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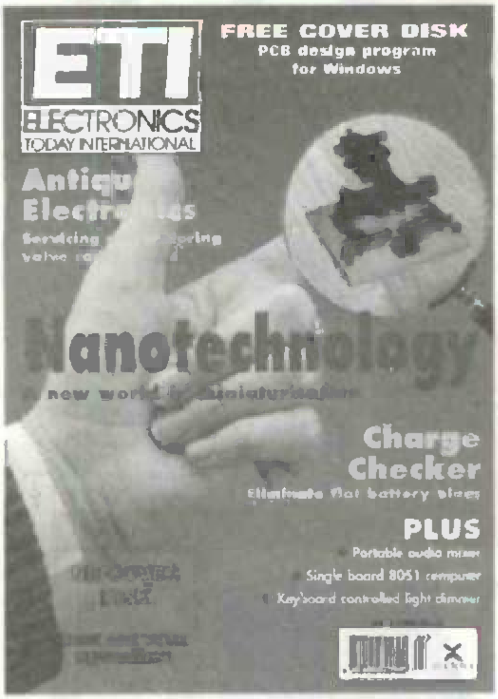
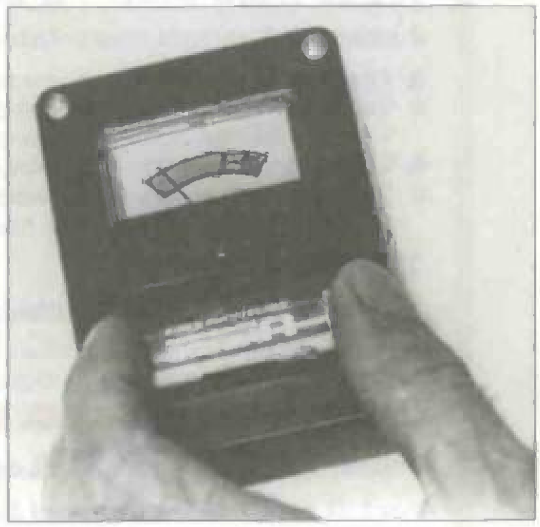
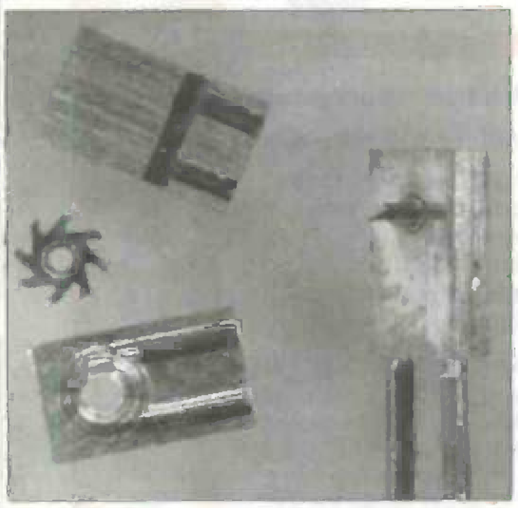
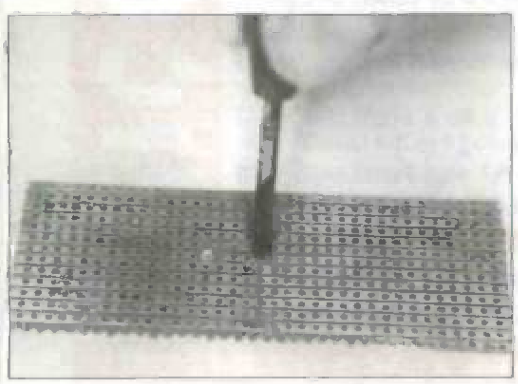


Volume 25 No.4

& Features Projects







Regulars

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

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

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

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

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

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

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

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

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

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

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INFINITY TRANSMITTERS The ultimate 'bug' fits to any phone or line, undetectable, listen to the conversations in the room from anywhere in the world! 24 hours a day 7 days a week! just call the number and press a button on the mini controller (supplied) and you can hear everything! Ring or Fax for latest price!

SWITCHED MODE PSU'S 244 watt, +5 32A, +12 6A, -5 0.2A, -12 0.2A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 d/drive connectors 1 m/board). £10 ref PSU1

VIDEO PROCESSOR UNITS?/6v 10AH BATTS/12V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 12v toroidal transformer (mains in). Condition not known, may have one or two broken knobs due to poor storage. £17.50 ref VP2

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

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

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

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

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

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

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

COMBINATION LOCK KIT 9 key, 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 eavesdropping on your line. £6 ref 1130.

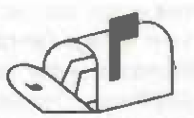
ROBOT VOICE KIT Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

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

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

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

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



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

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

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

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

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

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

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 miniature. 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

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

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.

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

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

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

PHILLIPS PRO COLOUR MONITORS, SCART INPUT OUR PRICE JUST £80 REF BAR328.

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

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PCB STRIPPERS TO CLEAR AT 2 FOR 99P REF BAR341
3 M 3CORE MAINS CABLE AND 13A PLUG. 60P REF BAR325

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ETI News...

Computer Products announces hundreds of CE-marked AC/DC power supplies

Computer Products has announced that following extensive test and product evaluation, its entire CL/SCL series of external AC/DC power supplies is now CE-marked (EMC and LVD). Furthermore, every open-frame AC/DC switch-mode power supply that the company manufactures also now carries the CE mark. Covering output powers from 25 to 790W, Computer Products' range of CE-marked power supplies represents one of the broadest in the industry, enabling systems integrators and OEMs to speed time-to-market by using preapproved units for a diversity of applications.

All of Computer Products' external power supplies comply with both the Low Voltage and EMC Directives. These include the CL25 and CL40 units, together with a new low-cost version, known as the SCL25. All three types of power supply feature a universal input that accepts AC or DC, providing a packaged power solution that is suitable for a wide variety of low-power, desktop-type applications, worldwide. The CL25 and SCL25 units offer a 25W continuous power output capability, whilst the CLAO offers 40W continuous, 50W peak.

Computer Products' CE-marked open-frame AC/DC power supplies include models from all popular families - such as the NFS, NFN, SL and XL series of switchers - and cover a power range from 25 to 790W. The company's new NAL/NAN series of low-cost power supplies also carry the CE mark. Available in 25W and 40W versions, the NAL/NAN series offers a choice of 38 models, with single, dual and triple outputs; each features a universal input, less than 1% output ripple and VDE noise compliance as standard.

• Computer Products was the first power supply company in the world to establish a formal EMC policy, and has made a significant investment in this area, including the installation of a specialist in-house EMC test laboratory and a rigorous product evaluation programme. Despite the fact that component power supplies - that is, any power supply intended for internal use within a product or system - need only meet the Low Voltage Directive in order to carry a CE mark, Computer Products is qualifying the full EMC performance of every power supply series that it manufactures. The company is committed to helping customers shorten design-in times by simplifying compliance testing of their own systems; the provision of detailed electromagnetic emission and immunity information will considerably assist this process.

Teknema shows ARM based Internet appliance at DEMO 96

Teknema Inc recently announced that it is demonstrating a prototype of its Internet appliance at DEMO 96. Dubbed 'Easy Rider', the network computer is an integrated software and hardware design incorporating Teknema's Web browser and systems software. Easy Rider uses the ARM7500 high integration multimedia system on a chip.

In its simplest form, the computer consists of a processing unit with 4 megabytes of RAM, modem connection to the Internet, VGA display, keyboard and mouse. Teknema estimates that the computer can be sold for under $500.

"Key to our design is a compact software architecture, that avoids the use of a standard operating system," said Marco Graziano, president and CEO of Teknema. "This really makes the browser the operating system of the network computer and simplifies both the use and the architecture of the system."

Easy Rider uses the ARM7500 microprocessor. Other designs of Internet appliances have stated their intention to use ARM microprocessors, but the Teknema design is the first to show full Web browsing functionality in a package so compact and inexpensive.

"Many designs in consumer electronics prove that ARM offers the best solution for high performance personal electronics," said Robin Saxby, managing director and CEO of ARM Ltd. "Teknema's Easy-Rider is a superb example of the capabilities of the ARM architecture and of compact software design."

Teknema plans to have production-ready units for the second quarter of 1996. Easy Rider is available for license to computer manufacturers or service providers. Teknema is actively pursuing partnerships for both the manufacture and marketing of the device.

Oki and ARM announce licence agreement on 32-bit embedded RISC core

Oki Electric Industry Co Ltd and Advanced RISC Machines Ltd (ARM) today announced the licensing of the ARM7TDM1 processor core to Oki.

The ARM7TDM1 is an easy to integrate 32-bit RISC processor core with ARM's advanced Embedded ICE debug, DSP optimised multiplier and the Thumb extension to reduce system cost. Like all ARM processors the ARM7TDM1 delivers industry leading ratios on performance/price and performance/power consumption Oki judged these versatile features make the ARM core ideal for integration into high performance custom chips and believes the architecture will give customers flexibility to build a wide variety of systems.

OKI will also be able to use and distribute ARM's development tool suite and has options on other existing and future ARM products. ARM licenses complete development capabilities including hardware, software, and models. ARM also has strong 3rd party support and has active programs to further it.

Capitalising on the versatility of the ARM7TDM1, Oki will create and sell custom application specific chips and controllers for car electronics and computer peripherals (including disk drives, CD-ROM drives and printers). Also since Oki is an expert in communications and audiovisual technologies, the company also plans to use the CPU core to develop ASICs for multimedia communications equipment such as mobile phones, PHS, and PDA. ARM's CEO and Managing Director Robin Saxby, says, "Oki brings new expertise to the ARM partnership and opens up new markets to the ARM architecture. Oki will further strengthen our position as the global embedded RISC: "standard" Oki's broad peripheral library, flash memories, and submicron process technology, together with ARM's powerful development environment and software support, will allow customers to rapidly develop effective 'system on a chip' solutions in the most cost effective manner. The ARM7TMD1 core will be added to Oki's lineup of ASICI MCU (quick cores) alongside 8- and 16-bit controller cores. The new ARM core will be supported in Oki's existing semicustom design environment such as cell bases and embedded arrays, as part of the company's enhanced customer services.

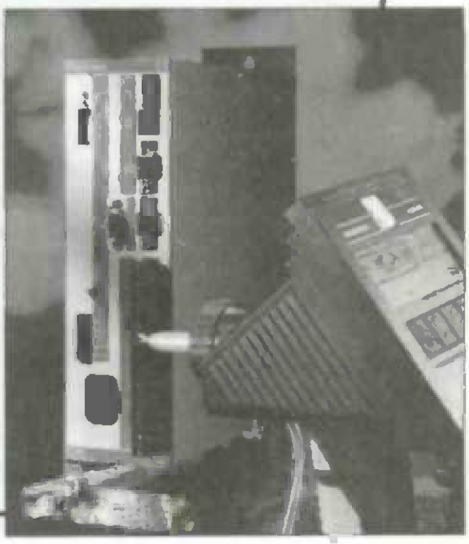
EMC-compliant ministepping indexer/drives feature 'go-anywhere' power supply.

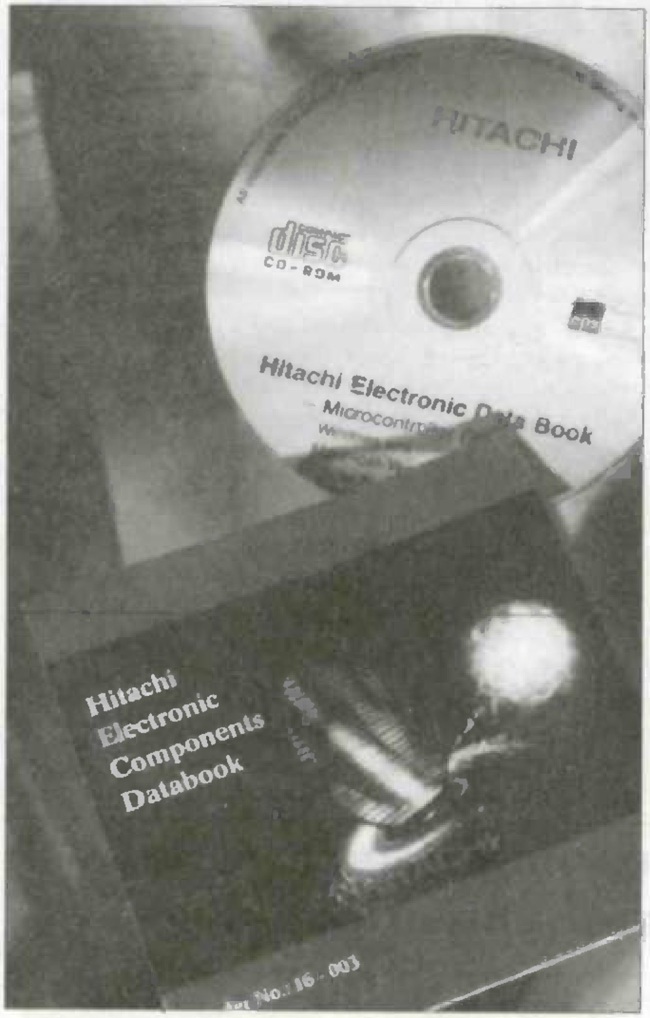
Parker-Digiplan has launched EMC-compliant versions of its highly successful PD series ministepping indexer/motor drive packages. Known as the PDHX-E series, the motor drives can operate from any AC supply voltage in the range 100 to 240V without adjustment, and contain all necessary line filter components to meet the EMC Directive - no external add-on units are needed. These latest-generation drives are ideal for OEMs and systems integrators seeking a complete, ready-to-run digital positioning system for automation equipment intended for the European market.

PDHX-E drives incorporate all the performance features of the other models in Digiplan's renowned PD series product range. These include the use of a 70VDC bus to maximise highspeed torque, a choice of 3A or SA/phase peak motor current, and an output resolution of up to 4000 steps/rev for smooth rotation at all operating speeds. The built-in intelligent switch-mode power supply automatically handles power factor correction, and the drive is comprehensively protected against thermal and electrical overload. For applications demanding fast deceleration of high-inertia loads, the 5A version of the drive can be fitted with an optional regenerative power dump.

The built-in indexer is equipped with an exceptionally powerful controller which can be programmed over a standard RS232C or RS485 serial link from any computer or terminal, using an enhanced version of Digiplan's popular X-code motion control language. Up to 64 separate programs can be downloaded over the link and stored in non-volatile memory, and then subsequently selected for execution by external input signals, thumbwheel switches, or automatically at power-up. Advanced programming features include extensive branching facilities and powerful maths functions, which enable even complex conditional sequences to be set up very easily. The indexer can handle position data in the range +1 to _+268,435,455 steps, velocities in the range 0.0001 to 200 revs/sec and acceleration rates from 0.06 to 999,999 revs/sec/sec. For large multi-axis applications, as many as 32 PDHX-E drive/indexer packages can be daisy-chained to a single RS232C or RS485 port.

Suitable for use with any standard 2-phase stepper motor, PBHX-E drives offer user selectable resolutions of 400, 1000, 2000 and 4000 steps/rev, making it very easy to implement the optimum control conditions. For simple motion control applications, or if users wish to employ an external controller, the drives are available with a step-direction input option instead of the built-in indexer. Known as the PDS-E series, these drives offer optically-isolated inputs for differential TTL-level step and direction signals, as well as nonisolated inputs for single-ended control signals operating at 12V levels. PDS-E drives incorporate a dual-speed clock generator with adjustable ramping for manual positioning or simple on-off control.





Hitachi data book now on CD-ROM

Hitachi Europe Limited recently announced a new CD-ROM product data book which covers the H8 series of microcontrollers, and the SuperH family of 32-bit RISC devices. The new title complements the existing CD-ROMs which cover optoelectronic devices and memories.

As well as offering the obvious advantages to Hitachi and its customers that CD-ROMs are easier to ship, store, handle and update, software available with the discs will allow flexible searching of the 19,000 pages of data.

For example, if a developer is interested in devices with multiple ADCs (analogue to digital converters), then a search facility will produce a list of suitable devices, and data sheets can be printed if needed. Information is presented as text, graphics and photos on a hybrid CD-ROM format that can be read by Macintosh(R) and Windows(R) users. The production process for these discs is ISO 9002 compliant to ensure the information is as reliable as possible.

The microcontroller documentation on CD-ROM is the next step in the Hitachi Electronic Application Document System (HEADS) which aims to distribute technical information to as wide an audience as possible. HEADS is a world-wide programme that aims to provide technical documentation in an electronic format to users no matter what system they use to read it. For example, the current CD-ROMs use Adobe's Portable Document Format (PDF). The PDF format allows documents to be read by Windows, DOS, Macintosh and UNIX users, and can be used directly on the World Wide Web.

High performance data acquisition sub-systems

The new Vanguard family of products from Pentland Systems offers a high level of performance and versatility, and will find applications in Radar, Sonar, Image Processing, High Energy Research, Simulation and Telecommunications.

The Vanguard concept utilises a proven digital motherboard design which can carry a wide range of high per fo rmance data acquisition daughterboard cards . A variety of Front Panel interface options are available for the motherboard which will provide connection to a number of system buses.

Off-the-shelf high performance analog daughtercards offer 2 channels of A/D conversion at rates of up to 30 million samples per second at 12-bit resolution; 16 channels of A/D conversion at rates of up to 3.75 million samples per second at 12-bit resolution; and 8 channels of A/D conversion at rates of up to 1.5 million samples per second at 12-bit resolution.

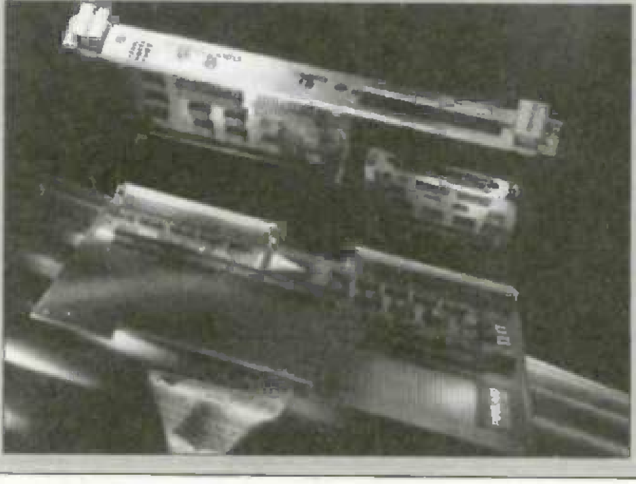
Front Panel interface options Include VME, VSB Front Panel Data Port (FPDP). FPDP is a standard interface allowing direct high speed connection to Mercury, CSPI, SKY and Ixthos boards. Future Direct Data Interface (DDI) options include RACEWAY, and C40 comm ports.

By allowing system designers to combine the analog daughtercard and data interface option of their choice, this exceptionally flexible product can be quickly tailored to provide solutions to highly specified data acquisition systems.

Additionally, this versatile approach allows the quick turn-around of custom design analog and digital daughtercards to meet individual customer requirements. Vanguard can be easily integrated into most architectures, and is flexible enough to accept the peculiarities of individual applications.

Further information about Pentland's other products and services can be found on the Pentland Home Page located at the following Internet address:

http://www.linnet.co.uk/linnet/pentland/



Renowned Toneohm family of PCB shorts and bus fault locators gains ultra low impedance measurement capability

Polar Instruments has introduced two new models to its ubiquitous Toneohm family of low-cost PCB short-circuit fault locator tools. Toneohms are widely regarded as one of the most indispensable tools - second only to a multimeter - for PCB test and repair; around 10,000 of these low-cost instruments are in use worldwide. The latest models, known as the 550A and the 850A, offer a high sensitivity 0 to 40 milliohm range which is ideal for tracing short-circuits on PCBs with large-tracks, such as high-current power distribution buses on backplanes, and the output stages of power supplies. The 850A also provides a current tracing mode for locating shorts on busstructured boards. Both models also feature a new case design: the display and all controls are mounted on a vertical front panel, allowing instruments to be stacked to save valuable workbench space.

Toneohms provide a particularly easy-to-use means of locating short-circuits, and can be employed on bare or loaded PCBs. The operator simply 'walks' a pair of probes along the suspect PCB track, while an audible tone provides guidance to within a few millimetres of the fault, enabling shorts to be located very accurately even on densely-packed boards. This approach has several key benefits. The operator does not have to cut PCB tracks or lift component leads in order to home in on the fault, and the board is tested in an unpowered state. This reduces repair times significantly and prevents any additional faults being caused by the test process, All fault tracing information is echoed on a front panel display; both the 550A and the 850A have a large 0.7 inch, 3 1/2 digit LCB. The latest supertwist LCD technology ensures that the display has a wide viewing angle and is clearly visible under a variety of ambient lighting conditions.

In addition to the new milliohm measurement range, the 850A also offers microvolt and current tracing functions for locating 'soft' shorts and faults in bus-structured boards. Both tracing functions use a voltage-limited drive signal to prevent any damage being caused to sensitive components. The microvolt range allows low resistance faults such as faulty decoupling capacitors to be located very quickly. Current-tracing employs a non-contact probe to measure the current produced by the drive signal, and is ideal for locating shorts on networks with multiple possible causes, such as 'stuck-at' logic devices on bus-structured boards or within banks of memory.

Polar's new 550A and 850A Toneohms provide the same exceptional cost/performance as other members of the family. The 850A, for example, costs less than £500, which is the same price as its equivalent ten years ago.

Quarter-size VGA LCD and touch screen controller

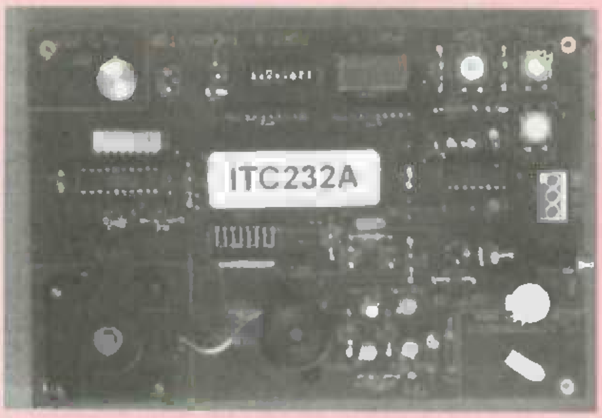
Arcom Control Systems announces a new STEbus interface board for driving quarter-size VGA LCD panels, providing a simple means of adding economical graphical man-machine interfaces to embedded systems and industrial computers. This approach is ideal for mounting a display on the front panel of a rugged 3U Eurocard rack containing STEbusbased hardware. An integrated driver for a touch-screen further simplifies the design of systems intended for use in harsh industrial environments. Dubbed SQVCrA, the new board offers a cost-effective solution for any computer system requiring a simple yet flexible user interface. Application areas include machine automation, standalone controllers and communications systems.

The board is based on the highly-integrated Vadem VG-660 controller, with 256kbyte of 70nanosecond video RAM. It can drive displays from 240x128 to 640x480, covering both quarter- and full-size VGA screens. It also supports a CRT, and features dual output connectors to allow two displays to be resident in the system. Connectors are provided to interface an optional resistive matrix touch sensor panel of up to 10 x 8 resolution, together with bias and contrast control button signals.

Powerful facilities help designers to optimise man-machine interfaces for industrial situations. These include hardware panning and zooming to allow users to focus in on - say - a MIMIC diagram of a process, or to 'page' around different text and graphics screen areas using touch-screen softkeys. The alternate CRT output allows systems to flip between a simplified display for an operator, for instance, and a full-size CRT display for a supervisor or maintenance engineer.

The new SQVGA board additionally forms part of Arcom's innovative EMC initiative, which provides a plug-together framework to allow designers to build custom control systems yet self-certify them as CE-compliant. To achieve this, Arcom supplies SQVGA with a quartersize LCD and integrated touch-screen, plus a dedicated front panel and cable assembly for its EMC-protected rack. SQVGA costs £280.

TUTOR 2 PROFESSIONAL EVALUATION BOARD



The Tutort is a 7" x 4.5" board designed for professional engineers, technicians and designers wishing to rapidly gain a comprehensive understanding of the ITC232A chip on which It Is based.

As it is based on the above Intelligent Serial Interface Multi-Function Data Acquisition and Control IC, it can be controlled directly from a dumb ASCII terminal, a PC Comms Utility like Windows Terminal, Procomm or Telix, or Timely Technology's entry level Windows SCADA (supervisory Control and Data Acquisition) program.

The hardware allows the following :

1) The manual setting of a digital 8 bit dipswitch which is then interrogated
2) Turning on and off individual LEDs on an 8 LED bar from your keyboard etc.
3) Usage of decimal, hexadecimal and binary notation for most data erchanges
4) Hardware Interrupts.
5) Pulse Width Modulation. Tones can be heard on a small transducer, duty cycle changes can be seen in the relative brightness of a small incandescent lamp. A transistor driver is also included to show how the speed of a DC motor mlght be controlled using the built in PWM features.
6) Temperature measurement using a thermistor.
7) Using external resistors and capacitors, the capabilities of the chip to directly read resistance and capacitance.
8) Analogue to Digital conversion.The Tutor2 features a 10 channel, 8 bit ADC attached to a thumbwheel potentiometer. The voltage on the pot can be read into the PC or terminal you are using at the time. A 12 bit ADC is also available.
9) The simplicity and power of the SPI serial interface protocol is laid open and every facet of its operation made available for investigation and monitoring.
10) Stepping Motors. The board includes a stepper and its driver chip, which can very readily be controlled in a number of sophisticated ways by means of a few ASCII keystrokes.
11) Remote control over a phone line. This feature is available on chip, but requires the addition of modem hardware and software .

The hardware consists of the populated PCB itself, together with 3 wire RS232 cable, a 240V plugtop power supply, and a disk featuring a DOS software simulator of the chip plus manuals and source code. The board has so many features that many customers use it for their low volume designs. The DIPSWITCH and LED Array are both socketed and therefore replaceable with DIL headers. This too assists those who wish to adapt an existing product for their particular application.

Prices for the Timely board start at £149.99 whilst the ITC232A chip at the heart of the board is available at £20 in volume. The CASE GUI can cost as little as £499..

PC-based calculator tool demystifies design and production of controlled impedance printed circuit boards

Polar Instruments has launched an innovative PC-based calculator that removes much of the mystique surrounding controlled impedance printed circuit boards. The calculator enables users to obtain the PCB trace dimensions necessary to achieve a specific impedance, simply by keying-in a few fundamental process details, such as the thickness and dielectric constant of the materials being used. Unlike commercial tools for this specialist application, which tend to be complex and expensive, Polar's calculator is exceptionally easy to use. Available free of charge from the company or its distributors, the calculator is an ideal tool for PCB designers and manufacturers serving the fast-growing market for these high technology boards,

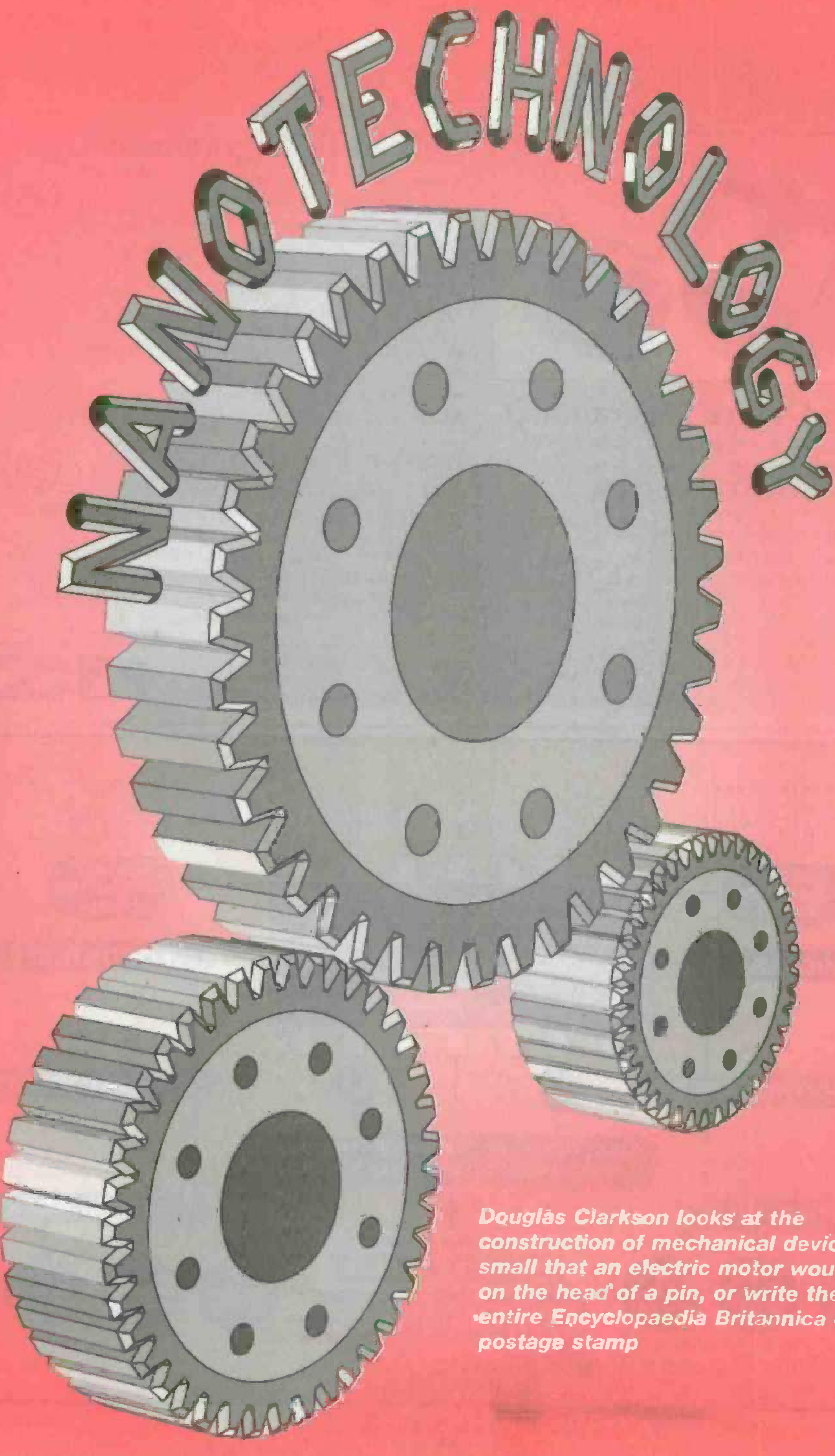
Running under Windows on any standard PC-compatible computer equipped with a colour monitor, the mouse-driven calculator employs a graphical user interface to convey information in a simple-to-understand format. Users simply point and click on the appropriate PCB trace icon, and enter the necessary process data on a numeric keypad; the calculated PCB trace geometry is displayed instantly, allowing the effect of minor changes to parameters such as trace positioning or board thickness to be previewed very easily. Results can also be output to a printer, for subsequent inclusion in manufacturing process reports or customer documentation.

The calculator features online help, and accommodates all popular controlled impedance PCB fabrication technologies, including surface, embedded and coated microstrip, and symmetric and coated stripline.

The calculation algorithms can handle both metric and imperial measurements, and are based on IPC Standard IPC-D-317A. Prior to releasing the calculator, Polar submitted it for extensive beta site evaluation with a number of leading manufacturers of controlled impedance boards, who - without exception - pronounced it an extremely useful tool for evaluating PCB production techniques.

Polar's controlled impedance calculator software may be freely copied and distributed, provided it is not sold for commercial gain and is not modified in any way.

NANOTECHNOLOGY



Douglas Clarkson looks at the construction of mechanical devices so small that an electric motor would fit on the head of a pin, or write the entire Encyclopaedia Britannica on a postage stamp

It was the ancient Greeks at the thought experiment level who were firmly convinced of the existence of small indivisible units that made up the physical world. The rapid development of physical sciences in the 19th century did not, however, confirm the existence of the atomic world, even though laws of chemical composition expounded by John Dalton in 1808 showed compelling evidence for the existence of atoms. There was great reluctance to believe in something that could not be directly observed. The basic problem was that no one could 'see' atoms.

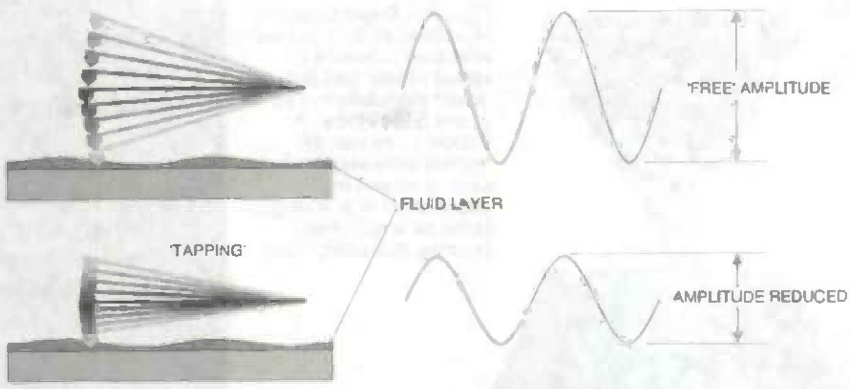


Figure 1: 'Tapping Mode' probe used for sampling atomic profile of atom/molecular surfaces. (Courtesy Digital Instruments)

The phenomenon of Brownian motion, discovered by Robert Brown in 1827 had, however, puzzled many observers. This effect is best observed by, for example, suspending minute pollen grains in a liquid and observing the rapid and random motion of the pollen grains. It was, however, Albert Einstein who interpreted the movement of the grains as being due to molecular collisions. Based on a steady state model of such grains settling under gravity in a vertical column, Einstein calculated how the density of grains could vary through the layers of the column. This model was in fact confirmed by the French scientist Jean Perrin in 1908. This was to encourage scientists to believe in the existence of atoms and molecules.

