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JUNE 1998

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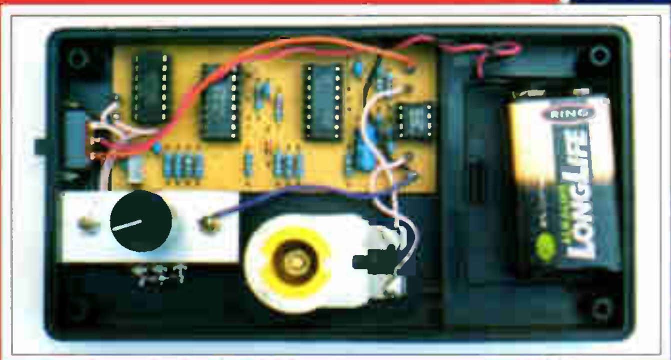
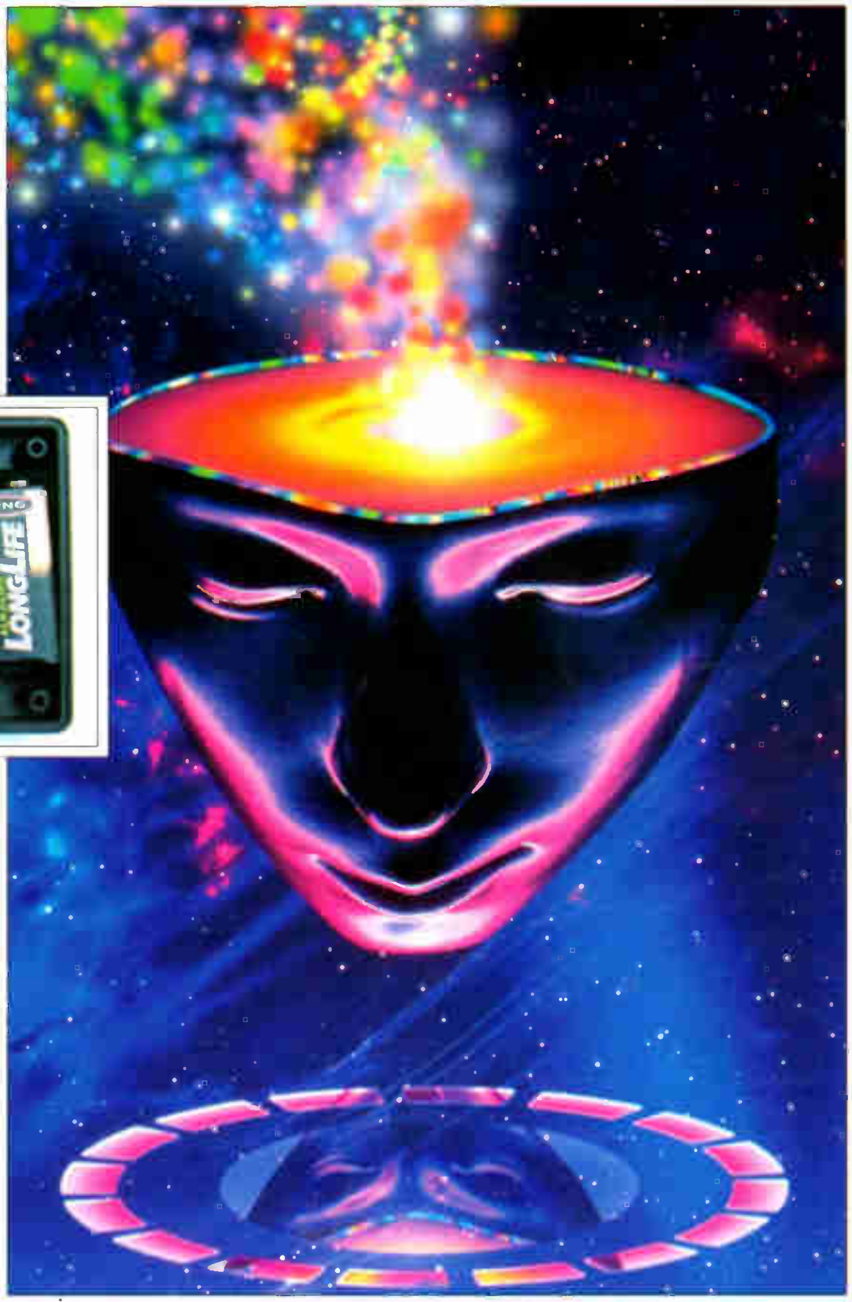
EPE MOOD CHANGER

Experimental Brainwave Generator for Alpha, Beta Delta & Theta frequencies





8051 BASED EEPROM MICROCONTROLLERS

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PLUS Ingenuity Unlimited - Circuit Surgery
Innovations - New Technology Update

WIND GENERATORS 380 WATT 1.14 metre dia blades, carbon matrix blades, 3 year warranty, 12vdc output, 24v version available, control electronics included, brushless neodymium cubic curve alternator, only two moving parts, maintenance free, simple roof top installation, start up speed 7mph, max output (30mph) 380w £499 ref AIR1

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We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, enviromental control, light fittings, plants, test equipment etc

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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

DYNAMO FLASHLIGHT Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

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

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

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

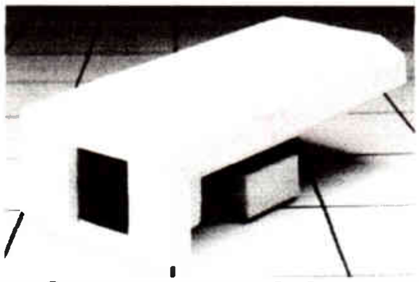
ELECTROMAGNETIC GUN PLANS Projects a metal object a considerable distance-requires adult supervision £5 ref F/EML2

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

SOLAR POWERED WIND UP RADIOS BACK IN! These FM/AM radio's have a solar panel and a hand operated charger! £17.95 ref SOLRAD

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



COLOUR CCTV VIDEO CAMERAS,

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

Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty,1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

CIRCUIT PACKS Packs of 35 circuit diagrams covering lasers, SW radios, geigers,bugs,char etc Pack1, Pack2, Pack3 £4.99 each.

SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings ,power point. £4.99 ref SMKX

CONVERT YOUR TV INTO A VGA MONITOR FOR £25! Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. Ideal for laptops or a cheap upgrade Supplied in kit form for home assembly. **SALE PRICE £25** REF SA34

***15 WATT FM TRANSMITTER** Already assembled but some RF knowledge will be useful for setting up. Preamp req'd, 4 stage 80-108mhz, 12-18vdc, can use ground plane, yagi or dipole £69 ref 1021

***4 WATT FM TRANSMITTER KIT** Small but powerful FM transmitter kit 3 RF stages, mic & audio preamp included £24 ref 1028

YUASHA SEALED LEAD ACID BATTERIES 12v 15AH at £18 ref LOT8 and below spec 6v 10AH at £5 a pair

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

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt **£12.99** REF AUG10P3

SOLAR POWER LAB SPECIAL You get 2 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor **£7.99** REF SA27

SOLAR NICAD CHARGERS 4 x AA size £9.99 ref 6P476, 2 x C size £9.99 ref 6P477

GIANT HOT AIR BALLOON KIT Build a 4.5m circumfrence, fully functioning balloon, can be launched with home made burner etc Reusable (until you loose it!) £12.50 ref HA1

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78 500 pellets £4.50 ref EF80

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INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs Easily cut to shape. 6" square £15 ref IRF2

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

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

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills etc. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102

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

NEW LOW COST VEHICLE TRACKING TRANSMITTER KIT £29 range 1.5-5 miles, 5,000 hours on AA batteries, transmits info on car direction, left and right turns, start and stop information. Works with any good FM radio. **£29 ref LOT101a**

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

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

UK SCANNING DIRECTORY As supplied to Police, MOD,M15 and GCHQ! covers everything from secret government frequencies, eye in the sky, prisons, military aviation etc £18.50 ref SCANB

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser , X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front &rearwaveguides, 1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS

Could be adapted for laser listener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 for one Ref LOT4

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating. £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

DIGITAL PROPORTIONAL B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc £20 each. sold as seen ref LOT2DP

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

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

HIGH POWER DC MOTORS, PERMANENT MAGNET

12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front

£22ea REF mot4

ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

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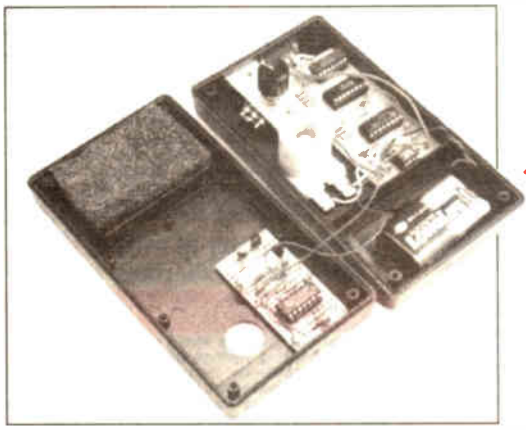
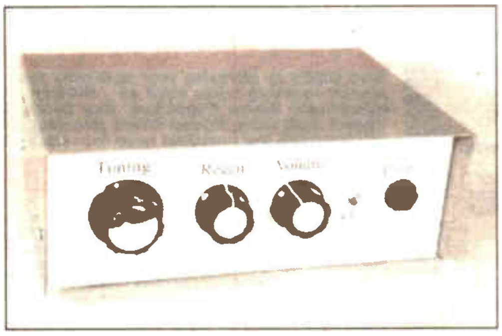
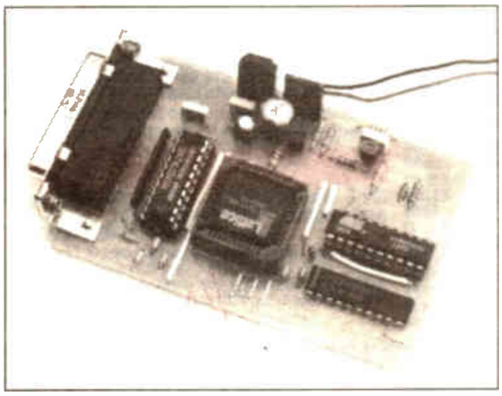
The No. 1 Magazine for Electronics Technology and Computer Projects







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Our July '98 issue will be published on Friday, 5 June 1998. See page 395 for details.

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5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
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Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
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8" **Mitsubishi M2894-63** double sided *NEW*	£295.00(E)
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Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

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2½" **TOSHIBA.**(19 mm H) MK2101MAN 2.16 Gb. ***New***	£199.00
2½" **TOSH.**(12.5 mm H) MK1002MAV 1.1 Gb laptop. ***New***	£115.00
2½" to 3½" conversion kit for Pc's, complete with connectors	£15.95
3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
3½" **CONNER** CP3044 40mb IDE I/F (or equiv.) RFE	£69.00
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00
3½" **QUANTUM 40S Prodrive** 42mb SCSI I/F, New RFE	£49.00
3½" **WESTERN DIGITAL** 850mb IDE I/F ***New***	£185.00
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5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95
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Many other drives in stock - Shipping on all drives is code (D)

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TV SOUND & VIDEO TUNER
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TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

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Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE.** Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.

Tilt & Swivel Base £4.75
VGA cable for IBM PC included.
External cables for other types of computers CALL

Only £119 (E) **Order as MITS-SVGA**

As New - Ex Demo
17" 0.28 SVGA Mitsubishi Diamond Pro monitors
Full multisync etc. Full 90 day guarantee. £325.00 (E)

Just in - Microvitec 20" VGA (800 x 600 res.) colour monitors. Good SH condition - from £299 - CALL for info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB** and **standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. **Integral audio power amp and speaker for all audio visual uses.** Will connect direct to **Amiga** and **Atari** BBC computers. **Ideal for all video monitoring / security applications with direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video** input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, **complete with composite video &** ***optional*** **sound** input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
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Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
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HP3781A Pattern generator & **HP3782A** Error Detector	£POA
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HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP7580A A1 8 pen HPGL high speed drum plotter	£1850
F&B Wardrobe size, insurance spec 1 hour rated fire safe	£650
EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Sony DXC-3000A High quality CCD colour TV camera	£1100
CSZ VERY Large 3 cavity thermal shock chamber	£POA
Philips PW1730/10 XRAY generator with accessories	£POA
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Intel SBC 486/125C08 Enhanced Multibus (MSA) NEW	£1450
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
Taylor Hobson Tallysurf amplifier / recorder	£750
System Video 1152 PAL waveform monitor	£485
Siemens K4400 64Kb to 140Mb demux analyser	£2950

19" RACK CABINETS

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Made by Eurocraft Enclosures Ltd to the **highest possible spec,** rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all are lockable with **five secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to **enable status indicators to be seen through the panel,** yet remain unobtrusive. Internally the rack **features fully slotted reinforced vertical fixing members to take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of **integral fans** to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied **in excellent,** slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)

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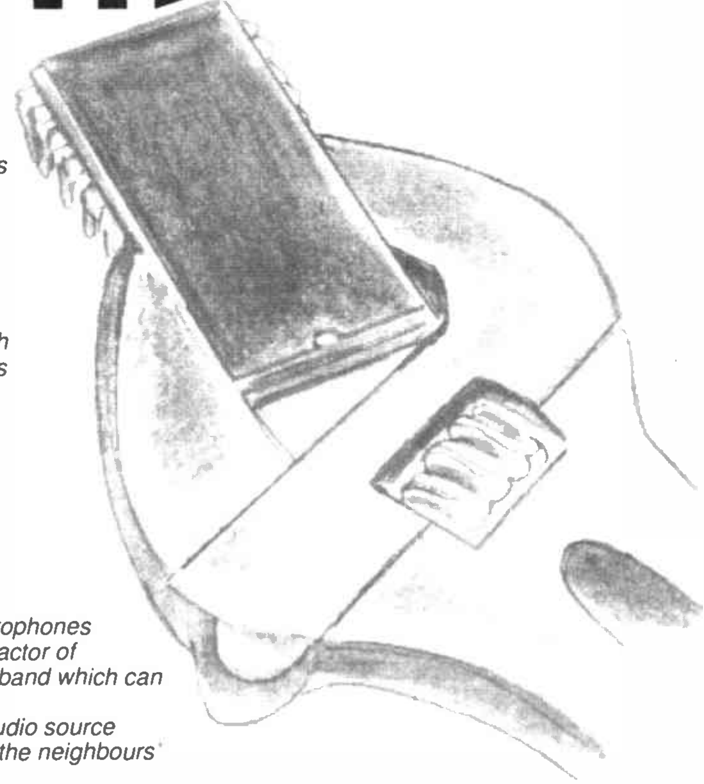

PIC16x84 TOOLKIT

At last, TASM and MPASM compatibility for PIC16x84 users! Versatility and high speed were the two chief design objectives for this PIC16x84 Toolkit. It can be used in conjunction with both TASM and MPASM source codes and is three tools in one: a programmer, a program disassembler, and a bi-lingual translator between the two assembly languages.

The Tookit is for use with PIC16C84 and PIC16F84 microcontrollers. All modes and external switching operations are controlled directly by a PC-compatible computer ('386 and above, with or without Windows). No manual intervention via hardware switches is needed. The computer must have either QBasic or QuickBASIC already installed.

The design may be used as a stand-alone unit, or interfaced with the EPE PIC Tutorial *demonstration board. The software can also be used on its own purely as a "language translator" without the Toolkit or Tutorial boards.*

NOISE CANCELLING UNIT

A fully tried and tested Noise Cancelling Unit which employs two microphones and a set of headphones fed with "anti-sound" to reduce noise by a factor of between 10 and 30, or more on the high efficiency narrow frequency band which can reduce specific "single frequency" sounds by a factor of up to 100.

