ETI

ELECTRONICS TODAY INTERNATIONAL

TOMORROW'S TECHNOLOGY TODAY

Introducing the revolutionary ETI Basic Microcontroller the electronic building block of the future

Electron Microscopy

taking a look at the heart of the matter

Versatile bench power supply

Build a 16 channel MIDI mixer

No PCB? Then ask your newsagent

Use this FREE PCB to build the ETI Basic Microcontroller

OCTOBER 1995 £ 2.50

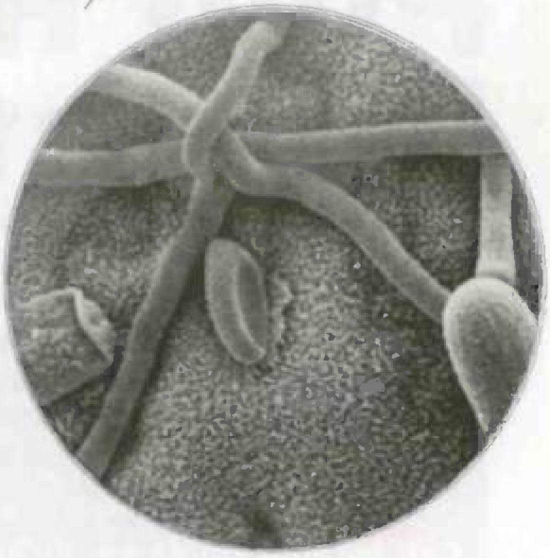
10

9 770142 722108

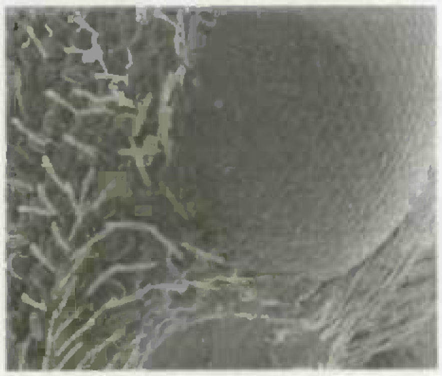
NEXUS

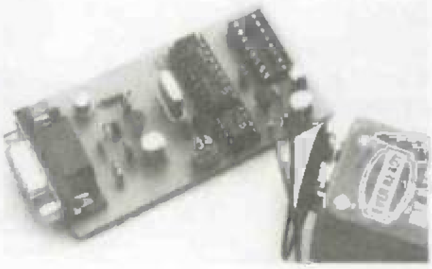
Contents

Volume 24 No.10



& Features Projects





Regulars

ETI News...

8Mbit synchronous graphic RAM improves price/performance in graphics applications

Hitachi has increased its range of synchronous DRAM with the launch of the HM5283206, an 8Mbit synchronous graphic RAM (SGRAM) that provides more than three times the data transfer rates of fast-page DRAM at comparable prices. Hitachi currently supplies 2 and 4Mbit SRAM for graphics applications and expects to launch a 16Mbit version later in the year.

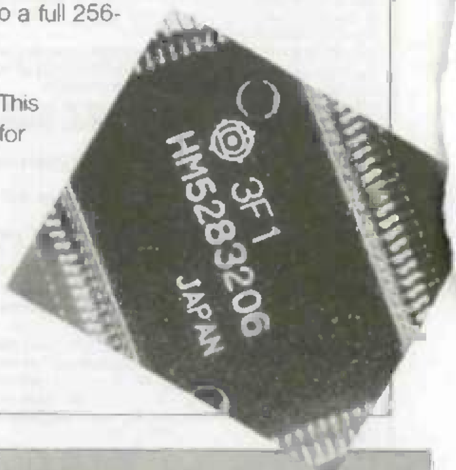
Like the rest of the range, the 3.3V, 8Mbit HM5283206 will be used in applications to replace standard DRAM to improve graphics performance and allow the CPU additional bandwidth during screen refresh. In addition, it will be used in some high-performance graphical applications to replace expensive video RAM (VRAM).

The HM5283206 is organised as 256K x 32 bits with clock frequencies of 66, 83 and 100Mhz achieved through pipelining, allowing data to arrive in a predictable fashion while the CPU schedules other activities. Burst mode length is programmable and can be selected from 1, 2, 4, 8 consecutive words up to a full 256-word page, and can be selected from one memory bank or interleaved between two.

The range of SDRAMs is configured with two memory banks that can be accessed simultaneously and independently, so that one bank is read while the other is precharged. This enables full on-chip interleaving of memory, which offers the high data bandwidth required for graphics applications. The 8Mbit device (HM5283206) can achieve a 100MHz burst rate giving 400-Mbyte/s bandwidth, needed for high resolution true colour displays. The 4Mbit (HM5241605) and 2Bit (HM5283206) devices, organised as 256k x 16 and 128k x 16 respectively, achieve a bust rate of 66Mhz and 80Mhz.

The 8Mbit SGRAM device uses the LV TTL standard, and is powered from a single 3.3V supply and is available in a 100 pin plastic QFP package. Versions of the device are available with 66, 83 and 100MHz clock frequency.

For further information contact Hitachi Europe Ltd, Tel: +44 1628 585163.



3.3V logic family with 5V performance

Hitachi has announced the new HD74LV series of standard logic ICs. These offer the same performance as the 5 volt HD74HC series, but at only 3.3 volts. The 17 products within the new family include simple logic functions, decoders, bus transceivers and bistables.

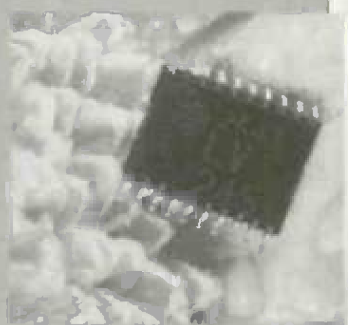
The devices have applications in areas where manufacturers are reducing the power consumption of their product, for example telecom switches where a large proportion of power is consumed by discrete logic.

The HD74LV series is also suitable as the level shifting interface for mixed 3.3 volt and 5 volt logic systems and will find applications in products such as camcorders, personal digital assistants, sub-notebook computers and portable phones.

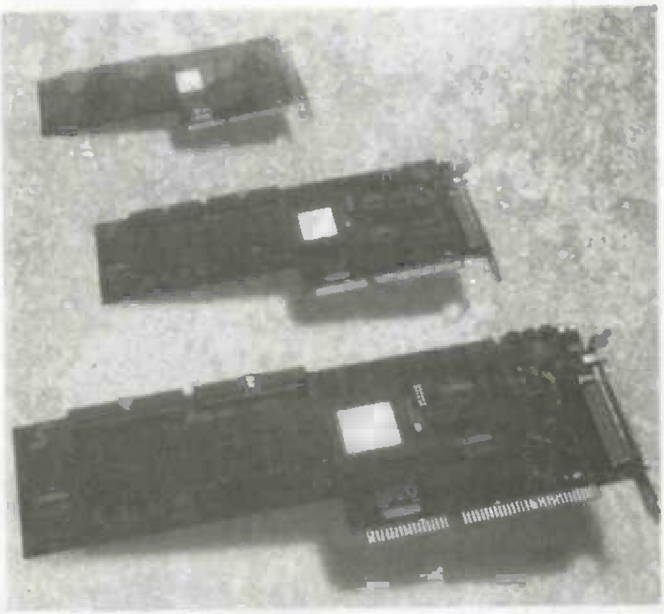
In addition to the effect of operating at 3.3 volt, power consumption is further reduced by a low input current of ±1uA and a quiescent current of only 20uA. The high impedance inputs are protected from ESD (electrostatic discharge) by modified zener diodes, reducing the leakage current compared to older logic families.

The HD74LV series uses well proven 2.5um CMOS technology with a low voltage range of 2.7 to 3/6 volts. Typical transmission delay time is 9ns, and load driving capability is ±8mA (output sink-source current). These specifications meet or exceed those of the HD74HC series operating at 5 volts.

For further information contact Hitachi Europe Ltd, on +44 1628 585163.



New 100 MFLOP DSP board transfers data at 200MB per second



Designed with a high speed auxiliary bus and a 100MFLOP processor, the new SP20 Digital Signal Processor Board from Strategic Test transfers data on or off the board at 200MB per second to set a new industry speed mark for a PC-based DSP product.

Manufactured by Signatec of the USA, the SP20's auxiliary bus is a double-wide 64 bit implementation of Data Translation's DT-Connect III bus. The SP 20 incorporates a 33MHz ADSP-21020 digital signal processor from Analog Devices. Operating at 0 wait states, the SP20 performs a 1K real FFT in 340 microseconds or a 1K complex FFT in only 578 ms.

The SP20 features 128Kx48 of program memory and data memory is available from 512 KB to 4 MB. An external 32-bit digital I/O allows the SP20 to interface with devices outside of the PC at transfer rates to 25 MB per second.

A complete interface library with source code in C is provided with the SP20. The Analog Devices Software Development Package, including the ADSP-21020 function library is available at additional cost.

For further information please contact Strategic Test on 01734 575150.

Latest from Maplin

The new timer from Maplin electronics is a 24-hour programmable light switch that can be programmed for up to 4 pairs of On/Off switch settings. This can be per day or for random switching which turns the load On/Off for 10-30 minute periods throughout the programmed times.

The 24-hour programmable light switch costs £24.99 (Including VAT).

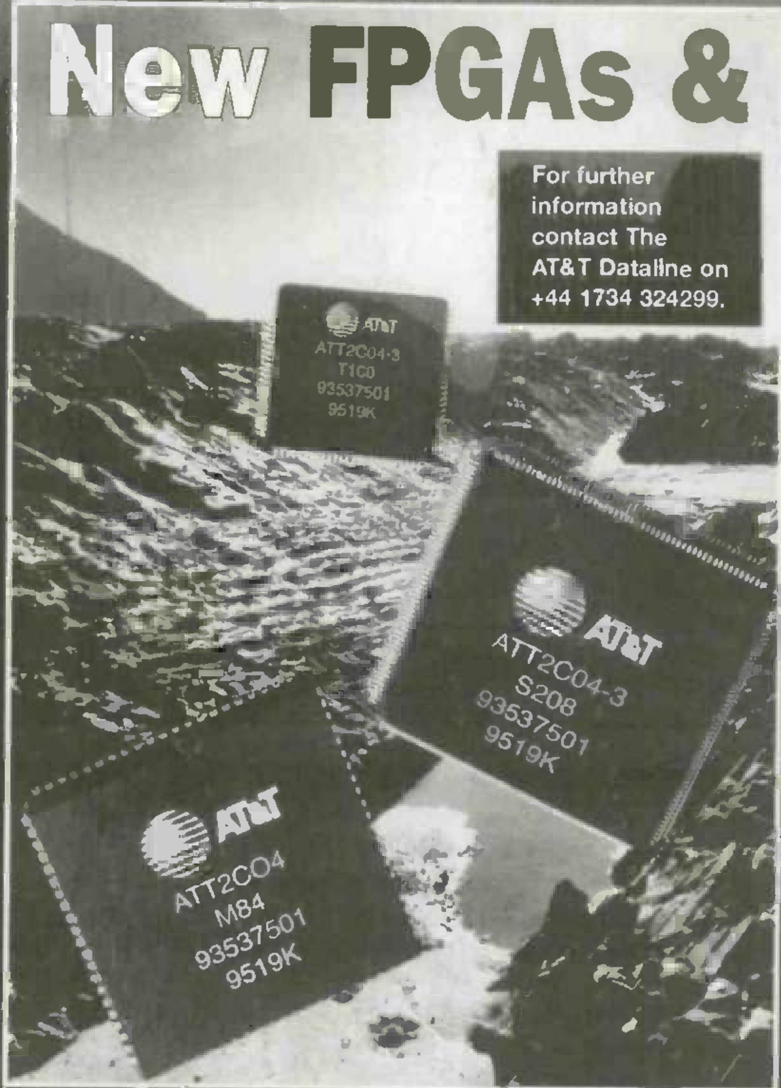
Also new from Maplin is the Car Battery Analyzer. This is a handy device for checking the state of a car's battery and charging circuit. Simply plug the device into the car's cigar lighter socket and read the display.

For testing the battery, the engine must be turned off and the car lights left on dipped beam for one minute. Next, the device must be connected and the display read. If the battery is defective the meter will register low. To check the alternator/dynamo state, the meter scale must be checked after driving for more than 15 minutes. A healthy charging circuit will register in the middle of the scale.

The legend on the meter is easy to read, and colour coded to show which areas of the scale are healthy and which are bad. Suitable for negative ground electrical systems, the Car Battery Analyzer costs £3.99 (Include. VAT).

For further information on either of these products, contact Maplin on 1702 552911.

New FPGAs & software



For further information contact The AT&T Dataline on +44 1734 324299.

AT&T Microelectronics has announced new 4000- and 6000-gate FPGAs for the ORCA product line, along with a new release of the AT&T Foundry software which provides place-and-route support for both the ORCA and ATT3000 families of FPGAs.

The new ATT2C04 and ATT2C06 devices complete the lower end of the ORCA product line which includes 8,000- to 40,000-gate FPGAs, and fill the gap between the ATT3000 and ORCA product families.

"Routeing these new devices is done in a fraction of the time that's needed for comparable devices," said Roman Polz, director of FPGAs at AT&T Microelectronics Europe. "And we're offering this combination of higher routability and greater ease of use at a fraction of the cost. These devices are priced to compete directly with gate arrays."

The new 0.5um FPGAs offer 60MHz system speed performance, and, like other devices in the ORCA family, feature fast-carry logic and on-chip SRAM.

The new AT&T Foundry release 7.0 is an upgrade to the NeoCAD version 6.1.1 software.

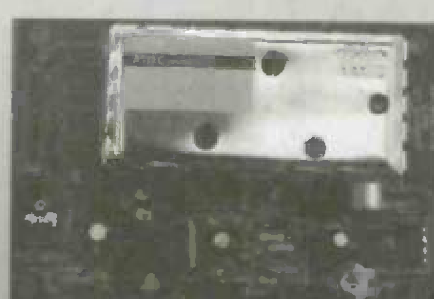
Video modulator boards

Electronics distributors Cubegate Ltd recently announced the introduction of two new boards designed to convert composite video and audio to UHF TV, approximately channel 37. They have been developed with the new generation of mini CCTV board cameras in mind for distribution of UHF TV signals to standard TVs and video recorders or specialised distribution systems.

Two versions are available: VM3 which has composite video input and audio input at line level and model VM5 which is composite video and electret microphone input. These models are board versions for OEM use but are also available boxed with input and output sockets for easy installation.

SPECIFICATIONS FOR VM3

Composite video input	1.0v P-P at 75 ohms load.
Audio input	47K ohms at 100mV.
UHF TV output	Channel 37 approximately.
Power Supply	9 to 12v DC at 50mA.
Size of circuit board	70 x 100mm



SPECIFICATION FOR VM5

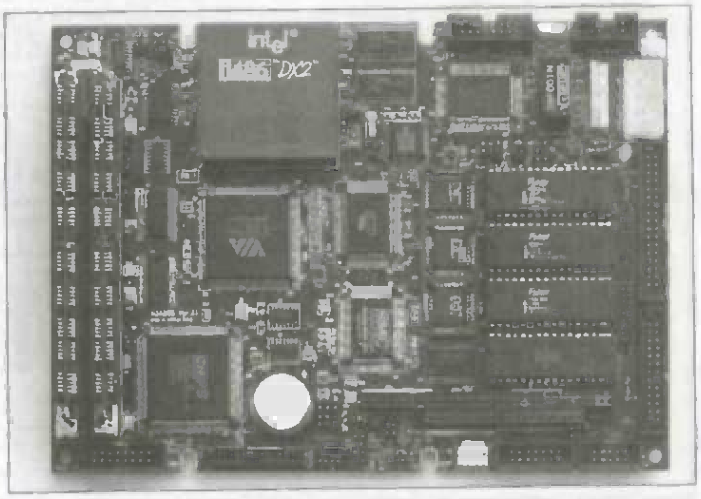
Composite video input	1.0v P-P at 75 ohms load.
Audio input	[illegible]K ohms at 2mV.
(5 volt Phantom Powered)	
UHF TV output	Channel 37 Approximately.
Power Supply	9 to 12v DC at 50mA.
Size of circuit board	70 x 100mm

General applications are for use with CCTV camera and camcorders to convert for use on UHF TV systems. They are also ideal for security surveillance applications.
All enquiries to Sales Dept. Cubegate Ltd., Tel: 0171 258 1831.

All in One
486 CPU SBC with PC/104 expansion

The AMC-4860 is an all-in-one single board 486 computer with an on-board 16-bit Ethernet (Novell NE2000 compatible) interface supporting both 10BASE-2/5 (AUI) and 10BASE-T. The board also features a VGA CRT/flat-panel controller with the flat-panel type configured in BIOS. The AMC-4860 offers all the functions of a PC-compatible industrial computer on a single board yet only occupies the space of a 5 1/4" floppy drive (just 5.75" x 8"). The board is 100% PC/AT compatible, enabling software to be developed and tested on a standard desktop PC and then downloaded and run without modification.

On-board features include two serial ports (RS-232 and RS-232/422/485), one parallel port, a IDE hard-drive controller, a floppy-drive controller and a keyboard/PS/2 mouse interface. The board's watchdog timer can automatically reset the system if it stops due to a program bug or EMI. Additional functionality can be added with up to six industry-standard PC/104 expansion modules.



An on-board solid state disk (SSD) emulates a floppy drive using EPROM or Flash memory devices. Capacity is up to 1.44MB, depending on the size of the memory chips. If you use Flash memory, you can read and write to the disk just like a floppy. If you use EPROM, the disk is read-only and you must program the chips with an EPROM programmer. You access the SSD using standard DOS commands or BIOS I/O. The system can even boot from the SSD.

For further information contact Advanced Modular Computers Ltd., on 01753 580660.

State of the art programming tools for industrial PC hardware

Arcom Control Systems has interfaced its STEbus, Pcbus and VMEbus boards to C and Visual BASIC programming tools running under Windows, greatly simplifying and speeding the development of robust PC-based systems for industrial and real-time applications. The link between Windows software and industrial hardware is a unique driver scheme called Super DRIVER, which provides predictable and high-speed I/O between PC programs and Arcom I/O boards for PC, VNE or STE buses.

They reduce application development time significantly, by allowing system designers to work through the intuitive Windows interface, and to call on the wealth of low-cost Windows software for peripheral analysis and presentation tasks which can occupy a disproportionately large part of project timescales using conventional programming methods.

Using SuperDRIVERs, application-specific industrial computer systems can now be developed in a fraction of the time previously required. Automated testing on the shop floor or in remote field stations, engineering analysis and investigation, and plan process analyses, monitoring and control - in fact any application requiring a high-quality user interface combined with flexible configuration facilities - will benefit from the unique SuperDRIVER architecture.

To deliver these benefits, Arcom has developed a virtual device driver architecture which operates at a very low level in the Windows environment. SuperDRIVERS for Visual BASIC and Windows C are implemented as virtual DLLs and operate at Ring 0, the lowest level of the Windows operating environment. By implementing virtual instrument drivers at a lower level than applications, Arcom ensures that I/O interfacing happens independently of the host virtual instrument and program, providing the degree of determinism and robustness demanded by the real-time industrial arena.

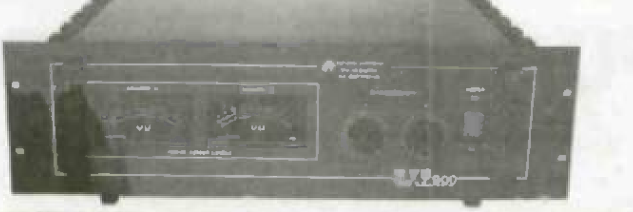
For further details, contact Arcom Control Systems Ltd on +44 (0) 1223 411200

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

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

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

THOUSANDS PURCHASED BY PROFESSIONAL USERS



THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

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

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

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

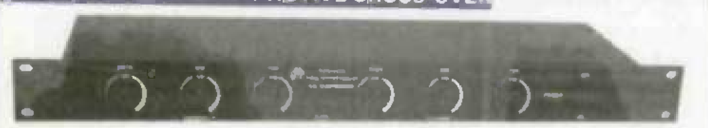
USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.

SIZES:- MXF200 W19"xH3½" (2U)xD11"
MXF400 W19"xH5¼" (3U)xD12"
MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14½"

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. Base 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★

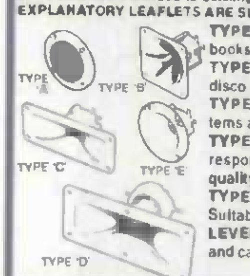
STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination 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

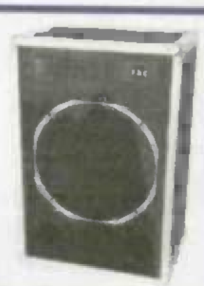
Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if two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

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

THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS
150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono
ALL POWERS INTO 4 OHMS

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

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

OMP MOS-FET POWER AMPLIFIER MODULES
SUPPLIED READY BUILT AND TESTED.

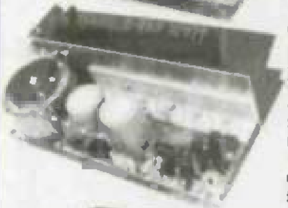
These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal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

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

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

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

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



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

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

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

LOUDSPEAKERS

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

McKenzie and Fane Loudspeakers are also available.

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

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

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

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

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

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

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

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

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

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

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

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

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

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

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

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

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

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

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

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

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

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

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

TRANSMITTER HOBBY KITS

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

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
PRICE £14.95 + £1.00 P&P

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

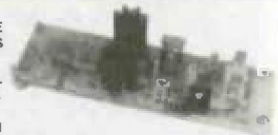


PHOTO: 3W FM TRANSMITTER

B.K. ELECTRONICS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CRAWLING INSECT ROASTER PLANS Harmless high frequency energy pulses destroy pests as they crawl into the energy field! £4/set Ref F/RCR1

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

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

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

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

ELECTROMAGNETIC COIL GUN PLANS Projects a metal object a considerable distance-requires adult

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

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

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

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

MINI FM TRANSMITTER KIT Very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but easily changed to cover 63-130 Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £7 Ref 1001.

ELECTRONIC SIREN KIT Impressive 5 watt power output. Ideal for car/bike alarm etc. 6-12v dc max current 1A. 1.2khz £6 Ref 1003.

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

1 WATT FM TRANSMITTER KIT Supplied with piezo electric microphone 8-30vdc. At 25-30v you will get nearly 2 watts! £12 ref 1009.

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

MOSQUITO REPELLER KIT Modern way to keep midges at bay! Runs for about a month on one 1.5v battery. £7 Ref 1015.

3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £14 Ref 1014

MOTORBIKE/CYCLE TREMBLER ALARM KIT Adjustable sensitivity, preset alarm time, auto reset. Could be connected to horn etc. £12 Ref 1011

0-6 MINUTE TIMER KIT adjustable, will switch up to 2A mains. Perfect for alarms, photography, etc. £7 Ref 1020.

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £20 Ref 1028

STROBE LIGHT KIT Adjustable from 1-60 hz (a lot faster than conventional strobes). Mains operated. £16 Ref 1037.

ULTRASONIC RADAR KIT Ideal as a movement detector with a range of about 10 metres, automate your cat flap! 12v dc. £15 Ref 1049.

LIQUID LEVEL DETECTOR KIT Useful for tanks, ponds, baths, rain alarm, leak detector etc. Will switch 2A mains. £5 Ref 1081.

COMBINATION LOCK KIT 9key, programmable complete with keypad, will switch 2A mains. 9v dc operation. £10 ref 1114.

PHONE BUG DETECTOR KIT This device will warn you if somebody is eavescropping on your line. £6 ref 1130.

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

TELEPHONE BUG KIT Small bug powered by the 'phone line, starts transmitting as soon as the phone is pickec up! £8 Ref 1135.

FUNCTION GENERATOR KIT Produces sinusoidal, saw tooth and square waves from 20-20khz, separate level controls for each shape. Will produce all 3 together. 24vac. £16 ref 1008.

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

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

VOX SWITCH KIT Sound activated swtich ideal for making bugging tape recorders etc, adjustable sensitivity. £8 ref 1073.

INCAR SOUND TO LIGHT KIT Put some atmosphere in your car with this mini 3 channel sound to light. Each channel has 6 led's. £10 ref 1086.

7W HI FI AMPLIFIER KIT Useful, powerful, ideal for audio systems, intercoms etc. 12-18vdc £7 ref 1025.

PHONE CALL RELAY KIT Useful device that operates a relay whenever the 'phone rings. Switches mains at 2A. £10 ref 1122

LEAD ACID CHARGER KIT Two automatic charging rates, visual indication of battery state, ideal for alarm systems etc. 100mA 12vdc £12 ref 1095

CAR ALARM KIT Works on voltage drop and vibration, entry/exit delays, adjustable alarm duration. Ideal caravans etc £12 ref 1019.

PORTABLE ALARM KIT Based on mercury switch, alrm continues to sound until reset by owner. Buzzer inc. £11 ref 1150.

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

METAL DETECTOR KIT Range 15-20cm, complete with case, 9vdc. £8 ref 1022.

SINGLE CHANNEL SOUND TO LIGHT KIT Mains operated, add ryhum to your party for only £8 ref 1006.

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

GUITAR PREAMP KIT Complete with tone controls, small enough to fit in any guiter, based on TL082 IC. 9-12vdc £8 Ref 1091.

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

TELEPHONE AMPLIFIER KIT Very sensitive amplifier which uses a pickup coil (supplied) will let you follow a conversation with out holding the 'phone. £11 ref 1059.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

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

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

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

TEL: 01273 203500

FAX 01273 323077

HUMIDITY METER KIT Builds into a precision LCD humidity meter, 9 ic design, pcb, lcd display and all components included. £49

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

DIVINING RODS Expensive technology cannot challenge the fool proof art of water divining, passed down from generation to generation. Seeing is believing. Use in the home, garden, countryside or desert. It's divinely simple! £4.99 a pair ref E/3

HUGE BUBBLE MAKING KIT You'll be amazed at the the size of the bubbles you can acheive with this bubble making kit. Once you have got the knack it is possible to make bubbles of up to 40 feet long. £11.99 ref E/9.

FM CORDLESS MICROPHONE This unit is an FM broadcasting station in minature, 3 transistor transmitter with electret condenser mic+fet amp design result in maximum sensitivity and broad frequency response. 90-105mhz, 50-1500hz, 500 foot range in open country! PP3 battery required. £15.00 ref 15P42A

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GI/R20

STETHOSCOPES A fully functioning stethoscope for all those intricate projects. Enables you to listen to motors, pipes, heartbeats, walls, insects etc. £6 ref MAR6P6

NICKEL PLATING KIT Proffesional electroplating kit that will transform rusting parts into showpieces in 3 hours! Will plate onto steel, iron, bronze, gunmetal, copper, welded, silver soldered or brazed joints. Kit includes enough to plate 1,000 sq inches. You will also need a 12v supply, a container and 2 12v light bulbs. £39.99 ref NIK39.

SHOP WOBBLERS! Small assemblies designed to take D size batteries and 'wobble' signs about in shops! £3.99 Ref SEP4P2

OMRON ELECTRONIC INTERVAL TIMERS.

*****NEW LOW PRICES TO CLEAR!!!******

Minature adjustable timers, 4 pole c/o output 3A 240v,

HY1230S, 12vDC adjustable from 0-30 secs. £4.99
HY1210M, 12vDC adjustable from 0-10 mins. £4.99
HY1260M, 12vDC adjustable from 0-60 mins. £4.99
HY2460M, 24vAC adjustable from 0-60 mins. £2.99
HY243H, 24vAC adjustable from 0-3 hours. £2.99
HY2401S, 240v adjustable from 0-1 secs. £4.99
HY2405S, 240v adjustable from 0-5 secs. £4.99
HY24060m, 240v adjustable from 0-60 mins. £6.99

DRINKING BIRD Remember these? hook onto wine glass (supplied) and they drink, standup, drink, standup ETC! £4 each Ref EF1

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

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

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

9v DC POWER SUPPLY Standard plug in type 150ma 9v DC with lead and DC power plug. price for two is £2.99 ref AUG3P4.

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

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

MAINS CABLE Precut black 2 core 2 metre lengths ideal for repairs, projects etc. 50 metres for £1.99 ref AUG2P7.

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

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc 200w at £20 REF: MAG20P3 (265x155x125mm).

GYROSCOPE About 3" high and an excellent educational toy for all ages! Price with instruction booklet £6 Ref EF15

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

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

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

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

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

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

3' by 1' AMORPHOUS SOLAR PANELS 14.5v, 700mA 10 watts, aluminium frame, screw terminals, £44.95 ref MAG45.

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

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

FLYING PARROTS Easily assembled kit that builds a parrot that actually flaps its wings and flies! 50 m range £6 ref EF2.

HIGH POWER CATAPULTS Hinged arm brace for stability, tempered steel yoke, super strength latex power bands. Departure speed of ammunition is in excess of 200 miles per hour! Range of over 200 metres! £7.99 ref R/9.

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

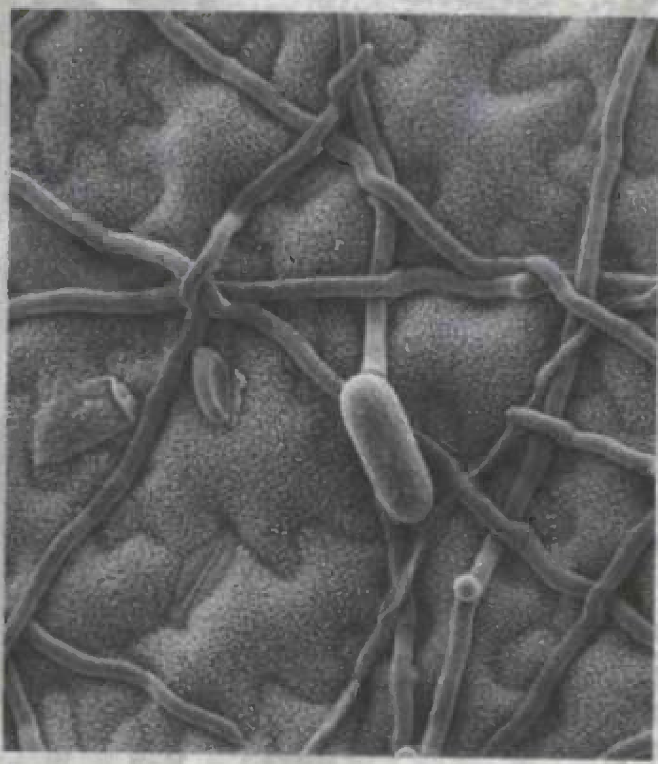
WE BUY SURPLUS STOCK FOR CASH

FREE CATALOGUE

1995 100 PAGE CATALOGUE NOW AVAILABLE, 45P STAMP OR FREE ON REQUEST WITH ORDER.

Looking into the heart of ma

Electron Microscopy has enabled scientists to look at smaller and smaller structures, and now even let us look at atoms themselves, as a result electron microscopes have become an invaluable tool in both research and industry. Douglas Clarkson takes a look at how they work and some of the applications.



As more and more scientific and technical developments centre round materials technology at the micron and sub micron scale, such as the fabrication of semiconductors, so the demand for powerful and flexible microscopy systems continues to expand. While the field of microscopy is in a rapid period of change with the exploitation of techniques of atomic force microscopy, conventional electron microscopy continues to serve many industries well. Also, a range of developments within this technology area are extending the scope of electron microscopy systems.

The electron microscope, while having some disadvantages such as the time consuming sample preparation for its transmission electron microscopes, has also developed into a flexible analytical tool for the analysis of materials. This now makes it possible, for example, to 'finger print' minute samples over a range of parameters - such as element composition and characteristic light emission. Electron microscopy at the more advanced levels in its scanning microscopes now includes an array of materials analysis techniques in addition to derivation of standard transmission and electron scattering images.

Wave Properties

Microscopists had long realised that the resolving power of their instruments was fundamentally limited by the wavelength of the

tter

light. The duality of waves and particles was first discussed around 1924 by Louis de Broglie and would have been a powerful stimulus to microscopy workers to investigate the potential of accelerated electrons for probing the structure of matter.

According to the De Broglie equation, the effective wavelength of a particle with mass m and velocity v is given by:-

$$\text{wavel} = \frac{h}{m\ v}$$

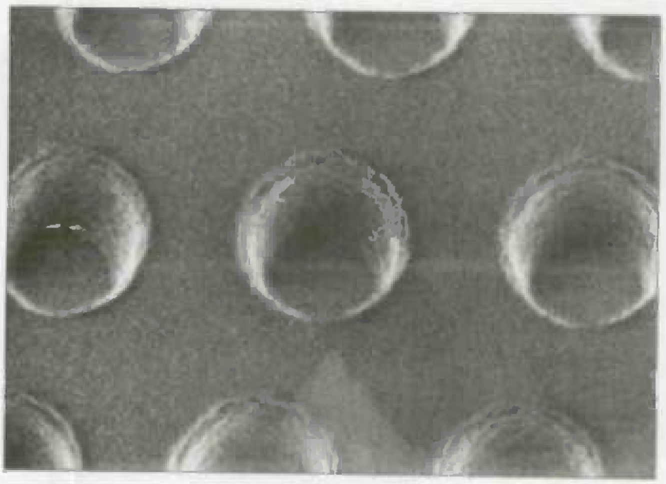
where h is Planck's constant. As electrons are accelerated in a high voltage field, a significant amount of the energy acquired from the electric field increases the mass of the particle according to relativity theory. Table 1 indicates how the electrons behave for a range of accelerating voltages.

Table 1 shows values of velocity, relative total mass and effective wavelength (nm) for electrons accelerated to specific voltages within the range 10,000 V to 150,000 V (The velocity of light is 3 x 10^8 m/s.)

This indicates that electrons even under moderate voltages behave as waves with short equivalent 'wavelengths'. At 50,000 V, the de Broglie wavelength of 0.0053 nm compares favourably with wavelength of 400 nm of conventional optical systems. In reality the maximum resolution typically attained at voltages around 300 kV is one Angstrom - 0.1 nm with medium performance systems having a resolution of

Table 1

accelerating voltage	electron velocity	relative mass	effective wavelength
V	x 10^8	m/s	(nm)
10000	0.586	1.020	0.0122
20000	0.816	1.039	0.0086
30000	0.986	1.059	0.0070
40000	1.123	1.078	0.0060
50000	1.239	1.098	0.0053
60000	1.340	1.118	0.0049
70000	1.429	1.137	0.0045
80000	1.508	1.157	0.0042
90000	1.580	1.176	0.0039
100000	1.646	1.196	0.0037
110000	1.706	1.216	0.0035
120000	1.761	1.235	0.0033
130000	1.812	1.255	0.0032
140000	1.860	1.275	0.0031
150000	1.904	1.294	0.0030

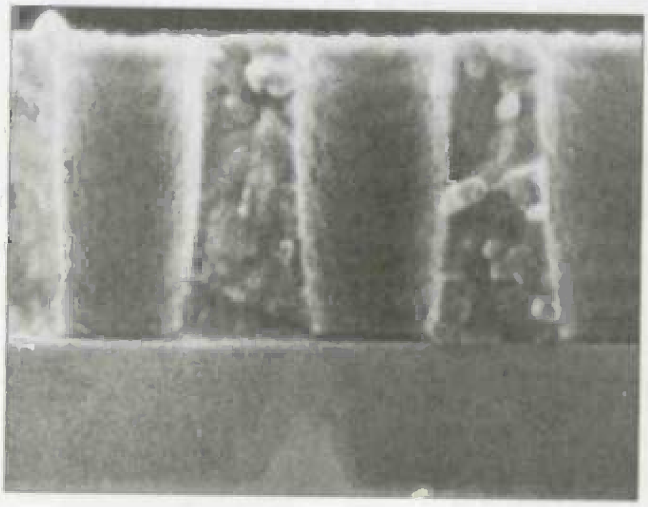


3.3 nm at 30 kV.

The initial principle of electron microscopy demonstrated with conventional transmission microscopy where the electrons were passing through the sample and the picture obtained was related to the relative absorption by the sample of the electrons.