It was only around 1955, however, that atoms as individual units became visible using techniques of electron field emission as developed by Erwin Muller in the USA. With this technology atoms were being detected by high energy electrons that streamed off a surface and were detected on a viewing screen. Electron beams, however, in this mode had limited application for imaging a wide range of materials and surfaces.

On the small side

The smallest of the atoms, Hydrogen, has an atomic diameter of around 0.1 nm (1 A). Larger atoms have larger diameters. Taking however a representative figure of atomic diameter of 0.25 nm the following table gives an indication of the scale and organisation of progressively smaller structures.

Side of Cube	No. of Atoms in side	No. in Cube
1 mm	4,000,000	6.4 1019
100 u	400,000	6 4 1016
10 u	40,000	6 4 1013
1 u	4,000	6 4 1010
100 nm	400	6.4 107
10 nm	40	6.4 104
1 nm	4	64

Table 1: Indication of relation of physical dimensions and associated number of atoms. Present semiconductor fabrication techniques are pushing towards track widths of 0.1 u or 100 nm. This is equivalent to gaps of 400 atoms wide.

There's plenty of room at the bottom

It was at the December 1959 meeting of the American Physical Society that the would be Nobel Prize Physicist Richard Feynman gave a talk entitled 'There's plenty of room at the bottom'. Not having given any clue about its content, speculation ranged over all kinds of topics. Feynman, however, made everything very clear to his audience. One main theme was the vast potential to store information at the level of atoms. Text characters could be coded using a 10 by 10 matrix of individual atoms. This would allow the entire text content of Encyclopaedia Britannica to be accommodated in an area the size of the head of a pin - an area one sixteenth of an inch in diameter.

Also, by using a three-dimensional storage of a cube of atoms in a 5 by 5 by 5 matrix, and using the dimension of thickness of 1/32th of an inch, then all of the data of 24 million books (such was the world's total in 1959), could be encoded into a volume smaller than the head of a pin. No doubt various members of the audience had been carrying out all kinds of calculations on napkins and odd scraps of paper. Up to this point, the talk had been playing with numbers.

The more controversial portion of his presentation, however, was related to assembly of atoms into structures. This was where Feynman began to lose his audience. He postulated the possibility of systems that could assemble structures - atom by atom. Such systems could be used to assemble computers and also be seen as a general purpose manufacturing resource. Some in the audience looked upon manufacturing at the atomic scale as completely impracticable while others were immediately struck by the inevitability of such 'nanotechnology'

Feynman threw down two challenges. A $1000 prize was offered for the construction of a motor to occupy a volume not greater than 1/64th of an inch and a $1000 prize for demonstrating the ability to pack the Encyclopaedia Britannica at the reduced scale of 1/25000. Both challenges would subsequently be met. The motor was fabricated in 1960 using conventional technology. Feynman had hoped that his incentive would help develop a new technology of microfabrication. The second prize was awarded in 1985 to workers at Stanford University. They successfully wrote the first paragraph of Dickens 'A Tale of Two Cities' at a scale of 1/25,000 using an electron scanning microscope.

Having defined the challenge of new technology of 'room at the bottom', Feynman was content to let others pursue the goals of achieving the challenge of small structures. There were plenty of other challenges in Physics for Feynman to explore which were also more immediately realisable

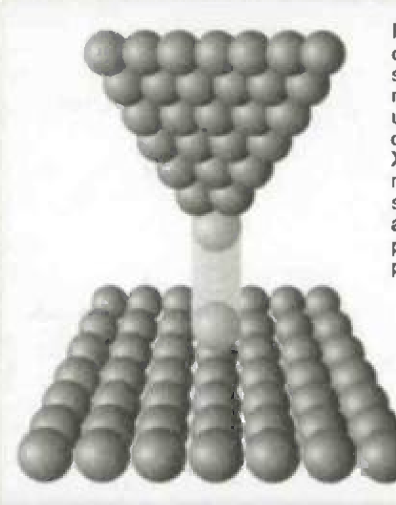


Figure 2: Basic structure of atomic switch. Lower structure consists of nickel atoms and the upper structure the tip of the STM probe. A Xenon atom can be moved between the two sets of atoms by application of a voltage pulse of appropriate polarity. (Courtesy IBM)

Touching and Sensing atoms

During the 1980's fundamental advances were achieved in the field of microscopy that would enable individual atoms to be 'imaged' with greater ease and clarity. The development by Gerard Binnig and Heinrich Rohrer during 1981 at IBM's research laboratories at Zurich of the Scanning Tunnelling Microscope (STM) provided a mechanism of 'imaging' atoms by means of moving a scanning probe over a sample and detecting atoms via the changes in scanning current that was detected. This major achievement was recognised with the award of the Nobel Prize to the duo in 1986. This fundamental breakthrough in imaging technology has in turn led to major scientific advances across a broad range of scientific disciplines.

This technique, therefore, could provide an image of atoms based on the values of scanning current detected. In some ways this process was like a three-dimensional 'sonar' method where objects were detected by the echo reflected back from the material surface. Once this first approach to 'atomic microscopy' had been developed, there followed a rapid expansion in other methods of detecting atomic structures.

One main development was the Atomic Force Microscope. This technique uses the measurement of the actual force encountered by the tip of a contact probe as it is drawn over a section of the surface being scanned. The basic principle that the presence of atoms is detected by a higher force and the absence of atoms by a lower force. The disadvantage of this approach is that the probe can only be used with 'robust' atom interfaces such as the surface of a 'cut' of Silicon. This method, for example, would not be relevant for scanning the delicate contours of a protein molecule. There is also the problem that most solid surfaces are contaminated by a layer of water vapour which tends by surface tension effects to modify the contact force.

Researchers at AT&T Bell Laboratories in 1986 successfully modified at the atomic scale the profile of a nearly perfect germanium crystal. By applying a small voltage across the STM tip, a 'blip' appeared on the crystal surface. An atom of some description had been transferred from the STM tip to the crystal surface. This was the first time that a single atom had been 'officially' moved. With, however, STM systems having been in use for almost five years, researchers must have on various occasions contaminated scanned surfaces with atoms from STM tips.

Variations on this technique, however, have provided improved observational methods where little, if any, damage is sustained by the surface being scanned. One approach is to use a so-called 'Tapping Mode' technology as developed by Digital Instruments of Santa Barbara, California. In this technique, a probe with an oscillating tip amplitude as indicated in Figure 1 is scanned over a specific area. The probe tip is driven by a piezoelectric oscillator and the probe tip amplitude is detected by a feedback system. When the probe tip is 'free' of the surface it oscillates with maximum tip amplitude. When driven down onto the atomic surface the tip amplitude would be considerably reduced. For a given (X,Y) co-ordinate, the vertical position of the probe is adjusted so that the probe tip is beginning to detect the presence of an atomic interface. This technique allows even delicate structures to be imaged successfully. In this way the profile on a 3 - D surface of atomic interfaces can be relatively easily scanned. Surfaces can also be 'imaged' under liquid.

Also, if sections of silicon are imaged by 'Tapping Mode' technology after it has been scanned by an Atomic Force probe which applies force in the plane of the surface, it is often observed that the sample surface has been altered significantly by the atomic force probe. 'Tapping Mode' probes, however, have been shown not to disturb molecular/atomic interfaces, even after numerous scans.

Other types of scanning probe have subsequently been developed - including sensor probes for electric and magnetic fields. These techniques are especially relevant for the investigation of semiconductor structures and optical/magnetic media.

Within the space of 10 years this has provided an array of techniques to image the world at the atomic level. It should be borne in mind, however, that such images are derived from

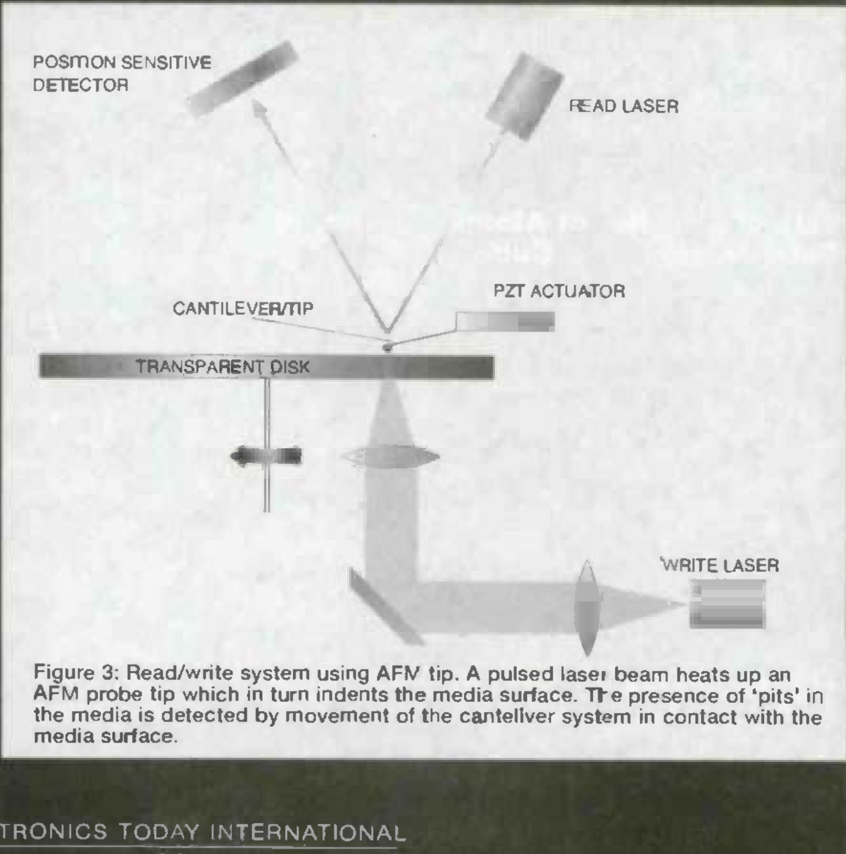


Figure 3: Read/write system using AFM tip. A pulsed laser beam heats up an AFM probe tip which in turn indents the media surface. The presence of 'pits' in the media is detected by movement of the cantilever system in contact with the media surface.

transducer parameters such as tunnelling current, atomic contact force and tip oscillating amplitude. The visual reconstruction interface of such systems provides a reconstruction image of such structures. While with electron microscopy pictures usually appear in grey, the images of atomic scale microscopy are usually shown in tasteful pinks and blues. The colour rendition, however, has more to do with art than science.

Led by the drive towards further miniaturisation of circuits in the semiconductor industry and also the demands of mass storage for magnetic and magnetic/optical systems, such systems for visualisation of structures at the atomic scale are directly helping to refine such fabrication techniques and will as a result permit such industries to maintain general trends towards greater miniaturisation.

Such imaging technology is also available across a much broader range of scientific endeavour. There is considerable scope, for example, in medicine and the life sciences to observe what is taking place at the atomic/molecular level. Such technology is significantly accelerating the pace of scientific development.

Playing with atoms

It was some time, however, before researchers realised that it was possible to work with individual atoms and move and arrange them in specific patterns. Eigler and Schweizer of IBM's Almaden Research Center at San Jose in California announced in 1990 that they had successfully arranged xenon atoms on a nickel substrate at a temperature of liquid Helium - 4 K and under conditions of high vacuum. Initially the STM image observed was of individual atoms arranged at random. Each atom is sensed as a 1.6 A high bump with a tip bias of 0.01 V and a tunnel current of 10-9 A. In order to 'pick up' an atom, the probe tip is moved over a selected atom, the tunnel current is increased by a factor of around 10 which causes the probe to approach the atom more closely. In this mode the force of attraction of the atom to the probe tip is greater than that of its attraction to the nickel surface and the atom can be moved by the operator. To disengage the tunnel current is reduced to previous image only value and the probe tip withdraws. The atoms of xenon, however, require to be placed at stable positions of the nickel crystal. This is how the arrangement of atoms looks 'neat'. The demonstration of this ability to manipulate individual atoms for days at a time was to encourage others to replicate such experiments. Before long all sorts of images had been created at the atomic level.
Later in 1991 Eigler was able to report that he had demonstrated a single atom switch using STM technology. The so-called atom switch is shown in Figure 2. The lower array of atoms consists of nickel atoms. The upper set of atoms are those of the probe tip of the STM. In imaging mode the STM imaged a xenon atom on the nickel surface - using a tip biased at -0.02 V. By pulsing the probe tip with a pulse of 0.8 V for 64 ms the tunnel current increased by a factor of around 8. In this mode the xenon atom had been transferred to the STM probe tip. The application of a pulse of -0.8 V restored the tunnel current to its initial imaging mode - the xenon atom is back on the nickel surface. It is conceivable that logic arrays could be designed at the atomic level. Manipulation of atoms has also been carried out successfully at room temperature.

Quantum Corrals

IBM broke new ground when it reported in 1993 what happened when so called 'quantum corrals' containing 48 iron

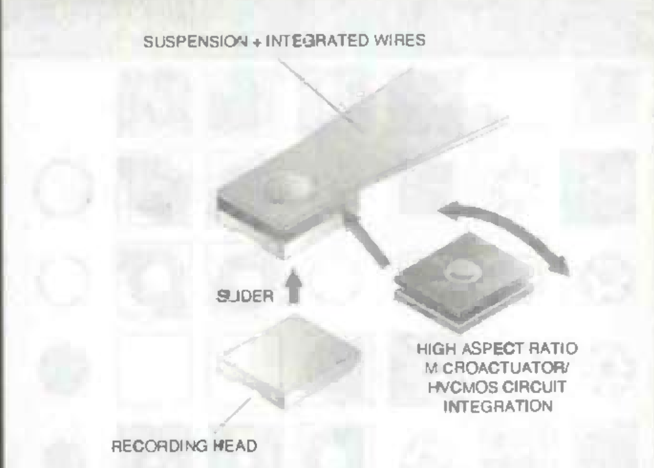


Figure 4: Incorporation of microactuator into the main suspension arm of the read/write head using magnetic recording technology. (Courtesy IBM)

atoms were assembled on top of a copper crystal surface. When the structure with a radius of 71.3 A was scanned with tunnelling spectroscopy, a series of resonances in the form of concentric rings were observed. These wave resonances were interpreted as a direct demonstration of the distribution of electrons within the confines of the ring of atoms. This is a direct indication of how the configuration of atoms in such a structure can influence the electron energy states. This may have applications in development of special waveguide structures and in probing structures of superconducting materials.

Data Read Write with Atomic Force Microscope tip

The development of atomic force microscopy, where surface contours are 'sensed' by a cantilever force tip is finding direct application in developments in mass storage. The write media used is a thin film of heat-sensitive material such as polymethyl methacrylate (PMMA) which has a softening point of 120 oC. The tip of a pyramidal AFM probe is in contact with rotating media. A pulsed laser on the underside of the media causes the probe tip to rapidly increase in temperature with the result that the probe melts a 'pit' on the media surface. Pulse times are as short as 0.3 us in present systems. In the 'read' mode, the cantilever/tip deforms as it detects pits on the media surface. This small movement is detected by a position sensitive detector which detects a beam reflected off the oscillating cantilever. The read/write system is shown in Figure 3. The size of a typical pit is around 150 nm across.

It could well be that mechanical deformation of surface at this level of resolution will provide the more dense storage than magnetic or optical technology. Pits on a CD must be several wavelengths of light in size. For a pit of diameter ten times the wavelength of red light of 670 nm, this is 6700 nm. If the pit size in decreased by a factor of N, the data storage capacity increases by N squared.

This technology, first reported in 1992, is actively being developed as a potential successor to existing magnetic type mass storage systems. Researchers at Stanford University are currently investigating systems using large arrays of around 100 such cantilever probes in parallel.

Microactuator for advanced data storage

It is widely anticipated that significant enhancements in mass storage capacity will be derived from spacing data tracks closer together - whatever technology is used to record the

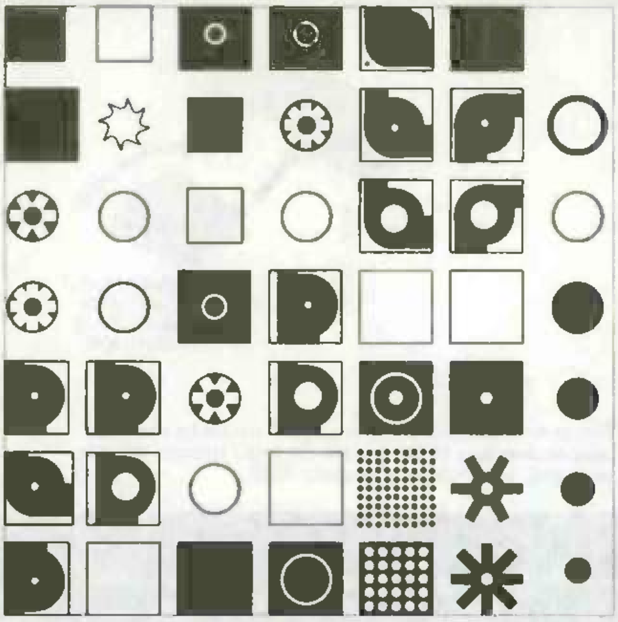


Figure 5b: Mask structure used for the fabrication of microturbine components. (Courtesy CMF at RAL)

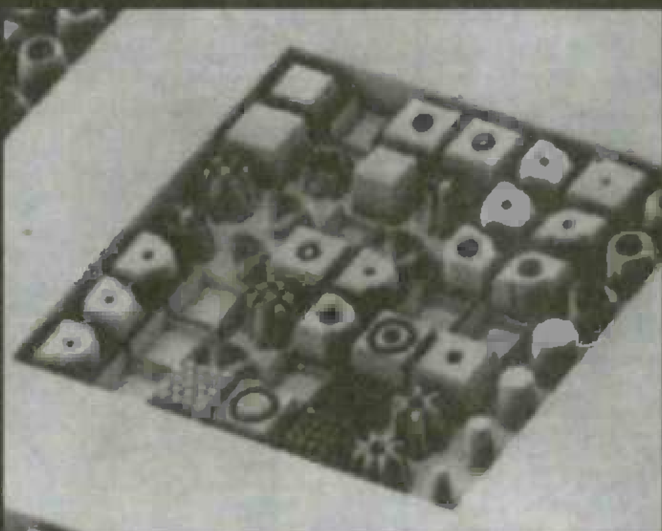


Figure 5a: Components in polyimide fabricated by use of mask/laser ablation. (Courtesy CMF at RAL)

actual data. It has become obvious, however, that the conventional voice call position system which presently can cope with track densities around 4,000 tracks per inch will be unable to access anticipated track densities of 25,000 tracks per inch by the year 2000. This high track density is consistent with data capacities of 25 Gb/in2.

It has been determined that the solution to this problem is to design a two-stage servo system where large-scale movements are undertaken using conventional servo systems (voice call) and smaller motions are undertaken by a microactuator which is lightweight and can undertake accurate ultra-small controlled movements.

Figure 4 indicates how the microactuator is incorporated into the main suspension arm of the read/write head using magnetic recording technology. The microactuator - around 1 mm square - is required to accelerate a mass of several mg at 10 G. Electrostatic microactuators have been successfully developed which can achieve displacements of several microns. The key, however, to using this technology successfully is to integrate large scale movement and small scale movement within independent servo feedback systems. A joint research programme is currently underway at IBM's Almaden Research Center and the University of Berkley, California.

The trend for the future, however, in media storage using moving media surfaces is obvious. Research is going to develop micro mechanical structures down through the micron (1000 nm) mark into the sub micron (100 nm) mark and below. At the 100 nm level the track separation is going to be around only 400 atoms wide.

The making of things

At present, there is a clear perspective of how things have been made by man over the millennia. Take as the first example the manufacture of flint tools. Using simple techniques, flints for both industrial applications (e.g. hide scraping) and ceremonial use (exotic flint daggers) were the pinnacle of achievement of hand-crafted goods. In time, the smelting of bronze became the dominant material for creating all manner of artifacts such as swords, axe heads and ornaments.

Throughout the industrial revolution, the fabrication of complex structures such as delicate clockwork mechanisms developed. It was, however, in the 20th century in the semiconductor industry where techniques of micro fabrication of semiconductors that the drive towards ever smaller structures has made most progress.

At an economic level the significance of semiconductor fabrication techniques is self evident. Major trading blocks do not want to lose their market share of such technology - witness the involvement of the USA, Europe and Japan to establish and maintain leading edge industries in this area.

While the economics of semiconductor fabrication techniques are at the heart of mainstream research and development, the use of microfabrication techniques for other applications are distinctly less well defined. It is probable, however, to distinguish two separate approaches. The conventional approach is to create micro components such as gears or elements of conductors etc using techniques which include laser ablation and micro fabrication and etching. The second approach is to assemble structures directly at the atomic level as first demonstrated by scientists at IBM Almaden Research Laboratory in 1990.

Prior to the development of the scanning probe microscope, there was always some reluctance to believe that individual atoms could be manipulated in this way. It always been pointed out, for example, that each atom would have vibrational energy of the order of kT (k Boltzman's constant and T = absolute temperature). The achievement, however, gave considerable comfort to a small core of theorists who had mapped out in thought experiments how structures could be assembled - atom by atom into useful structures.

Central Microstructure Facility at Rutherford

While various centres in the UK are developing the area of nanotechnology, the Central Microstructure Facility at Rutherford Appleton Laboratory at Chilton in Oxfordshire has a wide range of systems used across a diverse range of scientific disciplines. Microstructure fabrication is taken to apply to structures where dimensions and tolerances are 100 nm or less. Photomasks for circuit design tend to use electron beam lithography while fabrication of microstructures can be undertaken using electron beams, focused ion beams and excimer lasers in association with protective masks.

There is particular interest in developing quantum devices which are able to exhibit discrete quantum effects - such as the detection of single electrons. Semiconductor structures can also be grown one layer of atoms at a time using a process of molecular epitaxy in order to create two-dimensional layers of charge carriers only 10 nm thick.

Thus while conventional electronics deals with aggregate events of large numbers of charge carriers, such quantum devices are being developed to demonstrate discrete 'lumpy' events such as the passage of an electron across a gate. The LIGA (Lithographie Galvanoformung Abformung) technology uses hard synchrotron x-rays to etch relatively deep structures - between 20 u and 1000 u. A gold mask of 20 u thickness is used to protect areas where no erosion of material is required.

Mask-making is a key requirement for a wide range of microfabrication techniques. With conventional technology now utilising gate widths of 0.5 u, a range of techniques are being developed to achieve line widths of less than 0.1 u (100 nm = 400 atoms wide). Such masks are used as a key stage of semiconductor fabrication techniques using lasers and LIGA methods.

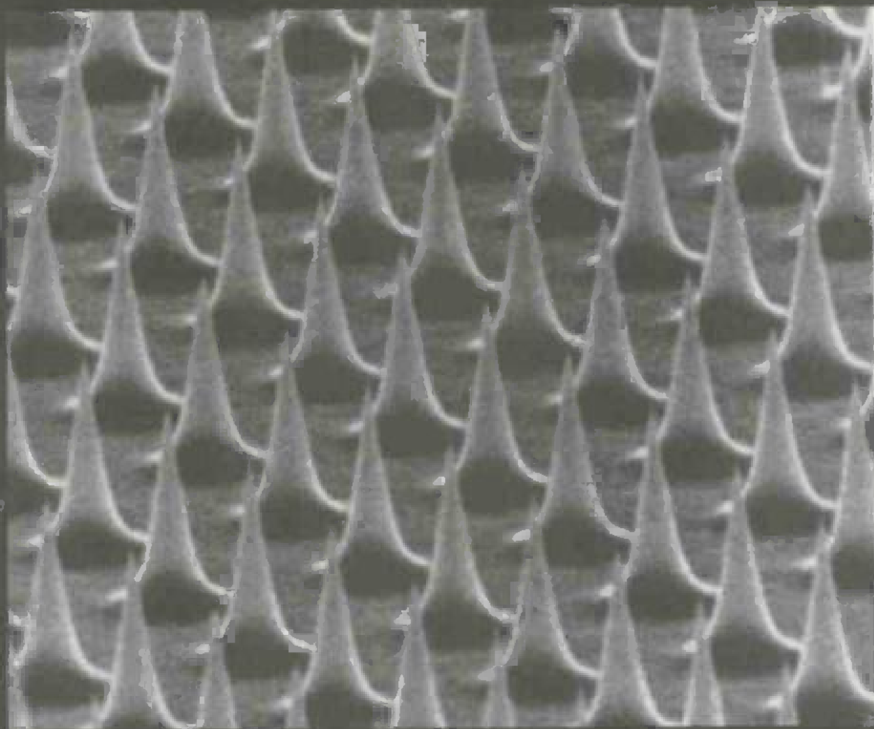
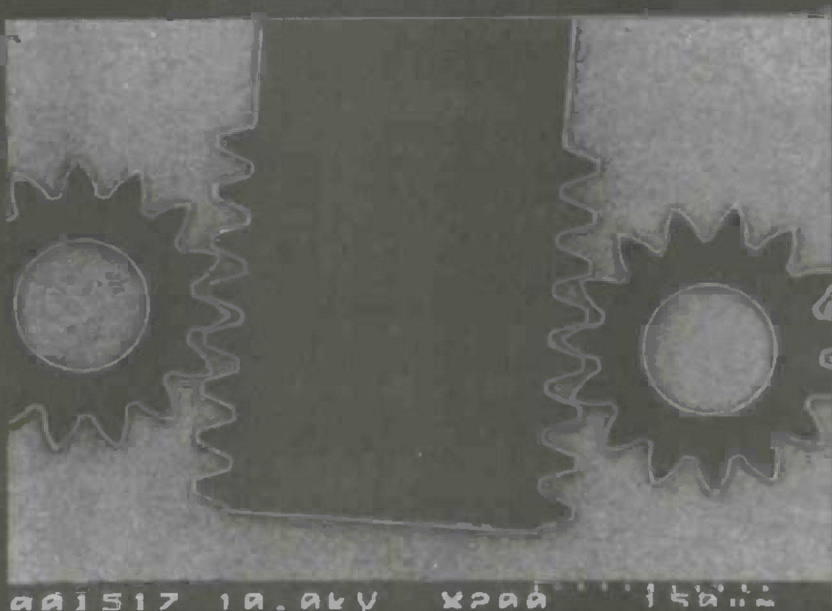


Figure 6: An array of sub- 10 nm diameter silicon field emitter tips manufactured by a novel CMF process at RAL. (Courtesy CMF at RAL)

Excimer lasers at 193 nm have been successfully used for micromachining. The masks used with such lasers, however, require to be capable of withstanding over 109 laser pulses. The CMF unit has successfully developed a multilayer dielectric stack capable of withstanding such a level of exposure. Figure 5a shows components in polyimide created for a chrome on quartz mask for a microturbine project. Using a mask and excimer laser at 248 nm, material was ablated to a maximum depth of 125 nm. 200 laser pulses were delivered in 4 seconds. The level of laser energy density was 1.5 J/cm2. Figure 5b shows the pattern of the original mask used to fabricate these devices. The successful production of components indicated that in this production mode excimer lasers could provide relatively cheap alternative methods compared with conventional LIGA processes.

Figure 7: A micro gear assembly produced by a 50 keV electron beam lithography in 4 um PMMA resist using surface image bilayer and reactive ion etching. (Courtesy CMF at RAL)



As indicated previously there is considerable interest in exploiting the characteristics of the atomic force microscope in diverse areas of technology. Figure 6 indicates an array of sub- 10 nm diameter silicon field emitter tips manufactured by a novel CMF process. Such units are being considered for flat panel displays and atomic force microscope probes.

Figure 7 indicates a 50 keV electron beam lithography in 4 um PMMA resist of a micro gear assembly. The methods used included a surface image bilayer process and reactive ion etching.

Conventional matching techniques can still be used successfully for fabrication of small structures. Figure 8 indicates the components of a prototype microturbine for eye surgery produced at RAL's microwave workshop. The unit was machined in brass. The rotor is 1.5 mm diameter and the casing 2 mm x 4 mm x 0.5 mm. Powered by water flow, the unit is capable of 3000 - 12000 rpm.

There is clearly, however considerable scope for techniques such as laser ablation in manufacture of components. Key aspects of such techniques are maintenance of uniform intensity over mask area and robustness of the photomask. The uniformity of the target material is also a factor.

Biomimetics

There is no doubt that the development of technology in the 20 th century has significantly helped by the development of a wide range of new materials - especially plastics and ceramics. As material scientists investigate the options of nanotechnology - the fabrication of structures at the atomic and molecular level, significant research is being undertaken to discover what nature has done well and the replicate this. This process of emulating

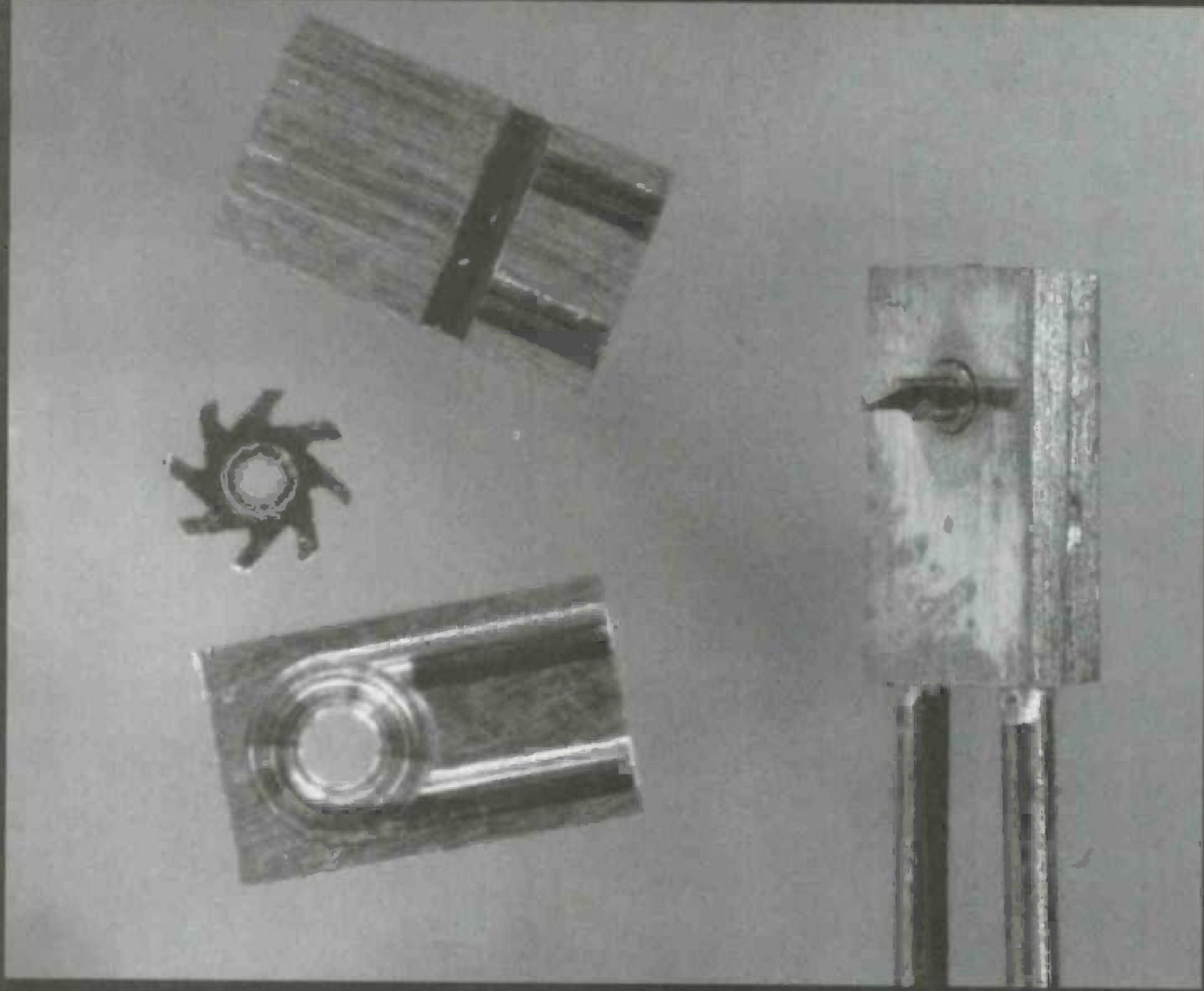


Figure 8:
Prototype microturbine 2 mm x 4 mm x 0.5 mm for eye surgery: Machined in brass by RAL's microwave workshop. (Courtesy RAL)

nature is called Biomimetics.

In particular, there is interest in developing ceramic materials which have the residual strength of bone and mother of pearl. Investigation of such natural compounds shows that ceramic particles are very small and isolated from each other within a protein matrix. This makes such structures less liable to fracture.

Nature also produces compounds very efficiently in terms of energy. By comparison, man-made compounds typically require significantly higher levels of energy for their fabrication and as a byproduct create pollutants. The process of manufacture derived from Biomimetics as well as creating materials with improved structures should also lead to consumption of less energy and be less polluting. This general drive towards more 'natural' materials is illustrated in Figure 9.

Enter Eric Drexler

While Feynman is recognised as having first defined the challenge of nanotechnology, Eric Drexler has become a key individual involved in the further development of its theory. Eric Drexler was some four years old when Feynman gave his talk in 1959. During his study at MIT, Drexler became drawn to studies in space science in fields primarily related to the conquest of space and the migration of humanity out into the galaxy. For Drexler, space travel was the solution to humanity's problems. Space travel would provide more resources, more opportunities - more challenges. Drexler became involved in the design of light sails that could be used for the propulsion of craft within the solar system. The key part of this technology would be to fabricate aluminium foil of a few atoms thickness so that very large sail arrays could be fabricated from small amounts of aluminium.

It was during the mid 1970's that Drexler began to form concepts of nanotechnology where processes of production could be undertaken at the atomic level. He was, however, inclined not to publish his theorems openly. He had serious reservations, however, about the down side of such technology. A key aspect of Drexler's vision was that of self replicating units or 'assemblers'. Once such units were made it was proposed that they could be programmed to self replicate - like cells of the human body. For Drexler this was seen to present vast risks.