The unit has audio inputs so that you can listen to your favourite audio source while background noise is cancelled. Enjoy your hi-fi without hearing the neighbours' music, lawnmower or the building site concrete mixer, etc.

GREENHOUSE COMPUTER

This microcontrolled design is for use with a small greenhouse or conservatory. Its main function is to monitor and control the heating and watering requirements of the plants. An additional feature is that it has the option of a wireless link (the subject of a future issue) to a remote display unit, so you can view and log the status of your greenhouse from the comfort of your house.

The main facilities of the controller are:

- *Two separate channels for monitoring temperature*
- *Immediate, minimum and maximum temperature display*
- *2-level thermostatic heater control*
- *Soil moisture monitoring*
- *Automatic plant watering*
- *Monitoring of water reservoir level*
- *Optional Radio Link to remote display unit*
- *2-line 20-character liquid crystal display*

The circuit is based around an Atmel AT89C2051 microcontroller, whose facilities are discussed elsewhere in the current issue, together with a programmer.

LOW BATTERY INDICATOR

An in-circuit, micropower battery condition indicator for your projects. This unit began life as a battery condition monitor for the EPE Mood-Changer *design described in the current issue. As it is not immediately apparent to the user whether the* EPE Mood-Changer *is operating or not, a low-battery warning of some kind is useful. However, the usual method, using an l.e.d. that remains lit above a pre-set supply voltage appeared unsatisfactory as it would inevitably draw more current than the main circuit!*

Thoughts on the problem led to the design of this circuit and it was then realised that, with micropower operation and a wide supply voltage range, it could be used in many other designs. The use of a compact layout allows it to be constructed cheaply and fitted into an odd corner of space that will exist in almost any project, and it can be adjusted to work with most common battery voltages.

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JULY ISSUE ON SALE FRIDAY, JUNE 5

PINHOLE CAMERA MODULE WITH AUDIO! Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance. Can be hidden inside anything, even a matchbox! Complete with 15 metre cable, psu and tv/vcr connnectors £73 95 ref CC6

BBC SELECTORS WITH SMART CARD SLOT AND VIDEO CRYPT Interesting new item in this week is this Selector Originally made for the BBC to send encrypted video films to your VCR at night time. The project seems to have failed. Very complex units consisting of a smart card slot in the front plus several switches and an IR receiver. Fully cased and measuring 230 x 430 x 90mm, new and boxed. On the back of the unit is a scart socket plus a UHF input and output. A channel tuning control numbered 28 to 40 and an IR socket. Inside is a comprehensive tuner section, smart card reader mechanism and control electronics plus a power supply section. These units are sold as strippers but we imagine you could use one to convert a monitor into a TV or maybe use the videocrypt side of things for something else. Supplied complete with manual and mains lead. Clearance price just £9.95 ref BBC1X

INLINE RCB UNITS This in line minature earth leakage unit instantly shut off the mains supply in the event of any current flowing between live and earth thus preventing a potentially lethal shock. IEC plug one end, socket the other, fitted in seconds, reset button. The ultimate safety aid when working on electronic equipment, computers etc. As these units are fitted with an in-line IEC plug on one end and socket on the other than could even be used to extend standard IEC computer leads **Pack of 3 £9.99 ref LOT5A**

THE ULTIMATE ENCLOSURE for your projects must be one of these! Well made ABS screw together beige case measuring 120 x 150 x 50mm. Already fitted with rubber feet and front mounted LED. Inside is a pcb fitted with other bits and pieces you may find useful. Sold either as a pack of five for £10 ref MD1, pack of 20 for £19.95 ref MD2

17 WATT 12V SOLAR PANEL A solar panel designed to give a nominal 12v. The solar cells are laminated within a high quality resin material! which offers excellent protection against UV and moisture. Mounted on tempered glass in an alauminium frame. The panel is ideal for charging sealed lead acid batteries and a protection diode in the circuit prevents reversed current flow. Mounting is by four adjustable hooks and connection is by screw terminals. Max power 17 wattts, 35 cells, 17vdc peak, 433x402x15mm, 1000mA max. 1.9kg **Solar panel £115 ref SOL4**

SOLAR POWERED AM/FM RADIO A compact AM/FM mono radio complete with earphone and a solar panel that recharges the built-in battery when placed in direct sunlight or under a strong lamp. It features a rotary Volume/On/Off control (which must be set to 'Off for recharging), AM/FM selector switch, rotary tuning control, metal belt clip and socket for external 3V DC supply. **Solar Radio £7.95 ref SR23**

MOTOR CYCLISTS RADAR DETECTOR New in is the Whistler 1560 Laser/Radar detector complete with a speaker for motorcycle helmets. Super wid band covering X,K and Ka plus lasers at 950nm+/-10nm. 360 deg total perimeter protection, detects laser, radar and VG-2 wherever they come from. **£159.95 ref RD4**

MAGIC EAR Unlike previous 'sound-magnifiers' we have offered, Magic Ear fits unobtrusively behind the ear itself. Magic Ear's micro technology is very advanced, its built-in microphone is extremely sensitive and there's also a volume control to help you adjust to all conditions In use, Magic Ear is startlingly effective. It'll help you to follow every word of conversation even at a distance, and enjoy theatre, cinema or live music with stunning new sound. Comes fitted with 3 long life batteries, a free travel pouch, plus a choice of 3 different ear pieces designed to fit all shapes of ear. **Magic ear £16.99 ref MAGE3**

RADIO METER Perhaps the best of the scientific knick-knacks of the past and well overdue for revival! Fascinating, soothing and educational. In the vacuum inside the inverted bulb like container the vanes revolve, driven round by light particles alone! (each vane is black on one side white on the other) **Radiometer £9.99 ref SC120B**

SATELLITE NAVIGATION £119 The GARMIN~ GPS 38~ is the one navigational tool for the great outdoors that offers big features in a small, lightweight package - all at a truly affordable price. Mark your favorite fishing spot, tree stand or camp site. Or retrace your steps back to the safety of your starting point using our all - new TracBack feature. The GPS 38 shows you exactly where you are, where you've been and where you're going. The GPS 38 features easy, one-thumb operation and weighs only 255g. There's a resettable trip odometer, graphic compass' and highway steering guidance. And it provides up to 20 hours of use on a set of 4 AA batteries. The GARMIN GPS 38. The affordable way to bring you back £119 ref GPS1

DIFFERENTIAL THERMOSTAT KIT An electronic self assembly kit designed for use in solar heating systems, heat recovery systems etc. The principle of the kit is that it has two thermistors that are placed on the items to be measured (typically a solar panel and a water storage tank) the controller then operates a relay all the time one temperature is higher than the other. The temperature difference is adjustable. A typical use would be to operate a pump all the time a solar panel was at a higher temperature than the water storage tank **Differential thermostat kit £29 ref LOT93**

10 WATT SOLAR PANEL Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. One of these panels will run our solar water pump in full sunlight although we would recommend that for optimum performance two panels would be prefereable **3' x 1' solar panel £56 ref MAG45**

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses, ranging from solar fountains to hydroponics! Small and compact yet powerful. Will work direct from our 10 watt solar panel in bright sunlight. Max head 17 ft Max flow rate 8.1pm Current 1.5A (Ref AC8) £18.99

BOOST CELL PHONE RECEPTION ON THE MOVE! Compared to high-powered carphones, hand-portable mobile phones don't always work too well in moving vehicles. Sometimes the signal 'drops out' during a call, other times there's too much interference to get through at all. However, the affordable Cell Patch provides a major improvement, dramatically boosting signal reception without wires or batteries. The 9.5 x 9.5cm (3.3" X 3.3") microthin antenna adheres to your car window sunvisor, ideally within 61-122cm (2-4') of the handset, or can be carried in a pocket. Works with all types of portable cellular phone. Cell Patch £11.99 ref CEL1

CAT SCARER produces a blanket of high sonic and low ultrasonic sound, which is inaudible to humans, birds and fish - so it is ideal where you want to protect your bird table or fish pond against feline predators. It will deter cats from your garden and other protected areas. It will also deter foxes. mains operated, 10 m of cable. Running cost will be approximately 1 p per day. Garden watcher £42.45 ref GW2

VIDEO PROCESSOR UNITS?/6v 10AH BATTS/24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v torroidial transformer (mains in) sold as seen, may have one or two broken knobs etc due to poor storage £9.95 ref VP2X

SOLAR MOTORS Another new line for us are these tiny motors which run quite happily on voltages from3-12vdc. We have tried one on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick £1.50 each

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed. Two piece construction with the following features- Illuminated keypad, nice clear easy to use keypad, tone or pulse (switchable), reacall, redial and pause, high/low and off ringer switch and quality construction. Each telephone is finished in a smart off white colour and is supplied with a standard international lead (same as US or modem card sockets) if you wish to have a BT lead supplied to convert the phones these are also available at £1.55 each ref BTLX **Phones £4.99 each ref PH2**

INFRARED CAR PHONE KIT £7.99 Interesting box of goodies! this kit was designed to convert car phones to enable hands free dialling, the kit contains the following items 1) A keypad designed to mount in the centre of the steering wheel, it requires a 9v PP3 battery and transmits the numbers using three on board high power infra red LEDs 140 x 120mm 2) An infra red receiver module containing a IR photo diode, IR filter and control electronics 60 x 30 x 15mm (cased) 3) Control box (nice case) 100 x 170 x 35mm which we understand is the interface between the infra red and the car phone, it is also supposed to adjust the volume of your car stereo at the same time! made for Phillips car phones (but we don't know the model)Complete kit is £7.99 ref CP1

Hi power 12v xenon strobe variable rate flasher modules and tubes £6Useful 12v PCB fitted with control electronics and a powerful Xenon tube! just apply 12v DC to the input and the tube will flash. On the board is a small potentiometer which can be used to vary the flash rat! PCB measures just 70x 55mm and could be incorporated into many interesting projects! £6 ref FLS1 Pack of 10 is £49 ref FLS2

WANT TO MAKE SOME MONEY? Stuck for an idea? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is a certificate enabling you to reproduce the manuals as much as you like! £14 ref EP74

TALKING WATCH Yes, it actually tells you the time at the push of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £8.99 ref EP26A

POWERBEAM INFRA RED Lamp,All this lamp gives out is infra red light, and loads of it! perfectfor supplimenting night sight and surveillance equipment. Most mono CCTV video cameras are infra red sensitive so used in conjunction with this lamp would greatly enhance their operating performance. Water resistant case and rubber covered switch make this unit perfect for all weathers. Krypton bulb. 4 D cells required. **Powerbeam lamp £29 ref PB1**

GIANT SCREEN VIEWER Turn your TV picture into a supersize screen! This high precision Fresnel lens converts even the smallest screen up to a massive 26', giving a crystal clear picture at a traction ot the cost of a big TV. Easily fitted in minutes. Also ideal for PC monitors etc £26.95 ref SVGA2

NOGALIGHT NIGHT VISION £129 Open up a new world of adventures and experiences. Wildlife enthusiasts and adventurers in the wilderness, amateur astronomers, hunters, wargamers, private eyes on surveillance, all find Nightspy indispensable for their use. Nightspy's unique features include a special tube protection device, to eliminate over exposure, and infrared illuminator used in total darkness, such as in cave exploration and operations in dark rooms. The Nightspy is light and hand held, or can be mounted on a standard tripod. It uses two standard AA batteries and can be operated by left or right hand users, with or without optical glasses. Optical Magnification X 1.7 Field of View 10Degrees Focusing Range 25cm to infinity objective Focal Length 50 mm F/N 1.6 Diopter Range +/- 3 Mechanical Length 182 mm Width 65mm Height 100 mm Weight 700 gr. Electrical Power Source 3 VDC 2AA batteries Battery Life 40 hours Infra-red Illuminator built-in Imaging Device Night Vision Image Intensifier Tube **£129 ref NOGA**

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JUMBO LED PACK 15 10mm bicolour leds, plus 5 giant (55mm) seven segment displays all on a pcb £8 ref JUM1 Pack of 30 55mm seven seg displays on pcbs is £19 ref LED4, pack of 50 £31 ref LED50

12VDC 40MM FANS MADE BY PANAFLO, NEW £4 REF FAN12

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17 Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

RUSSIAN 900X MAGNIFICATION ZOOM MICROSCOPE metal construction, built in light, mirror etc. Russian shrimp farm!, group viewing screen, lots of accessories £29 ref ANAYLT

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

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

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16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further information 20kg, 885x800x1650mm ref TAL-1, £249

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PHOTOMULTIPLIER TUBES Boxed and unused straight from the ministry of defence. Made by EMI with a MOD part no of 10/CV/5114 and packed almost 30 years ago ! Do you have a use? do you want to count light particles? They would look nice on the mantle piece!Offered to you at £15 each (we think the MOD paid more than this is 1958! £15 each ref PM3

CLOCK CAMERA WITH AUDIO Discretely monitor living rooms, reception, office, tills or any other area. Fully working clock houses an invisible spy camera complete with audio. Complete setup includes clock, camera, microphone, clock battery, 15 metres of cable, power supply, adapter for either scart or phono. Everything you need, no soldering required. Full instructions included. Easily installed in just a few minutes. Plugs straight into VCR or TV (scart or phono)Clock camera with audio £89.95 ref CC5

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TELEPHONE VOICE CHANGER Changes your voice to a new or unfamiliar one. Simply place over the telephone mouth piece and speak into the changer. Fully adjustable for different voices. Supplied complete with batteries, ready to go. Unit measures 90 x 60 x20mm Telephone voice changer **£14.95 ref CC3**

EXTERNAL CAMERA Introducing the Bulldog model 4 vandal resistant camera in heavy steel case for interior or exterior use. Top quality case housing a 420 line camera module. Each camera is supplied with a 15m cable terminating in Scart and phono plugs. Multi angle bracket for easy installation in any situation. A 12vdc psu is also included. Easily installed in a few minutes, plugs straight into VCR or TV (phono or scart) **Bargain price £89.95 ref CC1**

GIANT INSULATORS Just in this week are some giant ceramic insulators, each one measures 130mm high and about 170mm diameter. Finished in a high gloss brown and black glaze. In the base of each insulator is a threaded hole approx 1" diameter, rather like a mop/broom head thread. If you are into shortwave radio, crystal sets or high voltage experiments then these are for you. (We've got one as a door stop) Not too sure what their original purpose was, all we know is they were made for export about 25 years ago, never exported and been in store since then. **Price is £8 each ref INSX**

NATO RADIATION MONITORS Interesting new line! These are small modules that strap on your wrist (strap supplied) and monitor radiation. We have stripped one apart and they contain a small piece of "crystal" this could be something like Naphthalene or any other rare radiation sensitive crystal. When radiation strikes the crystal, it scintillates and a small amount of light is produced in the crystal in reaction to the radiation exposure. That light is then picked up by a micro pv cell measuring about 2mm square! Also in the unit is a sheet of foil, a circular metal plate (insulation between the two) and a small pair of additional parallel metal plates. NATO part no is 6665-99-225-2314 any information gratefully received!! Alternatively if you wish to buy one they are just **£3 each** ref NATOX

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oscilloscopes: the ability to print and save waveforms is just one example. Advanced trigger modes, such as save to disk on trigger, make tracking down elusive intermittent faults easy. Combining several instruments into one small unit means it is lighter and more portable. When used with a notebook computer, field engineers can carry a complete electronics lab in their PC.

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BY LEAPS . . .

Perhaps not quite science fiction but, PICs aside, some of the most popular projects we have published in recent years have been the unusual "medical"/brainwave type gizmos. The *Mind Machine* originally published back in 1991 has been updated three times with the last publication being in the March, April and May 1996 issues. Now we have the *EPE Mood Changer*, an experimental device that produces Alpha, Beta, Delta and Theta frequencies and should help you to sleep, relax or get your brain in gear.