EM History

The first TEM system is claimed to have been developed by Dr. Ernst Ruska at the University of Berlin in 1931 although it was to be 1986 until he was belatedly awarded the Nobel Prize for Physics for his contribution to this important technology. This initial system used two electromagnetic lenses and with the addition of a third lens a resolution twice as good as that of a light microscope was achieved. The first commercially built electron microscope was developed at Cambridge, England around 1935 though many would claim that all the important early developments in EM technology were made at Cambridge. The major problem with the early systems was the rapid destruction of samples by the beam of incident electrons.



A major problem, however, with such systems was also the stability of the focusing optics used. The development of the so called 'stagmator' lens in 1946 led to development of systems with a resolution point to point of less than three anstroms.

While such transmission microscopy was able to provide much additional information of the structure of materials, such a technique could only be undertaken using thin samples of material. Increased thicknesses could be utilised with high voltage systems though these were naturally more extensive and were more difficult to control.

A range of options were developed in order to obtain an image from the pattern of electron transmission thus produced. A fluorescent screen at the base of the electron column could be used in order to build up a pattern of the image. Alternately an photographic emulsion could be exposed and then developed. Using today's state of the art technology, TEM systems with resolving power of 0.1 nm at magnifications of over 1 million can be achieved.

While the history of the TEM is reasonably well documented, the history of the Scanning Electron Microscope (SEM) is not so clear. Some early work was undertaken by a German Physicist Dr. Max. Knoll in 1935 though the first practical system was developed in 1942 by three Americans Dr. Zworykin, Dr. Hillier and Dr. Snijder. Their system could achieve a resolving power of 50 nm and a magnification of 8000.

A combination system of TEM and SEM technology known as STEM has also been developed. The resolving power of such dual systems is typically 1 nm with a magnification of up to 1 million times. Figure 1 shows an interesting low magnification image produced from such a STEM system. The image was obtained in the Application Laboratory for EM, Philips Electron Optics, Eindhoven. In the image the ant holds a silicon chip some 2 mm by 2 mm in its mandibles.

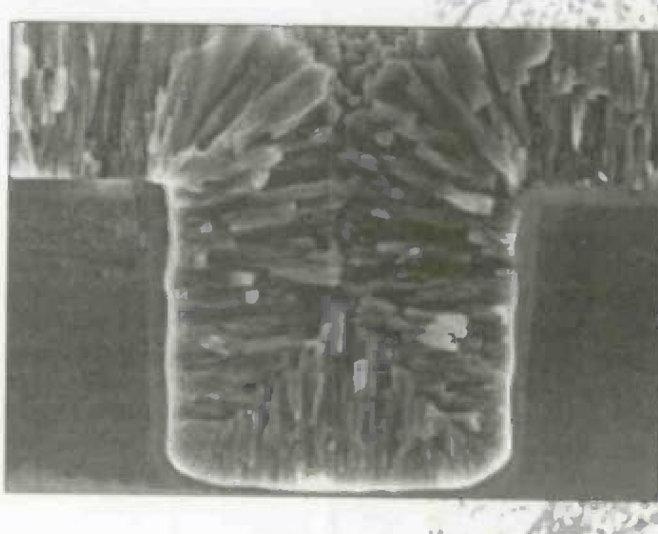
TEM Design

Figure 2 shows the similarities between the light microscope (LM) and the transmission electron microscope (TEM). The source of illumination in the TEM corresponds to the electron gun and the electromagnetic lenses to the glass lenses of the light microscope. The entire sample in the TEM is therefore irradiated by electrons.

While the glass optics of the light microscope are essentially fixed, the focusing of the TEM can be adjusted by varying the currents fed to the series of electromagnetic lenses.

A key element of any type of electron microscope is the electron gun. Figure 3 indicates the typical design of this component. The filament, usually of tungsten, is typically maintained at a temperature of 2700 C. Electrons are drawn down from the filament by the anode potential but are also made to pass through an aperture in a Wehnelt cylinder. The electric field in the region of this aperture maps the electrons into a beam with a sharply defined focus as shown in the figure.

There are, however, advantages in achieving higher electron emission. With a small active spot is achieved in an SEM system, increased resolution can be achieved. The use of a



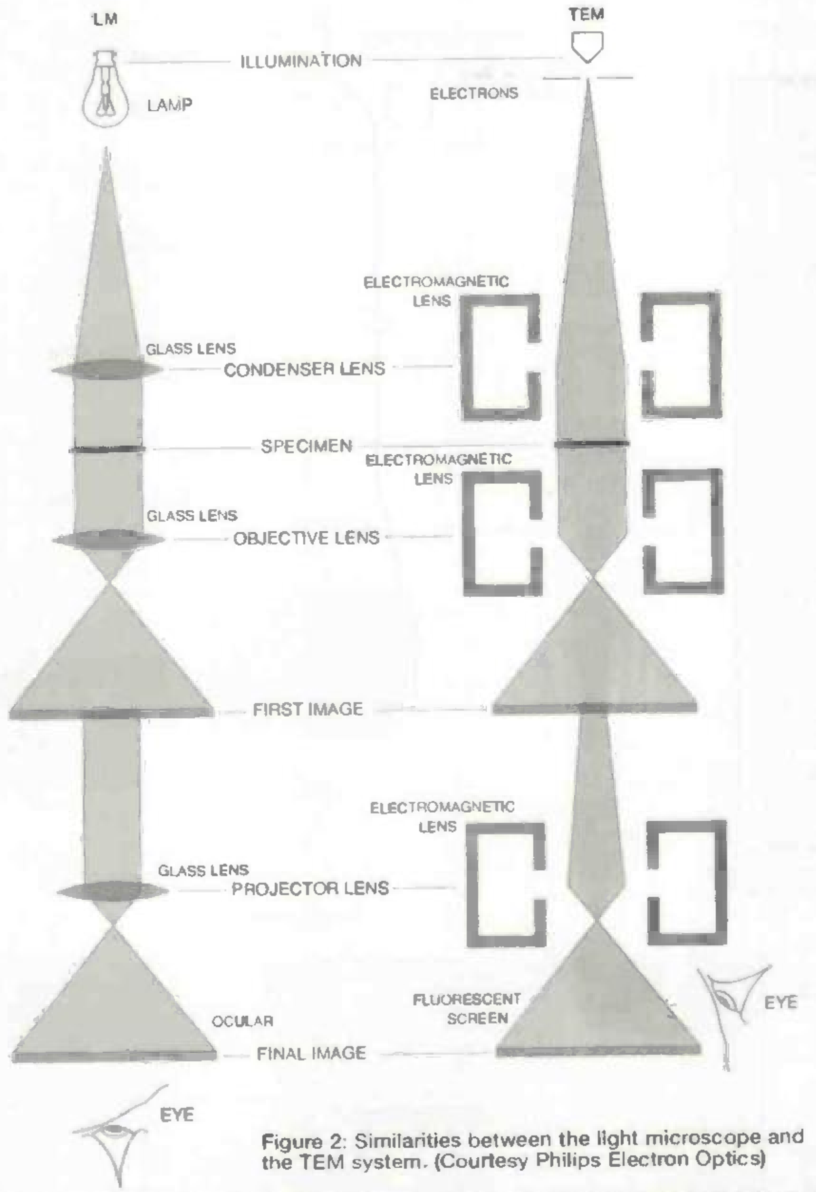


Figure 2: Similarities between the light microscope and the TEM system. (Courtesy Philips Electron Optics)

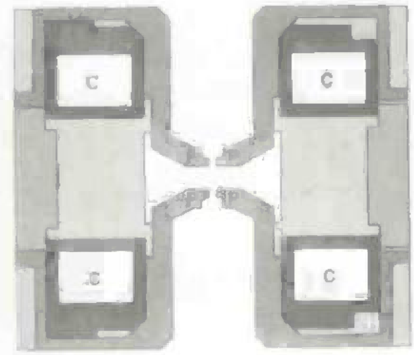
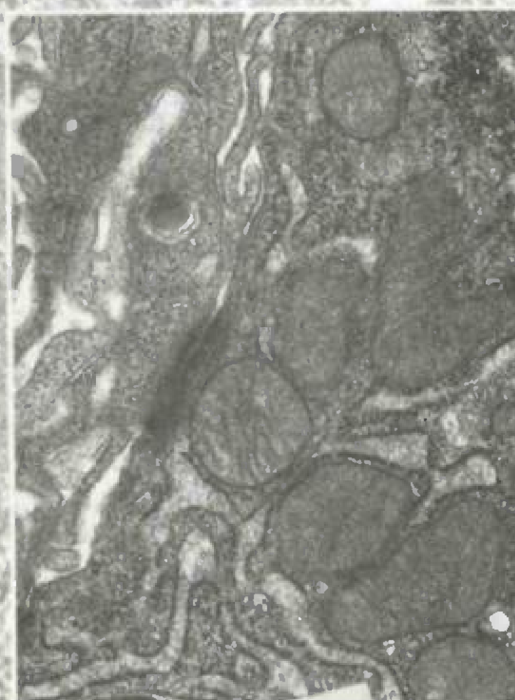


Figure 4: Cross section of electromagnetic lens used to focus electron bean in TEM system. (Courtesy Philips Electron Optics)



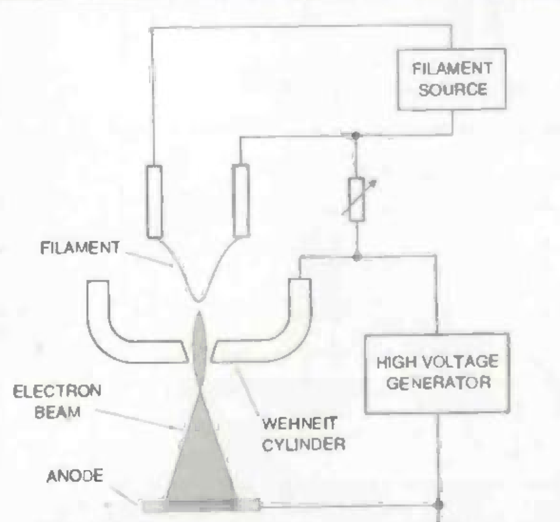
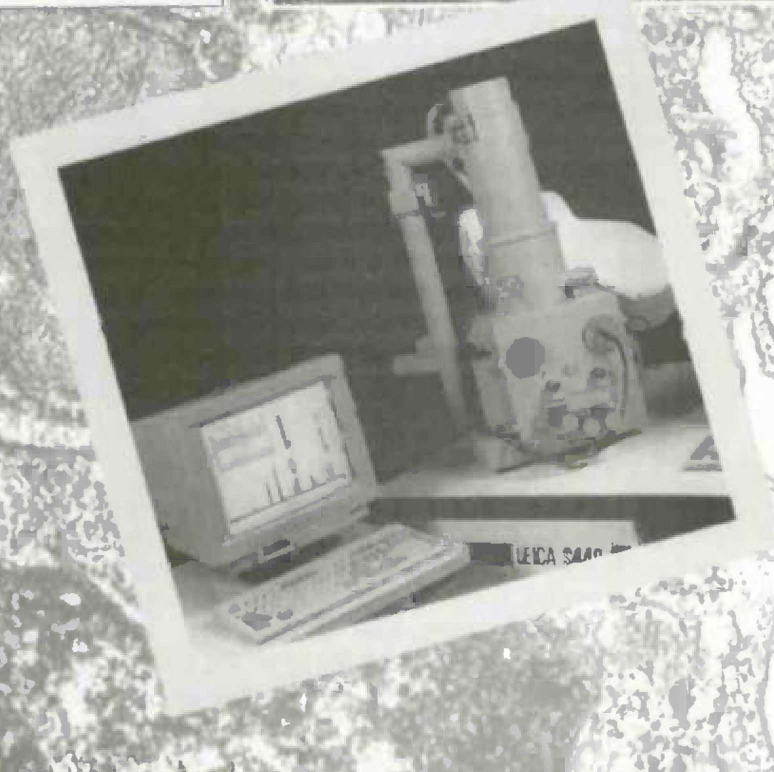


Figure 3: Typical design of electron gun - the source of electrons used for EM analysis. Electrons are drawn off the tungsten filament by the anode voltage and in passing through the aperture in the Wehnelt cylinder are focused. (Courtesy Philips Electron Optics)



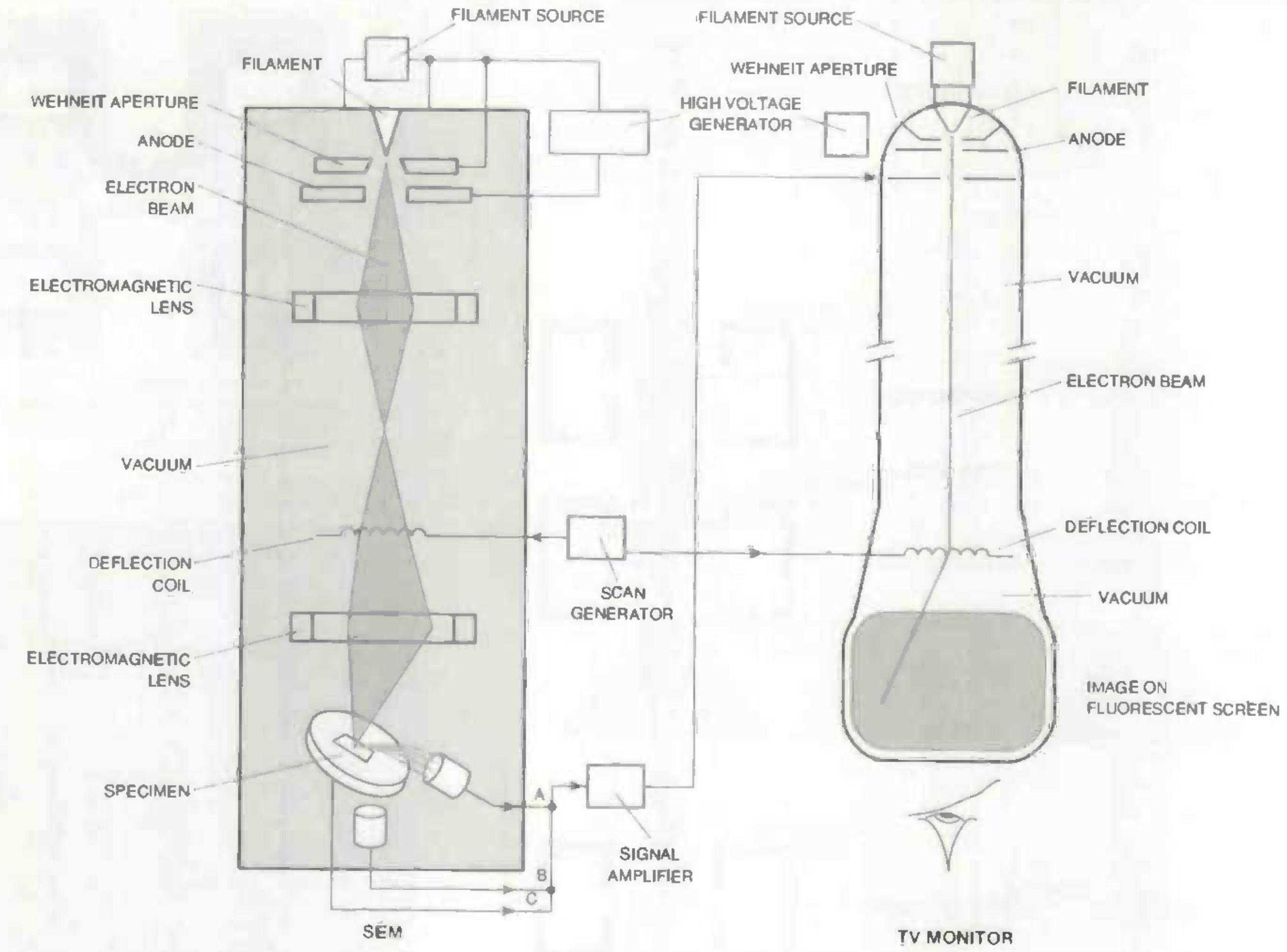


Figure 8:Simplified design of SEM system - compared with conventional video image signal system. (Courtesy Philips Electron Optics)

lanthium hexaboride crystal heated to similar temperatures as Tungsten will achieve a ten fold increase in electron emission. The use of a field emission gun (FEG) can achieve a thousand fold increase in electron emission. This can be important, for example, in x-ray emission analysis where spectra can be more rapidly captured and analysis undertaken.

While the lanthium hexaboride and the field emission gun are more expensive options, they enable much higher performance to be achieved. Higher rates of electron emission will also enable thicker sections of sample to be analysed.

Figure 4 Indicates the typical cross section of an electromagnetic lens. The function of the lens can be controlled by adjustment of the currents in the series of coils. High levels of stability are essential in field levels and requires excellent control of coil currents and winding temperatures.

Photons of light, however, have better propagation properties than charged electrons which tend to repel each other due to electrostatic forces. There will also be an effect of interaction of incident electrons with electrons

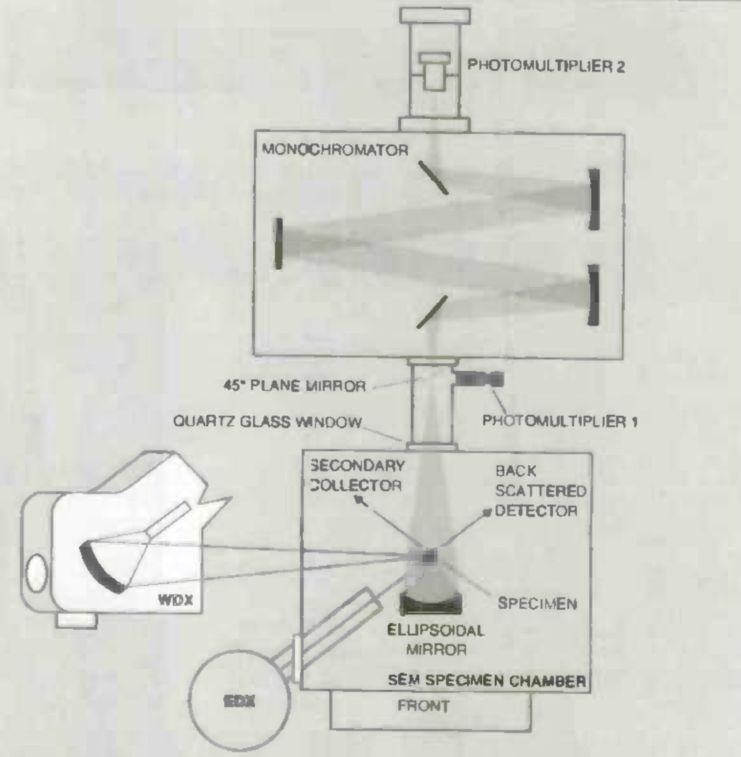


Figure 9: Analytical scanning electron microscope with cathodoluminescence (CL) (upper section), WDX and EDX options. The CL option analyses light emitted from the sample and the WDX and EDX options x-ray spectra. In the Cathodoluminescence option light from the sample is processed by the monochromator system which projects light of a specific wavelength into the input plane of a photomultiplier. (Courtesy Gresham-Camscan).

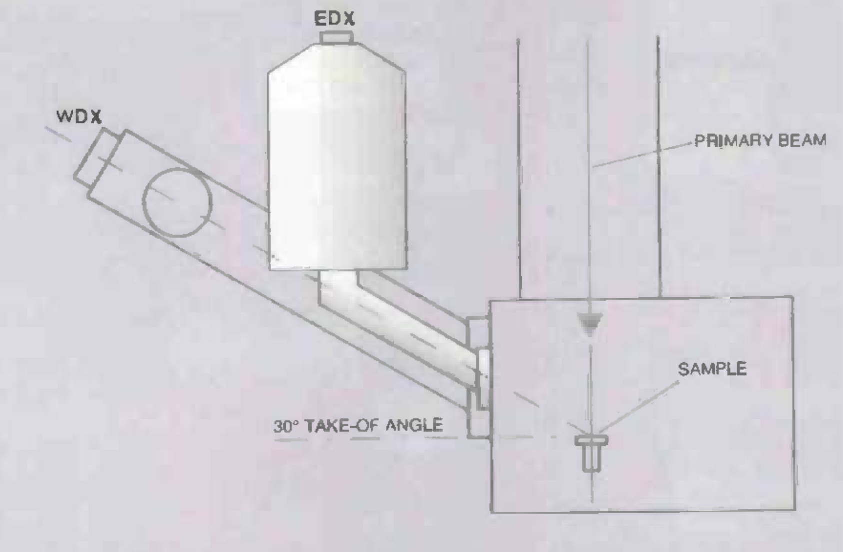


Figure 10: Side view of typical WXD and EDX locations with reference to the primary beam. (Courtesy Gresham-Camscan).

microscope stage assembly which is itself cooled to liquid nitrogen temperatures.

Interest is growing, however, in systems which dispense with even basic sample coating with gold or platinum to reduce build up of charge on the sample being processed. The technique used is one of using a specialised vacuum pumping system which maintains a higher pressure in the sample chamber so that problems of charge accumulation on sample do not arise. Such a system, introduced by Gresham-Camscam as the EnVac scanning electron microscope will help TEM workers achieve higher rates of sample analysis.

Figure 5 indicates a typical TEM system used in analysis of materials. The images from TEM systems are 'flat' and contain no 3D information. Figure 6 shows an image at 42000 magnification of an epithelial cell of human colon.

Figure 7 shows a high magnification image at 325000 magnification of bacterio-phages. The bacterio phages are approximately 150 nm long.

which are ejected from the sample being studied. Beams of light photons are able to pass through each other with practically no interaction.

Sample Preparation

In transmission electron microscopes, samples are usually less than 500 nm thick. Much of the specialisation and complexity in the use of the TEM relates to the preparation of the sample. This process usually involves the fixing of the specimen in a solid resin/plastic structure and then its ultra thin slicing with ultramicrotome system. Sections of thin sample are then mounted and surface treated with a thin layer of Gold of Platinum.

With the beam of electrons being incident on the sample in a vacuum environment, this limits the range of materials with which the sample can be 'fixed'. One new development is that of high pressure Osmium/Acetone freezing process which provides images of excellent contrast and visibility for medical TEM work.

Just as optical techniques of microscopy depend on staining specimens with chemicals which improve the optical contrast of the resulting image, so also in conventional TEM, staining with compounds to enhance the transmission contrast is widely undertaken. Chemical agents used include salts of Osmium and Uranium.

Use is also being made of so called freeze-fracture TEM sample preparation where the sample is rapidly immersed in propane cooled by liquid nitrogen and mounted on a

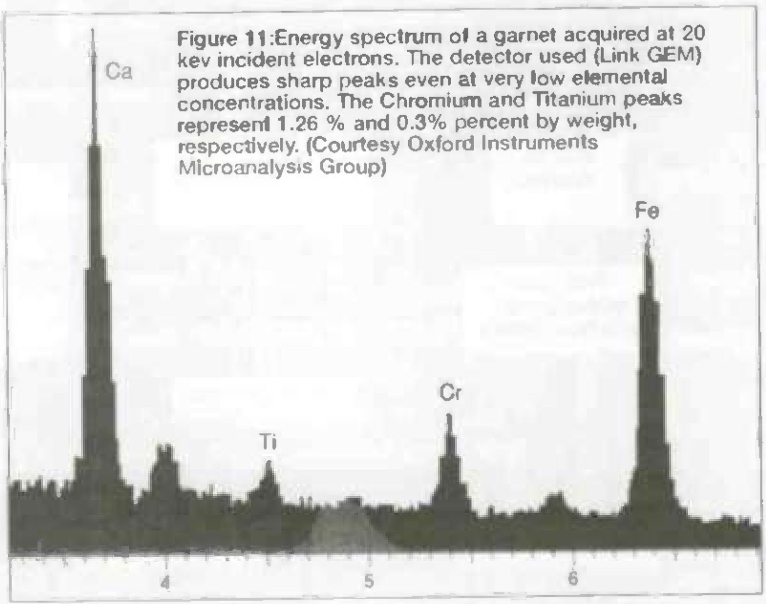


Figure 11:Energy spectrum of a garnet acquired at 20 kev incident electrons. The detector used (Link GEM) produces sharp peaks even at very low elemental concentrations. The Chromium and Titanium peaks represent 1.26 % and 0.3% percent by weight, respectively. (Courtesy Oxford Instruments Microanalysis Group)

The Scanning Electron Microscope (SEM)

The development of the scanning electron microscope was to rejuvenate considerably the field of electron microscopy. Rather than rely on signals from electrons

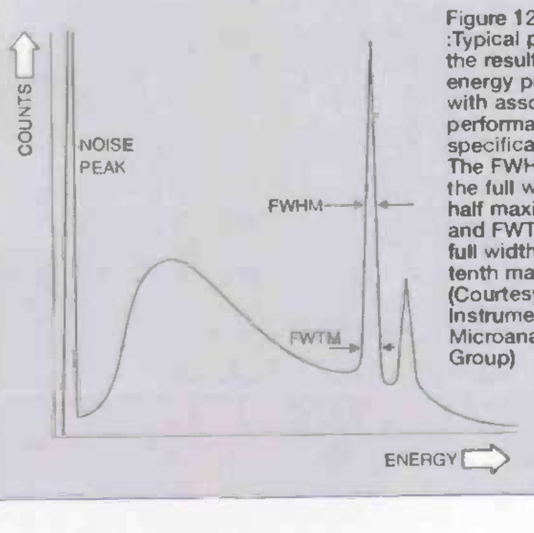
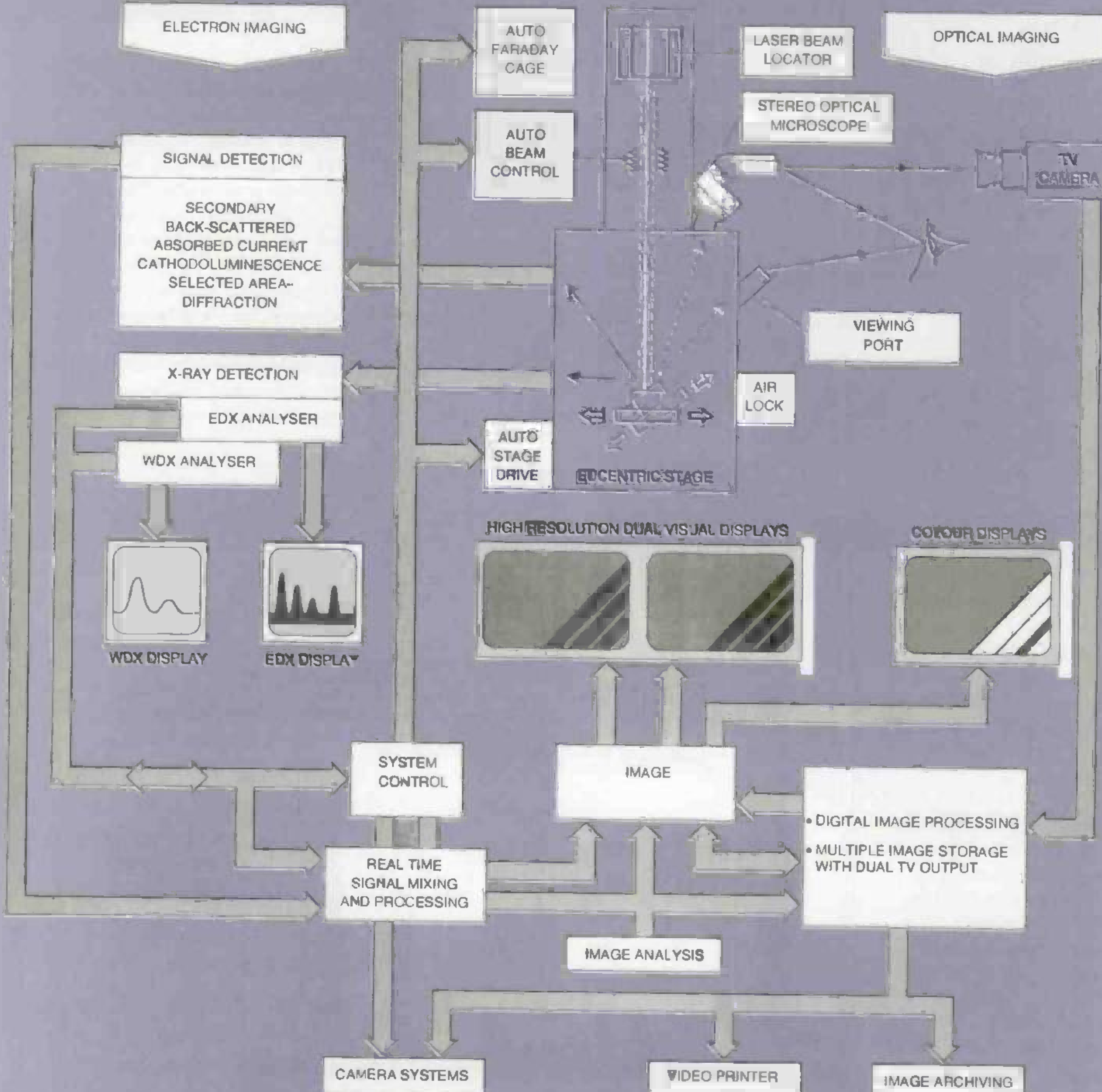


Figure 12 :Typical profile of the resultant energy profile with associated performance specifications. The FWHM is the full width at half maximum and FWTM is the full width at one tenth maximum. (Courtesy Oxford Instruments Microanalysis Group)



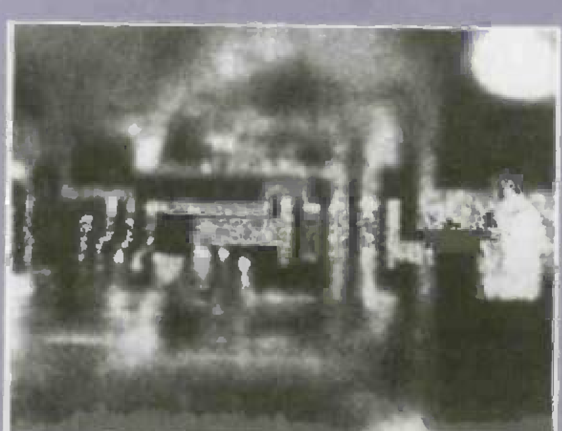
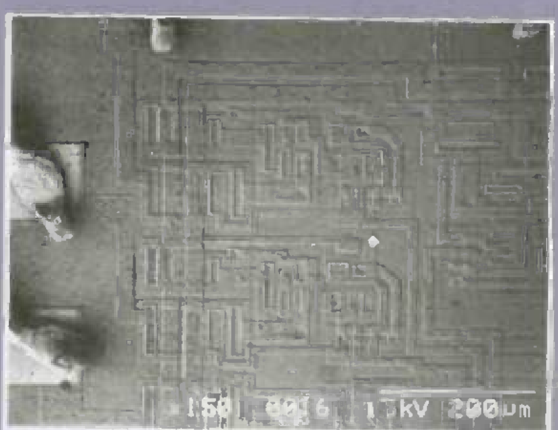
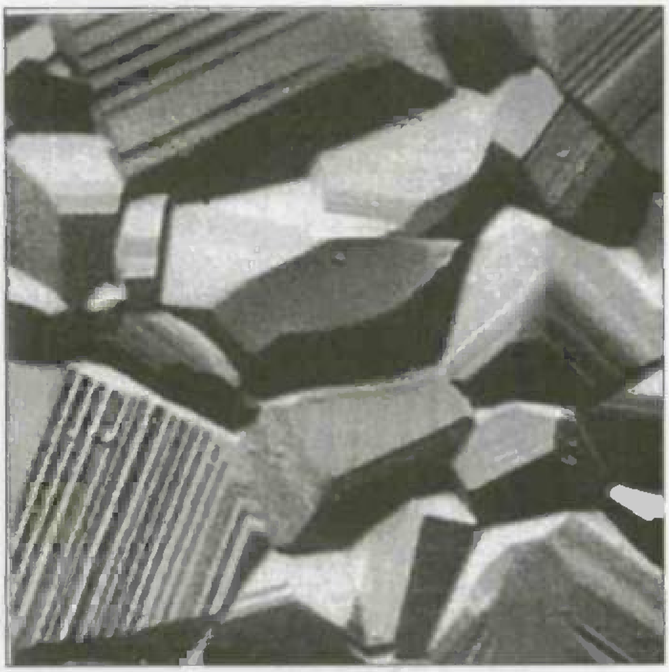


Figure 12 :Typical profile of the resultant energy profile with associated performance specifications. The FWHM is the full width at half maximum and FWTM is the full width at one tenth maximum. (Courtesy Oxford Instruments Microanalysis Group)





transmitted through a sample, systems began to be developed based on information derived from scanning a sample with a beam of electrons and mapping the intensity of the electrons scattered from the sample. The primary energetic electrons result in secondary electrons being emitted from the sample surface. These are in turn collected by a scintillator crystal which translates incident electrons in to light photons which are in turn collected by a photomultiplier tube.

For each co-ordinate on the sample being scanned there is an associated scattered signal obtained from the detection system. This results in a real time image of the surface being derived based on the scattering properties of the sample being examined. Precise control is also required over the focal position of the scanning beam.

This allows thick samples to be analysed and the samples do not have to be extensively prepared as with the transmission method. It is beneficial, however, to render the sample electrically conducting in order to minimise charge build up on the specimen. This can either be undertaken by coating the sample with a thin layer of metal in a vacuum or by simply spraying the sample with an appropriate anti-static spray. Such SEM technology has been extensively used in the semiconductor industry.

In the SEM, while the principle of initial electron production is similar to that of the TEM, the method of obtaining the final image is radically different. The electron beam is essentially focused into a minute spot on the surface of the sample. A typical beam diameter in the plane of the image would be around 2 nm. This spot is rapidly scanned across the surface of the sample by means of a deflection coil and an electromagnetic lens system as shown in figure 8 which also makes comparison with a conventional TV image system.

The electron energies are typically lower for an SEM - in the region 200 to 30,000 V since the electrons are not required to penetrate the sample. Higher electron energies would be used for x-ray analysis of materials where sufficient energy was required to stimulate emission of specific x-rays.

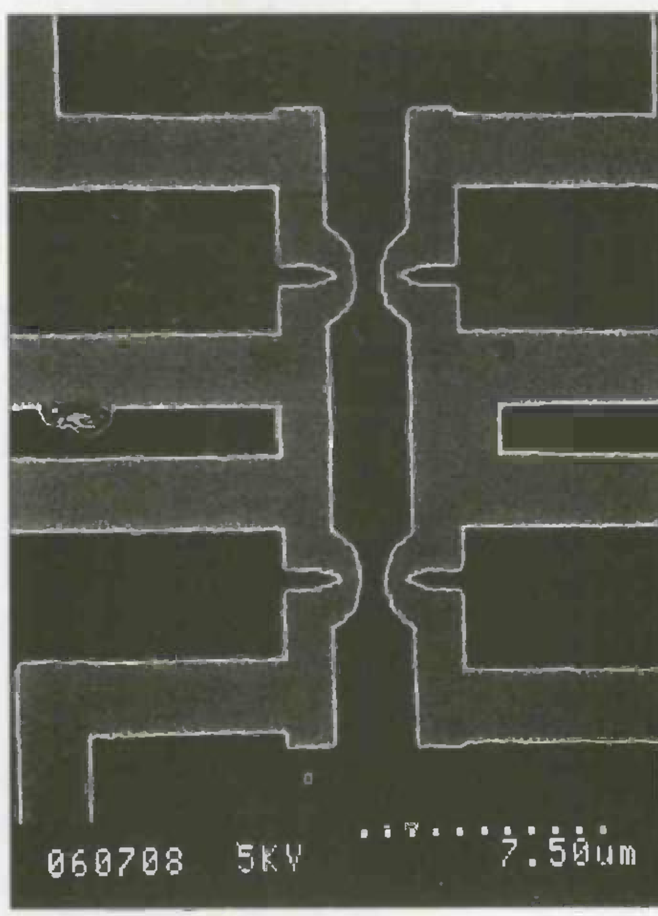
In terms of resolution, therefore, the resolution of SEM systems is usually less than that of the TEM and is determined by the smallest spot size of electrons which can be brought into play. The best SEM systems will have a resolution of around 1 nm. With ultra small spot sizes, however, there is introduced the problem of detection of smaller levels of secondary electron emission.