Drexler became convinced that he should maintain a public silence so that society as a whole would be able to postpone for as long as possible the day when it would have to confront such controversial technology. At this point Drexler had been unaware of the ground breaking work of Feynman in 1959. It was with mixed feelings that Drexler read in the November 1979 issue of Physics Today a review of nanotechnology - citing Feynman's talk some 20 years previously. From this point it was evident to Drexler that nanotechnology was moving into the public domain where all its diverse pros and cons were already being debated. Drexler would seek to clarify his concept of nanotechnology by writing scientific papers and presenting tutorials. His book, Engines of Creation, was published in 1986.

In the present, Nature is the Great Assembler. Cells grow, cells multiply - using DNA to continue the identity of their function. Each unit of identity corresponds to an assembly of around 50 atoms. Bacteria also replicate and at an even smaller scale viruses invade cells and hijack their genetic material. The world of living things replicate with remarkably few errors using systems which have slowly evolved for thousands of millions of years.

In Drexler's vision of the future, a man-made unit called an assembler would be able in the first instance to assemble atoms into a pre-determined structure. This could involve, for example, seeking out a molecule of dioxin and rendering it harmless. This could involve manufacturing hydrocarbon fuel from the molecular structure of leaves and grass. In this bright perception such devices could meet all of humanity's needs for energy, food, raw materials etc. Nanotechnology had become not just an interesting curiosity. It would be the means of total global domination of all processes. This could be both the environmentalist's final nightmare or the dawn of a New Green Age. As with the very early work now being undertaken on genetic engineering, developments tend to be linked to commercial returns. The stability and welfare of the eco system is not the prime directive. Will this also be the path followed by nanotechnology?

The other property of these assemblers would be self replication. This would be essential for setting up unit manufacture so that processes could be undertaken at bulk level. Skeptics, however, have indicated the view that while as a thought experiment such concepts are highly creative and lead to all sorts of lecture tours and stimulating social engagements, there is as yet no possibility of constructing such nanomachines.

As part of the Brave New World concept expounded by Drexler, there is also room in his philosophy for the defeat of human ageing and the colonisation of space - very much also in conflict with any theory that would tend to limit the growth of human potential and the world economy and force humanity to 'fit' in with natural ecosystems.

The most recent book published by Drexler 'Nanosystems: Molecular Machinery, Manufacturing and Computation' is brim full of complex equations which seek to define and model the behaviour of atomic based structures.

At this very early stage in nanotechnology, it is simply not possible to envisage how the concept of 'intelligent' atomic assemblers can be realised. It is clear, however, that they could not be developed until well into the next century if at all.

Atomic football and atomic Lego

The existing experience, however, of 'atomic football' give some clues about what may be possible. The atomic switch experiment indicates how an atom could be picked from a surface, and then replaced. There is also the accuracy with which individual atoms can be located. In the (X,Y) plane this is of the order of 0.1 A or better. The key to any kind of useful atom by atom manipulation - 'atom Lego' is going to be high levels of automation. Assuming a constant supply of atoms from an 'atomic hopper' which could be 'injected' onto a set surface 100 nm x 100 nm in size it is possible to do some quick sums to estimate the translational speed of the scanning tip.

Assuming the atoms are 0.25 nm apart, the 100x100 nm surface corresponds to an array of 400x400 atoms. If it is assumed that these 160,000 atoms can be placed in 10 seconds, then the time between placements is 62.5 us and the tip velocity is approximately 4000 nm/s. This speed is something like 10,000 times faster than the STM probe that moved the xenon atoms in IBM's logo in 1990.

This system for atomic placement obviously requires a highly developed actuation system - of a type which has not yet been developed. The history of STM and AFM technology, however, does indicate that the breakthroughs in this area tend to come unlooked for. It may be possible, for example, to fabricate tubes made from carbon - as variants of Buckminsterfullerines and use these as components of atomic hoppers. Atoms could be pulsed along stacks using electrostatic actuators. There's room at the bottom for a lot of invention.

Enter MEMS

The new buzzword within the nanotechnology world is Micromechanical systems or MEMS. Already whole new ranges of devices and products - many of these unfortunately of interest to the world's defence industries - are on the drawing board.
MEMS is a technology area where miniaturisation of components makes possible distinct new products. A small set of examples cited so far include distributed unattended sensors for asset tracking and environmental/security surveillance, miniature analytical instruments, embedded pressure sensors for tyres, electromagnetic beam steering, active structural control and inertial measurement.

MEMS is not primarily about forcing technology to the atom level of fabrication and design but designing new products to take advantage of the existing levels of electronic microfabrication. MEMS is going to have very significant economic importance as it embraces a diverse set of new products, processes and activities in the next century.

Summary:technology overlap

Figure 10 indicates regions of atomic fabrication using two main technologies. Structure A corresponds to what could at present (with some patience) be assembled from hand moved atoms - an array of atoms 20x20. Structure B corresponds to structures fabricated using mask fabrication technology. The current lower limit of structures is around 0.1 nm. In time the two areas will overlap - indeed it may be the case that they already overlap.

It is clear, however, that the 'atomic Lego' approach will require significant development of microactuators which can combine high acceleration and excellent stability. There is no reason to doubt that this area of technology will be developed in the future. Also, the era of responsibility for nanotechnology is already with us.

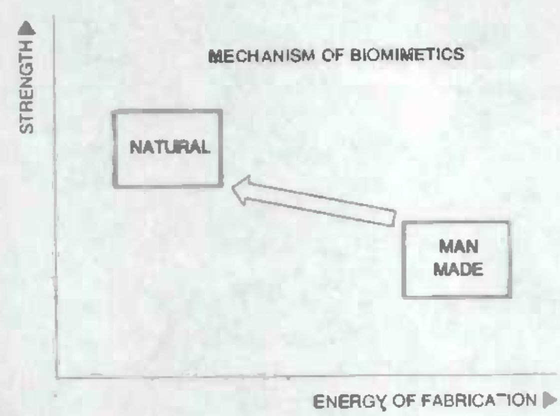


Figure 9: Comparison between 'natural' and 'man made' materials expressed in terms of strength and energy required for fabrication

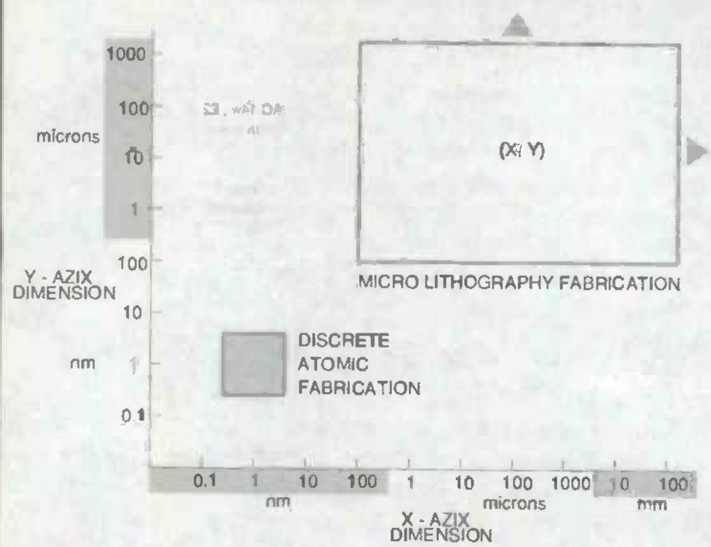


Figure 10: Extent of A - 'atomic Lego' fabrication of atoms and B - fabrication using mask technology.

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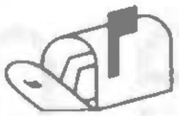

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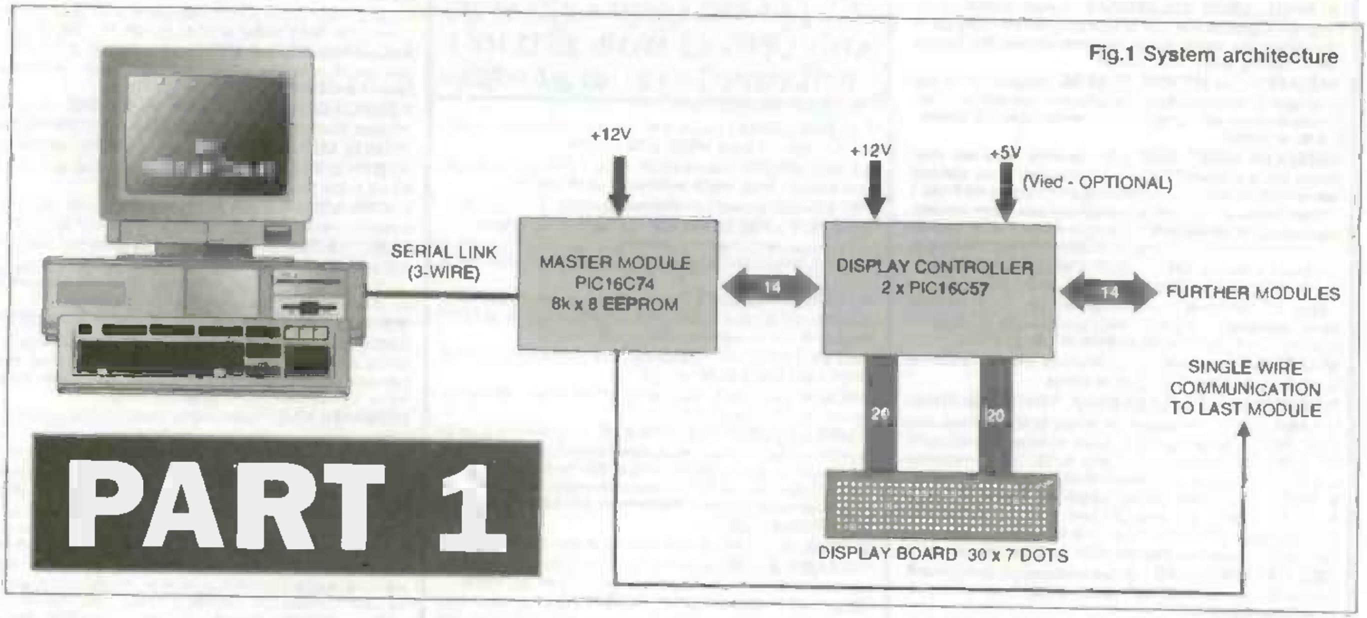


PART 1

LED matrix message display

Robin Abbott looks at the construction of a LED Matrix message display driver

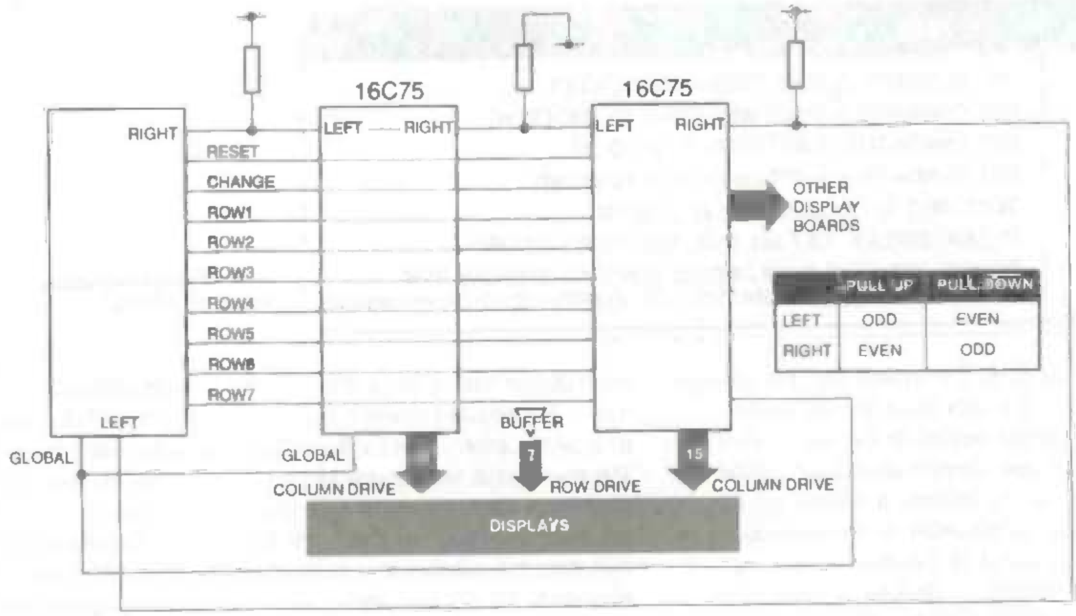
This article describes a project for driving an LED matrix display used for public announcements, such as these seen in post offices, airports etc. Apart from offering some unique features, it provides an insight into the problems of running a system with a large number of microcontrollers which all have to operate, synchronise and communicate in real time. It was designed originally for an amateur theatrical production, and offers the following features:

- The basic unit of six 5x7 displays (offering a display of 30x7 LEDs) can be stacked lengthways theoretically to an infinite number of modules (in practice around 20 modules for a display of length 600 dots, or 20 metres !)
- The system is set up from a PC running Windows software.
- The controller module contains an 8Kx8 EEPROM allowing very long messages to be stored and run in a loop automatically, and then the module can be operated independently of a controlling PC.
- The fonts used by the module are also stored in the controller EEPROM, allowing user defined fonts to be designed on the PC and downloaded at will.
- Control from PC allows messages to be sent directly from the PC to allow messages longer than 8K to be used, or to allow very rapid message change, or even to display messages as they are typed.
- Messages may be scrolled left and right, and may be scrolled up and down off the display.
- Display effects include variable brightness, message pausing, variable scroll speeds, flashing text and inverted text.
- Uses standard 5x7 LED display blocks, although in practice any short persistence display technology may be used.
- Multiplexed design minimises on system connections, and allows very high pulse drive currents for maximum display brightness.

The commercial applications of electronics are becoming so widespread, that the only reason for home constructors to embark on a project must be that it is available considerably more cheaply than commercial equivalents, or that it offers features unavailable commercially. This project falls into the former category. For each 5x7 display the cost of the display driver is about £3.50 plus the cast of the displays. In addition there is a controller module which should cost about £22.00. Thus a complete display with eighteen 5x7 displays (90 by 7 dots) can be built for under £100. The only comparable project that I could find available as a kit costs around £100 for a display of 16 dots by 8 dots !

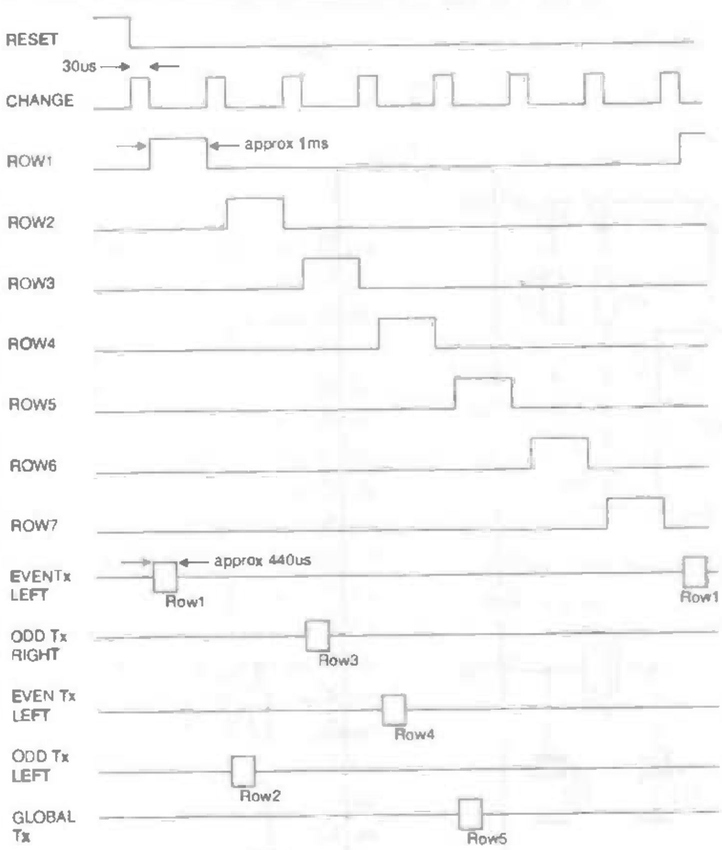
Architecture

There are three basic modules for the display driver. These are illustrated together with their connections in Figure 1. The master module contains a PIC16C74, together with the 8Kx8 EEPROM device which is used to store the fonts and messages to be scrolled. This module communicates to the PC using a 3-wire serial interface (RS232), running an



	PULL UP	PULL DOWN
LEFT	ODD	EVEN
RIGHT	EVEN	ODD

Fig.2 Communications architecture



	TRANSMIT	RECEIVE
LEFT ODD	2	4
LEFT EVEN	1	3
RIGHT ODD	3	1
RIGHT EVEN	4	2

Fig.3 System timing program (not to scale)

XON/XOFF protocol. For each block of six 5x7 displays there is a single display controller board which uses two PIC16C57 devices. Each display controller board communicates to adjacent controller boards and to the master module using a 14-way IDC cable. The display board holds the 5x7 LED displays and is connected to the display controller board using two 20-way IDC cables. Finally there is a single communication link between the last module in the chain and the master module.

Each display controller board contains a 5V regulator which may be optionally used as the power supply to drive the displays. However, with higher drive currents the LED displays may use an external power supply. The master module contains a single 5V regulated supply. Power consumption for the prototype (which operated at 30mA drive current per dot) averaged at around 200mA per display controller and display board, rising to over 600mA when all dots are driven. This allowed several hours of battery operation using sealed lead acid technology.

The operation of the system is complex, and a full understanding is not necessary for its construction. However, an understanding of the operation of the system may be useful for other designers of real time systems using microcontrollers.

System operation

Figure 2 shows a block diagram of the communications paths used in the operation of the system and Figure 3 shows the system timing diagram. Figure 2 shows the system as configured with only one display controller module. The display controller module contains two PIC46C57 devices shown on Figure 2. One of the devices is termed "odd" and one "even". Each device has one serial communications path to the right, and one to the left which connect to adjacent devices. The master module also has a left and a right communications serial path which connect to the two PIC15C57 devices at each end of the chain of devices.

Multiplexing

The system operates on a time division multiplexed scheme. Each row is turned on by a row drive signal from the master module. Each row is turned on in sequence, and is driven for about 990uS. Before each row drive is turned on, the master

GLOBAL COMMAND	EFFECT
COMMAND 0	SET CHARACTER SHIFT DIRECTION TO LEFT
COMMAND 1	SET CHARACTER SHIFT DIRECTION TO THE RIGHT
COMMAND 2	SET CHARACTER SHIFT DIRECTION TO UP
COMMAND 3	SET CHARACTER SHIFT DIRECTION TO DOWN
COMMAND 4	TEST - SET ALL COLUMN DRIVES TO ON
COMMAND 5	CLEAR DISPLAY - SET ALL COLUMN DRIVES TO OFF
COMMAND 6	DURING THE NEXT ROW 7 DRIVE, SHIFT ALL DISPLAY RAM IN THE DIRECTION SET BY THE LAST SHIFT DIRECTION COMMAND

Fig.4 Global commands and their effects

module sends a change signal on the change line. The change signal is about 30uS long and is also driven by the master module. It informs all the 16C57 devices in the system that the row is to be changed. The reset signal is also driven by the master module to synchronise all devices. It is sent high for about 1 second following a system reset (or on command from the PC). During the change signal all row drive signals are turned off. This allows the PIC16C57 devices to change the column drive signals without disturbing the display.

Following the reset signal, which is active high, the first change signal causes all the 16C57 devices to shift to row 1. Each device then turns on the dot drives for the columns for row 1. Subsequent change signals cause the 16C57 devices to drive the information for the columns for each row in turn. The row signals are not used by the 16C57 devices directly; they count the current row from the change signals synchronised from row 1 after the reset signal. For efficiency of switching the column drive from row to row within the 30uS allowed by the change signal, each 16C57 calculates the next information to be driven to each column for a row whilst the last row is still being displayed.

As the row drive signals are not used by the 16C57

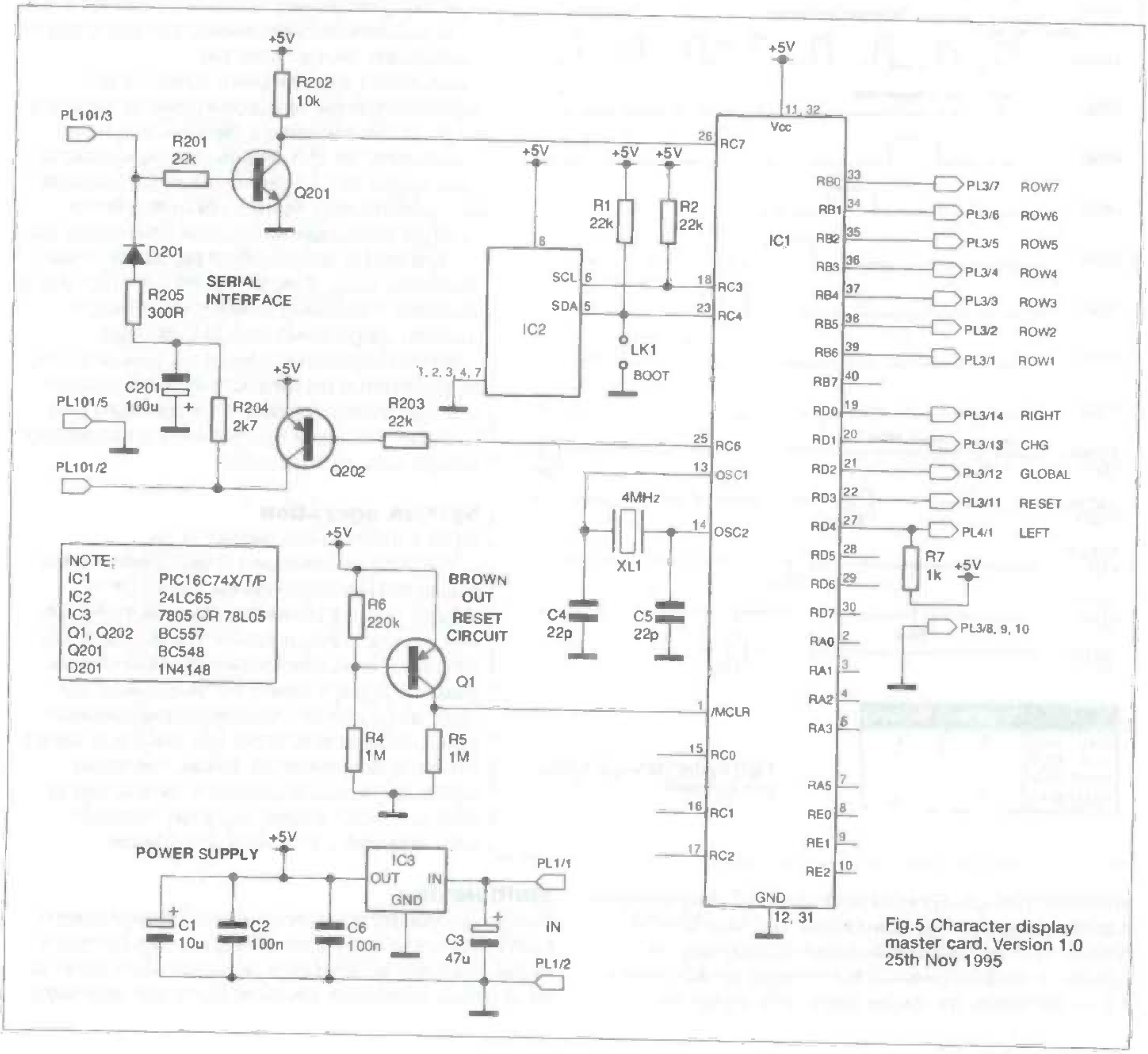


Fig.5 Character display master card. Version 1.0 25th Nov 1995

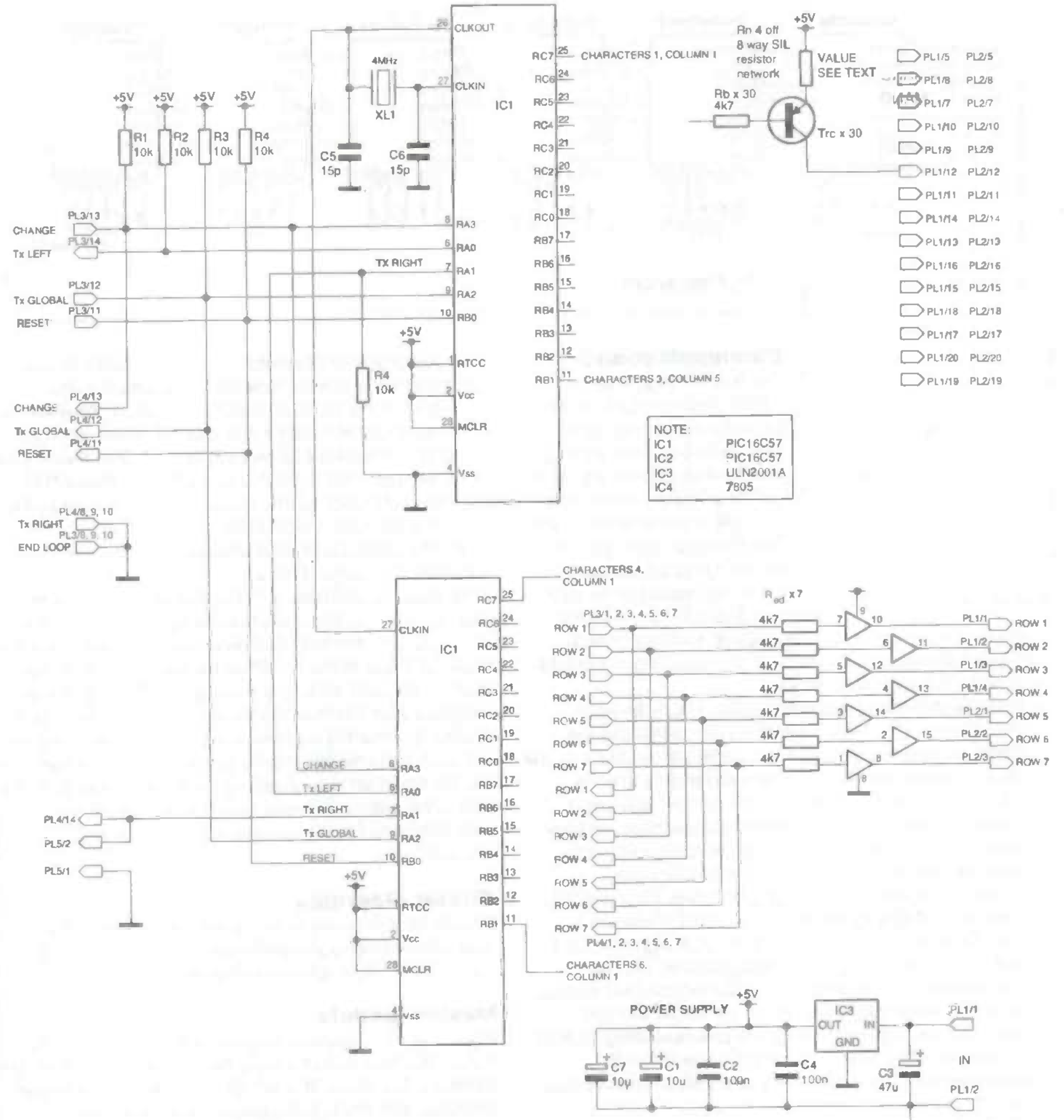


Fig.6 Character display controller card

devices, they can be controlled by the master module to control display effects. The master module turns off the row drive signals for 250mS, and then back on for 250mS to create the flashing effect. To control brightness, the master module turns the row drive signals off for between 1 and 3 multiplexing cycles for every multiplexing cycle which it is turned on; this effectively dims the display. Flashing and dimming effects may be combined.

During flashing and brightness effects the change signals and communications signals are maintained, this allows the 16C57 devices to remain in synchronism and to continue shifting characters on the display.

Each 16C57 maintains an area of 15 bytes of RAM which hold the column drive information for the 15 columns driven by each device. To decide on the next information to be driven to the columns of the display, the bit corresponding to the row to be driven is tested in each byte of RAM, and if it is set then the corresponding column drive bit is set. When shifting characters across the display (left or right) the 15 bytes of RAM are shifted one to the left or right; the byte to be shifted into the edge of the display is obtained from serial communications on the left and right ports.

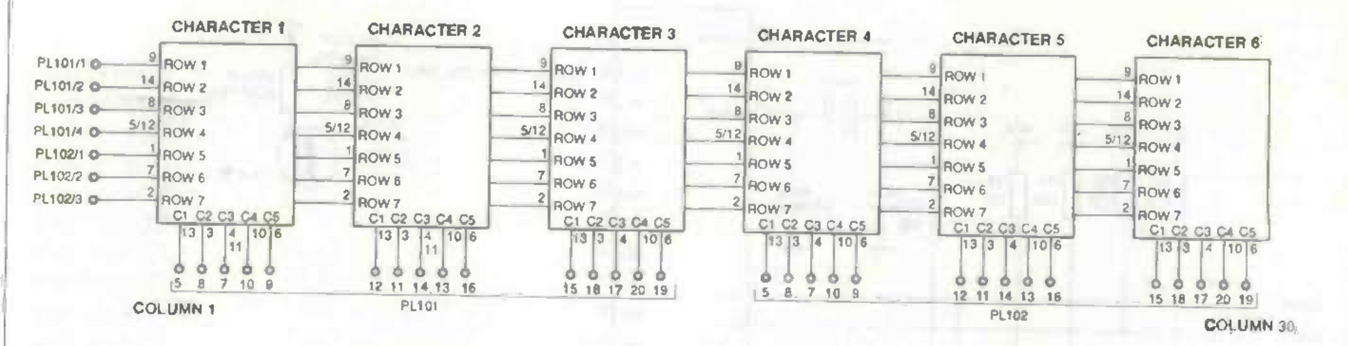
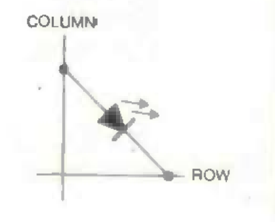


Fig.7 Display card



Communications

The code running in each 16C57 device is identical, and the program running detects whether it is an even device or an odd device by the pull up or pull down resistors on its left and right communications port. An odd device has a pull up resistor on its left port and a pull down resistor on its right port. Even devices have the opposite directions of pull up and pull down resistors. In Figure 2 the leftmost 16C57 is an odd device, and the right hand 16C57 is an even device.

There are three communications paths in total for each 16C57, the left and right communication paths, and the global communications path. The global path is driven by the master module and communicates commands to every 16Ç57 device at the same time. The left and right paths operate at different times in the multiplexing cycle, and are used to send information about the display pattern to be driven on adjacent 16C57s when the display shifts.

All communications operate using the same serial protocol. Each bit is 40uS long (resulting in a 25KHz transmission rate). To send a single 8 -bit word an 80uS high start bit is sent first, followed by a single 40uS low start bit. This multiple start bit is to allow for two different devices working on slightly different timing (such as the 16C57 and the 16C74 on the master module when communicating) to take a common timing from the start of the low timing bit. Following this the 8 data bits are sent LSB first, active high for a '1' bit.

The full timing diagram for communications is shown in Figure 3. During rows 1 to 4 each device in the system (including the master module) transmits and receives on their left and right ports. The actual rows used depend on whether the device is even or odd as shown in Figure 3.

There are two types of information sent on left and right ports.

The first is display information. The byte received on the left port is the next byte to be shifted into the leftmost edge of the display on the next right display shift. Similarly, the byte received on the right port is the next to be shifted into the rightmost edge of the display on the next left display shift. Display information is sent with the pattern for the column in bits 6 to 0 of the received byte; bit 7 is always set for display information.

The second type of information to be sent on the left and right ports is command information. Currently the only command sent is the module command count. Whenever a byte is received on the right port with bit 7 reset, and bit 6 set, then one is added to the byte, and it is then transmitted on the left port. This is used to count the number of 16C57 devices TRANSITED by the module count command and to determine the total display width.

Finally, the global commands are used for a number of purposes as shown in Figure 4.

Thus, to shift a character left onto the display, the master module sends the bytes which make up the columns of the character, one after the other on its left port (which connects to the right port of the 16C57 on the extreme right of the display). Between each byte it sends a shift command on the global port. On receiving the shift command, the 16C57 devices all move the columns in the display RAM to the left, and each shifts the last display byte received on its right port into the rightmost byte of display RAM. The frequency of the shift commands controls the speed of the display, the maximum speed being achieved with a shift on each multiplex cycle.

Circuit diagrams

Despite the complexity of the system design, the circuits used are reasonably straightforward, all the communications being performed in software in the PIC devices.

Master module

Figure 5 shows the circuit diagram of the master module. Those who have been following the ETI PIC BASIC series will recognise this circuit. The PIC16C74 is used for the master controller, and although the amount of EPROM and I/O provided on this device is beyond the needs of the project it is used because it sports an independent asynchronous serial port. For further details on the 16C74 see the separate panel.

To cut the cost of the crystal oscillator, only one PIC has a crystal oscillator, and its oscillator output is used to drive the oscillator input of the second PIC. A crystal oscillator is used because the timing of communications between PICs in the system is very tight for serial Links of just 40uS per bit with a master clock of only 4MHz.

Each display controller board buffers both column and row drives to the LED displays. The signals for the rows are active high and are active low for the columns. The row drives are buffered using a ULN2001A. This 8 bit Darlington array (which is very cheap) provides a drive of up to 500mA for each row. In practice, the prototype drew nearly 600mA per row when all LEDs were turned on, and higher drive currents require even greater currents when all LEDs are turned on. To meet the drive capability of the ULN2001A, then two of the devices should be connected in parallel. The easiest way to achieve this is to solder a ULN2001A on top of another one, and then solder the bottom device into the board. This will allow up to 1A drive per row (33mA per LED). Increased currents can be achieved by stacking even more ULN2001As !