Our initial tests with the prototype have produced some interesting results and we would like feedback from readers on your experiences with this unusual unit. As always, with these types of devices, it should not be used by anyone who suffers from epilepsy.

We have some other ideas for unusual "medical" type projects which we are sure will fascinate you; so, keep reading, we are working on these.

RETRO

It is fascinating to push the technological frontiers with microcontrollers and the like but, as I have said before, it is also interesting to have some fun with simple circuits and one of the most rewarding areas to do this is in amateur radio. Our *Simple Short Wave Receiver* will allow you to receive amateur transmissions from around the world using just a few components in a relatively inexpensive project.

Many people use commercial equipment costing hundreds of pounds to communicate with each other across the Globe but the fascination and gratification of receiving these far off transmissions on a home-made simple receiver makes it worthwhile. There is still, in this 300MHz digital age, much to be said for building your own "radio set" – give it a try – we are sure you will enjoy the results, and you may just get hooked and finish up "working the ether" yourself.

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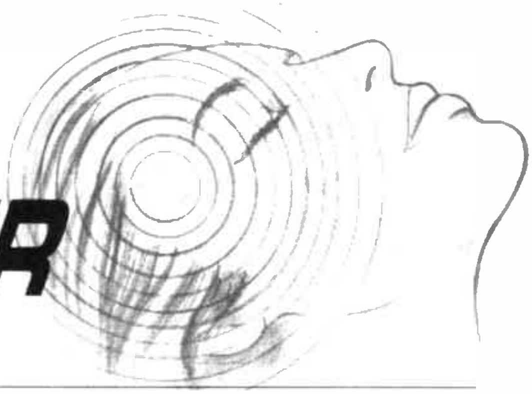
Constructional Project



EPE MOOD CHANGER

ANDY FLIND

Don't become stressed-out, let this experimental pocket-size "psychiatrist" take the heat out of everyday living.

SOME time ago the author was given an expensive little electronic gizmo that was claimed to reduce "stress". It aimed to achieve this by surrounding the body with an alternating electromagnetic field of the same frequency as electrical signals found in the brain during various stages of relaxation.

Needless to say, this gadget was soon prised open to see what, if anything, was inside. The answer was quite surprising.

It contained a PIC microcontroller, which generated and applied a rather jagged synthesised sinewave to an air-cored "bobbin" coil. A total of five frequencies were available, selectable with a d.i.l. switch projecting through the front of the unit bearing legends from "sleep" through to "optimism".

The output of the device was about 300mV peak-to-peak and the coil had a measured resistance of about 550 ohms, so the radiated output was obviously very small indeed. It wasn't long before thoughts arose as to what might be achieved through the use of increased power!

BRAINWAVE

Brainwaves of various kinds are nowadays fairly well understood. In brief, the brain generates electrical activity with a frequency related to the current mental state, and encouraging production of one of these frequencies is often claimed to induce the associated state.

Various methods of stimulation can be used, by far the most effective being photic stimulation using glasses or goggles fitted with l.e.d.s. Sound is sometimes employed, generally as a "binaural" signal where two slightly different frequencies are played separately through headphones. *(See the* Mind Machine *in the March to May '96 issues of* EPE.*)*

Some of the original brainwave-inducing gadgets sold in the USA offered magnetic field stimulation, so it may well have a useful effect. The frequencies sought fall into four broad bands whose names, frequency ranges and effects are shown in Table 1.

It is obviously possible to construct a suitable magnetic field generator quite cheaply, and it is not necessary to program a PIC in order to do so. There are many ways to generate a sinewave of the required frequency. Digital synthesis was chosen for this project as it is easy to adjust the frequency without associated amplitude variations.

A simplified version of the method is shown in Fig.1. Five D-type flip-flops are shown connected in series, with the final $\overline{Q}$ connected back to the D input of the first to complete the loop.

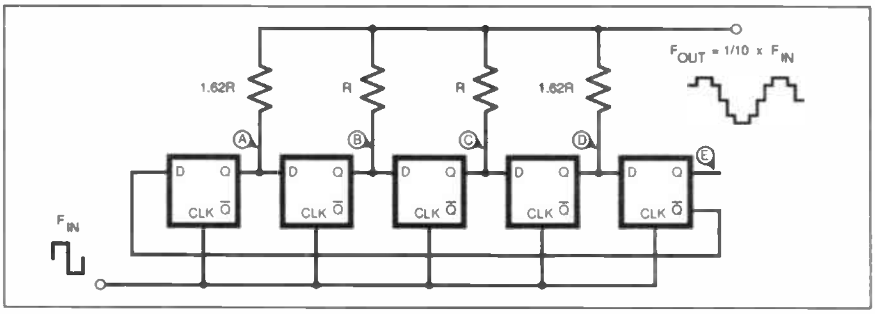


Fig.1. Simplified digital sinewave generator using D-type flip-flops.

Assuming all outputs are zero at the outset, clocking the flip-flops will generate a repeating sequence of the output states as shown in Table 2. If four of these outputs are now parallel connected through resistors with suitable value ratios as marked, the output will be the "stepped" approximation of a sinewave as shown in Fig.1. The fifth output is not used so the highest and lowest output voltages remain the same for two clock cycles to simulate the flatter "tops" and "bottoms".

The frequency of this "sinewave" is one tenth of that from the input clock and the amplitude reaches rail-to-rail peak voltages when not loaded. Resistive loading

Table 1. Brainwave Frequencies and Effects

Name	Frequency	Conditions
Delta	0·5Hz to 4Hz	Sleep
Theta	4Hz to 8Hz	Creativity, Dreaming
Alpha	8Hz to 13Hz	Deep Relaxation, Meditation, Stress Relief
Beta	14Hz to 25Hz	Normal alert mental state

WARNING NOTICE

It is known that photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. We would therefore also suggest that it is not wise for such people to try this project.

A user who is not a known epileptic, but when using the *EPE Mood Changer* begins to experience an odd smell, sound or other unexplained effects, should TURN IT OFF IMMEDIATELY and seek professional medical advice.

will attenuate it and may cause a d.c. shift towards one of the supply rails, but will not increase distortion. The combination of D-type flip-flops in this way is known as a "walking ring" counter, and a ready made five-stage version is available as the CMOS 4018B i.c.

IN THE MOOD

The full circuit diagram of the *EPE* Mood Changer is shown in Fig.2. It uses two 4018B counters, IC2 and IC3, which are connected in series to produce a "sinewave" having twenty clocked steps per cycle.

Clocking is provided by one half of IC1, a 7556 dual timer, connected as an oscillator. The frequency is set by capacitor C2, resistor R1 and the "Frequency" control VR1 which give a variable clock speed between about 20Hz and 440Hz.

The two counters divide this by 20 for an output frequency of 1Hz to 22Hz. Use of a log component for VR1 provides reasonably easy adjustment, although it has to be used "back-to-front" with the highest frequency at the anti-clockwise end of the scale.

Table 2. Output States for the D-Type Flip-Flops

A	B	C	D	E
0	0	0	0	0
1	0	0	0	0
1	1	0	0	0
1	1	1	0	0
1	1	1	1	0
1	1	1	1	1
0	1	1	1	1
0	0	1	1	1
0	0	0	1	1
0	0	0	0	1
0	0	0	0	0

A couple of additions are necessary for IC2 and IC3 to operate correctly in series. To begin with, they are intended to be used as programmable counters. To simplify this their outputs are all Q so that applying any one to the "input", equivalent to the first Data (D) input of Fig.1, will complete the loop for the appropriate number of clock cycles.

To construct a longer loop with two 4018Bs it is necessary to invert the last output of the first (IC2) before applying it to the input of the second. This inversion is obtained from the second timer in IC1, where a signal applied to the threshold and trigger inputs, pins 8 and 12, appears in inverted form at output pin 9.

A state can arise where an "illegal" sequence of 0s and 1s is circulating. A single 4018B has internal circuitry to prevent this but it doesn't always work for two connected in series, so an extra circuit must be included to ensure correct operation.

From Table 2, it will be seen that when both the first and last outputs are high, all the intermediate outputs should also be high. The "micky mouse" logic of resistor R2 and diode D1 provides a "high" output only for this state. This is differentiated by capacitor C3 and resistor R3 and used to pulse the "reset" inputs of IC2 and IC3, which causes all the outputs to go high, thereby ensuring that the circuit operates as intended.

The resistor values used for sinewave simulation were chosen for the closest possible approximation using single values from the E12 series resistors. The result isn't perfect, but when viewed on an oscilloscope the output looks surprisingly good, especially if a suitable filter capacitor is used to smooth out the "steps".

Smoothing is not used in this circuit by the way, as it wasn't in the commercial one. It may be that the harmonic content of the "steps" helps to produce the desired effect.

WASHED-OUT

The source of a suitable air-cored coil for the output was initially a problem, until casually mentioned to a washing machine service engineer of the author's acquaintance. To him it was obvious, 230V solenoid coils!

A scrapped three-way valve was duly provided with three of these coils attached to it. They were simply pressed into place and could be prised free instantly with a screwdriver. Each had a pressed steel hollow core which could be dismantled simply by twisting the joints

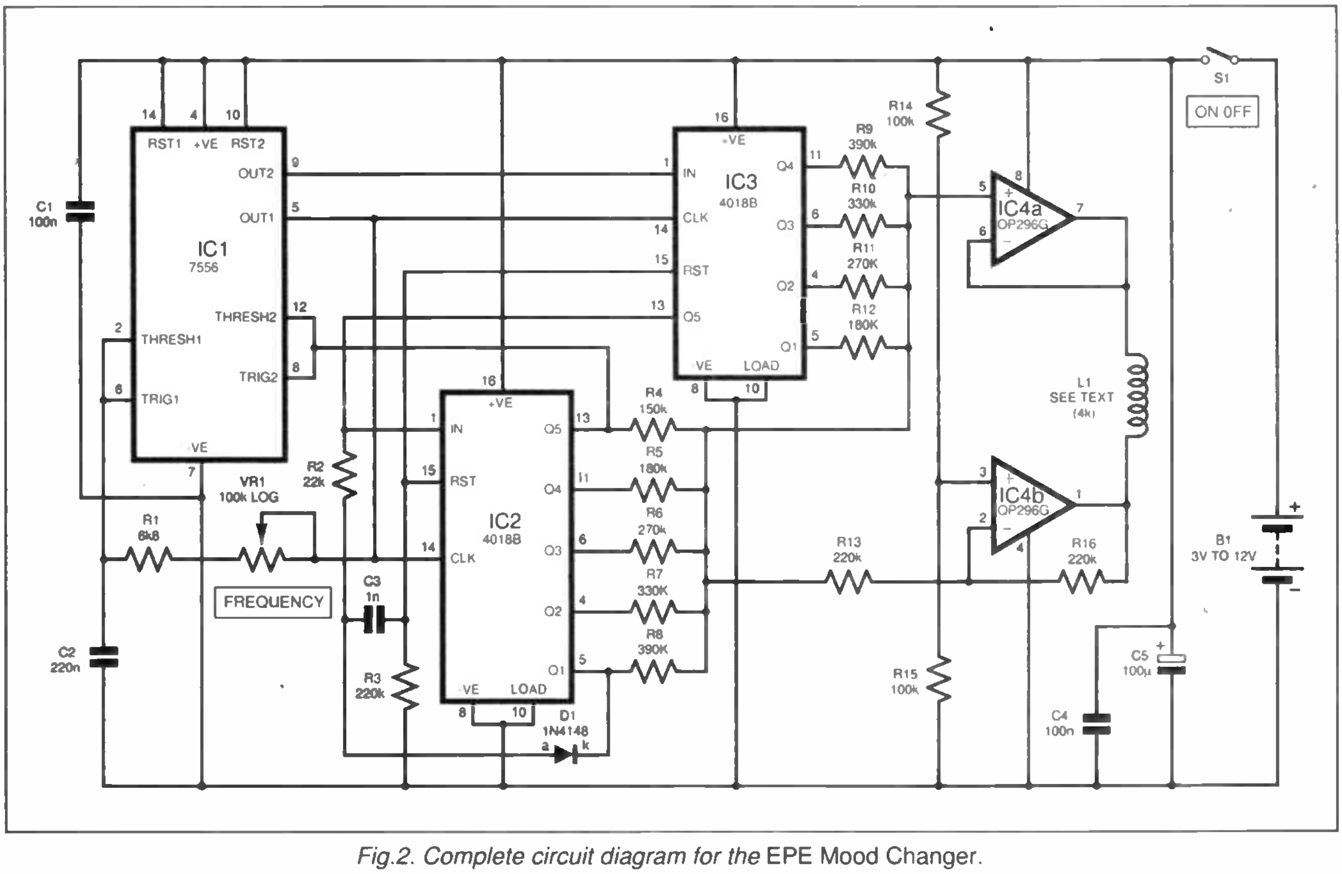


Fig.2. Complete circuit diagram for the EPE Mood Changer.

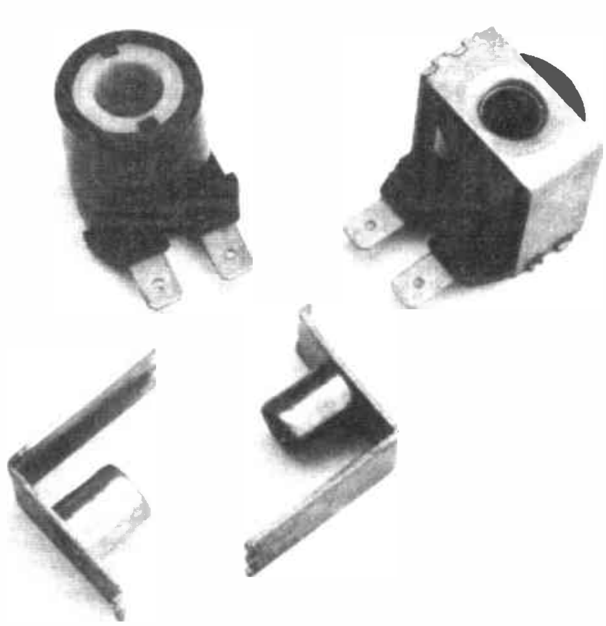
apart with sidecutters. The photograph shows this.

Subsequent enquiries have revealed that these valves are available almost everywhere as service spares with a single solenoid coil on a valve costing less than £9. It is worth checking scrapyards first though, as these are even cheaper.

The coil used had a d.c. resistance of about four kilohms. To obtain the maximum output from this from the available supply voltage a "bridge" output stage is used.

This is built with IC4, an OP296G op.amp which has rail-to-rail inputs and outputs. This is a low-power device so when loaded its output will not actually reach the supply rails, so a small amount of input attenuation is needed, preferably through a resistor returned to half the supply voltage.

Loading the generator output with the input of the inverting stage IC4b achieves this. It avoids any shift in the d.c. level of the output, and the resulting attenuation also applies to the non-inverting stage IC4a to give a symmetrical output. For acceptable distortion, loads driven by this stage should be higher than 3·5 kilohms.



Producing an air-cored coil from a 230V solenoid coil salvaged from a washing machine three-way valve.

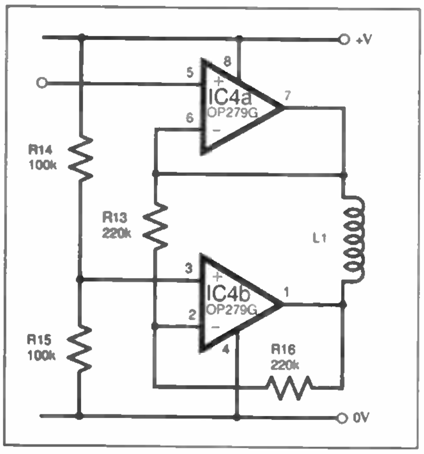


Fig.3. Modifying the output stage for higher power.

