ; (semi-colon) words. In the above input example, we can define a word, say INA, which will input the port at address 4. This is done as follows

```
: INA 4 P(at sign) ;
```

The board will respond with an 'ok'. Note that there must be a space between the : and the INA. We can now use this word by simply typing INA, which will leave the contents of the port on the stack which we can look at by typing . (dot). Once defined, it can be used in other colon definitions. For example, suppose we wanted to see the contents of the port rather than leave it on the stack. We can define a word as follows

```
: .INA . ;
```

Again the board will respond with an 'ok'. I have called the new word .INA (dot-ina), by convention words that print something usually begin with a dot. The action of the word is to use INA to get the contents and then print them out using the . (dot) word. Now, when we type .INA, the contents of the port are printed at the terminal.

In a similar way, we can write a word to output to port address 0 by typing

```
: OUTA 0 p! ;
```

I have called this word OUTA. In this case, when using the word we have to be careful because OUTA expects you to put the value you want to output onto the stack before calling it. So, 3 OUTA (greater than)ent(less than) would put lines 0 and 1 high and the rest low. Now try the following code

```
: REFLECT
  BEGIN
    KEY? IF ABORT ENDIF
    INA OUTA
  AGAIN
;  ok [H]
```

In the above word REFLECT, the output port will reflect the input port, until you press a key at the terminal. If you hold line 0 low on the input, the output will also go low. The words BEGIN AGAIN would normally keep the word REFLECT in an endless loop, but each time it goes round, the terminal is tested with the word KEY? This will return a TRUE value if a key has been pressed at the terminal, thus activating the IF word and aborting the program.

To understand this and the operation of the stack, KEY? will either put a 0 or 1 onto the stack. After this, IF consumes the top value of the stack which will, of course, be either a 0 or 1 left by KEY?. If the value is 0 (false) then nothing happens and the IF is bypassed. If the value is 1 then the words between IF and ENDIF will be executed. In this case it is ABORT.

Once again be careful - to see the true results you must control all the lines. The HC devices are very sensitive to signals on adjacent lines.

Warm and Cold Start

The first time the board is switched on with undetermined contents in the RAM, the firmware will initialise with a cold start, ready to receive your programs. After this, with the battery connected, pressing reset or switching off and on again, the board will perform a warm start. Anything you have programmed into the board will remain intact, ready to use again. If you want to start again, you can type the word COLD, which will perform a cold start, or disconnect the battery, switch off and then on again, although with this method I found I had to short out the power supply pins to the RAM in order to make it forget!

Loading Programs

After a while, you will want to write down the programs you write and use a text editor. It's not practical to type everything in at the terminal, as this is error prone and laborious. All COMMS programs will upload text files after some fashion or another and I used the Terminal program provided free with Windows and the notepad as a text editor, also provided free with Windows. A word of warning here, TABS are not recognised by the board and will cause an error, so make sure you use spaces, or that the text editor converts the tabs to spaces, Notepad doesn't.

The COMMS program should be set to send one line at a time and then wait for a control A (hex 01) before sending another line. Terminal can be set to do this and so can QMODEM, a shareware COMMS program.

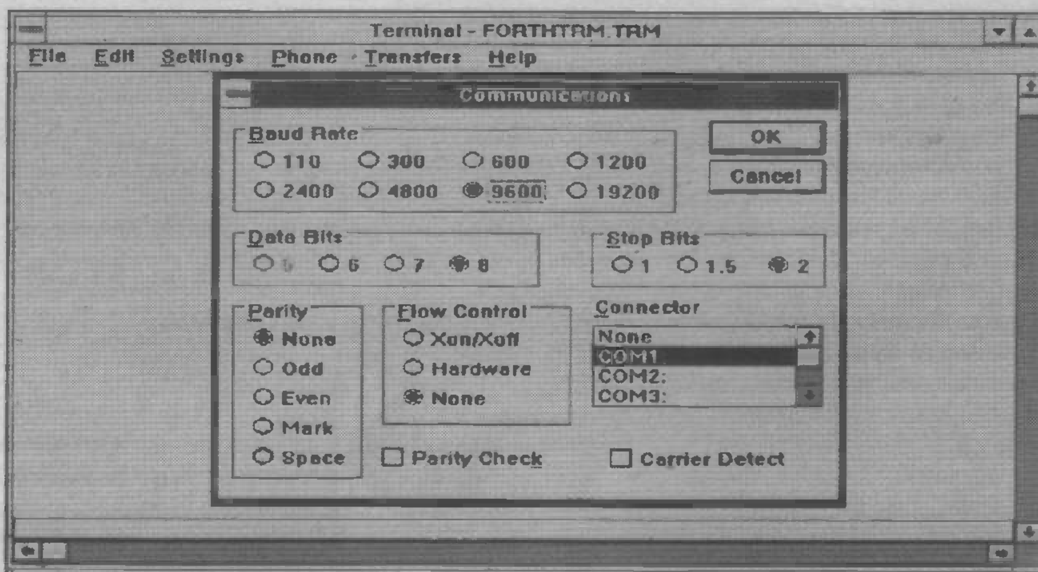
At the terminal, type LOAD and the board will wait for you to send the file. If you change your mind simply type (greater than)ent(less than) and then ;end (semi-colon-end) which will terminate the file transfer. As an example type the following into the text editor

```
\ Alternate pulse all
output lines

: outa 0 p! ;        (
output port A )

: delay f00 0 do loop
;  ( short delay )

: pulse         ( Pulse all round )
  FF 0 do       ( 0 to FF )
       delay    ( delay )
       i outa   ( get number and output )
       loop     ( again )
;

;end
```

The word PULSE will step through all the combinations from 0 to 255. The words OUTA and DELAY must have been previously defined. Comments can take two forms, anything following a slash \ ON THAT LINE will be ignored and anything in brackets-space will be ignored. Note that it is a bracket followed by a space, not simply a bracket and likewise a closing bracket followed by a space terminates the comment.

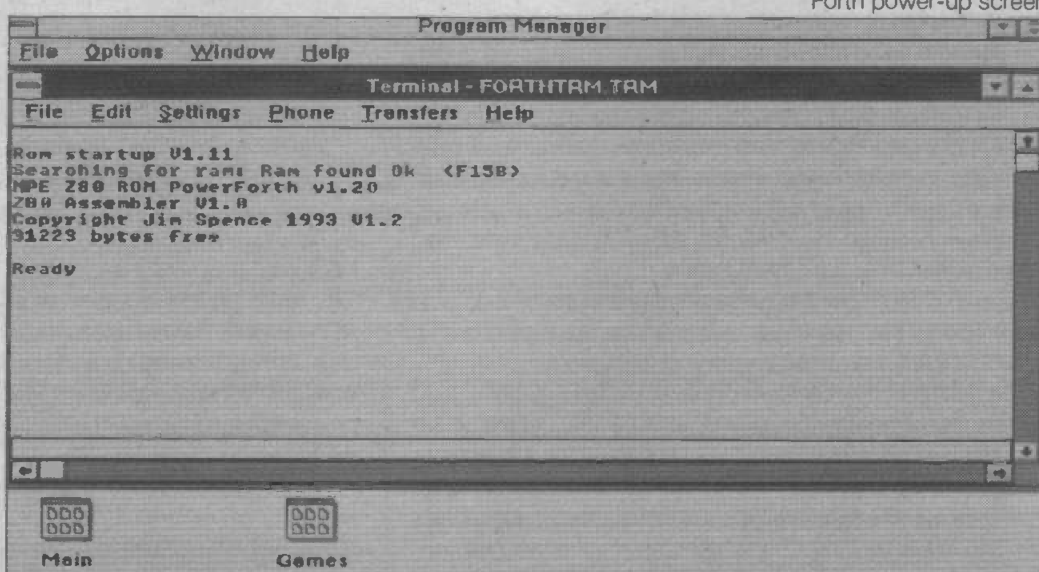
The DO — LOOP structure is very similar to the FOR NEXT loop in BASIC. The 'i' is the index and when used it places the current index on the stack. So, the first time round i will place 0 on the stack, the next time 1 and so on. We have already seen the action of OUTA, which is to take a value from the stack and output it. The final ;end terminates the loading and is only required when uploading files from the terminal.

Type LOAD and you will get a message, then start your



Terminal set-up in Windows

Forth power-up screen



upload. As each line is loaded, it is echoed to the terminal. This is useful if you have any errors, as you can more easily see what caused the error. You can switch this off by typing LOG-OFF first. Only dots will appear as lines are loaded and this will speed up the transfer.

You may have noticed by now that if you define a word twice you get a warning. This is simply a reminder to yourself that you are using the same word twice. There is a word FORGET, which is used in the form FORGET WORD, which will do just that.

```
  ok [H]
forget pulse  ok [H]
```

I hope you will notice that almost every line I have given is commented. Get into this habit, it takes a little longer loading but occupies no program space on the board. Six months later your programs have a chance of making some sense.

The Assembler

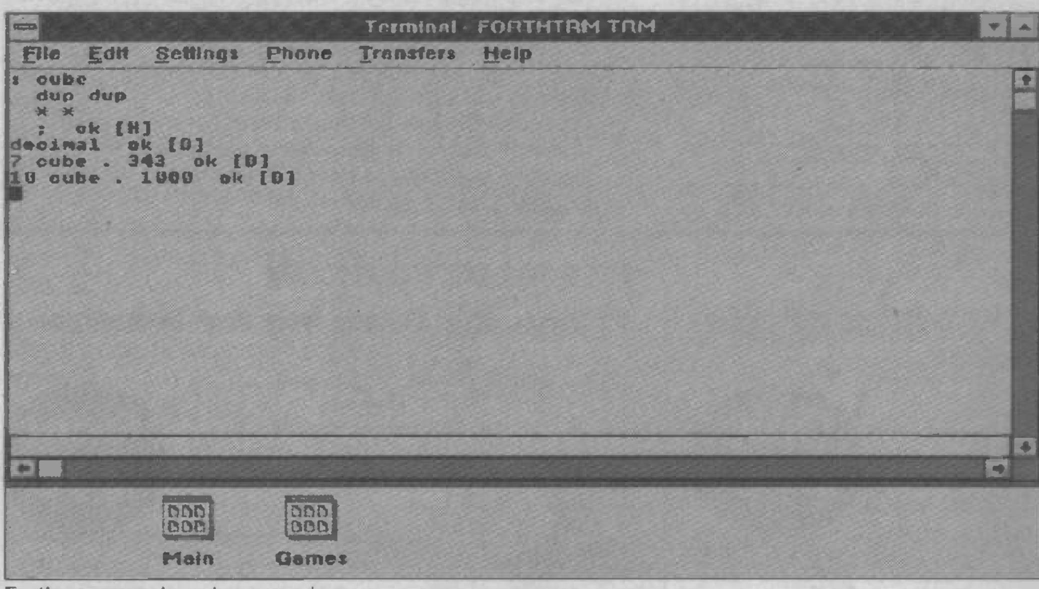
FORTH, because it is compiled, is much faster than BASIC. However, nothing is as fast as the native machine code and in some instances strict timing may be required, which can only be achieved at machine level.

Traditionally, FORTH assemblers have used Postfix notation and so ld a,12 becomes a, # 12 ld. Again this has its advantages but I find assembler hard enough without having to translate it to this odd notation. The assembler included in this firmware is very close to a standard assembler, so ld a,12 becomes ld a,12, i.e. it's the same. The main differences are

Comments are preceded by \ and not by a ;
Labels are preceded by L: example L: label
EQU is not supported
The BIT instructions are not supported (use AND, OR instead)
Numbers must be in upper case, i.e. A34D not a34d. The first is taken to be a number the second is a label.
CREATE and ;CODE not fully implemented
Labels are truncated to 6 characters and the maximum number of labels in any one word is 10

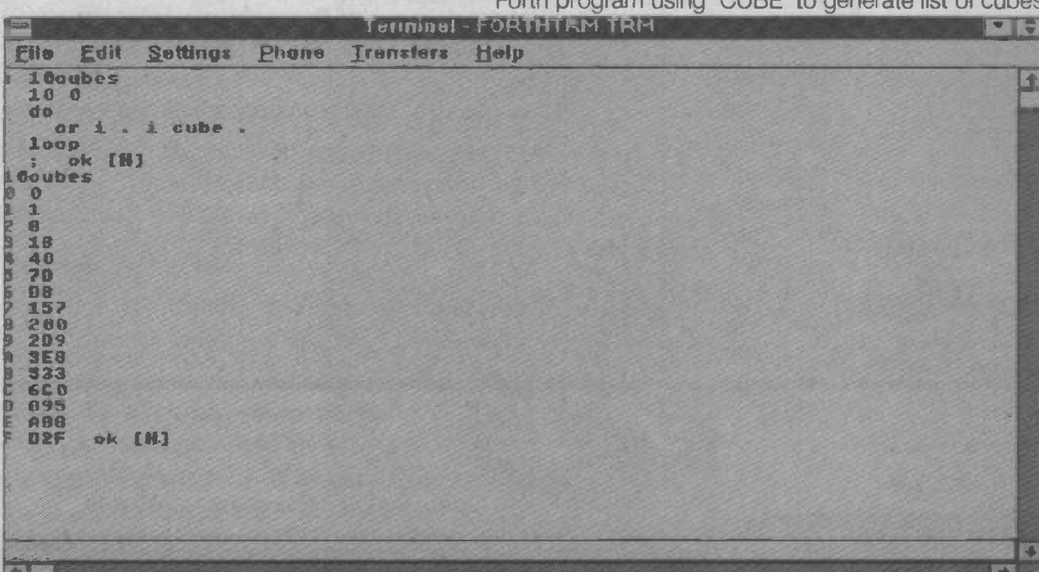
FORTH uses BC, IX, SP and IY. These must be preserved if you want to use them and return back to FORTH.

```
A Simple Example

:code plus
          pop   hl           \ Get top item
          pop   de           \ get next item
          add hl,de   \ Add them
          push  hl           \ put result on
stack
                             ;end-code
```



Forth program to cube a number

Forth program using 'CUBE' to generate list of cubes



Define a word called PLUS, which takes the top two items from the stack, adds them together and places the result on the stack (i.e. same as '+')

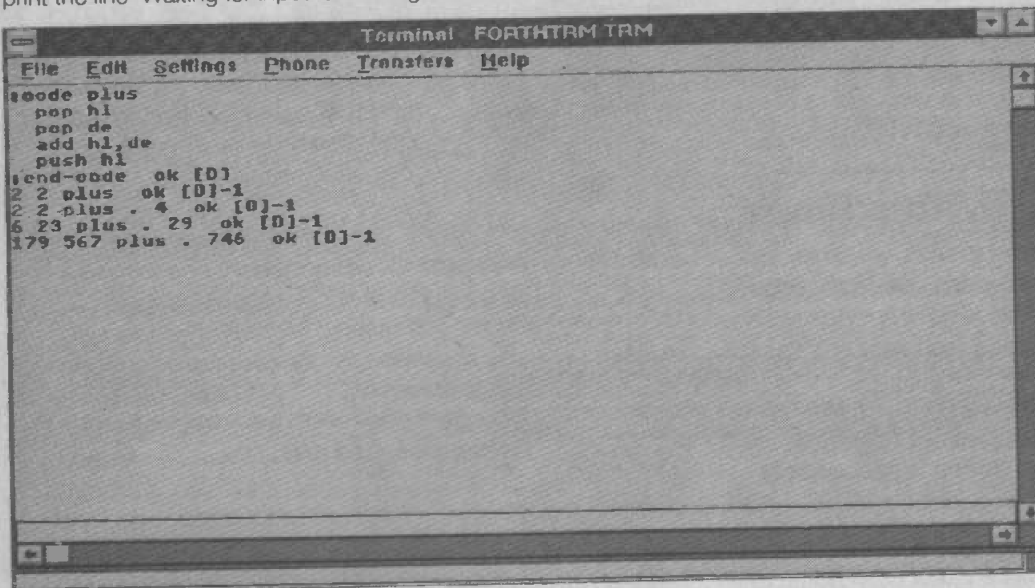
Use in the form 2 2 plus. Note now how the word PLUS is defined within :code (colon-code) and ;end-code (semi-colon endcode) These are directly equivalent to the colon and semi-colon used for defining FORTH words. In the example, notice how the machine stack is used for storing the values. The DE register can be used freely and the HL register can be used, but only in the same definition.

A More Complex Example

```
\ Assembler example

\ This code will wait
until input port bit
0
\ goes low
:code waita
l: wait1
\ define a label
     in   a,(4)
```

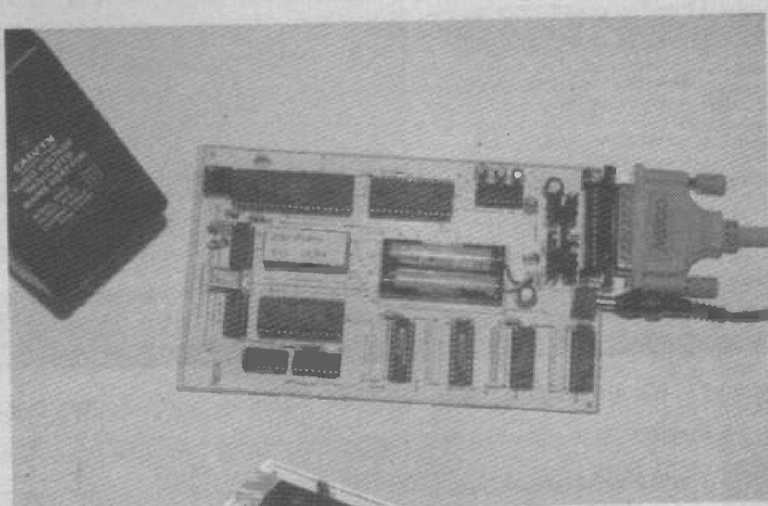
```
\ Get input port A
      and  1                  \ mask all but bit 0
      jr   nz,wait1           \ wait until bit 0 goes
low
;end-code

: test
  cr ." Waiting for input"
  waita
   cr ." Input occurred"
;
;end
```

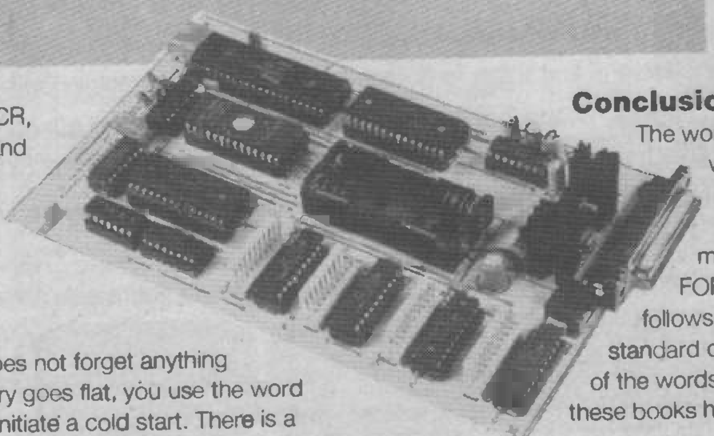
In the above example, when you type TEST the machine will print the line 'Waiting for input' and hang until bit 0 of port A



Z80 assembly code programming in Forth

goes low, when the other message will occur, 'Input occurred'. The things to notice about this are that the assembler is defined between :code and ;end-code and you can call assembly code the same way you can call a FORTH word. Incidentally, you could have typed WAITA itself - there is no requirement to call it from another FORTH word. Two new words have been introduced and these are CR, which is simply carriage return and ." (dot-quote) which prints to the terminal the text between the quotes. Note that there must be a space after the ."





Stand Alone Running

As you have, seen the board does not forget anything you have done unless the battery goes flat, you use the word FORGET or you type COLD to initiate a cold start. There is a further enhancement with this, in that it can be made to perform a word of your choice at start up. All FORTH applications eventually culminate in one word which runs the application, no matter how big the program is. In a serious application, this word will be a closed loop program which may or may not involve the terminal. In fact, all you need to do is add a keyboard and a display to this board, along with some software and you have a portable terminal.

For this example, we will not have a closed loop application but one that simply signs on and lets you get on with the normal running of the board

```
\ Sign on message example

: application
          cr cr
          ." This is my sign
on message "
          cr
;
```

Type in the above and test it by typing the word APPLICATION. You should see the sign on message. To make the word, "APPLICATION" run at switch on or reset, you need to do two things.

1) Type ASSIGN APPLICATION TO-DO JOB (greater than)ent(less than)
2) Type AUTO (greater than)ent(less than)

Auto will give you a reminder to do number 1, it does not matter which order you do them in. Now press reset, or switch off then on again and your message will appear.

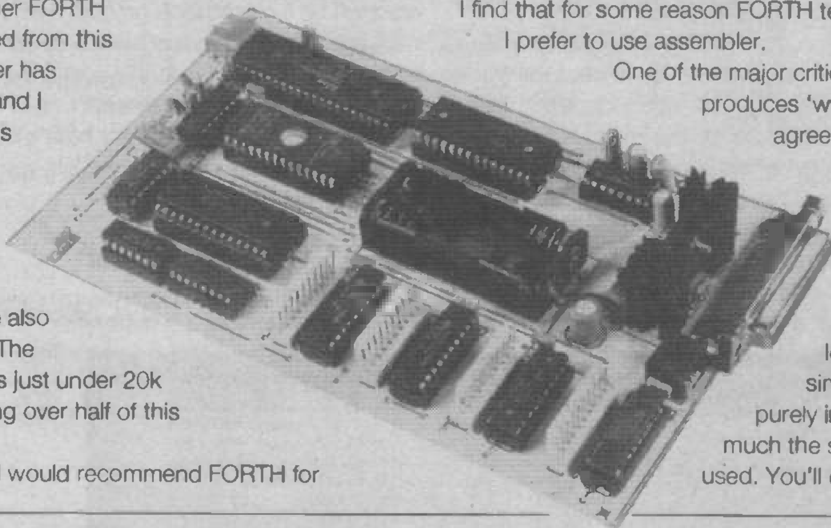
You may assign another word to JOB at any time after this to run a different application. If you want to switch off the automatic running of the program, then type AUTO-OFF or COLD.

Conclusion

The words used in FORTH are like key words and functions in BASIC and a list of these words is called a glossary. There are many books written about FORTH and this implementation follows, with some exceptions, the 83 standard of direct threaded code. Most of the words found in a glossary in one of these books have been implemented. Table

2 shows words which will only be found on this board. The FORTH was compiled into ROM using a cross compiler supplied by MPE Engineering, 133 Hill Lane, Shirley, Southampton, Telephone 0703 631441. Books and other FORTH systems can be obtained from this company The Assembler has been added by myself and I have removed the words concerning disk access, which are not applicable for this board. The auto running and loading extensions have also been added by myself. The compiled code occupies just under 20k with the assembler taking over half of this space.

On a personal note, I would recommend FORTH for experimenting with devices to see how they work. A good example of this is stepper motors. Its surprising how much you can learn about their characteristics by using FORTH to try 'what if' situations. As far as largish applications are concerned, I find that for some reason FORTH tends to get out of hand and I prefer to use assembler.



One of the major criticisms of FORTH is that it produces 'write only' code. I can only agree with this as, even if you document your code fairly well, you can do such complex things that it is difficult to read later on.

FORTH is such a challenge that it is possible to simply develop programs as purely intellectual exercises, in much the same way as pure maths is used. You'll either love it or hate it.

Words only used by this board.

LOAD	Waits for the terminal to send words until an error is encountered or the input is terminated by ;END. To give the compiler time to respond, the terminal should not send another line until it receives a CTRL A (hex 01).
;END	Correctly terminates a serial file transfer.
LOG-ON	After using this word during a file transfer, the file contents will be echoed to the screen.
LOG-OFF	After using this word, during a file transfer the file contents will NOT be echoed to the screen. Each line transferred will be replaced be a dot.
HLOAD	This will load a machine code file in INTEL HEX format to memory.
AUTO	Activates the automatic word start up (see text).
AUTO-OFF	Reverses the effect of AUTO

The firmware for this project can be supplied on a 32k EPROM, direct from the author at the address given below. The price is £15 including P&P (no VAT) and this includes a 3.5in MS-DOS disk with a text file containing the documentation to go with the EPROM. For an extra £2, the documentation can be supplied on paper.

Jim Spence,
1 Gerard Avenue,
Morley,
Leeds LS27 9LZ.

Next Month...

We continue this project with the construction of a hex keypad & LCD display

Don't miss it!

FORTH - *The Language*

As Jim Spence has already stated in his article, FORTH is extremely powerful and versatile, but unfortunately not an easy language to learn. To make matters worse there is also very little readily available published literature on the language. I am therefore printing a list of the standard FORTH commands.

When using this command list, the first thing to note is that FORTH is a stack oriented language, and the columns marked 'uses' and 'leaves' shows how the execution of that command affects the top of the stack. When writing FORTH programs it is very important that the programmer keeps track of stack usage, hence in the notes that follow each command there is an indication of the state of the stack before and after the command's execution.

It should be said that this is not an exhaustive list of FORTH commands, there are many more than this. But it should give readers some indication of how the language looks and behaves. Over the coming months, we will have several projects using this board and these will come with the appropriate FORTH control programs, which can be used as the software building blocks for more sophisticated applications.