Each column is buffered by a PNP transistor with a base resistor and an emitter resistor which controls the current drive to the LED. The emitter resistors are actually formed by a SIL resistor network. The prototype used a 75ohm SIL resistor pack which resulted in an LED drive current of around 25mA. The equation for drive current is R=1.9/I, where I is the drive current for the LED and R is the value of the SIL network. The prototype displays could handle a drive current of 75mA with a ImS pulse drive as used in the multiplexed drive, which is achieved with a 22-ohm SIL network. However with this drive current the row drive may get as high as 2A per display module. In the prototype the 25mA drive current gave a display which was perfectly legible indoors in daylight or artificial light. The use of very high drive currents like this is not recommended without some consideration for the power supply, and probably changing of the UL2001A for discrete power transistors. In this case, the raw drive circuit may be capable of driving several modules at once.

Do not be tempted to leave out the PNP buffer transistors for the columns. Although the PIC16C57 is capable of handling 20mA per output pin it is not capable of handling 20mA on 15 pins simultaneously, the output drive for all output pins in total is limited to 100mA.

Display board

Figure 7 shows the circuit diagram of the display card. It contains six 5x7 LED matrix blocks, each of which interlocks with the next display in sequence. The pinout of these displays is standard, and almost any LED block display may be used provided that it has cathodes connected to rows, and anodes to columns. The prototype used surplus displays from Greenweld which cost less than £1.00 each. However, new display blocks are available for around £3 - £4 each, dependent on size and configuration. There is no reason why a LED matrix of 30 by 7 LEDs should not be constructed and a double-sided PCB to handle this would be straightforward to design. However, soldering in 210 LEDs with over 400 leads (and all in the correct orientation) is not a simple task !

A display with columns as cathodes may also be driven. However, this will require inversion of the signals on the controller card. Please contact the author if you would like a version of the PIC16C57 which drives active high signals on the outputs.

The display board connects to the display controller card with two 20-way IDC connectors. Connectors with locking ears should be used for greatest robustness.

The next article in the series shows the component lists, PCB overlays, and how to construct, test and operate the display system.

ELECTRONICS TODAY INTERNATIONAL

Free cover disk

On the cover of this month's issue of ETI there is a free disk containing a copy of Quickroute 3.5 Lite, a comprehensive PCB design program for Windows 3.x based PCs.

Quickroute 3.5 Lite is based on the popular and highly regarded Quickroute 3.5 Personal. The user can create schematic and PCB designs and the full range of 'Personal Edition' editing tools are provided. However, with the version we are giving away the user can only save designs containing 750 nodes or less (a node is roughly equivalent to one pad). In addition although you can create new library symbols, you cannot save them. Printing of designs is enabled, although only in 2:1 scale.

To install Quickroule 3.5 Lite, simply run the program SETUP.EXE included on the disk from your Windows Program Manager. The user will be prompted to enter a directory in which to install Quickroute, and to enter a User Name. The User Name can be any text. Once this has been done, the software will be installed. The manual is available as on-line help In Quickroute 3.5 Lite.

Quickroute 3.5 Personal retails at £68.00 (excluding P+P and VAT) and is supplied without a manual. Rather, the manual contents are available as on-line help. This is done to save money on material and distribution costs so as to keep our entry level product as cheap as possible. However, as a special offer to ETI readers Quickroute are prepared to offer Quickroute 3.5 Personal in a box with a full manual for £99.00 (excluding P+P and VAT). This offer will be kept open until 1st June 1996. Readers will need to send Quickroute (address at the bottom of this article) their cover disk to prove their eligibility for the offer.

For the latest information on Quickroute readers can now contact us over the Internet using either world wide web (WWW) on :

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or on Email using :

info@quicksys.demon.co.uk

The Web page is a good place for users to get the latest information about Quickroute and to download the latest demonstration software, etc. Quickroute 3.5 is available in a range of different versions, the current ones are listed below:

Quickroute 3.5 Personal

An entry level product with support for PCB and schematic drafting. PCBs with up to two copper layers can be designed. The basic set of PCB and schematic libraries are included and the manual is available as 'online' help only (no printed manual is supplied).

Quickroute 3.5 Designer

This product has support for PCB and schematic design. It includes schematic capture which will turn a schematic into a PCB rat's-nest which can then be manually routed. There is support for two copper layers. Basic design rule and connectivity checking is included, and a 'rat check' feature for highlighting rat lines which have been manually routed.

Quickroute 3.5 PRO

This product includes support for multi-sheet schematics (up to eight sheets), schematic capture and supports PCB's with up to eight copper layers. An auto-router is included which has support for automatic via placement. The product supports Gerber and NC-Drill file export, and WMF and Tango net-list export. The extended library pack is also included as is basic design rule and connectivity checking.

Quickroute 3.5 PRO+

In addition to all the features of Quickroute 3.5 PRO, this product includes support for exporting SPICE and DXF files, support for exporting net-lists to SpiceAge using a DDE link, the ability to import Tango (PCB) net-lists, and the ability to import Gerber files. The product also includes a 'copper fill' facility and has the capability of updating a PCB from a schematic net-list ('engineering change').

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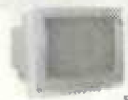

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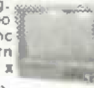

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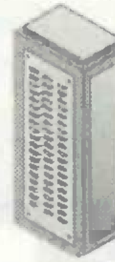

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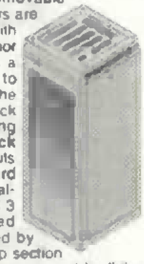

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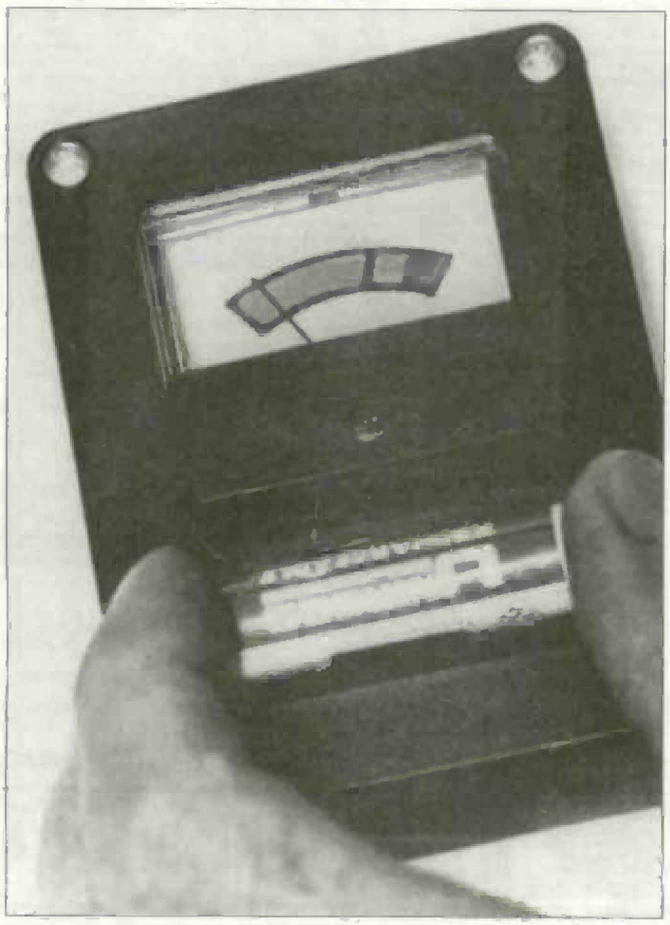
CHARGE

A project from Terry Balbirnie to q

Nickel cadmium (rechargeable) batteries are found in most homes. Typical uses include powering photographic equipment (flash guns, etc.) toys, personal stereos, calculators, razors and small power tools. This article is concerned with checking the charge state of the most popular variety - the "AA" size sometimes known as SP7/HP7, UM3/AM3, MN1500, R6/LR6/RX6 and Penlight among others. Some of these terms really apply to the non-rechargeable equivalent but they are widely used to describe any cell of this size. Simply by substituting the battery holder on the unit with a different one, this tester could be used to check various other sizes of nickel-cadmium cell.

Charge Check is extremely easy to use; the cell to be tested is placed in the holder and a meter read. The pointer shows green for good, yellow for serviceable and red for flat. Current is drawn from the cell itself so no internal battery is needed. The unit will therefore always be available for use. It will not give consistent readings if it is subjected to wide temperature variations. However, it will operate correctly over the "normal room temperature" range.



Cell cheap

Since "AA"size nickel-cadmium cells may now be bought for about £1 (if you shop around) and with a throw-away alkaline one costing around 70p, there is very little difference in price. Nickel-cadmium cells are therefore often used to replace ordinary ones. Taking into account the cost of a charger, long-term savings can be substantial. These cells may be re-charged many times - as much as 10,000 in theory but usually 500 to 1,000 times in practice.

Unfortunately, the capacity of this type of cell is considerably less than the equivalent alkaline variety. In use, they therefore run down more quickly. They also discharge fairly rapidly even when not being used. This self-discharge effect may amount to a 50% loss in only 12 weeks. This is why some means of measuring their state of charge is helpful. Typically, an alkaline cell has a capacity of 2Ah. This means, in theory, that it could deliver two amps for one hour. At this high rate, it would probably not succeed for the full time and it would be more realistic to say that it could provide, say, 20mA for 100 hours. The most common nickel-cadmium "AA" cell has a capacity of 500mAH (0.5Ah) - that is, about one-quarter the charge. There are several members of the same family having higher capacities - 700mAH, 850mAH and 1.2Ah. However, they are more expensive and those listed by discount mail order suppliers are generally of the lower capacity type.

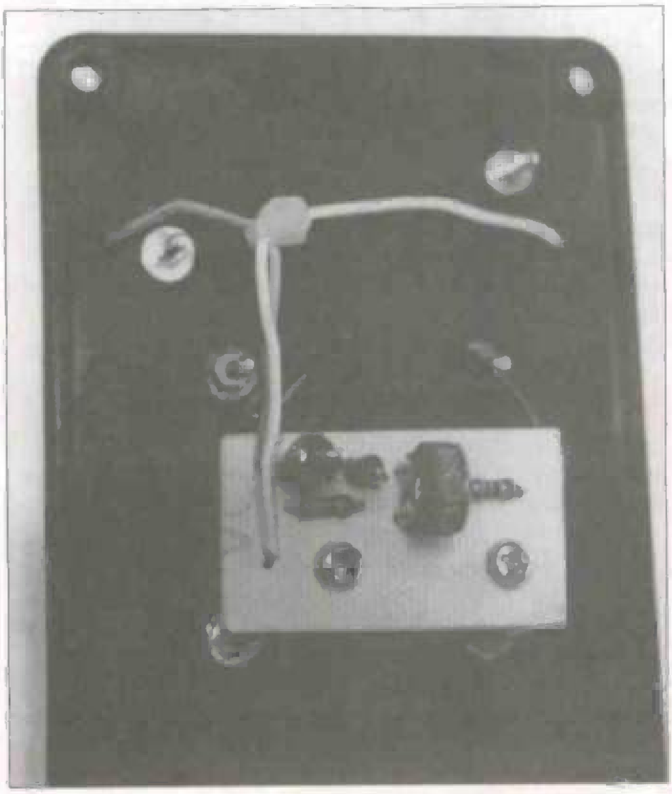
Bearing the load

This unit determines the state of charge by measuring the voltage of the cell under load (that is, while drawing a moderate current from it). When freshly-charged, it will be about 1.4V. This falls in a non-regular way to the useful low point which may regarded as about 0.9V to 1.0V. Measurement shows that when half-charged it will be about 1.27V and at one-quarter charge about 1.2V. The load helps to obtain meaningful readings. This is because, when a battery is left standing off-load for a while, the voltage tends to rise. It would therefore appear to have a greater charge than is really the case. This is particularly true when the charge nears the end point.

The Charge Check is basically a narrow-range voltmeter. An ordinary analogue instrument with a full-scale deflection (FSD) of, say, 2.5V would waste most of its scale length (about 84%)

CHECK

uick-test those "AA" Ni-Cad cells



since the regions below 1V and above 1.4V would have no significance. This would make small changes very difficult to see. A digital meter could be used but it would not apply a load to the cell under test. Also, not everyone wants children and others to use their valuable test instrument for this purpose. Non-technically minded people would also find difficulty translating a basic voltage into the state of charge.

To mark the scale with coloured bands rather than voltage readings does require some care to remove and re-mark the existing one. Timid readers could stick a label on top of the face above the pointer and colour that but the final appearance would not be as good. Also, it would be more difficult to interpret. In the prototype, it was arranged for readings above 1.3V to be green; below this and down to about 1.2V yellow; and, below that, red showing that the cell has little life left in it. However, these boundaries are subjective and readers will perform their own calibration at the setting-up stage.

Circuit description

The circuit for Charge Check is shown in Fig. 1. When cell B1 under test is connected, current completes a circuit through diodes D1/D2 and resistor, R1. With the specified value of R1, the current drawn from a freshly-charged cell will be some 150mA falling as the battery drains. Ignore the effect of RV1, R2 and ME1 for the moment - these components form the narrow-scale voltmeter and have negligible effect on the current.

A diode exhibits a forward voltage drop. This is the voltage which appears across it when current flows. The voltage drop is reasonably constant over a wide range of current. Diode D1 is a Schottky Barrier device and this has a very low forward voltage drop - around 0.25V with the range of current flowing In this circuit. D2 is an ordinary silicon diode and it will have a voltage drop of 0.7V approximately. The diodes are connected in series so the sum of the voltages (0.95V or, say, "1V) appears across the pair.

Taking account of the drop across the pair of diodes, the voltage across R1 will be that of the battery minus 1V approximately. When the battery voltage is 1.4V (about right for a fully charged cell), the voltage across R1 will be 0.4V. The device works by using the basic 0-50uA microammeter, ME1, to provide full-scale deflection when it detects this voltage. In theory, the scale will therefore cover a battery voltage from 1 to 1.4V. In practice, it will be about 0.6V to 1.4V and this point will be explained later. To make the microammeter behave as a voltmeter, a resistor connected in series with it is needed. In this circuit, this is achieved using two resistors fixed resistor R2 and preset potentiometer, RV1 I It Is then only necessary to adjust RV1 at the end of construction to provide the correct FSD. Ohm's Law suggests that a lower value for RV1 could be used. However, using this one will take account of any component differences.

Construction

Construction of the charge tester is based on a single-sided printed circuit board (PCB). The component overlay is shown in Figure 2 and it will be noted that everything, apart from the cell holder, is mounted on the PCB. In fact, it would be more accurate to say that the PCB is mounted on the meter and needs no further support (see photograph).

Bend the cathode end lead of each diode (those near the stripe on the body) down the side. Solder these components in position vertically, noting that the cathode connections are marked "k" in Figures 1 and 2. Mount the other soldered components and attach lOcm pieces of light-duty connecting wire to the points marked B1+ and B1-. Remove the bolts and washers from the meter terminals. Secure the circuit panel to the posts using the bolts through the holes in the PCB, observing the polarity (which is marked on the underside of

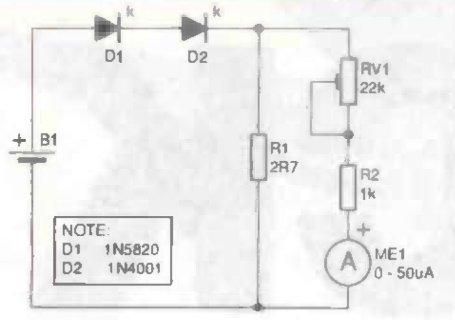


Fig.1 Circuit

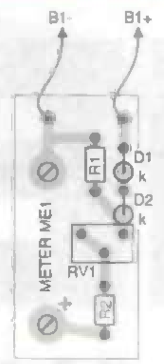


Fig.2 PCB overlay

the meter). It may be necessary to discard the washers to provide sufficient length. Check that, when in position, the tops of the meter terminal posts make firm contact with the pads on the PCB. Adjust RV1 to approximately midtrack position .

Testing

Initial testing may be carried out simply by touching the wires on to the cell terminals, observing the polarity. Remove only a very small amount of insulation from the ends so that there is no possibility of causing a short circuit. Start with the cell fully-charged. Connect it up and adjust RV1 so that full-scale deflection is obtained. Put the cell in a piece of equipment so that it runs down to the point where it does not work properly. Test it again. The meter should now show a low reading.

As the cell voltage approaches 1V, the diodes will be at the point of failing to conduct. However, the forward voltage drops reduce under these low current conditions and this maintains a current greater than expected. This results in a scale where 1V ends up at about the 20uA mark rather than zero. Do not expect a reading of zero unless the voltage has fallen to 0.6V or so. The important point is that the useful range - 1V to 1.4V covers most of the scale length. In this way, very small voltage differences may be interpreted.

Practising scales

Before modifying the existing meter scale, it will be necessary to test the cell during a controlled discharge. This may be done by running it down (as part of a set) in, say, a personal stereo. Begin with all cells fully charged. Switch the equipment on and remove the cell at intervals to test it and record the reading (it is probably better to use the same one each time). Judge what will be reasonable for the boundaries between green/yellow and yellow/red. The green and yellow bands will be much narrower than the red one. This is because the voltage falls only very slowly over much of the discharge cycle.

Next, modify the meter to show coloured bands instead of microamp readings. The plastic face is easily removed by applying gentle force around the edge. Great care must be taken not to bend the pointer from now on. Remove the two small screws which secure the scale and slide it out. Using tracing paper, and taking note of the readings, mark the outline of the existing scale and the positions of the boundaries which will exist between the coloured bands. The scale may now be turned over and sprayed using matt paint (car-type cellulose primer was used in the prototype). Another method would be to cover it with a thin self-adhesive label and cut it to shape. Using the tracing, draw in the outlines of the bands and colour them in using fine fibre-tip pens. It would also be possible to leave the scale as it is and simply mark the boundaries with lines or spots of the appropriate colour. Re-assemble the meter and replace the front cover ensuring that the zero-adjustment peg on it engages with the fork on the movement. It may be necessary to re-set the zero using a flat blade in the adjuster slot.

A plastic box is used to house this circuit. Both the meter, carrying the circuit panel, and the cell holder are mounted on the lid. First, make the large hole for the meter body and the four small ones used for fixing it to the case (the original packaging provides a template for this purpose). Make the large hole by drilling a circle of small ones then join them together using a miniature hacksaw. The edge may then be filed smooth. Drill the two holes for cell holder mounting and attach it. Drill one at each end for the wires passing through from the PCB. Attach the meter by first removing the fixing nuts and manoeuvring the PCB through the large hole. Pass the wires from the circuit panel through their holes leaving some slack. A small cable tie was used in the prototype to keep them neat. Solder the ends to the battery holder terminals observing the polarity. Use minimum heat for this - the plastic body easily melts. Assemble the case and make some trials. Over a period of service, make small adjustments to RV1 if necessary to provide the best operating points.

Final points

This device will check a cell which has been discharged in the normal course of use. It may not provide a reliable reading if the cell has just been charged.

Always observe the reading for up to half a minute - it should be steady. It is falls, it indicates a flat cell which has picked up on standing - it therefore needs charging. Do not leave a cell in the holder for long after a test since the unit will gradually discharge it.

PARTS LIST

Resistors

R1	2R7,0.25W 5%
R2	1 Ik,0.25W 5%
RV1	22k,sub-min vertical preset

Semiconductors

D1	1N5820 Schottky barrier diode
D2	1N4001 silicon diode

Miscellaneous

ME 1 0-50 microamp meter. Face size 51 x 45mm approximately, terminals having 20mm between centres.
PCB materials
Single "AA" size cell holder
Plastic box size 100 x 75 x 40mm.

Buy Lines

The meter used in the prototype was obtained from Greenweld Electronics, Ltd. It was an Altai meter from the "50mm" range. Diode D1 was obtained from Maplin. Everything else is freely available.

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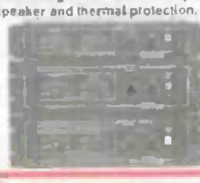

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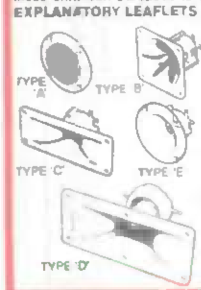

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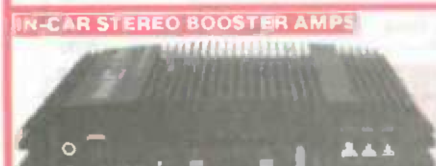

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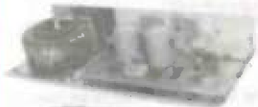
THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

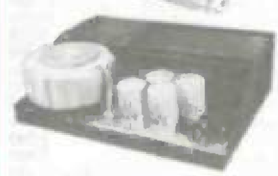


OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

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.

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RES. FREQ. 58Hz, FREQ. RESP TO 6KHz, SENS 98dB. PRICE £46.71 + £3.50 P&P
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RES. FREQ 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. PRICE £70.19 + £3.50 P&P
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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

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PHOTO: 3W FM TRANSMITTER

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Hameg – 203/203-4/203-5/203-6 - 20 MHz Dual Channel	from £175
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Phillips 3211, 3217, 3240, 3243, 3244, 3261, 3262 (2ch + 4ch)	from £125 to £350
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a keyboard controlled
LIGHT DIMMER

Bart Trepak looks at how to construct a PIC microcontroller based light dimmer

Light dimmers have been around since the early 70's and in that time have undergone many changes in design. Although the fundamental principle of operation has remained the same, namely phase control, the methods of achieving this has changed from using a simple resistor/capacitor/diac in the early "rotary" circuits to special integrated circuit designs featuring touch and even remote control. Whatever type of light dimmer is used, anyone who has fitted one in his or her lounge or dining room will probably agree that it is hardly ever used at minimum brightness or indeed at many of the other possible settings. More often than not, it is set to maximum brightness or perhaps some slightly lower setting and switched on and off at this setting. This is seldom altered even to suit some specific activity and the available settings remain unused mainly because it is too much bother to think about what level may be required on entering a room and once the lights are switched on, no-one wants to return to the switch (or even reach for the remote control) to change the brightness. This is not too much of a problem in domestic settings (other than perhaps wasting power by running lights brighter than required for a given situation) and it has in any case been cheaper to provide a continuously variable brightness control rather than a number of pre-set levels whether people use it or not..

In commercial premises such as hotels, conference halls and restaurants this can be a bit of a disadvantage as setting an optimum (and repeatable) light level for a given function then becomes a bit of a "hit and miss" affair and it is difficult for, say, a senior member of the staff to specify the lighting levels for a function and leave it to one of his subordinates to set. The problem is compounded if several settings need to be arranged during a function. In a conference hall, for example, this could be a relatively high setting while delegates are arriving followed by low general lighting for a presentation or film. This may then be increased again for the discussion (and lowered for the drinks and social gathering afterwards?) and followed by a high setting at the end of the meeting to allow (or invite) the delegates to leave.

In the past, this would have presented quite a design problem with lots of pre-set or variable resistors to define the various lighting levels which may be required and these would be connected to a voltage controlled light dimmer. The required lighting level would be selected by a bank of mechanically or electronically interlocked switches making the whole assembly both large and expensive and confining its use to non-domestic premises. Such a dimmer could also easily find applications in a domestic setting where light levels could be selected easily and immediately on entering a room rather than by fiddling around adjusting a potentiometer afterwards.

The micro-controller can perform all of these functions digitally, removing the need for pre-sets, voltage controlled dimmers, interlocking switches etc. and by reducing the total component count to a keyboard, triac, chip and a few resistors making the whole unit small and inexpensive as well as providing features which the designer of the "analogue" system could only dream

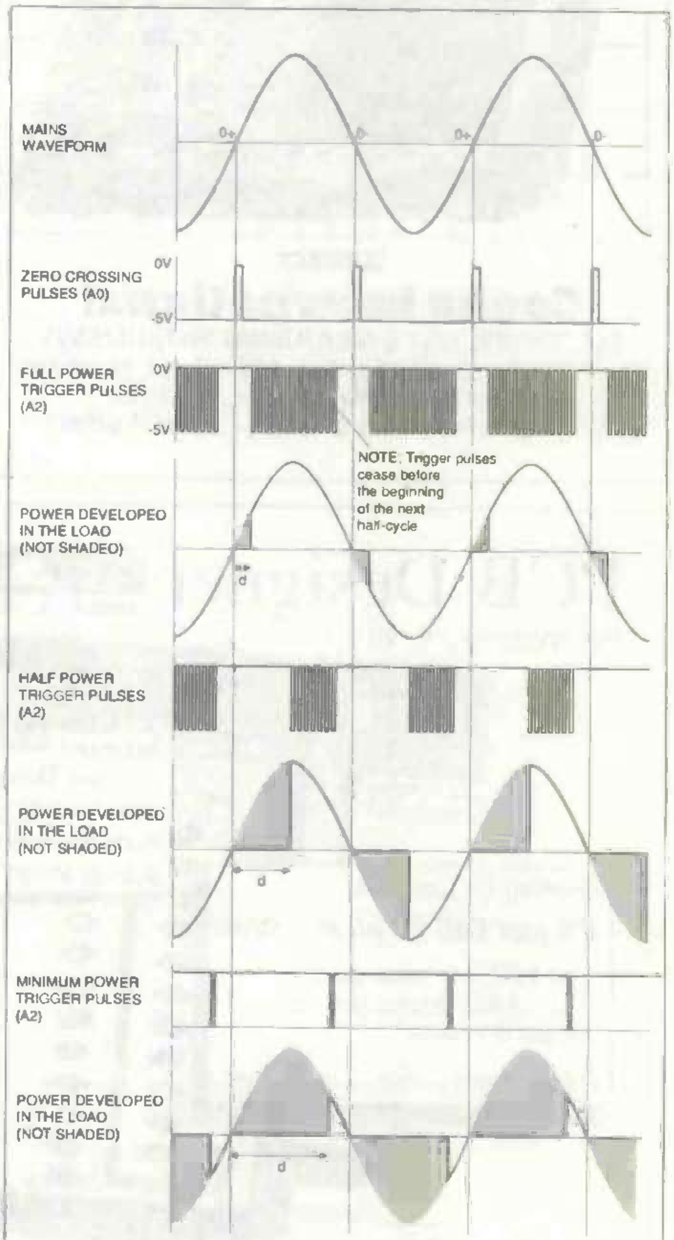

Fig.1

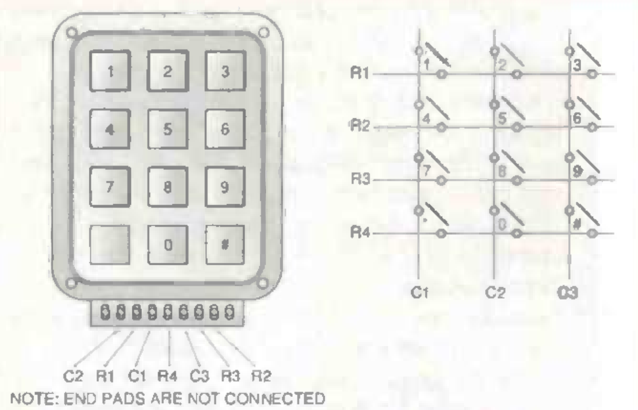

Fig.2 Keyboard connections

about. Although this has not been done in this design, the set levels could easily be made programmable (instead of pre-set) and the light levels could be made to fade from one level to another. A real time clock could also be added to make the lights assume pre-set levels at predetermined times and all of these features would not require a single extra component but just a few more lines of programme. In this design, nine pre-set levels 1-9 have been programmed with the "0" key reserved for switching the lights off. The "*" and "#" keys have been programmed to enable intermediate brightness levels to be set with the * key causing the brightness to decrease while it is pressed and the # key causing it to increase for as long as they are held down.

Phase control

As mentioned, the standard way of achieving dimming using a triac is to use the Phase Control technique which involves triggering a triac later in each mains half-cycle, the lower the light level required. On a.c. supplies, if the triac has been on (conducting), then it switches off automatically at the end of each half-cycle and is therefore off at the beginning of each new half-cycle. If it is triggered into conduction immediately or very soon after the new half-cycle begins, full brightness will result but, if the triggering is delayed, the brightness will be reduced depending on the delay. Fig 1 shows the waveforms which will be seen in light dimmer systems resulting from delaying the trigger pulses to the triac by different times marked "d". The shaded areas represent the portions of the mains half-cycle during which the triac remains off resulting from different delays. Since the power supplied to the lamp is proportional to the area of the unshaded part of the waveform and the power determines the brightness of the lamp, varying the delay results in a variation of the brightness of the lamp.

Conventional dimmers use a resistor/capacitor arrangement to introduce the required delay which is made variable by making the resistor variable while more sophisticated circuits may use some form of monostable to define the delay.However, the first step is to detect the beginning of each half-cycle to provide a reference point for the start of the delay and this is done by sensing when the mains voltage has dropped to zero. This ensures that the triac will be triggered at the same point in each half-cycle thus giving a steady brightness setting for the lamp.

Software

A software technique for detecting the mains zero crossing using a PIC microcontroller was described in an earlier article and so will not be repeated here. The generation of a delay is also quite standard and involves loading a counter (which is called PHSCTR or PHaSe CounTeR in the programme listing) with a suitable value when the zero crossing is detected and allowing that counter to count down to zero before switching on an output port (A2) to trigger the triac. The rate at which the counter counts down (which depends on the micro-controller clock frequency) is adjusted so that the largest number loaded results in the counter reaching zero in 10mS and produces a trigger pulse right at the end of the half-cycle giving a minimum brightness (i.e. off). Other brightness settings may then be obtained by loading smaller numbers into the counter to obtain delays of 8, 4 or even 1mS. In practice, delays are varied from around 8mS to 2mS which enables the brightness to be varied between 10 and 90% while "off" is achieved by switching the output port driving the triac to input mode, preventing any trigger pulses from appearing at this pin.

The number which is loaded into the counter at the beginning of each half-cycle is stored in a register (defined in the programme as BRG or Brightness register) and it is the contents of this register which determine the current brightness level in any given half-cycle. This then enables this counter to be incremented, decremented or its contents changed depending on which keys are pressed, permitting the brightness to be decreased, increased or set at any required value.

As well as performing the above functions, the micro-controller also scans the keyboard to detect which key (if any) has been pressed. The keyboard is connected in a 4x3 matrix which enables 12 keys to be connected using only 7 lines (see Fig. 2). The software for this is written as a subroutine which is called once every mains cycle and returns with a value in the "W" register which depends on the key which was pressed. The subroutine pulls each of the rows connected to output ports B4, B5, B6 and B7 low in turn and monitors the resulting states of the column lines on inputs B0, B1 and B2. These are normally high because they are fitted with pull up resistors R5, R6 and R7. If any of these inputs is low, it is as a result of a key being pressed and the programme returns from the subroutine with the corresponding number in the "W" register using the RETLW instruction.

The keys numbered 1 to 9 return with numbers chosen to give 9 different brightness levels in ascending order from low (1) to maximum (9) and these are simply loaded into the BRG register. The keys "0" , "*" and "#" are treated differently and provide the OFF, FADE DOWN and FADE UP (brighten) functions respectively. Pressing key 0 causes the programme to branch to a routine which re-defines port A2 as an input, preventing trigger pulses from being generated so that the triac remains off. Keys * and # cause the BRG register to be incremented or decremented once per mains cycle for as long as the keys are depressed, resulting in the brightness increasing or decreasing until maximum or minimum is reached.

Subroutines

The flowchart for the unit is shown in Fig. 3 and, as can be seen, the main programme does little more than continually test input A3 to see if the zero crossing point has occurred and, depending on the result of the test ,calls the various subroutines. The advantage of writing a programme in this way is that it enables each subroutine to be tested separately and makes the operation much easier to follow. It also enables these subroutines to be used in other programmes removing the need to "re-invent the wheel" each time a zero crossing detector or a keyboard routine is required in another application.

The ZERO CROSSING routine loads the value in the BRG register into the PHSCTR which determines the delay which will

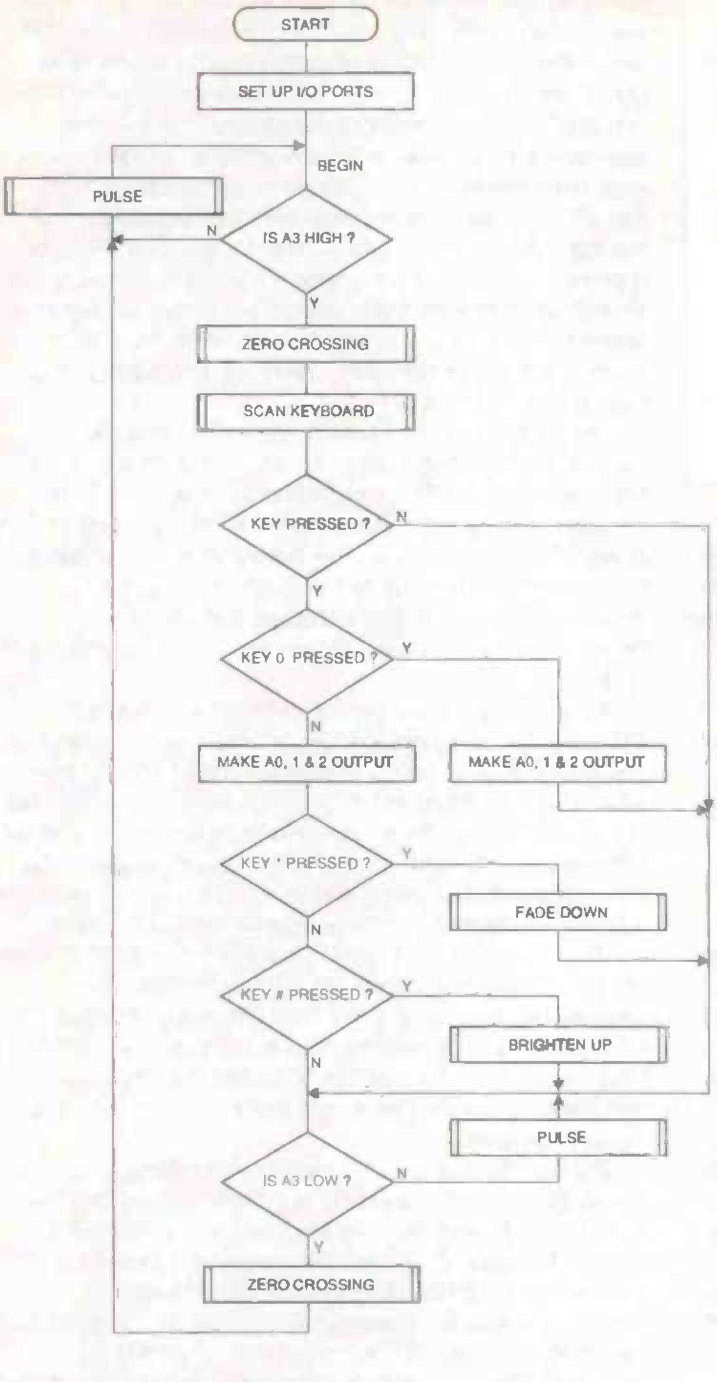

Fig.3 Light dimmer Flowchart

occur before the triac is triggered and hence the brightness of the lamp. As well as this, it also loads a pulse counter which counts the number of pulses generated. This is used to ensure that trigger pulses are not produced beyond the end of each half-cycle. This is necessary to prevent false triggering at the beginning of the succeeding half-cycle which could occur due to the limited accuracy of the zero crossing detector. In addition, this routine also generates a pulse on port A0 which can be used to aid in setting up the circuit (see Fig. 1).