In microscopy the recent addition of Scanning Probe Microscopes which provide details of sample topography by scanning sample surfaces with a range of ultra small scanning probes has been introduced as a rival to conventional TEM and SEM technology. Some electron microscope manufacturers, however, have incorporated the new technology of SPMs into SEM systems where the SPM is located inside the sampling chamber of the SEM. Such systems utilise the rapid field of view and high scan rate of the SEM together with the ability of the SPM to provide accurate high resolution data of the surface topology of samples.

While the primary role of electron microscopes has been the determination of sample characteristics by transmission of the electron beam or the reflected beam signal, a diverse range of detector technology has been developed to derive additional information from scanned samples. A range of these additional detections modes are reviewed.

The SEM system, can be considered as a microprobe of a material, where material characteristics can be determined over areas corresponding to the size of the scanning beam. Often the standard secondary electron image can be compared with an image of the same area derived from a different detection system - e.g. x-ray emission or absorbed current. In the case of x-ray emission, this can be used to map the relative concentration of selected elements across a sample.

A standard SEM will tend to have a modular design where a basic instrument can be upgraded to accommodate a series of additional detection options. This in turn extends considerably the options available for analysis of specimens.



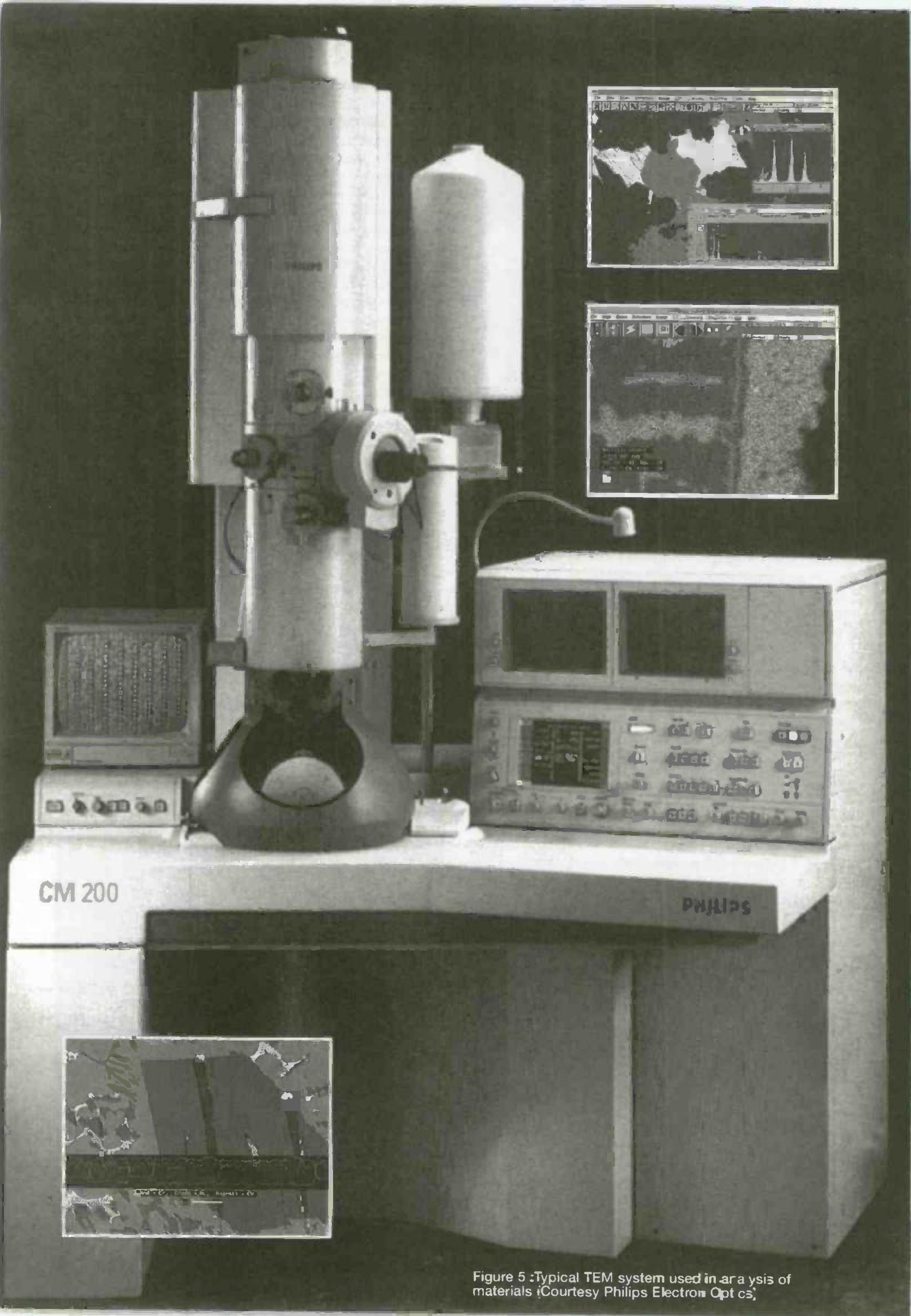


Figure 5 :Typical TEM system used in analysis of materials (Courtesy Philips Electron Optics)

Cathodoluminescence (CL)

When a sample is bombarded with high energy electrons, its component atoms can emit characteristic visible light - a phenomenon termed photoluminescence. The range of wavelengths emitted can vary from the ultra violet to the infra red. This process is associated with the disturbance of electrons in the outer (lower energy) shell of the component atoms. Figure 9 indicates how light from the sample is transmitted through a quartz glass window into a monochromator system which projects light of a specific wavelength into the input plane of a photomultiplier. During the scanning process, there is control of range of wavelengths being scanned, the speed of the scan and the entrance slit size into the monochromator.

The level of cathodoluminescence output is highly dependent on the temperature of the sample with increased levels of output being associated with lower sample temperatures. Most systems providing cathodoluminescnce provide cooling stages to optimise signal levels.

Cathodoluminescence is widely used in forensic science where it is especially useful in providing evidence for burglaries and motor and ship collisions. Used in conjunction with other microscope modalities such as X-ray, secondary and back scattered electron detectors, convincing evidence can readily be obtained.

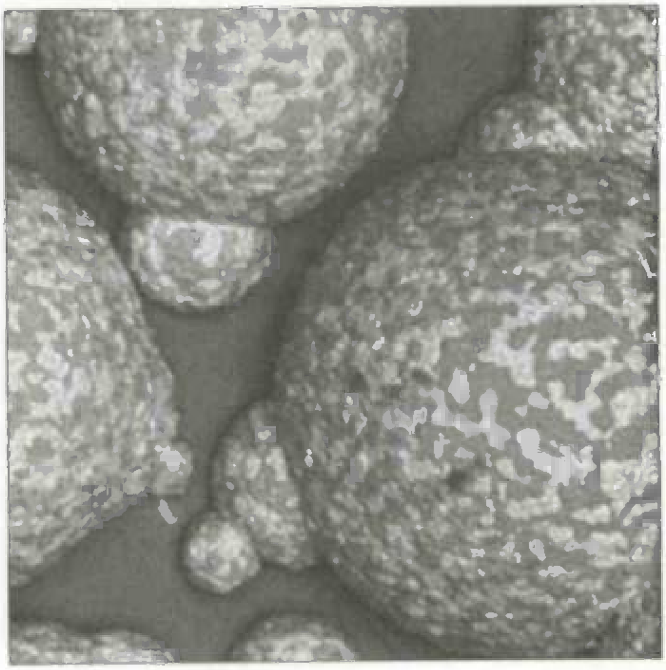
In many ways, CL is another 'fingerprint' of the material. Extensive work is also undertaken in ballistics investigations.The CL facility can also be used in the discrimination of glass specimens, real and synthetic gems as well as examination of prints, copy materials and false signatures. Where, also, fragments of paint is available from works of art, this will provide means of detecting art forgeries.CL technology is extensively used in Geology where it is a valuable tool for the determination of crystal structures, defects and chemical impurities.

In most general purpose SEM systems, the cathodoluminescence detector is an additional module which can be added to the base scanning microscope. It is also possible to obtain information of the excitation and decay times of the CL signal by the addition of a beam blanking option where the beam of electrons can be switched off or on.

X-Ray Microanalysis

As a beam of high energy electrons is incident upon a sample in transmission, x-rays are created by the electrons colliding with atoms in the sample and ejecting electrons of characteristic energy based on the atomic number of the element.

Scanning and detection systems have been developed to scan an electron beam over a sample and resolve the spectrum of emitted x-rays in such detail to allow identification of concentration of a wide range of specific atoms in samples.



There are two principal options for X-Ray Microanalysis - WDX and EDX.

WDX: (Wavelength Dispersive Spectrometer)

The WXD option, see figure 9, uses crystal orientated in a specific direction to transmit x-rays of a characteristic wavelength according to the Bragg equation. Such a detection system is acting in some ways like a monochromator for optical photons. In its operation the axis of the detecting crystal structure has to be rotated in order to vary the wavelength of xrays transmitted by the crystal.

The WDX system typically provides element detection ranging from Boron (atomic number 5) to Uranium (atomic number 92).

EXD: (Energy Dispersive Spectrometer)

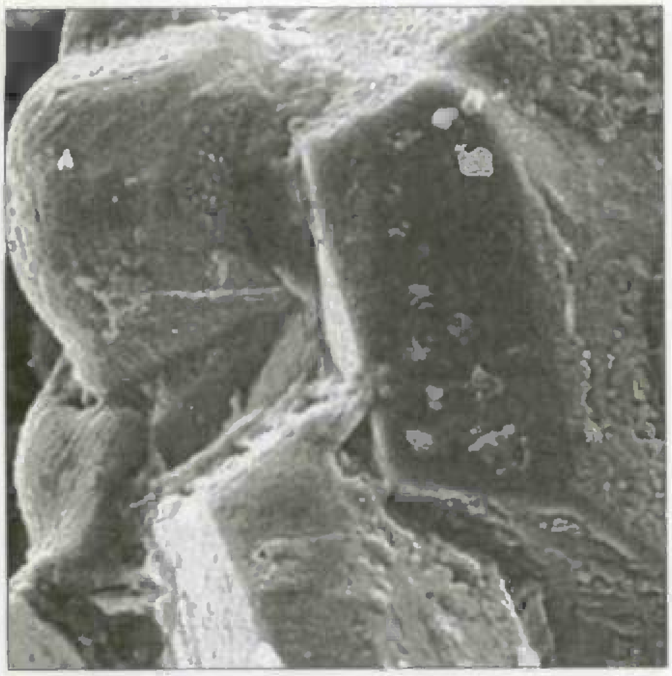
The option for EDX (energy dispersive x-ray) detection uses typically electron production in Silicon as the means of detecting x-rays emission. Each characteristic x-ray photon is associated with a specific number of detected electrons.

The EDX option is faster in practice since it can effectively count on channels 'in parallel' whereas the WDX option relies on translation of the discriminating crystal. The typical side view of the WDX and EDX systems is shown in figure 10 - a 30 degree take off angle is typically used.

Figure 11 indicates the energy spectrum of a garnet acquired at 20 kev incident electrons. The detector used produces sharp peaks even at very low elemental concentrations. The Chromium and Titanium peaks represent 1.26 % and 0.3% percent by weight, respectively.

Table 2: Typical percentage transmission characteristics of various window materials. (Courtesy Oxford Instruments Microanalysis Group)

Window	Be	B	C	N	O	F	Na
Link Super ATW	10	36	60	38	60	70	95
Link ATW			15	43	41	61	90
Boron Nitride	40	13	40	31	53	55	100



A key aspect of this type of technology is the transmission quality of the detector window. Table 2 indicates the percentage transmission characteristics of various window materials.

The specialist Link Super ATW provides the best transmission characteristics. Such detection systems are extensively used in materials research and are of especial value in detecting and identifying environmental pollution of diverse types.

Figure 12 indicates the typical profile of the resultant energy profile with associated performance specifications. The FWHM is the full width at half maximum and FWTM is the full width at one tenth maximum. The ration determines the unity of the Gaussian shaped peak. A perfect Gaussian profile has a ratio of 1.82:1.

Using this technique, a sample can be scanned and separate images be obtained for specific elements. This is therefore a form of microscopy which effectively 'sees' elements. Extensive software used with such systems can both acquire the data rapidly but also produce rapid reports on elemental composition. In addition to identifying the elemental composition of a sample at a specific point, this option can be used to scan a sample and process the data in terms of relative elemental composition.

Absorbed/Specimen Current Signals

An image profile based on the absorbed or specimen current is another scanning modality. This option is typically used with semiconductor samples where resistivity of samples is of key relevance for monitoring the process of semiconductor fabrication. The range typically accommodates ranges from micro amps to pico amps.

BSD : Back Scatter Detectors

Solid state detectors which detect electrons scattered from the sample provide another 'fingerprint' for the analytical scanning electron microscope. Backscatter emission is characteristic of Atomic Number of the sample elements and this mode of scan provides yet another parameter with which to scan samples. Samples can be 'tagged' with heavy metal atoms such as gold in order to try and identify specific portions of the sample which have a different physiological function - eg in studies of cell metabolism.

Figure 13 shows the schematic design of an SEM system with a range of associated modules. Such systems are interfaced typically to Windows based software packages to control system function and capture, process and store captured images. Usually the images from such systems are stored in TIF file format.

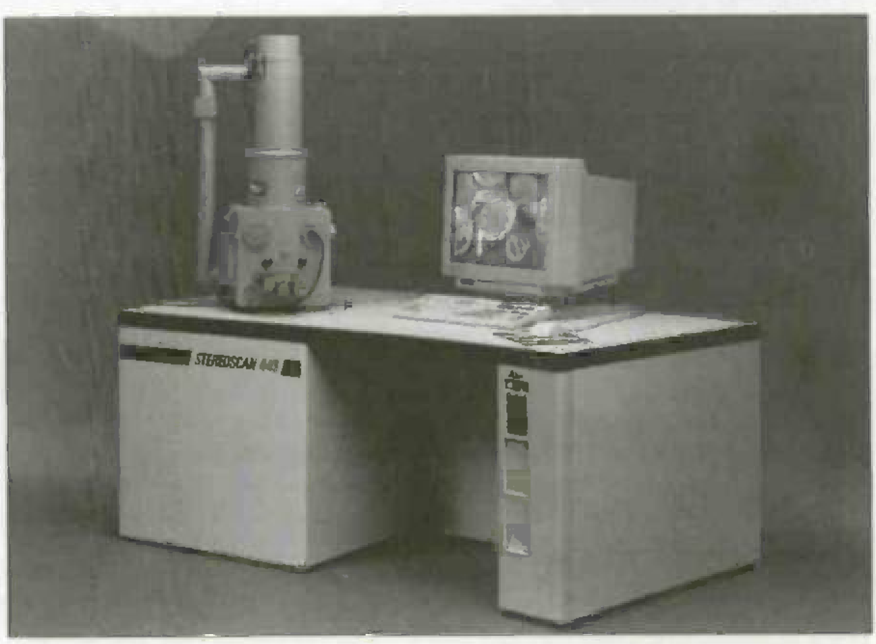
In Conclusion

Electron microscopy has expanded considerable in the range and sophistication of its various modes of investigation. In addition to the standard transmission and scanning systems, a range of powerful materials analysis techniques now provide a formidable tool for forensic and general scientific analysis. With growing interest in the field of nanotechnology, people all over the world will no doubt be spending even more time probing matter with electrons.

This review of electron microscopy has touched on the 'core' of EM technology. Within each specific facet and aspect, however, there is considerable detail and complexity.

Futher Reading:

All you wanted to know about Electron Microscopy: Philips Electron Devices, Building AAE, PO Box 218, 5600 MD Eindhoven, The Netherlands.



ETI PIC BASIC Controller

The developer of this unique project Robin Abbott, describes how to build and use the ETI PIC based controller module. A very small and cheap computer which runs BASIC and is intended as a building block for any project requiring program control. The project can be built on this months free cover mounted PCB.

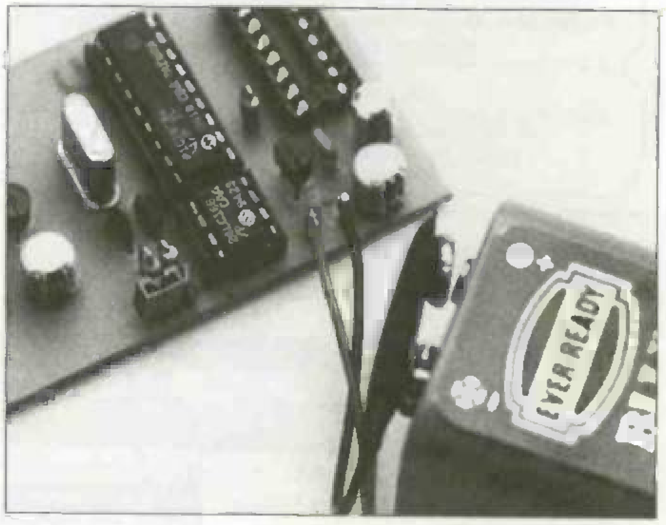
Although PIC's are very flexible, they can be quite hard to program requiring relatively long development times with a knowledge of PIC assembler a necessity. This project overcomes some of the principle limitations of the PIC controllers. The main controller is a module with a small number of components which can be built autonomously, or which can be integrated into the main board of a project occupying as little as 12 cm2 of board space.

There is a program store of up to 8192 Kbyte EEPROM (in an 8 bit package) which may be increased as larger serial devices become available in future. Program development time is significantly cut as BASIC is far easier to learn and program than PIC assembler, and the EEPROM used in the controller offers rapid reprogramming when the program is changed. Debugging support is provided through examination of variables from the host PC, and single stepping is available with some versions of the project. Program variables may be stored in PIC RAM, or in the EEPROM used for the program store. Variables stored in EEPROM are maintained through power down.

The only downside of this system is that programs run more slower than PIC assembler. This is mainly due to the time taken to read instructions from the serial EEPROM.

The main features of the project are as follows:

- Software is available for the following PIC controllers : PIC16C56, PIC16C57, PIC16C64, PIC16C71 and PIC16C84. Development for other controllers is straightforward.
- The control modules have one or more 8 bit output ports (depending on the PIC device), and one serial port as standard.
- Supports peripheral devices of the PIC controllers. For instance the version running on the PIC16C84 allows variables to be defined and used in the PIC local EEPROM area as well as on the program EEPROM, the version for the 16C71 allows A/D converters to be read.



- Supports interrupts on those devices which support them internally. On interrupt a BASIC subroutine is called, this can be used to keep time, or to perform certain functions when inputs change.
- A development system hosted on a PC running Windows allows programs to be written, modules to be read, and written, and programs to be run. There is also debugging support allowing variables to be inspected.
- The programming language supports RS232 compatible serial interfaces to external devices, or between controllers.
- Auto-boot configuration allows the PIC to run programs stored in EEPROM automatically on power up.

The BASIC language offers the following features:

- Variables may be from 1 to 16 bits in length, and are packed in memory to save PIC RAM. Thus an array of eight, one bit variables occupies only 1 byte of PIC memory space.
- Variables may be stored in PIC RAM, in the EEPROM used

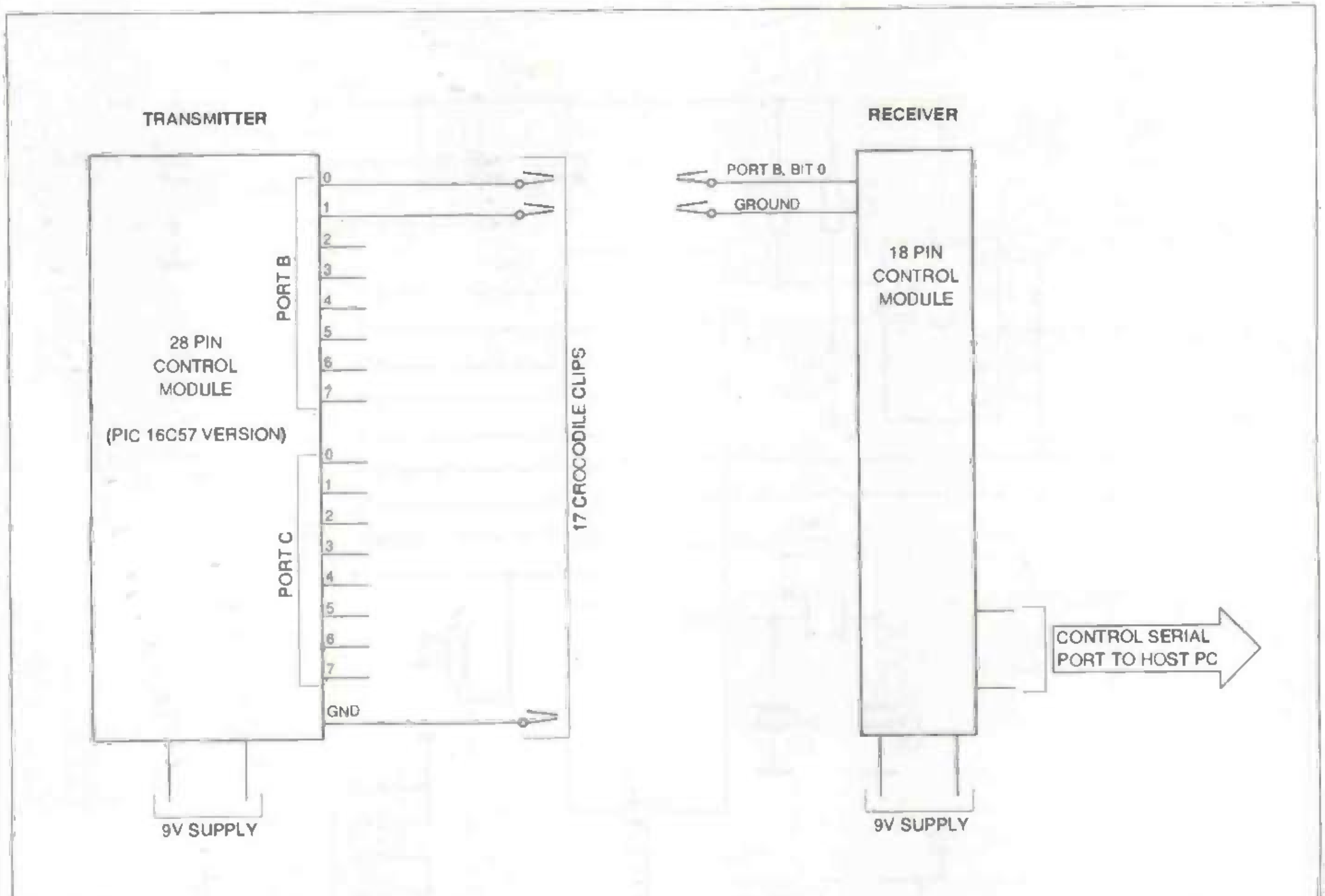
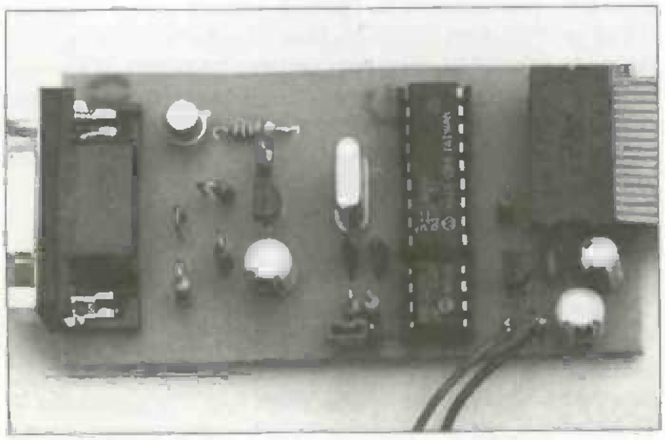


Fig.1. Example project

to store the program, or in local EEPROM on 16C8xx devices.
- The language supports strings in a limited form.
- Both string and numeric arrays may be defined.
- Subroutines may be defined and called with any number of parameters.
- User defined functions take any number of parameters, and return a value which can be used in expressions.
- Subroutines and functions may have local variables.
- The language has extensions for the various peripheral devices available on specific PIC's.The language supports structured blocks using IF/ELSE/ENDIF, WHILE/WEND, FOR/STEP/NEXT.

The project is described in several parts. This first article explains the capabilities and use of the hardware in the project, including the compile time options used to program the PIC's.



The next article will describe the development system, and the programming language, further articles will describe the operation and use of the module in some real projects.

Example use of Basic controller board

To show how the module can be used figure 1 shows an example which uses a 28 pin PIC BASIC module, and an 18 pin PIC BASIC module. This is for a multi-core wire identification system. When wiring up a project which uses a number of wire connections, such as in a large scale network, or a fire/burglar alarm system, then it can often be difficult to identify individual wires in the bundle. The example contains a transmitting module and a receiver module. The transmitting module has 16 output wires, each of which connects to a crocodile clip together with a ground connection. Each of the outputs is clipped to a wire in the bundle, whilst the ground connection is clipped to a suitable earth connection such as a radiator. Now the receiver module has an input connection, and a ground connection which is also clipped to earth. When the input connection is clipped to a wire the receiver displays the wire number that it is connected to.

The transmitter uses a module based on a 28 pin PIC (16C57) with two output ports (port B and port C) which are both set to outputs giving 16 driving bits. Each output bit is connected to a length of flexible wire connected to a crocodile clip. The receiver uses a control module based on an 18 pin PIC and simply uses one input bit on its 8 bit port (port B). The receiver module prints the wire number to its serial port which can be then be displayed on a PC or terminal. Next month we will look at an example project which uses a 2 digit LED display which could be used for output in this example.

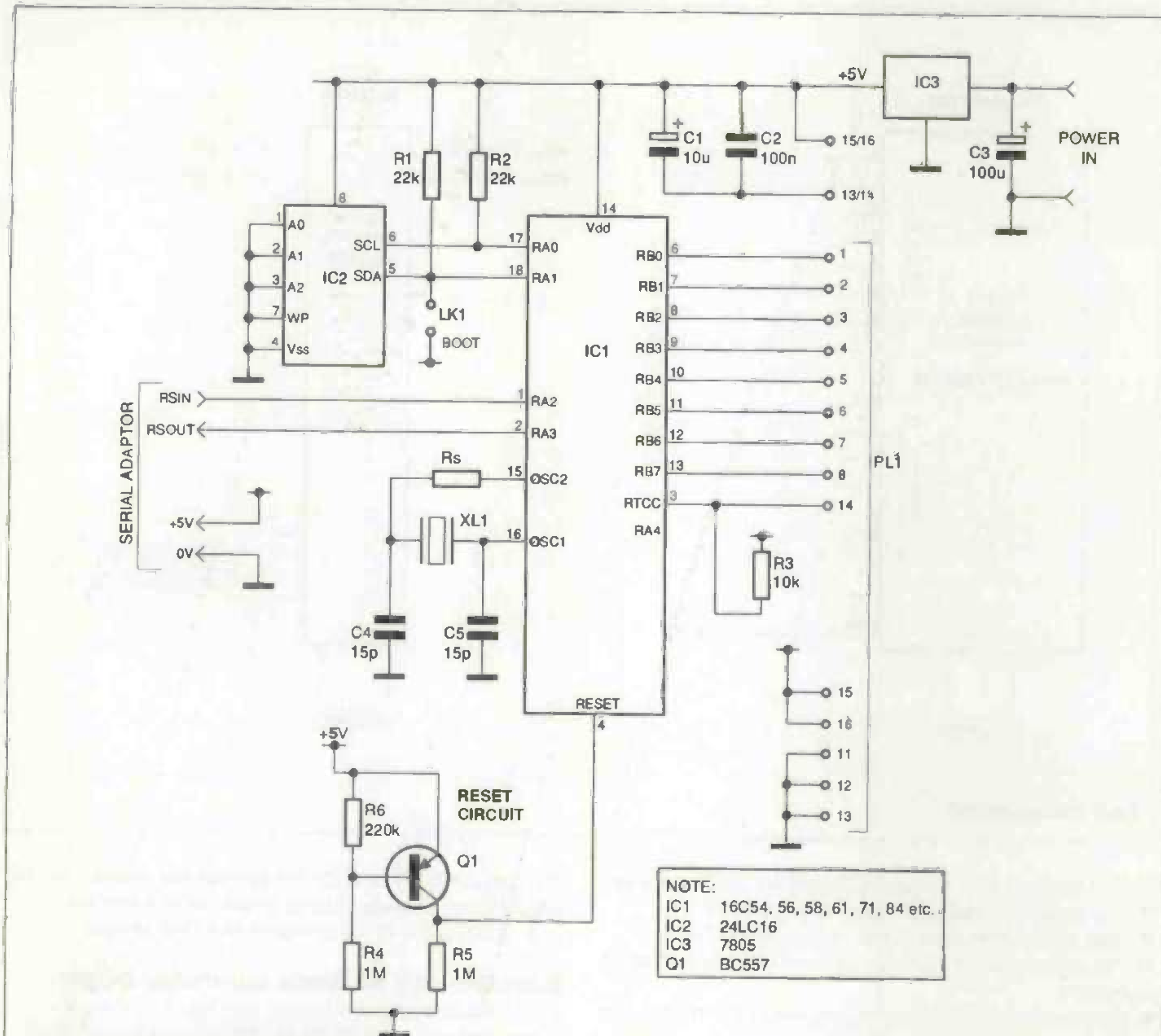


Fig.4. Circuit diagram of BASIC controller

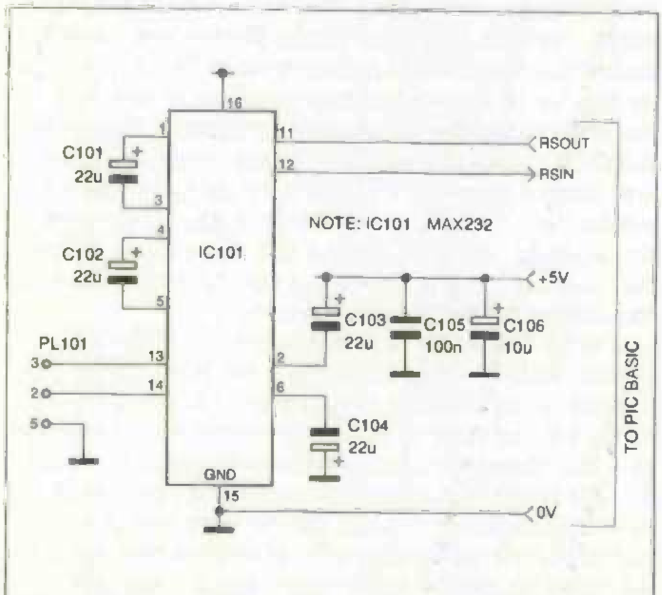
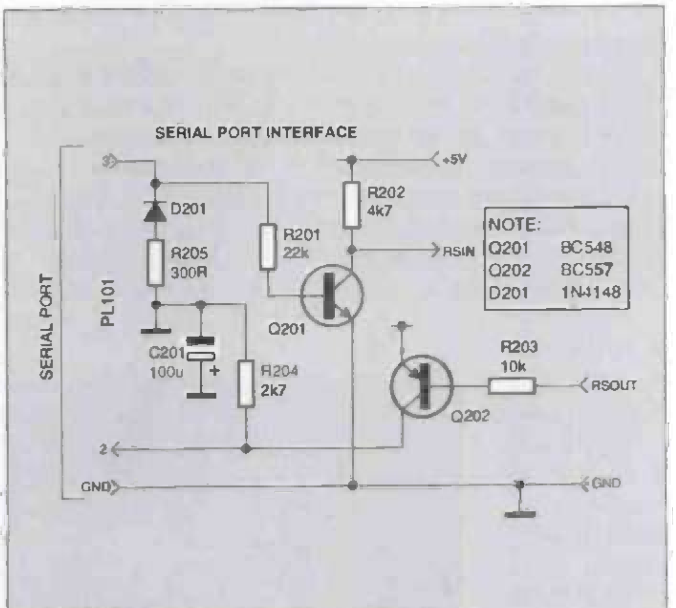


Fig.5a Serial circuits

In the example the transmitter drives the wires directly, which will limit the length of wire which can be driven, however in practice for a real application it would be better to use RS232 line drivers on each output, and an RS232 receiver on the input.

Figure 2 shows the basic code for the transmitter. It is 16 lines long, and occupies 82 bytes of program space which is 1% of an 8192 byte EEPROM. Most of it is commented, however some of the lines bear further explanation. The program runs in an infinite loop which takes each output wire in turn on which it sends a code in serial format. The code output is an 8 bit value which is 65 for wire 1, 66 for wire 2 etc. (This is ASCII for 'A', 'B', 'C' etc). The format of the code is standard serial, the output level is normally high, with a low stop bit and then each data bit, LSB first.

The line which starts TYPESUB defines a subroutine, called DRIVE which takes one parameter - the wire number which is to be driven. The lines which start TRISB and TRISC set the port B and port C outputs to drive. The program uses a variable I, which is defined to be 5 bits long. The subroutine DRIVE checks the wire number, if it is 8 or less then the output



5b. Serial circuits

is driven to port B, if it is more than 8 then port C is driven. The command SEROUT puts a byte in serial format on an output line of the PIC. It takes two parameters, the first is the byte to be output, the second is a port definition byte. The port definition byte is the address of the port plus the bit number to be used multiplied by 16.

Figure 3 shows the basic code for the receiver. This code occupies 70 bytes. The program loops forever reading any serial information detected on Port B, bit 0. If a byte is received then it is converted to a wire number from 1 to 16. A message is displayed to the module's standard serial interface. For instance if wire number 12 is connected then the message "DETECTED : 12" will be sent followed by a line feed.

The variable WIRENUM is set to the value of the serial code received. The SERIN function takes two parameters, the first is the port definition in the same format as for the SEROUT command. In this case we only ever look at port B bit 0. The second parameter is the time to wait for a byte. If this value is set to 0 then we wait forever until a byte is received.

The SEROUTSTRING command puts a string to the supplied port. The port definition in this case is shown as DEFSEROUT. This is a special value which represents the standard serial interface of the module. The remaining code converts the wire number to a decimal value in ASCII. (In a later article we will look at a subroutine to print numbers to the serial port).

Hardware - Circuit Diagram

Figure 4 shows the circuit diagram for the basic controller, which can be built on the general purpose PIC PCB supplied with this months ETI - in this case the circuit is for 18 pin devices (such as the PIC16C56, PC16C71 and PIC16C84). This is extremely simple to allow the circuit to be used in target projects. Circuits for the 28 and 40pin PIC devices will be shown in later articles.

IC3 provides the power supply, the 78L05 may be used for lower consumption projects, the 7805 can be used for projects of up to 1A consumption. In target projects IC3 may be left out and replaced by the power supply used in the main circuitry.

IC2 is the EEPROM. Devices of any size may be used provided that they have the pin out shown in the circuit diagram, and that they have the I2C interface. Two types of EEPROM may be used dependant on the PIC in use, 12 bit address devices (e.g. 2Kbyte and below), and 16 bit address devices (e.g. 8Kbyte). This is described in detail below. R1 and R2 pull up the data and clock lines used on the I2C interface. Link 1 is used to prevent the PIC from running the program stored in EEPROM. This is used when the autoboot flag has been set (causing the program to run automatically on power up) but when the PC control software is to be used to change the module software, or to debug it. For normal operation the link is left unconnected. To stop the module auto-booting then with power removed the link is connected, the power is then connected, and then the link is disconnected which will boot the module into the control program.

IC1 is the PIC. The lower 4 bits of port A are used for the EEPROM interface, and also for the external serial interface, these bits are not available for use by the application, however the RTCC input (which forms the RA4 input of the PIC16C71, and PIC16C84) may be freely used.

The oscillator circuitry around pins 15 and 16 of the PIC is based on crystal or ceramic resonator devices. The frequency of the oscillator may be selected between 4MHz and 20MHz, to allow the timing of the EEPROM and serial interfaces to operate successfully.

The serial interface is provided as standard, and is maintained internally. It may be used by the module during normal operation, as well as to communicate to the host PC. The interface at the PIC is inactive high - i.e. when the interface is idle the input and output of the PIC is held at +5V. The start bit is signalled by a low going pulse followed by the 8 data bits. The standard interface is specified at 9600bps, no parity, one stop bit.