FORTH - *The Language*

WORD	USES	LEAVES	NOTES
{ ! } (store)	2	0	Sees top-of-stack as address of a 2-byte variable and stores second-on-stack in this variable. For example, suppose that address 20000 points to a 2-byte variable; then before: 9 9 -1150 20000 after: 9 9(-1550 is stored in a 1-byte variable.)
{ " }	0	0	{ "HI THERE!" }, when executed, prints HI THERE! on the video display.
{ ' } (tic)	0	1	Puts onto top-of-stack the address of the word that follows it.
{ (}	0	0	{ (THIS IS A COMMENT) }, if included in a definition, will not be compiled; { (} requires a {) } to end the comment
*	2	1	Multiplication; example: before: 9 9 3 5 after: 9 9 15 The word * multiples 5 and 3, leaving 15.
+	2	1	Addition; example: before: 9 9 3 5 after: 9 9 8 The words + adds 5 and 3, leaving 8.
{ , }	1	0	Embeds the number on the top of the stack into a dictionary definition, incrementing the dictionary pointer
-	2	1	Subtraction; example: before: 9 9 3 5 after: 9 9 -2 The word - subtracts 5 from 3, leaving -2.
{ . }	1	0	Displays the number on the top of the stack; example: before: 9 9 3 5 after: 9 9 3 (5 is printed on screen).
/	2	1	Division; example: before: 9 9 13 2 after: 9 9 6 The word / divides 13 by 2, leaving 6 (remainder is lost).
0<	1	1	If top-of-stack is <0, it is replaced with a 1 (true); if top-of-stack is >= 0, it is replaced with a 0 (false); example before: 9 9 3 5 after: 9 9 3 0
1+	1	1	Adds 1 to top-of-stack; example: before: 9 9 3 5 after: 9 9 3 6
{ : ... ; }	*	*	{ : } begins the definition of a word, { ; } ends the definition; example: { : 3* 3* ; } defines the word 3*.
=	2	1	If the two top items on the stack are exactly equal, both of them are removed and replaced with a single 1 (true). If not, both are replaced with a single 0 (false); example: before: 9 9 3 5 after: 9 9 0
<	2	1	If the second item on the stack is less than the top item on the stack, both of them are removed and replaced with a single 1 (true); if not both of them are replaced with a single 0 (false); example: before: 9 9 3 5 after: 9 9 1

FORTH - *The Language*

WORD	USES	LEAVES	NOTES
>	2	1	Similar to entry for <; example: before: 9 9 3 5 after: 9 9 0 (3 is not less than 5)
{ ? }	1	0	Sees top-of-stack as address for 2-byte variable; displays value of that variable; using the example for {!}, then: before: 9 9 20000 after: 9 9(-1150, contents of 20000, prints on screen).
@ (fetch)	1	1	Sees top-of-stack as address for 2-byte variable and replaces it with value of that variable; using the example in {!}: before: 9 9 20000 after: 9 9 -1150 (-1150 is contents of 2-byte variable at 20000).
ALLOT	1	0	Sees top-of-stack as number of bytes to be reserved (and filled in later) during the definition of a word.
AND	2	1	Does an AND operation on the corresponding bits of the top two stack entries (both 16-bit numbers); example: before: 9 9 3 5 after: 9 9 1 (3 AND 5, in binary, is 1).
BASE	0	1	BASE is a 1-byte variable that contains the number base being used; for example, { 2 BASE C! } causes all subsequent input and output to be in binary (base 2); execution of this word causes the address of this 1-byte variable to be placed on top-of-stack. After the phrase has been executed, the stack looks like: 9 9 and the word CON, when executed, will place 25140 on the top of the stack.
CR	0	0	Causes the cursor to jump to the beginning of the next line of the display.
{ DO ... LOOP }	2	0	Looping construct that specifies a beginning and an ending-value-plus-one.
DROP	1	0	Drops top entry from stack; example: before: 9 9 3 5 after: 9 9 3
DUP	1	2	Duplicates item on top-of-stack; example: before: 9 9 3 5 after: 9 9 3 5 5
ECHO	1	0	Isolates the low-order byte of the 2-byte entry on top of the stack and writes it to the video display; example: before: 9 9 32 after: 9 9(A space, ASCII decimal 32, is printed.) ECHO is named EMIT in some versions.
FILL	3	0	Fills an area of memory with a given value; for example, { 255 3000 100 FILL } fills memory locations from 3000 thru 3099 (100 bytes) with the value 255.
FORGET	0	0	Causes system to delete all definitions including and after the word following FORGET; for example, { FORGET BASEPGM } causes the system to delete BASEPGM and all FORTH words, variables and constants defined after it.
H	0	1	2-byte variable containing address of the top of the dictionary; execution of this word causes the address of the variable H (not its value, which equals the address of the top of the dictionary) to be placed on top of the stack.
HERE	0	1	Places the address of the next byte in the dictionary (the value of H) on top of the stack.

WORD	USES	LEAVES	NOTES
I	0	1	When executed within a { DO ... LOOP }, the word I pushes onto the top of the stack the value of the index counter; for example: { 10 0 DO I. LOOP } prints the numbers from 0 to 9.
{ IF ... ELSE ... THEN }		1	0 Conditional execution of words depending on value of top-of-stack. If non-zero, execute words between IF and ELSE. If zero, execute words between ELSE and THEN. For example, { IF " NUMBER ON TOP IS NONZERO" ELSE " NUMBER ON TOP IS ZERO" THEN } prints the appropriate message, depending on the value on top of the stack.
KEY	0	1	Gets a single character from the keyboard; for example, if the stack before we press the space bar is: 9 9 3 5 Then, after we press the space bar (ASCII value decimal 32), the stack is: 9 9 3 5 32
MAX	2	1	Compares the two top entries on the stack and leaves only the larger; example: before: 9 9 3 5 after: 9 9 5
MIN	2	1	Compares the two top entries on the stack and leaves only the smaller; example: before: 9 9 3 5 after: 9 9 3
MINUS	1	1	Changes the sign of the entry on top of the stack; example: before: 9 9 3 5 after: 9 9 3 -5
OVER	2	3	Copies the second-to-top entry onto the top of the stack; example: before: 9 9 3 5 after: 9 9 3 5 3
PAD	0	1	PAD is a 2-byte variable that points to the beginning of a 64-byte area for temporary storage of character strings. Execution of this word causes the address of this 2-byte variable to be placed on top of the stack.
SWAP	2	2	Exchanges the two top entries on the stack; example: before: 9 9 3 5 after: 9 9 5 3
U*	2	1	The lower 8 bits of the two top entries on the stack are isolated and multiplied together, leaving their unsigned 16-bit product; example: before: 9 9 3 5 after: 9 9 15 Each factor will effectively be 255 or less, giving a product that will not overflow in 16 bits.
VARIABLE	1	0	Creates a variable that has the value of top-of-stack; example, before executing the phrase { VARIABLE VAR }, the stack looks like: 9 9 -14017 After the phrase has been executed, the stack looks like: 9 9 and the word VAR, when executed, will place the address of the variable on the stack. (The 2-byte number stored at that address will contain the value -14017). Unlike a constant, the value of a variable can be changed using { ! } (store).
{] }	*	*	Resumes compilation of a colon definition.

8 CAVANS WAY,
BINLEY INDUSTRIAL ESTATE,
COVENTRY CV3 2SF
Tel: 0203 650702
Fax: 0203 650773
Mobile: 0860 400683

(Premises situated close to Eastern-by-pass in Coventry with easy access to M1, M6, M40, M42, M45 and M69)

OSCILLOSCOPES

- Gould 400 - 20MHz D.S.O. 100 Ms/s £1000
- Gould 4072 -100MHz D.S.O. 400 Ms/s £2000
- Gould OS4000, OS4200, OS4020, OS245 .... from £125
- Hewlett Packard 1740A, 1741A, 17744A, 100MHz dual ch. .... from £350
- Hewlett Packard 182C - 100MHz 4 ch £350
- Hewlett Packard 1707A, 1707B - 75MHz 2ch .... from £275
- Hewlett Packard 1715A 200MHz with DMM Ch. £650
- Hewlett Packard 1745A 100MHz dual channel (+ DMM) £450
- Tektronix 2201 - 20MHz D.S.O. dual ch. £675
- Tektronix 2246 100MHz-4 channel .... (as new) £995
- Tektronix 2215 60MHz dual trace £450
- Tektronix 2235 Dual trace 100MHz (portable) £800
- Tektronix 2335 Dual trace 100MHz (portable) £750
- Tektronix 2225 -50MHz dual ch. £450
- Tektronix 465/465B -100MHz dual ch. .... from £350
- Tektronix 475 - 200MHz dual ch. £450
- Tektronix 468 -100MHz D.S.O. dual ch. £850
- Tektronix 7313, 7603, 7613, 7623, 7633, 100MHz 4 ch .... from £300
- Tektronix 7704 - 250MHz 4 ch .... from £650
- Tektronix 7834/7844 - 400MHz 4 ch .... from £750
- Tektronix 7904 - 500MHz .... from £850
- Phillips 3070 -100MHz 2+ 1 channel + cursors, as new £900
- Phillips 3206, 3211, 3212, 3217, 3226, 3240, 3243, 3244, 3261, 3262 (2ch + 4 ch.) .... from £125 to £350
- Solartron Schlumberger CD1740 - 20MHz 4 ch £250

Other scopes available too

SPECTRUM ANALYSERS

- Alltech 727 -20GHz £2200
- Advantest TR4131 -10KHz - 3.5GHz £4500
- Hewlett Packard 3580A - -5Hz-50KHz £1250
- Hewlett Packard 3585A - 20Hz - 40MHz (GPIB) £4250
- Hewlett Packard 8590A - t0MHz - 1.5GHz - 1.5GHz (as new) £4500
- Hewlett Packard 182T with 8559A (10MHz - 21GHz) £3750
- Hewlett Packard 141T with 8554B/8552B - (1250MHz) £1500
- Marconi 2370 - 110MHz £1250
- Hewlett Packard 4953 Protocol analyser £2500
- Tektronix 7L18 with 7603 main frame 1.5 GHZ/18GHZ £3500

MISCELLANEOUS

- Anritsu ML93B/ML92B Optical power meter with sensor £2000
- Anritsu ME538C Microwave system analyser (BX + Tx) £3500
- B&K 2511 + 1621 Vibration test set £2000
- B&K 2511 Vibration meter £1500
- B&K 2515 Vibration analyser £4500
- Datron 1061A Autocal digital multimeter (6½ digits) £850
- Datron 1071 Autocal digital multimeter (7½ DIGITS) £1150
- Daymarc 1735 Transistor tester/sorter (with all jigs) £5000
- Dranetz 305 Phase meter £250
- Dymar 1585 AF Power meter £175
- Dymar 2085 AF Power meter £200
- Farnell RB 1030-35 Electronic load 1Kw £450
- Farnell AMM/B Automatic modulation meter £150
- Farnell 2081 R/F Power meter .... POA
- Feedback TWG300 Test waveform generator £200
- Fischer Betascope 2040/2060 Coating thickness computer & non destructive coating measurement instrument & many jigs and extras .... all for £2000
- Fluke 8840A Multimeter (IEEE) £300
- Fluke 515A Portable calibrator £500
- Fluke 8010A Digital multimeter £125
- Fluke 8922A True RMS voltmeter .... POA
- Fluke 95020 Current shunt .... POA
- Gay Milano FTMIC/FTM3C - FTM - Fast transient monitor £250
- General Rad 1658 LCR Digibridge £250
- General Rad 1621 Precision capacitance measurement system .... POA
- Hewlett Packard 180TR Display unit with 8755B swept. amp. an. £350
- Hewlett Packard 3200B VHF oscillator, 10-5000MHz £175
- Hewlett Packard 3325A Synthesizer/function generator £1450
- Hewlett Packard 3400A RMS voltmeter £150
- Hewlett Packard 3406A Broadband sampling voltmeter £175
- Hewlett Packard 3437A System voltmeter £350
- Hewlett Packard 3456A Digital voltmeter £650
- Hewlett Packard 3476 Digital multimeter £100
- Hewlett Packard 347 Digital voltmeter, 4 wire system, 1EEE £650
- Hewlett Packard 3702B/3705A/3710A/3716A Microwave link analyser £1500
- Hewlett Packard 3730A Down converter (with 3738A or 3737A) £200
- Hewlett Packard 3760/3761 Data gen + error detector .... each £300
- Hewlett Packard 3762/3763 Data gen + error detector .... each £350
- Hewlett Packard 3777A Challen selector £250
- Hewlett Packard 3779A Primary multiplex analyser £800
- Hewlett Packard 400E/F AC voltmeter £150
- Hewlett Packard 4204A Oscillator 10Hz-1MHz £250
- Hewlett Packard 435A Power meter (less sensor) £350
- Hewlett Packard 456A AC current probe .... POA
- Hewlett Packard 415E SWR meter £275
- Hewlett Packard 4193A Vector impedance meter £3500
- Hewlett Packard 5335A Universal counter with 1EE £1800
- Hewlett Packard 5342A Microwave freq. count. 18GHz £1400
- Hewlett Packard 7402 Recorder with 17401A x 2 plug-ins £300
- Hewlett Packard 8005B Pulse generator £250
- Hewlett Packard 8011A Pulse gen. 0.1Hz-20MHz £500
- Hewlett Packard 8013B Pulse gen. 1Hz-50MHz £750
- Hewlett Packard 8012B Pulse generator £750
- Hewlett packard 8406A Frequency comb. generator £500
- Hewlett Packard 8443A Tracking gen/counter with 1EEE £450
- Hewlett Packard 8445B Automatic presetter £700
- Hewlett Packard 8601A 110MHz Gen/sweeper 110MHz £350
- Hewlett Packard 8620C Sweep oscillator mainframe £250
- Hewlett Packard 8750A Storage normaliser £400
- Hewlett Packard 938A Freq. doubler £250
- Keithley 197 20MHz with 1EEE £400
- Lyons PG73N/PG75/PG2B/PG Pulse gnerator .... from £225
- Marconi 2019A 80KHz-1040MHz sig. gen. £1800
- Marconi 2432A 500MHz digital freq. meter £200
- Marconi 2337 Automatic dist. meter .... POA
- Marconi 2356 20MHz level oscillator £300
- Marconi 2306 Programmable interface £500
- Marconi 2610 True RMMS voltmeter £900
- Marconi 2830 Multiplex tester £1250
- Marconi 2831 Channel access switch £500
- Marconi 6920 Power sensor £400
- Marconi 5390 1GHz signal gen £1250
- Philips PM 5167 10MHz function gen. £400
- Philips 5190 LF synthesizer w/th G.P.I.B. £800
- Philips PM 5519 Colour TV pattern gen. £400
- Philips PM 2525 Multimeter WF 1EEE £850
- Philips 5716 Pulse generator high freq. MOS £600
- Philips PM 5770 Pulse gen. - 1MHz-100MHz £150
- Philips PM 6672 1GHz timer/counter WF 1EEE £650
- Philips PM 8272 XYT chart recorder £500
- Photodyne 800 Fibre optic attenuator £350
- Projectina CH9345 Microscope £800
- Racal 9009 Modulation meter £225
- Racal Dana 202 Logic analyser + 68000 disassembler £250
- Racal Dana 9242D Programmable PSU 25V-2A £300
- Racal Dana 9246S Programmable PSU 25V-10A £400
- Racal Dana 3100 40-130MHz synthesiser £750
- Racal Dana 5002 Wideband level meter £650
- Racal Dana 5003 Digital m/meter £150
- Racal Dana 9000 Microprocessing timer/count. 52MHz £550
- Racal Dana 9081 Synth. sig. gen. 520MHz £550
- Racal Dana 9084 Synth. sig. gen. 104MHz £450
- Racal Dana 9303 True RMS/RF level meter £650
- Racal Dana 9341 LCR databridge £250
- Racal Dana 9500 Universal timer/counter 100MHz £200
- Racal Dana 9917 UHF frequency meter 560MHz £175
- Racal Dana 9919 UHF frequency meter 1GHz £275
- Rohde & Schwartz BN36711 Digital Q meter £400
- Solartron Schlumb 1170 Freq. response analyser £500
- Tektronix TM503, SG503, PG506, TG501 Scope calibrator £2200
- Tektronix 834 Data comms analyser £500
- W&G SPM12 Level meter 200Hz-6MHz £500
- W&G PS12 level generator 200Hz-6MHHz £500
- W&G SPM60 Level meter 6KHz-18.6MHz £500
- W&G PS60 Level meter 6KHz-18.6MHz £500
- W&G SPM6 Level meter 6KHz-18.6MHz £250
- W&G PS6 Level generator 6KHz-18.6MHz £250
- W&G SPM6 Level meter 6KHz-18.6MHz £250
- Wavetek 157 Programmable waveform synthesier £300
- Wayne Kerr B424/N LCR Component meter set £200
- Wayne Kerr 4250 LCR meter .... (as new) £1000
- Wayne Kerr 642 Autobalance universal bridge £200
- Wayne Kerr B905 Automatic precision bridge £800
- Weller D800/D801 Desoldering station £175
- Weller D900 Desoldering station £150
- Wiltron 352 Low freq. differential input phase meter £350
- Wilton 560 Scalar network analyser + 2 heads £900
- Yokogawa 3655 Analyser recoredr £850

SPECIAL OFFERS - **Phoenix 5500A Telecoms analyser, ex. demo. as new with 12 months calibration + 12 months guarantee fitted with V24 interface. A variety of interface options available - Ring/Fax for details. Navtel 9440 Protocol analyser, ex. demo. as new £8000 new - cost now £3500. Navtel 9410 PCB based protocol analyser ex. demo. as new £3000 new - cost now £1500.**

MANY MORE ITEMS AVAILABLE - SEND LARGE S.A.E. FOR LIST OF EQUIPMENT ALL EQUIPMENT IS USED - WITH 30 DAYS GUARANTEE. PLEASE CHECK FOR AVAILABILITY BEFORE ORDERING - CARRIAGE & VAT TO BE ADDED TO ALL GOODS

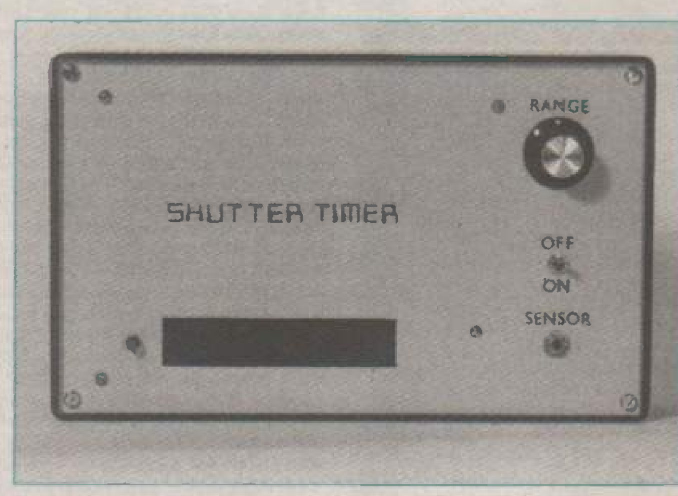
PROJECT

Shutter Timer

Robert Penfold builds a simple device for testing photographic shutter speeds

Electronic test equipment is no longer restricted to testing electronic components and equipment. In the modern world electronic test gear is used to check just about everything, including things that are completely non-electronic in nature. This project is an example of an electronic testing device for a piece of non-electronic equipment.

It is primarily intended for checking the timing of focal plane shutters in single lens reflex cameras. However, it works equally well with most rangefinder or viewfinder cameras which have interchangeable lenses and focal plane shutters. The only exceptions are Leica screw-mount cameras and close copies such as the Russian FED. The backs of these cameras are fixed, making it impossible to get the shutter timer's sensor into position behind the shutter. Cameras of this type require the shutter to be removed from the body for testing (which is something that should only be undertaken by a suitably experienced camera technician). The timer also seems to work quite well with large format lenses, which have built-in leaf shutters and most compact cameras which have leaf shutters. When used with a focal plane shutter, it will measure the effective shutter speed at any point on the focal plane. It can, therefore, be used to check for uneven exposure due to one shutter curtain operating at a higher velocity than the other.



Resolution

For this application, it is not essential to have a very high degree of resolution, because the tolerances allowed on shutter times are surprisingly generous. An analogue read-out would give perfectly adequate accuracy, but these days a three or four digit counter circuit probably costs no more than a moving coil panel meter of reasonable quality. Also, this application lends itself well to the digital approach. The unit finally evolved with a four digit LED display and three measuring ranges. These have full scale values of 99.99 milliseconds, 999.9 milliseconds, and 9.999 seconds. An overflow LED is included.

With most cameras, it is possible to check all the shutter speeds using this tester. The only cameras which go beyond its capabilities are those which have marked shutter speeds beyond 9.999 seconds, but only a few modern cameras fall into this category. The Canon EOS RT, for instance, has a maximum shutter speed setting of some 30 seconds. The maximum limit of 9.999 seconds is not really a major limitation since longer shutter times are easily checked against a clock or watch with seconds indication.

At fast shutter speeds, the 0.01 millisecond electronic resolution of the unit comfortably accommodates most cameras. However, it is not the electronic resolution that is likely to be the main limitation when checking fast shutter speeds. The way in which focal plane shutters operate makes it difficult to produce precise measurements on the faster settings. The basic scheme of things is to have two fabric or metal shutter curtains. With the shutter cocked, one of these is in place in front of the film to prevent exposure. This curtain rapidly moves out of the way when the shutter is fired. After the appropriate period the other curtain moves into place in front of the film to end the exposure.

This method works well for long shutter times, but the finite speed at which the shutter curtains move becomes problematic at short shutter durations. The time taken for the first shutter curtain to move out of the way and fully expose the film varies from one camera design to another, but it is generally between 4 and 30 milliseconds. It takes the same time for the second curtain to move into place and close the shutter. In order to obtain fast effective shutter speeds, the second curtain must start to close the shutter before the first curtain has fully opened it.

This gives what is effectively a slit moving across the film plane, with the shutter speed being controlled by varying the width of the slit. The faster the shutter speed, the narrower the slit. It is for this reason that normal electronic flash is unusable on the higher shutter speeds. With the shutter never fully opening, the flash can only expose the part of the film that is revealed by the shutter at the instant the flash fires and this could be less than 10% of the full frame area.

Although each crystal of the film's emulsion might be exposed for precisely the correct length of time, the duration of each exposure is relatively long. At a thousandth of a second, any point on the film will be exposed for about 1 millisecond, but it would typically take around 15 milliseconds for the shutter to produce the complete picture. Checking the effective shutter speed at the film plane, therefore, requires a sensor that has a very small light sensitive area.

A focal plane shutter will typically produce a slit about 3 or 4mm at the highest shutter speeds, so even something like a 3mm diameter phototransistor has quite a wide detection area, relative to the width of the slit. This tends to give a relatively long output pulse from the sensor and significantly elongated shutter timings. The phototransistor used in the prototype timer has a width of 1mm, which gives reasonable accuracy. However, even using a sensor as small as this it is possible to obtain greater accuracy by masking it to give an even smaller effective detection area.

New Leaf

Leaf shutters are normally fitted within a multi-element lens, although in some cases they are mounted immediately behind the lens. They operate in a manner which is similar to the diaphragm which controls the effective lens aperture. Normally, the shutter is stopped right down so that no light can pass, but when triggered, the shutter rapidly opens up and, after the appropriate time span, it then closes right down again. In practice, the shutter blades are quite an elaborate shape so that the semi-opened shutter produces a sort of six pointed star shape. This ensures that the shutter has little effect on the effective aperture of the system by using the full diameter of the lens, even when the shutter is not fully opened.

Measuring the effective speed of a leaf shutter also tends to be problematic. At the highest shutter speed, the shutter opens and then almost immediately closes again. A typical leaf shutter has a maximum shutter speed of 1/500th of a second, but the shutter would typically be open to significant degree for about 3 milliseconds rather than 2. The exposure given is still quite accurate, because for much of the 3 milliseconds the shutter is effectively stopping down the lens to some extent.

This unit is not primarily designed for testing leaf shutters and has no way of combating this problem of elongated timings at fast shutter speeds. You simply have to allow for the fact that the indicated times will be up to about 50% too long at the fastest shutter speed.

System Operation

The timer uses a simple pulse counting technique, with the camera's shutter and optical sensor generating the gate pulse. Figure 1 shows the block diagram for the shutter timer.

A crystal oscillator and divider chain generates clock frequencies of 100kHz, 10kHz and 1kHz, which give the unit its three measuring ranges. A switch is used to select the required clock frequency. The sensor is a phototransistor and, in use, this is aimed at a bright light source via the camera's shutter. The phototransistor drives a switching transistor which generates a logic compatible output. This stage controls a simple logic gate circuit. Under stand-by conditions, the phototransistor receives a relatively low light level and the gate blocks the clock signal. When the shutter is open, the phototransistor receives a higher light level and the gate couples the clock signal through to a counter circuit.

The counter is a basic four digit type which drives seven segment LED displays. Using the 1kHz clock signal, the counter obviously registers shutter times in milliseconds and therefore handles a maximum shutter time of 9999 milliseconds, or 9.999 seconds. Using the 10kHz clock signal increases the resolution to 100 nanoseconds, but the maximum time that can be accommodated is reduced to 999.9 milliseconds. Similarly, using the 100kHz clock frequency improves the resolution to 10ns, but with a maximum time of 99.99 milliseconds. A flip/flop operates an overflow indicator if the maximum count is exceeded.

The circuit is designed to automatically reset itself about 3 seconds after a timing run has been completed. This is very much more convenient in use than having to manually reset the counter. A monostable is activated by the trailing edge of the gate pulse and, after about 3 seconds, the output pulse from the monostable ends. This falling edge is processed by a pulse shaper and used to reset the counter and the overflow flip/flop.