The PULSE subroutine determines if the PHSCTR has reached zero and produces a pulse on A2 to trigger the triac if this has occurred. Because this routine is called continuously if no zero crossing has been detected, multiple pulses are produced on A2 once PHSCTR has reached zero, resulting in a more reliable triac triggering especially with lower power lamps.

The SCAN subroutine deals with reading the keyboard and, as already mentioned, returns from the subroutine with a number corresponding to the key pressed in the W register. If no key is pressed, the number in the W register is zero, enabling the programme to test for this easily and take no further action. The keyboard is read once per mains cycle and no key debounce routine is used as each key performs only one function irrespective of how many times it is pressed or the contacts bounce.

Before the main programme is entered, following a reset which occurs when power is first applied, the programme jumps to the label START and follows a SETUP routine which defines the input and output ports and sets the initial condition of the dimmer to OFF after which the main programme is entered at the label BEGIN.

The circuit

The complete circuit is shown in Fig. 4 and as all the functions are performed in software, very few components are required.

Capacitor C1 together with resistor R1 and zener diode D1 provide a "loss-less" mains dropper which results in a 4.7V square wave appearing across D1. This is rectified and smoothed by D2 and C2 to provide a nominal -4 Volt dc supply for the micro-controller.

C3, R4 and VR1 define the micro-controller clock frequency which determines the speed at which the programme is executed and sets the minimum brightness and, hence, the zero crossing point accurately. The mains signal for the zero crossing detector is derived via R2 with the internal protection diodes of the PIC clamping the voltage on A3 to the -4V or 0V supply rail depending on the polarity of the signal and preventing it from rising to high levels and causing damage to the chip. The output A2 drives the triac gate directly via R3 and consists of a large number of pulses which are generated when the triac is required to switch on.

L1 in conjunction with C3 forms a filter to reduce the radio interference caused by the fast switching of the triac.

Construction

The small number of components makes construction very easy and leaves little scope for errors. It is recommended, howeve,r that the unit is built on a printed circuit board because of the presence of mains voltages in the circuit and a layout and track pattern for this is shown in Fig. 5. The micro-controller IC1 should be mounted in an 18-pin dil socket and care should be taken that it and the diodes D1-D3 and capacitor C2 are inserted into the circuit the correct way around. The leads of the triac should be carefully bent as shown in Fig. 6 before mounting it flat on the PCB by holding them with a pair of pliers at the point where the bend is required. Do this carefully as repeated bending will break the lead.

When the PCB has been assembled, solder seven wires (discarded resistor leads will do) to the copper side of the PCB leaving them to protrude 1 or 2 cms on the copper side while trimming them flush with the surface of the component side of the PCB. Assemble the keyboard and PCB "back to back" with the seven wires mating with the corresponding holes on the

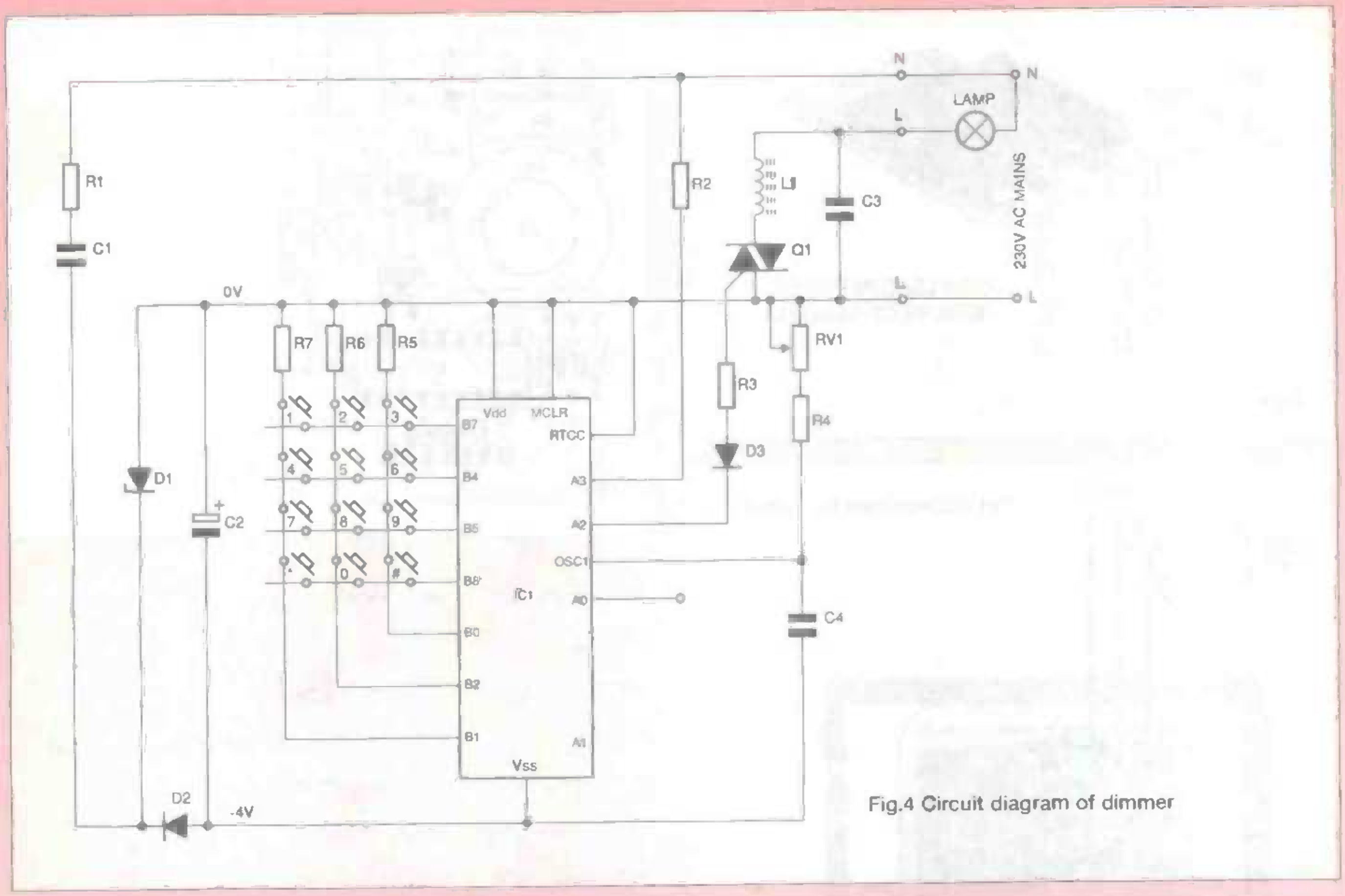

Fig.4 Circuit diagram of dimmer

keyboard PCB and solder. Note that the keyboard specified has nine holes but the two outer ones are not connected. A piece of double-sided adhesive tape placed between the PCB and keyboard sandwich will make a solid assembly which can then be mounted onto a panel if required. Initially, it is perhaps best to leave the wires between the keyboard and the PCB somewhat longer and the circuit tested in case access to the copper side of the PCB is required to correct soldering etc. Once the unit is working satisfactorily, the connections may be shortened by melting the solder on the keyboard pads and the two boards pushed closer together before trimming the leads as required.

TESTING

REMEMBER THAT THIS UNIT OPERATES AT MAINS VOLTAGE WHICH CAN BE LETHAL. SWITCH OFF ALL SUPPLIES AND DISCONNECT THE UNIT BEFORE ATTEMPTING ANY SOLDERING. DO NOT EARTH ANY PART OF THE CIRCUIT AS DAMAGE TO COMPONENTS WILL OCCUR. DO NOT TOUCH ANY PART OF THE CIRCUIT AS YOU MAY NEVER FIND OUT IF YOUR CIRCUIT WORKED.

an the place where the unit is to be installed To avoid damage and blown fuses in case of mistakes it is a good idea to connect a lamp of, say, 150W temporarily in series with the L lead of the mains supply to act as a current limit. Connect the unit to the mains supply with a 40W lamp connected to the output (between Lo and N) as shown in Fig. 7 and switch on. With a voltmeter set to 10V d.c. range, measure the voltage between pins 5 and 14 of the IC holder which should show a reading of approximately 4 Volts (pin 5 negative). Provided that this voltage is not greater than 5 Volts, switch off the supply and plug in the micro-controller chip making sure that it is inserted the correct way around. The PIC is a CMOS device and although it has got built in protection against static damage, it should still be handled carefully, taking all the usual precautions. It is also a good idea to short out capacitor C2 to discharge it before fitting the PIC into its socket. This is because without the micro-controller in the circuit, there is no discharge path for C2 so that it could remain charged after the previous test and prevent a proper internal reset from occurring when power is re-applied.

Turn the pre-set VR1 fully anti-clockwise and reconnect the supply. Both lamps should remain off. If the 150W lamp lights there is a fault in your wiring while if the 40W lamp lights, the triac is short circuited. If all is well, press key 1 to light the lamp and turn VR1 until minimum brightness is obtained. If the pre-set is adjusted beyond this point, the lamp will begin to flash so VR1 should be backed off slightly. Note that level 1 is not the minimum brightness to which the unit will dim and the brightness may be further reduced from this level by means of the * key if required. It was felt, however, that levels lower than this would not normally be required so more of the brighter settings were incorporated. Pressing keys 2 to 9 in turn will make the brightness increase in roughly equal stages to maximum. When key 0 is pressed, the light should switch off while pressing any other key will cause the light to switch on at the level selected. If keys * or # are pressed when the light is off, the light will come on at the level at which it was switched off and commence dimming or brightening from there.

This completes the setting up procedure and the unit is now ready to use. With the triac specified, the maximum lighting load should not exceed 200W but if higher lamp loads are envisaged, a TIC 225D or equivalent 8 Amp device may be fitted. This will enable 300W to be controlled. This device may

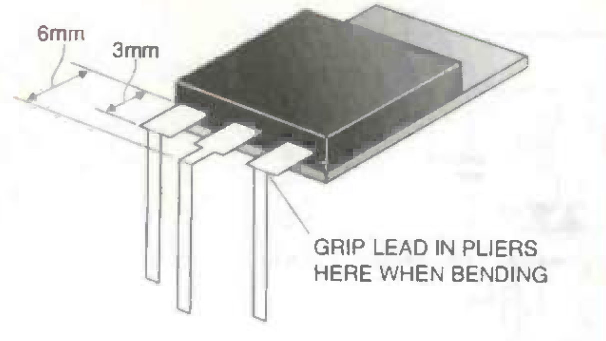

Fig.6

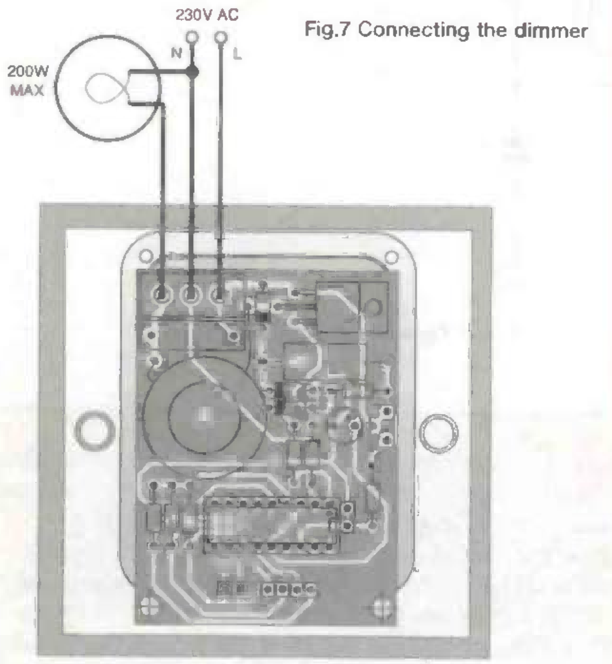

Fig.7 Connecting the dimmer

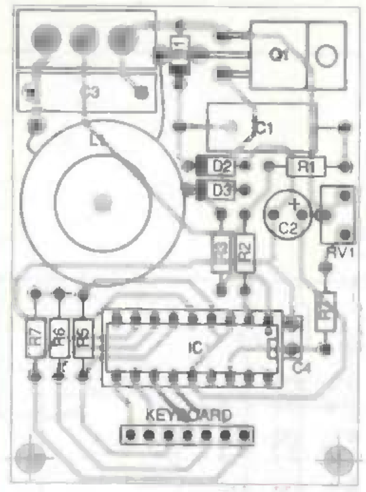

Fig.5

control up to 500W if a small heatsink is fitted although the choke would also need to be suitably rated.

No details are given for mounting the unit as much will depend on where the unit is to be used. The size of the enclosure will depend on the power to be controlled as this will determine the size of the choke and any heatsink which may be required. In any event, it should be mounted preferably in a plastic box, or if higher powers are to be controlled, a metal box which should be earthed, and the normal precautions taken when dealing with mains powered equipment. A suitably rated fuse should also be fitted into the Live lead and a panel mounted fuse holder mounted on the box would probably be best for this purpose. For lower powers where no heatsink is required, the unit could be mounted on a standard electrical wall blanking plate with a suitably shaped cut out to accept the keyboard. The circuit is not suitable however for use as a direct replacement for a wall switch as the mains neutral connection is required and this is not normally available at the wall switch.

Code listing

```
;PBDIM.ASM - KEYBOARD CONTROLLED DIMMER

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

LKP    equ 0Ch ; Last Key Pressed

DYCTR1          equ 08h ; DelaY CounTeR1

DYCTR2          equ 09h ; DelaY CounTeR2

DYCTR3          equ 0Ah ; DelaY CounTeR3

FLAG   equ 0Bh ; FLAG register

PHCTR equ 0Dh ; PHase CounTeR

BRG    equ 0Eh ; BRiGhtness register

PLSCTR          equ 0Fh ; PuLSe CounTeR -
counts 120 pulses ie. full range

;

 LIST P=16C54

 include "PIC.h"

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

 goto START

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

;

ZRX   clrwdt              ;***ZERO CROSSING
SUBROUTINE***

 bsf PORTA,0

 movlw .120

 movwf PLSCTR             ; load Pulse counter with
                                                   120

 movf BRG,w

 movwf PHCTR              ; load Phase counter from
                                                   BRG

 bcf PORTA,0

 retlw 00

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

DIMR  clrwdt              ;***DIMMING AND TRIGGER
                               SUBROUTINE***

 movf PLSCTR,1
```

```
 btfsc STATUS,2          ; PLSCTR=0?
 retlw 00                ; yes - no more trigger
                                      pulses
 decf PLSCTR,1           ; no - decrement PLSCTR
 movf PHCTR,1
 btfss STATUS,2          ; PHCTR=0?
 goto DIMR1              ; no
 bcf PORTA,2             ; yes - generate trigger
                                 pulse on A2
 bsf PORTA,2
 retlw 00

DIMR1 decf PHCTR,1
 retlw 00

;***FADE SUBROUTINE***
FADEUP decf BRG,1        ; brighten lamp
 movlw 04h               ; is BRG=4?
 xorwf BRG,w
 btfss STATUS,2
 retlw 00                ; no
 movlw 05h               ; yes - reload BRG with 5
 movwf BRG
 retlw 00

FADEDN incf BRG,1        ; dim lamp
 movlw .121
 xorwf BRG,w             ; is BRG=121?
 btfss STATUS,2
 retlw 00                ; no
 movlw .120              ; yes -reload BRG with
                                          120
 movwf BRG
 retlw 00
;****************************************

SCAN  clrwdt               ;**KEYBOARD SCAN
                                   SUBROUTINE**
 movlw 07h               ; ie. 0000 0111
 tris PORTB              ; make port B0-B2 i/ps
                             and B3-B7 o/ps
 movlw 0FFh              ; ie. 1111 1111
 movwf PORTB             ; make all o/ps high
 bcf PORTB,4             ; make B4 low
 nop
 btfss PORTB,0           ; B0 low?
 retlw .53               ; yes - KEY6 pressed
 btfss PORTB,1           ; B1 low?
 retlw .67               ; yes - KEY4 pressed
 btfss PORTB,2           ; B2 low?
 retlw .60               ; yes - KEY5 pressed
 bsf PORTB,4             ; no keys pressed - make
                                          B4 high
 bcf PORTB,5             ; make B5 low
 nop
 btfss PORTB,0           ; B0 low?
 retlw .30               ; yes - KEY9 pressed -
                           return with 0000 0001
 btfss PORTB,1           ; B1 low?
 retlw .47               ; yes - KEY7 pressed -
                           return with 0000 0011
 btfss PORTB,2           ; B2 low?
 retlw .40               ; yes - KEY8 pressed -
                           return with 0010 0010
 bsf PORTB,5             ; no keys pressed - make
                                          B5 high
 bcf PORTB,6             ; make B6 low
 nop
 btfss PORTB,0           ; B0 low?
 retlw 02h               ; yes - KEY# pressed
 btfss PORTB,1           ; B1 low?
 retlw 03h               ; yes - KEY* pressed
 btfss PORTB,2           ; B2 low?
 retlw 01h               ; yes - KEY0 pressed -
                           return with 0000 0100
 bsf PORTB,6             ; no keys pressed - make
B6 high
 bcf PORTB,7             ; make B7 low
 nop
 btfss PORTB,0           ; B0 low?
 retlw .75               ; yes - KEY3 pressed
 btfss PORTB,1           ; B1 low?
 retlw .92               ; yes - KEY1 pressed
 btfss PORTB,2           ; B2 low?
 retlw .82               ; yes - KEY2 pressed
 bsf PORTB,7             ; no keys pressed - make
                                          B7 high
 retlw 00                ; no keys pressed
;****************************************
```

```
START nop

SETUP movlw 0Ch            ; ie. 0000 1100

 tris PORTA                ; make port A2 & A3 i/p -
                                 triac off

 ; movlw 0FFh

 ; movwf PORTA             ; make port A high -
                                triac off.

 movlw .60

 movwf BRG

BEGIN btfss PORTA,3        ; is A3 = 1 ie. zero
                                crossing

 goto BEGA                 ; no

 call ZRX                  ; yes

 call SCAN

 movwf LKP                 ; place returned key code
                                  into LKP

 movf LKP,1

 btfsc STATUS,2            ; LKP=0 if no key pressed
                              ie. is key pressed?

 goto LOOP                 ; no - make trigger
                           pulses and await neg zero x

 movlw 0FEh                ; yes a key is pressed -
                               select brightness

 andwf LKP,w               ; ie. 1111 1110 to mask
                                    bit 0

 btfsc STATUS,2            ; is LKP = 0? ie 0 key
                                  pressed

 goto SWTOFF               ; yes - switch off

 movlw 08h                 ; no - ie. 0000 1000 -
                                 SWITCH ON

 tris PORTA                ; switch on A2 (make it
                                  an o/p)

 movlw 03h

 xorwf LKP,w

 btfsc STATUS,2            ; is LKP=3?

 goto STAR                 ; yes - STAR key pressed
                                  - fade down

 movlw 02h                 ; no - try # key

 xorwf LKP,w

 btfsc STATUS,2            ; is LKP=2?

 goto HASH                 ; yes - HASH key pressed
                                  - fade up

 movf LKP,w                ; no - so key must be a
                              brightness level

 movwf BRG                 ; load BRG with key value

 goto LOOP

STAR  call FADEDN

 goto BRGLKP

HASH  call FADEUP

BRGLKP movf BRG,w

 movwf LKP

 goto LOOP

SWTOFF                     movlw 0Ch    ; switch o/p
                                  off ie. 0000 1100

 tris PORTA                ; make A2 an i/p

LOOP  btfsc PORTA,3        ; is A3 = 0? ie. zero
                                  crossing

 goto LOOPA                ; no

 call ZRX                  ; yes

 goto BEGIN

BEGA  call DIMR

 goto BEGIN

LOOPA call DIMR

 goto LOOP

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

 org 1FFh

 END
```

PARTS LIST

Resistors

R1	1k
R2	4M7
R3	100R
R4	22k
R5-R7	10k

Capacitors

C1	100nF/250V ac
C2	100uF/16V
C3	10nF 250V ac
C4	22pF Ceramic
L1	torroidal choke
D1	4V7 Zener diode
D2-D3	1N4148 diode
Q1	TIC206D triac
IC1	PIC16C54-4 (programmmed)
VR1	10k vertical pre-set

Miscellaneous

Printed circuit board
12-way keyboard (matrix type)
18-pin dil socket
3-way terminal block
Plastic blanking plate.

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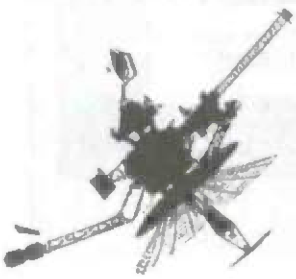

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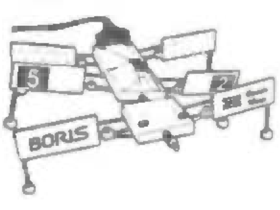

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8031 & 80535 Single Board Computers

Dr Pei An begins a new project to construct a single board computer based upon the popular MCS-51 series microcontrollers

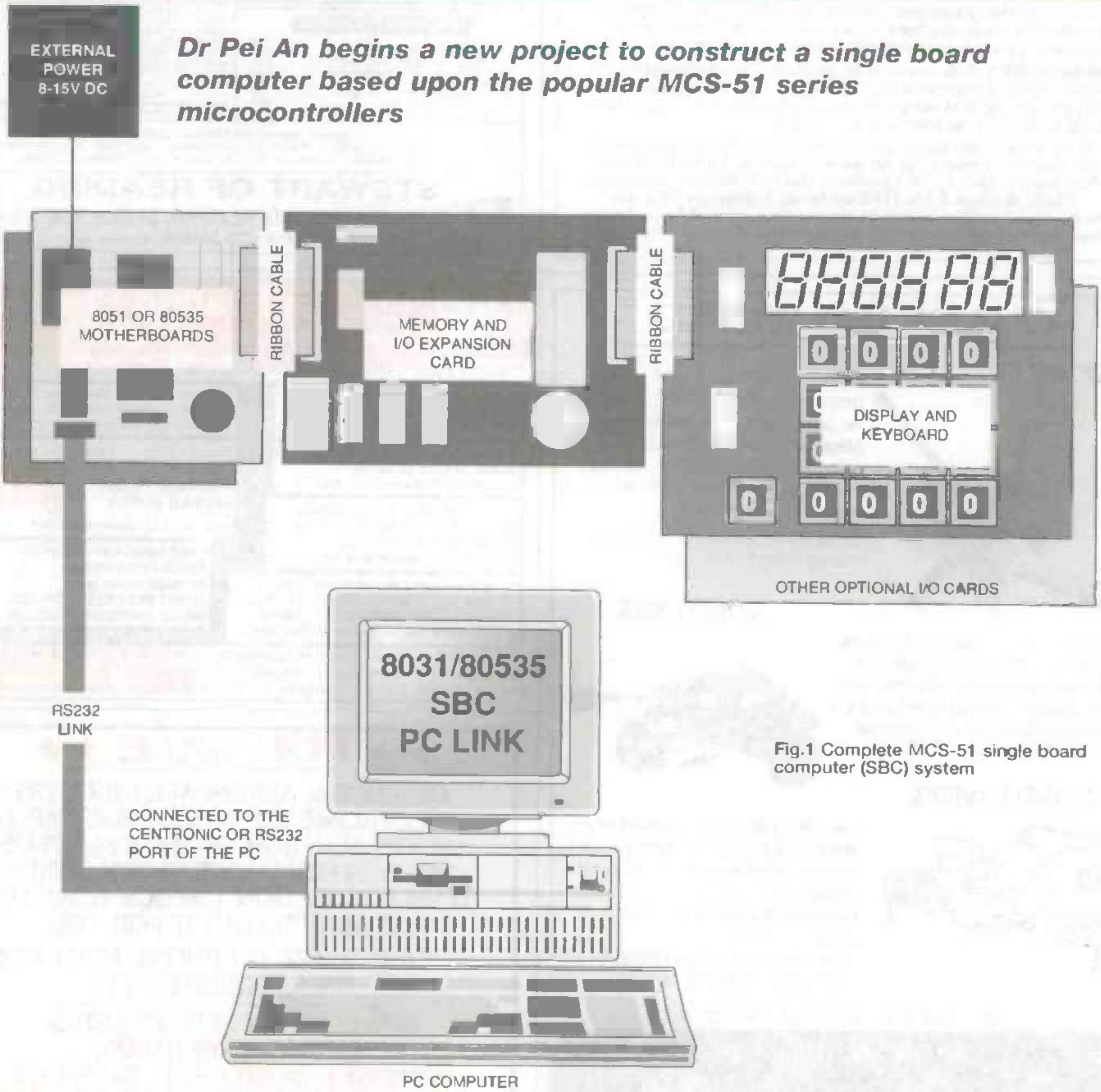


Fig.1 Complete MCS-51 single board computer (SBC) system

This article will describe a single board computer (SBC) system which offers some very unique features. Firstly, the SBC is built on three independent changeable modules, namely, the microcontroller motherboard, the memory and I/O expansion board and the display/keyboard. This allows various microcontrollers and I/O expansion modules to be used. For example, if an 8031 motherboard is used, an 8031 single board computer is formed. Replacing the 8031 motherboard with an 80535 (note that the 80535 is a far more powerful microcontroller in the MCS-51 series!), an 80535 single board computer is formed.

Another feature is that the SBC provides the users with two facilities for inputting programs. Users can either input a program from a keyboard or download the program into the SBC from a personal computer via a RS232 link. Keyboard input is a useful facility for users to experiment with. The PC link is far more convenient and advanced and is intended for high-level programming.

The third feature is that this SBC can be built very easily. It is constructed around commonly available components and on single-sided PCB boards. By constructing the SBC and carrying out machine language programming, beginners can acquire the very basic knowledge of how a computer system works. For advanced users, it provides an environment for developing hardware and software of a sophiscated MCS-51 microcontroller system.

Figure 1 shows the schematic of the SBC system. Table 1 gives some of the main specifications of the three modules of the SBC.

Table 1. Specifications of the MCS-51 single board computer

Microcontroller motherboards

Dimension: 85 x 85 x 35 mm
On-board 8031 or 80535 microcontroller
6 MHz crystal clock oscillator (2 micro second machine cycle)
Reset facility
Full-duplex RS232 interface (maximum Baud rate: 4800);
5V 1A DC power supply
Connectors for 8 peripheral digital I/O lines (for 8031)
Connectors for extended peripheral digital I/O lines and analogue input lines for A/D conversion (for 80535)
Connectors for MCS-51 buses expansion

Memory and I/O expansion module

Dimension: 85 x 120 x 35 mm
8k byte on-board RAM
On-board 3.6V rechargeable battery for RAM backup
16k byte on-board ROM with selection for upper and lower 8k byte blocks
Selectable single-step and continuous program execution mode
Pizero electric sounder
Industrial standard 8155 programmable peripheral interface

Display and keyboard module

Dimension: 115 x 140 x 40 mm
Six 7-segment LED displays
One 4x4 multi-function keypad
One digit/function selection key

Software

Keyboard monitor software in 8k 2764 EPROMs
PC monitor software on 8k 2764 EPROMs and driver software for PCs
Two-in-one monitor software in 16k 27128 EPROMs

This article will be separated into five parts. The first part introduces fundamentals of MCS-51 microcontrollers and the 8031 single board computer system. It is followed by a detailed description of how to construct this single computer system, including the present 8031 motherboard, memory and I/O expansion board and display and keyboard. Part 3 summarizes the MCS-51 instruction sets and Part 4 describes the monitor programs (keyboard and PC-link) for the present SBC. In the final part, an introduction to the 80535 microcontroller and the construction of an 80535 motherboard will be given.

Overview

A single board computer is a very simple computer system (compared to your personal computer). Nevertheless it includes almost all the functional units that a PC boasts. It has a CPU (central processing unit) which, instead of being a 486 or a Pentium processor, is an 8031 or an 80535 microcontroller. The SBC has read-only memories (ROMs) to store program, random-access memories (RAMs) to store data, keyboard for data input, LED displays to show information and serial and parallel I/O ports for data exchanges with external devices. This is illustrated in the SBC block diagram in Figure 2. Figure 3 gives the complete circuit diagrams of the 8031 motherboard (Figure 3a), memory and I/O expansion board (Figure 3b) and display/keyboard (Figure 3c). The circuit diagram of the 80535 motherboard will be given in a future issue.

8031 single chip microcontroller

The Intel 8-bit MCS-51 series microcontrollers are widely used as stand-alone single-chip microcontrollers which form the intelligence centres for many modern electronic devices. Some members of the series are shown in Table 2:

Table 2. MCS-51 microcontroller series

	External ROM	Internal ROM	Internal EPROM	Internal ROM [kbyte]	Internal RAM [byte]	Maximum ROM and RAM [kbyte]
Standard CMOS version	8031 80C31	8051 80C51	8751 87C51	4	128	64
Enhanced CMOS version	8032 80C32	8052 80C52	8752 87C51	8	256	64

The 8051 has a 4k byte on-chip program ROM and it is able to address up to 64K bytes of external program memories and 64k byte of external data memory. The 8031 is a version which does not have the on-chip ROM, hence it relies on external program memory to store instructions. Again, it can address up to 64K bytes of program memory and 64k bytes of data memory. The present SBC utilizes an 8031 microcontroller.

There are some 'super members' in the MCS-51 series, which offer increased peripheral performance in terms of increased number of digital I/O lines and added features such as A/D and D/A conversion, watchdog timer, etc. The SIEMENS 80535 microcontroller is an example and is used in the present SBC.

The pin-out of the the 8031 is shown in Figure 4a. Figure 4b gives the logic symbol. The pin functions are described briefly as follows.

Port 0 (P00-P07) is a time multiplexed 8-bit bidirectional I/O port. When 8031 accessing external memories, it supplies the low byte address (A0 -A7). It also acts as a bi-directional data bus (D0 - D7). When it outputs the address, a line called Address Latch Enable (ALE) becomes high. The port sinks or

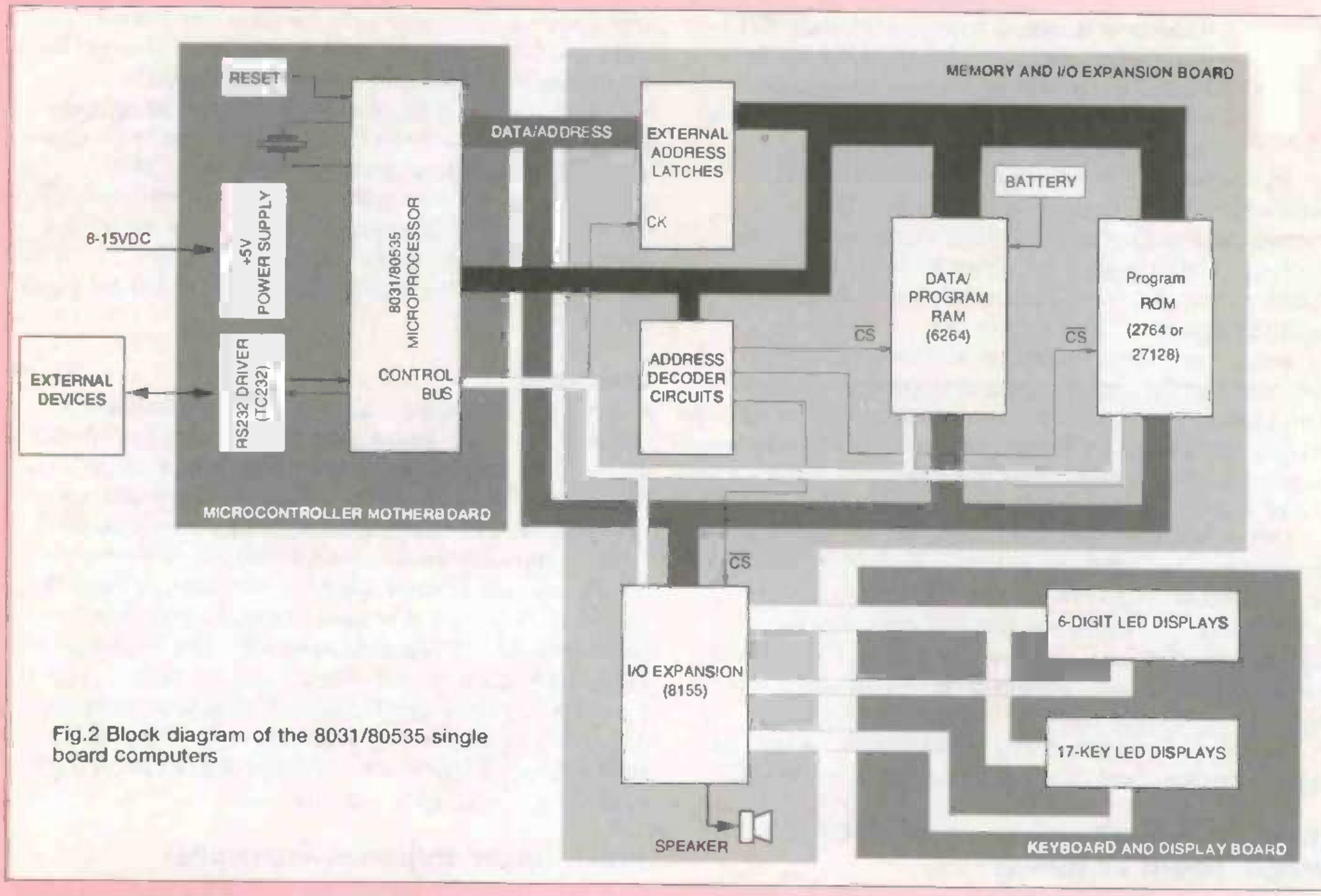


Fig.2 Block diagram of the 8031/80535 single board computers

sources 8 LS TTL loads. For the 8051 microcontroller, the port can be used as a general purpose 8-bit bi-directional I/O port.