Fig 5a and fig 5b show the serial interface circuit options. Fig 5a is a standard RS232 interface which is based on the MAX232 device. Fig 5b is a much simpler (and cheaper) circuit which works quite well in practice with half or full duplex links and is the circuit used with the general purpose board. C201 stores the negative voltage which is normally present on the inactive input line, filters it, and uses it as a negative supply for the signal driven from the module. This circuit may only be used for communication with other systems which provide a standard RS232 output, and worked with all PC's with which it was tested.

It is possible to operate without an RS232 serial interface circuit, however in this case EEPROM's should be

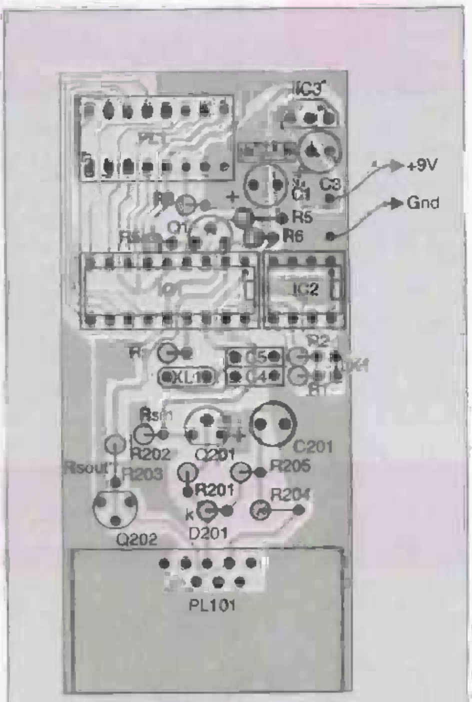
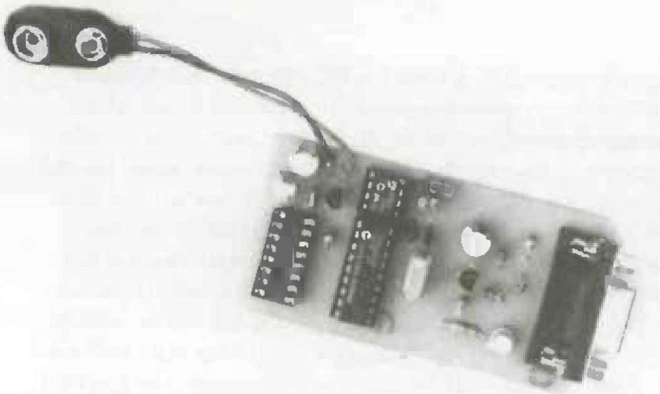


Fig.8. PCB component overlay



programmed separately. By combining the circuits of fig 4 and fig 5, it is possible to design a simple serial EEPROM programmer which can be used for this purpose. If the design is to be used at the heart of a project then the only components needed are IC1, IC2, R1, R2 and the oscillator circuit.

Operation of BASIC interpreter

The BASIC interpreter runs on the PIC on the module. The PIC does not contain sufficient program space to interpret a program sent to it directly in text form. The host development system on the PC converts programs into an intermediate code. This code is called Pseudo-Code or P-Code for short. The PCode is downloaded to the module where it is stored in EEPROM and can be run from the host PC, or set to boot automatically when power is applied.

It is not necessary to understand the operation of P-CODE to use the module, however a brief explanation is presented here for those who are interested. The host development system can assemble and link P-Code programs as well as BASIC programs. An understanding of P-Code can be useful for creating more efficient library routines, or for debugging. We will look at P-Code in further detail in a later article.

The compiler on the host PC converts the BASIC program into P-Code which is in a text format which can be examined or edited. The various text P-Code files which form a project are then assembled and linked into a binary P-Code file which can be downloaded to the module.

PCode is similar to machine code. The BASIC interpreter has a stack which is maintained in PIC RAM. The stack starts at the top of memory, and grows downwards. Values can be copied between PIC RAM and the stack and between EEPROM and the stack. Once on the stack values can be manipulated. There are around 70 P-Code instructions. Most instructions take one byte in EEPROM, but some of them take more than this. Instructions fall into the following groups:

- Program flow control, goto, call and return, and conditional goto.
- Stacking and unstacking values to and from RAM/EEPROM.
- Arithmetic
- PIC specific instructions e.g. analogue port control.

For example suppose we want to take the 8 bit value stored in PIC RAM address 27, and the number 46, then multiply them and put them to PORT B (which is at PIC

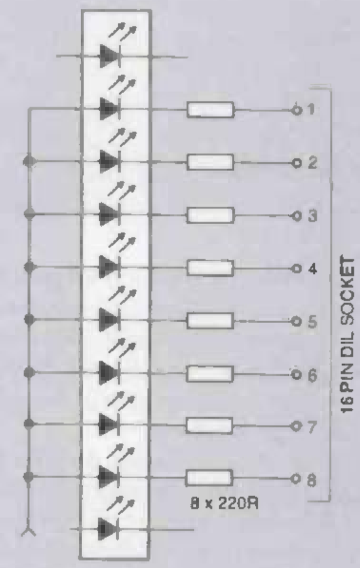


Fig.10. LED test circuit

Figure 6
Feature offered for BASIC with each PIC type

PIC type	16C56	16C57	16C64	16C71	16C84
Size of EEPROM for program store	2048	8192	8192	8192	8192
Number of bits in calculations	8	16	16	15	15
Number of I/O bits	8	8	24	8	8
Local Variables	Yes	Yes	Yes	No	No
Uses PIC EEPROM	Not Available	Not Available	Not Available	Not Available	Yes
A/D converter	Not Available	Not Available	Not Available	Yes	Not Available

Figure 11
Serial Cable from programmer to host PC

Programmer SK2	PC connector type 9 way Female	9 way Male	25 way Female	25 way Male
2	3	2	3	2
3	2	3	2	3
5	5	5	7	7

address 6). The following P-Code will achieve this:

Instruction	Stack
STACK 66	
STACK 27	27,6
STACKADDS	(27),6
STACK 46	46,(27),6
MULTIPLY	46*(27),6
UNSTACKADDS	-

The numbers show the contents of the stack. The form "(27)" shows that the stack contains the 8 bit number which was stored at address 27. This code occupies 6 bytes in EEPROM. P-Code executes at between 3000 and 5000 instructions per second with a 4MHz main clock. This can increase to 10-15000 instructions per second with a 20MHz clock.

PIC BASIC variants

There are three versions of the interpreter which offer different arithmetic types. These are as follows:

1 The 8 bit version calculates all results within 8 bit integers. Thus the minimum value which can be stored is -128, and the maximum value is +127.

2 The 16 bit version extends this to -32768 to +32767. The 8 bit version operates more quickly, and uses less stack space, thus there is more room for variables, and more levels of subroutine call can be used.

3 The third version is used for certain 18 pin devices. This has 15 bit arithmetic allowing numbers from -16384 to +16363 to be used. In this form the interpreter compresses values on the stack so that small numbers can be stored in a single byte. This version of the interpreter cannot pass parameters to functions, or use local variables, these limitations will be explained in next months article.

Figure 6 shows the PIC types, the variable types, and other features for each PIC device which can be used with BASIC.

PARTS LIST

Resistors

R1,2	22K
R3	10K
R4,5	1M
R6	220K
R201	22K
R202	4K7
R203	10K
R204	2K7
R205	300R
Rs	see text

Capacitors

C1	10uF 10V Electrolytic
C2	100n, Ceramic
C3	100uF 10V Electrolytic
C4,5	15pF, ceramic
C201	100uF 16V Electrolytic

Semiconductors

IC1	PIC - see text
IC2	24LC16 etc. see text
IC3	7805 or 78L05
TR1	BC557
TR201	BC548
TR202	BC557
D201	1N4148

Other

XL1	4.000MHz crystal or ceramic resonator
PCB	
PL101	9 pin D socket
PL1	16 pin DIL IC socket
LK1	0.1" link with jumper
IC sockets	8pin, 18pin
Veropins	2
Heatsink	IC3, optional

Test System - Use and Construction

Figure 8 shows the PCB layout for the 18 pin version of control BASIC which is the PCB supplied with this months ETI. This is a complete controller board with power supply and PC serial interface and only needs a 5-30Vdc supply to operate. It can be used as a programmer for serial EEPROM's if they are to be used within a target system without a serial RS232 link. The components list for this version of the controller is shown in Figure 9.

This circuit is extremely cheap to build (around £2 without IC2 or IC3), and it is recommended that at least one should be built to experiment with the BASIC language used for the project before attempting an embedded system. Photograph 1and 2 show the completed board.

Construction is very straightforward, and components may be inserted in any order, most of the two leaded components are mounted vertically. IC2 and IC3 must be socketed. PL1 is a 16 pin IC socket. Link 1 is a two pin strip on a 0.1" pitch. A standard miniature jumper can be used on the link such as those used on PC interface cards. XL1 is a crystal or ceramic resonator, frequency can be chosen at compile time.

If an external 5V supply is used then IC3 can be replaced with a wire link, higher supply voltages will need IC3 to provide a stable supply to the module. IC3 can be a 78L05 or a 7805, the device chosen will depend on the application current consumption. If a 7805 device is used then it may be mounted on a heatsink. Rs is only needed for special applications with certain crystals and can be left out for most uses. If Rs is to be used then cut the track which shorts it out before soldering it in circuit.

For test purposes an LED display can be constructed. A suitable circuit is shown in figure10. The display is a 10 segment bar graph device, the two end LED's can be left disconnected. The connector to the main board is a 16pin DIL socket. The display is connected to port B, and test patterns can be written to it. A lead to connect the two boards can be constructed using 16way IDC cable with a 16 pin IDC header on each end. Photograph 1 shows the completed prototype module with the LED display.

A serial cable needs to be constructed, or a standard serial cable can be used to connect the module to the host PC. As there are a variety of serial ports connectors available then it is likely that different host PC's will need different connectors. If you choose to make up a cable for the host PC then follow the connections shown in figure 11.

Testing

The circuit is so simple that elementary testing is all that is required. The host development system can then be used to check out the module properly by writing and running test programs. To test the system connect the module to the host PC. Do not insert IC1 and IC2 yet. Now connect the power supply to the board check that there is a +5VDC supply to IC1. Now on the PC set up a communications package such as Windows Terminal. Set the package to 9600bps (or whatever rate has been programmed to IC1), No Parity, One stop bit and short pins 1 and 2 of IC1. Check that any characters typed on the PC are echoed by the module. Power down, insert IC1 and IC2 and power up, the module should return a 'Y' to the PC. Type an 'A' character on the PC and the module will return a 'Y' (this is the standard "are you there?" diagnostic). Now the development system may be used on the PC to check the module out properly.

A suitable test program for the LED board is shown in figure 7. This is supplied with the PIC BASIC development environment, and flashes the LED in various bar patterns in an endless loop.

Availability

Most of the components are widely available from Maplin and other similar companies. The PCB is available free on this month's cover (they will not be available without the magazine so I am afraid that if you want more than one you will have to buy another magazine!).

Programmed 16C84 PIC chips are available from the author price £25 each, or £15 if you supply the PIC chip (make sure it is a new chip with nothing programmed on it!). Also included in the price will be an updated copy of the development system software (but only if there has been an update with respect to the free copy given away with next month's ETI)

IMPORTANT:- When ordering your PIC chip please specify whether you will be using the 24LC16 (2K EEPROM) or the 24LC65 (8K EEPROM). Also specify whether you will be using a 4MHz or 16MHz clock. The PIC chips will be code protected (the author has put an enormous amount of work into this project and quite understandably wishes to protect his work from unauthorised copying).

Please send an SAE with order and make cheques or postal orders payable to Robin Abbott. Orders should be sent to: 37 Plantation Drive, Christchurch, Dorset, BH23 5SG. The author regrets that he is unable to answer phone queries, but he can be contacted via email; his address is: @compuserve.com.100023,535.

The PC based development system software will be available free as part of the cover disk on next month's ETI, or if you want it before then, it can be obtained directly from Robin Abbott price £10.

```
typesub drive(i)              ; Define Subroutine
trisb(0)                           ; Drive on port B
trisc(0)                           ; Drive on port C

dim i.5                                  ; i is a 5
bit variable
while(1)                           ; loop forever
 for i=1 to 16                     ; For each output
  drive(i)
 nex
wend

sub drive(wirenum)
 wirenum=wirenum-1
 if (wirenum <=7) then
    serout(wirenum+'A',ADDPORTB+wirenum*16)  ; O/p
port B
    return
 endif
 serout(wirenum+'A',ADDPORTC+(wirenum-8)*16) ; O/p
port C
end
```

Figure 2 - Example code for Transmitter

```
while(1)
 u=0 wirenum=serin(ADDPORTB,0)-'A'+1
 seroutstring("\nDetected : ",defserout)
 if wirenum>10 then u=1 : wirenum=wirenum-10
 serout('0'+u,defserout)
 serout('0'+wirenum,defserout)
wend
```

Figure 3 - Example Receiver BASIC code

```
trisb(0)                    ; Drive on port B
typesub del()               ; Delay subroutine
const pat[16]               ; Array of patterns to
write to leds
pat[0]=081h                 ; Patterns have a 0 to
turn on a led
pat[1]=0c3h
pat[2]=0e7h
pat[3]=0ffh
pat[4]=0e7h
pat[5]=0c3h
pat[6]=081h
pat[7]=0
pat[8]=18h
pat[9]=3ch
pat[10]=7eh
pat[11]=0ffh
pat[12]=7eh
pat[13]=3ch
pat[14]=18h
pat[15]=0
dim i.6,j.4,k.5             ; Variables
while(1)                    ; Loop forever
 for i=1 to 16              ; Simple binary pattern
  portb=i+i*16
  del()
 next
 for j=0 to 5               ; In/Out pattern
  for i=0 to 7
   portb=~pat[i]
   del()
  next
 next
 for j=0 to 5               ; In/Out pattern
  for i=8 to 15
   portb=~pat[i]
   del()
  next
 next
wend  ; Loop forever
sub del()                   ; Delay subroutine
 for k=1 to 8
 next
end
```

Fig.7. LED test programme

Next Month...

ETI will have a cover mounted PC disk containing a free copy of the ETI BASIC microcontroller development system software (in order not to miss it don't forget to order your copy now!). In Part 2 we'll take a more in depth look at the BASIC language and development environment used for the controller as well as a complete project using the BASIC controller with 7 segment LED output and push button inputs. Following articles will look at larger scale projects using the module.

TELNET

8 CAVANS WAY,
BINLEY INDUSTRIAL ESTATE,
COVENTRY CV3 2SF
Tel: 01203 650702
Fax: 01203 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 OS3000/ADVANCE 3000 – 30MHz Dual ch £200
- Gould 4035 – 20MHz Digital storage £500
- Gould 4050 – 35MHz Digital storage £650
- Gould 5110 – 100MHz Intelligent oscilloscope £850
- Gould OS4000, OS4200, OS4100, OS1000B .... from £125
- Hewlett Packard 1740A, 1741A, 17744A, 100MHz dual ch .... from £350
- Hewlett Packard 1707A, 1707B – 75MHz 2ch .... from £275
- Hewlett Packard 54201A - 300MHz Digitizing £1750
- Hewlett Packard 54501A - 100MHz - Digitizing 4 channel £1950
- Hewlett Packard 54504A - 400MHz Digitizing £3500
- Hewlett Packard 54100D - 1GHz Digitizing £4500
- Tektronix 468 - 100MHz - D.S.O. £800
- Lecroy 140 - 100MHz - D.S.O. .... £POA
- Hitachi V212 20MHz Dual Channel £175
- Nicolet 3091 – LF D.S.O £1100
- Philips PM 3315 - 60MHz - D.S.O. £750
- Philips 3206, 3211, 3212, 3217, 3226, 3240, 3243, 3244, 3261, 3262 (2ch + 4ch) .... from £125 to £350
- Philips PM 3295A - 400MHz Dual Channel £1950
- Tektronix 2213 – 60MHz Dual Channel £425
- Tektronix 2215 60MHz dual trace £450
- Tektronix 2235 Dual trace 100MHz (portable) £800
- Tektronic 2236 - 100 Mhz - 4 channel with Counter/Timer/D.M.M £995
- Tektronix 2335 Dual trace 100MHz (portable) £750
- Tektronix 2225 – 50MHz dual ch £450
- Tektronix 2465B - 400 Mhz 4 channel £3950
- Tektronix 464/466 – 100MHz An storage .... from £350
- Tektronix 465/465B – 100MHz dual ch .... from £350
- Tektronix 7313, 7603, 7613, 7623, 7633, 100MHz 4 ch .... from £300
- Tektronix 7704 – 250MHz 4 ch .... from £650
- Tektronix 7844 – Fitted with 7A42, 7B80, 7B85 Plug-ins £1500
- Tektronix 7904 – 500MHz .... from £850
- Tektronix 468 - 100MHz Digital Storage £800
- Telequipment D68 - 50MHz Dual Channel £200
- Iwatsu TS 8123 - 100 Mhz - D. Storage £850

Other scopes available too

SPECTRUM ANALYSERS

- Alltech 727 – Spec. Analyser 22.4 GHZ with Alltech 70727 – Tracking Generator (10KHz – 12.4 GHz) £2000
- Hewlett Packard 3580A – -5Hz-50KHz £995
- Hewlett Packard 3709B - Constellation Analyser with 15709A High Impedance Interface (As New) £6750
- Hewlett Packard 182T with 8559A (10MHz – 21GHz) £3750
- HP 3582A – 25KHz Analyser, dual channel £2500
- Hewlett Packard 35601A - Spectrum Analyser Interface £1000
- Hewlett Packard 8754A - Network Analyser 4 - 1300MHz £3250
- Marconi 2370 – 110MHz £995
- Marconi 2371 – 30KHz - 200MHz £1250
- Polrad 641-1 – 10MHz – 18GHz £1500
- Rohde & Schwarz – SWOB 5 Polyskop 0.1 – 1300MHz £2500
- Schlumberger 1250 - Frequency Response Analyser £2500
- Tektronix 7L12 with 7603 mainframe (1.8GHz) £1500
- Tektronix 7L14 with 7603 mainframe (1.8GHz) £2000
- Tektronix 7L18 with 7603 mainframe (18GHz) £2950
- Texscan AL51A (4MHZ – 1GHZ) £850

MISCELLANEOUS

- Anritsu MG642A Pulse Pattern Generator £1500
- Ballantine 323 True RMS Voltmeter £350
- Datalab DL 1080 Programmable Transient Recorder £350
- Dyanpert TP20 Intelliplace – Tape peel Tester – immacualte condition £1950
- Farnell 2081 R/F Power meter £350
- Farnell TSV 70 MkII Power Supply (70V-5A or 35V-10A) £200
- Ferrograph RTS-2 Audio Test Set with ATU 1 .... £500
- Fluke 8010A/8012A/8050A Digital multimeters - from £125
- Fluke 5101A AC/DC Calibrator £3500
- Fluke 5101B AC/DC Calibrator £6500
- Marconi - 2019A - 80KHz - 1040MHz - Synthesised Signal Generator £1950
- Hewlett Packard 8662A - (10KHz-1280MHz) - Synthesised Signal Generator £7950
- Hewlett Packard 4953A - Protocol Analyser £3500
- Hewlett Packard 1630G - Logic Analyser - 65 Channels £850
- E.I.P. 548A - Frequency Counter (26.5 GHz) £3500
- Marconi 6950 Power Meter with 6910 Sensor £800
- Racal 1992 - 1.3GHz Frequency Counter £850
- Datron 1061 - Precision Multimeter £650
- Fluke 5220A Transconductance Amplifier (20A) £3000
- Fluke 720A Kelvin-Varley Voltage Divider £450
- Fluke 750A Reference Divider £450
- Gould TA 600 – Thermal Array Recorder £400
- Gould K100D – 100MHz Logic Analyser with Pods £350
- Heiden 1107 – 30V-10A Programmable Power Supply (IEEE) £650
- Hewlett Packard 3437A System voltmeter £350
- Hewlett Packard 3456A Digital voltmeter £850
- Hewlett Packard 3760/3761 Data gen + error detector .... each £300
- Hewlett Packard 3762/3763 Data gen + error detector .... each £350
- Hewlett Packard 5420A Digital Signal Analyser £350
- Hewlett Packard 5423A Structural Dynamics Analyser £350
- Hewlett Packard 54470B Digital Filter £100
- Hewlett Packard 54410A Analogue/Digital Converter £100
- Hewlett Packard 7402 Recorder with 17401A x 2 plug-ins £300
- Hewlett Packard 8011A Pulse gen 0.1Hz-20MHz £500
- Hewlett Packard 8443A Tracking gen/counter with IEEE £300/400
- Hewlett Packard 8620C Sweep oscillator mainframe £400
- Hewlett Packard 8750A Storage normaliser £375
- Hewlett Packard 8684A 5.4GHz to 12.5GHz Sig-Gen £3000
- Hewlett Packard 8640B – AM/FM Signal Gen (512MHz) £850
- Hewlett Packard 5340A – 18GHz Frequency Counter £900
- Hewlett Packard 5356A – 18GHz Frequency Converter head £450
- Hewlett Packard 432A – Power Meter (with 478A Sensor) £275
- Hewlett Packard 435A or B Power Meter (with 8481A/8484A) .... from £750
- Hewlett Packard 3438A Digital multimeter £200
- Hewlett Packard 6181C D.C. current source £150
- Hewlett Packard 59501B HP.1B Isolated D/A power supply programmer £150
- Hewlett Packard 3711A/3712A/3791B/3793B Microwave Link Analyser £3500
- Hewlett Packard 5316A Universal Counter HP1B £550
- Hewlett Packard 5316B Universal Counter HP1B £775
- Hewlett Packard 5385A Frequency Counter - 1GHz - (HP1B) with OPTS 001/003/004/005 .... £995
- Hewlett Packard 3779C Primary Multiplex Analyser £1000
- Hewlett Packard 6623A Triple output system power supply £1950
- Hewlett Packard 3764A (Opt 002) Digital Transmission Analyser £2250
- Hewlett Packard 3586A Selective level meter £1750
- Hewlett Packard 3325A - 21MHz Synthesiser/Function Gen £1500
- Hewlett Packard 8152A - Optical Average Power Meter £1250
- Hewlett Packard 8158B - Optical Attenuator (OPTS 002 + 011) £1100

HEWLETT PACKARD 6261B
Power Supply 20v-50A £500 ***Discount for Quantities***

- International Light - IL 1700 Research Radiometer with Erythermal Sensor Head £1250
- Krohn-Hite 2200 Lin/Log Sweep Generator £995
- Krohn-Hite 4024A Oscillator £250
- Krohn-Hite 6500 Phase Meter £250
- Lyons PG73N/PG75/PG28/PG Pulse generator .... from £225
- Marconi 2432A 500MHz digital freq. meter £200
- Marconi 2337A Automatic dist. meter £150
- Marconi 2356 20MHz level oscillator £300
- Marconi 2306 Programmable interface £450
- Marconi 2830 Multiplex tester £850
- Marconi 2831 Channel access switch £250
- Marconi 2019 – AM/FM Signal generator – 1040 MHz £1800
- Multicore "Vapourette" Bench Top Vapour Phase SMD Soldering Machine (New + Unused) £650
- Philips PM 5167 10MHz function gen £400
- Phoenix 5500A - Telecomms Analyser with various Interface Options £2500
- 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 evel meter £650
- Racal Dana 5003 Digital m/meter £150
- Racal Dana 9000 Microprocessing timer/count. 520MHz £550
- Racal Dana 9081 Synth. sig. gen. 520MHz £550
- Racal Dana 9084 Synth. sig. gen. 104MHz £450
- Racal Dana 9303 True RMS/RFevel 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 9302A R/F millivoltmeter (new version) £375
- Racal Dana 9082 Synthesised am/fm sig gen (520MHz) £500
- Racal 9301A - True RMS R/F Millivoltmeter £300
- Racal 9921 - 3GHz Frequency Counter £450
- Rohde & Schwartz BN36711 Digital Q meter £400
- Rohde & Schwarz - Scud Radio Code Test Set £995
- Rohde & Schwarz - LFM 2 Sweep Generator 0.02 - 60MHz £1500
- Rohde & Schwarz SUF 2 Noise Generator £300
- Rotek 3980A AC/DC Precision Calibrator with Rotek 350A High Current Adaptor .... £POA
- Schlumberger S.I. 4040 Stabilock - High accuracy 1GHz Radio Test Set £5950
- Schlumberger 4923 Radio Code Test Set £1500
- Schlumberger 2720 1250 MHz Frequency Counter £500
- Solarton Schlumb 1170 Freq. response analyser £250
- Systems Video 1258 Waveform Analyser + 1255 Vector Monitor + 1407 Differential Phase and Gain Module + 1270 Remote Control Panel £2250
- Systron Donner 1702 Synthesised Sig. Gen 1GHz £990
- Systron Donner 6054B or D 18GHz or 24GHz Freq. Counter .... from £800
- Telequipment CT71 Curve Tracer £250
- Tektronix TM5003 + AFG 5101 Arbitrary Function Gen. £1750
- Tektronix 1240 Logic Analyser £750
- Tektronix 1480 Waveform Monitor .... POA
- Tektronix 651 HR Monitor .... POA
- Tektronix DAS9100 – Series Logic Analyser £500
- Tektronix – Plug-ins – many available such as SC504, SW503, SG502, PG508, FG504, FG503, TG501, TR503 + many more .... £POA
- Time 9811 Programmable Resistance £600
- Time 9814 Voltage Calibrator £750
- Wayne Kerr B424/N LCR Component Meter Set £200
- W&G SPM12 Level Meter (200Hz – 6MHz) £500
- W&G PS12 Level Oscillator (200Hz – 6MHz) £500
- Weller D801/D802 Desoldering station £175
- Wiltron 560 Scalar Network Analyser £800
- Wiltron 352 Low Frequency Differential Input Phase Meter £350
- EIP 331 – Frequency counter 18GHz £700

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

Versatile regulated power supply unit

A practical upgradeable bench power supply for electronic circuits designed and developed by Tim Parker

PART 1

Apart from an oscilloscope, one of the most valued pieces of equipment on the electronics workbench is a decent power supply unit (PSU). The one presented here is not a high powered, all singing, all dancing switched-mode model. It's a straight forward linear design with a perfectly usable output voltage and current range, which can be upgraded at a later date if desired. It is not initially designed for powering CB radios or in-car entertainment systems - and let's face it, the types of amplifiers incorporated into some car stereo systems these days (especially those with enough output to transform the vehicle into a speaker cabinet on wheels) would bend the knees of ANY power supply that does not have 'serious' power handling capabilities.

More than anything else, this one is designed to fulfil the majority of requirements likely to be encountered by the electronics hobbyist and designers alike. It provides regulated DC outputs of +12V (fixed), -12V (fixed) and +5V (fixed), each with a current capability of up to about 250mA if all of them are in use. Up to 1 Amp can be drawn from any one output at a time. Also included is a variable voltage output between approximately +3V and +14V with variable current limiting between 10mA and 200mA. There aren't many electronic designs which cannot be powered either directly from these supplies, or by manipulation of the various outputs available. A lot of beginners and novices believe that they need a power supply with 'bags' of current. But ask any experienced designer and they will tell you that this is not the case.

To allow the use of the full current handling capacity of each output, they can all be 'beefed up' by upgrading certain parts of the circuit. For example, the fixed outputs can be increased up to 1 Amp each, and the variable output is capable of voltages up to 36V, at currents of up to 2 Amps. This is explained in more detail later.

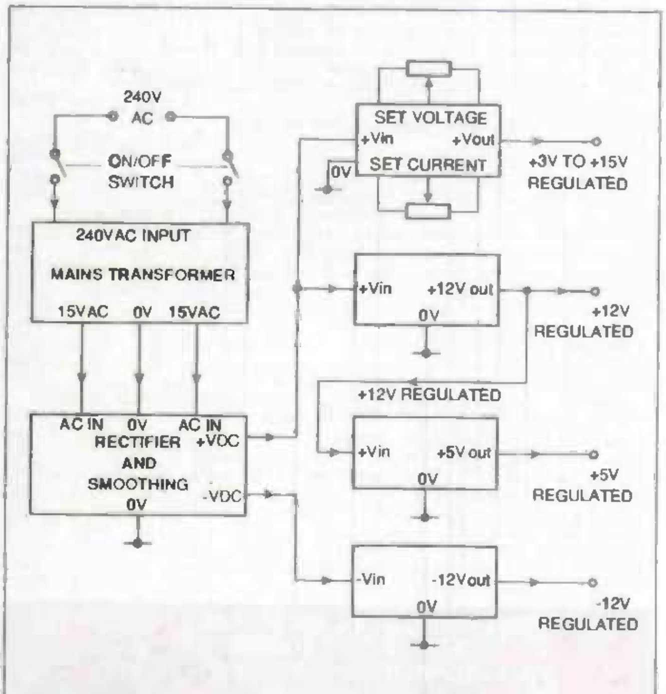


Fig. 1 Block diagram of the regulated PSU

The circuit

Fig 1 shows a block diagram of the regulated power supply unit broken down into six sections and the complete circuit diagram appears in figure 2. Transformer T1 produces 30V AC across its secondary winding, which is used as two 15V AC outputs when referenced to the centre tap point. This centre tap is used as a 0V potential for all of the regulator circuits and thus the output terminals. The contact suppressor CS1 is fitted directly across the mains input to reduce turn off spikes and may be omitted if desired.

The 100Hz rough DC from the bridge rectifier formed by D1 to D4 is smoothed on the positive side by C1, and on the negative side by C2. This results in 'off load' DC levels up to about +25V across C1 and about -25V across C2 (with reference to 0V of course). These are referred to as +V and -V respectively.

Fixed voltage outputs

Working upwards from the bottom of the circuit diagram of fig 2, regulator IC3 is fed from the smoothed -V potential and produces a regulated -12V output on pin 3. Regulator IC1 is fed from the +V potential and produces a regulated +12V output, again on pin 3. Not only does this provide the fixed +12V output, but also the input potential for IC4, which itself

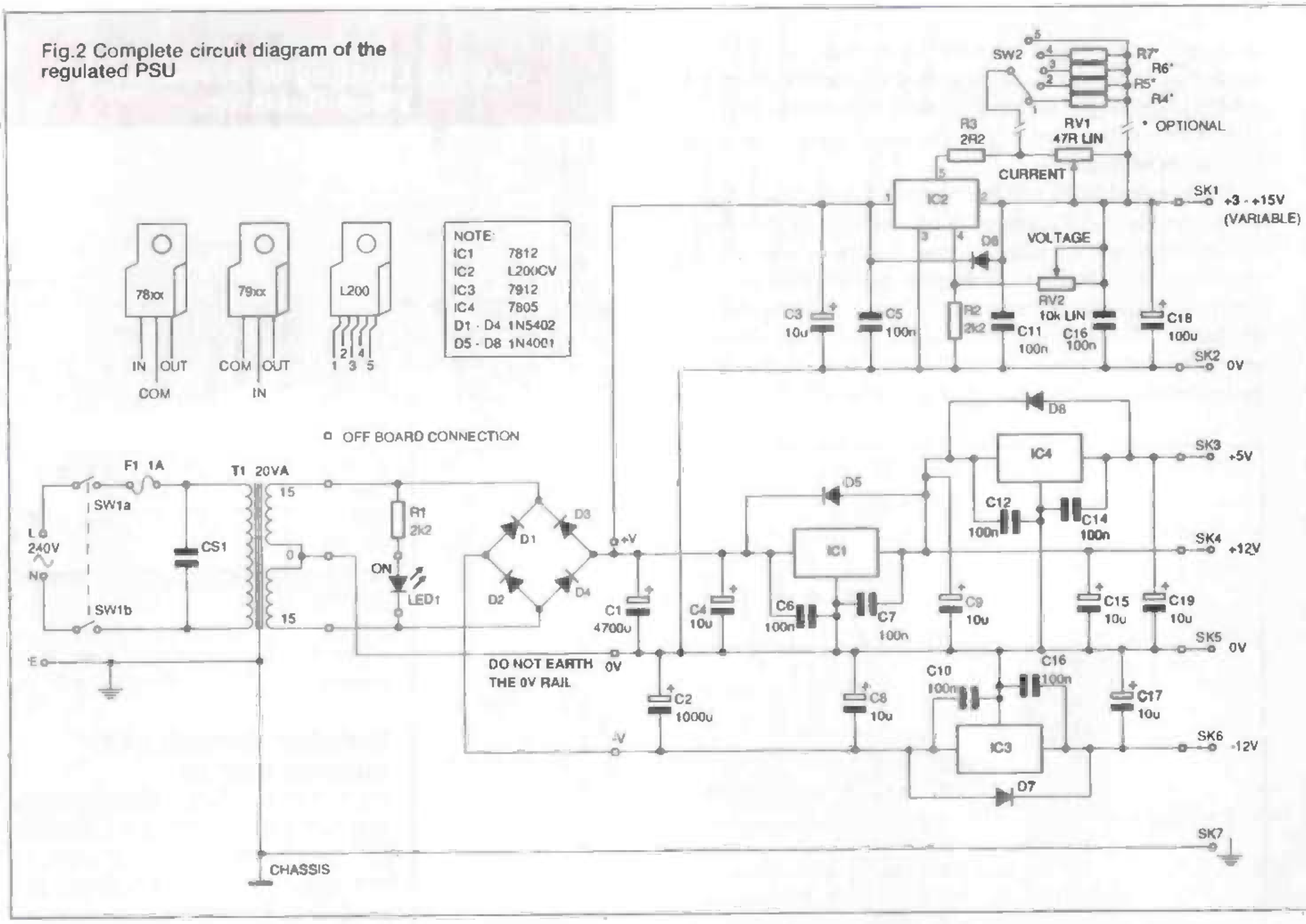


Fig.2 Complete circuit diagram of the regulated PSU

provides the fixed +5V regulated output on pin 3. The reason for supplying IC4 from the output of IC1 is to reduce the power dissipation of IC4, which, whilst capable itself of handling input voltages up to 40V, would require separate heatsinking in order to keep its 'on load' operating temperature down at an acceptable level. If the input to IC4 were to be supplied directly from the +V rail, the power dissipation would take it beyond its safe operating limits, with the possibility of it repeatedly shutting down through thermal overload. Unfortunately, this would not be discovered until a short time after a load had been connected across its output.

The low value capacitors close to each of the regulators (100nF & 10uF) improve the noise rejection, transient response and stability against high frequency oscillation of each device.

Diodes D5 to D8 protect the regulators against certain conditions that could arise during operation. Quite often there are a couple of points that are - possibly inadvertently - overlooked in power supply designs based on fixed voltage regulators. The first is what happens when the INPUT to the regulator is suddenly shorted to 0V, and the second is the effect of turning off the supply with large capacitor values connected across the output; formed by (say) the supply decoupling capacitors of the equipment being powered from the power supply unit. In both cases, the regulator's input voltage rapidly reaches the 0V potential, whilst the output would remain at the regulator's original voltage for a short length of time due to the stored charge. This voltage will then be discharged back into the OUTPUT terminal of the regulator, and if the energy released by the capacitors is large enough, would almost certainly result in the destruction of the regulator. By including diodes across the regulators as shown, the excess energy is shunted to the low potential at its input and so protects the device.

Strangely enough, the damage to the power supply caused by this tends to lead to some confusion for the user, because it will be assumed that the equipment being powered at the time caused the damage to the supply when it was turned on.

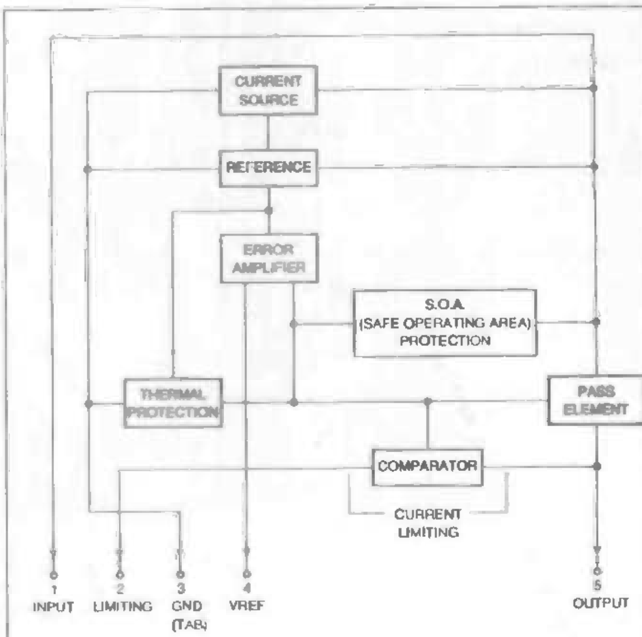


Fig. 3 Internal architecture of the L200CV

Whereas, in reality, the damage was caused by the equipment previously connected to the supply when it was last turned off, which might not be the same piece of equipment connected now. This results in the wrong piece of equipment being checked for faults, even though none of them might actually have any! Confusing eh!