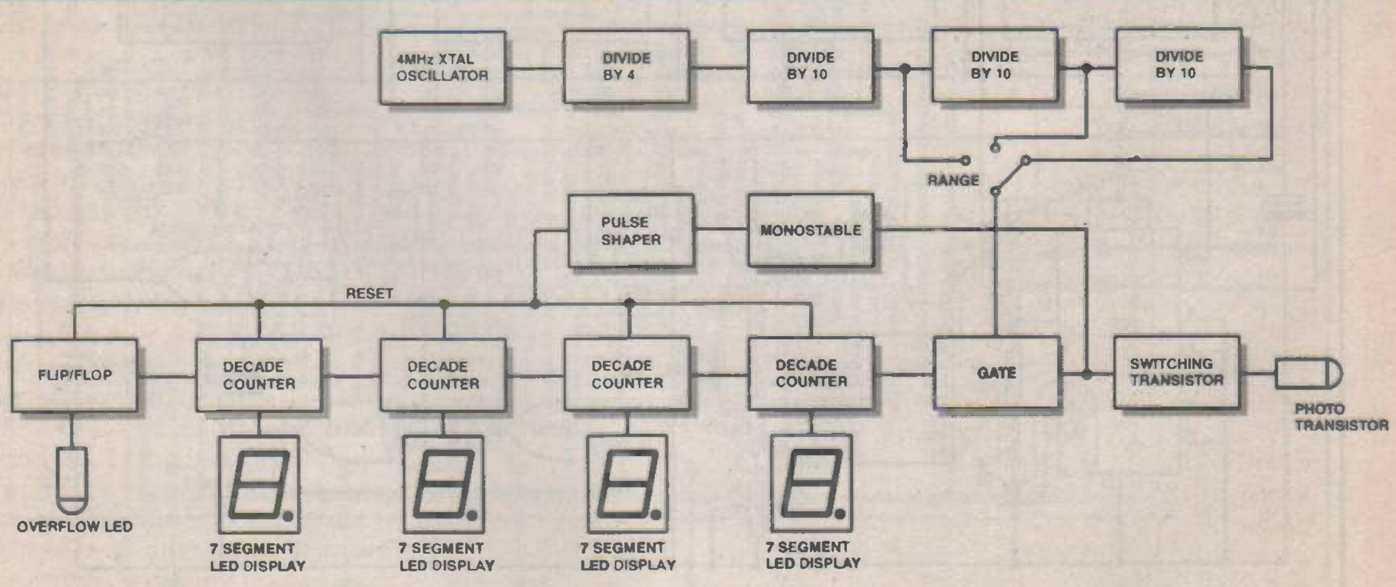


Fig. 1 The shutter timer block diagram.

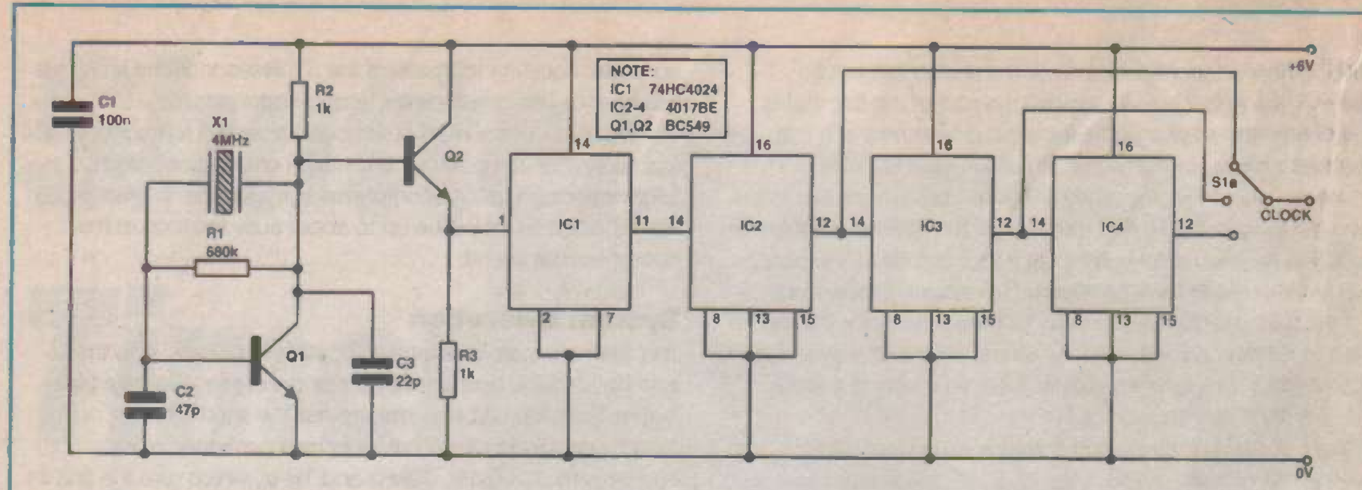


Fig. 2 The clock and divider stages.

Circuit Operation

Figure 2 shows the circuit diagram for the clock oscillator and divider stages of the timer. The oscillator is a conventional crystal type based on TR1 and operating at about 4MHz. TR2 is an emitter follower buffer at the output of the oscillator. IC1 is a CMOS seven stage binary counter, but in this case only the first two stages are utilised. An ordinary 4024BE might not operate properly with a 6V supply and a clock frequency of 4MHz. A 74HC4024 must therefore be used for IC1.

IC1 produces a 1MHz output signal which is fed to IC2. This is the first of three divide by ten stages based on 4017BE decade counters/one of ten decoders. In this case, the decoder sections are left unused and it is only the divide by ten outputs that are used. These provide the required clock frequencies of 100kHz, 10kHz and 1kHz, with the required clock frequency being selected using range switch S1a.

The main circuit diagram for the shutter timer appears in Figure 3. The counter is built around IC5 to IC8, which are CMOS 4026BE decade counters, seven segment decoders and drivers. These can directly drive seven segment LED displays, but require discrete current limiting resistors (R4 to R31). Note that the four displays must be of the common cathode variety

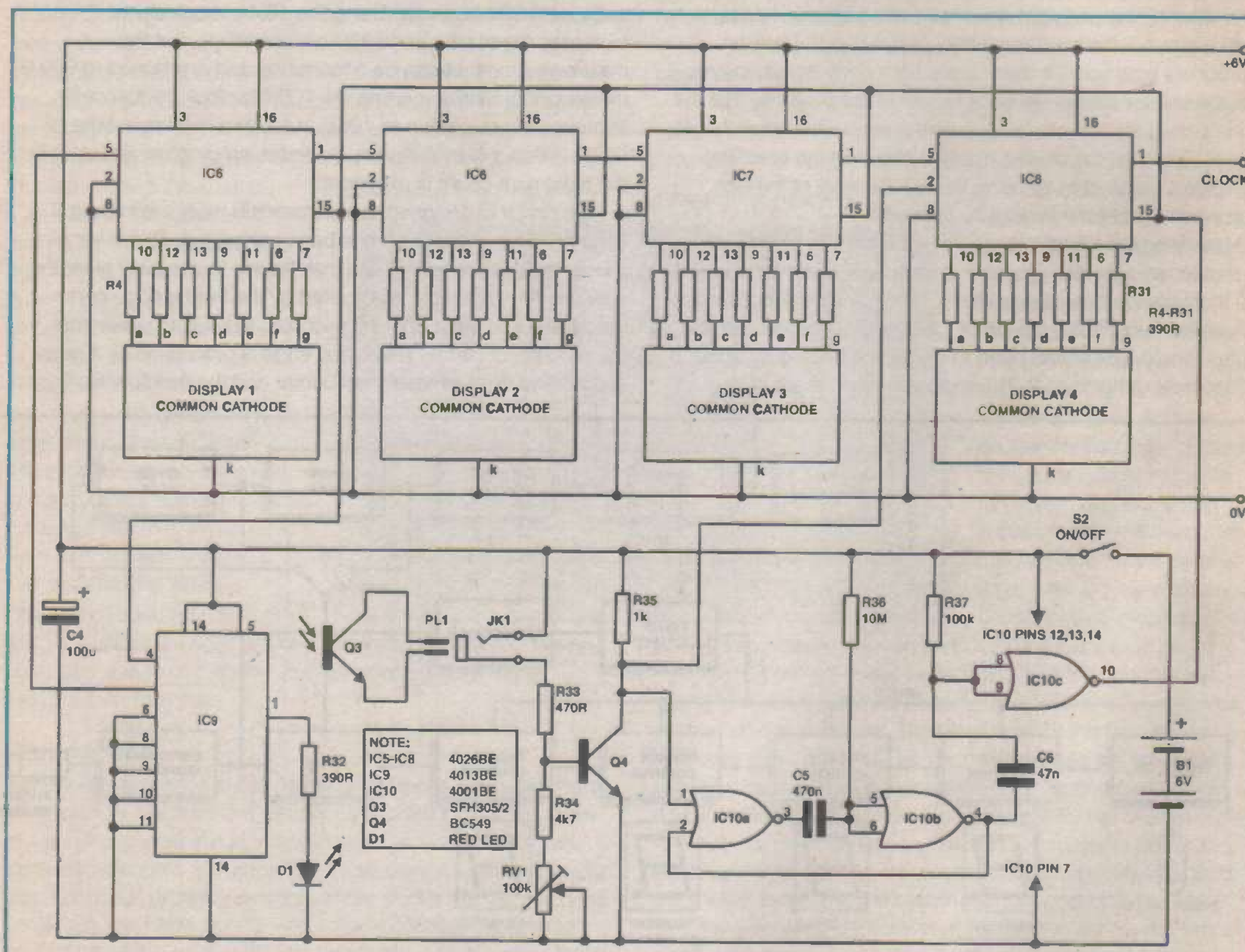


Fig. 3 The main shutter timer circuit.

and that the circuit will not work with common anode displays. The 4026BE has a built-in gate at the clock input, making the use of an external clock gating circuit unnecessary. The count is controlled via the gate at the input of the least significant counter (IC8). The clock inputs of the other three counter chips are wired to ground so that they are permanently enabled.

IC9 is a CMOS dual D type flip/flop, but in this circuit only one section of the device is used. This is used as the basis of the overflow indicator. The clock input of the flip/flop is fed from the 'carry out' output of IC5. The data input of IC9 is connected to the positive supply rail. If an overflow occurs, IC9 is fed with a clock pulse which results in the high level on its data input being latched onto the Q output. The Q output drives LED indicator D1 via current limiting resistor R32.

The light detector circuit must be reasonably sensitive, so that the unit does not require a very strong light source in order to operate properly, but it must also operate very fast, in order to give good accuracy on fast shutter speeds. Both requirements are met by using a phototransistor (TR3) as an emitter follower, driving a common emitter switch (TR4). VR1 is a preset sensitivity control which is used to set a suitable light threshold level.

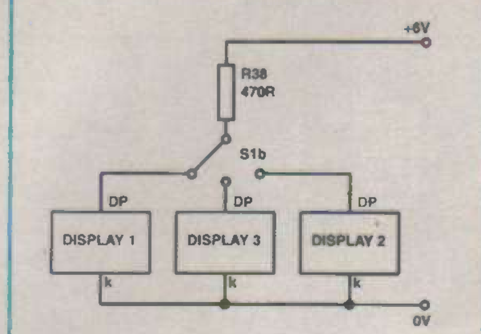


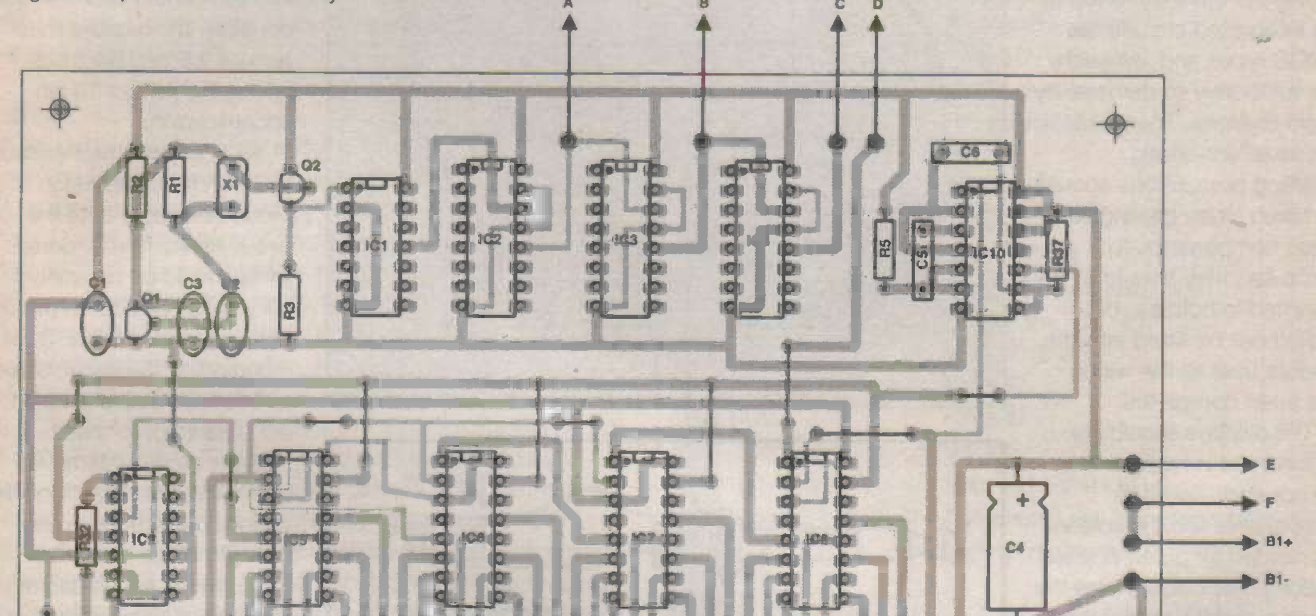
Fig. 4 The decimal point switching.

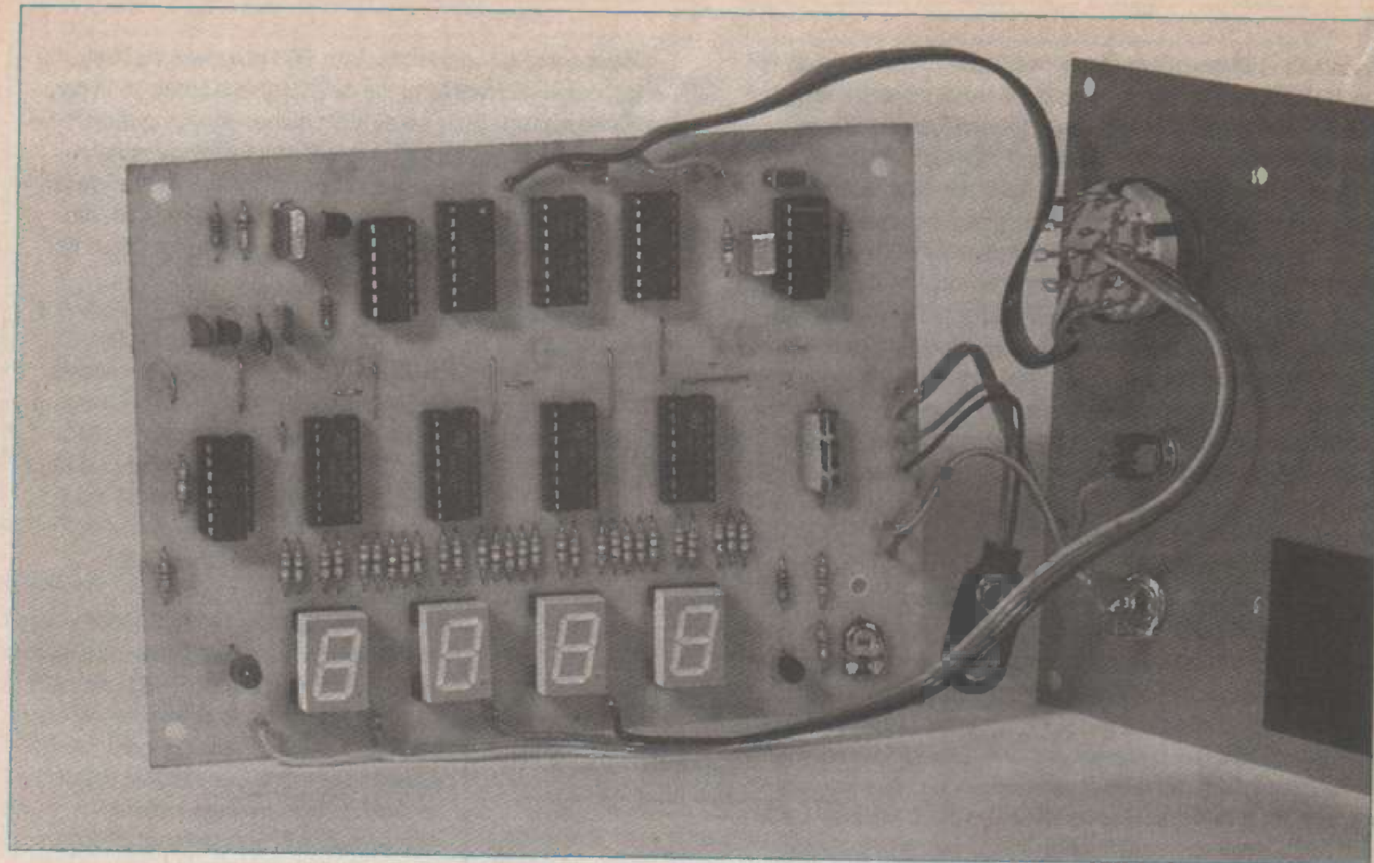
Under stand-by conditions (with TR3 in a low light level), the collector of TR4 is high and the clock signal is blocked. When the shutter opens, TR3 has a much higher leakage current, TR4 is switched on, its collector goes low and the clock signal passes through to the counter circuit. When the shutter closes again, TR4 switches off, the clock signal is blocked from the counter circuit and the display shows the period for which the shutter was open.

As the collector of TR4 returns to the high state, it triggers a monostable made up from NOR gates (IC10a and IC10b). C5 and R36 set the output pulse duration at approximately three seconds. At the end of the monostable pulse, the negative transition is coupled to the input of an inverter formed from IC10c. This produces a short positive output pulse from IC10c, which resets the counter and the overflow indicator. The unit is then ready to take another reading.

Figure 4 shows the circuit for the decimal point switching. This is just a matter of driving the decimal point segment of the appropriate display from the positive supply, via current limiting resistor R38. The unit requires a 5 or 6V supply and the average current consumption is approximately 75mA. Four HP7 size cells are adequate as the power source.

Fig. 5 The printed circuit overlay.

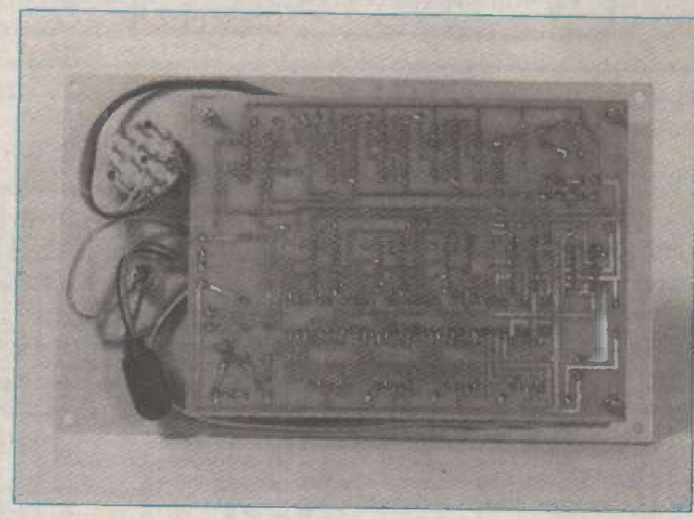




Construction

The printed circuit overlay is shown in Figure 5. All ten of the integrated circuits are CMOS types and, as such, are vulnerable to damage by static charges. Therefore, the usual anti-static handling precautions should be taken when dealing with these components. In particular, they should all be mounted in holders, but should not be fitted into the holders until all the wiring has been completed.

The displays should also be mounted in holders. They are not static-sensitive components and the holders are needed for purely physical reasons. The holders raise the displays slightly, so that they fit closely behind the display window when the board is fixed to the rear of the front panel. Holders having two rows of five pins with 0.6in row spacing are required, but these might prove to be unobtainable. An alternative is to use 'Soldercon' pins, or suitable sockets can be cut from 28 to 40 pin DIL holders. From the electrical point of view, any high brightness seven segment common cathode LED displays can be used. However, in order to fit into this printed circuit layout correctly, the displays must also be 0.5 or 0.6in types having the correct 10 pin encapsulation.



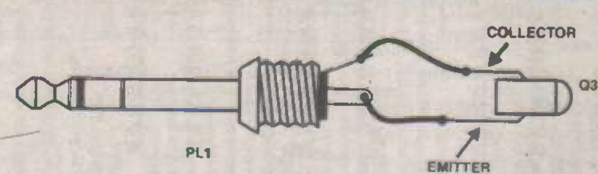


Fig. 6 Connecting TR3 to the jack plug. TR3 has no base leadout wire

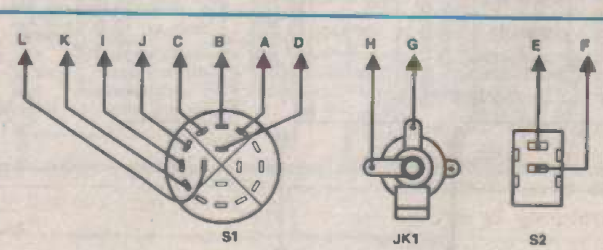


Fig. 7 Details of the hard wiring

X1 is a 4MHz wire-ended (HC-49/U) crystal, which is mounted directly onto the circuit board. The soldered joints should be completed fairly swiftly in order to avoid damage to the crystal. D1 is mounted on the circuit board and its lead-outs should be left quite long, so that it projects several millimetres above the other components on the board. Do not overlook any of the eleven link wires, which are made from 22 or 24 swg tinned copper wire. Double-sided solder pins are fitted to the board at the points where connections to the off-board components will be made.

A largish sloping front case is probably the best choice for this project. The component panel is mounted on the rear of the front panel, well over to the left hand side and component side uppermost. The board is held in place using M3 or 6BA fixings, including spacers to hold the board about 14 to 15mm clear of the front panel. This should bring the tops of the displays within a few millimetres of the front panel. A rectangular 'window' for the displays must be cut in the front panel. A rough initial cut-out can be made using a fretsaw, 'Abrafile', etc., with a small flat file then being used to tidy things up. A piece of red display filter material is glued in place behind the cut-out and a 5mm hole for D1 must be drilled at the appropriate point on the panel.

S1, S2 and JK1 are mounted on the right hand section of the front panel. TR3 could be mounted in the main unit, but in use it is more convenient to have it fitted in a separate probe type assembly. This is connected to the main unit via 3.5mm jack connectors and a twin cable about 0.5m long. It is necessary to Improvise a little with the probe assembly, but it is not difficult to produce a reasonably neat probe based on something like an old ball-point pen.

The SFH305/2 phototransistor only has two lead-out wires, since the base terminal is not externally accessible. The shorter lead is the collector and Figure 6 shows the correct method of connecting TR3 to the jack plug (PL1). The inexpensive SFH309/5 phototransistor also works well in this circuit, but due to its larger diameter of 3mm it will not give good results at fast shutter speeds, unless it is masked down to a smaller effective size. Even with the SFH305/2 results can be significantly improved if it is masked down to an effective width of about 0.3 to 0.5mm. It is worth experimenting a little in order to optimise accuracy.

To complete the unit, the hard wiring is added. This is illustrated in Figure 7 (which should be used in conjunction with Figure 5). S1 is a 3 way pole rotary switch, but in this case only two poles are used. The four HP7 size cells are fitted in a plastic battery holder. Connections to the holder are made via a standard PP3 size battery clip.

In Use

VR1 should be set initially for about one third of maximum resistance. The light threshold level used and therefore the setting of VR1, is not likely to be particularly critical. If, in the light of experience, a lower light threshold level is found to be necessary, try setting VR1 for a higher resistance. If a higher light threshold level is required, set VR1 for a lower resistance.

For the unit to work properly, the camera must be aimed at a reasonably bright light source, which can simply be a torch, a table lamp, or even daylight coming through a window. The lens In the phototransistor renders the sensor quite directional, but it is still necessary to avoid having strong light falling directly onto the sensor. Where the camera to be tested has an interchangeable lens, it is generally easier to get thing working properly if the lens is removed. However, with a little experimentation it should still be possible to get good results with the lens in place. Remember to set the lens for maximum aperture though, so that it transmits as much light as possible through to the sensor.

The 'B' setting of the shutter is useful when trying to get everything set up correctly. This enables the shutter to be held open while the sensor position, etc., are adjusted for reliable operation. The sensor should be positioned quite closely behind a focal plane shutter, but you must obviously be careful not to damage the shutter. Remember to orient the phototransistor so that the shutter runs across its 1mm width, especially when checking the faster shutter speeds. Bear in mind that camera shutters are not generally very accurate, or very consistent. Firing a shutter several times at the same speed setting will usually produce variations of a few per cent from one firing to the next. A shutter that keeps within 20% of its marked speeds is considered to be very good. At the higher speeds, most shutters significantly over expose and you should remember that the timer will tend to give slightly long readings on these speeds. Modern cameras having electronic timing circuits are generally more accurate and consistent than older cameras, which have clockwork timers. However, even some modern, electronically timed shutters are less accurate and consistent than one might expect.