If higher power is required, the output can be altered as shown in Fig.3. An OP279G is used here as a direct replacement for the OP296G. It can drive rail-to-rail loads down to about 200 ohms, which may consist of a lower resistance coil or several coils in parallel. A simple alteration to the circuit, provided for on the p.c.b., removes the attenuation of the input signal.

The drawback to this modification is an extra 4mA in quiescent current, which may be acceptable where a higher output current is required and a suitable supply is available. It also becomes unstable with supplies below 4V whereas the unmodified circuit operates down to 2V.

CONSTRUCTION

Construction of the printed circuit board (p.c.b.) for this project is straightforward with the layout of all components, together with full size copper foil master, shown in Fig.4. This board is available from the *EPE PCB Service*, code 193.

The usual procedure of assembling components in order of physical height, lowest first, is recommended with d.i.l. sockets for the i.c.s. Note that there are two possible positions for the lower end of resistor R13. For the standard circuit using the OP296G the lower hole should be used as shown. The upper one is for use with the OP279G higher power version as described above.

For a low profile, capacitor C5 is placed horizontally on the board. A dab of glue will help to secure it firmly.

The coil L1 is not required to test the output as this is a voltage that should be present anyway. With potentiometer VR1 temporarily connected it can be checked with an oscilloscope using the highest frequency, or with an analogue meter at the lowest speed.

ASSEMBLY

The unit can be housed in any suitable case of the constructor's choice. The author chose a small black plastic box with an integral compartment for a PP3

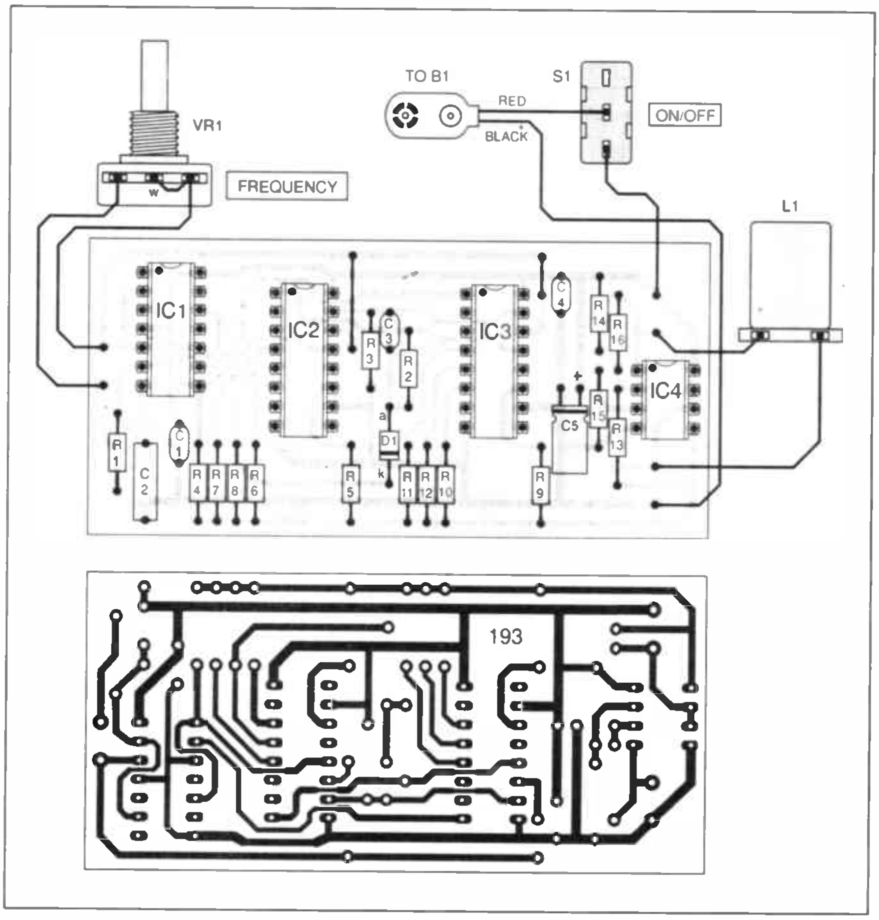


Fig.4. Printed circuit board component layout, off-board wiring and full size copper master pattern for the EPE Mood Changer.

battery. The general layout can be seen from the photographs.

Since the device will probably be carried in a pocket whilst operating, some thought was given to making the frequency control easy to operate but difficult to accidentally displace. An edgewise control would work, but these are difficult for home constructors to obtain and fit.

The method finally adopted is shown in Fig.5, where the top of the control knob is level with the surface of the case. It can easily be rotated by a finger pressed against the top but the flush mounting makes it comfortable to carry in a pocket and difficult to alter accidentally.

The coil is secured with a single ***brass*** (not steel) screw as shown in Fig.6. A piece of rubber tube is placed over this with a washer at each end. As the top nut is tightened it compresses the tube, causing it to expand outwards and grip the coil.

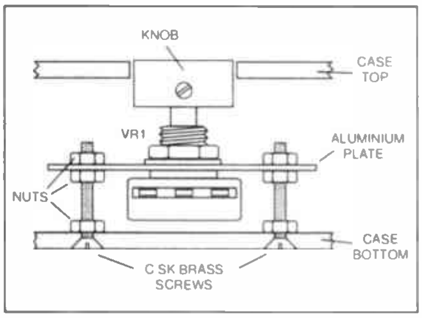


Fig.5. Suggested method of securing the Frequency control in the case.

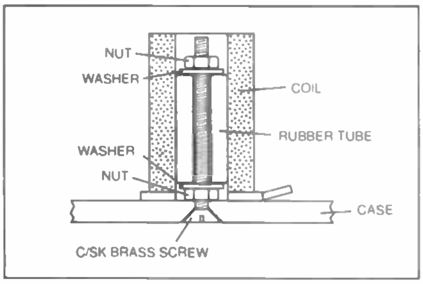


Fig.6. Coil mounting details.

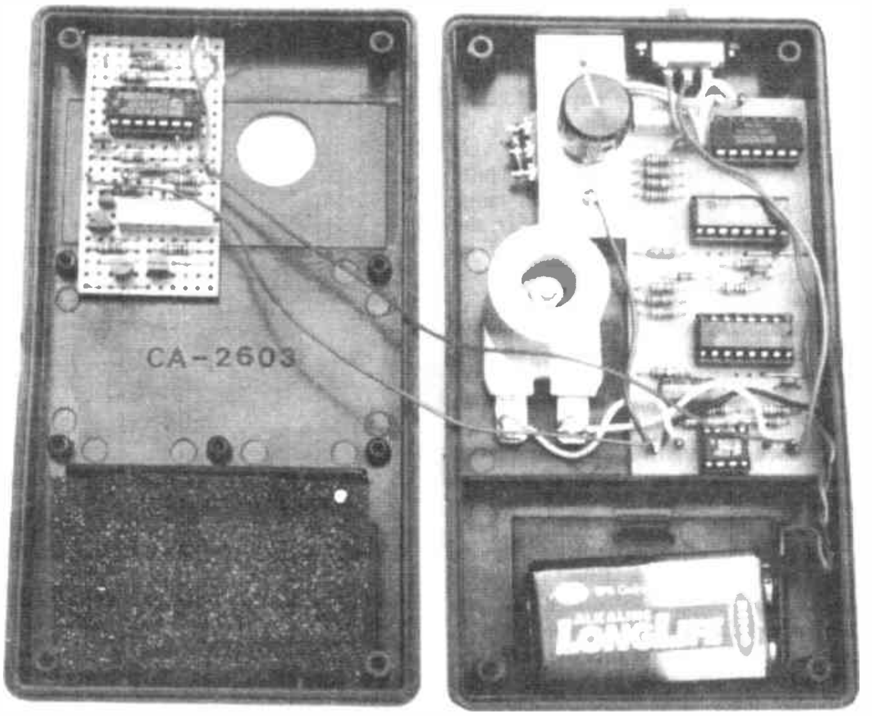
CALIBRATION

Calibration of the control can be carried out in either of two ways. If a frequency meter is available it can be connected to the clock signal from IC1, which is present on both the wire links on the p.c.b. This is a clean square wave at twenty times the output frequency so it is easy to measure it and apply the appropriate calibration markings to the control.

Alternatively, the frequency is related to the value of resistance of VR1, so this can be measured with a DVM and used for marking the calibration points. Table 3 shows the values of VR1 resistance against frequency.

Note that frequency also depends on the exact value of capacitor C2 so this method of calibration depends on this being fairly accurate. The component specified has a 10 per cent tolerance.

Since there is no indication if this unit stops working (!) a means of monitoring the battery voltage is essential. The simplest way is to fit a small moving-coil indicator but these tend to be expensive nowadays.



The two halves of the project case showing the component positioning. The small board in the case lid is the Low-Power L.E.D. Battery Monitor, *to be described next month.*

An alternative solution is to construct the *Low-Power L.E.D. Battery Monitor*, to be described in next month's issue, and fit this. It was in fact developed for this project, though its versatility and potential usefulness led to its presentation as a separate design.

The basic *EPE* Mood Changer circuit can operate from supplies between 2V and 10V. The upper limit is set by the voltage rating of capacitor C5 so if this is replaced by a higher voltage type the circuit can be operated up to 15V, the limit for the CMOS components.

With a 9V supply it draws about 3·5mA. It can work from a 3V supply with a drain of about 1mA, and operation down to 2V means that the use of two AAA cells or even a single lithium cell is practicable. At these voltages it still packs greater magnetic "punch" than its commercial counterpart, since it provides several times the output voltage to push more current through many more coil turns.

Table 3. Resistance/Frequency Calibration

Output Freq. (Hz)	Clock Freq. (Hz)	VR1 Resistance (Ohms)
1	20	157·143
2	40	75·171
4	80	34·186
6	120	20·524
8	160	13·693
11	220	8·104
15	300	4·130
20	400	1·397
22	440	0·652

COMPONENTS

See SHOP TALK Page

Resistors

R1	6k8
R2	22k
R3, R13, R16	220k (3 off)
R4	150k
R5, R12	180k (2 off)
R6, R11	270k (2 off)
R7, R10	330k (2 off)
R8, R9	390k (2 off)
R14, R15	100k (2 off)

All 0·6W 1% metal film

Potentiometer

VR1	100k sub-min. rotary carbon, log

Capacitors

C1, C4	100n resin-dipped ceramic (2 off)
C2	220n polyester layer
C3	1n resin-dipped ceramic
C5	100µ radial elect. 10V

Semiconductors

D1	1N4148 signal diode
IC1	7556 CMOS dual timer
IC2, IC3	4018B CMOS counter (2 off)
IC4	OP296G dual op.amp (see text)

Miscellaneous

L1	solenoid coil (approx. 4 kilohm – see text)
S1	s.p.d.t. sub-min. slide switch

Printed circuit board available from *EPE PCB Service*, code 193; plastic case (HH2), size 145mm × 80mm × 34mm; 8-pin d.i.l. socket; 14-pin socket; 16-pin d.i.l. socket (2 off); battery holder, with clips (see text); plastic knob; multistrand connecting wire; solder pins; solder etc.

Approx Cost Guidance Only £25 excluding batts.

A BETA WAY OF LIVING!

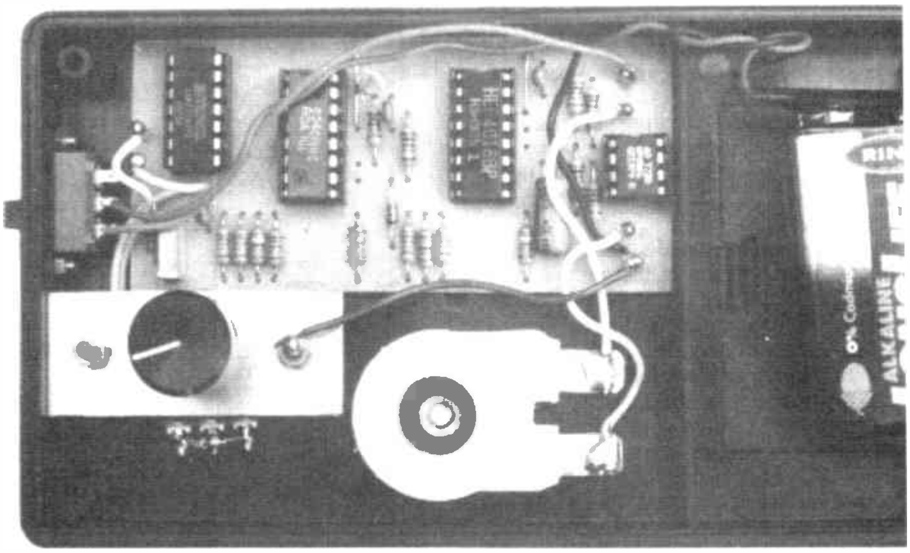
Of course, the ultimate question is "Does it work?"! Two experiences of the author may be of interest.

On one occasion the commercial version was set to "sleep" and placed under the pillow, putting it also within range of the author's wife. The next day she awoke and immediately commented on a wonderful night's sleep, without ever knowing the device was there!

At a meeting one evening the author felt exceptionally "laid-back", and suddenly realised that most of the day had been spent working on this project with the coil well within range on the workbench although most of the time it had been operating at "beta" frequencies because these are the easiest to view on an oscilloscope.

Much of the effect of such of a device may, of course, stem from the well-known auto-suggestion effect. If you think it will do you good it probably will, especially if it cost you a lot of money!

Practically speaking, there's no doubt that the brain does generate electrical signals at these frequencies, and it is electrically conductive. Exposing it to an alternating magnetic field must therefore have some induced effect, however minute.



Completed unit showing components installed in the base of the case. Suggested methods for mounting the Frequency control and output coil are given in Fig.5. and Fig.6.

How susceptible the brain is to such a tiny effect, especially over long periods of time, is probably totally open to conjecture. It may be that practical experiment is the best way to find out.

Any feedback from readers will be very welcome. If it works, and especially if it can be improved, it may become a vital tool for coping with life in this age of stress, disaster and road-rage.

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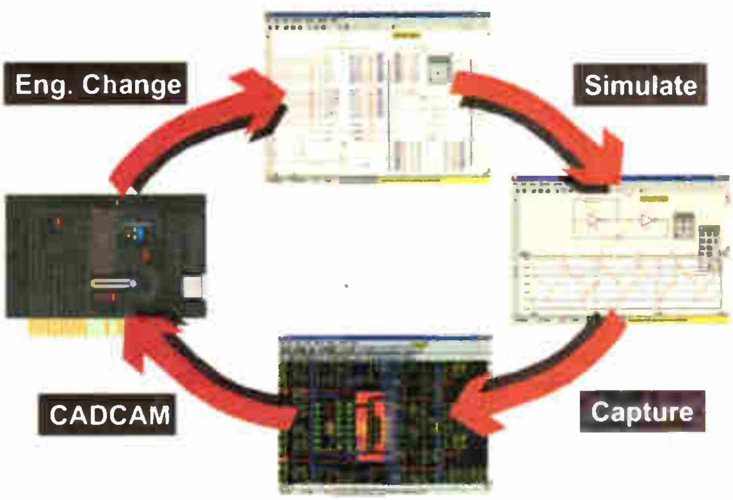

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NET ON THE GRID

Could electric power lines carry Internet data? A new consortium believes so, reports Barry Fox.

Last October, Nortel and Norweb announced their work on a system which uses mains electricity power lines to carry Internet data. In late March the two companies announced a joint venture Nor.Web, to market the Digital Power Line system around the world.

Nor.Web claims to have received more than a thousand enquiries, which whittled down to forty serious approaches. Now ten companies, including Norweb in the UK, Singapore Power and Edon of the Netherlands have signed agreements to use the technology.