The only restriction to this protection is when extremely large value (tens of thousands of microfarads) capacitors are connected across the output, where the energy released is so great there is a danger of blowing the protection diode itself. Fortunately this is rare under normal circumstances, and diodes of this type do generally tend to blow short circuit - as opposed to open circuit, so the regulator should still be protected against backward discharge. But BEWARE. If the protection diode has blown short circuit, the regulator will also be shunted from input to output, so what you expect to be (say) a regulated +5V output suddenly becomes the same potential as the +V unregulated input voltage, which would be capable of destroying an entire board full of TTL devices in a fraction of a second.

Table 1
Current Limiting With Preferred Value Resistors

Rsc	Iout	Rsc	Iout
47	9.5mA	3.3	136.3mA
33	13.6mA	2.2	204.5mA
22	20.0mA	1.0	450.0mA
15	30.0mA	0.47	957.4mA
10	45.0mA	0.33	1.36A
4.7	95.7mA	0.22	2.04A

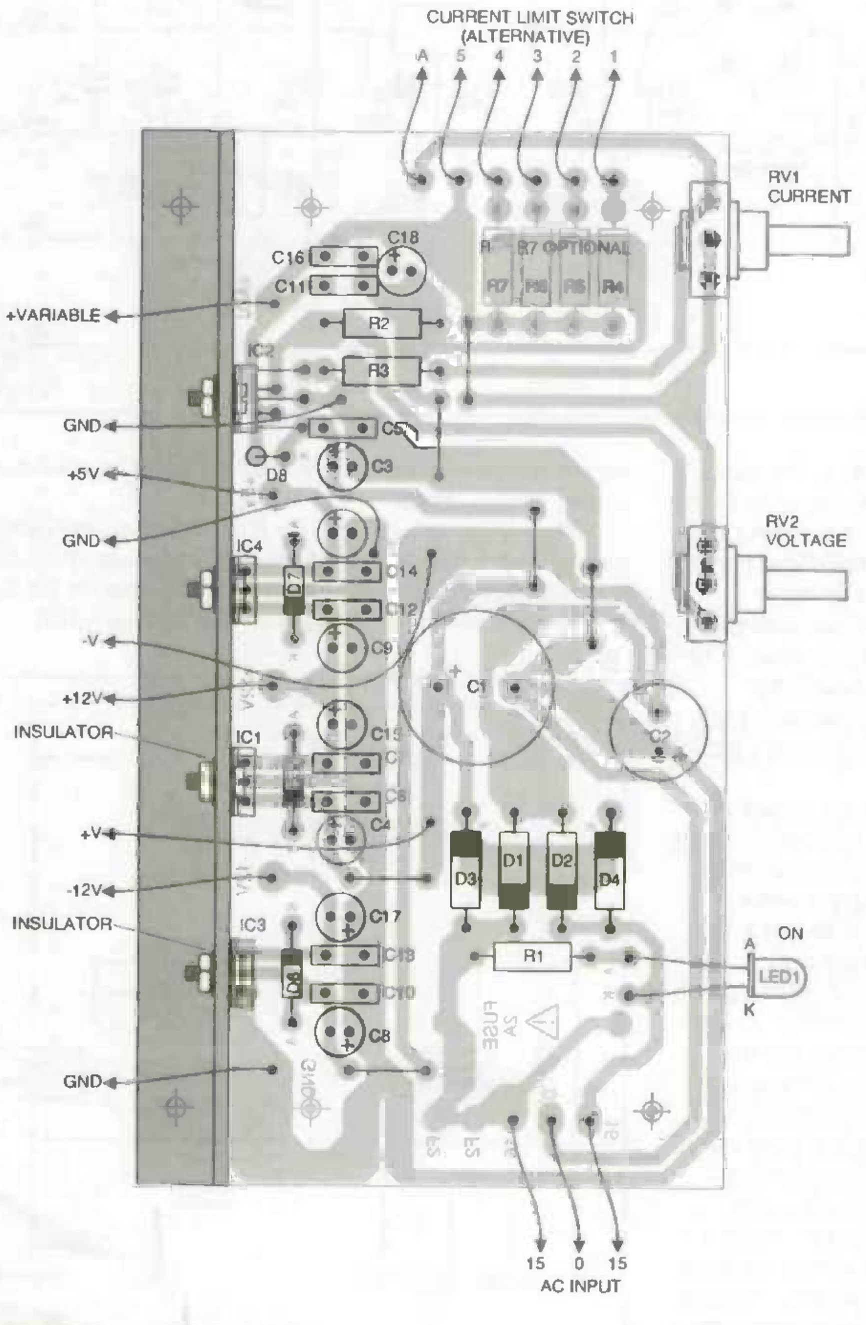


Fig. 4 PCB component overlay

Variable voltage and current output

The task of supplying a variable voltage and current limited output is handled by IC2 - an LC200CV adjustable voltage and current regulator. Fig 3 shows, in block form, the basic design of its internal architecture. According to the technical specification, this device is virtually 'bomb proof'. Given sufficient current and a 40V (max) input, it is capable of regulated output voltages from 2.85V to +36V, at currents of up to 2A, although our basic power supply application does not drive it to these limits. As a rule of thumb the maximum available output voltage can be approximated from the formula;

$$V_{out} = V_{ref}\left(1 + \frac{VR2}{R2}\right)$$

Where Vout is the resultant output voltage gained from the formula, VR2 and R2 are component values taken from Fig 2 (remember VR2 can be any value between less than 1 and its rated value). Vref may vary slightly, but as a general rule can be assumed to be typically 2.77V.

The available output current can be obtained from the formula;

$$I_{out} = \frac{V_{sc}}{R_{sc}}$$

Where Iout is the resultant output current gained from the formula, Vsc is the current limit sense voltage between pins 5 and 2, and Rsc is the resistance (in Ohms) between pins 5 and 2. The actual value of Vsc is dependent on (amongst other things) regulator output load and operating temperature, but can be taken to be typically 0.45V.

R2 and VR2 set the output voltage, whilst R3 and VR1 set the current limiting cutoff point. The values of these components are selected to give the best overall control of the output from the available input. Although the input voltage could be as high as +25V, this will fall quite considerably when the regulators have a load connected across their outputs, and since IC2 has quite a high dropout voltage it's no use selecting component values that allow the device to operate up to its maximum capacity if it's never likely to use it.

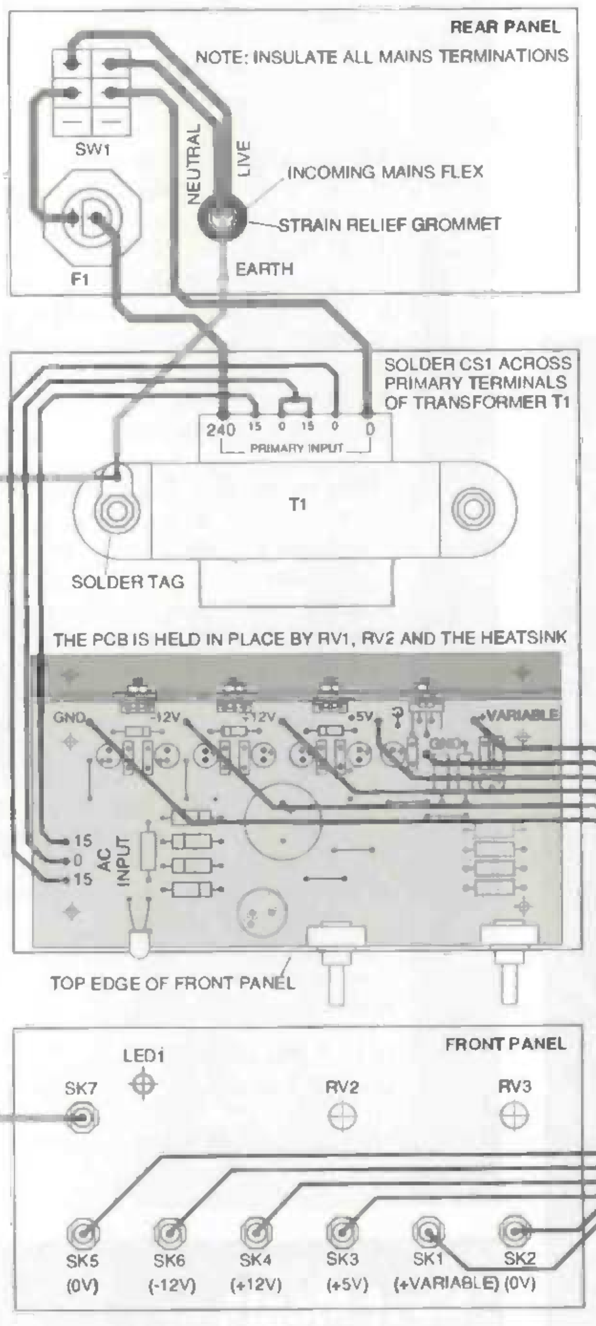


Fig. 5 Wiring diagram (Note: front and rear panels shown flat and separated for clarity)

Switched or variable current limiting

When using a continuously variable control to limit the current output (such as the use of VR1), it can be difficult to set the current limit cutoff point with any degree of accuracy - generally it has to be a very approximate setting. For this reason, VR1 may be replaced with four fixed value resistors (R4-R7) and a 1 pole 12-way rotary switch. This will allow switched selection of up to five pre-determined current limit settings that will be far more accurate than a potentiometer. The range of settings can be extended by soldering more resistors directly to the switch itself. The art of current limiting using this method is the ability to synthesize resistor values suitable for the cutoff points you wish to set, which may involve paralleling two or more together to obtain the required value.

The PCB positions available for R4 to R7 instead of VR1 (NOT as well as VR1) are shown as dotted outlines in fig. 4, with the connections required between the PCB and the switch shown in fig. 6. No resistance values have been specified because these will depend on your own requirements. However, Table 1 below gives an idea of the various current limits when using preferred value resistors. Note that Rsc is the TOTAL resistance between pins 5 and 2, and that the current must not rise above 250mA unless the power supply has been upgraded.

Current Limiting With Preferred Value Resistors

Iout values are all very close approximations

Closer Inspection of Table 1 will reveal why it is so difficult to set the current limit using a variable control, particularly at the higher current outputs where the resistance becomes uncontrollably small. Notice how an adjustment of just 0.11 results in almost a 700mA change in current limiting. To make matters worse, as the resistance decreases, the power dissipation in the control results in self-induced variations that only add to the problem.

The only simple way to gain better control at high current outputs would be to trade off the controllability of the lower current settings and plump for a reverse log potentiometer, which has the same characteristic logarithmic curve, only in reverse. These are available, but so uncommon they are very difficult to obtain - and virtually impossible in high power versions. Of course, you could always use a 10-turn version, but then you'd also require a 10-turn counting dial in order to know whereabouts the track-to-wiper position was, and even then you'd have to convert the readings from the dial into current limit settings. All told, about ten quid's worth!

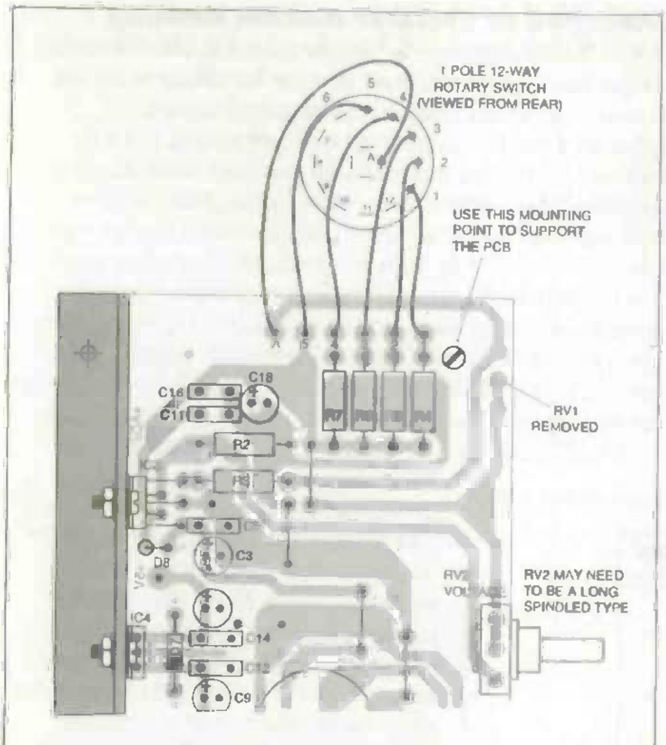


Fig. 6 Connections for switched current limit selection (VR1 must be removed)

Kit available

A kit of parts for the variable low current version of the power supply (using potentiometers) including PCB, 20VA transformer and heatsink (but not including the case - this is left to personal choice) is available from the author by mail order only at the following address:

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

The price for the kit of parts is:
£39.00 inc.
The PCB is also available separately at:
£ 6.50 inc.
Please add postage and handling (per order):
£ 2.50 for the UK
£ 4.00 elsewhere.

Please make Cheques/Postal Orders payable to 'DTE MICRO SYSTEMS'. If ordering from overseas, payment must be in Pounds Sterling (£) and cheques must be drawn on a British bank.

Goods will normally be dispatched within five working days from receipt of order (subject to availability and cheque clearance), but please allow up to 28 days for delivery.

PARTS LIST

Resistors

- R1, 2 — 2K2 — 0.5W carbon (2 off)
- R3 — 2n2 — 2.5W wirewound
- R4 - R7 — optional - (selected by user) *
- VR1 — 47n LIN potentiometer
- VR2 — 10Kn LIN potentiometer

Capacitors

- C1 — 4700uF/35V radial electrolytic
- 2 — 1000uF/35V radial electrolytic
- C3,4,8,9,15,17,19 — 10uF/35V radial electrolytic (7 off)
- C5,6,7,10,11,12,13,14,16 — 100nF/50V ceramic or polyester (9 off)
- C18 — 100uF/35V radial electrolytic
- CS1 — 100n+100nF 250V RC contact suppressor

Semiconductors

- D1 - D4 — 1N5402 3Amp rectifier diodes (4 off)
- D5 - D8 — 1N4001 1Amp rectifier diodes (4 off)
- IC1 — 7812 +12V 1Amp voltage regulator
- IC2 — L200CV 2Amp adjustable regulator
- IC3 — 7912 -12V 1Amp voltage regulator
- IC4 — 7805 +5V 1Amp voltage regulator
- LED1 — 5mm standard red LED

Hardware & miscellaneous

- F1 — 20mm 1Amp fuse
- fuseholder — 20mm panel mounting fuseholder
- SK1,3,4,6 — 4mm red terminal posts (4 off)
- SK2,5 — 4mm black terminal posts (2 off)
- SK7 — 4mm green terminal post
- SW1 — DPST rocker switch rated 6A/250V
- T1 — 0-15-0-15 20VA mains transformer

heatsink thick aluminium angle 150 x 50 x 50
fixings screws, nuts & washers as required
knobs control knobs for VR1 & VR2
insulators insulating kits for IC1 - IC4
terminals lucar connectors for SW1 (4 off)
flex 6A mains flex
grommet strain relief grommet
cover terminal cover for T1
sleeving heat-shrink sleeving
case enclosure to suit *
legend front panel label *

PCB DTE "PSU" printed circuit board £6.50 available from DTE MICRO SYSTEMS

* Not supplied with the kit

Next Month...

we will look at constructing and testing the PSU

SOMETHING FOR NOTHING?

Inspired by a sunny summer Terry Balbirnie looks at Alternative Energy in miniature

Renewable energy sources make interesting providers of electricity where no mains supply exists. For example, the sun's energy can be converted directly using solar cells. These have been available on the amateur market for a long time and individual units providing an output of some 0.45V at 200mA are listed by several suppliers. Using a large number of these to provide a useful voltage and current output is, however, expensive. It is only comparatively recently that large solar panels based on amorphous silicon have been available at a reasonable price.

A 3ft x 1ft (90cm x 30cm approximately) solar panel is now available from Bull Electrical by mail order. This is capable of providing 800mA in bright sunlight. One of these may be used to charge a 12V lead-acid battery and supply sufficient power to operate small pieces of low-voltage equipment such as lights, radio, TV, etc. for a boat or caravan. It could also be useful for radio amateurs, educationists and experimenters working in the field.

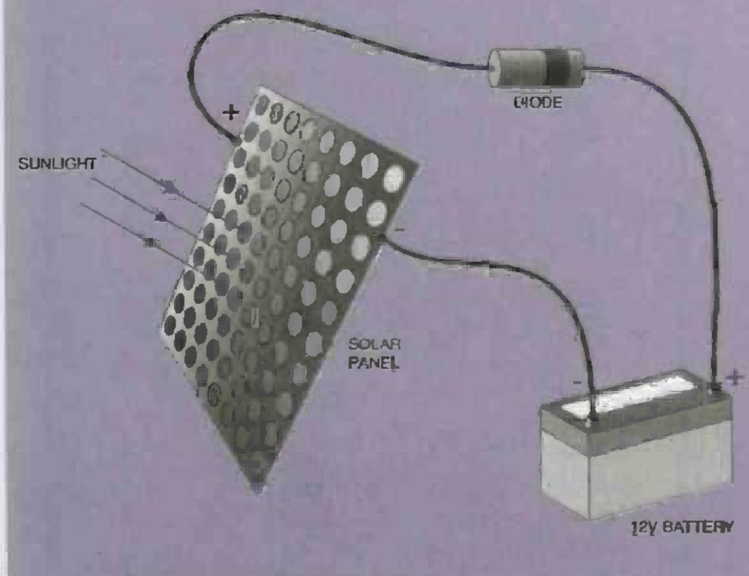


Fig.1. Basic solar battery charger

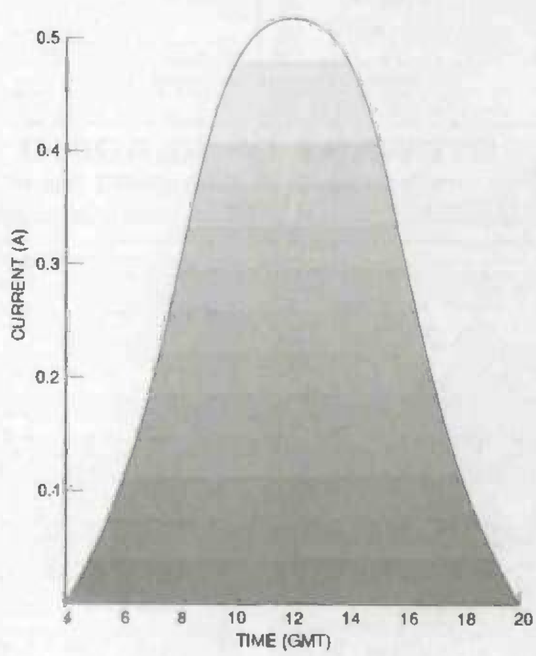


Fig.2. Approximate graph of solar battery charging current against time of day

Of course, using solar power is not really getting "something for nothing" due to the price of the equipment. It could take several decades to recover the true cost in terms of mains electricity saved. On the other hand, there are situations where conventional power is unavailable or charged for at a premium rate - on camp sites, for example. It is at such times that solar panels make a convenient and satisfying small-scale source of electricity. Obviously, the power available is limited by the intensity of light falling on the solar panel's sensitive surface and this, in turn, depends on the season of the year, time of day, amount of cloud cover and direction in which it is facing. It also depends on such factors as latitude and height above sea level.

The preferred way of using solar cells is to charge a small battery. As long as the average power drained does not exceed that supplied, the system may operate indefinitely. During winter months, there will not be much solar radiation available but bright daylight will be sufficient to trickle-charge a battery and keep it in good condition.

Silliest under the sun

The solar panel arrives well packed in a wooden case. You need a screwdriver to detach the lid and remove the contents. Before using it, wires need to be attached to the output electrodes since "flying lead" connections are not provided. Bull's advice is to use spring clips or cold solder. It would probably be disastrous to use conventional soldering and I didn't try it. I used paper clips and a little epoxy resin adhesive to hold them in position. Something more permanent would be needed for long-term use.

A test was made during early afternoon on a sunny June day in the UK. With the panel directly facing the sun, there was an open-circuit voltage of over 18V. It was then found possible to draw just over 800mA. A small 12V bulb connected direct lit brightly - a totally silly but satisfying exercise. Care is needed if electronic equipment is to be connected in an attempt to power it. The output voltage may reach a destructive level if the current drawn is low. I tried a small 12V television and it worked perfectly. However, as stated previously, it is more useful to use the output to charge a battery since this will provide a reserve of power. When using equipment while the sun is shining on the solar panel, the battery will make up any deficiency between the solar power and that required by the equipment. The battery will also stabilise the output to 12V nominal.

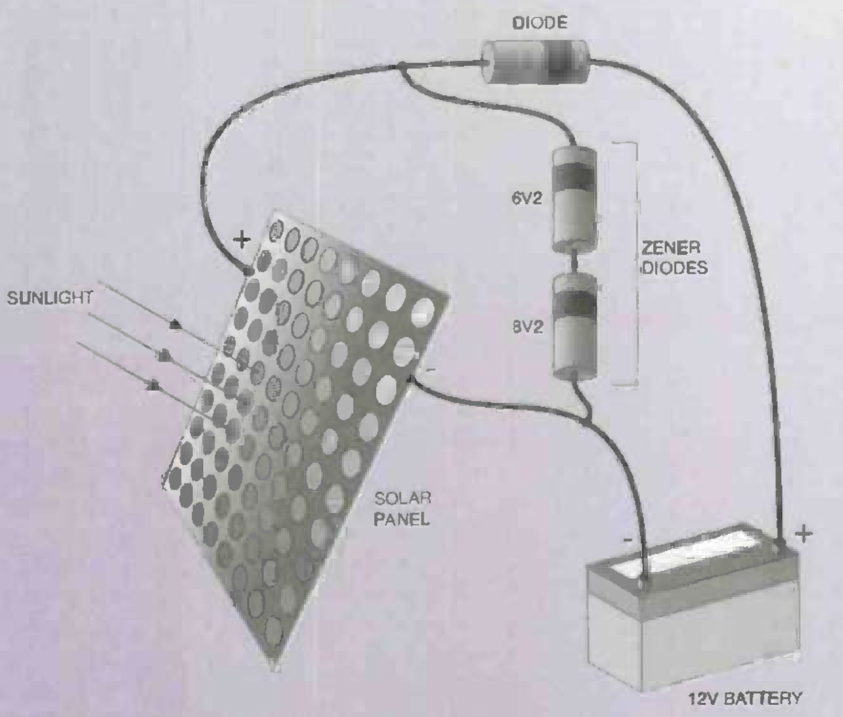
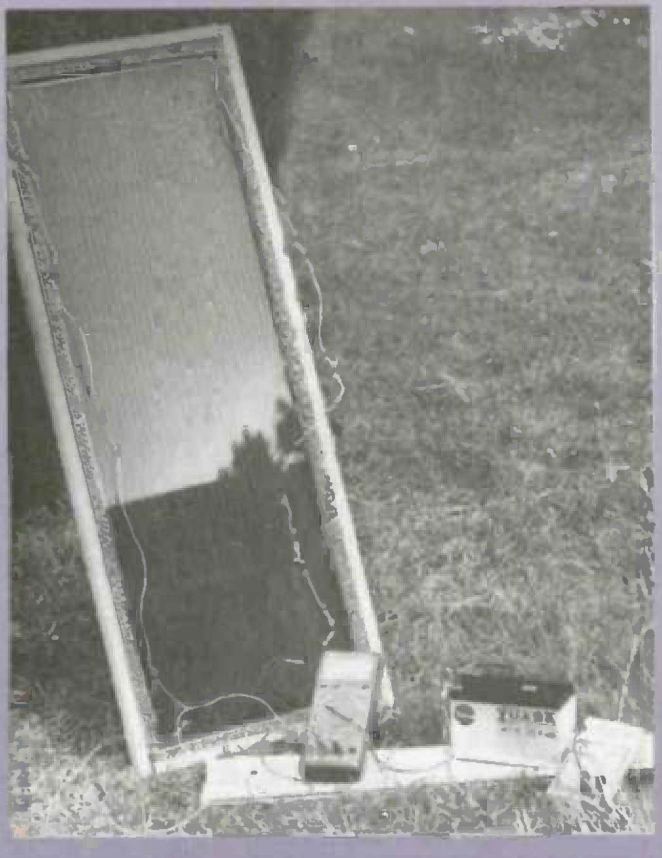


Fig.3. A 12V solar battery charger



Schottky rectifier

I used the solar panel to charge a 12V 7Ah Yuasa sealed lead-acid battery (the actual capacity is unimportant). It is necessary to included a diode in the circuit (see Fig. 1). This will prevent the battery discharging through the solar panel when the output voltage falls below that of the battery - this would happen under dim conditions. An ordinary silicon diode (type 1N4001) is adequate with about 0.7V being "lost" due to its forward drop. A significant improvement is obtained by using a Schottky barrier diode since it has a lower turn-on voltage (about 0.5V or less). This was found to improve the charge rate by some 50mA. A suitable one would be Maplin order code GX29G (1N5820 Schottky rectifier diode).

It is important to note that the rated 800mA referred to earlier will not be available when battery charging. I found that up to 500mA was provided in bright sunlight (depending on the state of charge). Note that when clouds obscure the sun, the current falls drastically - to 100mA or less. The graph (Fig. 2) gives an idea of how the charge rate varies with the time of day -this, of course, will depend on conditions. The area under the curve gives the total charge supplied during a 24 hour period under ideal conditions - in this case about 4.5Ah. The photograph shows an experimental arrangement with the solar panel charging a battery.

Shunt regulator

If the battery is left on charge without being used (so-called "floating" or "standby" use), it would be possible for it to be overcharged - especially if it was a small one. To avoid this, a simple shunt regulator may be used. A limit of between 13.5 and 13.8V measured at the battery terminals should be set. Taking into account the voltage drop across the series diode, there will need to be about 14.0 to 14.3V measured at the solar panel if a Schottky diode is used or 14.2 and 14.5 for an ordinary silicon diode. Since no standard value falls within this range, it may be made up (near enough) by using a 6.2V and an 8.2V Zener diode connected in series as shown in Fig. 3. As the battery nears full charge, the terminal voltage rises and approaches that imposed by the regulator. Most of the current is then diverted through the Zener diodes and charging falls to a small "trickle". The Zener diodes must be adequate for the purpose and a power rating of 5W is recommended.

Make-believe camping

I simulated a camping holiday during a sunny week in June using the solar panel to charge the 7Ah battery. Short periods of power were needed for a black and white television, a small (8W) fluorescent light and for the occasional use of a water pump. The solar panel was moved from time to time to face the sun. Few people will bother to do this although it does provide more power. It was found possible to operate the TV and the light for 2 hours and a water pump for several short periods each day without running the battery down - energy in matching energy out. Note that a lead-acid battery should never be completely discharged. The moment it shows signs of falling output (dimming lights or a terminal voltage less than 11V), it must be charged as soon as possible. Good modern batteries will tolerate some abuse but such treatment will certainly reduce their life and impair the capacity.

The transit case in which the panel is supplied may be used to support it in use and provide protection against damage. This is necessary because these panels are made of glass and very fragile. By strengthening the corners of the case and placing foam plastic beneath, good protection is provided. Additional weatherproofing would be needed against rain. It is possible to cover the front of the box with clear plastic but a check would be needed to ensure that it did not reduce the amount of sunlight reaching the sensitive surface unduly. A similar-sized panel in a polycarbonate weather resistant frame is offered by the same supplier. Here, the solar panel is laminated with an additional sheet of glass which gives it greater strength.

For caravan use, the panel could be left inside raised at an angle on a few books and placed near a window. There would then be sufficient current to maintain the charge in a battery throughout the winter.

Supplier

The solar panels referred to in the text are obtained from:
Bull Electrical
250 Portland Road
Hove
Sussex
BN3 5QT
Tel: 0273 203500

The product reference of the standard panel is MAG34 and the cost is £33.95 plus VAT. The weather resistant version (product reference 45P) costs £45. In each case there is an additional £2 postage and packing charge. Experimenters should note that various other types and sizes of solar panels are listed in the Bull Electrical mail order catalogue available on request from the address above.

simple circuits
children's night light

Terry Balbirnie takes a look at the design and construction of a low-intensity light with micropower consumption that is suitable as a child's night light

This project is a mains-operated lamp designed to be plugged into the ceiling light fitting of a child's bedroom. The circuit is housed in a glass coffee jar which is similar in size to the standard light bulb which it replaces.

It is very important to note that this light must only be used in the ceiling fitting and not into a bedside reading lamp. The child must not be able to reach it, possibly dismantle it and expose live mains connections with lethal consequences.

The night light will operate for some 3000 hours on one kilowatt-hour of electricity. At today's prices this works out at about 400 hours - or over one month of normal operation - for one penny!

Although this is a very simple circuit, construction is not recommended for a beginner. This is because mains connections need to be made and some experience is needed to do this safely.

Comforting thought

The light given by this device is admittedly rather dim. However, it is sufficient for the purpose - to comfort a child. If in doubt about its suitability for other applications - for use by an elderly person, for example - it would be a good idea to connect the specified bulb direct to a 6V battery and hold it close to its final position. It will then be possible to judge whether the light is sufficient before beginning construction work. It may be sufficient to help in avoiding obstacles in an otherwise unlit corridor, for example.

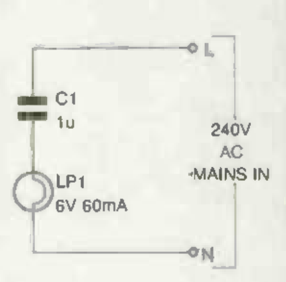


Fig.1. Basic circuit

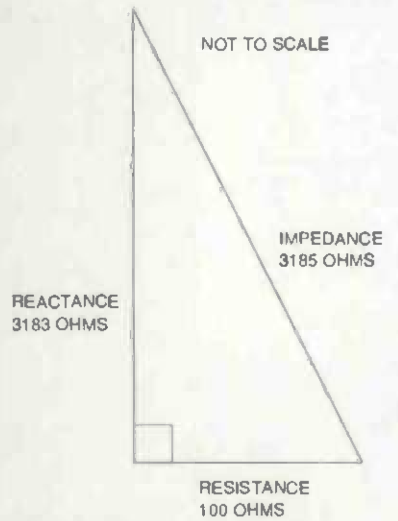


Fig.2. Relationship between impedance, reactance and resistance

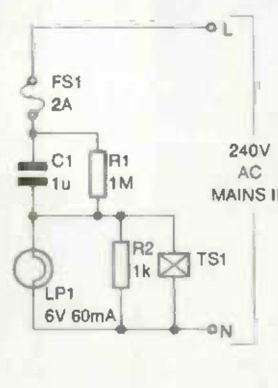


Fig.3. Improved circuit for child's night light

How it works

The circuit uses a 6V 60mA bulb as its basis. To connect this direct to the mains would obviously be disastrousl Here, a rather unusual method of current-limiting is used. Reducing the voltage to 6V by means of a transformer would be the usual way. However, this would make for a rather bulky and heavy device. Also, the small variety of transformer would become quite warm in operation. Not only would this waste energy

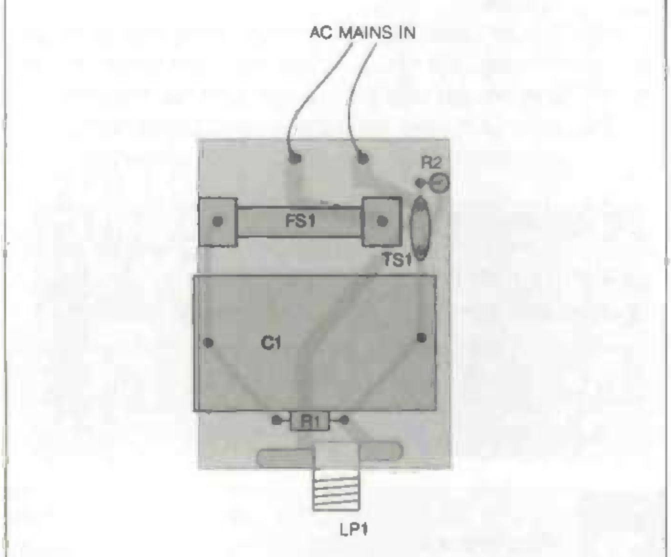


Fig.4. PCB component overlay

have to be paid for, but it could be a nuisance to get rid of.

The method used here is to connect a capacitor in series with the bulb. The basic circuit is shown In Fig. 1. The capacitor exhibits reactance to the flow of current in an a.c. circuit. The current is limited in a way which depends on the capacitor's value and the voltage and frequency of the supply. The higher the frequency and/or the higher the capacitor value, the lower will be the reactance and the greater the current will be. A higher supply voltage will also increase the current. The circuit, as described, uses a 1mF capacitor used on the U.K. mains supply - that is, 240V with a frequency of 50Hz. This capacitor has the nearest standard value to that needed to produce the required reactance. Continental readers having a 220V 50Hz supply should find that the circuit works perfectly well. This, of course, apples to the supposedly harmonized 230V mains also. Those having a 120V 60Hz main such as in the United States are given an alternative capacitor value later.

Although capacitive reactance has a superficial resemblance to resistance, it produces no waste heat. Virtually no current flows through the capacitor - the flow of current is simply a consequence of repeated charging and discharging in alternate directions. On the positive half-cycles, charge will flow on to one plate and off the other one. On the negative half-cycles it will flow in the opposite sense. The pulsing of current backwards and forwards gives the impression that it is flowing through the insulating material (dielectric) between the plates even though it does not.

Due to inevitable small losses, there is a certain amount of heat produced in a capacitor but this is negligible and, in practice, it remains cool in operation. Using a capacitor in this way makes the design smaller, lighter and less expensive to construct than a transformer-based circuit.

In theory

The reactance (X) of a capacitor is measured in ohms (as is resistance) and is calculated using the formula:

$$X = {}^{1}/_{2}\, P_2\, \pi$$

In the above equation, f is the frequency of the supply and C the value of the capacitor in Farads. For a 1mF capacitor on a 240V supply this gives a reactance of 3183Ω.

If the effect of the resistance of the bulb filament is ignored (this assumption is valid and the reason will be explained presently) the current (I) can be calculated by placing capacitive reactance in the Ohm's Law formula instead of resistance - that is, I = V/X. Thus:

$$I = V/X = 240/3183 = 75mA$$

This is 20% too high for the bulb and will need to be reduced. The method used to do this is explained later.

My resistance is low

The following section is purely theoretical so may be ignored by those wishing simply to construct the circuit. However, readers having some previous knowledge of a.c. theory may wish to know why the effect of the bulb itself is negligible in the above calculation.

Refer to the basic circuit shown in Fig. 1. This shows the lamp, LP1, in series with capacitor, C1, connected to the mains. The filament of the specified bulb may be regarded as a pure resistance of value 100Ω (as calculated using Ohm's Law). This is a simplification since it will have some capacitive and inductive reactance of its own. Also, the resistance of the filament depends greatly on temperature - that is, due to the current flowing through it.

At any instant, the current flowing through all parts of the circuit is the same. However, the voltage across the capacitor

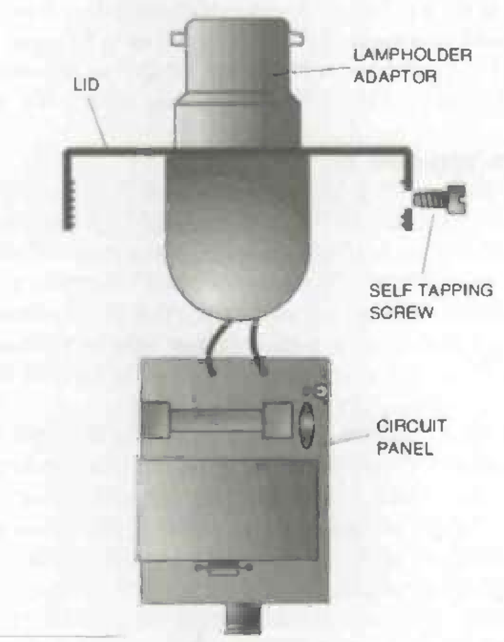


Fig.5. Wiring the PCB to the mains connector

will be 90 degrees out of phase with that appearing across the lamp. Any text book on a.c. theory will explain this in detail.