PARTS LIST

Resistors (All 0.25W 5% carbon film)

R1	680k
R2	1k
R3	1k
R4 to R32	390R (29 off)
R33	470R
R34	4k7
R35	1k
R36	10M
R37	100k
R38	470R

Potentiometer

VR1	100k min hor present

Capacitors

C1	100n ceramic
C2	47p ceramic plate
C3	22p ceramic plate
C4	100µ 10V axial elect
C5	470n polyester
C6	47n polyester

Semiconductors

TR1, 2, 4	BC549 (3 off)
TR3	SFH305/2 (see text)
IC1	74HC4024
IC2, 3, 4	4017BE (3 off)
IC5, 6, 7	4026BE
IC9	4013BE
IC10	4001BE
D1	5mm red panel LED
Display 1, 2, 3, 4	7 segment LED, high brightness, common cathode

Miscellaneous

B1	6V (4 x HP7 size cells)
S1	3 way 4 pole rotary (only two poles used)
S2	SPST sub-min toggle
X1	4MHz wire-ended crystal;
JK1	3.5mm jack socket
PL1	3.5mm jack plug

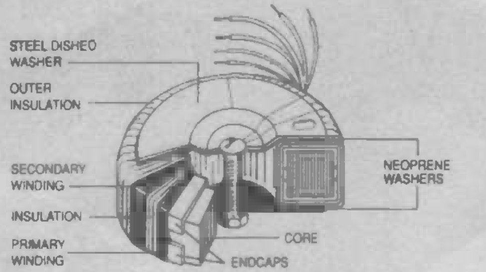
Printed circuit board, sloping front case about 215 x 130 x 78/47mm, control knob, 14 pin d.i.l. IC holder (3 off), 16 pin d.i.l. IC holder (7 off), display holders (see text), battery holder for 4 x HP7 size cells, battery clip (PP3 type), wire, solder, solder pins, etc.

OLP TRANSFORMERS from

JAYTEE

UK Distributor for Standard Toroidal Transformers

- 107 types available from stock
- Sizes from 15VA to 625VA
- Dual 120v primaries allowing 110/120v or 220/240v operation



TYPE	SERIES NO.	SEC VOLTS	RMS CURRENT
15VA	03010	6+6	1.25
£10.68	03011	9+9	0.83
	03012	12+12	0.63
	03013	15+15	0.50
	03014	18+18	0.42
	03015	22+22	0.34
	03016	25+25	0.30
	03017	30+30	0.25
30VA	13010	6+6	2.50
£12.21	13011	9+9	1.66
	13012	12+12	1.25
	13013	15+15	1.00
	13014	18+18	0.83
	13015	22+22	0.68
	13016	25+25	0.60
	13017	30+30	0.50
50VA	23010	6+6	4.16
£13.84	23011	9+9	2.77
	23012	12+12	2.08
	23013	15+15	1.66
	23014	18+18	1.38
	23015	22+22	1.13
	23016	25+25	1.00
	23017	30+30	0.83
	23028	110	0.45
	23029	220	0.22
	23030	240	0.20
80VA	33010	6+6	6.66
£15.43	33011	9+9	4.44
	33012	12+12	3.33
	33013	15+15	2.66
	33014	18+18	2.22
	33015	22+22	1.81
	33016	25+25	1.60
	33017	30+30	1.33
	33028	110	0.72
	33029	220	0.36
	33030	240	0.33
120VA	43010	6+6	10.00
£16.45	43011	9+9	6.66
	43012	12+12	5.00
	43013	15+15	4.00
	43014	18+18	3.33
	43015	22+22	2.72
	43016	25+25	2.40
	43017	30+30	2.00
	43018	35+35	1.71
	43027	20+20	3.00
	43028	110	1.09
	43029	220	0.54
	43030	240	0.50
160VA	53011	9+9	8.89
£19.21	53012	12+12	6.66
	53013	15+15	5.33
	53014	18+18	4.44
	53015	22+22	3.63
	53016	25+25	3.20
	53017	30+30	2.66
	53018	35+35	2.28
	53026	40+40	2.00
	53028	110	1.45
	53029	220	0.72
	53030	240	0.66
225VA	63012	12+12	9.38
£21.04	63013	15+15	7.50
	63014	18+18	6.25
	63015	22+22	5.11
	63016	25+25	4.50
	63017	30+30	3.75
	63018	35+35	3.21
	63026	40+40	2.81
	63025	45+45	2.50
	63033	50+50	2.25
	63028	110	2.04
	63029	220	1.02
	63030	240	0.93
300VA	73013	15+15	10.00
£22.94	73014	18+18	8.33
	73015	22+22	6.82
	73016	25+25	6.00
	73017	30+30	5.00
	73018	35+35	4.28
	73026	40+40	3.75
	73025	45+45	3.33
	73033	50+50	3.00
	73028	110	2.72
	73029	220	1.36
	73030	240	1.25
500VA	83016	25+25	10.00
£29.57	83017	30+30	8.33
	83018	35+35	7.14
	83026	40+40	6.25
	83025	45+45	5.55
	83033	50+50	5.00
	83042	55+55	4.54
	83028	110	4.54
	83029	220	2.27
	83030	240	2.08
625VA	93017	30+30	10.41
£32.64	93018	35+35	8.92
	93026	40+40	7.81
	93025	45+45	6.94
	93033	50+50	6.25
	93042	55+55	5.68
	93028	110	5.68
	93029	220	2.84
	93030	240	2.60

13.8V DC POWER SUPPLY TRANSFORMERS

8C267	500VA	18+18V	£32.64
9T845	675VA	16.1V	£38.06

Prices include VAT and carriage

Quantity prices available on request

Write, phone or fax for free Data Pack

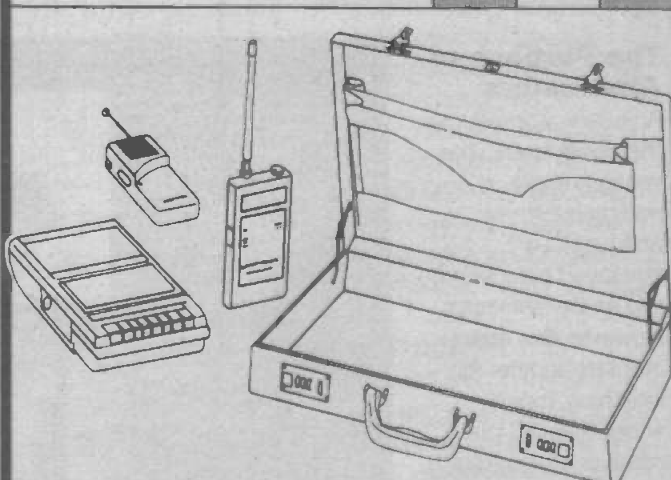
Jaytee Electronic Services

Unit 171/172, John Wilson Business Park,
Whitstable, Kent CT5 3RB. U.K.
Tel: (0227) 265333 Fax: (0227) 265331

SURVEILLANCE

SURVEILLANCE

A SMALL SAMPLE OF OUR RANGE	KIT	MODULE	PROF. FINISHED
ROOM TRANSMITTER RT1 An extremely sensitive miniature transmitter with long battery life. Dimensions: 20 x 20mm	9.95	13.75	19.00
MAINS TRANSMITTER MT4 Can be connected inside any equipment that is mains powered. Dimensions 35 x 20mm	19.75	31.50	45.00
TELEPHONE TRANSMITTER TTS Small enough to conceal within a telephone. Will transmit both sides of a conversation (series connection) Dimensions: 10 x 20mm	12.75	17.50	25.00
TELEPHONE SOCKET TRANSMITTER TSTS Replace your telephone socket with this one within which a transmitter has been concealed.	14.74	—	29.00
ROOM AND TELEPHONE TRANSMITTER RTT Operates as a room transmitter, then switches to telephone transmitter mode during telephone calls. Dimensions: 30 x 25mm	31.50	45.50	68.00
AUTOMATIC TELEPHONE RECORDER SWITCH TRS2 Record telephone conversations with this interface unit and your own tape recorder. Dimensions: 36 x 50mm	16.80	25.90	39.00
AUTOMATIC TELEPHONE RECORDER ATR1 Adapt the tape recorder included to record telephone calls automatically.	34.95	—	59.00
TELEPHONE TAP ALERT TTA1 Visual warning of any invasions of privacy on your telephone line. Dimensions: 38 x 52mm	21.95	31.50	45.00
RF DETECTOR RFD1 Highly sensitive hand-held detector. Range between 10Mhz and 600Mhz. Silent operation. Dimensions: 70 x 50mm	42.75	69.00	95.00
CAMERA DETECTOR CD8 Detects hidden video cameras (even miniature CCD models). Dimensions: 63 x 38mm	69.00	89.00	125.00
RECORDING BRIEFCASE RBC1 Completely discreet recordings at a value for money price.	—	—	145.00
SHOTGUN MICROPHONE AMPLIFIER SMA Ideal for surveillance. The amplifier will pick up sounds from a long distance.	24.95	36.00	48.00
SIGNALLING TRANSMITTER SIGT Sends a continual audio pulse. Can be integrated into alarm, tracking or warning systems. Dimensions: 20 x 50mm	21.95	34.89	45.00
TELEPHONE AMPLIFIER TA5 Connected directly to the telephone, this unit will amplify both sides of a telephone call. Dimensions: 25 x 52mm	10.95	16.95	19.95
PROFESSIONAL SOUND TO LIGHT UNIT SK72 Custom built for disco or home use. Audio signal divided into bass, mid and treble bands, with internal microphone and spotlight option. Dimensions 210 x 45mm	21.95	32.49	44.95
MICRO METAL DETECTOR MMD Detect the presence of ferrous and various non-ferrous metals. Useful for all those DIY jobs. Dimensions: 40 x 25mm	9.95	16.95	—



Please add £2.00 P & P to all orders and 17.5% VAT on all U.K. orders.

For full catalogue please send two 1st class stamps or 2 IRC'S

172 Caledonian Road
Dept ET
London N1 0SG

CANAL BRIDGE AUDIO

071-837 4423

Palesaver Load/ Attenuator

Also known as the spouse saver, this little project acts as both a dummy load and as a loudspeaker attenuator. Design by Dave Bradshaw

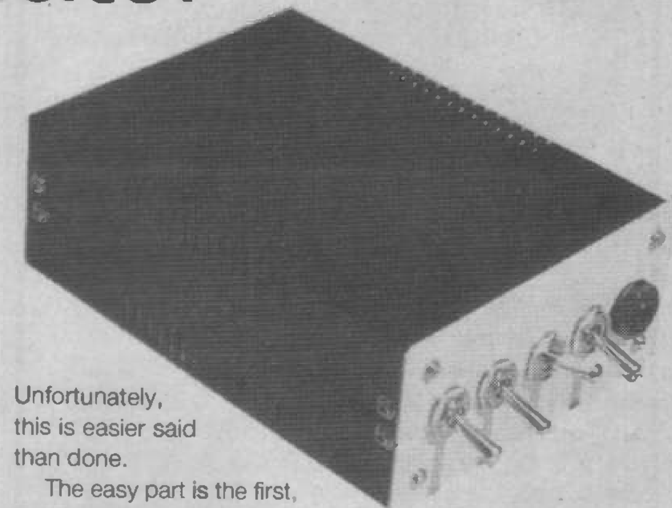
This little unit serves two purposes. Firstly, it acts as a flexible loudspeaker attenuator, but secondly, it is also an accurate 8 ohm load, for setting up and testing power amplifiers. It was mainly designed for the first use, as an attenuator for the Paleface series of amplifiers, the second use coming as a bonus. There are three versions, with different power levels: 25W, 50W and 100W.

An attenuator makes it easier to play instrument amplifiers at low volume levels for practising. Even the Paleface Minor's 15W is very noisy indeed in a domestic environment. My experience, when using it for regular practice, was that cutting the signal by a few dB just wasn't enough. Quite a large degree of attenuation was needed, particularly as some of the effects I was using generated lots of hiss and mains hum (I'm proud to say that the amp itself contributed hardly any). The attenuation needed to be 10 to 15dB and there had to be an even quieter setting for late night use.

Now, using the attenuator, low level volume settings are much more controllable. A slip of the finger doesn't result in instant deafening for the neighbours. Of course, it's not really like playing loud, but it is now possible to overload the power amplifier - and obtain the much sought-after valve distortion - without alienating the entire family.

The Purpose of Attenuators

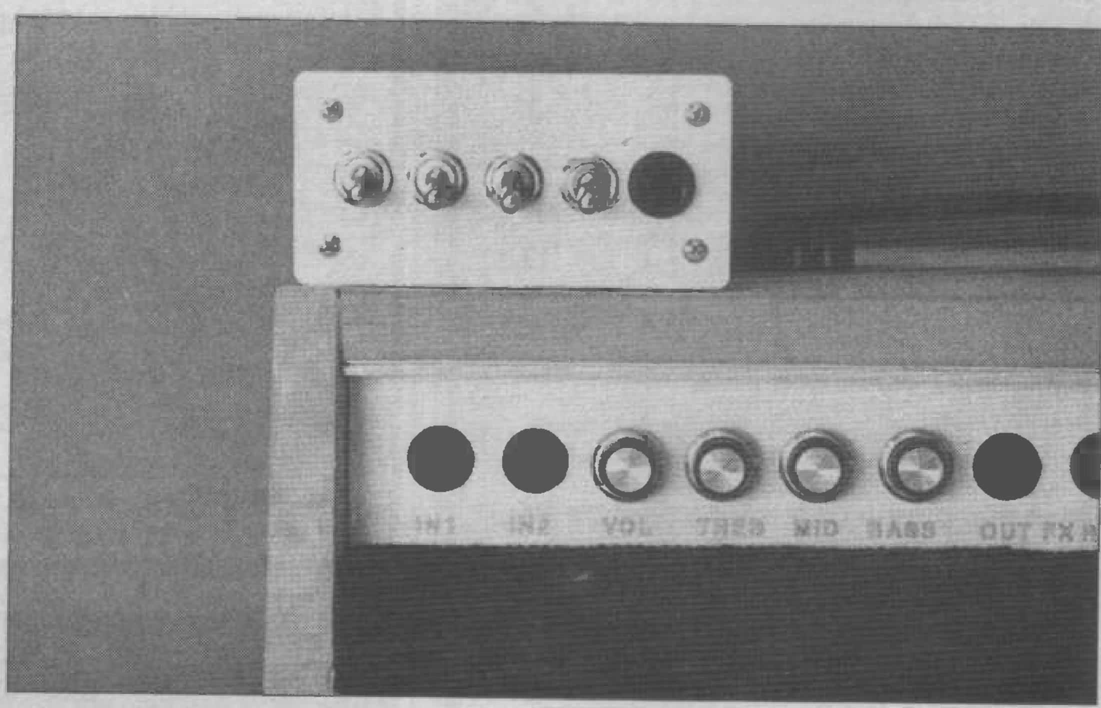
An attenuator reduces the signal levels. The voltage divider, a common form of attenuator, is employed here with a few embellishments. However, this attenuator has another job - matching Impedances. Ideally, loudspeaker attenuators are two-way mimics, the loudspeaker should see the same source impedance as it would from the amplifier and the amplifier should see the same load.



Unfortunately, this is easier said than done.

The easy part is the first, imitating the amplifier's output impedance, but even this is not straightforward. Transistor amplifiers often have output impedances well under an ohm. To imitate this you have to put a very low resistance, say a tenth of an ohm, in parallel with the loudspeaker, but then you are not going to get very much signal going into the speaker. The lowest impedance the Palesaver has is slightly under 0.5 ohm, with the output level switch set to LOW and all the ballast resistors out of circuit. Although this is still higher than the better semiconductor amplifiers, it is going to be comparable with the minimum impedance added by most cross over units.

However, valve amplifiers generally have much lower levels of feedback in the power amplifier and, as a result, they have much higher impedances. For example, the output impedance of the Paleface Minor guitar amp varies from around 4 ohms at



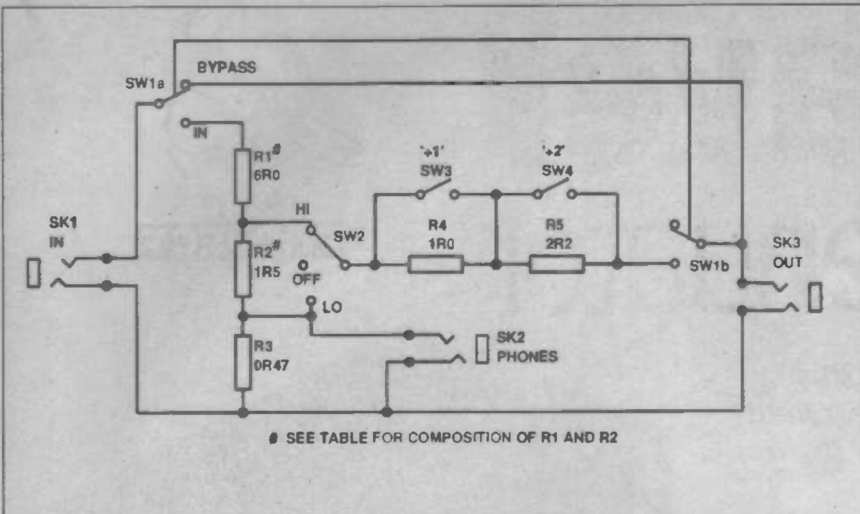


Fig. 1 The circuit diagram of the Palesaver attenuator.

100Hz to 2 ohms at 1kHz, almost completely resistive. Here we will need to add extra resistance to the basic attenuator. There are two switchable ballast resistances to increase its output impedance. However, the Palesaver cannot emulate the frequency dependency, so a mid-value should be used. For example, to emulate an output impedance of around 3 ohms, use a single 1 ohm ballast resistor on the HIGH output setting, but 2 ohms on the LOW setting.

The other aspect of a loudspeaker attenuator is how well it mimics the impedance of the loudspeaker which the amplifier normally drives. Loudspeakers have lots of variation in their impedances and they also have strong reactive elements. The Palesaver confines itself to emulating the resistive part of the impedance only. If I ever get a year or two to experiment with a room full of acoustic measuring gear, I'll make Palesaver II emulate the frequency-dependent reactive part of the typical loudspeaker.

The Circuit

An input selector, SW1, allows the attenuator to be taken completely out of circuit. With the attenuator in circuit, the signal passes through three resistors in series, the top one (R1) of around 6 ohms, the second (R2) of around 1.5 ohms and the third (R3) at 0.5 ohms. Switch SW2 controls the tapping point that the loudspeaker is attached to. It is a centre-off switch, so the loudspeaker can be disconnected completely.

Using the limited range of values of high power resistors, I have assembled multiple parallel resistors for R1 and R2, to get as close as I can to 8 ohms overall impedance, with at least the rated power capability. I have used 3W to 10W resistors - I considered using 25W types, but the very limited range of values and expense stopped me. Table 2 shows the values for the three different versions. In fact the 25W and 50W versions are identical except for power ratings. However, the 100W version had to have a different R2, and this meant a small change in R1 as well. Assuming perfect components, all versions are well within 1% of 8 ohms in input impedance with no loudspeaker connected. Even with some component variance, the impedance will be pretty close, as paralleling resistors together effectively averages their values.

Output Level Settings	HIGH	LOW
Power Attenuation	13.5dB	24.5dB
Output Impedance (no ballast resistors, zero source impedance)	1.6 ohm	0.45 ohm

Table 1 Attenuation and output impedance of the Palesaver, all versions.

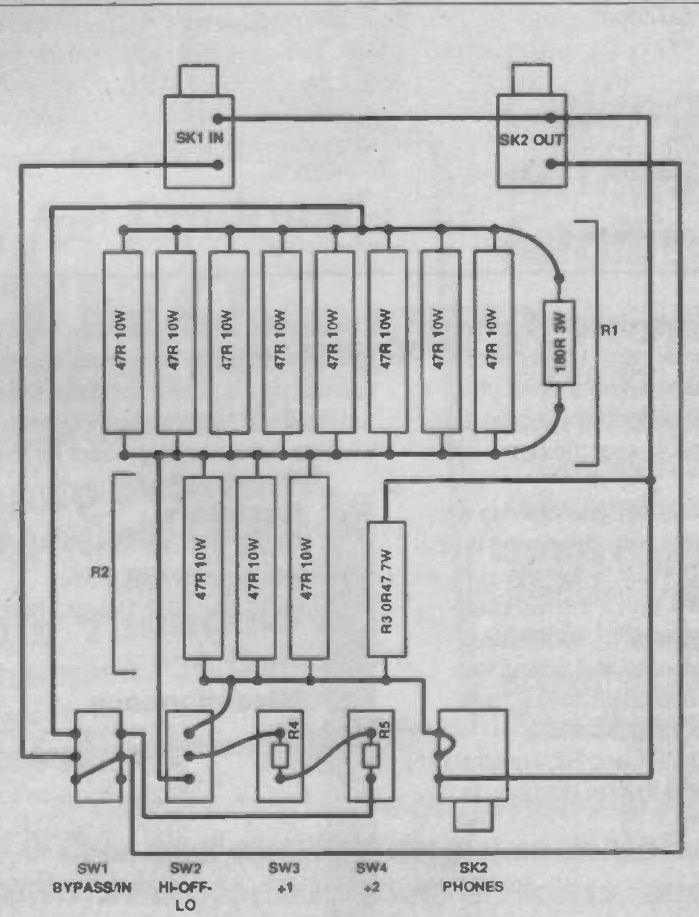


Fig. 2 Internal layout of the Palesaver.

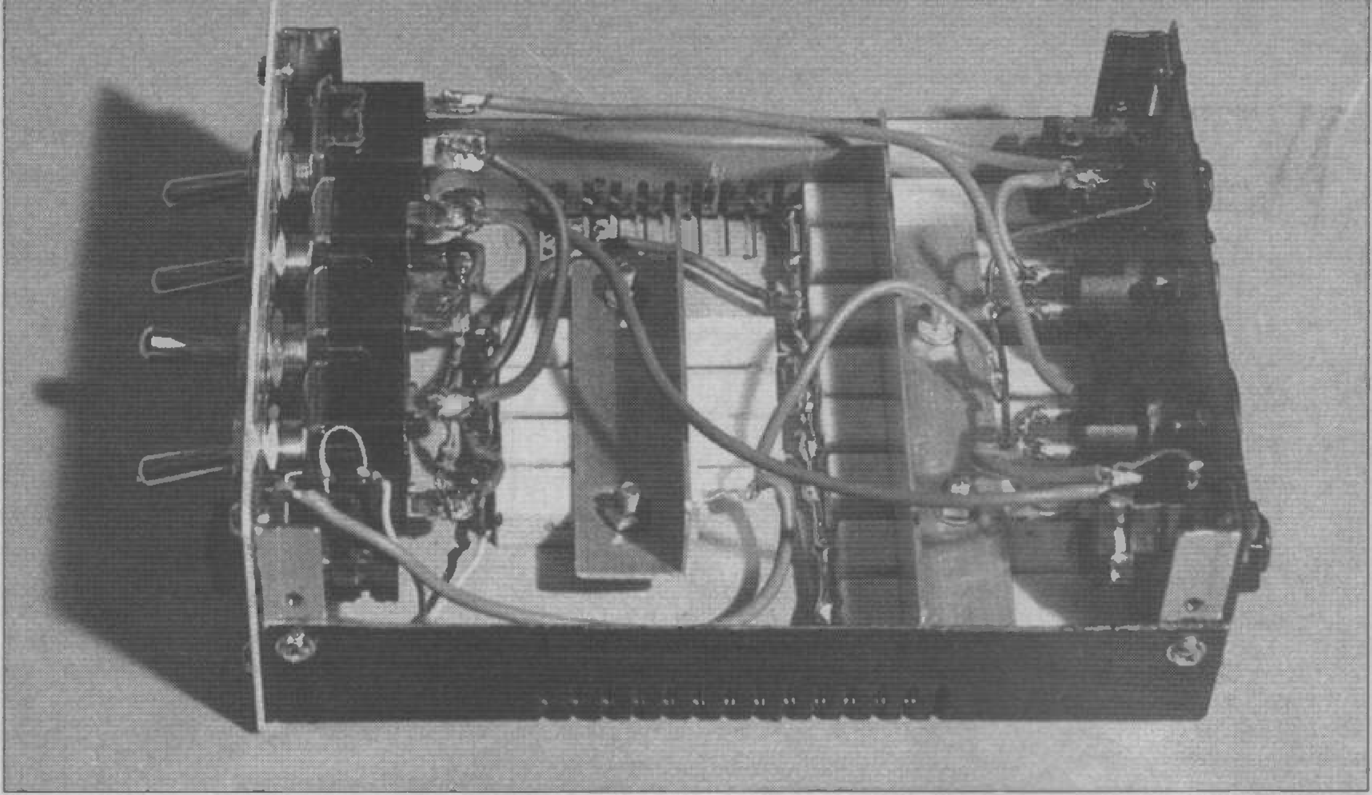
Table 1 shows the attenuation levels and the output impedances without ballast resistors. To emulate valve amplifier outputs, the ballast resistors (R4 and R5) can be switched in or out of the signal path by two switches (R3 and R4).

When it is being used for measurements, the speaker should be turned off as this affects the impedance. A phones socket is included so that the output con be monitored over phones. Most types of phones will make negligible difference to the input impedance of the unit.

Construction

The layout shown in the diagram and photographs is for the 100W unit, but the 25W and 50W versions are similar. The extra connectors in the prototype are XLR sockets in parallel with SK1 and 3, to give some extra versatility with the connections.

The main constructional effort goes into preparing the case. As the unit gets hot, I



Power	25W	50W	100W
R1	8 x 47R 3W (5.88 ohm)	8 x 47R 7W (5.88 ohm)	8 x 47R 10W + 180R 3W (5.69ohm)
R2	2 x 3R3 3W (1.65 ohm)	2 x 3R3 5W (1.65 ohm)	3 x 4R7 10W (1.87 ohm)
R3	0R47 2W	0R47 3W	0R47 7W
Resistance with no load	8.00 ohm	8.00 ohm	8.03ohm
Resistance with 8 ohm load on HIGH setting and no ballast	7.55ohm	7.55ohm	7.50ohm

Table 2 Component values for different power levels.

built it into a metal box with no plastic fittings or vinyl covering and painted it using heat-resistant black paint. I clamped the high power resistors to the case bottom, using a piece of aluminium L-channel and some bolts, so that whole case acts as a heatsink. I used some epoxy resin to seat the clamp on the resistors.