Port 1 (P10-P17) It is a general purpose 8-bit bidirectional I/O port. It can be configured as an input or an output port by software. It sinks or sources 3 LS TTL loads.

Port 2 (P20-P27) is an 8-bit bi-directional I/O port. When accessing external memories, it places the high-order address (A8-A15). It sinks or sources 3 LS TTL loads. For 8051, it can be used as a general purpose 8-bit bidirectional I/O port.

Port 3 (P30-P37) is an 8-bit bi-directional I/O port and can sink or source 3 LS TTL loads. All pins have secondary functions.

P3,0 (RXD):	serial data input.
P3,1 (TXD):	serial data output.
P3,2 (-INT0):	input of interrupt 0
P3,3 (-INT1):	input of interrupt 1
P3,4 (T0):	input trigger signal for counter/timer #0
P3,5 (T1):	input trigger signal for counter/timer #1
P3,6 (-WR):	write control which latches data into external data memory
P3,7 (-RD):	read control which strobes the external data memory to place data on the data bus

RST/VPD Reset input. A high level over a period of two machine cycles (see note 1) resets the microprocessor. It also provides standby power supply to the internal RAM. (Note: A machine cycle consists of 6 states. Each state has two oscillator periods.)

ALE/PROG Address Latch Enable. The function is to provide a signal to latch the low byte address (A0-A7, output from Port 0) into an external latch when accessing external memories. The address is valid at the high-to-low transition of ALE. It is activated twice for every machine cycle, even if the cycle involves no external fetch. The only time when ALE is not activated is during an access to external data memory when -RD and -WR are active. In a system that does not use external data memory, ALE will be activated at a constant rate of 1/16 of the oscillator frequency. The output can sink or source 8 LS TTL loads.

-PSEN	Program Store Enable. This is the read strobe for external program memory fetches and it is not activated for internal program memory fetches. When the microcontroller is accessing external program memory, it is activated twice every machine cycle, except during external data memory accesses when -RD is active. It can source or sink 8 LS TTL loads.
-EA/VPP	If it is held high, the microcontroller fetches the low 4k byte program codes from its internal ROMs (8051 and 8751). When held low, it fetches from external program memory. As 8031 uses external ROMs, this pin must be tied to low.
XTAL1	The pin for connecting crystal oscillators. When an external oscillator source is used, it is connected to GND.
XTAL2	The pin for connecting crystal oscillators. When an external oscillation is used, the clock signal is fed in.
VSS	Ground rail of the power supply (0V).
VCC	Positive rail of the power supply (+5V).

Internal structure of the 8031

Figure 5 shows the internal block diagram of the 8031 microcontroller. It has a variety of functional blocks built on a single chip, including the CPU, internal 4k byte ROM (8051 and 8751 only), internal 256 byte RAM, two 16-bit timers, parallel and full-duplex serial I/O interfaces, etc. All the units are connected by an internal bus and work harmonically under the control of the CPU.

D7	D6	D5	D4	D3	D2	D1	D0
CY	AC	F0	RS1	RS0	OV	1	P
CY	*Carry flag. It is set or cleared by hardware or software during arithmetic and logical operations.*						
AC	*Auxiliary carry flag. It is set or cleared by hardware during addition or substraction operations to indicate carry or borrow out of bit 3.*						
F0	*Flag 0. It is set or cleared by software-as a user-defined status flag.*						
RS1 and RS0	*Bits for selecting working register banks in the internal RAM. It is set or cleared by software.* *RS1 RS0 register bank address in memory* *0 0 Bank 0 00H - 07H* *0 1 Bank 1 08H - 0FH* *1 0 Bank 2 10H - 17H* *1 1 Bank 3 18H - 1FH*						
OV	*Overflow flag. It is set or cleared by hardware during arithmetic operations to indicate an overflow condition*						
1	*Reserved.*						
P	*Parity flag. It is set or cleared by hardware to indicate an odd/even number of '1's in the accumulator (1 = even parity).*						

Table 3. Bit functions of the program status word (PSW)

CPU

The CPU consists of three sections, namely, the instruction decoder, the arithmetic section and the program control section.

Program codes are decoded by the instruction decoder. The unit generates internal signals for controlling individual unit.

The arithmetic section performs data manipulation and is comprised of an arithmetic and logic unit (ALU), an accumulator A, a register B, a program status word (PSW), a stack pointer (SP), a data pointer (DPTR) and an instruction register, etc. The ALU is responsible for arithmetic operations such as addition, substraction, multiply, divide, increment, decrement and compare and logic operations such as AND, OR Exclusive-OR, bit rotation, etc. The accumulator is a special 8-bit register and it is used in accumulator-specific instructions. Register B is another register which is used for multiply, divide and other operations. The data pointer (DPTR) is a 16-bit register, which consists of a high byte (DPH) and a low byte (DPL) address. It holds a 16-bit address when addressing the external data memory. The program status word (PSW) is an 8-bit register which contains the current status of the program. It is used frequently in conditional jump operations. The bit functions of the register are shown in table 3.

The program control section controls the sequence in which the instruction is executed. A 16-bit program counter (PC) holds the

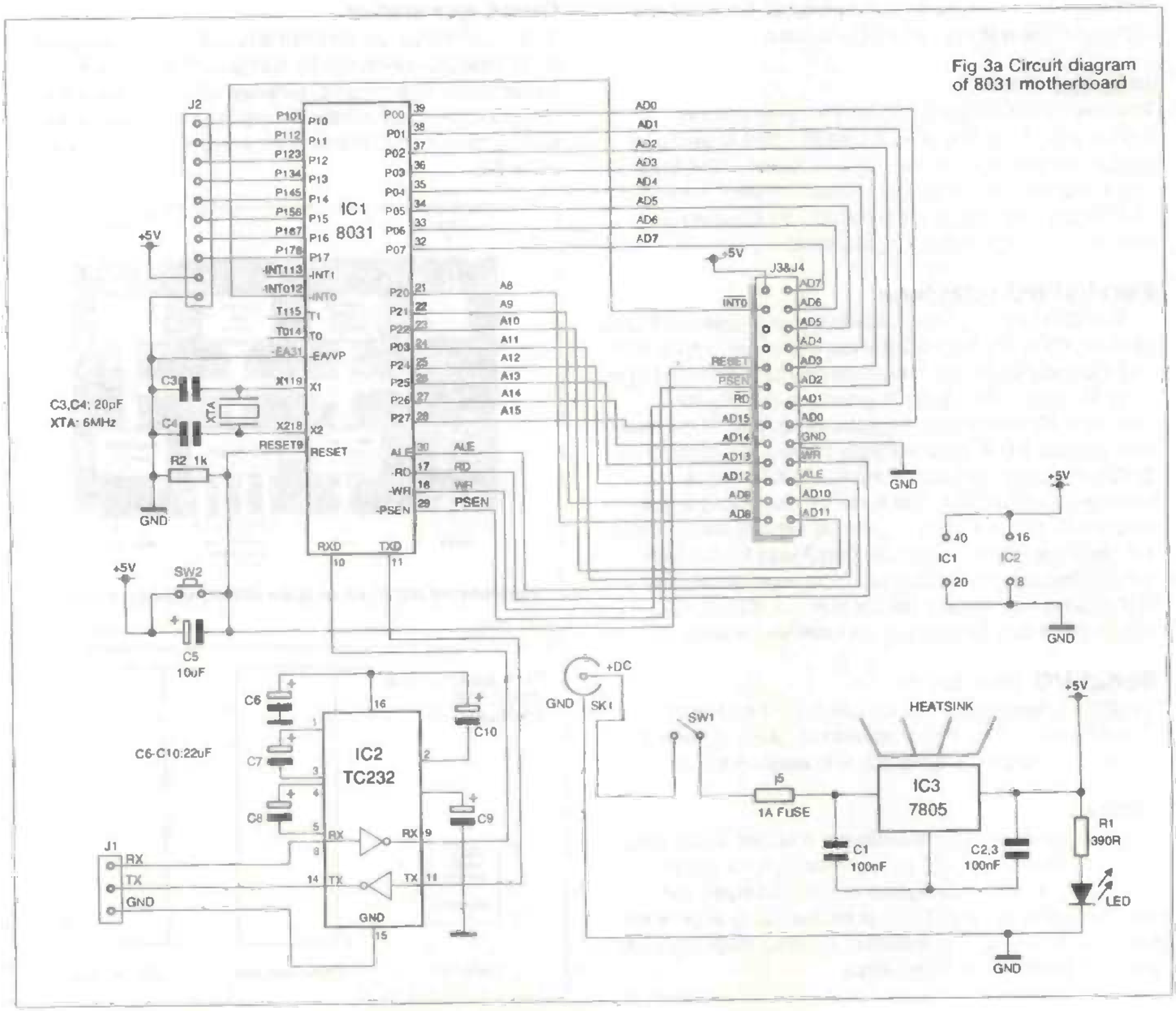


Fig 3a Circuit diagram of 8031 motherboard

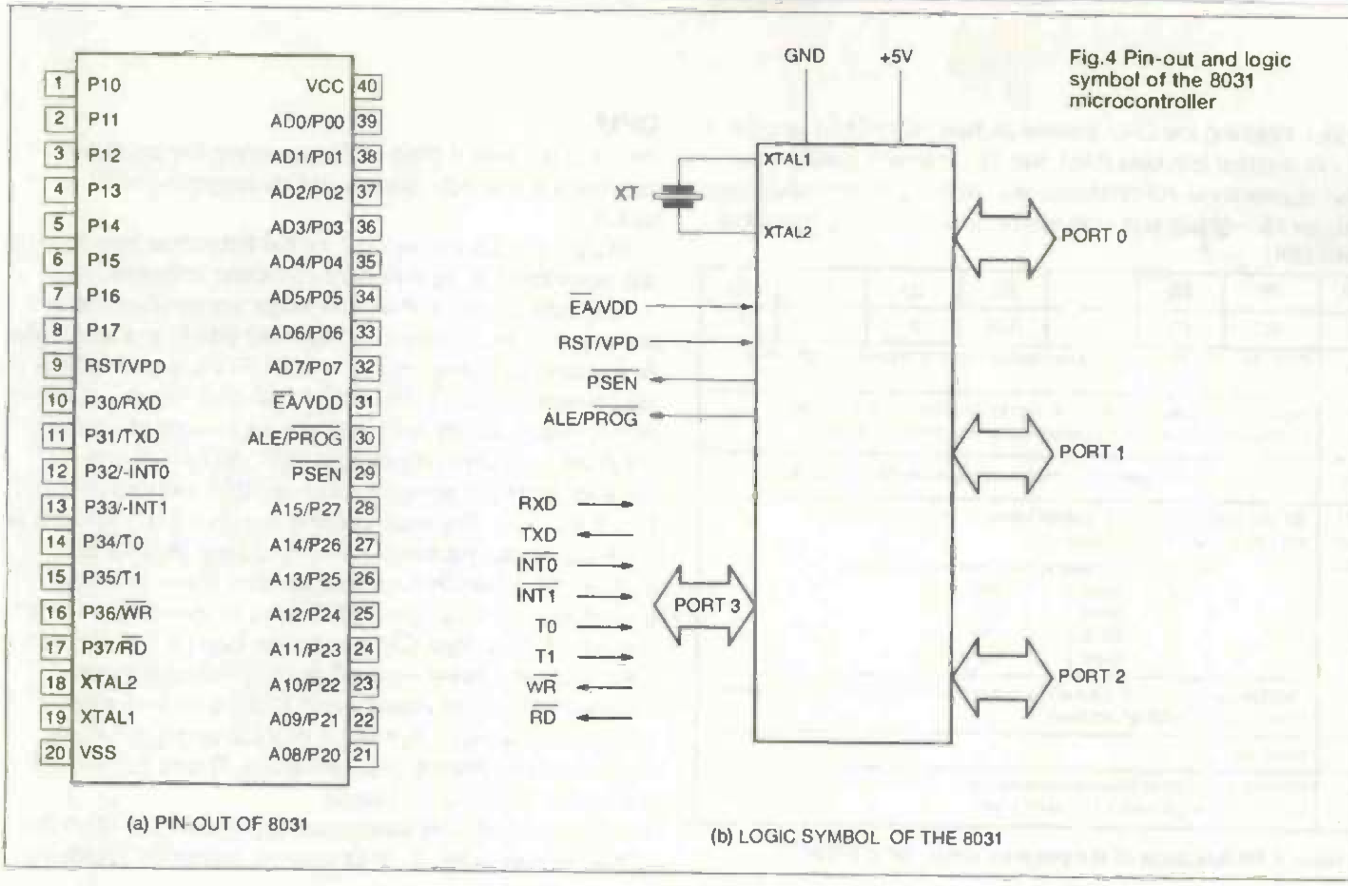


Fig.4 Pin-out and logic symbol of the 8031 microcontroller

address of the next instruction to be executed. It consists of a high byte (PCH) and a low byte (PCL) address.

Internal RAM

The internal RAM of the 8031 has 256 bytes memory locations (00-FFH). The lower half (00H - 7FH) is used as a random access memory. The upper half (80H - FFH) is an area containing various special function registers, such as A, B, PSW, etc. The details of the memory structure will be discussed in '8031 memory organization'.

Parallel I/O interface

The 8031 has 32 I/O lines, which are organized into four 8-bit ports, P0 to P3. Each I/O line has a latch, an output driver and a tri-state buffer and can be configured either as an input or as an output. When 8031 is accessing the external memories, Port 0 has two functions. Firstly, it emits the lower 8-bit address (A0-A7) and secondly it is a bi-direction I/O port for data transactions between the 8031 and external memories. For the 8051, Port 0 can be used as a general purpose I/O port, if it does not use the external memory. Port 1 is used only for I/O operations. Port 2 supplies the high-order address (A8-A15) when accessing external memories. Port 3, apart from being a general purpose I/O port, has various secondary functions as we have seen earlier.

Serial I/O interface

The 8031 is equipped with a standard UART (Universal Asynchronous Receiver and Transmitter), which allows a full-duplex serial data communication with external devices.

Timer

The 8031 has two 16-bit timers/event counters. When used as timers, the contents will be increased by 1 for every machine cycle. When configured as event counters, the contents will be increased by 1 at the low-going edge of the input external signal. The maximum counting frequency in this case is 1/24 of the clock frequency.

Clock generator

XTAL1 and XTAL2 are the input and output of an on-board clock generator which can be configured for uses with a crystal oscillator, a ceramic resonator or an external source. The clock generator divides the oscillator frequency by two and supplies the two phase clock signal to all units of the controller.

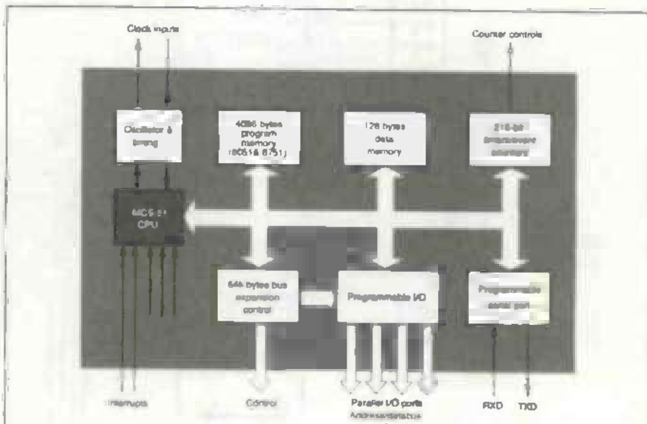


Fig.5 Internal unit block diagram of 8031 microcontroller

Fig.6 Memory map of the 8031 microcontroller

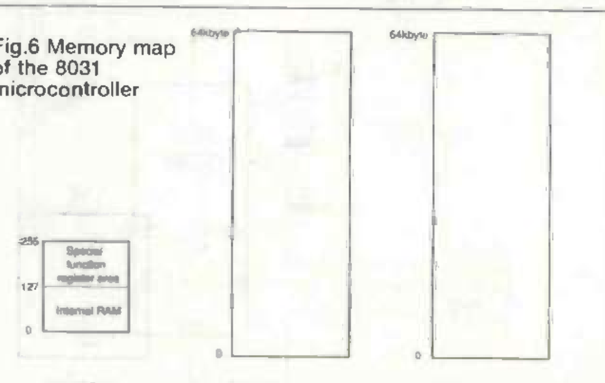


Fig.3b Circuit diagram of the memory and I/O expansion board

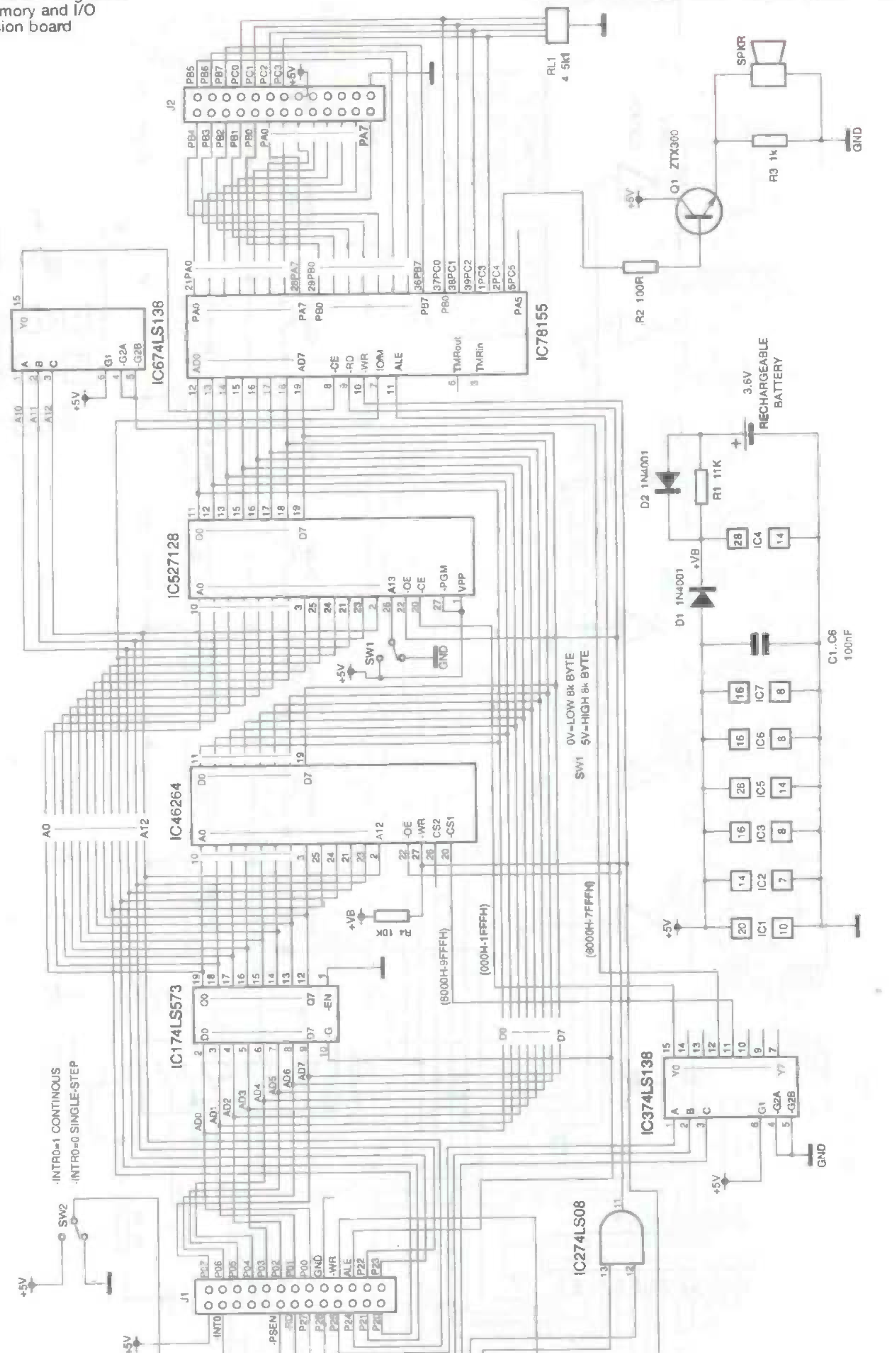
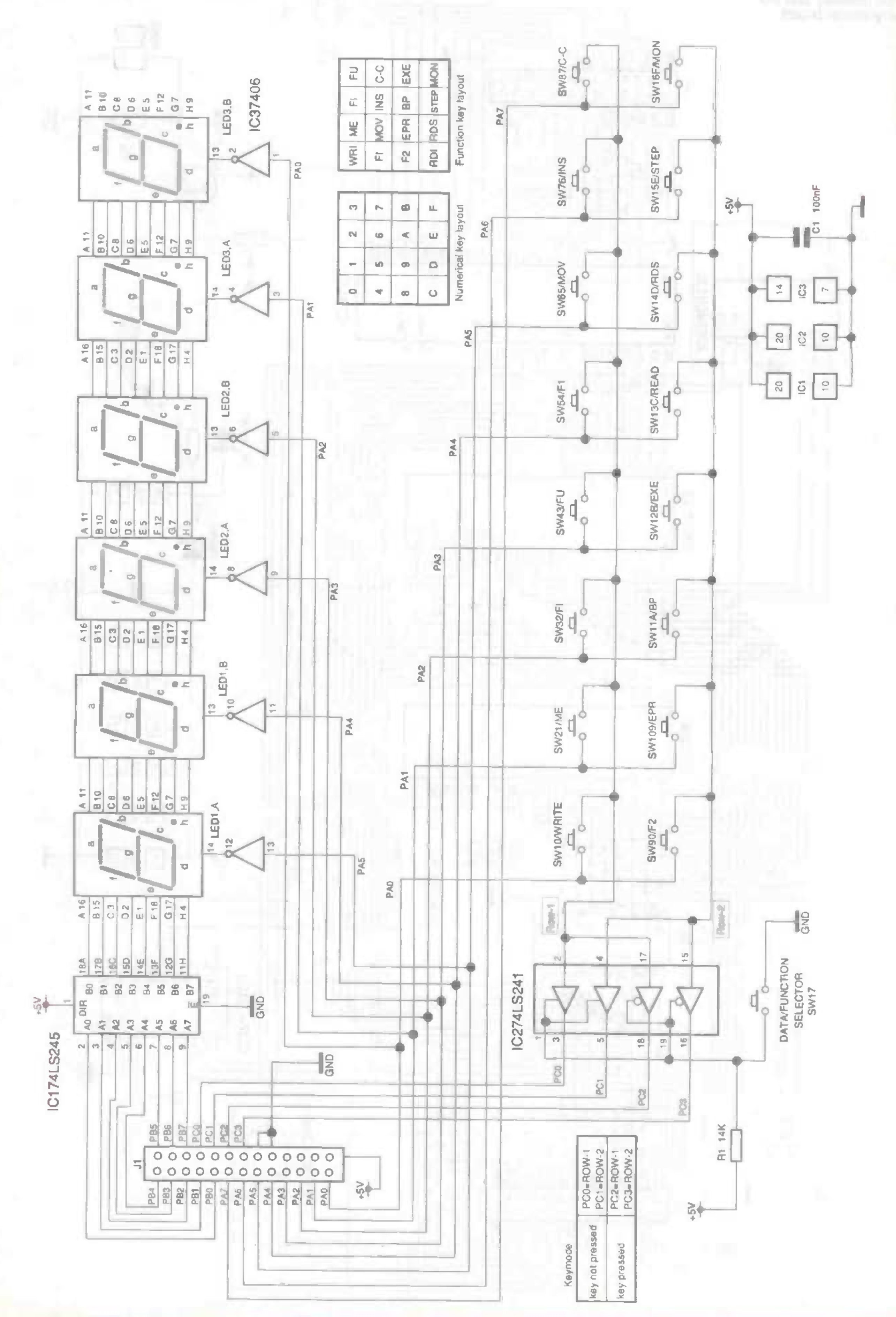


Fig. 3c Circuit diagram of the display and keyboard



8031 memory organization

There are two distinct blocks of memories in the MCS-51 microcontrollers. One is the program memory and the other is the data memory. The former stores the program codes and the latter stores the data. The 8031 CPU accesses to these memory blocks using different hardware schemes. To access the external program memory, -PSEN is used as a read strobe. To access the external data memory, -RD and -WR are used as read and write strobes.

The 8031 has three memory spaces (see Figure 6):

- up to 64k byte of program memory including internal and external memory (4k byte on board program memory for 8051 and 8751)
- up to 64k byte of external data memory
- 256 byte of internal data memory (consisting of an 128 byte of random access data memory and an 128 byte special function register area)

Program memory

The program memory stores the program codes. Connecting -EA pin to GND, the 8031 will read program codes from the external program memory. For the 8051 or 8751, making -EA high causes the microcontroller to access the internal program memory if the memory location is lower than 1FFFH. The maximum accessible size of the program memory is 64k byte. There are seven special memory locations which hold the starting addresses of interrupt service subroutines. They are listed in Table 4.

Memory Address	Name of the subroutines
0000H	Starting address of the program memory
0003H	External Interrupt #0
000BH	Timer 0 overflow interrupt
0013H	External Interrupt #1
001BH	Timer 1 overflow interrupt
0023H	Serial port Interrupt

After the 8031 is reset, the content of the program counter (PC) is 0000H. The CPU will therefore fetch program codes from 0000H location of the program memory. Usually, this location stores a jump command which makes the program jump to the beginning of the user's program.

Data memory

There are two data memory portions in the 8031: an internal data memory area consisting of 256 byte and an external data memory area which is expandable up to 64k byte. They are accessed by the CPU using different instructions. When 8031 accesses the internal memory, a 'MOV' instruction is used. For external memory, 'MOVX' is used. The structure of the data memory is shown in Figure 7.

The internal data memory is further divided into two blocks: a lower 128 byte internal data memory from 00H to 7FH and an upper 128 byte special register area from 80H to FFH. In the lower block, the first 32 bytes (00H - 1FH) are allocated for 4 working register banks 0 to 3. Each bank contains 8 working registers (R0 to R7). A particular bank is selected by RS0 and RS1 bits in the PSW register (Table 3). Locations from 20H to 2FH (128 bits in total) are bit accessible memories. The upper block contains 21 special function registers (SFRs). Table 5 lists these registers, their functions and addresses.

Address	Name	Description
F0	B	Register B
E0	A	Register A, accumulator
D0	PSW	Program status word
CD	TH2	Timer 2 counter, high byte
CC	TL2	Timer 2 counter, low byte
CB	RCAP2H	Timer 2
CA	RCAP2L	Timer 2
C8	TC2CON	Time 2 control
B8	IP	Interrupt priority
B0	P3	Port 3
A8	IE	Interrupt enable
AC	P2	Port 2
99	SBUF	Serial port buffer
98	SCON	Serial port control
90	P1	Port 1
8D	TH1	Timer 1, high byte
8C	TH0	Timer 0, high byte
8B	TL1	Timer 1, high byte
8A	TL0	Timer 0, lower byte
89	TMOD	Timer mode
88	TCON	Timer controller
87	PCON	Power controller
83	DPH	Data pointer, high byte
82	DPL	Date pointer, low byte
81	SP	Stack pointer
80	P0	Port 0

8031 CPU timing

Figure 8 gives the 8031 CPU timing sequences when it accesses to the external program and data memory. One machine cycle consists of six status and each status consists of two clock periods. The two periods are referred to as Phase 1 and Phase 2. A machine cycle, therefore, consists of 12 oscillator periods, which are numbered from S1P1 through to S6P2.

External program memory fetch

From Figure 8a, it can be seen that ALE is activated twice every machine cycle: once during S1P2 and S2P1 and once during S4P2 and S5P1. -PSEN is also activated twice every machine cycle. At the beginning of S2P1, the 8031 sends the 16-bit address contained in the Program Counter (PC) to Port 2 and Port 0. The high 8-bit address (A8-A15) is output from Port 2 and it lasts until the end of S4P2. The low 8-bit address (A0-A7) is output from Port 0 only in S2. As Port 0 will also be used as a bi-directional data bus, the address must be latched to external latches in order to provide a stable address for external memories. ALE is used for this purpose. At the high-to-low transition at the end of S2P1, ALE strobes the address A0 - A7 at Port 0 into the external latches. At the beginning of S3P1, -PSEN becomes low (active), which enables the selected external program memory to place data on the data bus. Just before -PSEN goes high at the end of S4P1, the 8031 reads the program code from Port 0.

In a machine cycle, ALE and -PSEN are activated twice. This means that 8031 is able to read program codes twice from the external program memory. If it is a one-byte instruction there is still a fetch at S4, but the byte read is ignored and the program counter is not incremented.

External data memory access

When accessing external data memory, a MOVX instruction is used. It is a one-byte, 2-cycle instruction. During this

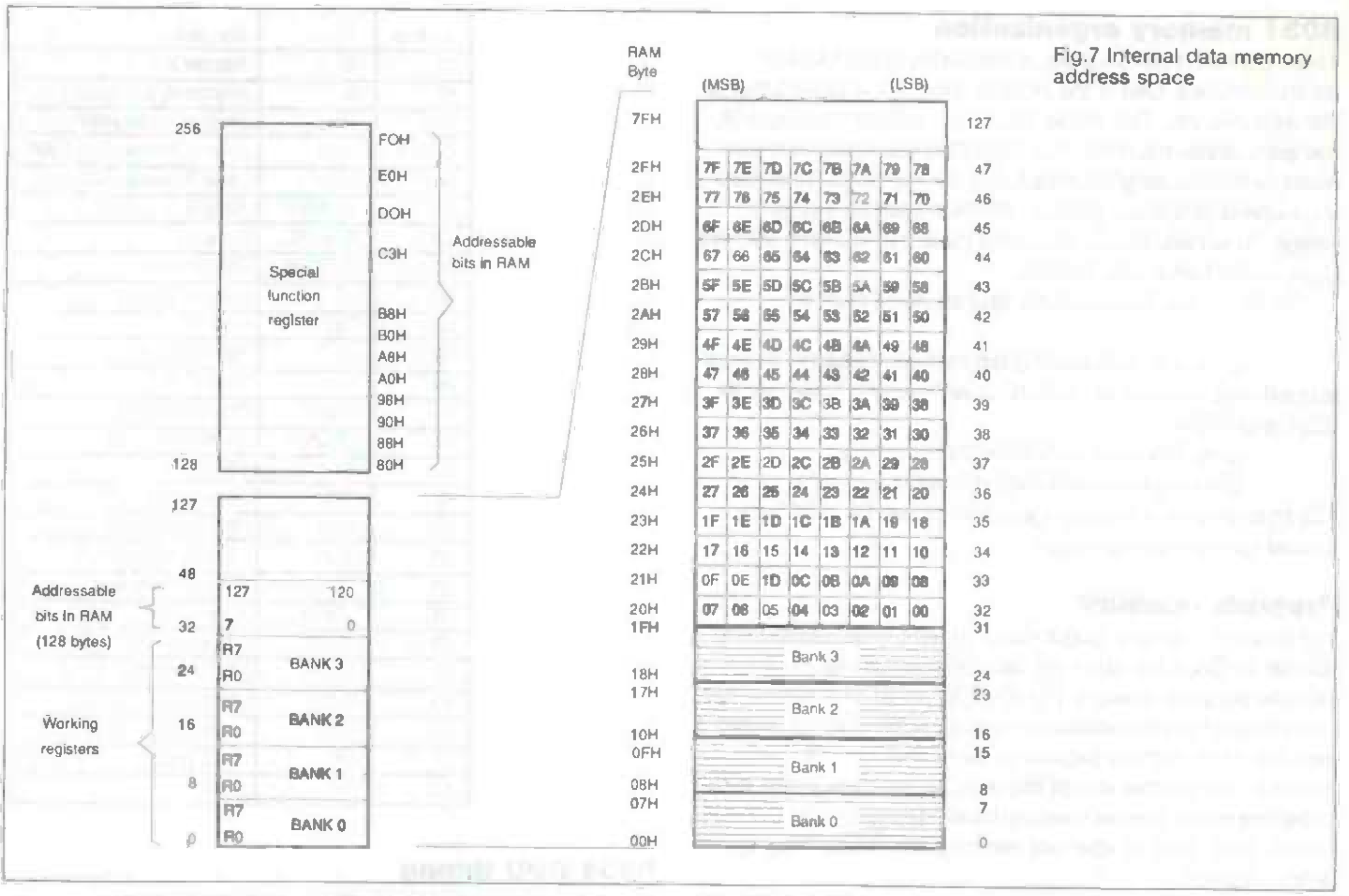


Fig.7 Internal data memory address space

execution, the two fetches in the second cycles are skipped while the external data memory is being addressed and strobed by -RD and -WR (see Figure 8b).