The impedance (Z) is the combined effect of reactance and resistance - they cannot be simply added together. Here, the solution involves using a right-angled triangle - see Fig. 2. The lengths of the two sides at right angles represent the resistance and capacitive reactance and the hypotenuse represents the impedance. Conventionally, the side representing capacitive reactance would be drawn projecting downwards but for this purpose it does not matter. If this diagram were drawn to scale, it would be obvious that the "resistance" side (100Ω) would be very small compared with the "reactance" one (3183Ω). The hypotenuse would therefore be only slightly longer than the capacitive reactance side. Pythagoras' Theorem may be used to calculate it thus:

$$Z^2 = X^2 + R^2 = (3183)^2 + (100)^2 = 10131489 + 10000 = 10141489$$

So: $Z = 10141489$ hence $Z = 3185\Omega$

This shows that the effect of the resistance of the bulb is negligible.

Circuit description

The complete circuit for the Children's Night Light project is illustrated in Fig. 3. This follows the theory outlined above - that is, capacitor C1 connected in series with bulb LP1. Fuse, FS1, is included which will blow in the event of a short-circuit. In practice, the mains Live and Neutral connections may be interchanged and will depend on the orientation of the device in the lampholder.

If the basic circuit shown in Fig. 1 were used, it would be found that the bulb would occasionally blow at the instant of switching on or off. Sometimes it would give a bright flash but manage to survive. This problem arises because, on making or breaking the supply, the switch contacts do not operate "cleanly". They tend to bounce and arc. If, on parting, the capacitor is left charged with one polarity and the contacts "make" and apply the supply in the opposite sense, a very large current can flow for an instant - sufficient to blow the bulb. Whether this happens or not is a matter of chance and depends on exactly where in the a.c. cycle the supply is made and broken.

Things unseen

To avoid the problem, a transient suppressor TS1 is connected in parallel with the bulb. Normally this has a very high resistance so has virtually no effect. When a voltage greater than 10V appears across it, its resistance immediately falls and it becomes a virtual short-circuit. This diverts current from the bulb and dissipates the energy harmlessly. A short burst of energy between 6V and 10V is "unseen" by the bulb because the thermal inertia of its filament is too great to allow a significant heating effect.

There are two further refinements to the basic circuit. The first is resistor, R1, connected in parallel with the capacitor. The value chosen - 1MΩ - provides a time constant of one second. Thus, a few seconds after switching off, the capacitor will be virtually discharged. Without this, it could possibly be left charged to a maximum of 339V (the peak voltage of 240V r.m.s. mains). This could be dangerous to anyone having unplugged the device then regarding it as safe to work on - e.g. to replace the bulb. This resistor will contribute to the current flowing through the lamp but the effect is so small, it may be ignored.

Blow it

The second refinement is to connect resistor, R2, in parallel with the bulb and transient suppressor. This is needed because the bulb is rated at 60mA yet approximately 75mA flows. This would make the bulb glow brightly but it would also have a much shorter life than if correctly operated. In tests, it was found that a 1KΩ resistor provided near-correct working conditions and this is the value specified. The resistor also lowers the voltage which will appear across the transient suppressor in the event of the bulb blowing and hence reduces its power dissipation.

When a bulb blows, which will happen every now and again, the current through the transient suppressor and resistor R2 will rise and these components will become quite hot. However, in one test on the prototype, the unit was operated for 48 hours with the bulb removed and it worked perfectly afterwards.

Important note:

It is absolutely essential to use the correct type of capacitor for C1. This must be rated for continuous connection to the 240V mains. Unless the specification states clearly that the capacitor is suitable for this purpose, it must not be used (see Buy Lines). Suitable capacitors are sold as suppression capacitors and described as suitable for Class X2 or Class Y applications.

PARTS LIST

Resistors

R1	1M
R2	1k

- Fixed resistors are 0.6W 1% metal film

Capacitor

C1	1mF Class X2 or Class Y mains suppression capacitor this capacitor must be rated for direct connection to the mains see text.

Miscellaneous

FS1	20mm PCB fuse holder and 2A ceramic mains type fuse to fit.
TS1	Transient suppressor Type 18Z1
LP1	6V 60mA LES lamp and solder tag type lamp holder

Mains lampholder adaptor, PCB, mains-type wire, self-tapping screw, solder, etc. Glass jar - see text.

Buy Lines

The suppression capacitor used in the prototype was obtained from Maplin order code JR37S. Suitable capacitors are also stocked by Electromail order code 116-183. The lamp must be a 6V 60mA type. LES lamps and lampholders are stocked by Maplin order codes BU12N and UJ72P respectively. The transient suppressor type 18Z1 is stocked by Maplin order code CP68Y. Mains lampholder adaptors are available from DIY stores and are also stocked by Greenweld. 20mm ceramic fuses are available from Electromail and Farnell. They could also be obtained from an electrical contractor - note that ordinary mains plug fuses are not the right size. Glass fuses must not be used.

Construction

Construction of the Children's Night Light is based on a single-sided printed circuit board (PCB). Fig. 4 shows the topside details (parts placement diagram). Solder the components into position - the order is unimportant and none are polarity-sensitive. Before mounting the LES lampholder, use a pair of fine-nose pliers to twist the tags through a right angle. Adjust them so that they will rest flat on the pads marked "LP1" on the copper track side of the board - note that one pad is higher than the other to match the form of the tags. Solder the lampholder in place and insert the fuse.

The jar to be used as an enclosure must have a screw top. Jars having press-fit lids are not satisfactory. The internal diameter of the top must be 50mm minimum to allow the circuit panel to be inserted. The jar used in the prototype had a ribbed lower part and this was found useful in diffusing the light slightly. Make a hole in the lid for the lampholder adaptor. The size should be such that the lid can be sandwiched between the top and lower sections as shown in Fig. 5. It may be necessary to provide additional re-inforcement to the lid if it is too thin. Readers using Edison screw lampholders will need to obtain the appropriate type of adaptor. Drill a small hole in the lid to allow expanded air to escape when it is heated by the lamp and by the transient suppressor and resistor R2 in the event of the bulb blowing.

Connect short pieces of light-duty mains-type wire to the lampholder adaptor and attach it to the lid. Solder the wires to the points labelled "a.c. mains in" on the PCB Check that when the lid is in position the PCB takes up a position with the bulb clear of the glass - it needs no further support. Drill a small hole in the side of the lid so that a self-tapping screw can be used to secure it. The lid should not be capable of being removed without the use of a screwdriver.

Testing

Mains voltage exists in all parts of the circuit. For safety reasons, it is essential to test and operate the circuit with it assembled inside the closed jar. It is also vital to remove it from the lampholder so that it is completely isolated from the mains before replacing a bulb.

Testing is simply a matter of checking for correct operation. The bulb should light at normal brightness. Switching on and off several times should show nothing abnormal such as bright flashes from the bulb.

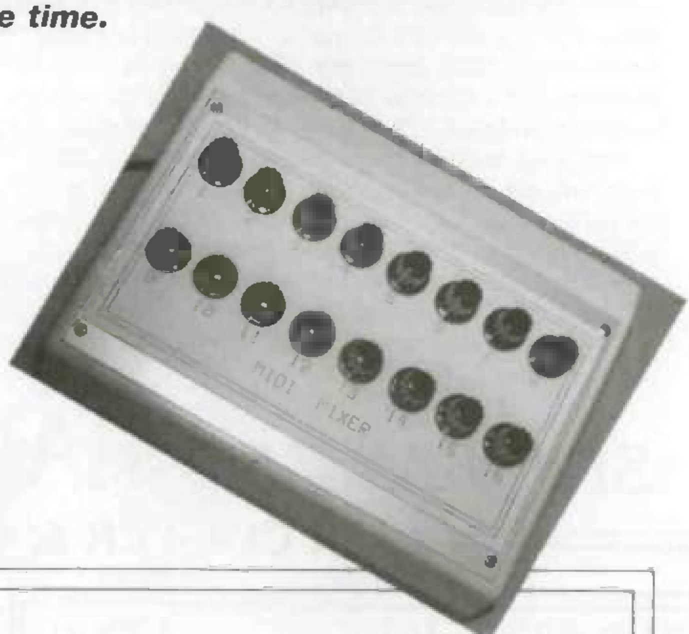
Going stateside

Readers wishing to use this project on a 120V 60Hz mains supply will need to increase the value of the C1 so that the specified bulb may be used. Calculation shows that 1.66mF should produce equivalent results. This is not a standard value but could be obtained very closely using three capacitors in parallel - 1mF, 0.47mF and 0.22mF. Some modification to the PCB would be needed to accommodate these. Good Night!

Warning: This project involves connecting a circuit to the mains electricity supply.
* Do not touch any part of the circuit when it is connected to the mains.
* Switch off and unplug from mains before doing anything to the circuit
* Make sure that it is fully insulated and the child can not dismantle it when in use.

MIDI MIXER

MIDI, as most people know by now, is the acronym for Musical Instrument Digital Interface and is at present the universal standard for connecting and controlling electronic musical instruments. MIDI synthesisers nowadays are often multi- timbral, allowing the playing of multiple instruments or voices at the same time.



While the level of these can be selected and controlled by a computer controlled sequencer, I wanted to be able to instantly fade up/down any MIDI channel or number of channels in real time. This enables instant control of MIDI file playback sequencers so that any instrument can be adjusted to suit a particular choice - for example, turn off all instruments except bass and drums. Also, it allows setting of the volume of different instruments to different levels when working in a live environment.

The circuit has dual operation and can be selected at switch-on to operate on incoming velocity bytes, allowing operation with synthesizers that may not respond to volume

Fig. 1. Front panel layout

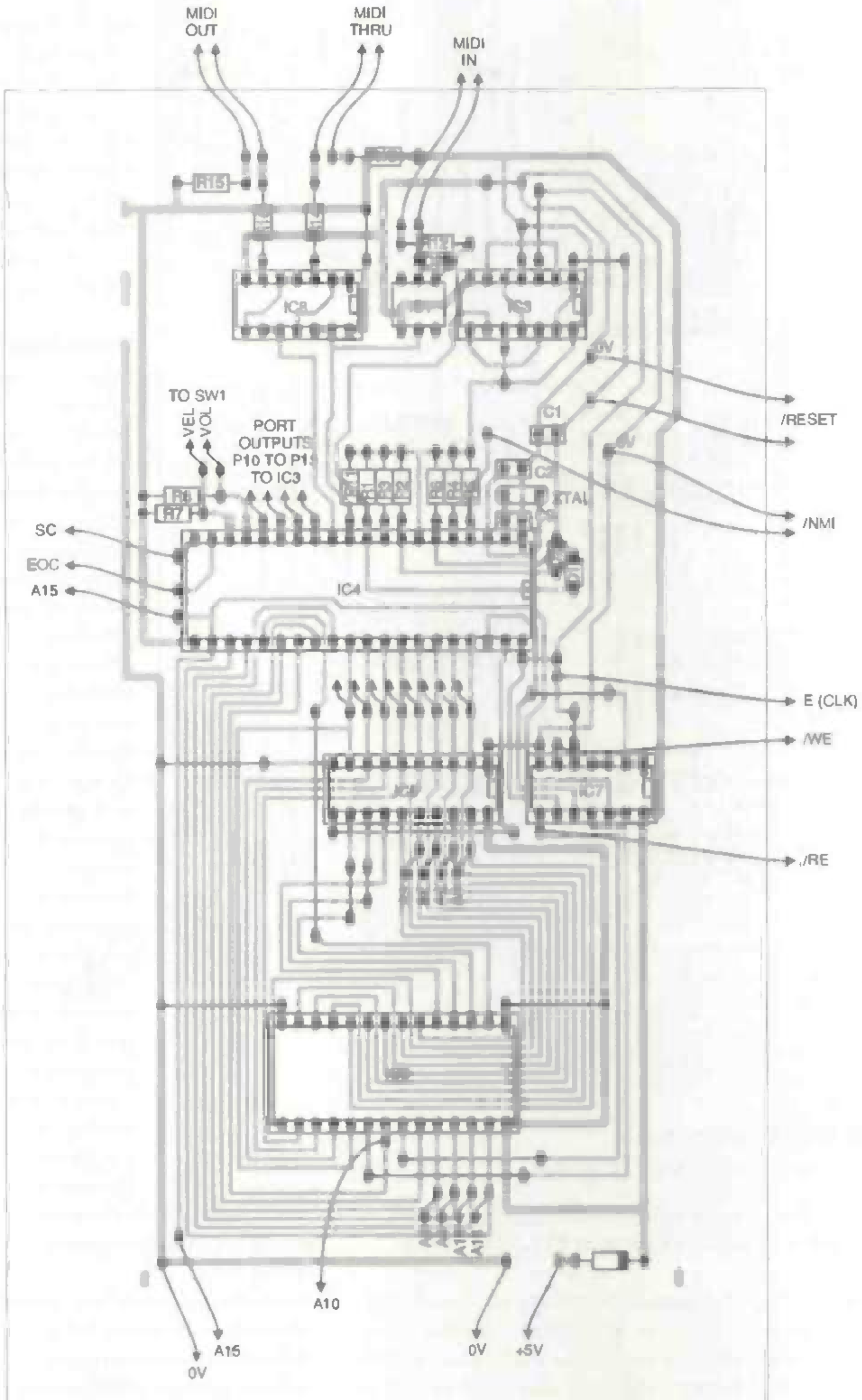


Fig. 2. PCB overlay for CPU board

byte control MIDI data, or to produce directly outgoing volume MIDI data bytes by operating the potentiometers. This allows operation with most types of multi-timbral synthesizers.

Hardware circuit

The circuit is designed around the 6803 microprocessor which contains 128 bytes of RAM, for the programme variables, a Serial Communications Interface, for interfacing to the MIDI in and out connectors, eight parallel input/output lines used to interface to the ADC, the Velocity/Volume switch and, to select an input on IC3, the 16 to 1 switch multiplexer.

An internal clock generator with a divide-by-four output is also present. The processor also allows the combination of two eight bit accumulators to provide operation of sixteen bit arithmetic. The NMOS 6803 CPU is also available cheaply and 6800 software has appeared in previous articles.

The operating mode of the 6803 is selected at power-on or reset by the voltage levels present on the Port 2 pins P20, P21 and P22. With the configuration shown, mode 2 is selected which makes use of the internal RAM and the multiplexed Data/Address bus.

The lower address byte has to be latched before feeding

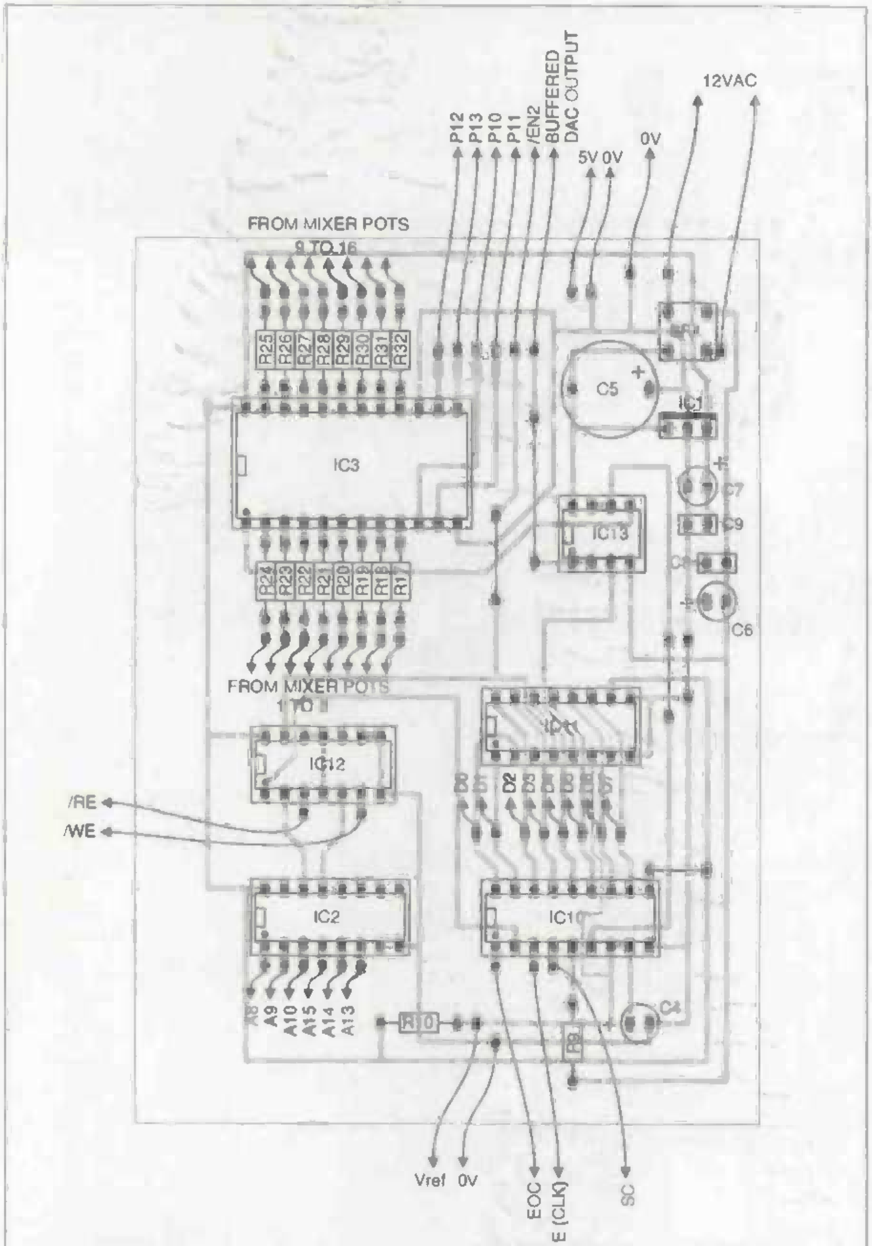


Fig. 3. PCB overlay for ADAC board

into the address bus. An output signal, the Address Strobe (AS), is provided to enable the latches in IC5 at the correct instant in time.

The EPROM is chip-enabled when address A15 goes high and fed to the active low input via nand gate IC7D wired as an inverter and is capable of being read when the E pulse and the read/write lines of the microprocessor are both high and fed to the active low read enable line of the EPROM via nand gate IC7C. The EPROM is address decoded to a hex base address of 8000h to FFFFh, allowing access to the Interrupt vectors. The internal RAM is address decoded to hex address range 0080h to 00FFh.

The 4MHz crystal is divided by 4 internally by the microprocessor to provide an E pulse of 1Mhz and a clock cycle time of 1 micro-second. The E timing signal is used as the clock signal for IC10 the ADC. Also the timing pulse E is further divided by four by the dual D-Type flip-flops IC9A,B and fed to the serial external clock input on port 2 pin 2 (P22), where it is further divided to provide the correct MIDI baud rate.

MIDI data is transmitted or received as asynchronous serial data at a rate of 31.25K baud with a format of 1 start bit, 8 data bits, and 1 stop bit. The MIDI Out connection operates using a 5mA current loop.

The MIDI IN connector is fed to 1C1 optocoupler type CNY17 whose output is fed to the serial input P23 of IC4 and via inverting nand gate IC8D and IC8A to the MIDI thru' outputs. The remaining NAND gates IC8B and IC8C are fed serial data from the transmit output port P24 to provide the MIDI out signal.

Software operation

When the circuit is switched on the software polls switch SW1 and decides to operate in Velocity or Volume mode. In velocity mode, the software waits for a MIDI input and tests to see if it is a Note-on or Note-off status byte and, if it is, then the software outputs this byte to the serial transmit port P24, then reads the next data byte and outputs it also.Then, it receives the velocity byte and branches to a subroutine to read the potentiometer associated with the incoming MIDI channel and outputs this new data byte.

Reading the potentiometer is accomplished by first setting up the correct input on the 16 to 1 selector 1C3 by converting the MIDI channel to an equivalent address on port outputs P10 to P13. The output of the selector is fed to the Analogue to Digital convertor (ADC) 1C10 via a unity gain buffer amplifier IC13A. The signal is converted to a digital byte by first starting the conversion by sending an active low pulse to the SC pin via port P16, then the end of conversion (EOC) pin is polled until it goes active high.

The output of the ADC is then enabled by reading addresses in the range 2100h to 210Fh and the digital byte is transmitted as the new velocity byte. The potentiometer voltage output is in the range 0 volts to Vref (2.55) which is converted to a corresponding velocity byte in the range from 00h to 7Fh.

The software checks for "running status" and when it occurs will continue to function correctly.

The second choice on switch-on is that SW1 is set to the Volume position. In this mode of operation the software first fills a table with the converted values of the 16 potentiometers and then continues to scan them. Whenever a value changes up/down by a value of 2 or greater then the corresponding volume MIDI data is transmitted to the MIDI out socket.

Power supply

The conventional power supply consists of a 12V - 0 - 12V transformer T1 with a VA rating capable of providing the required DC current of nearly 300mA. A capacitor, C5, provides smoothing of the positive output of the bridge rectifier BR1, providing the +12 volt output, before being fed to IC14, the 5 volt regulator type 7805 whose output is further decoupled by capacitors C7 and C9. The negative output of BR1 is decoupled by C6 and C8 providing the -12 volt output.

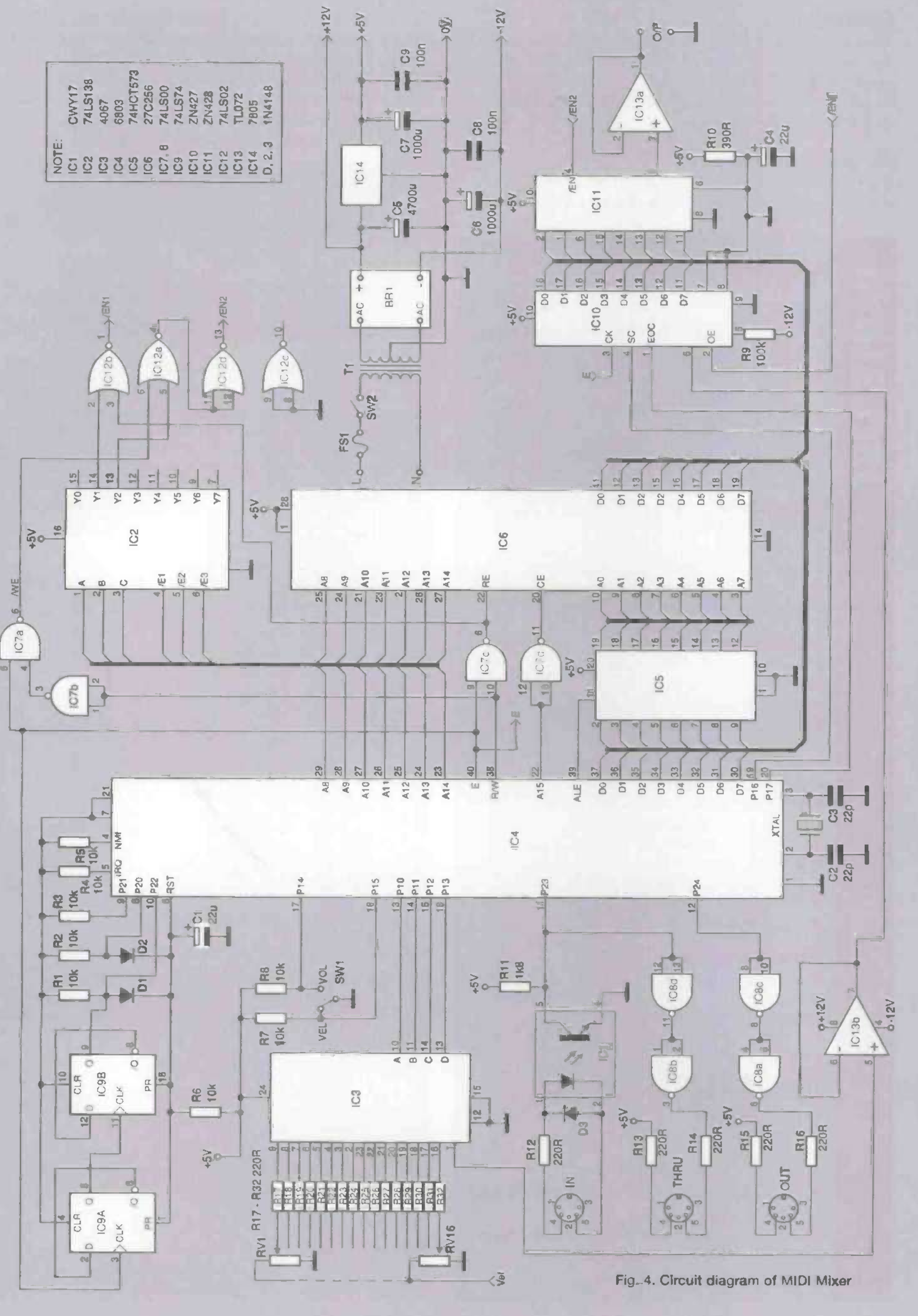


Fig. 4. Circuit diagram of MIDI Mixer

Construction

The internal layout of the PCBs and other components can be seen from the photographs with the ADAC PCB mounted above the CPU PCB on two pillars The front panel layout can be photocopied and used as a template for cutting the holes for the mixer potentiometers.

Future development

I have included a Digital to Analogue convertor (DAC) 1C11 which is not required for the Velocity/Volume MIDI mixer but can be used to drive external Voltage Controlled Amplifiers (VCA) so that audio sources can be controlled as well as MIDI sources. The software sends a DC voltage from the DAC to the output buffer 1C13A equivalent to the received input velocity or volume byte, so that a MIDI sequencer can be used to provide a completely automated audio mixing desk. Hopefully I can have this circuit available in the near future.

PARTS LIST

Resistors

- R1,R2,R3,R4
- R5,R6,R7 and R8 10k
- R9 180k
- RIO 390
- R11 1K8
- R12,R13,R14
- R15 and R16 220
- R17 to R32 270
- VRI to VR16 10k Lin. Pot.

Capacitors

- C1 and C4 22uF
- C2 and C3 22pF
- C5 4700uF
- C6 and C7 1000uF
- C8 and C9 100nF

Semiconductors

- IC1 CNY17
- IC2 74LS138
- IC3 4067
- IC4 6803
- IC5 74HCT573
- 1C6 27C256
- IC7,8 74LS00
- 1C9 74LS74
- 1C10 ZN427
- 1C11 ZN428
- IC12 74LS02
- 1C13 TL072
- IC14 7805
- D1,D2 and D3 IN4148

Miscellaneous

- Transformer 12V-0-12V
- Fuse
- BR1 Bridge rectifier type S04
- SPDT switch (48V DC)
- SPST switch (220V AC)
- 5-Pin DIN (180) (3 OFF)
- IC holders, 6-PIN (1 OFF), 8-PIN (1 OFF), 14-PIN (4-OFF), 16-PIN (2 OFF), 18-PIN (1 OFF), 20-PIN (1 OFF), 24-PIN (1 OFF), 28-PIN (1 OFF), 40-PIN (1 OFF)
  XTAL 4MHZ
- Box with external dimensions 220 x 155 x 100/53 or equivalent.
- The author can supply a pre-programmed 27C256 EPROM for £12.00 from Tom Scarff, 1 Martello Court, Portmarnock, Co. Dublin, Ireland.

```
       *       MIDI MIXER Velocity or Volume PROGRAM *

       0000            mxvelvol.src

       *       Initialise Reset Vector *

               0090    tableequ $0090

                               asct
       7FFE                    org $7FFE
       7FFE    8400            fdb $8400

                               asct
               0800            org $0080
       0800    0001    adcres  rmb  1
       0081    0001    midi    rmb  1
       0082    0001    result  rmb  1

       *       Initialise Stack Pointer *

                               asct
       0400                    org $0400

       0400    8E 00FF         lds £$00FF

       *       Set up Parallel and Serial Ports *

       0403    86      4F      ldaa £$4F set port 1 as o/p's
       0405    97      00      staa $0000 and i/p's
       0407    86      0C      ldaa £$0C set serial port
       0409    97      10      staa $0010
       040B    86      0A      ldaa £$0A enable RE and TE
       040D    97      11      staa $0011

       *       Read input switch *

       040F    96      02      swtest ldaa $0002
       0411    84      30      anda £$30 0011 0000
       0413    81      10      cmpa £$10
       0415    27      06      beq start1
       0417    81      20      cmpa £$20
       0419    27      7D      beq start2
```

```
0418   20    F2      bra swtest

             *       MIDI Mixer using Velocity Byte
             *

041D 8D 67   start1  bsr inch
041F 97 81   status  staa midi
0421 84 F0           anda £$F0
0423 81 90           cmpa £$90
note on ?
0425 27 0A           beq vel
0427 81 80           cmpa £$80
note off ?
0429 27 06           beq vel
042B 96 81           ldaa midi
042D 8D 60           bsr outch
042F 20 EC           bra start1

0431 96 81      vel  ldaa midi
0433 8D 5A           bsr outch
TX Status
0435 8D 4F           bsr inch
0437 8D 56           bsr outch
TX Data
0439 8D 4B           bsr inch
043B 8D 12           bsr readfader
043D 8D 50           bsr outch
TX new velocity
043F 8D 45   rxdata  bsr inch
running status Loop
0441 85 80                  bita £$80
0443 26 DA                  bne status
0445 8D 48                  bsr outch
TX data
0447 8D 3D                  bsr inch
0449 8D 04      readfader
044B  8D 42                 bsr outch
TX new velocity
044D 20 FO                  bra rxdata

             *       Read Fader value via ADC   *

044F D6 81      readfader  ldab midi
channel no.
0451 C4 0F                 nadb £$0F
= fader no.
0453 86 40          loop16 ldaa £$40
Start Conversion
0455 1B                    aba
0456 97 02                 staa $0002
0458 84 BF                 anda £$BF
045A 97 02                 staa $0002
045C 86 40                 ldaa £$40
045E 9B 02                 adda $0002
0460 97 02                 staa $0002
0462 96 02          eoc    ldaa $0002
test MSB
0464 4D                        tsta
branch if N bit clear
0465 2A FB                 bpl eoc

0467 CE 2100               ldx £$2100
                               read adc
046A 3A                    abx
046B A6 00                 ldaa 0,x
046D 44                    lsra
046E 84 7F                 anda £$7F
new vel/vol byte
0470 97 80                 staa adcres
0472 CE 2200               ldx £$2200
0475 3A                    abx
0476 4F                        clra
0477 A7 00                 staa 0,x
0479 A7 00                 staa 0,x
047B A7 00                 staa 0,x
047D A7 00                 staa 0,x
047F A7 00                 staa 0,x
0481 96 80                 ldaa adcres
0483 A7 00                 staa 0,x
0485 39                    rts

 *           Routine to r eceive a MIDI byte
*

0486 D6 11          inch   ldab $0011
0488 C5 80                 bitb £$80
048A 27 FA                 beq inch
048C 96 12                 ldaa $0012
048E 39                    rts

 *           Routne to transmit a MIDI byte
*

048F D6 11          outch  ldab $0011
0491 C5 20                 bitb £$20
0493 27 FA                 beq outch
0495 97 13                 staa $0013
0497 39                    rts

 *           Routine to Tx. Volume bytes MSB
and LSB      *
```

```
0498 5F          start2     clrb

0499 D7 81       filltab    stab midi

049B 8D B2                  bsr readfader

049D CE 0090                ldx ftable
04A0 3A                     abx
04A1 A7 00                  staa 0,x

04A3 5C                     incb
04A4 C1 10                  cmpb £$10
04A6 26 F1                  bne filltab


04A8 C6 FF       comptab    ldab £$ff

04AA 5C          nexttab    incb
04AB C1 10                  cmpb £$10
04Ad 27 F9                  beq comptab

04AF D7 81                  stab midi

04B1 8D 9C                  bsr readfader

04B3 97 82                  staa result

04B5 CE 0090                ldx ftable
04B8 3A                     abx
04B9 A100                   cmpa 0,x
04BB 2A 06                  bpl sub1

04BD A6 00                  ldaa 0,x
04BF 90 82                  suba result
04C1 20 02                  bra sub2

04C3 A0 00          sub1    suba 0,x
04C5 80 01          sub2    suba £$01
04C7 23 E1                  bls nexttab


04C9 96 82                  ldaa result
04CB A& 00                  staa 0,x

04CD D6 81                  ldab midi tx
                                 msb of cc
04CF 86 BO                  ldaa £$B0
04D1 1B                     aba
04D2 8D BB                  bsr outch

04D4 86 07                  ldaa £$07
04D6 8D B7                  bsr outch

04D8 A6 00                  ldaa 0,x
04DA 8D B3                  bsr outch

04DC D6 81                  ldab midi
                               tx lsb of cc
04DE 86 BO                  ldaa £$B0
04E0 1B                     aba
04E1 8D AC                  bsr outch

04E3 86 25                  ldaa £$25
04E5 8D A8                  bsr outch

04E7 86 00                  ldaa £$00
04E9 8D A4                  bsr outch

04EB D6 81                  ldab midi

04ED 20 BB                  bra nexttab




end
```

Designing a Pic Microcontroller based project

PART 4

In part 4 of this short tutorial series, Bart Trepak continues his construction of a PIC based alarm clock

Last month's article dealt with developing a flowchart and writing a programme to generate a time base for the clock as well as the use of an assembler programme. This month we will examine the problems associated with LED display driving and counting techniques and introduce some of the other instructions available to the programmer.

In the last article in this series we developed a programme to generate a 10mS timebase for the clock and followed the procedure for programming a micro-controller using the PICSTART programmer. This chip was then used in the circuit to check the operation of the programme by switching port A high and low at 50Hz. Once this programme is working, the chip can be erased using a UV EPROM eraser and the next piece of the programme developed. This month we will deal with display driving, seven segment decoding, delay routines and develop the flowcharts for counting hours and minutes for the clock.

LED display driving

Now that the timebase routine is working, the part of the flowchart marked PROGRAM in fig 6. can be expanded (see fig 12). This will be explained more fully later but it will obviously contain routines to count minutes and hours as well as having provision for setting the time. To be able to check these easily, however, the LED display routine must first be developed and in keeping with our logical method of working, we will jump straight into the middle of this flowchart and start by expanding the portion marked DISPLAY.