With this type of construction, the 100W Palesaver can withstand around five to ten minutes of full power, depending on the amount of ventilation. To withstand 100W RMS for long periods, the Palesaver needs a heatsink with a thermal coefficient of around 0.5C/W, or two heatsinks with coefficients of 1.1 to 1.2C/W. Rather than choosing a case and bolting the heatsinks to it, it is probably cheaper and easier to build a simple case using the heatsinks as an integral part.

To make up the compound resistors R1 and R2, I used short lengths of copper wire from mains cable to form busbars, to which I soldered the individual resistors.

The remainder of the construction is straightforward.

BUYLINES

Nothing here should present problems. The high power resistors came from Maplin, but other suppliers like Electrovalue and Cricklewood stock suitable types. It's always safer to under-rate resistors, so go for the power above rather than below if you cannot get the power specified. Buy the case once you have the resistors, switches and connectors, so you can work out whether there's enough room for them all.

PARTS LIST

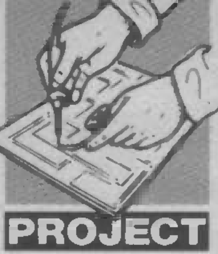
Resistors

R1,2,3	See Table 1
R4	0.47R 0.5W
R5	2R2 1W (or 2 ohm 3R9 0.5W)

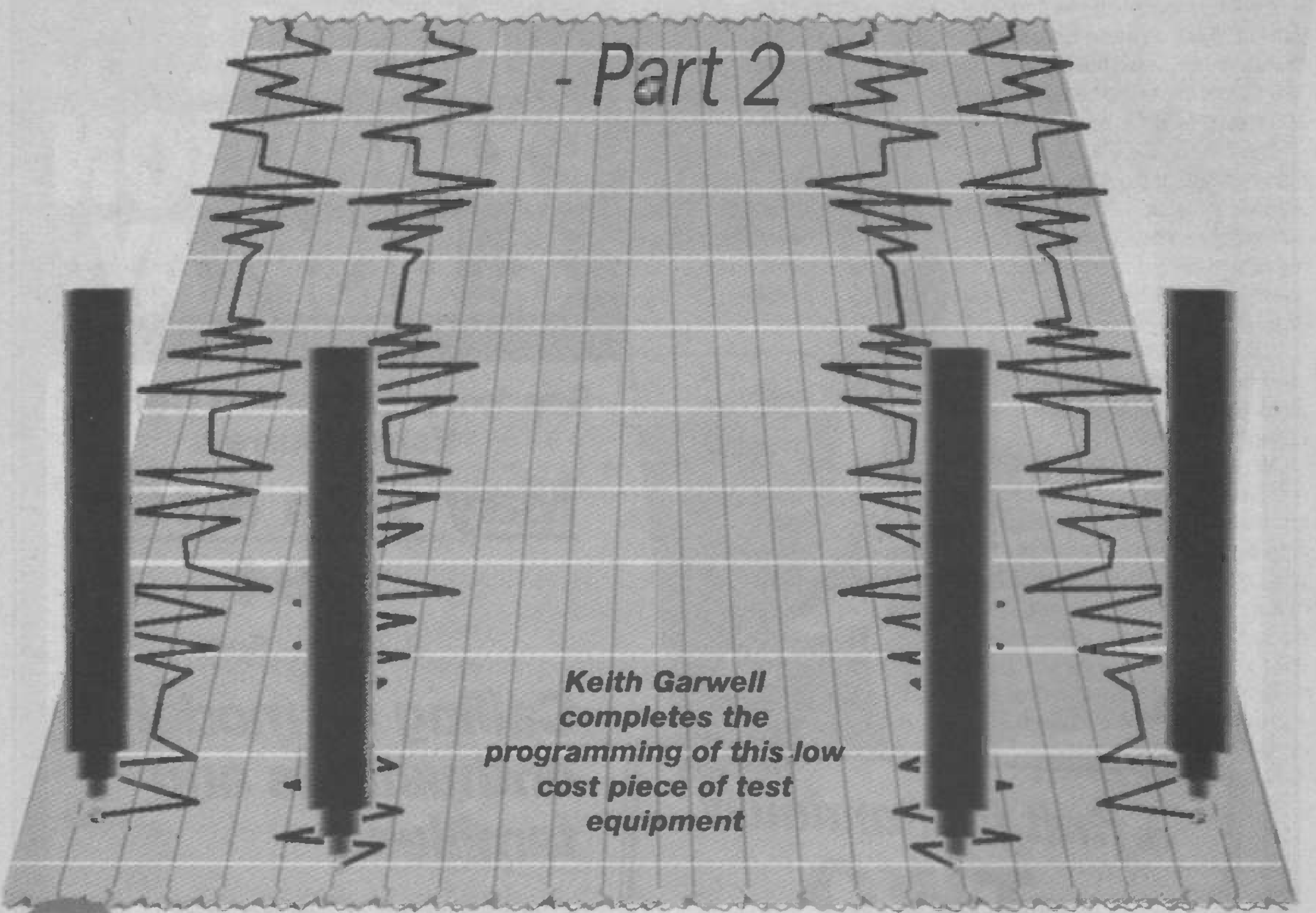
Miscellaneous

SW1	DPDT toggle switch
SW2	SPDT centre off toggle switch
SW2,3	SPST toggle switches
SK1,3	mono jacks, XLR, or any suitable connectors, to choice
SK2	headphone socket (e.g. stereo jack)

Case, wire, heat resisting paint, aluminium L-channel extrusion for clamping resistors, M4 bolts to fit clamps



A Virtual Chart Recorder



- Part 2

Keith Garwell completes the programming of this low cost piece of test equipment

Now that we have the hardware for the chart recorder and the ADC routine at line 200, the next step is to plan and then write the rest of the program. The outline of the software is quite simple viz-

```
Set up the buffer and other variables

Put up headings

Read in from the user any controls e.g.
        Clock time, number of traces (inputs)
        Any notes for the start of the run
        Starting time

Calculate any values required for clock, etc.
Calculate the maximum duration of the run and put
it on the screen

Start recorder loop
        Read keyboard to see if action required
        Read ADCs and put on screen and in buffer
        Check for buffer full
        Wait for clock tick
Repeat loop

Perform any actions required
Back to loop or finished

If finished
        End of run notes
        Dump data to file

END
```

Although simple the outline does require a number of design questions to be answered. These are centred around two functions - how to display the data on the screen and how to save the data in the buffer? Unfortunately, life is made a little difficult because these two questions cannot be dealt with in isolation.

The size of the screen in this case has to be measured in pixels and the usual common values are around the following, horizontal first.

256 x 192
640 x 200
640 x 350
640 x 480
720 x 348

I will assume the chart will be drawn horizontally to fit the normal convention of time along the X or horizontal axis and amplitude along the Y axis. This doesn't have to be the case and it should be fairly easy to turn the argument through 90 degrees.

It will be most convenient to set the horizontal axis in a multiple of 60, so that it fits either seconds or minutes. Consequently, using the above figures then 240, 600, 660 or 720 fits the bill. In the demonstration program coming shortly, 600 seems to fit the bill nicely.

The vertical axis will, on the face of it, be dependant upon the resolution of the ADC. However, there is really a more immediate consideration, namely the user. I think it will be difficult to appreciate a trace more than 128 pixels vertically. Indeed my chart recorder uses a Dragon, the ADCs of which only have a resolution of 6 bits, i.e. 0 to 63, giving charts only 64 pixels deep and I have never (so far) found this restrictive.

So those are the basic arguments about the screen. When I come to talk about the software in detail it should be possible to make these dimensions variable or at least easily changed, by changing the code.

Now for the buffer. At first sight there doesn't seem to be any problem with the buffer. Since most of the ADCs are 8 bit, just bang the data in, one sample per byte. Which is fine, so long as it's only ADC data that's being put into the buffer. But what about the notes at the start and end of the run? How about some comments during the run? What about details of the run, like start time, tick time, etc.? Where will they be kept? Will the ADC data ever be sent over a serial RS232 link? I do this, sending the data from the Dragon buffer to a file on the PC and the snag is that low values are used as control characters on serial links. In fact, decimal 26 is the end of file character and, if sent, would stop the PC in its tracks!

The only problem really is to mark the start and finish of different types of data. Why not have some control codes such as 255 for start of ADC data and 254 for end of ADC data. 253 for start of text message and 252 for end of text message.

Take this a step further and never use a value of less than 40. If we do this, then all the data can go into the buffer of whatever type and there is no problem transferring it around any system, or recording it on disk and so on.

If we are using 8 bit ADCs, how about restricting the scale to 0 to 200, i.e. 0 to 2 V? Then adding 40 so that nothing less than 40 appears in the data. That gives a maximum ADC data value of 240, leaving 241 to 255 to be used as control codes.

If you are going to use one of the units that will digitise up to 16 bits, then a similar technique could be used, while using two bytes of the buffer for each item.

There are various ways of encoding data of different types, as our MIDI users will know. For example, if the byte has its most significant bit set, it's a control code and there is only one byte to it. If the most significant bit is zero, then it is the first byte of a pair containing ADC data.

Software in Detail

Its time to get down to the nitty gritty, enough talking. I am going to design a system using BASIC, a PC and an ADC-16. This will enable me to illustrate most of the points, using a fairly universal language and a hardware sub-routine for gathering the data. This will be the only bit that might be different to your own system.

```
5 DATA Chart Recorder for PC and ADC-16
  V1.00
8 DATA Copyright K.Garwell 1993.
```

(But free etc.!)

```
10 DEFINT A-Z:DEF SEG=&H9000:DIM
   ADCVAL(7),DIFFVAL(8)
20 DIFFVAL(0)=128:DIFFVAL(1)=64:DIFFVAL
   (2)=32:DIFFVAL(3)=16
30 DIFFVAL(4)=8:DIFFVAL(5)=4:DIFFVAL
   (6)=2:DIFFVAL(7)=1
40 DIFFVAL(8)=1:BUFLIMIT!=64000:RESMODE
   =15
90 GOTO 1000
```

The DEF SEG defines a segment address 64K below the top of my memory, which is 640K. If you don't have this facility and the buffer has to be within the BASIC area, then use the CLEAR instruction, e.g. :CLEAR 100,&H2900-1:. This will save 100 bytes for strings and set the top of memory so that the buffer can start at &H2900. This allows sufficient for the program I should think. If you get an out of memory error, increase the value in steps until it works. BUFLIMIT! sets the value at which the buffer warning is given, while RESMODE defines the resolution and mode for use by the line 200 routine.

```
100 IC$=INKEY$:IF IC$="" THEN 100
110 RETURN
```

A simple keyboard routine to read single characters.

```
200 FOR CHAN=0 TO 7
210 CTRLBYTE=RESMODE+CHAN*32
220 PRINT #1,CHR$(CTRLBYTE);
230 IF LOF(1)
230 IF LOF(1)<0 THEN 230
240 ADC$=INPUT$(3,#1)
250 ADCVAL(CHAN)=ASC(MID$(ADC$,3,1))
260 IF ADCVAL(CHAN)<MINVAL THEN
ADCVAL(CHAN)=MINVAL
270 IF ADCVAL(CHAN)>MAXVAL THEN
    ADCVAL(CHAN)=MAXVAL
280 NEXT:RETURN
```

This is the same as the previous driver, except that the ADC value is limited to 8 bits positive, otherwise more than 1 byte would be needed to store it. The other difference is that the channel number is generated within the routine. RESMODE is part of the control byte and identifies resolution and mode. In addition, two lines are added, 260 and 270, which enforce the limits allowing the inclusion of control characters in the buffer.

```
300 LINE INPUT"MSG ? ";IC$
310 POKE BPTR!,253:BPTR!=BPTR!+1
320 FOR I=1 TO LEN(IC$)
330 POKE BPTR!,ASC(MID$(IC$,I,1)):BPTR!=
    BPTR!+1
340 NEXT
350 POKE BPTR!,252:BPTR!=BPTR!+1 360
    IC$="":RETURN
```

This routine allows a message to be inserted in the buffer, updating the buffer pointer BPTR! as it goes along. The message is surrounded by two control characters, values 253 as start-message and 252 as end-message.

That's all the subroutines, now for the start of the main code.

```
1000 SCREEN 2:CLS:RESTORE:READ IC$:PRINT
     IC$:READ IC$:PRINT IC$
```

Put up the header messages. Screen 2 indicates the type of graphics screen in use and is one of the commands/functions that does depend on the origin of the BASIC. It is dependant also on the machine in use. For example, to the BASIC compiler which I usually use, SCREEN 2 indicates the high resolution graphics screen often referred to as "Hercules". However, to the ancient IBM XT that I have also used, this means the colour graphics screen. Oddly enough, therefore, this program will run unchanged on either machine, either compiled or interpreted.

```
1010 PRINT"Dump, Stop, Restart, Quit,
     Message"
1020 INPUT"Tick time in seconds ";TICK-
     TIME:LOCATE CSRLIN-1,40
1030 INPUT"Number of traces ";NUMTRACES
1040 LINE INPUT"Start message ?
     ";STMSG$:LOCATE CSRLIN-1,40
1050 PRINT"Chart duration ";
1060 PRINT USING "####.# HOURS";2^16
     /NUMTRACES*TICKTIME/3600
1070 OPEN"COM1:9600, N,8,1,RS,CS, DS,CD"
     AS #1
1080 INPUT"Start time hhmm ";STTIME$
1090 TW=100:OF=190:DS=40:BPTR!=1:MINVAL=
     0:MAXVAL=200
1100 LOOPTIME!=INT(TIMER):POKE 0,255
```

Fairly straightforward, setting up the working variables after reminding the user (1010) what the options will be when running. As I am going to use a full segment of 64K for the buffer, line 1050 uses 2^16 as the buffer length. Any other way of giving the correct figure for 64K will do. This method just saved me from having to think about it as I wrote it.

TW is the trace width and OF the offset to position the traces up or down the screen. 190 is suitable for many screens but can be changed as necessary, to accommodate particular machine/BASIC combination.

DS is the data shift added so that no values less than 40 are inserted in the buffer, in case its contents are ever passed over a serial link where low values may be interpreted as control codes. BPTR! is the buffer pointer. Note that the buffer pointer cannot be an integer as declared at the beginning in line 10, because it would cause overflow. A BASIC integer only handles - 35K to +35K and so would be too small for a 64K pointer.

MINVAL and MAXVAL are the limits placed on the ADC value to allow control codes and data to be included in one byte. I have used two letter identifiers in one or two places to shorten the lines of code, really only for the purpose of this article, give them their proper names by all means. A word about the time statements later, and lastly poke 255 as the first byte of the buffer, indicating beginning of ADC values. I am going to take the easy option and have two separate files, one for text and one for binary.

Now for the main loop

```
1140 IC$=INKEY$:IF IC$>"" THEN 2000
1150 LINE(X,OF)-(X,OF-TW),0
1160 IF X<600 THEN LINE(X+1,OF)-(X+1,OF-
     TW),1
```

The first line checks to see if a key has been pressed and, if it has, bombs off to line 2000 to do something about it. The code at line 2000 doesn't exist yet (I hadn't written it at the time of writing - remember this has all been edited in the light of experience since it was first written) but it's a good line number to start on when we get there. The next two lines clear a vertical line and draw the cursor. The 0 and 1 refers to black and white - again it may be machine/BASIC dependant.

Now for the heart of the matter. To actually put useful information on the screen.

```
1200 GOSUB 200
1220 FOR CHAN=0 TO NUMTRACES-1
1230 PSET(X,OF-ADCVAL (CHAN)/2):POKE
     BPTR!,ADCVAL(CHAN)+DS:BPTR!=BPTR!+1
1240 NEXT
1250 X=X+1:IF X>600 THEN X=0
1260 IF BPTR! <BUFLIMIT! THEN 1300
1270 PRINT"BUFFER OVERFLOW, PRESS ANY KEY
     TO DUMP"
1280 GOSUB 100:GOTO 3000
```

Again fairly straightforward. Each channel selected by NUMTRACES (it could have been NUMCHANS) is put on the screen and into the buffer. If the screen pointer, or X as I've called it, is greater than 600, then it starts again at 0. This is one of the best of reasons for having the cursor. 600 seemed a suitable choice of value as many systems provide a horizontal resolution of 600-720 or more.

Likewise, the buffer pointer is checked. If it has reached the end of the buffer, we must stop the recorder and make it clear that we have run out of buffer space.

The next step is slightly tricky. We have to wait until the tick time has expired before going round the loop again for the next set of samples. On the PC this is fairly easy to achieve as we have two options. There is a TIMER, which gives the time since midnight in 100ths of a second and a TIME$, which returns the time in hours, minutes and seconds. Either of these can be used, it's just a question of getting the thinking straight to allow for the advent of midnight in one case and the clock number base of 60 for seconds and minutes.

There is also the possibility of another type of TIMER function, as is provided on the Dragon. This has a timer which ticks 50ths of a second but which is not linked to real time. It can be set, e.g. :TIMER=0: and read, e.g. :TI=TIMER:. The problem with this is that you may not know at what value the timer spills, i.e. goes back to zero. If this is the case, try the following. I have used fictitious line numbers so as not to confuse it with the program for the PC.

```
X000 IF TIMER<LT THEN X000 ELSE LT=LT+TT
X010 IF LT>50000 THEN TIMER=0:LT=TT
X020 GOTO start of loop
```

LT is the loop time, the time at which the loop should continue. TT is the number of ticks between readings, as set at the beginning of the run. In this case it is seconds multiplied by 50.

At the beginning of the run, LT is set equal to TT. Thus, at the end of the loop, the program waits for this value to be reached. TT is then added to LT to give the value for the next time round and so on, but not ad infinitum because at some point the time will spill to zero (the equivalent of midnight for the PC type of timers already mentioned). To avoid trying to get the arithmetic right, the second line, X010, resets the counter when it gets to 50000.

However, with the PC we have to get the arithmetic right because resetting the timers would alter the PC's clock.

Using the PC timer function is easiest, so here goes.

```
1300 LOOPTIME!=LOOPTIME!+TICKTIME
1310 IF INT(TIMER) <LOOPTIME!-86400 THEN
     LOOPTIME! =LOOPTIME!-86400
1320 IF INT(TIMER) <LOOPTIME! THEN 1320
1330 GOTO 1140
```

First calculate LOOPTIME, the time at which the loop repeats and then, in line 1310, check that the timer has not reset, i.e. just gone past midnight, and correct the LOOPTIME if it has by subtracting 86400, the number of seconds in a day. Then wait for the time to expire in line 1320.

This timer routine is written such that the time is in seconds and the fastest recording speed is therefore 1 sample every second. The TIMER function usually returns hundredths or tenths of a second as a decimal fraction (hence the INT functions) so, in fact, the program could be tweaked to run faster than in 1 second steps.

In any case, it would be wise to add a line which checks that the program is not running slow, by adding a line which checks for this in front of line 1320. Do the experiment with all channels selected. For instance:

```
1315 LOCATE CSRLIN,1:IF INT(TIMER)>LOOP-
     TIME! THEN PRINT"L"; ELSE PRINT"E";
```

The "E" indicates early, i.e. ready and waiting. I'm sure you will guess what the "L" stands for! This would give, by experiment, the fastest the program will run - then take the line out. I have tried this program on an early IBM and it ticks seconds perfectly with all 8 channels in operation.

Next the actions, dump, quit, etc.

```
2000 IF IC$="d" THEN 3000
2010 IF IC$="s" THEN END
2020 IF IC$="q" THEN SYSTEM
2030 IF IC$="r" THEN RUN
2040 IF IC$="m" THEN GOSUB 300:GOTO 1140
2050 GOTO 1140
```

The actions offer dump to disk, stop but remain in BASIC, quit, i.e. leave BASIC, restart and message, i.e. insert a message in the buffer. You will find that after inserting a message it ticks quickly to make up the time lost while typing the message. I have found the in-line message very useful to note unforeseen changes during a run, e.g. "It just blew up!".

Which leaves only the dump to disk.

```
3000 LINE INPUT"End message ? ";ENDMSG$
3010 INPUT"File name without suffix
     ";FILENAME$
3020 IF FILENAME$="" THEN RUN
3030 OPEN"O",#2,FILENAME$+".CRT"
3040 PRINT #2,STMSG$;":";STR$(TICK-
     TIME);":";STR$(NUMTRACES);":";
3050 PRINT #2,STTIME$;":";ENDMSG$
3060 CLOSE #2

3100 POKE BPTR!,254
3110 BSAVE FILENAME$+". CRB",0,BPTR!+1
```

Nothing very spectacular here, I even took the easy way and put the setting up text in one file, filename.CRT and the ADC data in another called filename.CRB. The first is a simple text file, the second a simple binary file. And that is why the file name is ask for "without suffix".

So here are the last two lines -

```
3120 PRINT"Finished" 3130 GOSUB 100:GOTO
     2000
```

The gosub line 100 is so that nothing is cleared from the screen until a key has been pressed.

The Display Program

Although the chart recorder program puts the trace(s) on the screen as well as in the buffer, it is useful to have a program which will replay the recording.

Much of what follows will have appeared already in the recorder program and the comments will apply to this also. Anyway here it is.

```
5 DATA Chart Recorder Display for ADC16
  V1.00
8 DATA Copyright K.Garwell 1993
10 DEFINT A-Z:DEF SEG=&H9000:DIM
   ADCVAL(7)
90 GOTO 1000
```

Not much setting up this time and the comments about the buffer, DEF SEG, etc., will be the same as before. In fact the statements in this program should be the same as those in the recorder program.

```
100 IC$=INKEY$:IF IC$="" THEN 100
110 RETURN
```

Wait for a key being pressed.

```
300 LINE(X,OF)-(X,OF-TW),0:IF X<600 THEN
    LINE(X+1,OF)-(X+1,OF- TW),1
310 RETURN
```

The same code as used to clear a line and set the cursor but this time used also to mark the position at which comments were made by means of the in line message facility.

```
1000 SCREEN 2:RESTORE:READ IC$:PRINT
     IC$:READ IC$:PRINT IC$:PRINT
```

Put up the heading and then read all the control values and the start and end messages from the text file filename.CRT. These were all separated by colons so the code looks for the colons to find the appropriate fields.

```
1010 INPUT"FILE NAME WITHOUT SUFFIX
     ";FILENAME$: LOCATE CSRLIN- 1,40
1020 OPEN"I",#2,FILENAME$+".CRT"
1030 LINE INPUT #2,TEXT$
```

```
1040 COLON=INSTR (1,TEXT$,":")
1050 STMSG$=LEFT$ (TEXT$,COLON-1)
1060 START=COLON+1
1070 COLON=INSTR(COLON+1,TEXT$,":")
1080 TICKTIME=VAL(MID$(TEXT$,START,COLON-
     START))
1090 START=COLON+1
1100 COLON=INSTR(COLON+1,TEXT$,":")
1110 NUMTRACES=VAL(MID$(TEXT$,START,
     COLON-START))
1120 START=COLON+1
1130 COLON=INSTR(COLON+1,TEXT$,":")
1140 STARTTIME$=MID$(TEXT$,START,COLON-
     START)
1170 ENDMSG$=RIGHT$(TEXT$,LEN(TEXT$)-
     COLON)
1180 CLOSE
1190 PRINT"Start msg ";STMSG$
1200 PRINT"Tick time seconds ";TICK-
     TIME;:LOCATE CSRLIN,40
1210 PRINT"Num traces ";NUMTRACES
1220 PRINT"Start time
     ";STARTTIME$;:LOCATE CSRLIN,40
1230 PRINT"End msg ";ENDMSG$
```

The descriptors ticktime, etc., having been recovered from the text file, now recover the ADC data from the binary file.

```
2000 BLOAD FILENAME$+".CRB"

2200 TW=100:OF=190:DS=40:BPTR!=0:TRACE=0:
     X=0:MSG=0
2210 GOSUB 300
```

Variables set up and cursor on screen, now read the buffer byte by byte.

```
2300 BUFVAL=PEEK(BPTR!):BPTR!=BPTR!+1
2310 IF BUFVAL=255 THEN 2300
```

ADC data starts skip to next byte

```
2320 IF BUFVAL=254 THEN PRINT"
     Finished":GOSUB 100:GOTO 4000
```

ADC data ends, finished but wait for key press before exit.

```
2330 IF BUFVAL=253 THEN MSG=-
     1:LINE(X,OF)-(X,OF-
     TW),1:PRINT"/";:GOTO 2300
```

Start of inline message detected. Set the MSG flag to show a message is in progress, set the cursor to show where message was inserted, print a / to show start of message (there might be more than one, so there needs to be a separator).

```
2340 IF BUFVAL=252 THEN MSG=0:GOTO 2300
```

If it's the end of a message, clear the message flag and read the next byte.

```
2350 IF MSG THEN PRINT CHR$(BUFVAL);:GOTO
     2300
```

If there's a message in progress, print the byte as a character and read the next byte. Don't miss the semicolon.

```
3010 PSET(X,OF-(BUFVAL-DS)/2)
3030 TRACE=TRACE+1
3040 IF TRACE>NUMTRACES THEN
     X=X+1:TRACE=0:GOSUB 300
```

Otherwise it's ADC data set the appropriate pixels for each trace, advance the screen pointer X and set the cursor.

```
3050 IF X>600 THEN X=0:GOSUB 100
```

If the full width has been reached, reset the screen pointer and wait for a key press before starting at the beginning of the screen again.

```
4000 IF IC$="q" THEN SYSTEM
4010 IF IC$="r" THEN RUN
4020 GOTO 2300
```

If the key pressed was a **q**, then leave BASIC, else if the key pressed was an 'R' restart the program, otherwise continue reading the buffer.