The company certainly thinks it is on a roll. "The technology is available today – and will revolutionize the mass communications on the Internet", said Chairman John Beckitt. "It's the most elegant solution. The most significant communication tool since the mobile phone".

Intelligent Junction Boxes

But Nor.Web could still only show a video of the system. It is being used by children at a school in Manchester, where parent company United Utilities is the local electricity supplier.

Although Nor.Web cannot hook its system into the London mains, there seemed no reason why they could not demonstrate a working prototype on the ring mains in the London building where Beckitt was speaking. Nor.Web's answer on this was revealing. The system relies on intelligent junction boxes which sit alongside the electricity meter and there were still only two working samples, both of which were in Germany.

Nor.Web is long on catch phrases and hyperbole, but short on hard technical fact. Steve Pusey, CEO of Nor.Web, speaks in the kind of sound bites that radio, TV and newsprint editors love. "We have a mission to lead the world. There is a light bulb everywhere. We see a massive opportunity in speeding access to the World Wide Wait". He describes the unit as an "information socket" which decouples the electricity supply from the data.

"The days are not far off", says Steve Pusey, "when every white goods product will have its own Internet address".

Digital Power Line provides a 1-Megabit/second signal both ways into and out of the home. But when quizzed on this, Pusey admits that the 1Mbit signal must be shared by the two hundred or so homes which are connected to the local sub-station.

"But if there is demand, we just put in multiple bearers", says Pusey.

Nothing, however, can be done to speed Internet access if the bottleneck is at the server, which may be anywhere in the world and connected through overloaded lines.

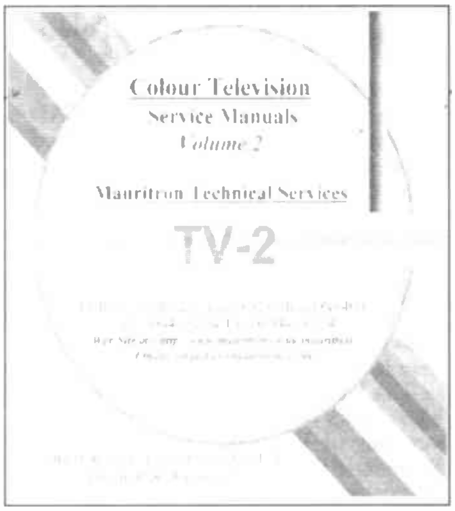
When quizzed, Nor.Web admits that all the two hundred or so homes served by the same sub-station will have access to the same digital bits and bytes. So the data will have to be encrypted for its two-way journey between each home and the sub-station. There are no details yet of how this will be achieved.

"We are working on the principle that if you build a motorway, people will come", says Pusey, dismissing the rival technologies of ADSL, ISDN, cable modem and broadband wireless as "all 20 per cent more expensive". Nor.Web says it will have 2,000 homes on trial in the UK by the end of this year, and Pusey promises "mass connection at low cost". But he can offer no information on the likely price on the intelligent socket, and not even a ballpark figure for monthly tariffs or the cost of transferring data files.

Last October Nor.Web admitted that it had little chance of selling the system into the USA, because the sub-stations in North America are often pole-mounted, and serve only around fifteen homes. But the recent London briefing was paralleled by a similar event in Atlanta, Georgia.

"Although we are focussing on Europe and Asia", says Pusey, "we have two possible solutions to make digital power lines cost effective in America. We may move the sub-station further up the network and if all fifteen homes connect to a single sub-station, giving 100 per cent penetration, it may be cost-effective anyway".

Service Manuals on CD-ROM



MAURITRON Technical Services, who say they are the UK's major supplier of service manuals, now supply their technical manuals as compilations on CD-ROM.

Each CD-ROM contains 25 service manuals for a comprehensive selection of equipment. The current range covers TVs, video recorders, computer monitors and vintage valve wireless sets. Future editions will include manuals for a vast range of test equipment, amateur radio equipment, office equipment etc. Each CD costs £24.95 plus VAT which, say Mauritron, makes this by far the cheapest method to purchase service information (although printed copies are still available).

Mauritron have a catalogue of the manuals on a 3.5-inch floppy disk, detailing all the makes and models covered by the CD-ROMs, as well as their range of technical publications. Just send two first-class stamps with your request.

The latest editions and current special offers can also be found on Mauritron's web site.

More information contact Mauritron Technical Services, Dept EPE, 8 Cherry Tree Road, Chinnor, Oxon OX9 4QY. Tel: 01844 351694. Fax: 01844 352554.

E-mail: enquiries@mauritron.co.uk.

Web: http://www.mauritron.co.uk/mauritron/.

JBC'S *COOL* SOLDERING!

SOLDERING specialists JBC describe their new soldering equipment as being *cool*! Well, cool at the right moments but stably hot when it needs to be. Their Advanced Series range is said to slash temperature fluctuations from 70°C in conventional irons to 30°C.

Says Robin Smith, JBC's National Sales Manager, "We can operate the Advanced Series at lower temperatures and tests prove it to be 80% more efficient than its nearest rivals".

The maximum working temperature of the series is 350°C instead of 450°C, thus lowering the risk of damage to circuits or components. The irons register when they are in use and in the rest-state temperatures drop dramatically, avoiding tip oxidization. Tips are thus expected to remain in the best possible condition and last up to five times longer than those of conventional irons.

For more information contact JBC Soldering Solutions Ltd., Dept EPE, Marshall House, 255 Wellington Road South, Stockport, Cheshire SK2 6NG. Tel: 0161 474 0299. Fax: 0161 474 0288.

WEBBED PC SOLUTION

THE PC Solution, the UK company that handles the renowned Ivex CAD software, tell us that Ivex has launched its World-Wide Web Knowledge Base. This data base contains information about the use of Ivex programs suitable for beginners and experienced users. Also included are answers to the most frequently asked questions, and you can use their search engine to seek answers to any other questions you may have.

The Ivex site at http://www.ivex.com also allows you to download free demo versions of WinBoard PCB, WinDraft Schematic Capture, Spectra Autorouter and other CAD software. The information and service are free.

For those who do not have Internet access, a free demo version of either WinDraft or WinBoard can be obtained by calling The PC Solution.

Make all enquiries to The PC Solution, Dept EPE, 2a High Road, Leyton, London E15 2BP. Tel: 0181 926 1161. Fax: 0181 926 1160.

E-mail: info@thepcsol.Demon.co.uk. Web: http://www.thepcsol.Demon.co.uk.

Wilmslow has Hart!

WILMSLOW Audio, the UK's largest distributor of loudspeaker kits, components and replacement drive units have announced their acquisition of Hart Electronic Kits. Hart are renowned for the design and supply of kit amplifiers based upon original designs by John Linsley Hood.

The Hart operation, based at Oswestry in Shropshire will be relocated to Wilmslow's premises in Leicestershire. The addition of amplifier kits to the already established loudspeaker kits will enable Wilmslow Audio to expand into new markets and offer a greater product range.

For more information contact Wilmslow Audio Ltd., Dept EPE, 50 Main Street, Broughton Astley, Leics LE9 6RD. Tel: 01455 286603. Fax: 01455 286605.
E-mail: wilmslow.audio@dial.pipex.com.

Telecoms via Canal

Canal towpaths seem prime territory for routing fibre-optics. By Barry Fox.

TWO hundred year old technology is kick-starting the digital revolution. British Waterways has sold GPT's Fibreway the right to lay 1000km of optic fibre cable under the towpaths once used by horses to pull barges. The fibres make a figure of eight loop round the UK, connecting London, Bristol, Birmingham, Nottingham, Leeds and Manchester.

Fibreway provides "dark" or "unlit" fibre which cable TV and telephone operators can use to carry digital data as light pulses. The loop was finished at Christmas and six companies have signed up. Cable company Telewest is the first to switch on. Says Peter Borer, Telewest's National Network Director, "Over a million people use our cable TV service for phone calls. So far we have had to route their calls over BT or Mercury lines. Now we can use our own network. We can also deliver digital TV programmes from a single play-out centre anywhere in the loop, and offer high speed Internet access with cable modems".

TV and telephone cables are currently buried under the streets, laid alongside railway lines or slung from electricity pylons. Capacity is running out. Britain's canals were built in the late 18th and early 19th century to carry freight between cities. Now 60 per cent of the population lives within 8km of a canal.

The fibres run 600mm under the path in reinforced plastics ducts. Amplifiers boost the signal every 100km. The ducts carry two cables, each with 48 fibres, capable of simultaneously carrying 32,000 phone calls and 400 digital TV programmes. The ducts are wide enough to pull through eight cables each containing 200 fibres.

Says Jane Reynolds, Fibreway Director, "The system is secure because no-one else, like the gas or electricity services, needs to dig up the towpaths".

British Waterways earns a wayleave fee of £0·25m a year plus around half Fibreway's profits after spending £50m on digging and laying.

Following complaints from some of the 10m people who walk or cycle the paths each year, Fibreway has held back £0·25m of the contractors' fees to ensure that everything is restored to its previous condition. The obligation runs for two years after completion.

SMALLEST OP.AMP

National Semiconductor has introduced the World's smallest integrated circuit, an op.amp so small that the packaged device is about the size of a flake of coarse-ground pepper.

The LMV321 device is encapsulated in the miniature (surface-mount) SC70-5 package, which measures only 2.0mm × 2.1mm (about 3/32-inch square). This package has previously only been used to house "discrete" devices such as single transistors. For more information, browse National's web site at http://www.national.com.

New Technology Update

Cellphones in particular are the driving force and beneficiaries of the latest developments in chip technology – Ian Poole reports.

IT used to be military hardware that was one of the major driving forces behind technological development. This has changed, and much military equipment is now bought off the shelf, and to high commercial standards. This is one indication of the reduction of military budgets.

Other areas of life have become the driving force behind improvements in technology. One is the computer industry, and the other is the telecommunications industry, in particular the cellular telephone sector. Here vast sums of money are being invested to ensure that each manufacturer stays up with the others or ahead of them. This results in a very rapid rate of progress.

Cellphone Origins

In the early 1980s the first analogue cellphone systems were launched. These grew rapidly, but soon the first digital systems arrived. In the UK and in many other countries the GSM (Global System for Mobile communications) was established. It arose from the vast number of analogue systems which were used around the world. It aimed to provide a single system which would enable users to move from one country to the next and still retain the facility to make mobile calls.

Nevertheless, other systems are used in some countries. The USA has based its systems on CDMA (Code Division Multiple Access) technology and many other countries have followed suit.

On the horizon is the third generation system called UMTS (Universal Mobile Telecommunications System). All of these developments have required considerable improvements in technology. In addition to this, the handsets or phones themselves have improved. The first cellular phones either had to be installed in a car, or they were large portable items which could not even fit in the largest pockets. Now most handsets easily fit into a top pocket and are minute by comparison.

To achieve this, circuits have had to be shrunk still further. Current consumption has also been slashed, enabling battery size to be reduced whilst still maintaining the time between charges.

This has resulted in a considerable improvement in the performance of i.c.s in a number of areas, but particularly in those associated with radio frequency circuits. Some years back the levels of integration were comparatively small and the circuits consumed large amounts of current to achieve their performance. Now this has changed. The levels of integration have increased very significantly with a resultant improvement in performance.

I.C. Performance

To illustrate the level of performance that is now being achieved, Siemens have produced an i.c. used for up-converting the signal in a cellular telephone handset. This technique is used to ensure that the noise spreading out either side of the main transmitted signal is kept to a minimum so that the transmitted signal does not interfere with the received signal.

Normally, high performance filters have to be used at the antenna to isolate the transmit and receive paths. This filter or duplexer is expensive as it requires a very high level of performance. Not only this, but like all other filters, it introduces loss and requires the output amplifier to give a higher output, which makes the amplifier more expensive.

Similarly, the receiver input has to be made more sensitive. Again this adds cost to the unit. In a market where enormous quantities are made, costs are all important. Not only is the market fiercely competitive, but even the saving of a few pence can add up over the life of the product and represent a very large sum.

The i.c. which has been developed by Siemens contains the elements of a phase locked loop synthesizer. It contains the down conversion mixer, I/Q modulator for the type of modulation used in GSM phones, two programmable counters, and a phase detector with charge pump. The circuit draws only 45mA from a supply which can be between 2·7V and 4·5V. The i.c. uses bipolar technology and has a transition frequency of 27GHz, making it ideal for all the cellular phone bands of 900MHz, 1800MHz and 1900MHz.

The performance of this chip has been optimised for cellphone applications. It uses a phase locked loop principle to overcome one of the main cost items in the cellphone and it shows the advances which have been made in technology over the past ten years or so.

On-Chip Inductors

Another area that has been the focus of a lot of attention is in the creation of on-chip inductors. For many years it has been possible to make very small values of capacitance simply by placing two conducting layers on one another and separating them by a thin layer of oxide, but the successful manufacture of inductors has been rather more difficult.

A number of methods are now available, each with its own advantages and limitations. However, a new method has been developed by Philips in a bipolar process named "silicon on anything" (s.o.a.).

A major component or building block in any cellular phone is the voltage controlled oscillator used to generate the local oscillator signals used in the r.f. path. These have to operate at the same order of frequencies as the phone itself. As cost is of prime importance, along with performance and low current consumption, full integration of the oscillator, including the inductor, is the obvious solution. This ensures the performance is sufficient, and reduces the cost as it reduces the need for external components, particularly the inductor which is inconvenient to construct.

In the manufacturing process, the passive components are fabricated on one side of the chip. This includes the inductor which is manufactured from a two layer aluminium stack with a thickness of 3·5μm. Once complete, this side is bonded onto a substrate, which is usually glass because it acts as a good insulator with low levels of loss.

Next the exposed side of the silicon is etched back so that bond pads can be connected to the buried oxide layer. Finally, the active device, an *npn* transistor is fabricated in the epitaxial layer of the silicon. This is sandwiched between the oxide layer and the glass.

To reduce current consumption the transistors operate at less than 25μA. This means that the output requires buffering. Even so, the overall chip consisting of the oscillator and the programmable divider chain is capable of operating at up to 1800MHz and consuming only about 800μA. Its top frequency means that the process can be used for the PCS1800 and DCS1900 cellular phone systems as well as the 900MHz GSM band.

Triple Band

Around the world there are now three main cellular phone bands, 900MHz, 1800MHz and 1900MHz. Many phone manufacturers seek to supply phones to markets all around the world. To make manufacturing more cost effective, it is useful to be able to adopt the same basic design, and tailor it to the individual region.

To address this problem Rockwell Semiconductor Systems have launched a chip set to do just this. They now claim that they are one of the few manufacturers able to supply the gallium arsenide r.f. chips along with the bipolar mixed signal sections, plus the complex digital areas.

The idea is that some alteration of the external sections is needed to accommodate the different bands, and there is a software change to accommodate the different signalling protocols used by the various systems.

SIMPLE SW RECEIVER

ROBERT PENFOLD

★ 1·6MHz to 5MHz ★ 5MHz to 15MHz ★ 15MHz to 30MHz ★

Plug-in to the world of short wave listening with this easy-build regen-receiver.

IF YOU take a look through some of the current short wave receiver and equipment catalogues, you can hardly fail to notice that all the short wave sets on offer are pretty complex. Virtually all the receivers now have a built-in microprocessor to control everything, together with digital displays, synthesised tuning, multi-timers, etc. This is just the relatively inexpensive portable sets, and the "proper" communications receivers are even more complex with features such as external computer control, digital signal processing, and just about every other feature imaginable!

We have probably reached the stage where it is not possible for the home constructor to genuinely compete with sophisticated ready made receivers, but this is not to say that it is not possible for the enthusiast to enjoy building and using short wave receivers.