As mentioned earlier, the four digit display for the clock is multiplexed which means that each digit is switched on in turn for a short time and during this time, the seven segment drive

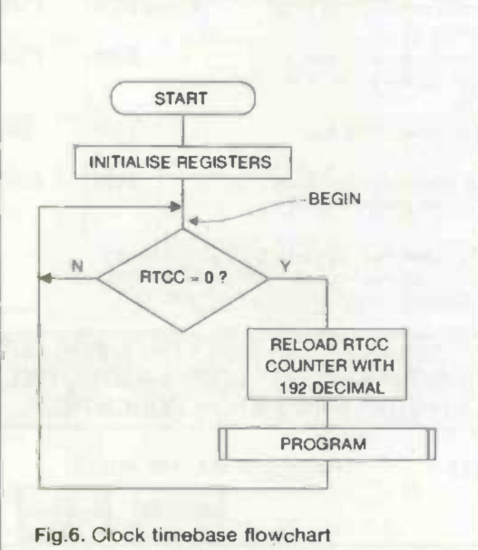


Fig.6. Clock timebase flowchart

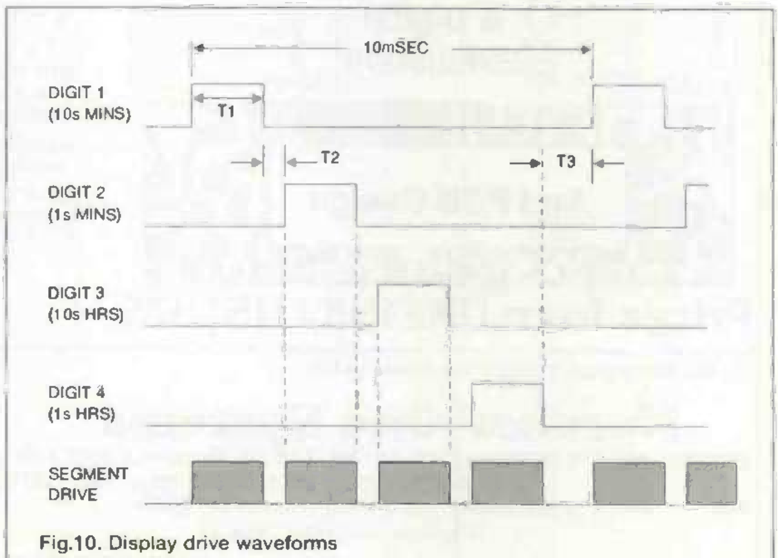


Fig.10. Display drive waveforms

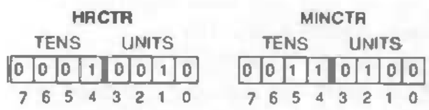


Fig.11. Hours and minutes counters

lines are also switched on to light the appropriate segments. The waveform required for this operation is shown in Fig. 10. Note that all four digits are switched on at some time during each 10mS period which means that each digit is switched on (or refreshed) every 10mS which is fast enough to make the display appear constant to an observer. The brightness of the display will depend on the current flowing through the display segments and the duration for which it flows (T1) which is controlled by a delay routine. Note also that each digit is turned off before the next one is turned on (period T2). This is done to eliminate ghosting which would otherwise occur with a faint image of the previous digit appearing on the digit currently being displayed. The segment drives are also turned on before the digit drive is turned on. After all the digits have been displayed, there is a period when all digits are off (T3) during which time the switches are read, counters updated and the rest of the programme executed before the processor settles down to reading the RTCC register in time for the next zero.

To generate an LED display, the system must have something to display and in this case it will obviously be the hours and minutes stored in the clock. Things are not quite so simple however because at times, such as when the alarm time is being set for example, the alarm time register will need to be displayed instead of the time reached by the hours and minutes counters. To make the programme simpler to understand (and therefore easier to write) we will design the clock to operate in three modes: - RUN which will display the current time together with colons, AM/PM and ALARM ON annunciators; SET TIME which will also display these but will not count; and SET ALARM which will only display the alarm hours and minutes registers and PM and ALARM ON annunciators. These modes will be selected by means of a switch which will advance the mode each time it is depressed so a MODE register will also be required so that the device can keep track of which mode it is in. To enable the user to differentiate between the modes easily, the colon will be made to flash in the RUN mode to indicate that the clock is working, stay on in the SET TIME mode and stay off in the SET ALARM mode thus eliminating the need to have a separate MODE indicator. In the SET TIME and SET ALARM modes, the digits will only change in response to the push buttons and will not count whereas in the RUN mode, the set hours and set minutes switches will be disabled.

Initially, the clock will be permanently in the RUN mode so that the basic display and counting routines can be developed and later, when this has been done, the other features can be added in subroutines called SETTIM and SETALRM. The flowchart incorporating this and the KEYBOARD routine which will be dealt with later is shown in FIG. 12. To begin with, the RUN, SETTIM, SETALRM and KEYBD routines can be made dummy ones which simply return as soon as they are called which will allow us to concentrate on developing the LED display routine.

Three registers will have to be defined at this stage, a MoDE register (which we will call MDEREG) and two others to store the hours and minute digits being displayed which we will call not unnaturally HouR CounTeR and MINute CounTeR (or HRCTR and MINCTR) and which, for the purposes of testing out the routine, will be loaded with 12h and 34h so that the numbers 1,2,3 and 4 will be displayed. The three registers

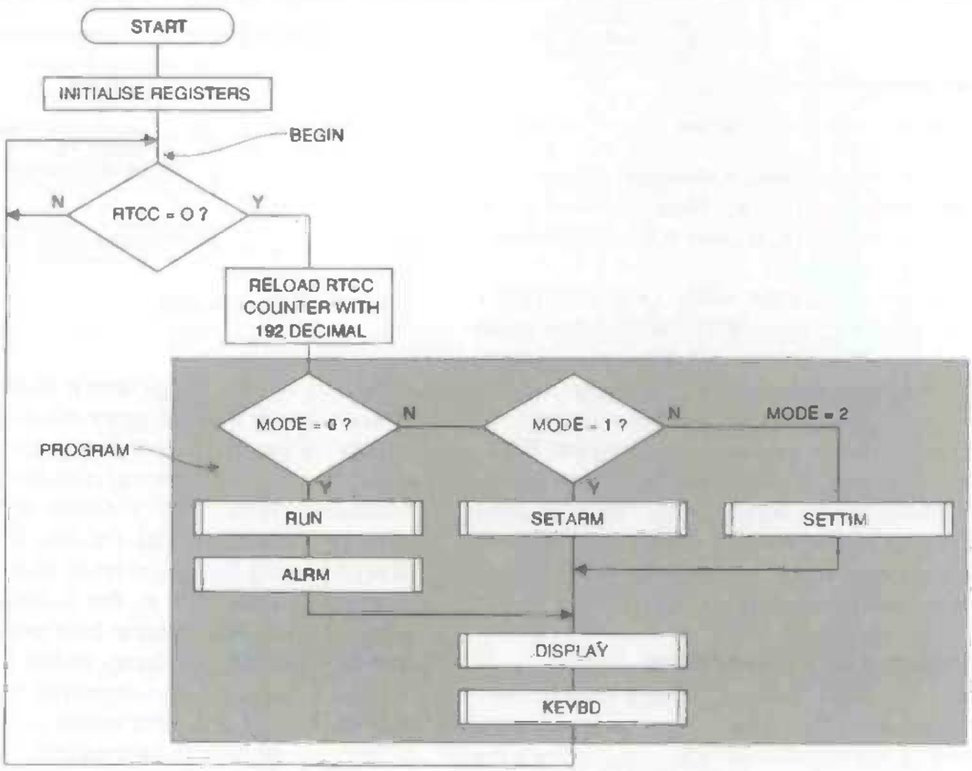


Fig12. Expanded clock flowchart

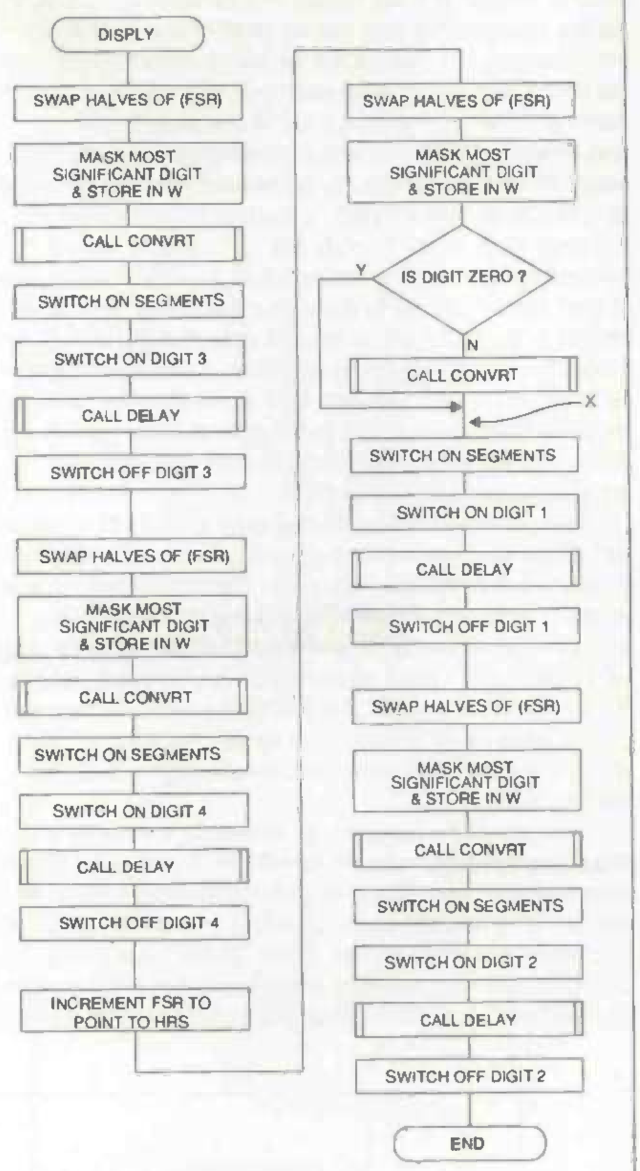


Fig12a. Clock display flowchart

can be given any of the addresses of the spare general purpose registers available in the PIC16C54 and the next free ones are 08, 09 and 0A and this is done in the programme listing using the "equ" statements.

These registers are represented in FIG. 11 and from this it can be seen that both HRCTR and MINCTR hold their values in BCD (binary coded decimal) form as two four bit numbers. Using a BCD format uses up a bit more memory as 6 possible states (A-F) are "wasted" but it saves the bother of counting and storing the time in binary and then converting into BCD before displaying each digit. It does mean that counting in these registers will need to be done in BCD. This is still easier than counting in binary and converting the count to BCD, especially where counting "time" is concerned as a "carry" occurs not only from 9 to 10 but also from 59 to 00.

BCD to 7-segment conversion

To display a digit, assuming common cathode displays, the contents of the register to be displayed must be converted to a seven segment format and the corresponding segment lines (port B) switched high after which the appropriate digit drive line must be taken low. After a suitable delay, the digit line must go high to switch off that digit before the segment drives are changed for the next digit to be displayed. A flowchart for this subroutine is shown in FIG. 12a.

Although at this stage only the hours and minute counters will be displayed, as mentioned before, the finished programme will also need to display the alarm time and the display routine for doing this would be essentially the same with only the names of the registers changing. The routine should therefore be designed so that the registers which are to be displayed will be defined in the programme depending on which mode the clock is in rather than being called by name. This is most easily done using indirect addressing by loading the address of MINCTR register into the FSR (file select register) before the subroutine is called and specifying file register 0 in the display routine as explained in part 1 of this series. The FSR may then be incremented to point to the HRCTR register (since it is the next register) when this is to be displayed. In the set alarm mode, the FSR will be loaded with the address of the alarm minutes register (not yet defined) so that this will be displayed instead, but the display subroutine will remain exactly the same.

Following the flowchart of FIG. 12a and beginning with the register pointed to by FSR (which is MINCTR and which at the moment contains 0011 0100 or 34h), the contents of this register are swapped to give 0100 0011 (or 43h) and then the most significant digit is masked by ANDing it with 0000 1111 (0Fh) to give 0000 0011 (03) which results in the first digit of MINCTR being stored in W while leaving the contents of the MINCTR register itself unchanged at 43h. To display this number on the LED display, it must first be converted to a 7-segment code for energising the LEDs. This is done in a separate subroutine called CONVRT, which is basically a "look-up" table which returns from the subroutine with the appropriate bits high to display a digit (in this case "3") in the W register which is then moved to port B switching on the segments. The digit drive is then switched low (output pins high if NPN driver transistors are used) and then the delay subroutine DLY is

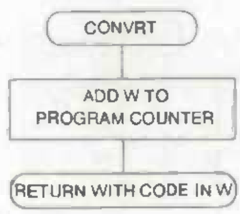


Fig12b. Delay flowchart

called after which the digit drive is switched off.

The contents of MINCTR (which still contain 43h) are now swapped again to give 34h and the process is repeated to display the "4" on the second digit after which the FSR is incremented to point to the HRCTR register which is processed in a similar way. The only difference here is that when displaying the tens of hours digit, the digit is first tested to see if it is zero and, if so, the conversion routine is skipped which prevents the segments from being switched on, effectively blanking the display so that a leading zero is not displayed. Since the other segments of this digit will drive the AM/PM, ALARM and colon indicators in the final version, this programme will have to be modified at point X later, to switch these indicators on as required.

A closer look at this flowchart shows that the routines for

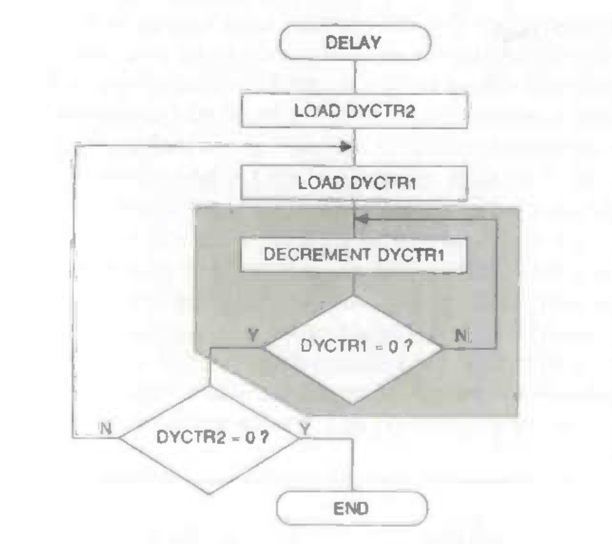


Fig12c.

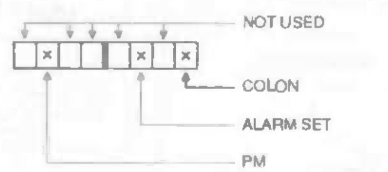


Fig14. Indicator flag register

displaying each digit are more or less the same except that, in one case, MINCTR is used and then the process is repeated using HRCTR instead. The display routine could therefore be written so that it is executed twice with a counter to keep track and to perform the zero blanking and indicator driver routine on the second time around but not the first. This would be a more elegant way of doing things and possibly result in a shorter programme especially if more digits were being driven. As mentioned previously however, the time taken to dream up such a scheme, even if it saved a few instructions and a bit of typing would hardly be worth the extra effort unless more digits were being driven or programme memory space was running short.

The digits could also be displayed in a different order and not the 3,4,1,2 sequence shown above. The only reason that this has been done is that it leaves the register contents in the correct order for future operations such as counting when the DISPLY subroutine is exited without the need to swap them around as would be the case if the display sequence were changed to 4,3,2,1.

Note that while the micro-controller is executing the DISPLY subroutine, two more subroutines are called, namely CONVRT and DLY. This is acceptable because the programme returns from the CONVRT subroutine before DLY is called so the stack does not overflow and the correct return address is stored (see INTERNAL ARCHITECTURE in the first article in this series).

A flowchart for the CONVRT subroutine, shown in Fig. 12b with the programme listing for this shown in Fig. 13, deserves a more detailed explanation because it is a very important technique with applications not only in display decoding but in keyboard routines, waveform generators or indeed anywhere where data stored in EPROM is to be introduced into the program. The number to be converted is placed in the W register and when the CONVRT routine is called, the start address of the subroutine is placed into the programme counter register PC by the CALL instruction. The first instruction in this subroutine is "ADDWF PC,same" which means add the contents of the W register to the PC register and store it in the PC register. If the value in W happened to be 3 as in the above example, the PC would now contain the address CONVRT+3 and the programme would go to this location where it would find the instruction "RETLW 57h". This would cause the programme to return from the subroutine with the binary equivalent of 57h which is 01010111 in the W register and which just happens to have the correct bits set to display the digit "3" on a seven segment display. All that then needs to be done is to output this to port B. The whole subroutine thus consists of a single ADD instruction and ten different return instructions and is extremely useful in decoding applications. Table 1 shows the segments corresponding to the output lines of port B in the printed circuit layout adopted for this project. If the tracks had been routed differently, it would be a simple matter to change the binary numbers in the

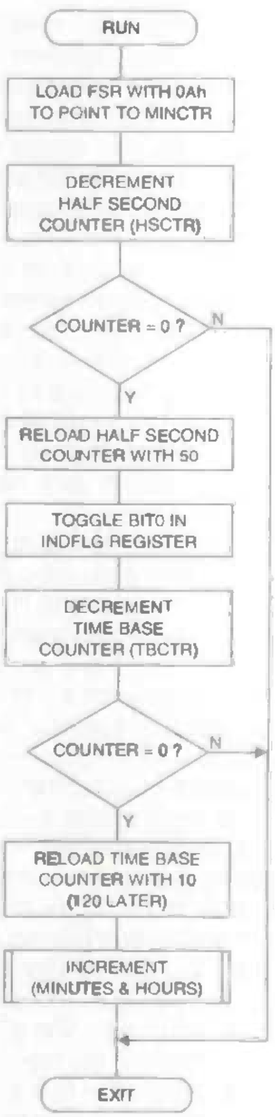
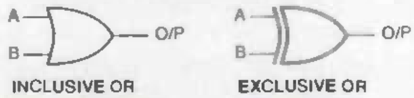


Fig15. Expanded run flowchart



A	B	O/P
0	0	0
0	1	1
1	0	1
1	1	1

A	B	O/P
0	0	0
0	1	1
1	0	1
1	1	0

Fig17. Inclusive and exclusive OR functions

"retlw" instructions to cope with the new layout and enable any recognisable character (and some unrecognisable ones) to be displayed.

Delay routines

The other subroutine which is used here is the DELAY routine (see flowchart in FIG.12c) and is also much used in microcomputer programmes. This routine relies on executing a large number of instructions by decrementing a counter until it reaches zero before returning to the original program, which takes time and therefore generates a delay in the programme execution.

Since with a 3.2768MHz crystal, each instruction takes 1.2uS to execute and a "goto" instruction takes 2.4uS, each loop (shown within the dotted lines and consisting of two instructions DECFSZ DYCTR1 and GOTO) will take 3.6uS to execute. By loading the DYCTR1 counter with 0FFh (255 decimal) the time taken to execute the routine will be 3.6x255=918uS. Shorter delays can be achieved by simply loading the counter with a smaller number. If a longer time than this is required, two counters or even more can be used with the second counter being decremented every 918uS giving a maximum possible delay of about 230mS. The delay required in this application is of the order of 2mS, giving a total display time of 8mS and leaving 2mS for the rest of the programme, so two counters are required. These are called DYCTR1 and DYCTR2 (DelaY CounTeR 1 and 2) and are assigned to registers 0C and 0D using the "equ" statements described.

Incidentally, this is not the only way to generate a delay. A NOP instruction which simply tells the computer to do nothing but increment the programme counter could also be used. This is however only of use for very short delays (2 or 3uS depending on the clock speed) because it also wastes programme memory. To generate a 120uS delay would require 100 NOP instructions which would also use up 100 programme memory locations (not to mention all that typing) compared with 3 using the counter method so this would not be a clever way to do this if a long delay were required.

Both of these methods waste time, however, and there is nothing to stop the programmer using this time to do something useful (such as reading the keyboard) if it needs to be done. It would be impossible to make a 230mS delay using the above methods if such a delay was required in this project because the processor would spend most of the time generating the delay and have no time to drive the displays or perform any other functions! In this case, a routine which always takes the same amount of time to execute could be used. If the programme has such a routine but the excecution time is variable, NOP instructions could be used to pad out shorter branches so that whichever route the programme takes, the execution time will be the same and give the required delay. This has not been done here so as not to unnecessarily complicate matters but it can be a useful technique to bear in mind. It can be especially useful if the delay does not need to be very precise such as say the delay required to de-bounce a keyboard as we shall see later.

Delay routines can also be useful in tone generating circuits. Repeatedly complementing an output port and then generating a 0.5mS delay for example, will cause the port to switch on and off (toggle) at a frequency of 1kHz with an accuracy dependent on the clock oscillator. Counting the number of times the loop is executed enables a precise number of cycles to be generated and therefore the length of the tone defined, while varying the delay (perhaps from data called up from a look-up table in memory as in the convert routine) would

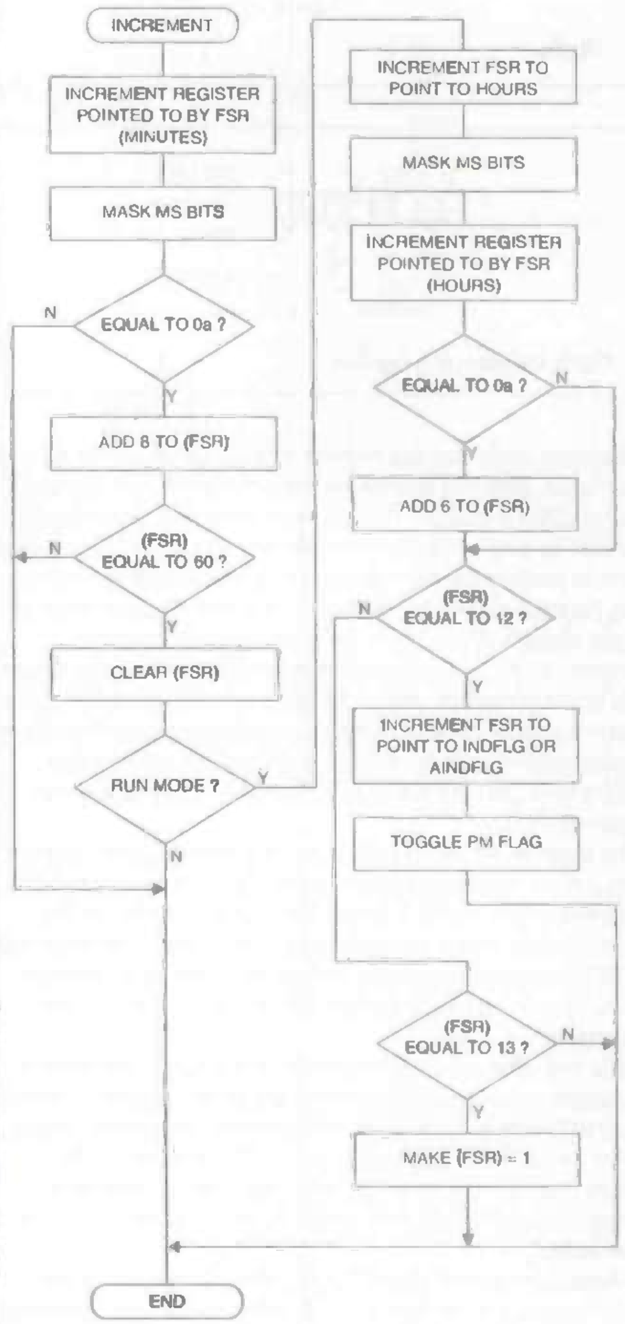


Fig18.Increment (hours and minutes) subroutine flowchart

determine the pitch. Add a push to make switch and a piezo sounder and you have your own personalised door chime playing your favourite tune! But we digress...

To go back to the DISPLY routine and test this new piece of the programme, the original PROGME line in Fig.9 must be replaced by code representing the expanded flowchart of Fig.12 and the initialise routine must be modified slightly to include statements to load HRCTR and MINCTR with 12h and 34h so that the digits 1, 2, 3 & 4 are displayed. (These instructions will be removed later, once the programme has been proved to work.) These modifications should now be added to the timebase routine listing (CLOCK.ASM) and now called CLOCK1.ASM as shown in Fig.13. The original PROG label has been retained to show where this new code has been inserted. After running the assembler programme a new chip can be programmed as before to test the display routine. This should of course display 1234 on the digits. The statements setting HRCTR and MINCTR could be changed to place 04h and 56h in these registers and after running the assembler a new (or erased) chip programmed to check the leading zero blanking and decoding for the numbers 4,5 and 6 and the process repeated for 0,7,8 and 9. This is not necessary at present and may be checked more easily later, once the counter routines have been designed, without the need to re-programme the chip each time. Any faults which become apparent then can be easily traced to the look-up table if the above programme works now.

Note that it is a good idea to save the new version of the programme under a different name such as CLOCK1 so that if the new routine which has been added does not work, or worse still prevents the previous part of the programme from working properly, it will be an easy matter to go back to the original programme which should still be stored on your computer under the original name and think again without trying to remember which lines were changed or where new lines were inserted.

Suck it and see

From this it can be seen that while it is possible to use only one micro-controller chip for development, two windowed parts may be better because one could be programmed with the newly developed code while the other was being erased. In practice, this is not likely to save a lot of time because the micro-controllers only seem to take about two minutes to erase (on my EPROM eraser at any rate which is a cheap and cheerful one) and it usually takes longer to modify the .ASM listing and run the assembler programme to obtain a new object file (.OBJ) for blowing a new chip.

This kind of "blow it and see" (or should that be "suck it and see") approach to programming micro-controllers does take time but enables complex programmes to be easily developed on relatively low cost equipment. Only a programmer and Eprom eraser are required assuming that you already have a PC. After a while, a library of solutions can be built up to perform standard functions so future programmes need not take so long to develop. A much faster method would be to use an emulator module but these are very expensive and more appropriate to industrial users where time is money. Cheaper emulators are also appearing on the market with fewer features compared to the "professional" ones but these all have limitations such as lower input impedance inputs or speed and, as with most things, you pays your money and takes your choice. There is, after all, no closer way to emulate a device than with the device itself.

Note that the new code for displaying the digits together with the 7-segment conversion and delay has been written as subroutines and it will also be noticed that these routines have been placed at the beginning of the listing. The reason for this is the internal working of the PIC chip when handling subroutines. Unlike the other registers in the PIC, the programme counter or PC register is 9-bits wide (in the PIC16C54) but during a CALL instruction, the 9th bit is always cleared to zero. This means that the start addresses of all subroutines must be located in the lower half of the programme memory below address 0FF if the correct address is to be called. It therefore makes sense to put all the subroutines first before the main programme. Since the STACK registers which store the return address from the subroutine are the same width as the PC register, the return address can be anywhere in the memory. Note that this limitation does not apply to the GOTO instruction which allows direct loading of the PC register with all 9 bits. The purpose of the first instruction (goto START) in Figs. 9 and 13 should now be clear.

Taking it further

The rest of the programme can be developed in a similar way so only the flowcharts and coding of the more important parts will be described. Which parts of the programme are developed first and how big each part becomes before it is blown into a chip for testing, will depend on how confident the programmer is in his skills. Remember, however, that the larger the programme, the greater will be the problem in finding a fault if it does not work so try not to get too carried away but keep each new step short if possible.

Once the LED display routine is working, the routines to count seconds, minutes and hours can be developed which will be placed in the RUN subroutine. The hours and minutes will be counted in the two counters HRCTR (HouR CounTeR) and MINCTR (MINute CounTeR) and the contents of these displayed when the display routine is called. First, however, we need to obtain a 0.5Hz signal to drive the colon so our first counter will need to count 50x10mS and this is done in the HSCTR (Half Second CounTeR which is defined as (0E). This is therefore loaded with 50 and counts down to zero.

Each time HSCTR reaches zero, bit 0 in the INDFLG (INDicator FLaG) register (0B) will need to be toggled to cause the "colon" to switch on and off. This register will also contain the "alarm set" and "pm" information in bits 2 and 6 respectively and will be "ORed" with the W register before the most significant digit of the display is switched on in the DSPLY routine so that these functions will be displayed. (B0, B2 and B6 control the colon, alarm set and pm indicators directly. See Fig. 14). The programme then reloads HSCTR with 50 and decrements the next counter TBCTR (Time Base CounTeR) for which the register 0F has been assigned.

By loading this counter with 120 at the beginning of the programme, it will reach zero after 120 half seconds which can be used to decrement the minutes counter. For testing, it is temporarily loaded with 10 so that the minutes will change much faster enabling the operation of the counters to be checked without having to wait all day.

These steps can now be coded and added to the programme. The new flowchart for the RUN routine is shown in Fig 15 which now includes the HSCTR and TBCTR routines, together with the colon driver using the INDFLG register. All of the new registers (HSCTR, INDFLG and TBCTR) will of course need to be assigned to the next available general purpose registers using the "equ" statements as before and set to their initial conditions if necessary in the INTSLE routine.

To enable the display to count, a new subroutine has been introduced called INCREMENT (INCR). At the moment it only contains the instruction "incf 0,same" which will operate on the MINCTR register since that is the one which the FSR will be pointing to. Later this will be expanded to increment the hours counter as well. The DISPLY routine will also need to be modified at the point marked X so that the colon LEDs flash at 1Hz (i.e. on for 0.5 sec and off for 0.5 secs). A listing is shown in Fig. 16 and this can be assembled and checked by blowing a new PIC and plugging it into the circuit as before. Note that the Hours and Minutes counters have been loaded with 02 and 34 and the TBCTR register with 10 to demonstrate the leading zero blanking and make the minutes counter run faster.

The Exclusive OR function

Most of the programme shown in Fig. 15 is simply concerned with loading and decrementing registers and testing for zero which has already been covered and the only "new" technique used in this section is the step marked "toggle bit 0 in INDFLG". The simplest way to do this is to use the XORWF instruction and to see how this works the Exclusive OR function must be examined. The truth table for a two input XOR gate is shown in Fig. 17 and from this it can be seen that the output is true (ie. a logic 1) only when both inputs are different. Contrast this to the normal or inclusive OR function when the output is also high when both inputs are high which is also shown in Fig. 17. This may not sound like a big deal but it makes the XOR function extremely useful.

If we consider input A as a "control" input, then it can be seen that the output will be the same as input B when A is 0 but will be inverted when A is 1 thus forming a sort of programmable logic inverter. In a micro-computer, this function operates on a bit by bit basis on the 8-bit word in a register, so that if we want to invert bit 0 of the INFLG register, all we need to do is to load a word with bit 0 set to 1 (ie. 0000 0001) into the W register (ie. MOVLW 01h) and follow this with "XORWF INDFLG,same" which will invert bit 0 of the INDFLG register and store the result back in that register. Since all the other bits in the original word loaded into the W register were zero, all the other bits in INDFLG will remain unchanged and only bit 0 will be inverted and will therefore toggle each time this sequence is executed. This will have the effect of switching the colon LEDs on and off when the INDFLG register is displayed.

In this way, not only bit 0 could be complemented but any other bits as well simply by loading 1's where required, into the original word loaded into the W register. If all the bits in a register are to be complemented, then of course the "COMF f,d" instruction could be used.

While on the subject of the XOR function, the other property of this instruction can be highlighted which will be useful in future routines and this is that the output or result is a 1 if the inputs are different but zero only when they are the same ie. a digital comparator. In the instruction set shown in Fig 3 there are two instructions, INCFSZ and DECFSZ which allow the programmer to branch if the contents of a register after it has been incremented or decremented are zero and he can also use the MOVF instruction and then test the zero bit (bit 2) of the STATUS register (using the BTFSS or BTFSC instructions) if he does not want to alter the contents of the register he is testing. But what if he needs to branch when a register is equal to 23h or some other value as we will need to do when we compare, say, the actual time with that set in the alarm register so that we can sound the alarm?

Here again, the XOR instruction can be used. The value 23h or the contents of the alarm register can be moved into W using either the MOVLW or MOVF instruction and followed by the XORWF instruction. If the two registers match, the result of the operation will be zero and the zero bit in the STATUS register will be set. This can then be tested in the normal way and the appropriate action taken by the programme. Note that In the case of testing a register for a specific value such as 23h above, the XORLW 23h instruction could also be used provided that the contents of the register were first moved to the W register.

BCD counting

If the programme of Fig. 16 is run, the display will start with 2:34 (note the leading zero is blanked) and the colon will flash once per second. After every 5 flashes, the minutes display will change and the clock will display 2:35 and so on. This is because the TBCTR register was loaded with 10 instead of 120 causing the clock to run 12 times faster. After 6 "minutes", however, instead of the display changing to read 2:40, the last digit will go out and the reading remain at 2:3 and later on the whole display goes haywire.

The reason for this is simple. The "incf 0(MINCTR),same" instruction increments the minutes counter but since this is basically a binary counter, the next state after 0011 1001 (39h) is 0011 1010 or 3Ah and not 40h. The "A" cannot be decoded by the CONVRT routine and simply causes a jump to the DLY routine - which is where it would have gone anyway except that it would normally have switched on the digit and segment drives first so this digit remains blank. The next state of the counter is 3Bh so that this time the CONVRT routine causes a jump into the middle of the DLY routine and the programme crashes. Clearly, the MINCTR counter must be persuaded to count in BCD and not binary by not allowing a count higher than 9.

One way that this can be done is by detecting when the last digit goes to "A" hex. The first step is to mask the four most significant bits (MSB) of the MINCTR register by ANDing it with 0Fh (0000 1111 in binary) to produce 0000 XXXX where X is the state of the lower order bits in MINCTR. The XOR instruction can then be used to compare this to 0Ah which will result in the zero bit in the STATUS register being set if MINCTR has XAh in it. If this test is successful, 6 is added to the register using the ADDWF instruction. Thus, if, as in the above case, MINCTR contained 3Ah, adding a 6 to it would result in MINCTR containing 40h which would give the correct display.

This routine can be extended to change the display to 3:00 when 2:60 is reached etc and also to 10:00 from 9:60 and 1:00 from 12:60. Also, when 12.00 is reached, the PM flag (bit 6 of INDFLG) needs to be toggled. The change in the hours counter when the minutes counter reaches 60 and is reset to zero, is only required in the RUN mode and not when the alarm or the time is being set. To make this subroutine useful in all modes, the mode register is checked before HRCTR is incremented. If MDREG is zero (ie. RUN mode) the subroutine execution is allowed to continue but if it is not, the program exits at this point and the HRCTR is not incremented.

A flowchart for this subroutine is shown in Fig. 18 and a listing for the INCR subroutine can be found in the complete listing for the clock in Fig. 24. Note that since this routine will be used to increment both the hours and minutes and the alarm time registers, it too has been written to make use of indirect addressing using the FSR register to point to the relevant registers as explained in the DISPLY routine. Before this subroutine is called therefore, the FSR must be loaded with the address of the MINCTR or its equivalent in the alarm setting mode.

This new code may be added to the listing shown in Fig. 16 and provided the value loaded into TBCTR is changed to 120, the clock part of the project is complete. It is now only necessary to write a routine to enable the clock to be set and to include the alarm function. The exclusive or (XOR) instruction will again prove useful when it comes to comparing the time with that set in the alarm registers.