In Conclusion

The programs shown are adaptable to considerable enhancements to suit your own purpose, which is one big advantage of this type of DIY exercise. Possible enhancements which occur to me.

If you use a colour monitor then the traces can be coloured to ease identification. Change the colour identity in the PSET Instruction for each channel.

The screen vertical offset OF could be altered from trace to trace, so that the traces were positioned one above the other, rather than on top of each other as they are here. I know the latter sounds bad but, in practice, unless the traces are all similar quantities, e.g. temperatures, or there are a lot of them, it is fairly easy to distinguish one from the other.

The easiest way to do it would be to have an array of channel offsets which could be set by the user, along with tick-time, etc. Then include this value in the loop which sets the pixel for each channel.

Adding any arithmetic to modify the value measured by the ADC is probably best done in the line 200 routine. You may then need to move the message handling routine up to line 400 from 300 to allow the ADC routine more elbow room.

Printing details from the screen is most easily done by using the print-screen supplied with the computer. This is a possible candidate for DIY but it's not so easy to get right. Most printers can be set into graphics mode and for the 9 pin models this allows 8 pins to be driven by every byte sent to the printer. Thus, 0 to 200 would be spread over 25 lines, the line spacing being adjusted so that there is no gap between successive lines. Use an array of 25 strings to represent the print lines and direct the data to them by dividing the ADC value by 8. This selects the string number and the remainder selects the pin to be activated.

The X value selects the byte in the string. Don't forget to OR the values into the bytes, so that if two traces select the same byte, one doesn't delete the other!

ADC-16 is available from: **Pico Technology Ltd. Broadway House, 149-151 St. Neots Road, Hardwick. Cambs. CB3 7QT.Tel: 0954 211716.**

ETI SUBSCRIPTION OFFER

GOOD READING

—Guaranteed!

Subscribe to

Electronics Today International and guarantee that every issue is priority delivered to your door for a whole year!

(post free in the UK)

Guarantee good reading with a subscription!

Yes! I would like to subscribe to **ETI magazine** for 1 year.
Please commence my subscription from the .... issue.
If renew/extending, please quote subscription number..............................)

ETI One Year Subscription Rate
UK £23.40 Europe & Eire £30.30
Sterling Overseas £31.50 US Dollars Overseas $52

I enclose a cheque/M.O. for £......................made payable to ASP or debit my Access/Visa:

Signature.............................. Expiry................Today's Date..............
Name..
Address..
....
.... Post Code..............

Please post this coupon to: Argus Subscription Dept, Queensway House, 2 Queensway, Redhill, Surrey, RH1 1QS. Or call us on 0737 768611.
If you've got a credit card it's faster by phone!
You may receive further information about offers and services which may be of interest to you. ETI/123.

MPU Fundamentals

In the last part of this series we look at communications between computers, and between a processor and peripheral I/O devices, as well as taking an in depth look at the mysteries of the RS232

Conventionally, when we talk about input and output from a microprocessor system we are talking about parallel communications. The use of an eight line I/O port to output, or input, a logic pattern corresponding to a single byte in the processor's memory, with each bit in that byte corresponding to a specific I/O line on the port.

Thus, if we want to output text from a computer system to a peripheral device, say a printer, we could use a parallel port to transmit the text as ASCII code (see table 1 for ASCII character codes) one character at a time. If we were to use the full ASCII code, we would require all eight I/O lines on a port, but we would also need a means of telling the peripheral device that there was valid data being output on the port. We can do this with the aid of one or more special lines, known as a handshaking lines. These are shown in Figure 1.

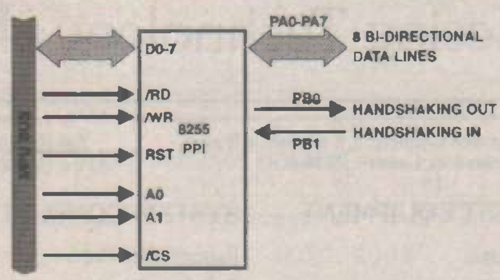


Fig. 1 An 8255 based parallel data communications circuit.

We cannot just keep changing the data on the I/O port lines without some way of synchronising this sequence of data output bytes with the hardware that is reading the incoming data. We cannot rely on the system reading the data being able to recognise a change in the data. For example, we might output the text word 'NEED' in ASCII code form. This has two consecutive Es and without some form of synchronisation, how is the receiving system expected to recognise that there are two Es rather than just one?

A bidirectional parallel I/O port would use two handshaking lines, one to synchronise output and one to synchronise input. The synchronisation function of either of these handshaking lines consists simply of toggling the line when there is valid data on the I/O port, this can be seen in the waveform diagram in Figure 2.

As far as the processor transmitting the data is concerned, handshaking simply consists of toggling the handshake line, but the processor or peripheral receiving the data has to keep looking at the state of the handshake line before it can read the data from its I/O port. There are two ways of doing this, one is to poll the handshake line and the other is to attach the handshake line to the processor interrupt.

Polling means that the processor is running a program which repetitively looks at the state of the handshake line, and checks to see if there is valid data waiting to be input. If there is, then the polling program branches to a routine which inputs the data. If the state of the handshake line indicates that there is no data waiting to be input then program control will return to the main task. Usually, the polling routine is initiated by a regular interrupt generated by some form of timing circuit. However, if the main application allows, it could be just a simple software loop.

The trouble with a polling technique is that it slows down a processor's operating speed, since program control is repeat-

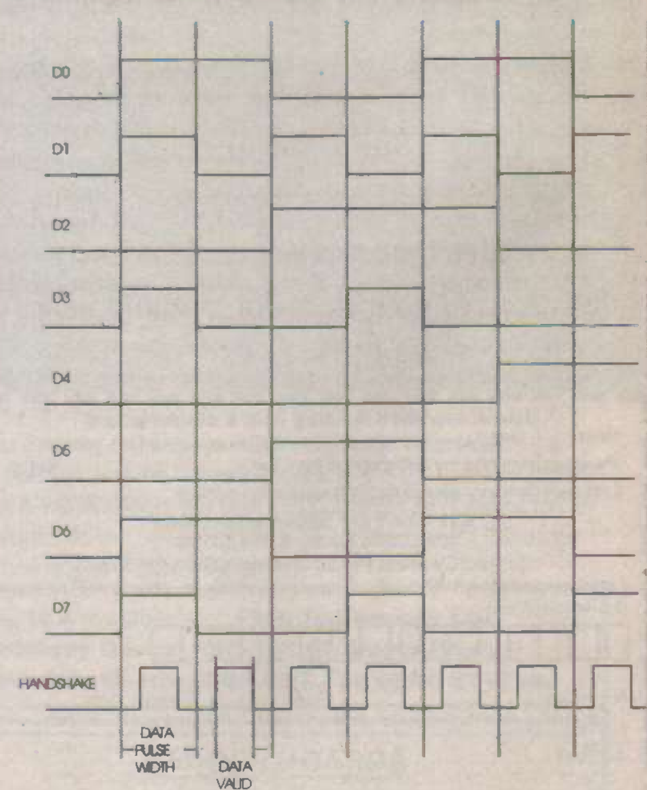


Fig. 2 Output waveform on parallel data communications port.

edly being diverted to check the state of the handshake line and perhaps also to input data. The higher the data transfer rate the greater this problem, since the polling rate needs to be considerably higher than the transfer rate.

For these reasons, the preferred technique is to attach the handshake line to a processor interrupt. In this way, the processor is not tied up looking at the state of the handshake line and there is no constraint on the speed of data transfer, it can be fast, slow or even of variable speed. This means that an interrupt connected handshake system is a lot more versatile and also a lot simpler to implement.

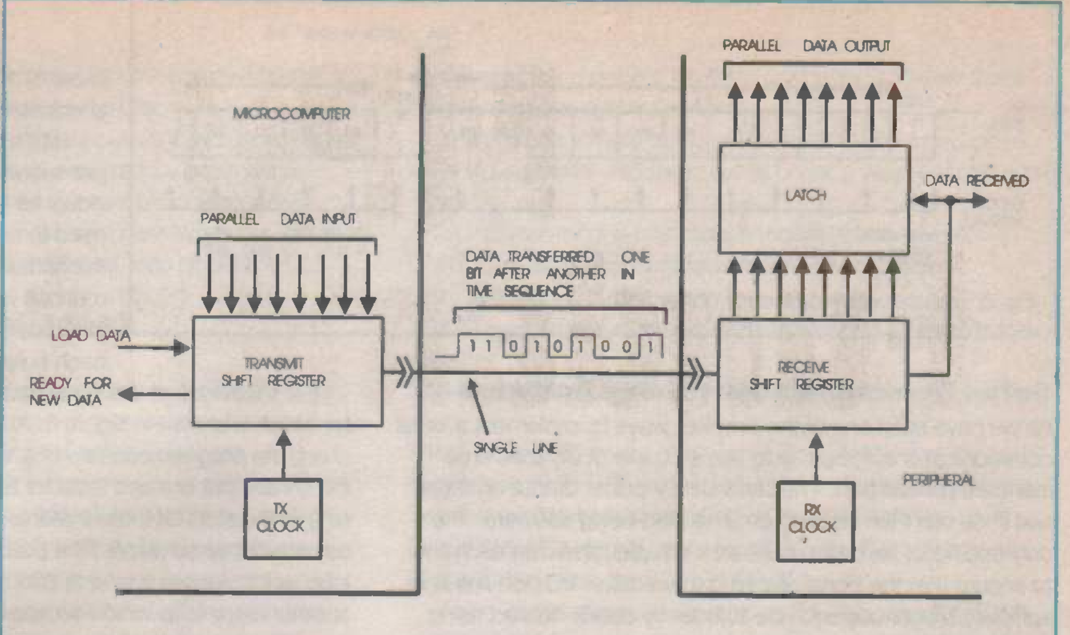


Fig. 3 Serial data transfer circuit.

Parallel data communications offer a very good way of rapidly transferring large quantities of data between two computing devices. Indeed with a properly designed parallel communications system, it is possible to transfer data at millions of bytes per second, though only over very short cable lengths. This high data transfer rate means that parallel communications are the preferred solution for linking computers to data hungry peripherals, such as laser printers.

Serial Communications

Parallel data communications may be easy to implement, but they also suffer from some major problems. The first drawback is that a parallel data communications system utilises a full eight bit I/O port as well as a couple of handshake lines and, in some systems, such hardware I/O resources are at a premium. Another drawback is that they require eleven separate wires - the eight data lines, two handshaking lines (one for data input and one for data output) and a ground line.

The large number of wires means that the cables are bulky and have to be kept fairly short because of signal degradation. This degradation is the result of many factors, including cross-talk, signal reflection, low drive voltage (you will rarely find a parallel printer cable more than two or three metres long). There is also the problem that data in a parallel form can not be transmitted long distances over conventional telecommunications systems.

The solution is to trade a high data transfer rate for a reduction in the number of wires, in other words send the data in serial form rather than parallel form. In its most fundamental form such a bidirectional serial communications link will consist of just three wires - one carrying data coming into the system, one carrying data being transmitted by the system and the third being a common ground line.

In a serial communications system, the data, in eight bit chunks, is converted from the parallel format used on the processor data bus to a string of pulses representing one bit after another in strict time sequence, which is output on a single line. The device receiving such serial data reverses the procedure and converts the sequence of eight pulses back into eight bit parallel form. This procedure can be seen in the diagram in Figure 3.

As can be seen in the diagram in Figure 3 the hardware used to implement serial data communications is relatively simple. Indeed a simple serial communications port can be constructed using just two lines on a conventional I/O port and performing the serial to parallel data conversion using software. However, in most cases, special hardware is used.

Since serial communications take place asynchronously, in other words there is no handshaking or clocking line, it is necessary for the serial data to include its own synchronisation signal. This synchronisation is achieved by the use of start and stop bits, these are shown in Figure 4. Note that in this waveform there is one start bit and two stop bits.

The normal state of the line is 'logic 1', allowing the system to test that the line is functioning. When receiving serial data, the computer or peripheral device waits for the falling edge of the start bit before clocking in the data. It is this falling edge

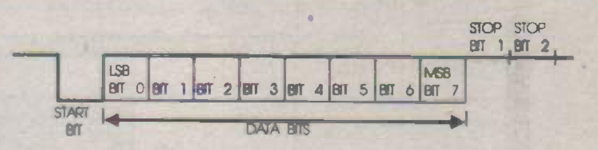


Fig. 4 Serial data transfer waveform.

which starts the synchronisation and it means that slight discrepancies in the clocking rate, up to a maximum of about 1/2 bit time, will not be added onto each other over successive bytes but will be corrected at the start of each byte. This automatic correction of clocking rate errors can be seen in Figure 5.

In order for the data to be correctly clocked in, it is of course important that transfer rates are at a predetermined frequency. This frequency is usually referred to as the Baud rate and is equal to the number of bits that are transmitted each second down the serial line. It should be noted that this count includes not just the eight data bits but also the start bit and the two stop bits. This means that a 300baud serial link will be capable of transferring data at the rate of 300/11 or 27.273 bytes per second. (There are other serial data formats than the one mentioned here, for example there may be only six data bits and perhaps just one stop bit. Obviously it is very important that the data formats of receiver and transmitter match, just as their baud rates should match)

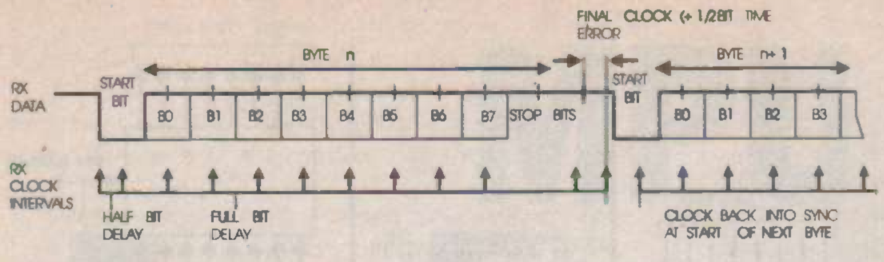


Fig. 5 Transfer waveform error correction.

Serial Communications Using Software

As we have seen one of the simplest ways to implement a serial communications system is to use a couple of I/O lines on a standard parallel port. The serial data input or output on those two lines can then be read or generated using software. The only additional hardware needed is a buffer/driver on each line, to ensure that the signal reaching the receiver I/O port line is of sufficient magnitude and has sufficiently clearly defined rising and falling edges to be readable. The buffers are also a useful way of protecting the I/O chip from the accidental introduction of higher voltages, which might result from the user connecting it to the wrong type of equipment.

The first thing to decide when designing such a system is the data transfer rate and the data format. These should correspond to one of the common standards and will probably be dictated by the equipment with which the system is communicating. Thus, we might decide to use the commonly used 2400baud data transfer rate, with a data format consisting of one start bit, eight data bits and two stop bits. In other words, a system capable of transferring data at 218.182 characters per second.

With a data transfer rate of 2400 bits per second, we can say that each individual bit has a duration of 417µs. We need to know this time duration, since the software serial input and output routines will have to generate a correctly timed delay in order to be able to clock each pulse in.

Let's first look at the serial data input routine, the flow chart for which is shown in Figure 6. At the beginning of the flow chart, the program consists of a loop which checks the state of the serial input line and tests for the falling edge at the beginning of the start bit (note that this is where the synchronisation adjustment takes place). The processor then goes into a delay loop which causes it to wait 208.5µs, half a bit time, then another delay loop which causes it to wait 417µs, a whole bit time. The reason for these two delays is to wait through the entire duration of the start bit and then half way through the duration of the first data bit. In this way the state of each bit in the data stream is tested in the middle of each pulse, to ensure optimum reading accuracy.

The serial input routine then repeatedly loops around the serial input part of the code - waiting 417µs, inputting the state of the serial line, adding that bit to the assembled character, decrementing a counter set to 8 at the start of the byte input routine, then checking to see whether that counter is zero and all eight bits have been input and if so exiting the bit input loop.

RS232 Communications *Revealed*

Virtually anyone who uses computers will be familiar with the tag RS232, used in association with serial data communications. We talk of RS232 cables and of RS232 ports, so what exactly is meant by RS232?

It stands for the Recommended Standard (RS) number 232, which was produced by the Electronic Industries Association (EIA). This standard, and we are now in fact on revision RS232C, specifies the interconnections between two systems, so that they can communicate serially over reasonably long distances, up to about 500ft in some applications. This is purely a physical standard, covering the permissible connectors, the pin designation on those connectors, the control lines and the way that the data is transmitted, the voltage levels, etc.

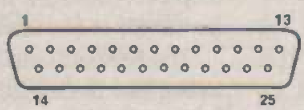


Fig. 1 Standard RS-232C "D" connector

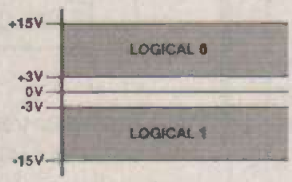


Fig. 2 RS-232C voltage levels.

Let's first look at the electrical specifications.

The first thing to note about the RS232 specifications is that they entail using much higher voltages. This has been done in order to reduce the problem of electrical noise. In most modem RS232 communications systems, a signal in the range +3V to +12V represents a 'logic 1', while a signal in the range -3V to -12V represents a 'logic 0'.

The specifications say that an RS232 transmitter should have a minimum output voltage swing of ±5V when loaded with the nominal 5kohm input resistance of an RS232 receiver. The specifications also dictate that the slew rate of the transmitter is limited to less than 30V/µs, a factor which limits the maximum usable RS232 baud rate to 19200.

The specifications indicate that the maximum baud rate can be traded for cable length - the shorter the cable the higher the baud rate. The factors which govern this are cable load capacitance, slew rate of the driver under high capacitive loading and the receiver's threshold and hysteresis. When determining the maximum cable length, bear in mind that the load capacitance of the cable should not exceed 2500pf.

Having looked at the electrical specifications of RS232 now lets look at the interconnections.

Considering that part of the rationale for serial data communications is that it uses as few lines as possible, it is rather surprising that the RS232 standard specifies a 25 pin D connector as the interconnection device. It is even more surprising to discover that all but three of those 25 lines have been assigned some particular function. In other words a full specification RS232 cable would have 22 separate wires and the following table shows these specified connections:

Pin	Description	Name	RS232
1	Protective ground	Prot	AA
2	Transmitted data	TXD	BA
3	Received data	RXD	BB
4	Request to send	RTS	CA

The rest of the routine just consists of a further set of delays equal to the time period of the two stop bits.

We now move on to the serial data output flowchart in Figure 7. This is very straightforward and requires little explanation. Obviously, in the above examples different baud rates would require different delay times and different data structures, different numbers in the bit counter and a different stop bit delay time.

Hardware Based Serial Data Communications

A software based serial data communications system is quite easy to implement, but it has several drawbacks which lead many designers to implement serial communications using hardware. One major limitation is that the use of software timing loops means that the processor is tied up performing data transfer and cannot be used for any other task while this is taking place. This could be a major problem in systems which have interrupt signalled data input functions. All the timing of a serial data transmission or reception will be thrown out if a system interrupt occurs during data transmission. Since the processor will have to jump to the interrupt handling routine, perform that and then return to the serial data routine, the result is that synchronisation will have been lost and input data will either be lost or garbled.

The other problem with software controlled serial communications is that they are specific for a particular system. In most cases, programs will run equally well on different systems, with different system clock rates (in other words, different processing speeds). But change the clock rate and our software generated delays are also changed, thereby making the software serial communications system useless.

The solution to both these problems is to use a dedicated serial I/O controller and these come under a variety of acronyms:

ACIA - asynchronous communications interface adaptor
UART - universal asynchronous receiver/transmitter
SIO - serial input/output
USART- universal synchronous/asynchronous receiver/transmitter
DART - dual asynchronous receiver/transmitter

These devices all perform the same kind of task and, by and large, the only real difference lies in the manufacturer and the family of microprocessors for which they were designed. Thus 6800/6502 MPU family users might use the 6850 ACIA and Intel or Z-80 users, the 8251A USART.

As far as the processor is concerned, chips like the 8251A and the 6850 look like a couple of memory or I/O locations which can be written to, or read from. In the 6850, the two addressable locations contain four registers, two of which are read only, the other two being write only. The read only registers are a status register and a receive data register. The write only registers are a control register and a transmit data register.

A circuit diagram for a typical USART based hardware serial communications system is shown in Figure 8. This circuit shows a 8251A, with associated 74138 address line decoder, producing a serial input line and a serial output line. The timing, in other words the baud rate at which the system will operate, is

5	Clear to send	CTS	CB
6	Data set ready	DSR	CC
7	Signal ground	GND	AB
8	Data carrier detect	CD	CF
9	-		
10	-		
11	Select XMT frequency	STF	CG
12	Secondary DCD	dcd	SCF
13	Secondary CTS	cts	SCB
14	Secondary XMT	xmt	SBA
15	Transmit clock	Xclk	DB
16	Secondary RCV	rcv	SBB
17	Receive clock	Rclk	DD
18	-		
19	Secondary RTS	rts	SCA
20	Data terminal ready	DTR	CD
21	Signal quality	SQ1	CG
22	Ring indicator	RI	CE
23	Data rate select	DRS	CH
24	External transmit clock	-	DA
25	Busy - standby	BY	-

Lets look at some of these lines in greater detail:

Prot
This is the protective ground line and will probably form a connection between the metal screening on the cable and the metal chassis of the two linked pieces of equipment.

GND
This is the signal ground line and provides a common reference for both input and output signals.

TXD
This is the line on which all serial data is transmitted, provided that the CTS signal, line 5, is active.

RXD
This is the line on which all serial data is received from other connected RS232 devices.

RTS
The logic level on this line indicates that an RS232 device is ready to transmit data. In order to find out when to expect data, this line is tested by the receiving device.

CTS
The state of this line is used to indicate that a device is ready to receive data transmitted to it by a connected RS232 device. It is used to inhibit data transfer until the receiving device is ready to accept it.

DTR
This line is used to indicate that the RS232 transmitting device is switched on.

DSR
This line is used to indicate that a connected RS232 receiving device is switched on.

Fortunately, hardly anyone would need to use a full specification cable and most applications require no more than three or four wires. Indeed, as one can see from the above table, many of the specified connections are exclusively for use with modems and thus unlikely to be used in any other application.

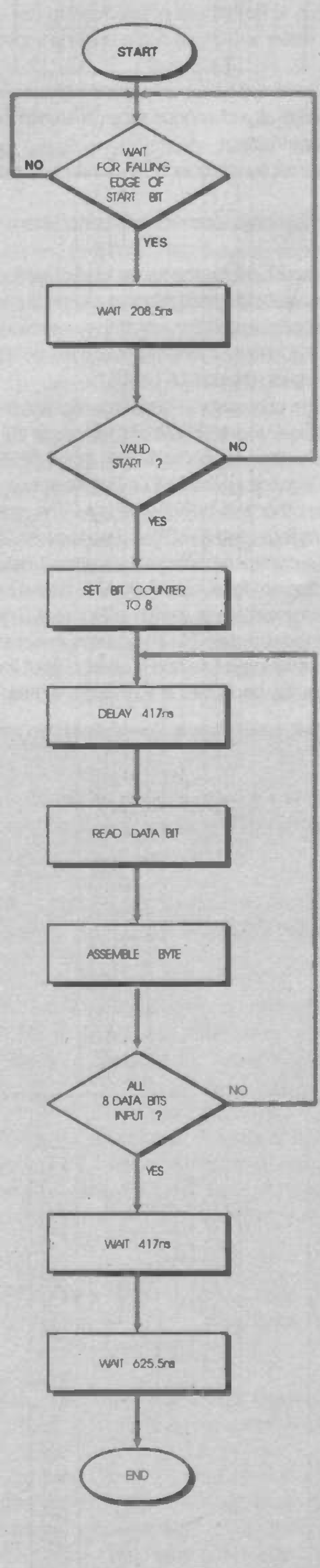


Fig. 6 Software serial data input flowchart (2400 Baud).

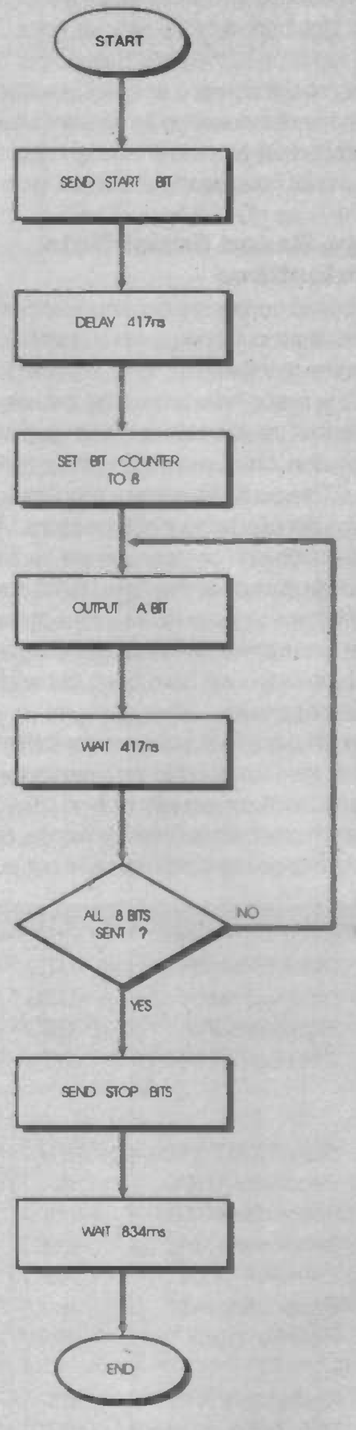


Fig. 6 Software serial data input flowchart (2400 Baud).

determined by a clock pulse input to the TXC and RXC lines of the 8251 (here they are tied together and receive the same clock frequency, but it is perfectly feasible to have a system with different transmit and receive baud rates).