The more traditional forms of receiver will not give the same level of performance as a ready made set costing hundreds or thousands of pounds, but sets such as these are still capable of receiving numerous transmissions from all over the world. Whether you are looking for a low cost introduction to short wave listening, or have used expensive equipment and would like to try something more challenging, a basic do-it-yourself receiver has a lot to offer.

IN RANGE

The simple short wave receiver featured here covers a frequency range of about 5MHz to 15MHz, which includes the most popular short wave broadcast bands. It is possible to plug in alternative coil units which bring in coverage of the low frequency bands around 1·6MHz to 5MHz, and the high frequency bands from 15MHz to 30MHz.

Results on the high and low frequency bands might not be very good with a simple short wave receiver of this type, and results on the high frequency bands are very much dependent on good propagation conditions whatever receiver you use. However, it costs little extra to try these bands, and some interesting transmissions may well be picked up.

Power is obtained from a nine volt battery, and the receiver can be used with either a long outdoor aerial or a short indoor type. It will actually work quite well using a short aerial, making the receiver suitable for portable operation.

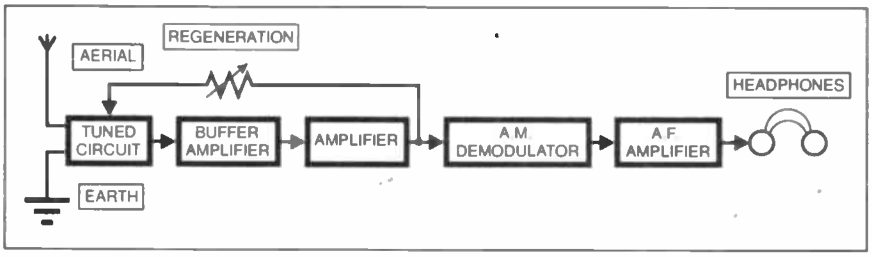


Fig.1. Block schematic diagram for the Simple SW Receiver.

BACK TO BASICS

Most radio receivers are of the superheterodyne (superhet) variety, and this means that the incoming transmission is first converted to a fixed frequency. This is known as the intermediate frequency (i.f.), and for many receivers it is at a relatively low frequency of about 455kHz.

After amplification and filtering, the signal is demodulated to recover the audio signal, and after further amplification it is used to drive a loudspeaker or headphones. The point of this round-about method is that it is easy to obtain high gain and a narrow bandwidth at the fixed intermediate frequency.

For a short wave receiver the narrow bandwidth provided by the filtering is every bit as important as the gain provided by the amplifiers. The short wave bands tend to be very crowded, and there are often quite strong signals in the channels either side of the station you are trying to receive. A short wave receiver needs good selectivity so that it only receives the transmission you want to listen to, and not the two signals on the adjacent channels as well.

STRAIGHT RECEIVER

Although a superhet design has definite advantages, it is relatively complex and expensive. Also, without the right test equipment it can be difficult to get the finished receiver set up and operating efficiently.

Consequently, the design featured here is a t.r.f. (tuned radio frequency) set, or "straight" receiver as they are also known. A receiver of this type operates by providing all the gain and selectivity at the reception frequency, with no frequency conversion and intermediate frequency stages being used. Fig.1 shows the block diagram for the Simple SW Receiver.

The aerial picks up the radio waves from the transmitter and converts them into minute electrical signals. An earth connection can boost signal levels, but this is optional and does not help much at higher frequencies.

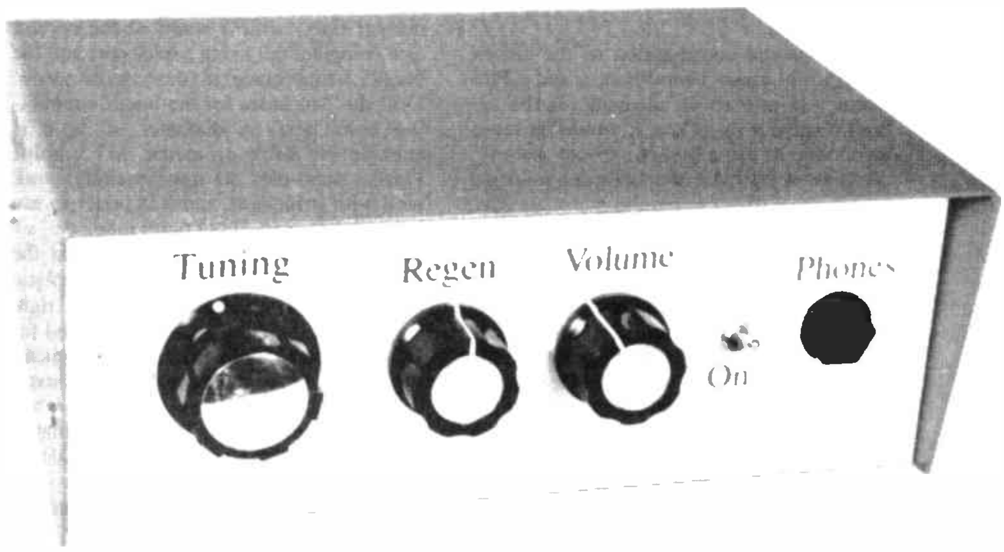
The input signal from the aerial is fed to a tuned circuit, and it is this that provides most of the receiver's selectivity. The tuned circuit is a parallel resonant type which just consists an inductor connected in parallel with a capacitor. The capacitor is a variable type, and this is the Tuning control.

At most frequencies this arrangement has a low impedance and it effectively short-circuits the input signals to earth. At and close to its resonance frequency the impedance is much higher, and signals at these frequencies are able to pass through to the subsequent stage.

This stage is a buffer amplifier which ensures that the tuned circuit feeds into a high impedance. A low load impedance would tend to broaden the response of the tuned circuit, giving poor selectivity.

The next stage is an amplifier, and it is this stage which provides much of the receiver's gain. The selectivity provided by a single tuned circuit operating at a high frequency is not very great, and without assistance it will not give usable results.

Fortunately, there is a simple ploy which can be used to both boost the gain of the circuit and greatly improve its selectivity. This is to apply positive feedback from the output of the amplifier to the input of the tuned circuit. In this context the positive feedback is generally known as "regeneration."



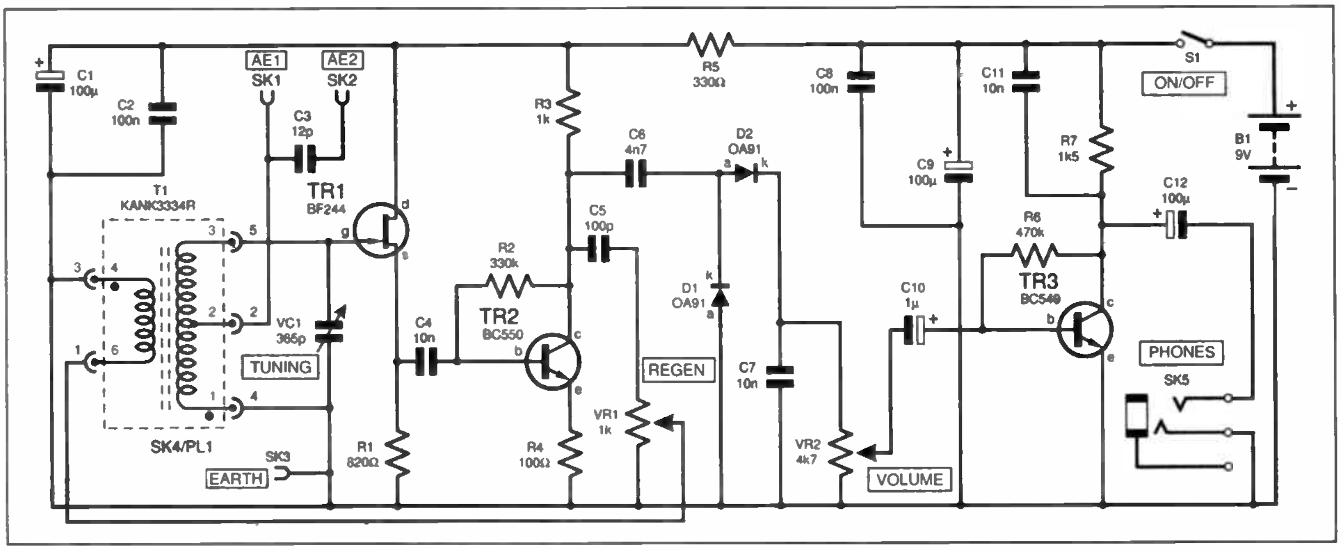


Fig.2. Full circuit diagram for the Simple SW Receiver. The numbers inside the unshaded area are for the plug-in r.f. transformer coils and those outside are for the 5-pin DIN socket.

REGENERATION

Feeding some of the output signal back to the input results in an effective boost in the input signal, and a much stronger output signal. However, the boost is greatest at the centre of the receiver's passband where the gain is highest, and there is the most feedback.

Slightly off-tune there is relatively little feedback, and only a small boost in gain. It is this factor that improves the selectivity of the receiver as the amount of regeneration is increased. The improvement is much greater than one would probably expect.

Unfortunately, advancing the Regeneration control slightly too far results in the set breaking into oscillation, making proper reception impossible. In order to obtain good results from a t.r.f. receiver it is essential that the regeneration level is kept just *below* the point at which the circuit breaks into oscillation.

AUDIO RECOVERY

The output from the amplifier is fed to a conventional a.m. (amplitude modulation) demodulator circuit. With amplitude modulation the strength of the radio signal varies in sympathy with the audio input voltage.

The average voltage in the radio signal is always zero, because the positive half cycles are cancelled out by negative half cycles of equal value. Half wave rectifying the signal removes one set of half cycles, and the average voltage then varies in sympathy with the audio modulation voltage.

Some lowpass filtering smoothes the signal and leaves a replica of the original audio signal. After some further amplification by a single stage audio amplifier the signal is fed to a pair of headphones.

CIRCUIT OPERATION

The full circuit diagram for the Simple SW Receiver is given in Fig.2. The tuned circuit is formed by the main winding of r.f. transformer T1 and variable capacitor VC1. The latter is the Tuning control.

The aerial signal is coupled into a tapping on T1's main winding, but a much more loose coupling is needed when using a long aerial. This is achieved by connecting the long aerial to SK2 rather than SK1, so that the aerial is coupled to T1 via low value capacitor C3.

A j.f.e.t. transistor TR1 acts as the buffer stage for the tuned circuit, and it is used in a conventional source follower circuit (the f.e.t. equivalent of a bipolar emitter follower stage). Capacitor C4 couples the output of TR1 to a simple common emitter amplifier based on transistor TR2. Capacitor C5 couples some of TR2's output signal to variable attenuator VR1, and from here it is coupled back to the input of the circuit by way of a small coupling winding on T1.

There is an inversion of the signal through TR2, but the phasing of T1 is such that it provides a further inversion so that the required positive feedback is obtained. VR1 controls the amount of feedback applied over the circuit, and it is, of course, the Regeneration control.

AUDIO DETECTOR

Diodes D1 and D2 are fed with the main output signal from TR2, and these form a conventional a.m. demodulator circuit. Germanium diodes are preferable to the more common silicon types in this application, due to the lower forward voltage drop of germanium diodes. Capacitor C7 provides smoothing at the output of the demodulator, and Volume control VR2 provides the load resistance.

Capacitor C10 couples the audio signal from VR2 to the input of a second common emitter amplifier (TR3). This provides sufficient drive for a pair of medium impedance headphones or a crystal earphone.

The current consumption of the circuit is typically about 10 milliamps, and a PP3 battery is just about adequate. If the set will receive a lot of use it would be more economic to use a higher capacity battery, such as six HP7/AA size cells in a holder.

CONSTRUCTION

Stripboard is not really ideal for a project of this type, but acceptable results can be obtained provided a sensible component layout is used. The component layout shown in Fig.3 gives good results, and unless you know what you are doing it is advisable to use this design rather than trying your own custom printed circuit board or other method of construction. Details of the breaks in the underside copper strips are also shown in this diagram.

Some of the breaks may seem to serve no useful purpose, but without them there is a risk of problems with stray coupling via the capacitance between the strips. Some of the breaks effectively remove unused lengths of copper strip, and the stray coupling that they might otherwise introduce.

Construction of the circuit board follows normal lines, with a board of the correct size being cut out using a hacksaw, and the breaks being made in the copper strips. Drill the two holes for the board's mounting bolts next. A diameter of 3mm is suitable for 6BA or metric M2·5 bolts. Plastic stand-offs do not generally work well with stripboard, and it is better to use bolts plus spacers about 6mm long.

Next the components are fitted to the board, being careful to fit the electrolytic capacitors and semiconductors the right way round. The germanium diodes used for D1 and D2 are more vulnerable to overheating than ordinary silicon diodes, and extra care should therefore be exercised when soldering them in place. It is not essential to use a heatshunt, but complete each soldered joint reasonably quickly.

Mylar capacitors are the best choice for C4, C6, C7, and C11 as these have relatively long leadout wires, and can readily accommodate various lead spacings. Fit single-sided solder pins at the points where connections to the controls and sockets will be made, and generously "tin" the tops of the pins with solder. Do not overlook the single link-wire just to the right of R1.

PLUG-IN COILS

A Toko r.f. transformer is used for T1 and has 0·15 inch pin spacing which makes it difficult to use with 0·1 inch matrix stripboard. The transformer is therefore wired onto a 5-way (180 degree) DIN plug (PL1) and connected to the component board by way of a printed circuit mounting DIN socket SK4. This socket has its pins on a 0·1 inch grid, and it therefore fits onto the stripboard without difficulty.

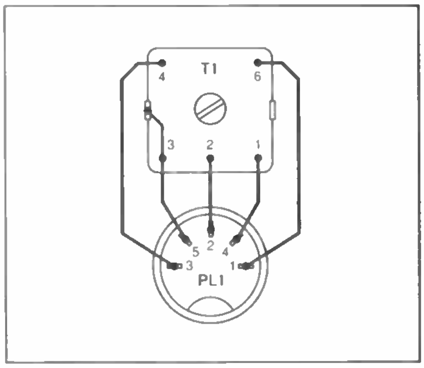


Fig.4. Pin connections from transformer T1 to the 5-way (180 degree) DIN plug.