How the 8031 microprocessor is used in the present SBC

Figures 3a and 3b give the circuit diagrams showing how the 8031 is used in the present SBC. A 74LS573 is used as the external address latch. The pin-out layout and functions of 74LS573 is given in Figure 9. The eight latches are D-type latches. While the enable (G, Pin 11) is high the Q outputs will follow the data (D) inputs. When it is taken low, the outputs will be latched at the levels that were set up at the D inputs. A buffered output control input (-OC, Pin 1) can be used to set the outputs in normal logic (0 and 1) or a high-impedance state.

It can be seen that the 8 inputs (Pins 2 to 9) are connected to Port 0 of the 8031. -OC input is pulled to GND to enable the outputs. G input is connected to the ALE of the 8031. When ALE is high, the outputs of 74LS573 will follow the inputs D1 to D8. When ALE goes from high to low, the lower 8-bit address (A0-A7), which has already output from Port 0, is latched to the output of the IC. The high-order byte of the address (A8-A15) is given by Port 2. During external memory write and read operations, Port 0 also acts as a bi-directional data bus. -PSEN, -WR and -RD, together with ALE form the control bus. The schematic of the address, data and control buses of the 8031 microcontroller is shown in Figure 10.

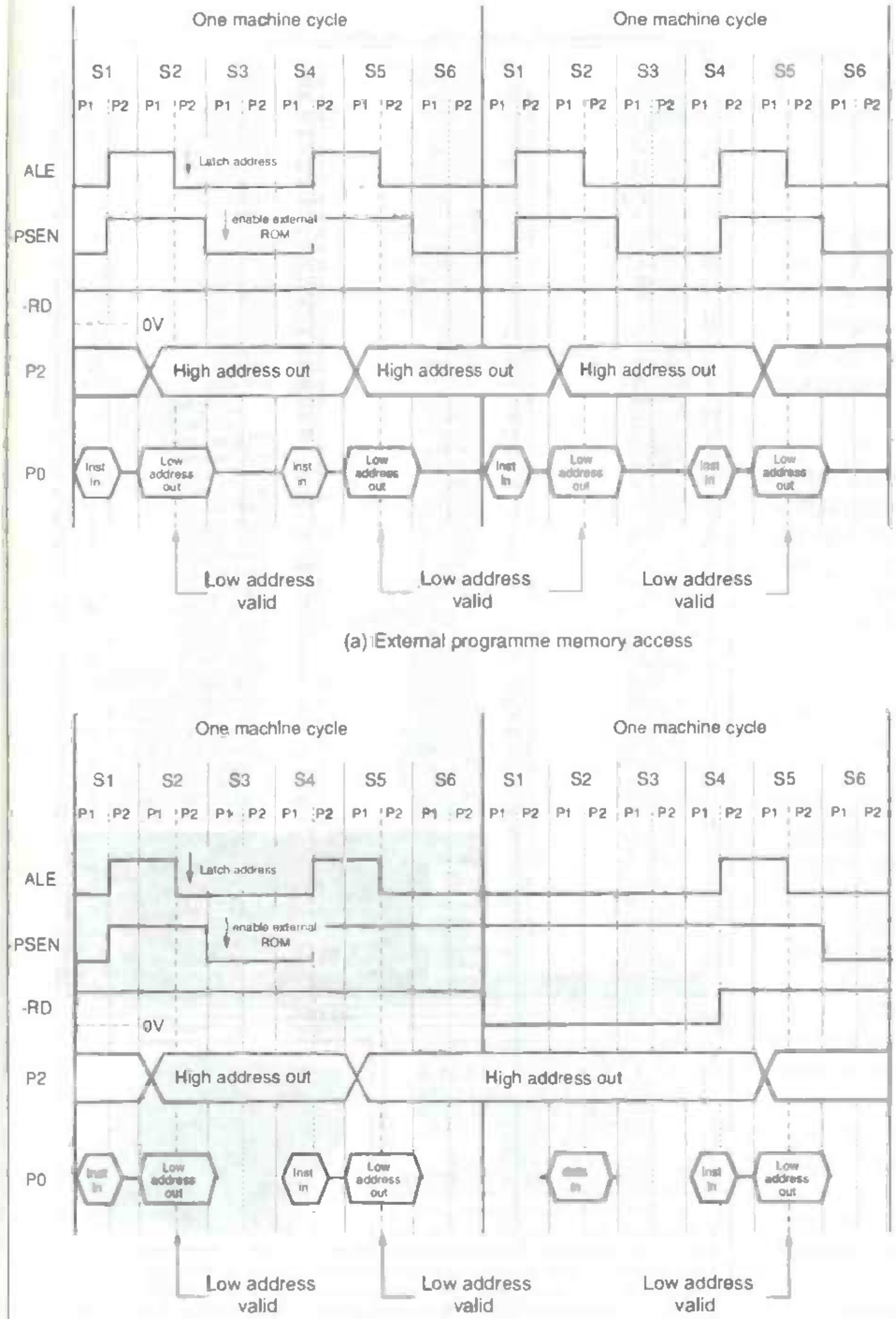
A 6MHz crystal oscillator is connected to the XTAL1 and XTAL2 pins. The clock frequency of the SBC system is therefore 6 MHz. This means that the clock period is 0.16 us and a machine cycle is 2 us (a machine cycle consists of 12 clock periods). -EA pin is connected to GND to allow the 8031 to read program codes from the external program memory. -INTO pin is the first external interrupt input which, when connected to GND, is used for single-step operation. If connected to +5V, the program will be executed continuously. The serial data input (RXD) and output (TXD) are connected to the TC232 RS232 line driver which manages the conversion of the voltage level between TTL and RS232. A reset facility is also provided in the SBC. Normally, the RST input is pulled to GND by R2. When the reset button is pressed, RST becomes high. If it remains high for two machine cycles (24 clock periods), the 8031 CPU resets. The RST input is connected to +5V via a capacitor C5. This allows the SBC to reset automatically after a power-on. After a reset, the contents of some internal registers return to the following values.

Registers	*Content*	*Registers*	*Content*
PC	*0000H*	*TL0*	*00H*
ACC	*00H*	*TH0*	*00H*
PSW	*00H*	*TL1*	*00H*
SP	*07H*	*TH1*	*00H*
DPTR	*0000H*	*SCON*	*00H*
P0 - P3	*FF*	*SBUF*	*00H*
IP	*XX000000B*	*PCON*	*0XXX0000B*
IE	*0X000000B*	*TMOD*	*00B*
TCON	*00H*		

A reset makes ALE and -PSEN high and doesn't affect contents in the internal RAM. PC register becomes 0000H, inferring that the program will be executed from the program memory location 0000H.

Memory expansion

External program memories are required by 8031. The present SBC hardware is equipped with an 8k byte ROM space and an 8k byte RAM space. An address decoder is used for allocating addresses of the ROM and RAM.



(a) External programme memory access

(b) External data memory access

Fig.8 CPU timing for program and data memory fetches

Address decoding

Address decoders are used to allocate addresses for memories so that each memory location has a unique address which can then be addressed by the 8031 microcontroller. In the SBC, two 74LS138 3 to 8 line decoders (IC3 and IC6) are utilized. The pin-out of the IC and its pin functions are shown in Figure 11. A, B and C (Pins 1, 2 and 3) are inputs. Y0 to Y7 (Pins 15 to 9 and Pin 7) are encoded outputs which are high when not selected. When an output is selected, it becomes low. -G2A, -G2B and G1 (pins 4 5 and 6) are enable pins. -G2A and -G2B pins are connected to GND and G1 is connected to +5V. A, B and C are connected to P25, P26 and P27 of the 8031, respectively. As we know that P25, P26 and P27 correspond to the address bits A13, A14 and A15, the decoder circuit divides the 64k bytes of memory into 8 blocks. Each block has 8k byte memory locations. The following table overleaf shows the addresses of the blocks.

From Figure 3b, it can be seen that the encoded outputs, Y0, Y3 and Y4, are connected to the chip enable inputs of the 27128 ROM, 8155 and 6264 RAM. These three address locations have 8k byte space and are not overlapped: 0000-1FFF for external program memory, 6000-7FFF for 8155 chip and 8000-9FFF for external program/data memory.

ROM - external program memory

An 8k byte ROM (such as 2764) can be used as an external program memory. However, the hardware of the SBC allows a 16k byte ROM (such as 27128, IC5) to be used. The 16k byte memory (C000H-3FFFH) is used in two memory portions: the lower 8k byte portion (0000H-1FFFH) and the upper 8k byte portion (2000h-3FFFH). Each of the memory portions contains an independent software and can be selected by an on-board memory portion selector, SW1.

For a quick reference, the pin-outs of 2764 and 27128 EPROM are shown in Figures 12a and 12b. The lower 8-bit address (A0-A7) to the ROM is supplied by the 74LS573 latch. A8 to A12 are supplied from Port 2 of the 8031. A13 is either connected to GND or +5V by the memory selector, SW1. When the selector is switched to GND, A13 is pulled to low state. Thus, the address accessed by 8031 is from 0000H to 1FFFH. If it is switched to +5V, the address accessed by 8031 is from 2000H to 3FFFH of the ROM. The data bus is connected to Port 0 of the 8031. -CE is connected to Y0 of the decoder IC3, which is effective in memory locations from 0000H to 1FFFH. The -OE input is connected to -RD and -PSEN of 8031 via a 74LS08 OR gate (IC2):

-OE = -RD x -PSEN

When accessing external memory, -PSEN becomes low. -RD is high. -OE becomes low which enables the memory to output data.

RAM - external program/data memory

The external RAM is the 6264 8k byte random access COMS memory (IC4, see Figure 12c for the pin-out). It acts both as a program memory and a data memory. Again, the lower 8-bit address (A0-A7) to the ROM is supplied by the 74LS573 latch. A8 to A12 are supplied from Port 2 of the 8031. CS2 (second enable) is connected to +5V to enable 6264. -CS1 input is connected to Y4 (pin 11) of IC3, which is effective in memory locations from 8000 to 9FFFH. The data bus of the memory is connected to Port 0 of the 8031. -WR of the 6264 is connected to -WR pin of the 8031. The -OE input is connected to -RD and -PSEN of 8031 via a 74LS08 OR gate, (IC2):

-OE = -RD * -PSEN

When the 8031 reading data from the external memory, -PSEN is always high and -RD is low. When 8031 reading instructions from the memory, -RD is high and -PSEN is active (low).

I/O expansion

8155 IC The input/output expansion is facilitated by a programmable peripheral interface chip, 8155 (IC7). It has the following functions: 256 bytes of on-board RAM, two 8-bit I/O ports, one 6-bit I/O port and one 14-bit event counter. The pin-out of the chip and its logic symbol are shown in Figure 13. The pin functions are briefly described as follows.

AD0-AD7 A time shared address and data bus. They are connected to Port 0 of the 8031. At the low-going edge of the ALE on the 8031, the 8-bit address is latched into the 8155. Whether the address is for accessing the I/O ports or the internal memory depends on IO/-M inputs.
PA0-AD7 Port A programmable peripheral I/O lines. There are 8 lines. It can be configured as an input or output port by software
PB0-AD7 Port B programable peripheral I/O lines. There are 8 lines. It can be configured as an input or output by software.
PC0-PC5 Port C programable peripheral I/O lines. There are 6 lines. It can be configured as an input or output port by software. The lines can be also used with Port A and Port B as handshake lines.
-CE Chip enable. Low to enable the 8155.
-RD Read strobe. When -CE and -RD are both low, the contents of I/O port registers (when IO/-M=1) or internal memory (IO/-M=0) appear on the AD0-7.
-WR Write strobe. When -CE and -WR are both low, data on AD0-7 will be written into memory (IO/-M = 0) or written to I/O registers (IO/-M = 1).
ALE Address latch enable. At the low-going edge, it latches the address on AD0-7 and the data on IO/-M into the 8155.
IO/-M Input/output and memory selection line. When it is low, memory is selected. When it is high, I/O registers are selected.
RESET Reset pin. A high level on this pin resets the 8155. After reset, the three ports are all configured as input ports.
TIMER IN Timer/counter input
TIMER OUT Timer/counter output. Output waveform is programmable.

Enable inputs of 74LS138			*Encoder inputs*			*Encoded outputs*	*Address block*	*Function*
-G2 A	*-G2 B*	*G1*	*C (A 15)*	*B (A 14)*	*A (A 13)*			
0	0	1	0	0	0	(YO)15	0000-1FFF	EXTERNAL PROGRAM MEMORY
0	0	1	0	0	1	(Y1)14	2000-3FFF	NOT USED
0	0	1	0	1	0	(Y2)13	4000-5FFF	NOT USED
0	0	1	0	1	1	(Y3)12	6000-7FFF	8155 I/O EXPANSION
0	0	1	1	0	0	(Y4)11	8000-9FFF	EXTERNAL PROGRAM/ DATA MEMORY
0	0	1	1	0	1	(Y5)10	A000-BFFF	NOT USED
0	0	1	1	1	0	(Y6)9	C000-DFFF	NOT USED
0	0	1	1	1	1	(Y7)7	E000-FFFF	NOT USED

PORTABLE MIXER

PART 1

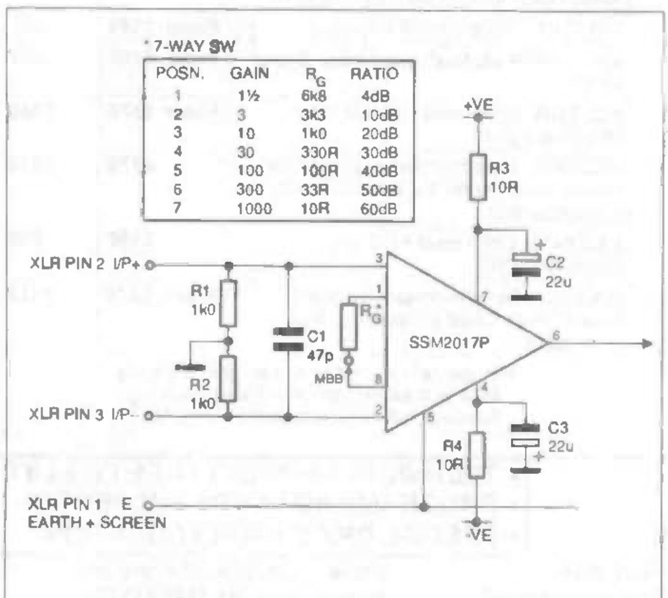
Tony Sercombe delves into the complexities of constructing a portable audio mixer

This project began when I decided I needed a good-quality sound mixer but, as it would only be used occasionally, it would not be worth paying a lot of money for a top-of-the-range, professional unit.

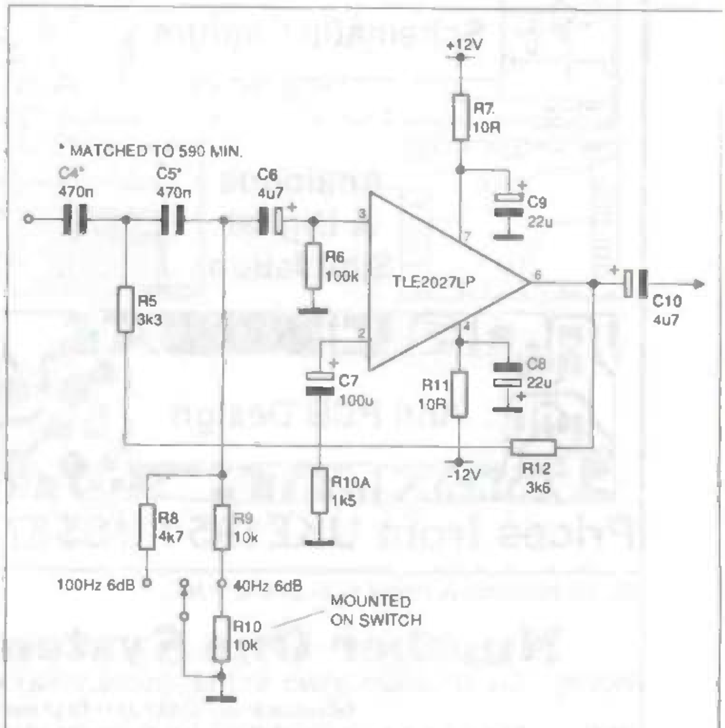
For field work, the mixer is, of course, battery-powered and an optional mains power unit is included for situations when mains power is available. The case is designed to be slung from the shoulder if necessary by a camera type strap. In the original, three input channels were thought to be adequate, but more may be added as desired by simple duplication. The line-oscillator and compressor/limitor may be omitted if not required. However, some form of dynamic control is advisable in most cases.

The circuit

Balanced input cables are essential, since any interference on one input is corrected by the same interference on the other, but in the exact opposite phase, i.e. 180 degrees out of phase. So, one cancels out the other and the result is no interference. This is the system I adopted and, with it, input cables could be up to several miles long at the extreme. The SSM 2017 is used in the input stage. This IC is designed to accept floating balanced inputs. The cost is such that input transformers of sufficient quality were ruled out. Although they can be said to give a degree of noiseless gain, due to the turns ratio, the modern design of ICs has rendered that a bit of a specious point. As may be seen, the input floats across two 1KO resistors, and a 47pF is paralleled across the two. The gain is set by the value of the resistor connected between pins 1 and 8 of the IC. A make-before-break switch selects gains of approx: 1 1/2 (Line input) then 10dB to 60dB in 10dB steps, giving a maximum gain of 1000 times. A mbb switch is important here, otherwise severe 'crashing' will occur



Portable mixer input module



Portable mixer - channel amp and L.F. Atten.

when it is operated. No output coupling capacitor is required since the next stage is capacitor coupled at its input. It is also worth noting that since the supplies are positive and negative, the output should exhibit no DC voltage. However, this is not always quite the case in practice with most IC amps - without nulling.

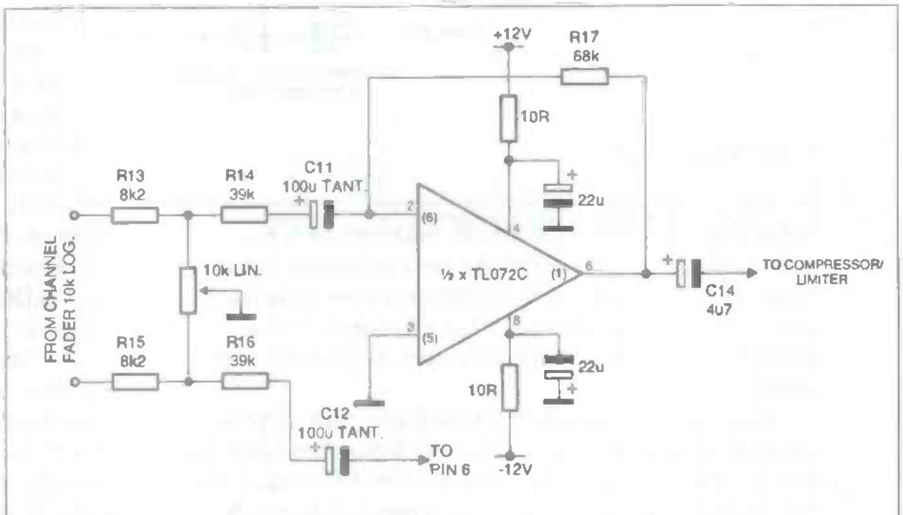
Next comes another amplifier of around 3 1/2 x (3.4) which also incorporates a two- position high pass filter, which may be switched out if not needed. It operates at 12dB at 40 or 120Hz. This uses a TLE 2027, and is fairly conventional.

The output of this amplifier is fed to the channel fader. I used the plastic conductive variety, although this is not strictly necessary - a good quality carbon unit would be sufficient. Capacitor coupling is used here since even a very small offset voltage at the output will make the control noisy in use. The slider of this control is connected directly to the mixing and pan resistor of the TL072C which, in turn, is connected as a virtual earth mixer. This is a dual amplifier in an 8-pin DIL package and has a gain of 1/7X.

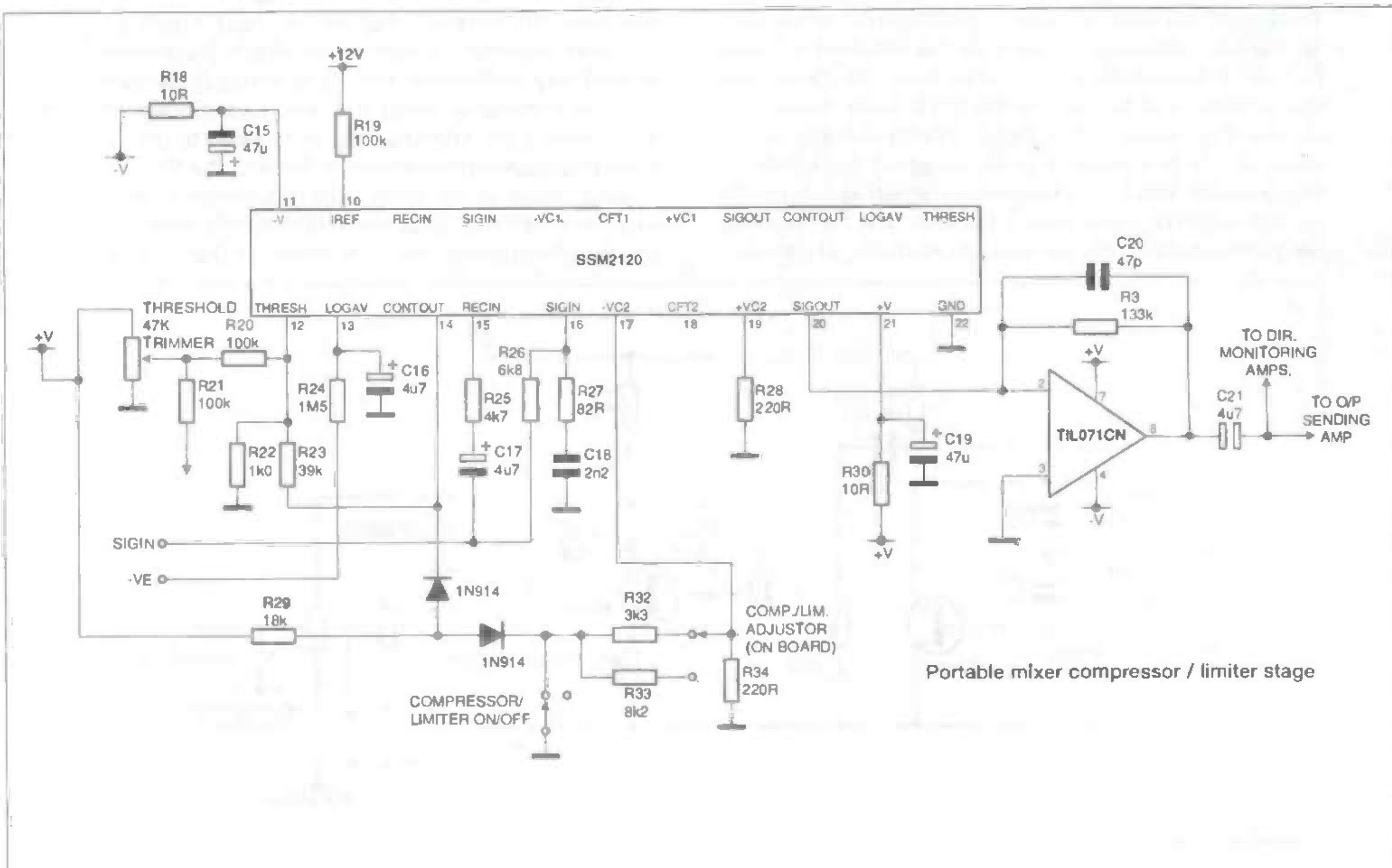
As mentioned earlier, extra channels may be used, and would be duplicated up to this point (i.e. pin 2). The output at this stage is fed to the compressor/limiter. Again this is a stereo IC, SSM 2120. The IC has been designed specifically for the control of dynamic range in various applications. In this case as a compressor or limiter, choice of function being dependent upon the connection of a flying jumper in each channel on the circuit board. Alternatively its action may be completely disabled with a switch on the control panel.

If the function is set to compress, the ratio is 2:1, that is to say that for every doubling of the input, the output will increase by half that amount. In the limit mode, the point at which limiting occurs is set by an on-board pre-set. The threshold of each mode is adjustable to any point by this control. This IC has virtual earth inputs and outputs and so, in this case, uses a TIL 071 to feed the output stages.

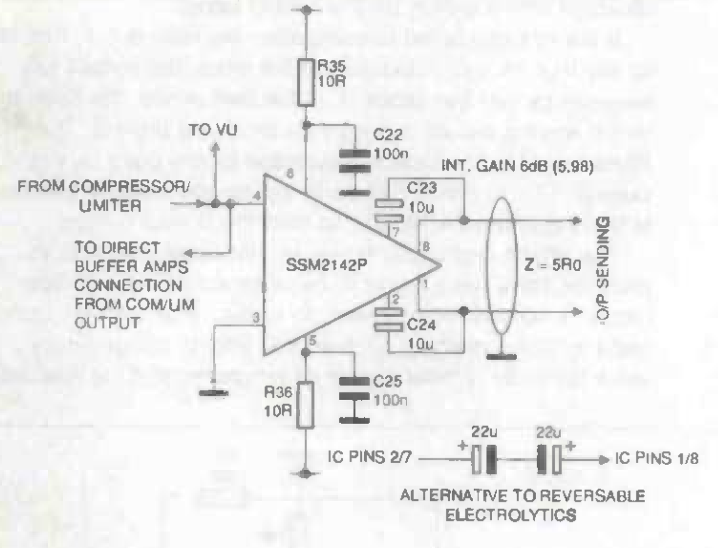
The attack and decay times are not adjustable but, in practice, have been found to be quite suitable for a wide range of material from speech to music. This is a very good test because breathing or thumping effects will generally show up under different types of programme. If the rise and



Mixing amps (Duel I.C.)



Portable mixer compressor / limiter stage



O/P Sendins amp

diode rectifiers should be set in the feedback loop to linearise the gain, taking Into account the forward voltage drop. In this case, they are not in the feedback loop but, assuming that they were, the deflection on the meter would only just be off the back stop, at around the -20dB point of the scale. This is of no practical use, particularly in the case of a VU meter.

However, it is essential to provide full wave since the voltage change on one side of the waveform may exceed those on the other, and if it is the lower half that is being measured, then the other half will not be registered on the meter and vice versa. The average reading on the meter will also be more accurately displayed with full wave rectification. The gain setting resistors are of the same value i.e.: 10Kohms.

Voltage excursions in the positive sense are fed to the non-inverting input and are thus inverted so as to be in phase with the non-inverting input, thus achieving full wave rectification. The output of this amplifier is a varying DC level and is fed via a further diode to the fourth and final amplifier in the chip. The purpose of this diode is to allow the 220hf capacitor connected from input to ground to charge up to the peak level of DC across it, and to retain this charge as the output of amplifier 3 falls again.

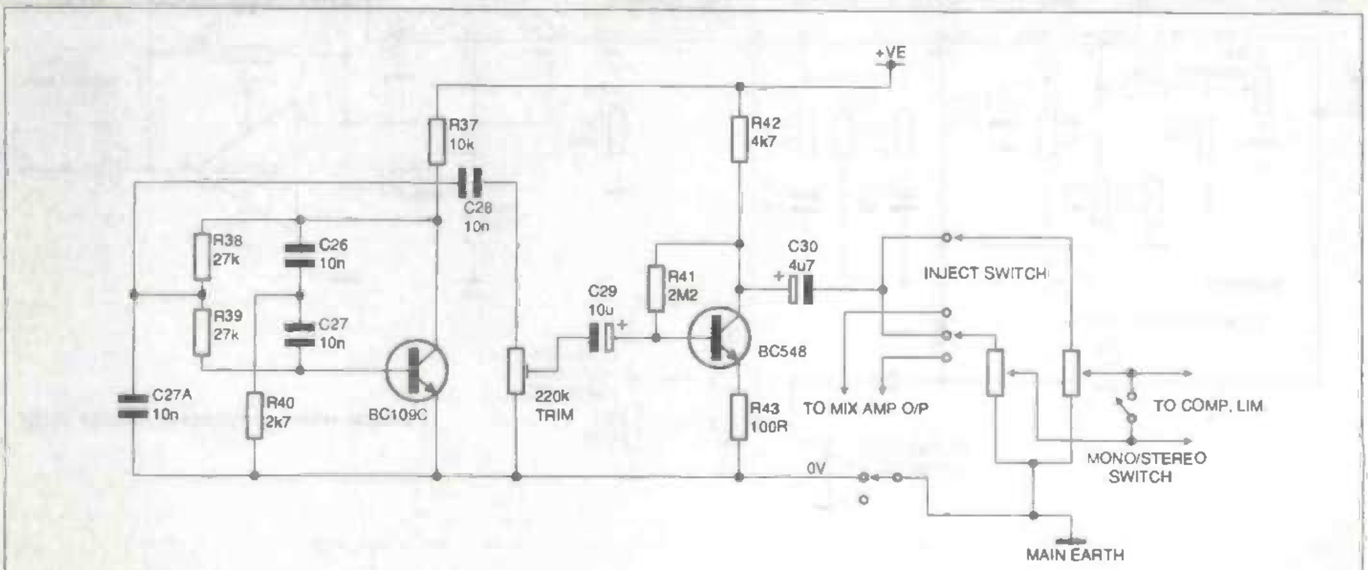
fall of some speech, for example, matches, or is the reciprocate of the attack/release time constants, it can show up as noticeable attenuation or a slow increase in level. However, this general effect was hardly, if ever, noticeable, and has given no problem whatever in the prototype.

The output stages use the SSM 2142. This amplifier provides a balanced output of about 5 ohms, so that any run of cable may be used. It has a gain of 5.98dB or 2x. This gain is internally set and the circuit is very simple.

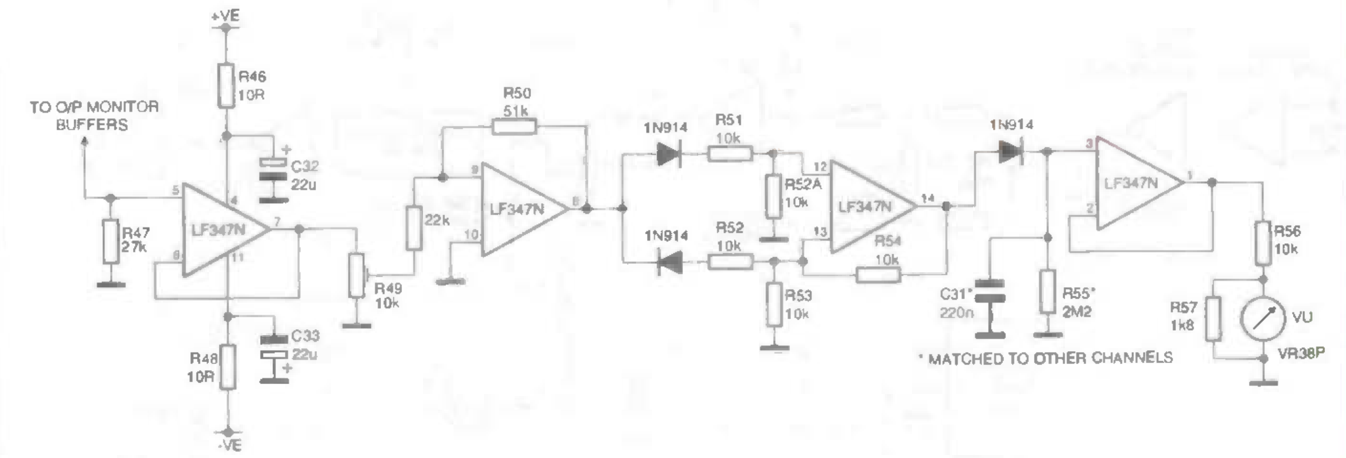
Now the somewhat vexed question of metering. Obviously a PPM would solve the problem, but the total cost would be very high. I considered a LCD column, but these seem non-existent even in professional catalogues. So the only recourse seemed to be the good old VU meter, but with a few alterations. As will be seen, the circuit uses four amplifiers, to be found in the IC LF 347N, but any simular chip will do for this stage. The first amplifier is wired as a high impedance buffer so as not to load the signal unduly. Next, the pre-set level adjustment feeds the second amplifier whose gain is set at 5.1x in the inverting mode. The rectification comes next. Normally, of course,

The last part of the circuit is connected as a buffer amplifier, and thus presents a high impedance, so a large value resistor is connected in parallel with the capacitor. This is to prevent the meter holding up on a high level for too long and thus not indicating lower levels that may follow. In practice, the meter pointer should rise quickly on sudden peaks, but fall-back, or decay, fairly slowly, making it very much easier to read. Missing a few low-level peaks during the fall-back time is not important, since they will be well within the dynamic range of the circuit. I used a dual VU meter assembly as supplied by Maplin Electronics. This worked very well indeed with the circuit as shown with a fast attack and slow decay time. However, if other units are used, some slight changes may be required to the resistor/capacitor combination at Pin 3 of the IC.