The USART transmit/receive clock input can be derived from a special purpose external clock generator, but it is far more usual to derive it from the system clock, which has been divided down. In this example the system has a clock rate of 7.32728MHz, which is divided by 12 using a 7492 to give an input to TXC and RXC of 614.4kHz. This is then divided internally by 64, by the 8251, to give a baud rate of 9600. The derivation of the serial clock from the system clock accounts for some of the rather strange system clock frequencies which are employed in some systems.

Making Your Own Cables

If there is one thing that is guaranteed to cause computer users considerable frustration, it is the question of cables between the processor and various peripherals, and between two or more computers.

It looks so easy. The average PC comes with one or more serial ports and one or more parallel ports, with peripherals having either a serial or a parallel port, or in some cases both. It should be just a matter of directly connecting them together, but in practice this is all too often not the case. You connect them together, but it does not work!

The problem is most acute with serial cables, since there is little standardisation. This means that finding the correct commercially made cable can be quite difficult and the best solution is to make your own.

Parallel Cables

In some situations, it may be necessary to make your own parallel cables. Although these are readily available from commercial sources, it is rare to find one that is longer than about 20ft, so if you want something a bit longer, you will have to make it yourself.

Officially, parallel cables can be up to about 50ft long. However, if the cable is shielded properly and carefully grounded then, assuming the interfaces at either end of the cable are properly designed, it should be possible to use cables of up to 100ft.

In fact, any parallel cable more than about 10ft long should be properly shielded and grounded, otherwise you run the risk of spurious signals being picked up and data corrupted. The diagram in Figure 1 shows the standard cable interconnection between a standard male D type 25 pin PC parallel port connector and a standard 36 pin Centronics printer connector.

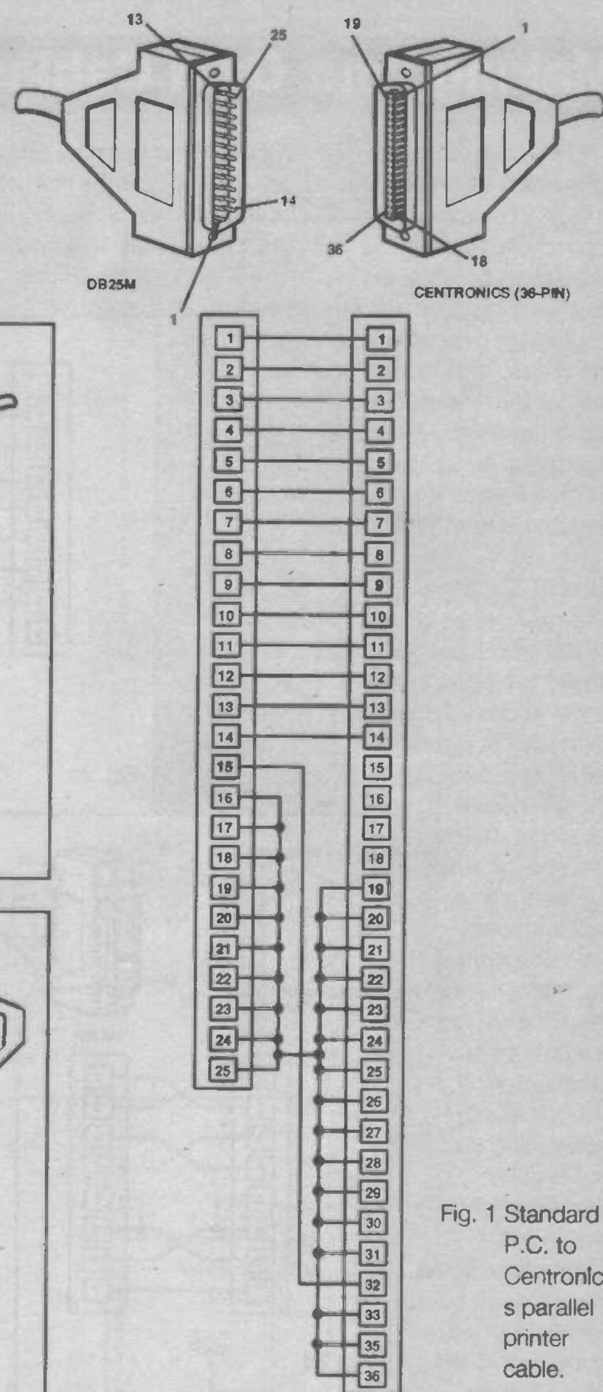


Fig. 1 Standard P.C. to Centronic s parallel printer cable.

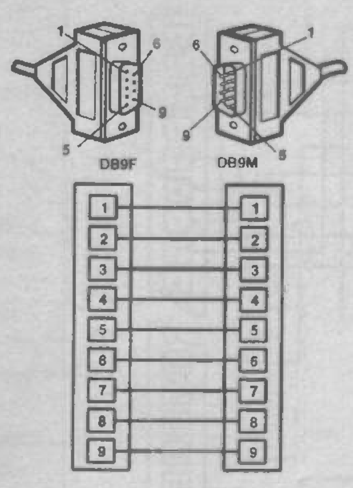


Fig. 2a Serial cable connections.

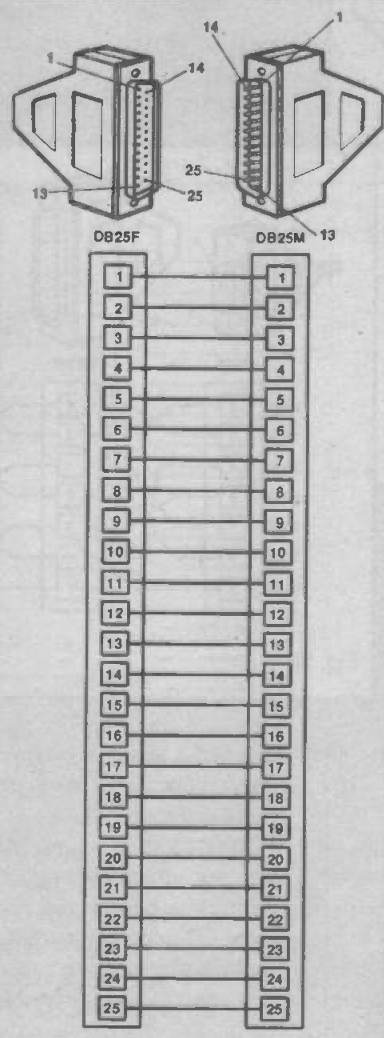


Fig. 2b

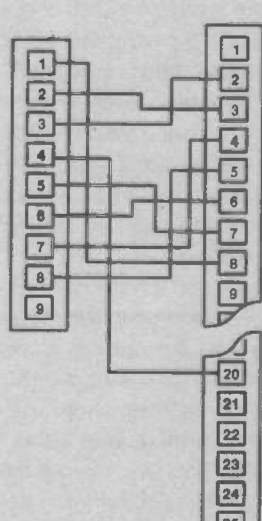


Fig. 2c

Making Your Own Cables

In this diagram note how all the ground line pins are connected together. This is most important if the cable is to work properly and unfortunately not seen on many commercial cables. Depending on the printer, this may not matter, but in some cases it will prevent the printer from working properly. For proper functioning over longer cable lengths, one should ensure that both the PC and the peripheral device have their cases connected to the same electrical ground (always a good practice) and that the shielding on the cable is connected to the PC's case.

Serial Cables

Serial cables driven be a standard RS232 port can, of course, be much longer than parallel ones, according to the specifications up to about 500ft, but in practice with a properly constructed cable, up to about 1200ft. This long cable length is one reason why it is difficult to find the appropriate commercial serial cables. The other reason is a lack of standardisation.

Lack of standardisation is a real problem, some systems have 9 pin connectors, some have 25 pin connectors, so some cables will have 25 pin connectors on either end, some 9 pin on either end and some 25 pin on one end and 9 pin on the other. Some cables have the lines straight through, connecting pin 1 to pin 1, pin 2 to pin 2 and so on. Other serial cables have the wires crossed over. Not to mention the fact that some systems will only use two or three of the connecting wires, whereas others might require ten or more for special purpose signals (see Box 1 for RS232 line specifications).

There are two main classifications of RS232 cable - straight-through and crossover. Broadly speaking, if the cable is linking the computer to a communications device, such as a modem, then a straight-through cable will be used - in other words, one where the transmit line is connected to the same pins at either end of the cable, as is the receive line, etc. However, if the cable is connecting the computer to a peripheral such as a printer, then the transmit line from the computer needs to be connected to the peripheral's receive line and vice versa. The two lines have to be crossed over.

The diagrams in Figure 2 show the main types of serial cable connections. The two simplest are the 9 pin and 25 pin straight-through cables (Figures 2a and 2b). These have a male connector on one end and a female connector on the other (some systems will need a male at both ends or a female at both ends - without standards life can be very trying). Be warned, however, that just to make life more difficult not all 9 pin connectors have the same connector designations. It is a good idea to always check the documentation first. Slightly more complex is the 9 pin to 25 pin straight-through cable (Figure 2c). Here, which connector is male and which is female depends on the system.

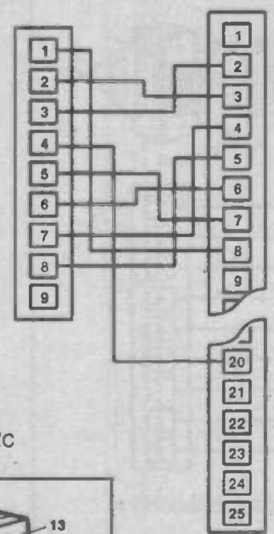


Fig. 2c

We now come to the crossover cables which are used to transfer data between two computers or between a computer and a peripheral other than a modem. These are sometimes known as null-modem cables. The standard crossover cable (Figure 2d) has a 25 pin female D type connector at both ends. We can also have a crossover cable between a 9 and 25 pin connector (Figure 2e). Finally, there is the minimalist three wire serial system, which makes no use of any handshaking lines and relies exclusively on software handshaking (Figure 2f).

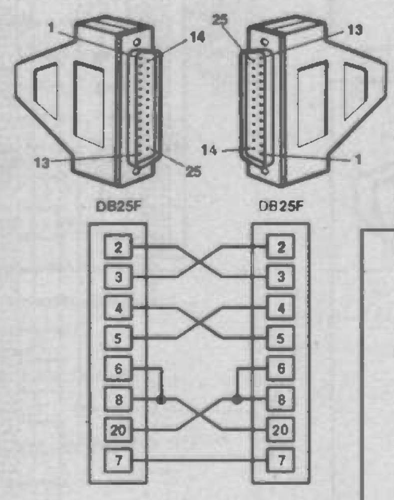


Fig. 2d

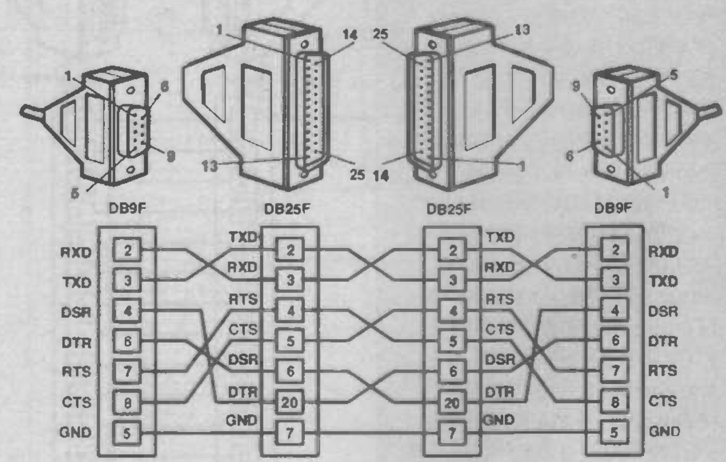


Fig. 2e

(Note: for PC users, DOS 5 and 6 include a utility called Interlink, which allows data to be transferred between two computers connected via a null modem cable on their serial I/O ports. This utility allows one computer to read the files or run programs on the other computer. It is a very useful way of transferring data between systems.)

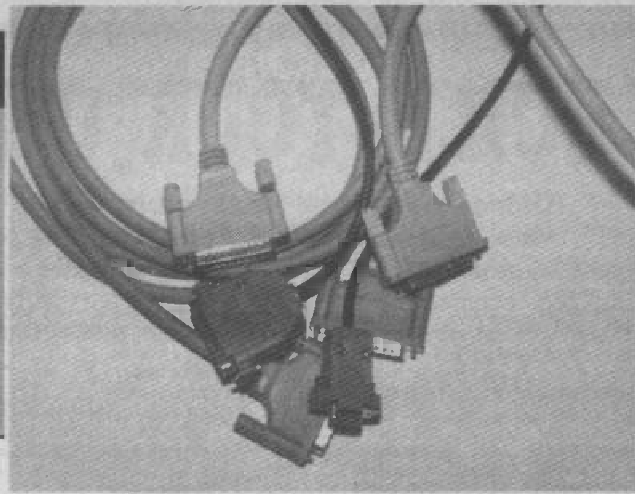
Practical Aspects of Making Cables

It has to be said that cable making is a rather fiddly

Making Your Own Cables

process, but if you are reasonably good at soldering, not very difficult. The most important thing to remember when choosing the cable is that it should be clearly colour coded, with all the wires easily distinguishable from each other. Unfortunately, on many cables it can be difficult to tell some colours apart.

The chosen cable should have enough cores for the application and, in the case of serial cables, probably a few to spare, since different applications might require extra



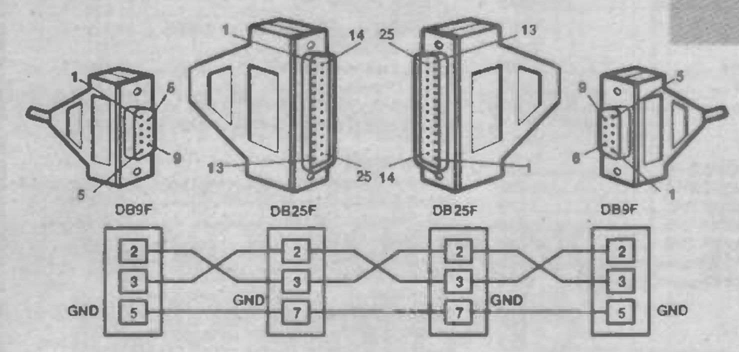
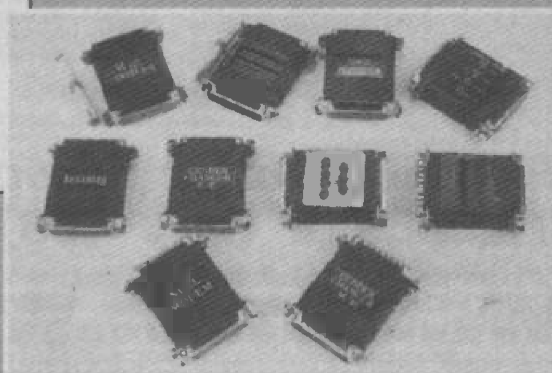


Fig. 2f

lines and it is easier to modify an existing cable than make a new one. Although telephone cable is cheap, it is not a good choice for minimalist connections, since it uses solid instead of stranded wire and is thus liable to break if flexed repeatedly or strained. Neither is ribbon cable a good choice, since it is easily damaged. In the long run, it is worth paying more for good quality cable, preferably screened.



You will notice on the circuit diagram in Figure 8 that the serial input and output from the 8251 are fed into a MAX232 chip, before being available as a standard RS232 serial I/O port. The MAX232 is a special RS232 receiver/transmitter circuit which converts the 5V TTL output of the 8251 into the ±12V RS232 standard voltages, without any need for special power supply lines - see Box 1 for a full description of the RS232 serial communications standard.

Last Word

This look at parallel and serial data communications techniques ends this series of articles, which has examined some of the fundamentals of microprocessor design. I hope that it has persuaded readers that building microprocessor based systems is not that difficult and, with the low price of MPU chips, they offer an ideal way of implementing some interesting and sophisticated applications.

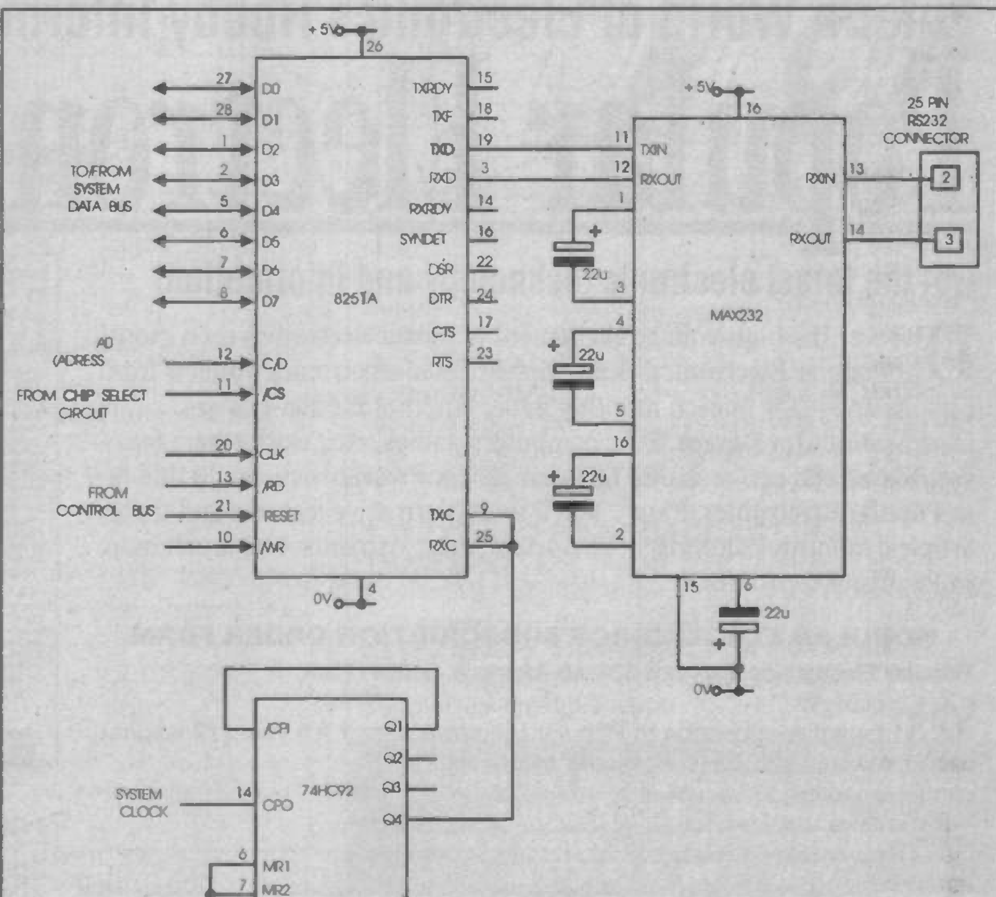


Fig. 8 Usart circuit for RS-232 I/O

ETI

ELECTRONICS
TODAY INTERNATIONAL

Most readers will have noticed that we have not been offering a PCB service for the last couple of months. I wish to reassure readers that this is not a permanent situation and is due to a change in PCB suppliers. In the very near future we shall be resuming the service and will be able to offer all PCBs, including those for the last few months' issues of ETI. I would like to appologise for this delay.

In the mean time we are clearing our back stocks of old PCBs, some of which go back to projects run four or five years ago. We are offering these at a bargain price of 2/3 of the original price, a bargain for project builders!

This month we are running the first half of our list of sale price PCBs. Don't miss out, because this is a never to be repeated offer and once sold out, we will not be restocking!

PCB SERVICE

Telephone your order on (0442) 66551 Access or Visa

E9109-5 Nighfighter Main Processor Board.O
E9110-1 Freeze Alarm ....E
E9110-2 Document Saver....E
E9110-3 Prototype Designer ....J
E9110-4 Nightfighter - Sound to light (2 sided)....L
E9110-6 Nightfighter - Cyclic Crossfade (2 sided)....M
E9110-7 Nightfighter - Strobe Board (2 sided)....J
E9111-1 Digital Code Lock L
E9111-2 Switched Mode Power Supply....E
E9111-5 Nightfighter - Bass Beat Trigger (2 sided)....L
E9111-6 Nightfighter - Sequence Select (2 sided) ....H
E9111-8 Nightfighter - Output Switch (2 sided)....M
E9112-4 Nightfighter Connector Board ....F
E9112-5 Nightfighter Sensor Switch PSU ....K
E9201-1 Laboratory Power Supply ....F
E9201-2 Test Card Generator Board ....M
E9201-3 LED Star (2 sided)....L
E9201-4 Enlarger Timer Main PCB (2 sided) ....N
E9201-5 Enlarger Time Selector Board (2 sided) ....K
E9201-6 Enlarger Timer Switch PCB....E
E9203-1 MIDI Switcher Main Board L
E9203-2 MIDI Switcher Power Supply ....E
E9203-3 Sine Wave Generator (surface mount)....F
E9204-1 Auto Car Lights....F
E9205-1 Bat Detector ....E
E9205-2 Pond Controller....F
E9206-FC Stereo amplifier....G
E9206-2 Xenon flash trigger Main Board ....J
E9206-3 Xenon flash trigger Flash Board ....F
E9206-4 Scanner for audio generator....D
E9207-1 Improved Rear Bike Lamp....D
E9110-4 Nightfighter - Sound to light (2 sided)....L
E9209-2 Alarm protector....C
E9209-3 Temperature controller ....M
E9209-FC 45W Hybrid power amp....F
E2910-2 Rapid Fuse Checker....E
E9210-3 Heartbeat/Audio Listener....E
E9210-FC Wizards Hat....E
E9211-1 Electronic Die ....E
E9211-FC Car Alarm ....F
E9212-1 Digital Circuit Tester....F
E9212-2 Communications Link by RS232.L
E9212-FC Mains Inverter....E
E9301-2 Fading Festoonery ....G
E9301-FC Infra Red Receiver ....F
E9302-3 Puddle Tec....E
E9302-FC Infra Red Transmitter....E
E9303-2 IC Tester ....E
E9303-3 Disco Amiga (motor driver board) ....H
E9303-4 Direct Conversion Reciever (2 Sided) ....N
E9303-FC LED Stoboscope ....F
E9304-1 Solo Mic Pre-Amplifier ....F
E9304-3 The Keepsafe Alarm ....F
E9304-4 Proving Unit....E
E9304-6 Infra Guide Transmitter ....F
E9304-FC (AutoMate) Peak Program Meter.F
E9305-4 Vibration Detector ....D
E9305-FC The Fuzztone....E
E9306-1 Graphic Equaliser ....F
E9306-2 Super Spooker....H
E9306-3 Middle & Side Stereo Coding ....D
E9306-FC The Chaperon....F
E9307-2 Mind Trainer ....F
E9307-FC Microwave Monitor....F
E9308-1 Window Monitor (4 Boards)....K
E9309-1 RF Signal Generator ....F
E9309-2 MIDI Analyser CPU Board ....K
E9309-3 MIDI Analyser Display Board....J
E9309-4 Metronome....G
E9310-1 Hot Wire Cutter....F
E9310-2 Electronic Picture....H
E9310-5 Home Minder (2 Boards)....N
E9310-FC Continuity Tester....D
E9311-1 Car Alarm ....G
E9311-2 MIDI Change Pedal (double sided) ....H
E9311-4 PSU Monitor ....N
E9311-FC RF Hound ....D
E9312-1 Car Alarm....D
E9312-2 NiCd Battery Charger ....F
E9312-4 Video Stabiliser ....G

ETI PCB Service, Reader Services, Argus House
Boundary Way, Hemel Hempstead, Herts HP2 7ST

Please Supply:

Quantity	Ref No.	Price Code	Price	Total Price
	E		£	£
	E		£	£
	E		£	£
			Post & Packing	£ 0.75
			Total Enclosed	£

Please send my PCBs to:

Name........

Address........

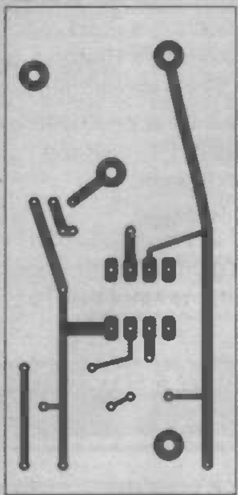
....

........Postcode........