FIG. 13
CLOCK1.ASM TIMEBASE, MODE, LED DISPLAY AND DELAY (Flowchart Fig 12)

```
MDREG equ 08h ; MoDe REGister - RUN=0, SET
ALARM=1, SET TIME=2
MINCTR equ 09h ; MINute DiSPlay
HRCTR equ OAh ; HouR DiSPlay
DYCTR1 equ 0Ch ; DelaY CounTeR 1
DYCTR2 equ 0Dh ; DelaY CounTeR 2


   LIST P=16C54;f=inhx16
   INCLUDE "PIC.H"

   goto START

DISPLY  clrf PORTA  ;switch off all display drives

                    ;LED DISPLAY SUBROUTINE

   swapf 0,w        ;load tens of mins into w
   andlw 0Fh        ;mask MSDs by ANDing with
                       0000 1111
   call CONVRT      ;no - decode segments
   movwf PORTB      ;switch on segment drive
   bsf PORTA,0      ;switch on digit drive
   call DLY         ;delay for
   bcf PORTA,0      ;switch off digit drive
                    ;
   movf 0,w         ;load units of mins into w
   andlw 0Fh        ;select units of mins for
                       display
   call CONVRT      ;decode segments
   movwf PORTB      ;switch on segment drive
   bsf PORTA,1      ;switch on digit drive
   call DLY         ;delay for
   bcf PORTA,1      ;switch off digit drive
   ;
   incf FSR,same    ;increment FSR to point
                       to Hours
   ;
   swapf 0,w        ;Swap counter pointed to by
                       FSR (10's HRS)
   andlw 0Fh        ;mask MSDs by ANDing with
                       0000 1111
   btfss STATUS,2   ;is digit zero? ie STATUS,2
                       is set
   call CONVRT      ;no - decode segments
                       (skipped if digit=0)
   nop              ;add other segments (to be
                       done later)
   movwf PORTB      ;switch on segment drive
   bsf PORTA,3      ;switch on digit drive
   call DLY         ;delay for
   bcf PORTA,3      ;switch off digit drive
   ;
   movf 0,w         ;load counter pointed to
                       by FSR
   andlw 0Fh        ;select units of hours for
                       display
   call CONVRT      ;decode segments
   movwf PORTB      ;switch on segment drive
   bsf PORTA,2      ;switch on digit drive
   call DLY         ;delay for
   bcf PORTA,2      ;switch off digit drive

   retlw 00         ;RETURN FROM SUBROUTINE
   ;

CONVRT  addwf PC,same   ;BCD-7SEG CONVERSION
SUBROUTINE
   retlw 1Fh        ;segment drives for 0
   retlw 12h        ;segment drives for 1
   retlw 4Fh        ;segment drives for 2
   retlw 57h        ;segment drives for 3
   retlw 72h        ;segment drives for 4
   retlw 75h        ;segment drives for 5
   retlw 7Dh        ;segment drives for 6
   retlw 13h        ;segment drives for 7
   retlw 7Fh        ;segment drives for 8
   retlw 77h        ;segment drives for 9


DLY  movlw .4       ;DELAY ROUTINE
   movwf DYCTR1     ;load DYCTR1 with 4 decimal
D1 movlw .100       ;
   movwf DYCTR2     ;load DYCTR2 with 100 decimal
D2 decfsz DYCTR2,same   ;decrement and skip
                       if zero
   goto D2          ;if not zero
   decfsz DYCTR1    ;decrement DYCTR1 if DYCTR2
                       is zero
   goto D1          ;reload DYCTR2 if DYCTR1
                       is not zero
   retlw 0          ;RETURN FROM SUBROUTINE if
                       DYCTR1 is zero
                    ;
                    ;
START               nop
                    ;
     ;INITIALISE ROUTINE
                    ;
INTLSE  movlw 00h   ;ie 0000 0000
   tris PORTA       ;make PORTA o/p
   movwf PORTA      ;make PORTA 0000
   tris PORTB       ;make PORTB i/p except B4
                    ;
   movlw 07h        ;ie 0000 0111
   OPTION           ;int signal, L to H,
                       prsclr 256 to RTCC
   movlw .224       ;move 244 decimal into
   movwf RTCC;RTCC - gives 10mS with 3.2768Mhz
                       xtal
                    ;
   movlw 12h
   movwf HRCTR      ;load HRCTR with 12
   movlw 34h
   movwf MINCTR     ;load MINCTR with 34
   clrf MDREG       ;set MDREG to 0 ie. run mode
                    ;
                    ;
BEGIN               movf RTCC,w
   btfss STATUS,2   ;test if w (RTCC) = 0
   goto BEGIN       ;w (RTCC) not aero
   ;
   movlw .224       ;if RTCC=0 move
   movwf RTCC       ;224 dec. into RTCC
                    ;
                    ;
PROGME  movf MDREG,w    ;places MDRE into w
   btfsc STATUS,2   ;test if MDREG=0
   goto RUN         ;yes
   ;
   xorlw 01h        ;no - XOR MDREG (w) with 01h
   btfsc STATUS,2   ;test if MDREG=1 - Z bit
                       will be set if it is
   goto SETARM      ;yes
```

```
                        ;
                        ;
SETTIM                  nop           ;no - set time
                           routine
  goto PROG
                        ;
SETARM   nop            ;set alarm routine
  goto PROG

RUN  nop                ;run routine
  movlw 09h             ;
  movwf FSR             ;load address of HECTR into
FSR

PROG call DISPLY
  goto BEGIN


  ORG 1Ffh

  END
```

Fig.16
Clock 2 Timebase, Mode, Run, Disply, & Dly (Flowchart 15)

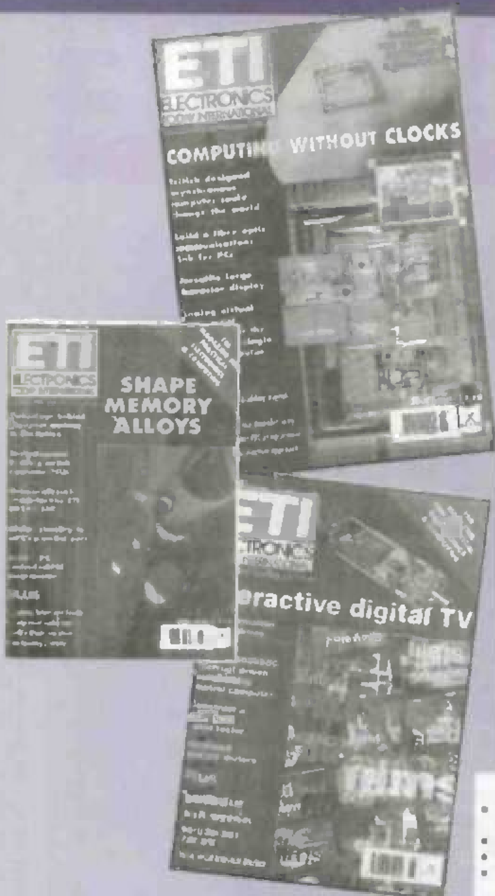
```
MDREG equ 08h           ; MoDe REGister - RUN=0, SET
ALARM=1, SET TIME=2
HRCTR equ 09h           ; HouR DISPlay
MINCTR equ 0Ah          ; MINute DISPlay
INDFLG equ 0Bh          ; INDicator FLaG holds status
of AM/PM, COLON & ALARMDUCTR1 equ 0Ch         ;
DelaY CounTeR 1
DYCTR2 equ 0Dh          ; DelaY CounTeR 2
HSCTR equ 0Eh           ; Half Second CounTer
TBCTR equ 1Fh           ; Time Base CounTeR - counts
120 half seconds


  LIST P=16C54;f=inhx16
  INCLUDE "PIC.H"


  goto START


DISPLY  clrf PORTA      ;switch off all display drives
                        ;LED DISPLAY SUBROUTINE
  swapf 0,w             ;load tens of mins into w
  andlw 0Fh             ;mask MSDs by ANDing with
                           0000 1111
  call CONVRT           ;no - decode segments
  movwf PORTB           ;switch on segment drive
  bsf PORTA,0           ;switch on digit drive
  call DLY              ;delay for
  bcf PORTA,0           ;switch off digit drive

  movf 0,w              ;load units of mins into w
  andlw 0Fh             ;select units of mins for
display

  call CONVRT           ;decode segments
  movwf PORTB           ;switch on segment drive
  bsf PORTA,1           ;switch on digit drive
  call DLY              ;delay for
  bcf PORTA,1           ;switch off digit drive

  incf FSR,same         ;increment FSR to point
                           to MINUTES

  swapf 0,w             ;Swap counter pointed to
                           by FSR (10's HRS)
  andlw 0Fh             ;mask MSDs by ANDing with
                           0000 1111
  btfss STATUS,2        ;is digit zero? ie STATUS,2
                           is set
  call CONVRT           ;no - decode segments
                           (skipped if digit=0)

  iorwf INDFLG,w        ;add colon (to be modified
later)

  movwf PORTB           ;switch on segment drive
  bsf PORTA,3           ;switch on digit drive
  call DLY              ;delay for
  bcf PORTA,3           ;switch off digit drive

  movf 0,w              ;load counter pointed to
                           by FSR
  andlw 0Fh             ;select units of hours
                           for display
  call CONVRT           ;decode segments


  movwf PORTB           ;switch on segment drive
  bsf PORTA,2           ;switch on digit drive
  call DLY              ;delay for
  bcf PORTA,2           ;switch off digit drive


  retlw 00              ;RETURN FROM SUBROUTINE



CONVRT  addwf PC,same   ;BCD-7SEG CONVERSION
                           SUBROUTINE
  retlwe 1Fh            ;segment drives for 0
  retlw 12h             ;segment drives for 1
  retlw 4Fh             ;segment drives for 2
  retlw 57h             ;segment drives for 3
  retlw 72h             ;segment drives for 4
  retlw 75h             ;segment drives for 5
  retlw 7Dh             ;segment drives for 6
  retlw 13h             ;segment drives for 7
  retlw 7Fh             ;segment drives for 8
  retlw 77h             ;segment drives for 9

                        ;


DLY  movlw .4           ;DELAY ROUTINE
  movwf DYCTR1          ;load DYCTR1 with 4 decimal
D1 movlw .100
  movwf DYCTR2          ;load DYCTR2 with 100 decimal
D2 decfsz DYCTR2,same   ;decrement and skip if
                           zero
  goto 2                ;if not zero
  decfsz DUCTR1         ;decrement DYCTR1 if DYCTR2
                           is zero
  goto D1               ;reload DYCTR2 if DYCTR1
                           is not zero
  retlw 00              ;RETURN FROM SUBROUTINE if
                           DYCTR1 is zero


INCR nop                ;INCREMENT COUNTERS SUBROUTINE
  incf 0,same           ;INCREMENT REGISTER POINTED
                           TO BY FSR
  retlw 00


START   nop
                        ;INITIALISE ROUTINE
INTLSE   movlw 00h      ;ie 0000 0000
  tris PORTA            ;make PORTA o/p
  movwf PORTA           ;make PORTA 0000
  tris PORTB            ;make PORTB i/p except B4


  movlw 07h             ;ie 0000 0111
  OPTION                ;int signal, L to H,
                           prescle 256 to RTCC
```

```
    movlw .224          ;move 244 decimal into
    movwf RTCC          ;RTCC - gives 10mS with 3.2768Mhz xtal

    movlw 02h           ;
    movwf HRCTR         ;load HRCTR with 02
    movlw 34h
    movwf MINCTR        ;load MINCTR with 34
    clrf MDREG          ;set MDREG to 0 ie. run mode

    movlw .50           ;load HSCTR with 50 dec to count halfsecs
    movwf HSCTR         ;load TBCTR with 10
                            (temporary) so that
    movwf TBCTR         ;clock runs faster (change
                            to 120 later)
    clrf INDFLG

BEGIN  movf RTCC,w
    btfss STATUS,2      ;test if w (RTCC) = 0
    goto BEGIN          ;w (RTCC) not zero

    movlw .224          ;if RTCC=0 move
    movwf RTCC          ;224 dec. into RTCC

    movf MDREG,w        ;places MDREG into w
    btfsc STATUS,2      ;test if MDREG=0
    goto RUN            ;yes
    xorlw 01h           ;no - XOR MDREG (w) with 01h
    btfsc STATUS,2      ;test if MDREG=1 - Z bit wil be set if it is

    goto SETARM         ;yes

SETTIM    nop           ;no - set time routine
    goto PROG

SETARM    nop           ;set alarm routine
    goto PROG

RUN  nop                ;run routine
    movlw 0Ah
    movwf FSR           ;load address of MINCTR into FSR

    decfsz HSCTR,same
    goto RUNEND         ;if HSCTE not zero go to RUNEND
    movlw .50
    movwf HSCTR         ;if zero - reload with 50 dec
    movlw 01h
    xorwf INDFLG,same     ;toggle bit 0 (colon) of INDFLG
    decfsz TBCTR,same
    goto RUNNEND        ;if TBCTR is not zero
    movlw .10           ;reload TBCTR with 10 (change to 120
    movwf TBCTR         ;later) if TBCTR=0
    call INCR
RUNEND    movlw 09h
    movwf FSR           ;load address of HRCTR into FSR

PROG call DISPLY
    goto BEGIN

    ORG 1FFh
    END
```

Subscription Price Freeze

Plus, excellent value with Direct Debit

The cover price of your favourite magazine has increased. But it's not too late... You can still subscribe at the old price!



Take Advantage of our Unbeatable Direct Debit Deal

- New way to pay in easy 6 month instal ments.
- Plus, long term price freeze.
- Save money on the retail price, 53p per issue - Introductory offer.
- No paperwork and no fuss. Subscribe now and you'll never need to renew again!

Option A

Direct Debit Introductory Offer

The easiest way to subscribe yet!

Pay for your 6 month subscription by Direct Debit and we will send you the next 8 issues for the price of 6, a saving of 53p per issue on your first 8 copies. Using Direct Debit means that your account will be automatically debited by £12.90 when we receive your order, and by the same amount at each renewal date thereafter.

Option B

For credit card, cheque or P.O. payments.

Subscribe & freeze the price for 1 or even 2 years!

Direct Debit Guarantee

- This guarantee is offered by all Banks and Building Societies that take part in the Direct Debit scheme. The efficiency and security of the scheme is monitored and protected by your own Bank or Building Society.
- If the amounts to be paid or the payment dates change, you will be told of this in advance by at least 14 days as agreed.
- If an error is made by us or your Bank/Building society, you are guaranteed a full and immediate refund from your branch of the amount paid.
- You can cancel a direct debit at any time by writing to your Bank or Building Society. Please also send a copy of the letter to us.

Send off the coupon now or order by CREDIT CARD on: 01858 435344

Please complete this section

Yes, I would like to subscribe to ETI at the price protected rates.
DD ☐ U.K Direct Debit £12.90 every 6 months.
Plus, 2 free issues with your first payment.
Please remember to fill in the direct debit instruction opposite.

1 year (12 issues)		2 years (24 issues)	
☐ U.K. Cheque/CC/P.O.	£25.80	☐ U.K. Cheque/CC/P.O.	£51.60
☐ Europe & Eire	£34.70	☐ Europe & Eire	£69.40
☐ Sterling O/Seas	£36.20	☐ Sterling O/Seas	£72.40
☐ U.S. $ O/Seas	$54.00	☐ U.S. $ O/Seas	$108.00

☐ Please commence my subscription from the next available issue
Please quote subscription number if renewing/extending
....

Your Details
Name(Mr/Mrs/Miss)Initial..........Surname..........
Address..........
....
..........Post Code..........
Telephone..........
Method of Payment
☐ Access/Visa ☐ Cheque/P.O.payable to Nexus ☐ Direct Debit
Card number: ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐
Signature..........Expiry..........

Please post this coupon together with your cheque or direct debit form to: Nexus Subscription Department, Tower House, Sovereign Park, Lathkill Street, Market Harborough, Leicestershire. LE16 9EF

Please tick this box if you do not wish to receive information from any other companies which may be of interest to you. ☐

ETI DIRECT DEBIT INSTRUCTIONS

This card instructs your bank or building society to make payments direct from your account. Please fill in parts 1,2,3,4 and 6 and then send to us at the address opposite. Banks or Building Societies may not accept direct debit instructions for some types of account.

1. Please write the full postal address of your Bank or Building Society branch

To: The Manager
Bank or Building Society..........
Address..........
....
..........Post Code..........

2. Name(s) of account holder(s)
....

3. Branch Sort Code: ☐☐ - ☐☐ - ☐☐

4. Bank or Building Society Account No: ☐☐ ☐☐ ☐☐ ☐☐

5. Ref No:.......... (Office use only)

6. Instruction to your bank or building Society. Please pay Nexus Media Ltd. Direct Debits from the account detailed on this instruction subject to safeguards by the Direct Debit Guarantee.
Originators Identification: 800132

Signature(s)..........

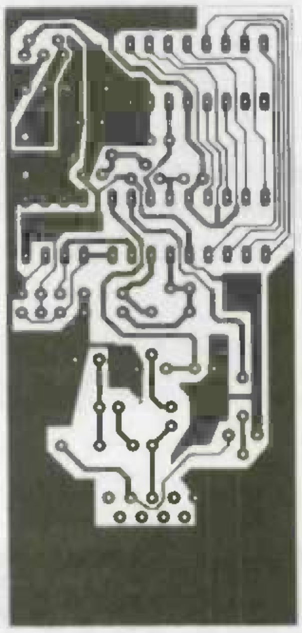
Date:..........

ET11

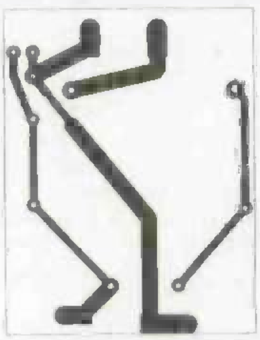
This exclusive offer must close on: 3/11/95

ETI ELECTRONICS TODAY INTERNATIONAL

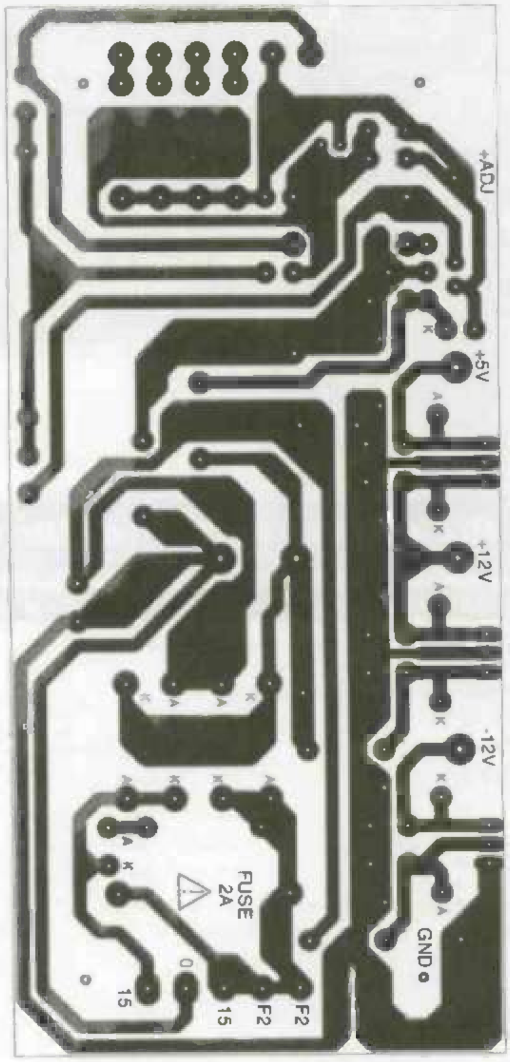
FOILS FOR THIS ISSUE



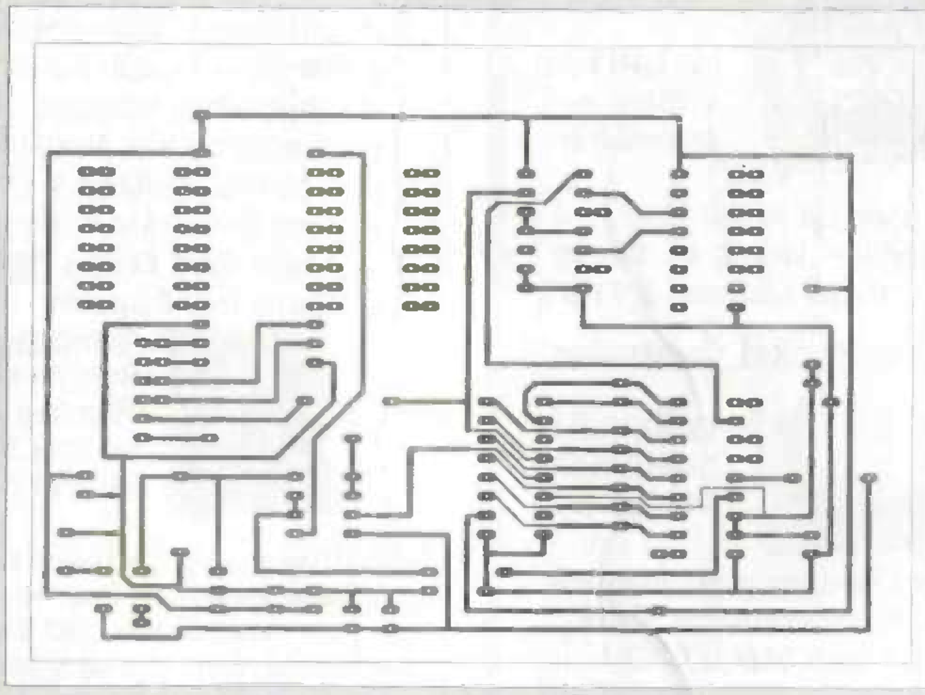
Eti Basic Microcontroller



Child Night Light



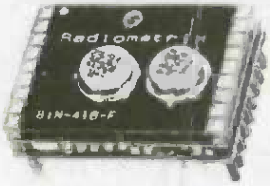
Bench Power Supply



Midi Mixer ADAC Board

Midi Mixer CPU Board

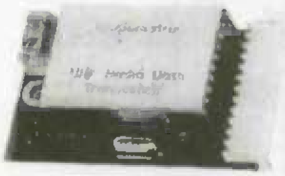
R.F Modem Transceiver



UK MPT1340
418MHz or
433.93MHz

- ✓ High speed up to 40K bps
- ✓ Price 100+ < £30.00 1+ £49.95
- ✓ Ideal for Radio Modems & EPOS

R.F Modem Packet Controller



TX/RX C.R.C
Only £79.95
4-bit I/O port

- ✓ Parallel microprocessor interface
- ✓ Automatic tx/rx protocol & CRC
- ✓ PIC micro with user E²PROM

Radio - Tech
Radio - Tech Limited
LOW POWER RF TELEMETRY MANUFACTURERS

Overbridge House, Weald Hall Lane, Thornwood, Epping, Essex CM16 6NB
Sales 0181-368 8277 Fax 0181-361 3434, Admin 01992-576107 Fax 01992-561994

Radio Data Modules

- ✓ Approved Transmitter Modules
- ✓ Receiver Modules & Systems
- ✓ Transceiver Modules
- ✓ Evaluation Kits Available
- ✓ 173MHz, 418MHz & 433.92MHz
- ✓ Free Catalogue & Support
- ✓ Credit Card Orders VISA
- ✓ Same Day Dispatch

Applications:
Remote Controls
Wire-free Security
Remote Monitoring
RF Computer links

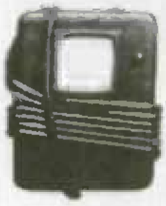
NEW! Transceiver evaluation kit. Includes: 2 x Transceivers, test PCB with PIC micro, bit error rate, range & self test firmware batteries, antenna and carry case. £149.00

Radio - Tech
Radio - Tech Limited
DISTRIBUTOR OF RADIOMETRIX PRODUCTS

Overbridge House, Weald Hall Lane, Thornwood, Epping, Essex CM16 6NB
Sales 0181-368 8277 Fax 0181-361 3434, Admin 01992-576107 Fax 01992-561994

R.F Linked Safety Aids

- ✓ Approved off the shelf systems
- ✓ Aids for the disabled and elderly



Fall-over Triggers
μ Power Receivers
Auto-diallers, Sirens
FM Pagers
Repeater Stations

- ✓ High quality lone worker systems
- ✓ Hand held FM remote controls
- ✓ Battery operated FM receivers

Relay Outputs!
Built-in Antennas

Applications for tenders welcome from Local Authorities, Retail Trade and Heavy Industry. Prices start from under £30.00 ex VAT & Carriage.

Radio - Tech
Radio - Tech Limited
LOW POWER RF TELEMETRY MANUFACTURERS

Overbridge House, Weald Hall Lane, Thornwood, Epping, Essex CM16 6NB
Sales 0181-368 8277 Fax 0181-361 3434, Admin 01992-576107 Fax 01992-561994

10mW VHF Modules

- ✓ 173.225MHz Approved MPT1344
- ✓ 173.250MHz Approved MPT1328
- ✓ Remote Meter Reading Modules
- ✓ Evaluation Kits Available
- ✓ New low prices 1+ £25.45 ex.
- ✓ Compatible with existing RXM-173-4666-60 receiver.
- ✓ Pin compatible with 1mW version

Applications:
Industrial Controls
Wire-free Monitors
Remote Metering
RF Data links

Note: VHF @ 10mW ERP gives a typical unobstructed TX range of up to 2.5Km. MPT1344 should be used for security and MPT1328 telemetry / telecommand applications.

Radio - Tech
Radio - Tech Limited
DISTRIBUTOR OF RADIOMETRIX PRODUCTS

Overbridge House, Weald Hall Lane, Thornwood, Epping, Essex CM16 6NB
Sales 0181-368 8277 Fax 0181-361 3434, Admin 01992-576107 Fax 01992-561994

ADVERTISERS INDEX

ETI Classified

James Gale
01442 66551

Send your requirements to:
ETI Classified Department, Nexus, Nexus House, Boundary Way, Hemel Hempstead, HP2 7ST
Lineage: 75p per word (+ VAT) (minimum 15 words)
Semi display: (minimum 2.5cms)
£10.50 + VAT per single column centimetre
Ring for information on series bookings/discounts.
All advertisements in this section must be pre-paid.
Advertisements are accepted subject to the terms and conditions printed on the advertisement rate card (available on request).

FOR SALE

PLANS

SOFTWARE

COURSES

ETI

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

Rates: Lineage 75p per word + VAT minimum 15 words.
Semi-display £10.50 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

By now most readers will have heard that Siemens have chosen Britain - Newcastle to be exact - as the site of a £1billion plant to manufacture ASICs (Application Specific Integrated Circuits). Not only will this plant, scheduled to open in 1996/7, provide over 2,000 jobs in a depressed area, many of them for skilled engineers, but it will also contribute about £800million a year to the UK electronics GDP - a welcome boost to UK manufacturing.

The German industrial giant chose Britain in the face of fierce competition for the plant from many other European countries. In doing so, it joins a long list of US, European and Japanese electronics companies which have set up manufacturing operations in the UK over the last decade. And, not just manufacturing and assembly facilities, but facilities which include leading edge product design and development departments.

Indeed, it was the availability of a well trained, flexible workforce, plus all the suitable infrastructure, which persuaded Siemens and all the other electronics companies which have invested here, to come to Britain. They could have found cheaper wages, lower priced property, and bigger financial inducements elsewhere, but what they could not find in such places was a skilled, disciplined workforce.

This brings us to the main thrust of this piece, the question of vocational training in Britain, and what can be done to improve it. Although there are plenty of skilled people, and in particular graduates, we in this country are in danger of having a shortage of people with craft and technician level qualifications. Indeed, according to the Organisation for Economic Co-operation and Development (OECD) only 25% of economically active people of working age have craft or technician qualifications, compared with 63% in Germany and 66% in Switzerland.

As far as university graduates are concerned, the percentage of the economically active working population with a degree in the UK is at 11% the same as that in Germany and Switzerland, and four percentage points higher than in France. Furthermore, overseas investors in the UK are finding that the wider educational basis of UK engineers and scientists is far more useful that the narrow specialisation of their European or Japanese equivalents.

The quality of graduate engineers means that electronics companies are keen to tap into that resource and do their research and development work in the UK. But the shortage of people with appropriate craft and technical skills will severely limit the number of manufacturing operations which can make use of the R&D work.

The solution to this problem lies in the education system.

In the UK, just 43% of 16-18 year olds are in full time education compared with 89% in Germany, 75% in the US and 87% in France. The result is that UK industrialists are increasingly complaining that young people coming into the job market do not have any of the necessary skills which will allow them to successfully contribute.

However, if traditional education is failing both the country, its industry and its young people, then perhaps the solution is to forget the old educational techniques and start using technology to create new learning techniques. One has only to look at how many otherwise academically undistinguished youngsters can successfully find their way around the Internet, or fly an F-16 on a simulated combat mission.

By creating new learning techniques for vocational education, not just for the young but for all of us in this rapidly changing world, it could be possible to very quickly propel the workforce in this country from being simply good to being the best. We, as a nation have, after all, few natural resources other our brains and our skills - to survive, we need to use them in the best possible way.

Next Month...

In the November 1995 issue of Electronics Today International we will be continuing our premier autumn, the ETI Basic programmable microcontroller. This is a simple, low-cost building block which will allow anyone to use microcontroller power in a project. No need to learn to programme in assembler code; instead this simple module can be programmed in the widely known and easy to use Basic computer language.

A PC disk containing the complete development system software for this project is being given away on the cover of the November issue. So don't forget to place your order for next month's ETI with newsagents now, in order to ensure that you get your copy!

Dr Pei An shows how to build a computerised radio control system that will allow a PC to remotely control any device with a range of several hundred yards. From David Geary there is a timed isolator system which should eliminate the chances of mains equipment being accidentally left on. From Tim Parker, there is the second part of his versatile upgradable bench power supply that should be of interest to all electronics experimenters. Bart Trepak concludes his practical look at designing a project around the PIC microcontroller.

In the main feature article in next month's ETI Dave Clarkson will also be taking a look at some world leading technology which will revolutionise the motor car.

ETI
ELECTRONICS TODAY INTERNATIONAL

EDITORIAL

Editor ***Nick Hampshire***
Sub Editor ***Eamonn Percival***
Editorial Assistant ***Lynn Bugden***

CREATIVE

Designer ***Nadia Ahdout***
Technical Illustration ***John Puczynski***
Photography ***Manny Cefai***

ADVERTISEMENT SALES

Display Sales
Alison Wetherill
Advertisement Copy Control
Marie Quilter
Classified Sales
Jim Gale
Group advertising manager
Diane Farnham

MANAGEMENT

Divisional Director
Terry Pattisson
Production Administrator
Theresa Davis
Business Manager
Claire Jenkinson
Marketing Manager
Jason Doran
Copy Sales Manager
David Pegendam

ABC CONSUMER PRESS

ISSN 0142-7229

Subscription rates-UK £25.80 Europe £34.70 Sterling Overseas £36.20 US Dollars Overseas $54.00

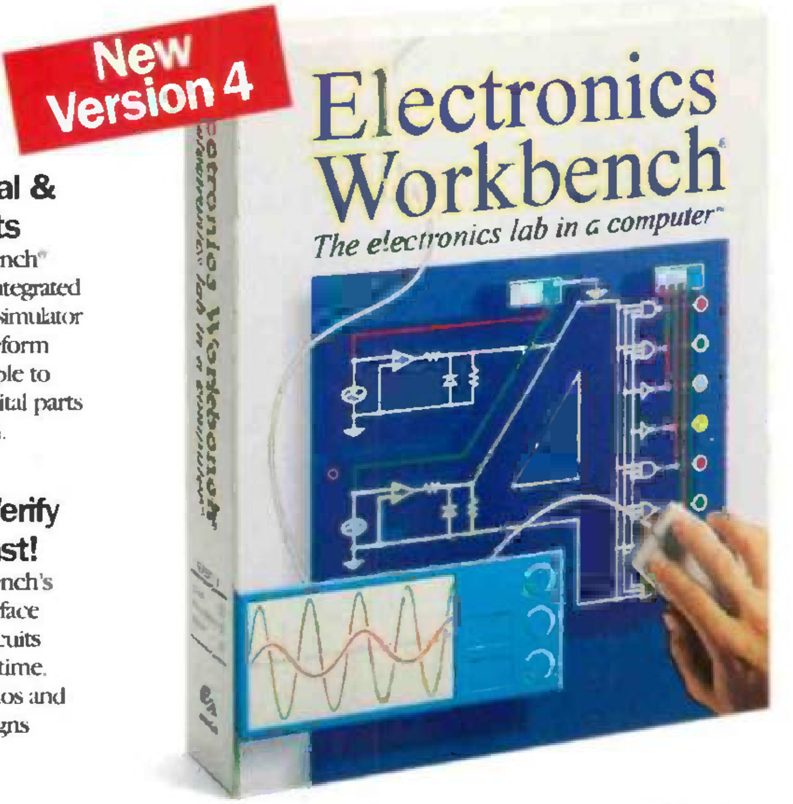
Published by Nexus Special Interests, Nexus House, Boundary Way, Hemel Hempstead HP2 7ST. Telephone (01442) 66551. UK newstrade distribution by SM Distribution Ltd, 6 Leigham Court Road, London SW16 2PG. Telephone 0181-667 8111. Overseas and non-newstrade sales by Magazine Sales Department, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST. Telephone (01442) 66551. Subscriptions by Nexus Subscription Services, ETI, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS. Telephone (01737) 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.

NEXUS Special Interests

Nexus House, Boundary Way,
Hemel Hempstead HP2 7ST
Telephone (01442) 66551
Fax (01442) 66998

MIXED-MODE SIMULATION. THE POWER OF VERSION 4.



Analog, Digital & Mixed Circuits

Electronics Workbench® Version 4 is a fully integrated schematic capture, simulator and graphical waveform generator. It is simple to mix analog and digital parts in any combination.

Design and Verify Circuits... Fast!

Electronics Workbench's simple, direct interface helps you build circuits in a fraction of the time. Try 'what if' scenarios and fine tune your designs painlessly.

More Power

Simulate bigger and more complex circuits. Faster. On average, Electronics Workbench Version 4 is more than 5 times faster than Version 3.

More Parts

Multiple parts bins contain over twice the components of Version 3.

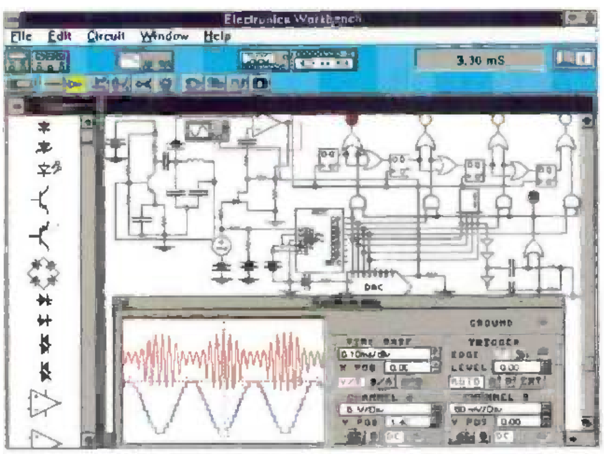
More Models

Over 350 real world analog and digital models are included free with Electronics Workbench. And, if you need more, an additional 2,000 models are available.

Incredibly Powerful. Incredibly Affordable.

If you need mixed-mode power at a price you can afford, take a look at this simulator and graphical waveform generator that mixes analog and digital with ease.

With over 20,000 users world-wide, Electronics Workbench has already been tried, tested and accepted as an invaluable tool to design and verify analog and digital circuits. With Version 4 true mixed-mode simulation is now a reality with incredible simplicity.



True mixed-mode simulation: Simultaneous AM transmission, digitization and pulse-code modulation of a signal.

Electronics Workbench™

The electronics lab in a computer™

Order Now! Just £199*

44-(0)1203-233-216

Robinson Marshall (Europe) Plc

Nadella Building, Progress Close,
Leofric Business Park,
Coventry, Warwickshire CV3 2TF
Fax: 44 (0)1203 233-210
E-mail: rme@cityscape.co.uk

Shipping charges UK £5.99. All prices are plus VAT.
All trade marks are the property of their respective owners.
Electronics Workbench is a trademark of Interactive Image Technologies Ltd., Toronto, Canada.
* 30 Day money-back guarantee.

Australia: 2-519-3933 • Brazil: 11-453-5588 • Cyprus: 2-62-1068 • Denmark: 33-25-0109 • Finland: 0-297-5033 • France: 14-908-9000 • Germany: 711-62-7740 • Greece: 1-524-9981 Hungary: 1-215-0082 • India: 11-5441343 • Israel: 3-647-5613 • Italy: 11-437-5549 • Japan: 3-3382-3136 • Malaysia: 603-7778945 • Mexico: 5-396-3075 • Netherlands: 18-031-7666 New Zealand: 9-267-1756 • Norway: 22-16-70-45 • Portugal: 1-814-6609 • Singapore: 462-0006 • Slovenia: 61-317-830 • South Africa: 331-68309 • South Korea: 2-2-222-3431 Spain: 1-553-3234 • Sri Lanka: 1-86-5970 • Sweden: 8-740-5500 • Thailand: 66-2-398-6952 • United Kingdom: 203-23-3216

INTERACTIVE

With over 14,000 products the new Maplin Catalogue is now bigger than ever

THE EIFFEL TOWER

Built in 1889 by Alexandre Gustave Eiffel, the Eiffel Tower is 984 feet high and gives an unrivalled view of the whole of Paris.

THE NEW MAPLIN CATALOGUE

Built in 1995 by Maplin, the new catalogue is almost 1,200 pages long and gives an unrivalled view of the whole world of electronics.
Now Only £2.95

Wide Range of Security Products 51027

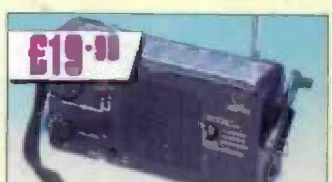
Latest Global Navigation Systems 51028

Full Range of Batteries and Chargers 51029

Ultra Accurate Clocks 51030

Exceptional Range of Tools and Test Equipment 51031

Over 300 Kits for You to Build 51032



The Latest Innovations Solar/Dynamo Powered Radio 51033

PCMCIA Card 51034
Over 100 pages of Computer Components

MAPLIN ELECTRONICS AND BEYOND

Catalogue available at branches of **WHSMITH**, **John Menzies and Maplin stores nationwide**, or

order direct NOW on 01702 554161

Catalogue Mail order Price £3.45 (inc p&p). Prices depicted are from the 1996 Maplin Catalogue and are inclusive of VAT. All items are subject to availability. E & OE. Maplin Electronics, P. O. Box 3, Rayleigh, Essex, England SS6 8LR.