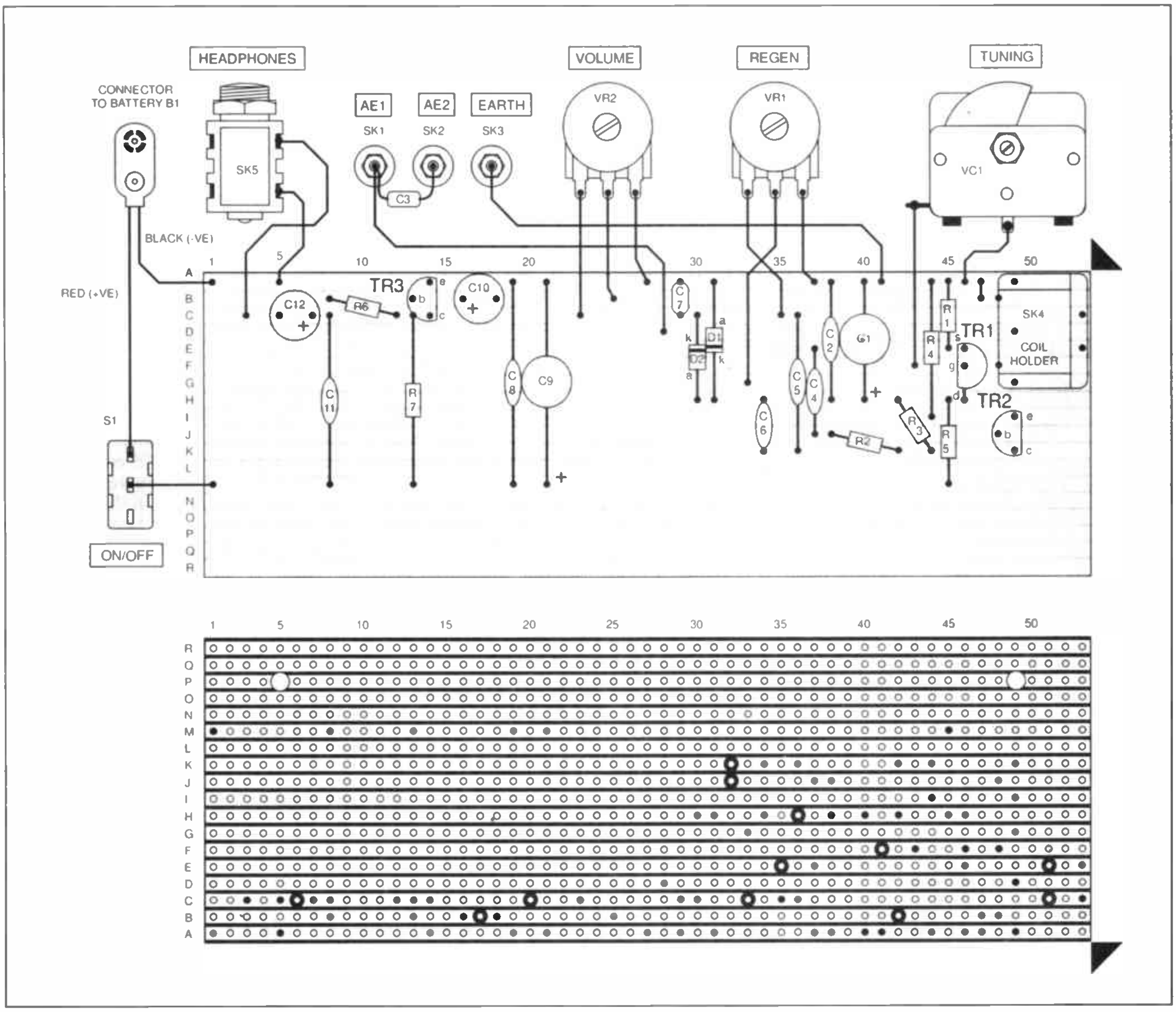


Fig.3. Stripboard component layout, interwiring and details of breaks required in the underside copper tracks. Note ALL copper breaks shown must be made.

An advantage of this method is that it enables coils for other ranges to be used by simply unplugging the existing coil and plugging in a different one. For the *low* frequency bands a Toko KANK3333R coil is required, and for the *high* frequency bands a Toko KANK3335R should be used.

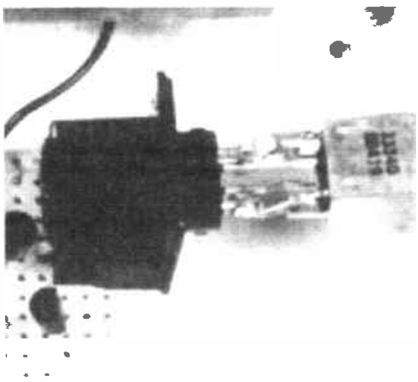
Wiring the coils to the DIN plug is a little fiddly, but is not very difficult. Only the piece of the plug which carries the pins is required in this case, and the entire shell assembly can be discarded.

Start by "tinning" the tags of the DIN plug and the pins of the coil with plenty of fresh solder. Fix the plug to the worktop using Bostik Blu-Tack or Plasticine, and then solder pieces of 0·56mm dia. (24 s.w.g.) tinned copper wire to the five tags.

Use pieces about 50mm long and then trim them to a length of about 10mm or so. It might seem easier to simply solder 10mm pieces of wire to the plug in the first place, but it is difficult to fit such short pieces of wire as they heat up very rapidly with the heat from the soldering iron.

"Tin" the ends of the wires with solder, and then form them so that they match up nicely with the pin arrangement of the r.f. transformer coils. It should then be quite easy to connect the wires to the pins of the coils. The interconnection details are shown in Fig.4.

To complete the plug-in coil unit, add the short link-wire which connects one of the pins to one of the tags on the metal screening can of the coil. If desired, some insulation tape can be used to cover the connecting wires to give a neater appearance to the finished coil unit.

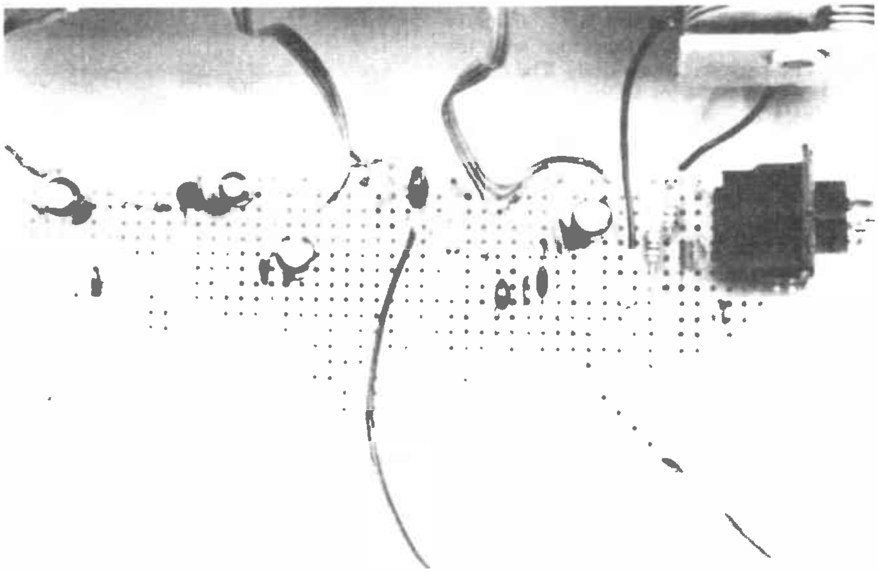


Finished coil unit plugged into the right-angle p.c.b. mounting DIN socket.

ASSEMBLY

An all-metal case is preferable for a project of this type, and an instrument case about 200mm wide will comfortably accommodate everything. It is important that the wiring to variable capacitor VC1 and potentiometer VR1 is kept as short as possible, and this largely dictates the front panel layout of the receiver.

Controls VC1 and VR1 must be mounted on the left hand section of the front panel, and the circuit board is mounted on the base panel of the case with the coil holder socket SK4 close to tuning capacitor VC1. Headphone socket SK5 and the other controls are mounted on the central and right hand section of the front panel. The Aerial and Earth sockets SK1 to SK3 are fitted to the rear panel.



Layout of components on the completed stripboard. The lower section area is used for the moutning bolts and 6mm spacers.

The component specified for VC1 has an unusual method of mounting, which requires a central 10mm diameter hole for its control shaft, and three holes of 4mm in diameter for the short 4BA mounting bolts. It can be difficult to accurately position the small mounting holes, but adequate precision can be achieved with the aid of some careful measurement. Alternatively, many find that using a paper template made with the aid of the capacitor itself gives accurate results.

The mounting bolts must be short countersunk types. Bolts more than a few millimetres long will penetrate too far into the component, possible damaging the metal plates (vanes).

It is not essential to use the specified component for tuning capacitor VC1. Any "air-spaced" variable capacitor having a maximum value of around 300p to 400p should work well. If you can obtain a surplus variable capacitor having suitable characteristics it should be very much cheaper than the specified component.

A large control knob must be fitted to the control spindle of VC1. This covers over the mounting bolts and makes accurate tuning slightly easier.

INTERWIRING

To complete the unit the point-to-point wiring should now be undertaken, and this is also shown in Fig.3. Capacitor C3 is connected directly across the tags of the aerial sockets SK1 and SK2. There should be no difficulty in soldering it in place provided the ends of the leadout wires and the tags of the sockets are "tinned" with solder first.

A 3·5mm stereo jack socket is used for SK5, but as the phones are wired in series and connected monophonically, no connection is made to the "earth" tag on the socket. SK5 must be an insulated type or one of the phones with be short circuited. Suitable sockets can be difficult to obtain, and the alternative used on the prototype is to use a standard (¼inch) jack socket plus an adapter to connect this socket to the headphones.

COMPONENTS

See SHOP TALK Page

Resistors

R1	820Ω
R2	330k
R3	1k
R4	100Ω
R5	330Ω
R6	470k
R7	1k5

All 0·25W 5% carbon film

Potentiometers

VR1	1k rotary carbon, lin.
VR2	4k7 rotary carbon, log.

Capacitors

C1, C9, C12	100µ radial elect. 10V (3 off)
C2,C8	100n ceramic (2 off)
C3	12p polystyrene
C4, C7, C11	10n Mylar (3 off)
C5	100p ceramic plate
C6	4n7 Mylar
C10	1µ radial elect. 50V
VC1	365p air spaced variable (Jackson Type 0)

Semiconductors

D1, D2	OA91 germanium signal diode (2 off)
TR1	BF244 *n*-channel j.f.e.t.
TR2	BC550 *npn* silicon transistor
TR3	BC549 *npn* silicon transistor

Miscellaneous

T1	r.f. transformer, Toko KANK3334R (see text)
SK1, SK2, SK3	4mm socket (3 off)
SK4/PL1	5-way 180 degree DIN plug and p.c.b. socket
SK5	3·5mm stereo jack socket (see text)
B1	9V battery (PP3 size)
S1	s.p.s.t. min toggle switch

Metal instrument case, about 200mm × 125mm × 75mm; 0·1 inch matrix stripboard, 53 holes × 18 copper strips; battery connector; control knob (3 off); multistrand connecting wire: solder pins; solder, etc.

Approx Cost Guidance Only £15
excluding 'phones & batt.

The headphones must be a medium impedance type, such as those sold for use with personal stereo units. The circuit will also work with a crystal earphone, and SK5 would then have to be a mono 3·5mm jack socket. The rest of the wiring is very straightforward, but remember to keep the wiring to VC1 and VR1 as short as possible.

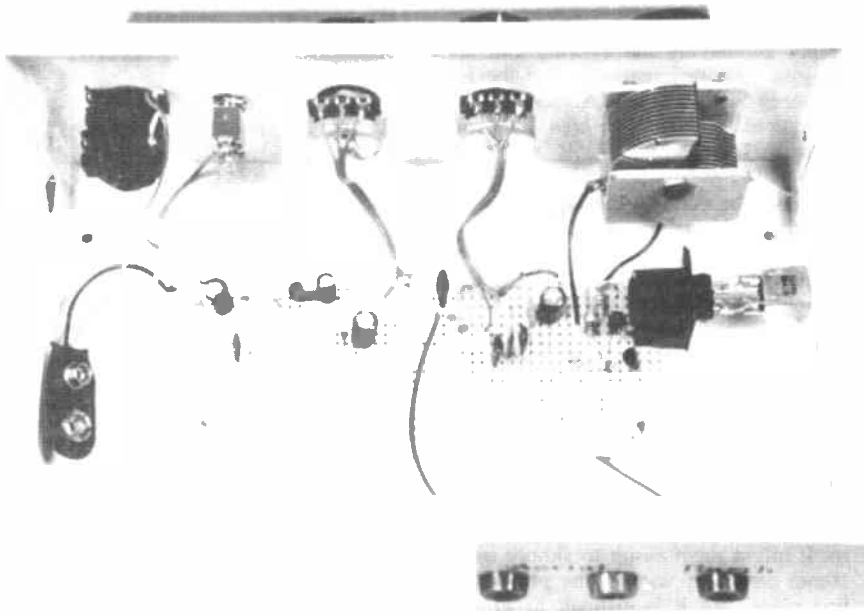
It can be a bit tedious to keep removing and replacing the screw-on top section of the case if you want to change bands (and therefore coils) quite often. The traditional solution is to cut out a section of the case and then hinge it, so that easy access to the coil holder is provided. An alternative is to modify the case by adding some pieces of springy metal to make the top section of the case a clip-on type.

IN USE

You may like to try using more elaborate aerials later on, but initially a short aerial will suffice. Either use a few feet of multi-strand connecting wire attached to socket SK1, or a somewhat longer aerial connected to SK2 (e.g. about 10 to 15 metres of connecting wire strung around the loft). An earth connection will provide a worthwhile improvement in results on the low frequency bands, but is not likely to have any affect on the higher frequency bands.

If you would like to try using an earth connection, a bare metal plate or pipe pushed into the ground is all that is needed. In theory, the bigger the plate or pipe the better, but an area of around 0·25 square metres will provide good results. The plate or pipe is connected to SK3 via a lead that should be no longer than absolutely necessary.

Start with the Volume control VR2 well advanced and Regeneration control VR1 well backed off. It will probably be possible to receive a few stations, but the sensitivity and selectivity will both be quite low. Advancing VR1 should provide much better results, but advancing it too far will result in whistling sounds of varying pitch (heterodynes) as the receiver is tuned across stations.

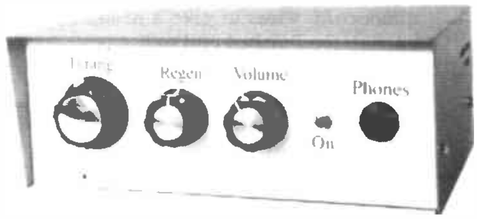


Completed Simple SW Receiver showing positioning of the circuit board and off-board components. Note the aerial and earth sockets are mounted on the rear panel.

The optimum setting is the most clockwise adjustment that does not cause oscillation and produce these heterodynes. It is not necessary to readjust VR1 each time the tuning is altered, but a large change in the tuning will require slight readjustment of VR1.

There should be no difficulty in locating the broadcast bands because they contain what are likely to be the strongest stations. In between the broadcast bands there will be various strange noises, which are mostly data transmissions, navigation beacons, etc.

It should be possible to receive some broadcast stations at any time of the day or night, but reception conditions vary according to the time of day, the time of the year, and other factors. Results will therefore be somewhat variable, and will not necessarily vary in a predictable fashion. Over a period of time a number of European stations should be received, together with a lesser number of stations from further afield.



Techniques

ACTUALLY DOING IT!

by Robert Penfold

FROM the theoretical point of view, there is no fundamental difference between power semiconductors and ordinary low power devices. Power transistors and other high power semiconductors are able to handle higher voltages and current but are otherwise the same as their low power equivalents.

When actually using high power semiconductors, the situation is very different, as it is usually necessary to help them get rid of the substantial amounts of heat that they generate. There are some exceptions to this, and some circuits use power devices that dissipate average power levels that are not high enough to generate much heat. This is usually where a circuit operates intermittently at high currents. A low-power component could handle the average power levels, but would be "zapped" by the high current pulses. In such cases power semiconductors are used in very much the same way as low power types, but the situation is very different when there is some excess heat to deal with.

Clip-Ons

Although a power device may be able to handle powers of 100 watts or more, it can only do so with the aid of a suitable heatsink. A heatsink is basically just a piece of metal that acts as a heat-fin and helps to conduct heat from the component and radiate it into the surrounding air. The power ratings quoted in data sheets tends to be rather optimistic and often assume that the device is mounted on an idealised "infinite" heatsink. These power levels are not quite attainable in practice no matter how large the heatsink used. If operated at high powers with no heatsink the average power device has a life expectancy of less than a minute, and possibly just a few seconds.

By no means all circuits use power devices close to their maximum ratings. In many cases the power dissipation is no more than a watt or two, and quite a small. heatsink will then suffice. The larger component catalogues list a number of small heatsinks that either clip onto the heat-tab or are secured by a single bolt. When using a heatsink of this type there are two things you have to be careful to get right.

Power semiconductors take a number of different physical forms, and you have to be careful to obtain a heatsink that is physically compatible with the device you are using. Probably the most common form of encapsulation for power semiconductors these days is the TO220 type, and most of the smaller heatsinks are designed for devices that have this style of case. There are other encapsulations in common used though, including the smaller TO126 variety. The component list of the project you are building should make it clear if a heatsink for something other than a TO220 case is required.