CHEQUES SHOULD BE MADE PAYABLE TO ASP

SALE PRICES

C....£.60
D....£0.83
E....£1.08
F....£1.33
G....£1.59
H....£1.83
J....£2.21
K....£2.40
L....£2.94
M....£3.54
N....£4.37
O....£5.26

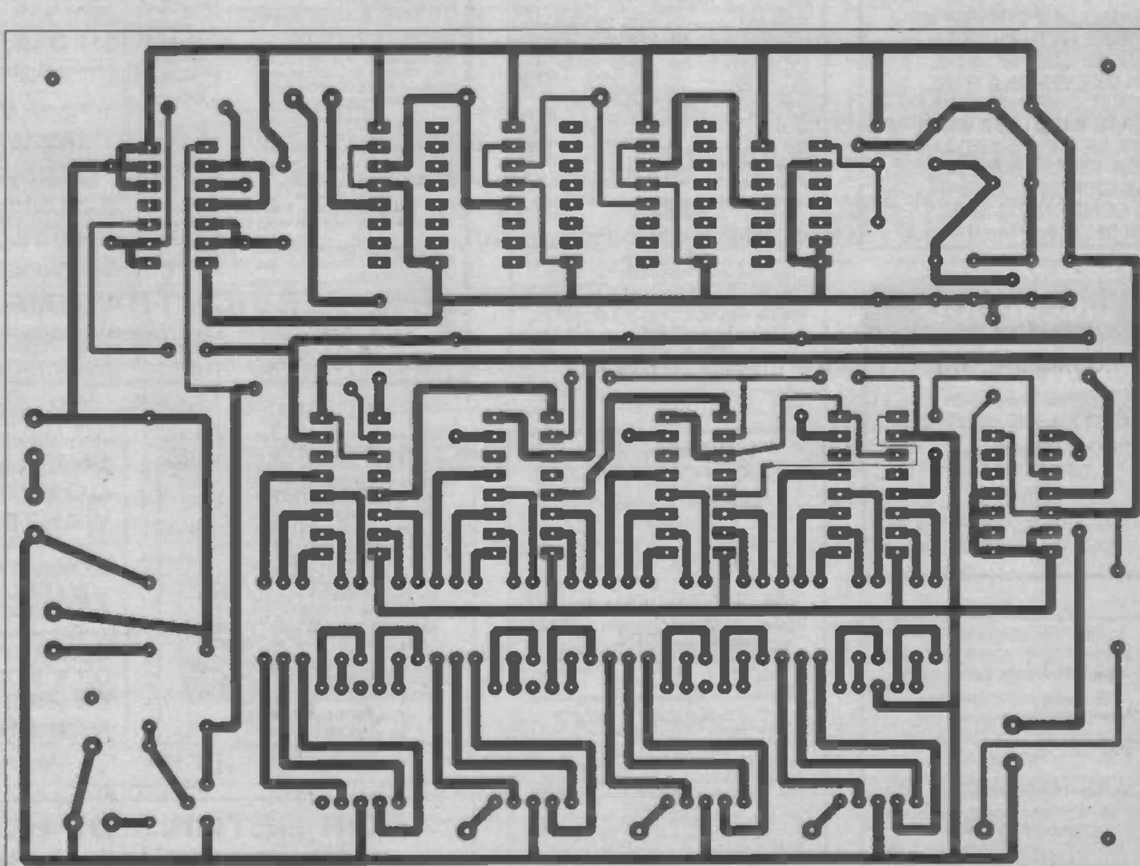


Brake Light Monitor

OOPS

Figure 8 of John Linsley Hood's article 'Power Supplies for Electronic Equipment' (page 24, April 1994) is incorrect. Please amend the values of R5 and R6 to 4k7, and delete C2 (2u2f) entirely.
Also, PCB foil for Raymond Haigh's 'Radio Revisited' (page 21, March 1994) has a small error. Break the track to pin 17 of IC1 and use a wire link to connect pin 16 of IC1 to -9V plane.

Digital Shutter Timer



ETI Classified

James Gale
0442 66551

Send your requirements to:
ETI Classified Department, ASP, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST
Lineage: 65p per word (+ VAT) (minimum 15 words)
Semi display: (minimum 2.5cms)
£8.70 + VAT per single column centimetre

VISA

Ring for information on series bookings/discounts.
All advertisements in this section must be prepaid.
Advertisements are accepted subject to the terms and conditions printed on the advertisement rate card (available on request).

FOR SALE

VISA

COOKE INTERNATIONAL

SUPPLIER OF QUALITY USED TEST INSTRUMENTS

ANALYSERS, BRIDGES, CALIBRATORS, VOLTMETERS, GENERATORS, OSCILLOSCOPES, POWER METERS, ETC
ALWAYS AVAILABLE

ORIGINAL SERVICE MANUALS FOR SALE
COPY SERVICE ALSO AVAILABLE

EXPORT, TRADE AND U.K. ENQUIRIES WELCOME
SEND LARGE S.A.E. FOR LISTS OF EQUIPMENT AND MANUALS
ALL PRICES EXCLUDE VAT AND CARRIAGE
DISCOUNT FOR BULK ORDERS SHIPPING ARRANGED

OPEN MONDAY TO FRIDAY 9AM - 5PM
COOKE INTERNATIONAL
ELECTRONIC TEST & MEASURING INSTRUMENTS
Unit Four, Fordingbridge Site, Main Road, Barnham, Bognor Regis, West Sussex, PO22 0EB Tel (+ 44) 0243 545111/2 Fax + 44) 0243 542457

VARIABLE VOLTAGE TRANSFORMERS

INPUT 220/240V AC 50/60
OUTPUT 0-260V

	Price	P&P
0.5KVA 2.5 amp max	£31.90	£6.00
	£44.53 inc VAT)	
1KVA 5 amp max	£41.15	£7.00
	(£56.58 inc VAT)	
2KVA 10 amp max	£59.40	£8.50
	(£79.78 inc VAT)	
3KVA 15 amp max	£78.65	£8.50
	(£102.40 inc VAT)	
5KVA 25 amp max	£139.15	
	(Plus Carriage)	

Buy direct from the importers. Keenest prices in the country

COMPREHENSIVE RANGE OF TRANSFORMERS–LT–ISOLATION & AUTO
(110-240V Auto transfer either cased with American socket and mains lead or open frame type. Available for immediate delivery

WIDE RANGE OF XENON FLASHTUBES
Write/Phone your enquiries

ULTRA VIOLET BLACK LIGHT FLOURESCENT TUBES
4ft 40 watt £12.00 (callers only) (£14.10 inc VAT)
2ft 20 watt £7.44 + £1.25 p&p (£10.21 inc VAT)
12in 8 watt £4.80 + 75p p&p (£6.52 inc VAT)
9in 6 watt £3.96 + 50p p&p (£5.24 inc VAT)
6in 4 watt £3.96 + 50p p&p (£5.24 inc VAT)

230V AC BALLAST KIT
For either 6in, 9in or 12in tubes £6.05 + £1.40 p&p (£8.75 incl)

400 WATT UV LAMP
Only £34.00 + £2.50 p&p £42.89 inc VAT)

160 WATT SELF BALLASTED BLACK LIGHT MERCURY BULB
Available with BC or ES fitting, price inc VAT & p&p and VAT £25.55

12V D.C. BILGE PUMPS

500 GPH 15ft head 3 amp £19.98
1750 G P H 15ft head 9 amp £34.55
Also now available 24V D.C. 1750 GPH 15ft head 5 amp £35.55. All designed to be used submerged. PRICES INCLUDE P&P & VAT

EPROM ERASURE KIT
Build your own EPROM ERASURE for a fraction of the price of a made-up unit kit of parts less case includes 12in 8 watt 2537 Angst Tube Ballast unit, pair of bi-pin leads, neon indicator, on/off switch, safety microswitch and circuit £15.00 + £2.00 p&p (£19.98 inc VAT)

SUPER HY-LIGHT STROBE KIT
Designed for Disco, Theatrical use etc.
Approx 16 joules. Adjustable speed £50.00 + £3.00 p&p (£62.28 inc VAT)
Case and reflector £24.00 + £3.00 p&p (£31.73 inc VAT).
SAE for further details including Hy-Light and industrial Strobe Kits

"BOFFINS SPECIAL" – UNIQUE OFFER
Surplus Precision Medical Unit. Internally in excellent condition. Designed primarily to eject a precise controllable amount of fluid from a medical syringe (latter not supplied). Contains the following removable components. Dual Micro Processor Boards and EPROMS. Escap Precision 12V DC Motor with 300:1 Gear Box and optical encoder coupled to a precision threaded drive mechanism. Mains supply with 6 x 1.5V Ni-Cad A.A. cells back-up. L.C.D. Digital read-out 17mm high with legends. Audible warning.
These are sold for the dismantling of the exceptional quality components. Regret no Circuits available.
Ridiculously low price: £18.00 + £4.00 p&p (£23.50 incl VAT).

12V D.C. GEARED MOTOR
12V D.C. Reversible precision-built Motor. Output speeds no load approx. 12V-28 rpm; 9V-20 rpm; 6V-12 rpm. Will work at lower voltages and still retain a reasonable torque. Ideal for robotics etc. Size: L 40mm W 29 mm H 39mm. Shaft: 3mm dia x 10mm long. Price: £8.00 + 50p p&p (£10.00 inc. VAT)

TORIN CENTRIFUGAL BLOWER
230V AC. 2,800 RPM. 0.9 amp. 130mm diameter, impellor outlet 63 x 37mm, overall size 195 x 160 x 150mm. long. Price £17.50 + £2.50 p&p (£23.50 inc. VAT)

SOLID STATE RELAY
7 amp @ 240V. A.C. when mounted on suitable Heat-sink. Can be driven from T.T.L. or Computer output between 3-10V D.C. Size: 24mm x 17mm x 15mm high. Fixing centres 30mm (TO-3). Price: £3.00 + 40p p&p (£4.00 inc. VAT)

GEARED MOTORS
71 RPM 20lb inch torque reversable 115V AC input including capacitor and transformer for 240V AC operation. Price inc VAT & p&p £23.60.

SOLID STATE EHT UNIT
Input 230/240V AC. Output approx 15KV. Producing 10mm spark. Built-in 10 sec timer. Easily modified for 20 sec. 30 sec to continuous. Designed for boiler ignition. Dozens of uses in the field of physics and electronics, eg supplying neon or argon tubes etc. Price less case £8.50 + £2.40 p&p (£12.81 inc VAT) NMS

SAVE POUNDS!!!
Build your own forged bank note detector. Can detect counterfeits amongst a quantity of notes. Complete kit of parts less case. 240V a.c. including 5" uV black light tube, starter and holder, a pair bi-pin tube holders Total price including p&p & VAT only £13.99

WASHING MACHINE WATER PUMP
Brand new 240V AC. fan cooled. Can be used for a variety of purposes. Inlet 1¼ in. outlet 1 in. dia. Price includes p&p & VAT £11.20 each or 2 for £20.50 inclusive.

MICROSWITCH
Pye 15 amp changeover lever microswitch, type S171. Brand new price 5 for £7.06 inc VAT & p&p

SERVICE TRADING CO
57 BRIDGMAN ROAD, CHISWICK, LONDON W4 5BB
FAX 081 995 0549 081-995 1560
ACCOUNT CUSTOMERS MIN. ORDER £10
Showroom open Monday/Friday
VISA
Ample Parking Space

SWC SCIENTIFIC WIRE COMPANY

ENAMELLED COPPER WIRE
TINNED WIRE SILVER
PLATED COPPER WIRE
SOLDER EUREKA WIRE
NICKEL CHROME WIRE.
BRASS WIRE LI TZ WIRE
BIFILAR WIRE MANGANIN
WIRE TEFZEL WIRE NICKEL
SAE BRINGS LIST 18 RAVEN RD LONDON E18 1HW
FAX 081 559 1114

!!!! ON OFFER THIS MONTH !!!!

Red Super Led 5mm	15p	Crystal Earphone	65p
IR Receiver	20p		
0.1uF X rated	65p	Neon Bulb	
0.1 Poly	5p	25OAC	15p
33uF 16v RAD	10p	BD332 PNP Dart	40p
47uF 35v RAD	10p	BC639 100V 1A	30p
4.7uF 16v RAD	10p	LM337 VREG	45p
2.2uF Non Pol	30p	LM7924 VREG	45p
250uF 16v RAD	10p	2718 Eprom	£1.00
2700pF 1% Tol	10p	2732 Eprom	£1.65
Contact Cleaner	£1.25	Contact Restorer	£1.25
Flux-Off	£1.25		
2pf-26pf	65p	2pf-10pf Trim	40p
1N4001	6p	Tilt Switch	£1.00
47uF 350v DC	45p	4Way Tilt SW	£2.95
74HC75	30p	5 Watt 300 OHM	10p
Crystal 45Mhz	40p	200uf 300V DC	85p

STRIP OF ASSORTED COMPONENTS 1M LENGTH £1.
WIDE RANGE OF ELECTRONIC COMPONENTS ALWAYS IN STOCK RING FOR DETAILS
- FM TRANSMITTERS ALSO IN STOCK -

ELEY ELECTRONIC LTD
100-104 BEATRICE ROAD, LEICESTER, LE3 9FF
TEL: 0533 515944
PAY BY:- VISA/ACCESS
OPEN 10-6 MON-SAT

LIVERPOOL

PROGRESSIVE RADIO
87/93 Dale Street
Tel: 051 236 0982 051 236 0154
47 Whitechapel
Tel: 051 236 5489
Liverpool 2
'THE ELECTRONICS SPECIALISTS'
Open: Tues-Sat 9.30-5.30

NEWMARKET TRANSFORMERS LTD

Mail Order Transformer Specialists.
Toroidal and Laminated Transformers, 3VA to 1kVA.
Fast delivery. Competitive prices. Quality guaranteed.
Phone: Michael Dornan on 0638 662989 for Immediate Quote

FIELD ELECTRIC Ltd

TEST & MEASUREMENT EQUIPMENT
IBM COMPATIBLE COMPUTERS:
POWER SUPPLIES: MONITORS:
AUDIO EQUIPMENT: DISK DRIVES:
MOTHERBOARDS: TELEPHONE EQUIPMENT: PLUGS & CONNECTORS: PRINTERS: WE ALSO BUY EQUIPMENT PLEASE RING.
MAIL ORDER SERVICE PAY BY CHEQUE: PO ACCESS OR VISA.
CALLERS BY APPOINTMENT
FIELD ELECTRIC LTD., UNIT 2 MARY MEAD WORKSHOPS, WILLOWS LINK STEVENAGE HERTS SG2 8AB
0438 353781 : 0836 640328 :
Fax 0438 359397

SURPLUS COMPONENTS WANTED

☆ COMPLETE CLEARANCE
☆ BEST PRICES PAID
☆ PCB BOARDS POPULATED

CONTACT
D.T.S. SERVICES
Tel: (0602) 208955
or Fax: (0602) 484530

TURN YOUR SURPLUS TRANSISTORS, ICS ETC INTO CASH immediate settlement.
We also welcome the opportunity to quote for complete factory clearance.
Contact:
COLES-HARDING & CO.
Unit 58, Queens Road, Wisbech, Cambs PE13 7PQ
BUYERS OF SURPLUS INVENTORY ESTABLISHED OVER 15 YEARS
Tel: 0945 584188
Fax: 0945 475216

COMPELEC

1994 BARGAIN LIST
THE ELECTRONIC ESSENTIAL MILLIONS OF COMPONENTS AT UNBEATABLE PRICES.
FOR A FREE COPY PHONE, FAX OR WRITE (TRADE ONLY)
COMPELEC,
14 CONSTABLE ROAD, ST IVES, HUNTINGDON, CAMBS. PE17 6EQ
0480 300819
WE ALSO PURCHASE ALL TYPES OF ELECTRONIC COMPONENTS, LISTS TO ABOVE ADDRESS.

FOR DETAILS OF HOW TO ADVERTISE CALL JAMES ON 0442 66551

FOR SALE

LEN COOKE ENTERPRISES

For the best value In Used Electronic Test Instruments

We buy, sell and repair Oscilloscopes, Signal Generators, Frequency Counters, Spectrum Analysers, Power Meters, Logic Testers etc.
Spare Parts available for most Tektronix Scopes.

Tel/Fax: 081 864 5551
Mobile: 0831 630820
Mail Order Address: 179 Northolt Road, Harrow, Middx. HA2 0LY.

We engineer what we buy, we support what we sell.

PLANS

ELECTRONIC PLANS, laser designs, solar and wind generators, high voltage teslas, surveillance devices, pyrotechnics and computer graphics tablet. 150 projects. For catalogue. SAE to Plancentre Publications, Unit 7, Old Wharf Industrial Estate, Dymock Road, Ledbury, Herefordshire, HR8 2HS.

PLANS, BOOKS AND MANUALS. Wind generators, petrol generators, inverters, portable welding generators, engine crane, electric bike, solar projects, electronic circuit and project books, and many more. Two first class stamps for descriptive catalogue. Jemmett Engineering, 8 Hallam Gardens, Pinner, Middlesex HA5 4PR

IF YOU ARE READING THIS THEN SO ARE THOUSANDS OF POTENTIAL CLIENTS. CALL 0442 66551 TO ADVERTISE.

COURSES

Start training now with the specialists for the following courses. Send for our brochure — without obligation or Telephone us on 0626 779398 ETI 3/94

Name ____________________

____

____

____

- ☐ Telecomms Tech C&G 2710
- ☐ Radio Amateur Licence C&G
- ☐ Micro-processor
- ☐ Introduction to Television

Radio & Telecommunications Correspondence School
12 Moor View Drive, Teignmouth, Devon TQ14 9UN

KITS

NEW VHF MICROTRANSMITTER KIT tuneable 70-115MHz, 500 metre range, sensitive electret microphone, high quality PCB, SPECIAL OFFER complete kit ONLY £5.95 assembled and ready to use £9.95 inclusive P&P. 3 Watt FM transmitter kit £15.95. Credit card orders Telephone: 021 486 3092, Fax: 021 411 2355. Cheques/PO's to: C.E.C.(Dept ETI), 515a Bristol Road, Birmingham, B29 6AU. Send 2 x 1st Class stamps for details of these and other kits.

100 WATT POWER - Amplifiers £20 ... Quality 12" rackamp + sockets ... Led/Glass PCB! 240 volt regulated powersupply & 4" fan & directions! KIA Audio, 8 Cunliffe Rd., Ilkley LS29.

CAR IMMOBILISER KIT negative earth vehicles only. Complete kit £10.99 Cheques payable to S Blower, 7 Newport Avenue, Fordham, Ely, Cambs. CB7 5NX.

HEATHKIT U.K. Spares and service centre / educational products distributor. Cedar Electronics, 12 Isbourne Way, Winchcombe, Cheltenham, GL5 5NS Tel: (0242) 602402.

SOFTWARE

PC TECHNICAL SHAREWARE

Would you like to see the best range of low cost technical and scientific public domain & shareware for IBM PC in the UK? HUGE RANGE includes:- PACKET, FAX, RX/TX control, PCB design, Circuit and ANTENNA analysis, QSO logging, CAD ELECTRONIC & MECH engineering, SCIENTIFIC, MATHS & STATS, MEDICAL, PROGRAMMING, SOURCE CODE, DATA, EDUCATIONAL, WINDOWS, BUSINESS and lots more
Write, phone or fax today for your free 124 page printed catalogue

The Public Domain Software Library
Winscombe House, Beacon Road,
Crowborough, Sussex TN6 1UL
Tel 0892 663298, Fax 0892 667473

PCB DESIGN

MURTON-PIKE SYSTEMS

FAST SCHEMATIC/PCB MANUAL DRAFTING SOFTWARE SIMILAR IN FUNCTIONALITY TO EASTPC + CLEARANCE CHECKING + GERBER VIEWER + MANUAL £39.99
FREE UPGRADES. DIFFERENCE IN PRICE UPGRADE TO PCBCAD2. TECHNICAL HELPLINE
PCBCAD2 FAST NETLIST BASED PCB PACKAGE + SCHEMATIC TO PCB TRANSLATOR + CLEARANCE CHECKING + GERBER VIEWER + PARTS LIST OUTPUT + INTEGRITY CHECK + MANUAL £49.99
PC CROSS ASSEMBLERS + MANUAL FROM £29.99
INTEGRATED LINKER OR SEPERATE LINKER VERSIONS
LEDS 50 FOR A POUND. 1.25 P + P.
ONE TO ONE CUSTOM MICRO/PROGRAMMING COURSES FROM 75.00/DAY.
HARDWARE/SOFTWARE, PCB DESIGN CONSULTANCY WITH MANUFACTURING FACILITIES.
DEMO DISCS 4.99 REFUNDABLE ON PURCHASE.
CHEQUE/DETAILS TO:
MURTON-PIKE SYSTEMS.
16 GLEBE CRESCENT, APPLEBY CUMBRIA CA16 6RX
OFFICE HOURS (07683) 51027 OTHER (07683) 51704
ASK FOR NIGEL

COMPONENTS

EPROM, PLDs + Microcontrollers copied or programmed. we supply devices/convert discrete logic to PLDs. PO Box 1561 Bath 0225 444467.

FAX YOUR ADVERT TO JAMES ON 0442 66998

CALL JAMES ON 0442 66551 TO PROMOTE YOUR BUSINESS COST EFFECTIVELY IN ETI CLASSIFIED.

ETI

ELECTRONICS TODAY INTERNATIONAL, CLASSIFIED ADVERTISEMENT DEPARTMENT, ARGUS HOUSE, BOUNDARY WAY, HEMEL HEMPSTEAD HP2 7ST

Rates: Lineage 65p per word + VAT minimum 15 words.
Semi-display £8.70 per single column cm plus VAT. No reimbursements for cancellations. All ads must be pre-paid.

Name ....

Address ....

.... Daytime Tel. No: ....

Signature .... Date ....

PLEASE DEBIT MY ACCESS/BARCLAYCARD No. ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ Expiry Date ....

FOR SALE **COMPONENTS** **PLANS** **OTHER PLEASE STATE**

Open Forum

A few days ago, I had a phone call from a reader who was complaining that the magazine now had too much emphasis on microprocessors and computing and not enough on traditional electronics. I am always interested to hear what readers have to say and, I was curious to know what he meant by traditional electronics. His response was simply that he considered traditional electronics to consist of circuits built from logic ICs, OP-Amps, transistors, etc.

Traditional electronics uses logic ICs and Op-Amps? Now, I am not that old, but I can remember when the first ICs were produced. If he had said transistors or valves, then I would perhaps have understood what he meant by traditional. In a technology which is developing as rapidly as electronics you cannot sit down and say this is classical traditional technology and everything developed from now on is of dubious worth.

The reason for this tale is to allow me to expound on a key element of editorial philosophy.

This magazine is about electronics, about all forms of electronics devices and about things that are controlled by electronics. Computers are electronic devices, we cannot draw a line between computing and electronics, they are one and the same thing.

In pure cybernetic terms, any digital IC is just a 'black box' which has a specific table of transformations controlling relationships between the inputs and the outputs. A computer is just another cybernetic 'black box' with input, output and a transformation table relating the two.

The only real difference is that a computer is a general purpose circuit, which allows the user to change the transformation table by changing the program. This means that we can use a computer to behave in exactly the same way as any other 'black box', simply by writing the appropriate program. And it matters little whether we are talking about digital input and output or analogue input and output.

Filling a foot square board with dozens of ICs may qualify for the term traditional electronics, but what is the point of designing and building such a board, when it could be replaced by a simple four or five chip microprocessor system programmed to behave in exactly the same way as our board full of ICs.

There has to be a proper balance of course, simple circuits will always be constructed using basic ICs, transistors, and discrete components. But most of the more complex applications are a lot easier to implement using a microprocessor or microcontroller. I, for one, am all for making life easier. Then, of course, there is the added bonus that processor based circuits are a lot easier to modify and update.

A lot of applications will consist of both a microprocessor and a reasonable number of analogue or digital circuits that are connected to it. In these cases we should think of the processor and its software as providing the 'glue' which links all the other pieces together. A 'glue' which allows us to design easily tested modular systems of considerable complexity. Systems which would probably be considered too complex to be built in any other way.

I feel, therefore, that it is only right that a magazine like ETI should reflect the current trends in electronics and cover what my caller referred to as 'traditional electronics', as well as the use of microprocessors and computers. Only by understanding all these elements can we make full use of the technology available to us.

My apologies to readers who think that computing has no place in an electronics magazine, but I think such readers are mistaken and I hope that the kind of projects which we shall be running over the coming months and years will demonstrate why.

This magazine and its readers have to move with the technology and be at the forefront of that technology. Traditional technology is the technology of today, not the technology of yesterday.

Next month...

We continue Jim Spence's project to build an experimenter's computer, with the design for a keyboard and LCD display. For cyclists, there is an electronic speedometer project from Bob Noyes and, on the home front, a passive infra-red alarm from Robert Penfold. We will also be starting a project to build an infra-red data communications system that can be used to link two computers in different buildings, without the need for cables.

Robert Penfold will be beginning an introductory series on MIDI and June also sees the start of series on repairing and upgrading PCs, and on basic electronic circuits, while our main feature article will be looking at circuit simulation software.

ETI

ELECTRONICS TODAY INTERNATIONAL

EDITORIAL

Editor ***Nick Hampshire***

Sub Editor ***Jim Bluck***

CREATIVE

Art Editor ***Peter Kirby***

Technical Illustration ***John Puczynski***

Photography ***Manny Cefai***

ADVERTISEMENT SALES

Display Sales

Tony Hill

Advertisement Copy Control

Marie Quilter

Classified Sales

James Gale

MANAGEMENT

Managing Director

Terry Pattisson

Circulation & Promotions Manager

Debra Stupple

Production Manager

Tony Dowdeswell

Group Editor

Stuart Cooke

Group Advertisement Manager

Claire Jenkinson

ABC CONSUMER PRESS

ISSN 0142-7229

Subscription rates-UK £23.40 Europe £30.30 Sterling Overseas £31.50 US Dollars Overseas $52.00

Published by Argus Specialist Publications, Argus House, Boundary Way, Hemel Hempstead HP2 7ST. Telephone (0442) 66551. UK newstrade distribution by SM Distribution Ltd, 6 Leigham Court Road, London SW16 2PG. Telephone 081-667 8111. Overseas and non-newstrade sales by Magazine Sales Department, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST. Telephone (0442) 66551. Subscriptions by Argus Subscription Services, ETI, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS. Telephone (0737) 768611.
US subscriptions by Wise Owl Worldwide Publications, 4314 West 238th Street, Torrance, CA90505 USA. For Visa/Mastercard orders in USA - Telephone (310) 375 6258 Fax (310) 375 0548. Pacific Time: 9am-9pm Weekdays. 10am-6pm Weekends. Typesetting and origination by Ebony, Liskeard, Cornwall. Printed by Wiltshire Ltd, Bristol.

AN Argus SPECIALIST PUBLICATION

Argus House, Boundary Way, Hemel Hempstead HP2 7ST
Telephone (0442) 66551
Fax (0442) 66998