When lining up a mixer or other equipment to be interconnected with other items, it is usually necessary to include a line-up oscillator. The circuit for this is quite



Portable mixer OSC



V.U. Drive

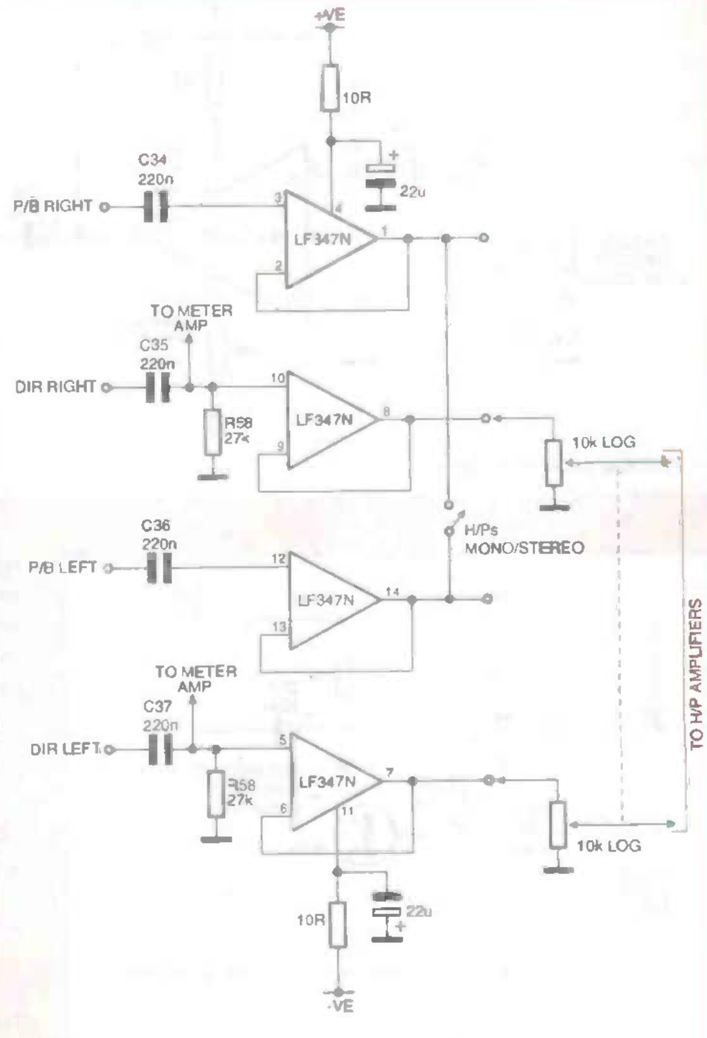
simple, and consists of a single transistor, oscillating and made available via a single amp. The normal frequency employed is 1Khz, although the actual frequency is not too vital. The monitoring buffer amplifiers use an LF 347N, and contribute no voltage gain to the monitoring circuits. It is important that when the direct/reply monit switch is used, it does not introduce clicks onto the signal path. Thus these amplifiers simply buffer the signal path to the headphone amplifiers. The headphone amplifiers consist of a dual IC, the TLO 72C, and this provides more than enough gain to drive two pairs of 8 ohms headphones if desired. Using the 10 ohms resistors in the outputs as shown provides a close match to 8 ohms with either one or two pairs of headphones in use. The 12 ohms resistor connected between the bottom of the input level control and earth serves to prevent the headphone signal being faded out altogether. It is surprising how often it is assumed a signal is missing, when in fact the amplifier is not operating. When using battery power it is necessary to know the state of the batteries at a glance, therefore a battery condition indicator is included.

Under normal conditions, when the voltage is 2/3 or more the BC 548 is forward biased and conducting through the green LED. Since in this condition the collector is almost at ground potential, there is insufficient current to switch on the second transistor.

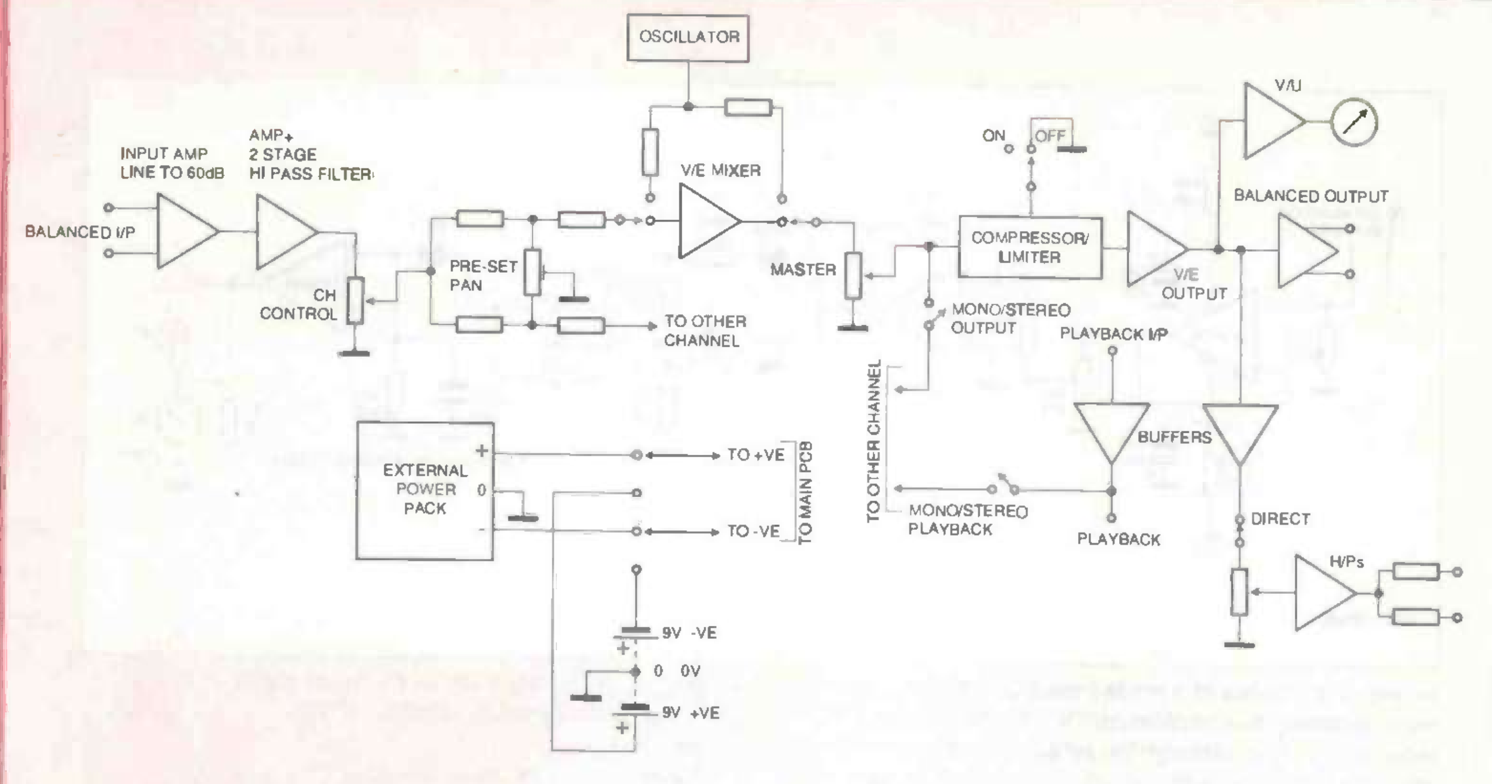
When the supply drops below 2/3, and therefore below the avalanche point of the Zener diode, the BC 548 is cut off, and so extinguishes the LED. However, enough current can now flow via the 470K resistor to switch on the second transistor BC549. Now the collector of this transistor is almost at ground so drawing current through the red LED. In the prototype, I used the LED type which has an internal circuit, causing it to blink at about 2Hz. This is easier to see when outdoors, or in other brightly lit conditions.

The external power unit is built into a die cast box, and is a project published in Practical Electronics some time ago. I used a pre-set to adjust the output voltage. Also it will be noticed that it is set to 12-0-12 volts, whereas the battery supply is 9-0-9 volts. This has the effect of allowing a higher signal level at any of the inputs. However the 9-0-9 volts battery supply is perfectly adequate for normal use. I used 741 ICs simply because they were to hand. The 801s originally specified are, of course, equally suitable. No mains switch is fitted since the power output is switched at the mixer end of the power cable.

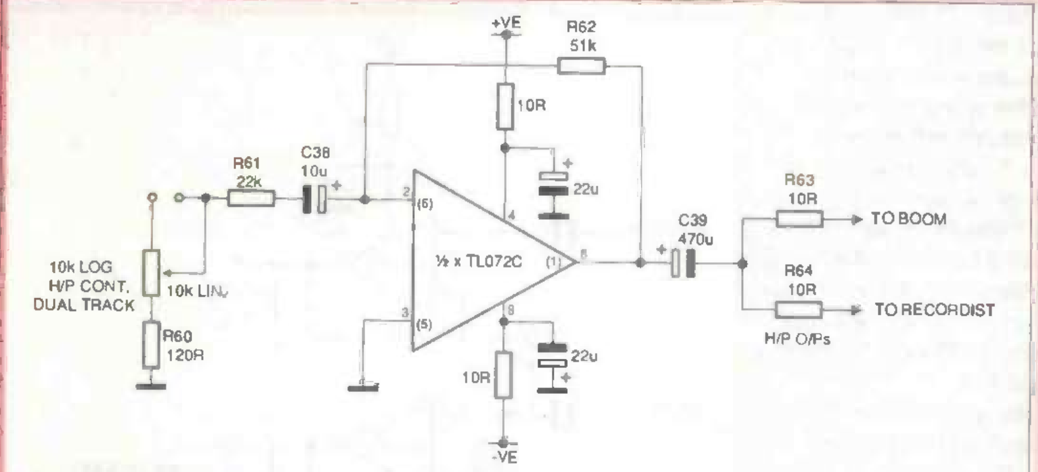
This completes the general outline of the unit Since it consists of a series of separate interconnected units, it may be adapted to suit individual requirements. For example, the input attenuator switch could be replaced with a 10K anti log potentiometer in series with 10 ohms. If powered inputs are



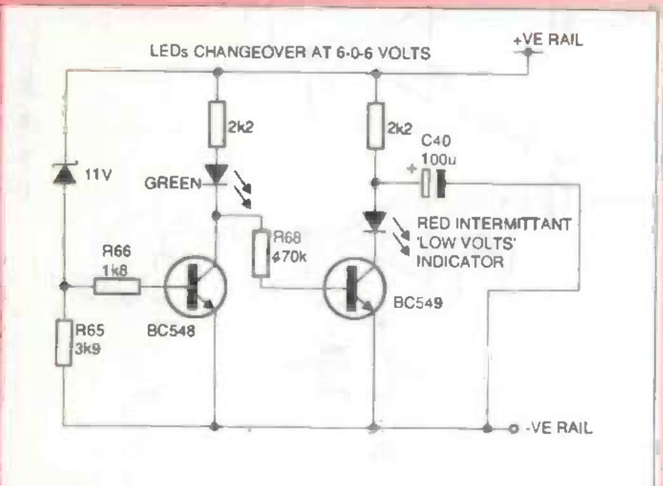
Monit circuits buffers



Portable mixer block diagram



Portable mixer H/P amps



Portable mixer batteries condition indicator

required, the input stages should be changed as shown, or the pan pots could be brought out to the control pane. If desired, veroboard could be used.

On the case, there is an overhang of 10mm on both side panels, at the top and both sides. The purpose of this is to offer some protection to the controls. The central section is a channel, set at right angles at three corners and joined at the fourth by, in my case, pop rivets. There is a 10mm skirt around the four edges, on both sides, and bent at right angles. The top section forms the control panel. The bottom section contains the battery compartments, and has rubber feet at each corner to hold the lids of these clear of the standing surface. The two upright sides contain the input and output plugs ano sockets and, opposite, the headphone monitoring and power supply switching.

One of the side panels has six small holes drilled through it to facilitate adjustment of the pan and input attenuator controls. The nature of these is pre-set, but in this application they will have only occasional use. The holes should be just large enough to accept the shaft of a small screwdriver.

Next month, we conclude the construction and testing of the mixer.

In case of difficulty in locating a suitable case or parts for this project, Partridge Electronics of Benfleet (01268 793256) and BK Electronics of Southend on Sea (01702 527572) both stock a wide range of components, sub frames, meters etc.

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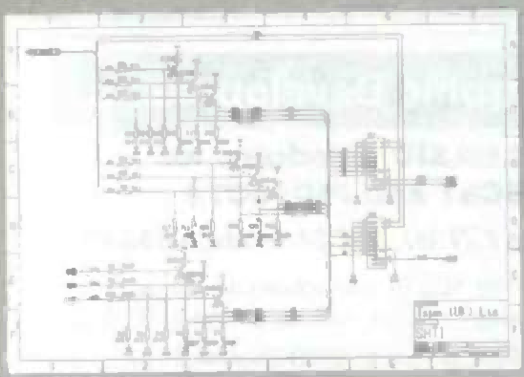

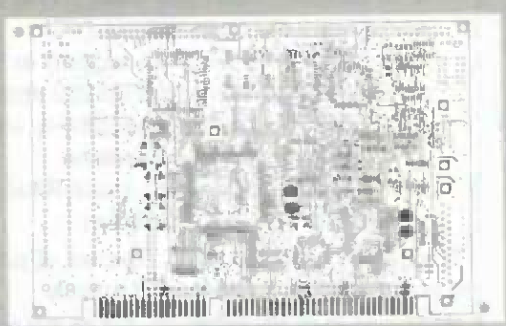

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valve radio SERVICING AND RESTORATION

PART 1

Paul Stenning begins a new, five-part series on the repair and restoration of valve radios

I have been collecting and restoring valve radios for about eight years. My interest began when I was given a Bush VHF80C set by a relative. Since that time I have repaired and restored approaching one hundred sets. My own collection consists of about 20 sets - although it would be larger if I had more space! Pride of place goes to a Bush VHF61, which is the same type of set as my grandparents owned when I was a child.

This series is based on my own experience and opinion - it is not intended to be a definitive guide to the subject. If you have any comments, or perhaps a useful technique for overcoming a particular problem, we would be pleased to hear from you.

Variety

Individual collections and interests vary widely. Some people collect amateur radio equipment, or communications equipment previously used by the Army, Navy, Air Force, or emergency services. Related fields include vintage television and computing equipment. Indeed virtually every item of vintage electronic equipment is collectible.

The definitive source book covering details of collection and interest hobbies of this kind is the "Sound and Vision Yearbook" by Andrew Emmerson. This contains a concise introduction to the subject (such as the examples on computing featured in this magazine), together with an extensive list of auctioneers, books, dealers, magazines, museums, societies and numerous other useful contacts. This highly recommended 96-page paperback is available from Sunrise Press, 2-4 Brook Street, Bampton, Devon, EX16 9LY for just £3.50.

This series will concentrate on domestic broadcast receivers, and within this field there is considerable range. Collections may consist of equipment from a particular period, a certain part of the world, a specific manufacturer or a certain style of cabinet. Some collections cover a broad range of tastes, others are more specific. My personal collection consists primarily of smaller bakelite sets from the 50's - and I am particularly keen on sets made by Bush.

Although this series is based on my experience with valve radios, much of the information will be relevant to the repair and restoration of other items of vintage electronics.

Obtaining sets

Twenty years ago, valve radios could be obtained from jumble sales for a few pence. Today, however, they are not regarded as junk, and sellers often have an inflated idea about their value.

There are several ways of finding sets. The obvious thought nowadays is probably car boot sales, but I have had little success with these. Car boot sales (particularly the larger regular ones) and indeed local auctions are sometimes used to pass off suspect or even stolen equipment anonymously, and should be viewed with caution.

There are a few specialised valve radio dealers around the country, who may have a stock of sets available. Some dealers only sell fully restored sets at an appropriate price - but others will sell sets for restoration. Most dealers will sell by mail order.

Specialist groups sometimes organise auctions of sets and related items. The publishers of "Radiophile" magazine organise two or three such events each year. However the prices paid at these auctions are often fairly high, and the sets are frequently fully restored.

It is sometimes worth looking round local second-hand shops, antique shops and house clearance dealers. They don't usually have much and the prices are often high, but you could be lucky.

A good way to obtain sets locally is to place a "Wanted" advert in the local paper. Expect to collect the sets from the seller's address - most people won't sell suspect goods from their own homes.

Wherever you buy from, keep an accurate record of the address of the seller and the price paid for the set.

Assessing the overall condition

Start by looking at the general condition of the set, in particular the tuning scale, speaker fabric, knobs and cabinet trim. If some of these are damaged or missing you may have problems finding replacements or satisfactory alternatives.

If the back is missing or hanging off, you can be sure someone has been inside a few times. The same applies if some of the screws are missing or don't look original, or if the back is tatty around the screw holes. Take a look through the ventilation slots at the innards (a torch is useful for this). Look out for missing valves, lack of dust, and any signs of previous repair work. If the set is in original condition it is a better restoration prospect.

It is NOT a good idea to test the set. If it has been out of use for a few years, applying mains power can cause major damage (such as exploding HT smoothing capacitors and smoking mains transformers).

Replacement valves

Many valves are still available. A good range are being manufactured again, and will be available from dealers. Many of these originate from the former Soviet Union, and the developing countries. Some are also made in the USA, where vintage radio is even more popular than in the UK. New valves are normally guaranteed for three months, but this is void if the valve is damaged by a set fault.

If a new replacement valve is not available or is too expensive for your budget, one or two dealers sell used-tested valves. Anode Electronics have a vast range, with many costing less than £5. Due to their nature, used-tested valves are not usually guaranteed.

Anode Electronics and a few other dealers offer a valve testing service. Normally this only consists of testing the essential characteristics to keep the price down, but this is generally sufficient to tell you if a valve is serviceable or junk.

Boxes of Unknown Valves

If you are advertising for valve radios in the local paper, you will inevitably receive calls from people offering boxes of old valves. This may sound wonderful, but from my experience they are normally useless.

There will often be many television types (PCL82, PY88 etc), which are no use for valve radio repairs! If there are any radio types, I suggest you pay no more than ten pence per valve, as the majority will be in a poor state (no matter what the seller claims). It was the practice of many engineers to put the old back in its new counterparts box as an emergency spare, so although you may be offered apparently "new valves in original boxes", always be aware of this ploy.

Scrap chassis

It is worth keeping any sets that are not worth repairing, as a source of spare parts. I currently have about five scrap chassis, and parts from these have saved me a considerable amount of money. Hang on to what remains of the cabinet and trim too, you never know what you might need!

Service Information

Unless the work required is minimal, you should obtain a copy of the relevant Service Sheet. Anode Electronics have a stock of over 5,000 sheets and can supply a comprehensive service information pack for a very reasonable cost.

A valve data book is useful, particularly if you do not have the service sheet for a set. The publishers of "Radio Bygones" are offering reprints for very reasonable prices. It is also worth looking out for original data books - particularly Mullard publications.

Test gear

The test equipment needed to get started is minimal. A multimeter is essential, but most electronics enthusiasts will have one already. A cheap digital type is ideal, and has the advantage of a high input impedance.

Sooner or later you will need to realign the RF and IF circuits of a set, and for this you will need an RF signal generator covering the range 150KHz to about 12MHz or maybe higher, and possibly also 87MHz to 100MHz. It must also have an option to modulate the output with an audio tone. I use one costing over £100, but an inexpensive basic unit designed for this specific purpose, will appear in this magazine soon!

For initial tests a high voltage DC (about 250V) supply is required. This should have a high output impedance (or a resistor in series with the output). This need not be very complex - a suitable simple design is shown elsewhere in this magazine!

Safety equipment and advice

An essential item is an Residual Current Device (RCD) or Earth Leakage Circuit Breaker. These are available as adaptors for use with power tools etc. Plug this into a wall socket, and power the set you are working on and the test equipment from it, via a four-way extension lead.

For ultimate safety I would strongly recommend the use of an isolating transformer. A 100VA type is adequate for most domestic sets, but it may be worth paying the extra to obtain a 250VA type which will also be suitable for larger console sets and radiograms.

Neither of these items will provide protection against a shock from a charged capacitor, and sensible precautions must be taken.

When working on live equipment, always work with one hand in your pocket or behind your back to prevent shock current from passing through your body. Switch off the supply and allow the capacitors to discharge before connecting or disconnecting anything, and before handling the chassis. Never work alone. Always ensure someone is available who knows how to administer the relevant first aid, and have them check regularly that all is well. Please take care.

It must be remembered that the majority of old sets were of the "live chassis" type, where the chassis is connected to one side of the mains. Also sets often used a single pole mains switch, and this did not always break the live mains lead. Take care when handling or moving sets still connected to the mains supply, whether switched on at the set or not. To be safe, withdraw the mains plug first.

If possible, work on a flat, stable surface with a piece of rubber mat between the table and the chassis. A car mat is ideal, and will provide some protection to the surface and yourself. Standing on a second car mat will provide some insulation between yourself and earth.

Disassembly

The first stage of any repair and restoration is to remove the chassis and establish what work is needed. Resist the temptation to plug the set into the mains and test it first, as this could cause further problems.

Disassembly should be carried out with care so as not to cause further damage. It may be worth sorting the various screws and small parts into separate containers, and making notes or sketches so that you can remember how it all goes back together.

Removing the knobs

It will often be necessary to remove the knobs before the chassis can be withdrawn. This is usually easy, but a little corrosion in the wrong place can cause problems.

There are three usual methods of fixing the control knobs. Probably the most common method is grub screws, accessible through small holes in the side of the knobs. Sometimes the screw passes through a hole in the shaft so complete removal is needed.

If the grub screw won't shift relatively easily, squirt a SMALL AMOUNT of WD40 into the hole and leave it for an hour or so. If the screw still refuses to budge, or the screwdriver slot is damaged, you may have no choice but to drill it out. This is a last resort, however, and will probably result in a badly damaged knob and possibly some cabinet damage too.

If there is no grub screw hole, the knob is either a push-on type or is retained by an internal screw. Internal screws may be accessible either from inside the cabinet or through holes in the base.

Push-on knobs can be difficult to remove. One old method is to lay the set so that the knobs are uppermost. Wrap a length of strong thin wire around the base of the knob two or three times to form a loop and gently pull the knob off. NEVER use a screwdriver to lever the knobs off, you will end up damaging the case or breaking the knob.

Removing the chassis

In most wooden and heavier bakelite cased sets, the chassis is retained by four bolts on the underside of the cabinet. On some lighter and modern sets, particularly AC/DC sets, the chassis fixing screws are internal.

You may have to disconnect the leads from the loudspeaker or output transformer, and possibly remove the dial lamps. Before disconnecting any wires, note their positions carefully.

Assessing the condition of the chassis

Check that the valves are the correct types. If the type numbers do not match the service sheet or internal label, do not assume they are wrong. Different valve manufacturers use different numbers for the same component, so the valve fitted may be a direct equivalent or a viable alternative.

If the valve markings are missing you will have to assume they are correct for now. If any of the valves have what looks like a milky white deposit on the inside of the glass, the vacuum has been lost and the valve must be replaced.

Make a note of the valve positions, and then remove them, to avoid damage. If the valves have plastic base sections, remove them by gripping the bases and not the glass. It is common for the glass bulb to become detached from the base, and be held only by the wires. Once the valve has been carefully removed, the two parts can be fixed back together by with a little super-glue.

Look closely at any signs of previous repair work or modifications. It is worth comparing the values and positions of any replaced parts with the service sheet.

Look for signs of excessive heat build-up. The high power resistors obviously run very hot, but charred or browned low power resistors should be noted. Check any high power resistors with a test meter. If you have the service information or can read the markings, you can measure the actual resistances, otherwise just check they are not open circuit.

While you've got the meter out, check the windings of the mains and output transformers. The actual resistances are given in the service sheet, but are not important at this stage. We are simply checking that the windings are not open circuit.

By far the most common causes of problems is capacitors. Many of the types used in valve radios are prone to failure, normally current leakage. On many AC/DC sets a capacitor is connected directly across the mains after the power switch, and this capacitor will often be found to have blown itself to pieces.

Next Month

In the second part of this series I will introduce the two example circuits that will form the subject of our discussions. We will cover the work needed before applying the mains, and some quick hints for fault diagnosis. I will then start a more detailed discussion of the circuit, highlighting common problem areas.

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Practically Speaking

BY TERRY BALBIRNIE

Recently, I was involved in examining practical coursework for GCSE Electronics. The idea is that the teacher assesses the candidates' work then a moderator (me), appointed by the examinations board, visits a proportion of the centres. He or she looks in detail at samples of the work with a view to confirming the teacher's marks.

Looking at hundreds of projects in schools and colleges and talking to candidates reveals some fascinating observations. Over the next few months of Practically Speaking, I shall pass on some of these since many will be helpful to those building projects at home. They will also be useful to candidates who are themselves preparing for examinations.

Making tracks

An increasing number of candidates produce their own PCBs (printed circuit boards) using computer aided design software. However, stripboard has been a popular construction medium for many years. For those not familiar with this material, it consists of an insulating base with rows of copper tracks drilled with holes usually having a diameter of 1 mm (see photograph). The spacing between them is generally 2.54 mm (0.1in) which makes it convenient for mounting integrated circuits.

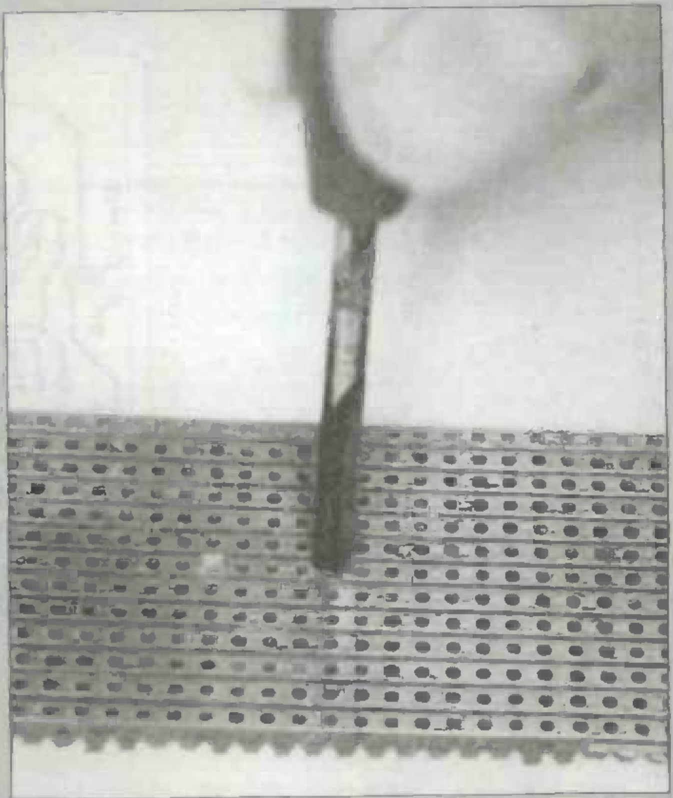
Components are mounted on the plain side of the board with the leads pushed through the holes and soldered to the copper tracks. The strips then form the electrical connections between components. With a little planning, even complicated circuits may be fabricated this way. In all but the simplest designs, tracks will need to be broken so that they may be used for various independent connections along their length. Also, where appropriate, tracks will need to be linked using short pieces of wire. Incidentally, the layout should be carefully planned in advance and all this work done before the components are mounted. The non-dedicated nature of this material makes it very useful and extremely versatile for one-off circuits. In fact, many of the projects I have designed for magazines have used this method of construction.

Bits and blobs

Although stripboard is a good material, there are some pitfalls in using it. Firstly, it is extremely easy for adjacent tracks to become "bridged" either with a blob of solder or with a stray strand of connecting wire. Sometimes, a scrap of conducting debris lodges between the tracks and causes trouble. Unaided visual inspection does not always find these faults. It needs careful scrutiny using a magnifying glass to reveal them. Some candidates switch on their circuit, find that it does not work, then inspect the tracks. The danger is that, depending on what the tracks are responsible for, there could be short-circuits formed and damage to components. This will make it all the more difficult to get the circuit working due to multiple faults. A multitester set to a low resistance range could be used to check for short-circuited tracks but, depending on the nature of the components connected to these tracks, the meter may give readings which are difficult to interpret. There is also the possibility of damage to semiconductor components due to the battery inside the multitester. At the very least, integrated circuits should be removed before making any such test.

Track breaks are often incomplete or omitted. I have seen tracks apparently broken but close inspection revealed a sliver of copper remaining. The problem can be reduced by using the proper tool for the job. I have see tracks broken with such things as compass points, hacksaw blades and screwdrivers - this is simply asking for trouble. A proper track breaker (spot face cutter) should always be used - see photograph. Problems arise when cracks occur in tracks. A hairline crack is difficult to detect and often shows up by intermittent operation of the device especially when the circuit board is bent slightly. Do not try to repair a crack by simply applying solder across it - this often cracks too. Instead, solder a short bridge wire over it. Always remove integrated circuits first. Cracks are sometimes caused when a soldered component is removed and the leads of a new one are pushed through the same holes without properly clearing the old solder away.

R.S. Components (and its retail outlet Electromail supply stripboard having a 3.81 mm (0.15 in) matrix which makes it more suitable for beginners. The wider spacing makes it less likely to develop solder bridges. Also, the tracks are slightly wider so are more robust. Remember, however, that this material will not accept the pin spacing of integrated circuits.



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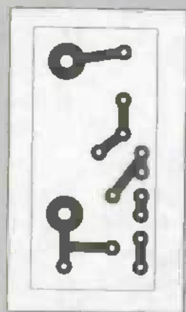

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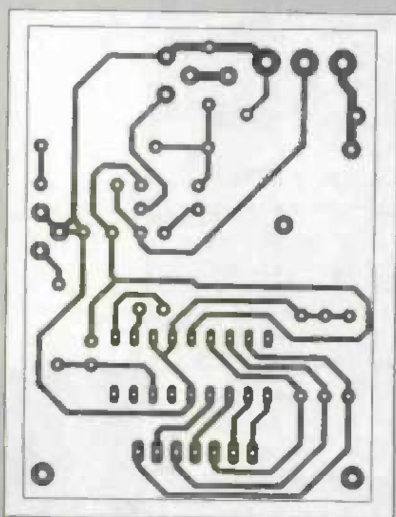

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Around the Corner

It is over ten years since the personal computer revolution started in real earnest, and we are now in the midst of another revolution, the electronic information revolution. Suddenly, over the last few months, I have started to see little cryptic strings of characters appearing at the bottom of ads, on posters for new films, in the Sunday papers, even on TV ads. A little cryptic string of characters which usually seems to start with - HTTP://WWW..........

These cryptic strings of characters are of course the URL, or Uniform Resource Locator, for a site on the World Wide Web, the sprawling hypertext information system which is rapidly becoming the most widely used part of the Internet. The Web has fired the imagination of users and information providers alike, and it is now expanding at an explosive rate.

New sites are being added to the Web at an estimated rate of over 700 per day, and there are now almost 40million pages of information on the Web, nearly all of which can be accessed by anyone with a PC and a modem. Information on every subject under the sun, and all just a local phone call away.

There is a lot of idle chatter about pornography and subversive material on the Internet, but this obscures the fact that there is now an enormous amount of useful and valuable information out there, and the great thing about it is that apart from the cost of a local phone call, and a subscription to one of the Internet Service Providers, it is nearly all free.

Amongst all these Web pages is an awful lot of stuff which is of interest to the electronics engineer. There are now whole catalogues of components published on the Web; nearly all the major semiconductor, computer, telecommunications, and electronics companies in the world now have Web sites of their own. These often include details of new products, and the great advantage for English speakers, is that 98% of the material published on the Web is in English.

Even small companies, including some one-man outfits, are now represented on the Web, with many seeing it as the most powerful medium yet invented to communicate information about new products, and services to a massive global market. The Web is also set to change the way in which traditional information services are provided. This includes books, magazines, radio, TV and, of course, libraries and conventional on-line information services.

For a start, information will become available faster. For example, information on a new product will now be available on the Web the day it is announced, not a month or two later in a trade magazine. The information can also be more comprehensive than would be the case with that published in a magazine, and perhaps most important of all it will be available globally at the same time; someone in India can thus have equal access to information with someone in California.

Once again the world shrinks, inequalities start to disappear, and competitiveness increases. With the Web, none of us will be able to be complacent about a commercial or technological lead. But to compensate it will also bring with it an explosion of opportunity. Already in the UK and around the world we are seeing an enormous upsurge in entrepreneurial activity related to the Web, an upsurge reminiscent of that which happened in personal computing. Just as fifteen/twenty years ago, enormous businesses like Microsoft, Sun, and Oracle were very small outfits, sometimes located in a garage or spare room.

We in the UK are uniquely favoured in the potential offered by the Web for new businesses, we speak English, the language of the Web, we have a highly developed and low-cost telecommunications network, we have lower wage rates than the US, and perhaps most important we in this country have a tradition of world trade. Who knows, the new megabusinesses on the Web could be created by individuals working in small offices and backrooms in the UK.

Let's hope so, and in the mean time if you have access to the Web why not try this site:

HTTP://WWW.EMAGS.COM/PR.HTM

It has an interesting collection of the latest press releases from a range of companies in electronics, computing, aerospace and defence.

Next Month......

In the May 1996 issue of Electronics Today International, Robin Abbott will conclude his project to construct a large matrix display, whilst from Terry Balbirnie there is a project. Bart Trepak introduces another PIC microcontroller project, whilst Dr Pei An will continue his 8051/80535 single board computer project. Tony Sercombe concludes his portable audio mixer project.

The feature articles will include a look at the impact of the World Wide Web on the electronics world by Nick Hampshire, and Paul Stenning will continue his practical look at repairing and restoring antique electronic equipment. Plus reviews of some more PC software.

Finally, we would like to thank (belatedly) Leo Electron Microscopy for their help in providing much valuable Information for the Electron Microscopy article in ETI Octber 1995.

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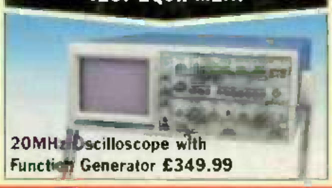

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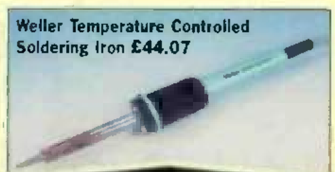

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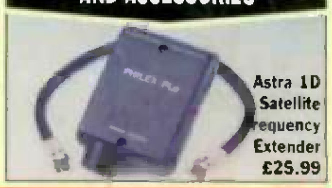

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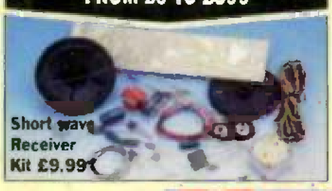

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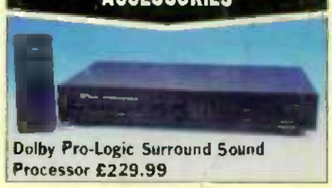

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