Size is Important

The other point to watch is the power rating of the heatsink you use. If you look in a component catalogue you will notice that each heatsink has a rating of so many degrees per watt. This is a measure of the temperature rise that will be produced per watt of power that is applied to the heatsink. The important point to realise here is that the larger the heatsink the lower its rating.

A heatsink having a rating of five degrees per watt is therefore twice as efficient as one that has a rating of 10 degrees per watt. The salient point here is that it is all right to use a heatsink having a lower rating than the one specified in the component list, but not one having a higher rating. For example, a heatsink rated at 7·5 degrees per watt is an acceptable substitute for one rated at 10 degrees per watt. On the other hand, a heatsink having a rating of 10 degrees per watt could not safely be used in place of one having a rating of 7·5 degrees per watt.

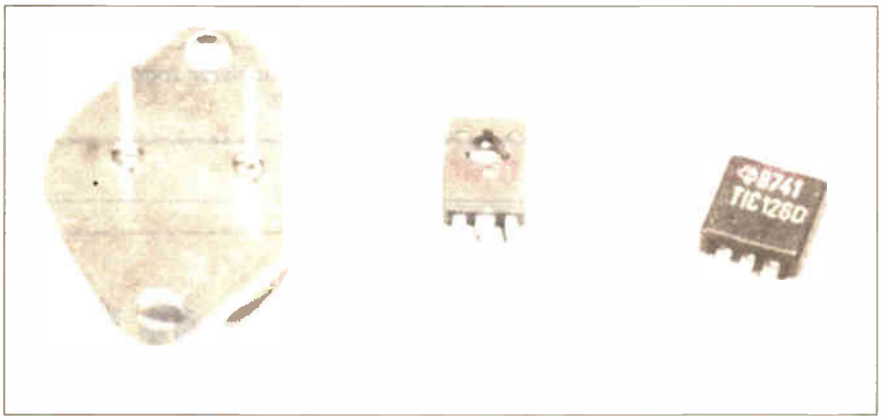
Of course, there may be physical considerations to take into account, and in general the lower the rating in degrees per watt the greater the physical size of the heatsink. Using one having a slightly better rating is unlikely to produce any problems, but where space is strictly limited it is advisable to measure up carefully to ensure that there is sufficient space for the heatsink. Using a heatsink having a grossly excessive rating is not usually a practical proposition.

When a power device is used at very high power levels it requires a large heatsink, which is usually quite elaborate with numerous fins. Heatsinks of this type can be quite expensive, and sometimes cost more than the semiconductors they are used to cool. Do not be tempted to use a heatsink having an inferior rating to save money. To do so would almost certainly result in the destruction of expensive semiconductors, and it could even be dangerous. Components that overheat clearly represent a fire hazard, and it is not uncommon for seriously overheated semiconductors having plastic cases to explode.

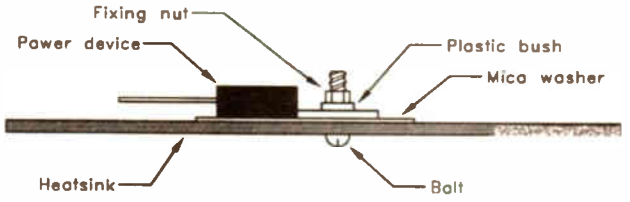
The Go-between

The metal heat-tabs or cases of some modern power devices are electrically isolated from their terminals. This makes life very much easier for the constructor as it avoids problems with unwanted connections from the power device to earth via the device's metal case or heat-tab. This is unlikely to be a problem where a small clip-on or bolt-on heatsink is used, but it is often problematic when a large heatsink is utilised. The heatsink is then mounted on what will usually be a metal case, and the case is normally connected to the zero volt supply rail.

Sometimes the case or heat-tab of the power device is connected internally to a terminal that connects to the earth rail anyway. This does not seem to happen very often though, and in most cases the case or heat-tab connects to the worst possible



Various power transistors. From left to right the case styles are TO3, TO126 and TO220.



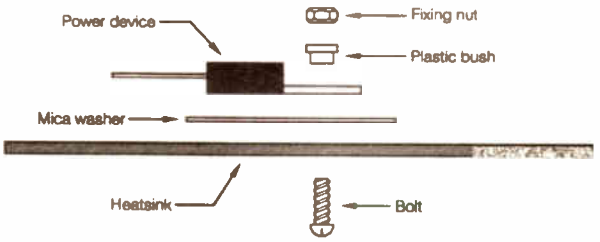


Fig. 1. Method of mounting a power transistor.

Fig.2 (right). Exploded view of Fig. 1.

part of the circuit. you usually find that mounting a power device direct on the heatsink produces something like a short circuit on the output of a power amplifier or a short circuit across the power rails of the equipment.

In order to avoid disaster in such cases the power device must be reliably insulated from the heatsink. Insulating kits for all the popular types of power semiconductor are readily available. These kits differ slightly in points of detail, but they all insulate the component from the heatsink in the same basic manner. Fig.1 shows the basic scheme of things, and Fig.2 shows an exploded view of the assembly. These diagrams show the arrangement used for a plastic power device such as one having a TO220 encapsulation. Things are much the same for components that have a metal TO3 style case, but two mounting bolts are then used.

On the face of it, an insulating washer between the power device and the heatsink is all that is needed to insulate one from the other. Matters are not quite as simple as that because the metal mounting bolt or bolts provide an electrical connection between the two. Consequential, plastic bushes must be used to insulate the mounting bolt or bolts from either the heatsink or the power device. In Fig.1 the plastic bush is insulating the bolt from the heat-tab. Using the bush on the underside of the heatsink to insulate the bolt from the heatsink would be equally effective, but is not the method generally used.

The insulating washer must be very thin so that it enables heat to easily pass-through to the heatsink. Originally these washers were always made from mica, which is a very hard and brittle material. Mica washers work well enough, but they must be handled very carefully as their thin and brittle nature makes them very vulnerable to physical damage.

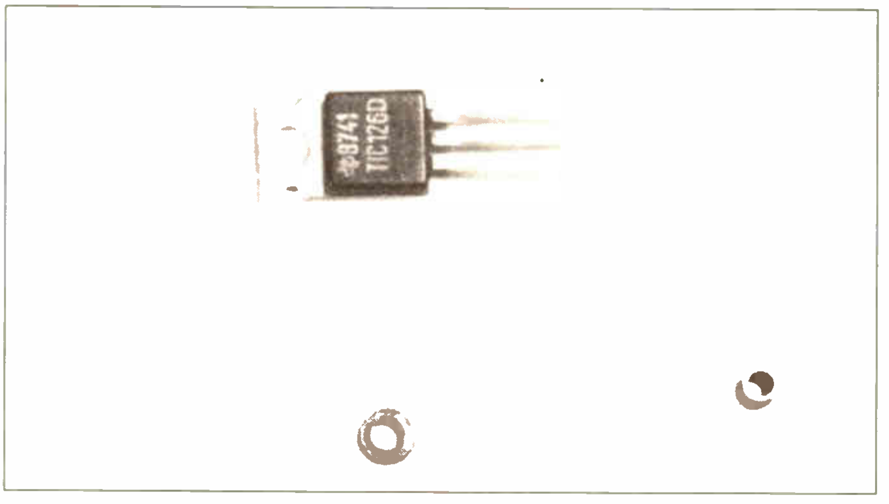
Mica washers are often used in conjunction with heatsink compound. This is a white greasy substance that is normally sold in large syringes, and its purpose is to ensure a good thermal contact between the power device and the heatsink. A small amount of the compound is smeared onto the underside of the power device, and it is important to use nothing more than the thinnest of smears. Plastering the underside of the component with anything more than this is likely to be counterproductive. It is also likely to be extremely messy.

Flexible Friend

The modern alternative to a mica washer is one made from plastic. These are in many ways the opposite of mica washers as they are generally made from a soft and flexible rubber-like plastic. This brings two big advantages, one of which is that these washers are very tough and do not need to be handled with "kid gloves". The other is that they obviate the need for any heatsink compound. The point of using a heatsink compound is that it fills in any gaps if the underside of the power device is something less than perfectly flat.

As it is made from a soft material, a plastic washer tends to fill in any slight contours in the underside of the power device, making any heatsink compound superfluous. Some of these plastic washers have a built-in insulating bush, which is supposed to render a separate insulating bush unnecessary. In practice I have not usually found these to be every effective, and using a separate bush is the safer option.

As pointed out previously, there will often be dire consequences if the insulation is not fully effective. After fitting any power device that has been insulated from the heatsink it is essential to use a continuity tester to check that it is genuinely insulated from the heatsink. This is particularly important when using mica washers, as they can be difficult to get accurately in place and working properly. Do not simply switch on and wait to see if smoke starts to rise, because it probably will!



A TO220 transistor together with both mica (left) and plastic washers and a plastic bush.

READOUT

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

Win a Peak DTA30 Transistor Analyser

The DTA30 will test and identify the type (*npn/pnp*) and the leads of any bipolar transistor connected to it.

Every month Peak Electronic Design Ltd will be giving a DTA30 to the author of the best *Readout* letter published.

★ LETTER OF THE MONTH ★

WHAT COMPUTER?

Dear EPE,

I have a problem I am almost at my wit's end with and would appreciate any help or advice you could give me.

About 15 years ago, as a hobby, I did machine code programming on Z80a and similar chips, concentrating mainly on strategic games such as chess, draughts etc. In the intervening years, fate and real life put other priorities in my path and I neglected this hobby.

The problem is that I now find myself with space, time and inclination to pursue this subject once more, but am bewildered by the medium. There is no Spectrum QL or BBC. When I ask "experts" about programming I am told about Turbo, Pascal and C. If I mention assembly language, people think that I'm building my own computer.

Having become unemployed for the first time in 10 years, and asking about courses on computing, I find the same attitudes and blankness. Surely bespoke code programming is always capable of being more efficient than artificial higher level languages, no matter what the field of implementation.

So I am left with the questions: What PC should I buy? What chip? Which books? Which magazines? Are there any courses leading to recognised qualifications. Are there any set-piece exercises I can do to prove my ability? Is that ability still valid?

Hugh Smith,
Corby, Northants

You are not the first reader to express similar puzzlement. First, let me comment that I am not qualified to answer your questions as posed! They are best addressed to a magazine which specialises in computers and computing. As to which magazine to approach is a subject for which a plethora of answers exists – you are advised to browse the bookshelves of a major newsagents and purchase several that take your eye and approach the one which appeals to you most.

I can, though, offer information on the migratory route which I took from early beginnings in the mid-to-late '70s to the PCs I use now. In fact, the choice now is, in essence, much easier to make than it was in the early days since today's machines are all "compatible", unlike those at my beginnings.

Twenty years or so ago, the computers available were, as you describe, such machines as the Spectrums, BBCs, PETs, VICs, Z80s, Apples and so on. By and large, none of these machines could be run with software from the others; even the disk formats were different and were not interchangeable. The choice of machine was, for many people, a matter of pot-luck.

In those days, one had to choose between utterly different operating systems, now the choice is as easy as choosing a car or TV or washing machine! You choose on price, reputation, quality and extra facilities offered – in all other respects they operate on the same principles.

I learned computing on a Commodore PET, a 32K machine for which I first used two cassette recorders for data storage, before acquiring a twin-floppy disk drive. Including a 9-pin dot matrix printer the whole lot eventually cost around £3000. Through this system I discovered how to use Commodore Basic and eventually how to program in 6502 machine language. I learned the hard way – trial and error. In doing so, I also learned economy of coding and the efficiency in running time that could be achieved with 32K running at 1MHz. Coding economically remains a benefit even today when programming PIC microcontrollers, for example (1K of programming space!).

By the mid/late 80s I had been exposed to PC computers in the form of the Amstrad 1640. This ran at 4MHz, had 640K of memory and a 20Mbyte hard disk. It was absolutely no problem whatsoever to change from one Basic dialect to several others (GW-Basic, QuickBASIC and QBasic), nor from 6502 to 8086 machine code language (8086 is still recognised by Pentium processors). The logical thinking required remained the same, and there were more commands to use. Minor grammatical differences were insignificant. The improved speeds and capacity, though, were highly significant and beneficial. So too was the ability to purchase software that was compatible with all PCs.

The same remains true today. I now have a two-year old Pentium Dell with 1·2Gbyte hard disk, CD-ROM drive, 120MHz running speed and 16Mb memory. Everything learned from the previous machines is still valid, and my capabilities are enriched by the various enhancements. However, for all the options offered by the Windows 95 operating system software, for situations when I wish to create my own software, I do not use Windows at all, but operate from within the DOS (disk operating system) function – whose use is much like that which you experienced with your early machines.

Whilst the choice of PC manufacturer and model open to you now is not something I shall presume to advise you on, you should be able to buy an excellent new machine for well under £1000, perhaps even below £600. You might also consider buying second-hand, and at a fraction of the original cost price (a colleague has recently bought an excellent machine for £50), but do buy from a reputable source so that you have some sort of safeguard if the machine proves to be defective.

If you are intent on buying new, ensure that the computer is described as PC-compatible, has a type 80486 or Pentium processor (the latter being better and more recent – avoid the earlier 80386 processor, it's too ancient now), a hard disk having at least 1·2 gigabytes of space (14Gb are just arriving on the scene), at least 16 megabytes of RAM (64Mb are commonplace), a 3·5-inch floppy drive (5·25-inch are obsolete), a CD-ROM drive having multiple speeds, and that the operating system has Windows 95 installed (avoid Windows 3.1, it is well superseded – indeed, even '95 is about to be replaced by Windows 98 in the next few months). Note, though, that each update always retains compatibility with earlier versions, and you will be able to upgrade from 3.1 or '95 to '98). You might also find an audio facility useful since a lot of software makes use of sound in various ways, from voice-over commentaries to games noises!

Go for the fastest speed plus the greatest memory and disk capacity that you can afford. Believe you me, such attributes available now compared with those you became familiar with may seem incredible, but you will rapidly reap their benefits.

With any modern PC you will be able to write software for any microprocessor or microcontroller far more easily than you became accustomed to. Moreover, you have a wide choice of off-the-shelf software packages to use to not only write your code but also test and debug it on-screen and then download to the processor. And, yes, it is still heavily worthwhile being able to program in machine code – look at the number of EPE projects that use it, and not just PICs.

But, most of all, any PC you choose is going to open up a world of opportunities of which you may as yet be totally unaware. Writing your own software is only a small part of what you will be able to do – don't delay, start looking now!

CRAZY CONVENTIONS

Dear EPE,

I read with great sympathy the problems encountered by Jose Antonio (*Circuit Surgery*, March '98) who ends by writing "I think it (*Teach-In*) should be more easy to understand." Writers seem to insist on describing the movement of electricity as current which moves from positive to negative. BUT we know that this was a mistake made many years ago by people who did not fully understand the nature of electricity.

Where I teach, we are teaching students (from infants onwards) that electricity is the movement of electrons, and alerting them to the fact that historically current was thought to flow from positive to negative but this is outdated. Indeed, 38 years ago, to quote *The Children's Britannic* of 1960 p.232b.:

"... and some knowledge of them (atoms and electrons) is needed to understand the theory, or idea, of electricity, although a useful working knowledge of everyday electricity can be gained without it. To get useful work out of electricity we need something that will give a continuous stream of it, or an electric current."

The subject you are dealing with in *Teach-In '98* is digital electronics. Electronics deals with electrons. Electrons move from positive to negative. I have not seen in recent times, apart from your Teach-In '98, electronics taught or explained in any other way.

I actually believe it is the purpose of an educator to enable the student not only to conceptualise the subject matter in hand, but also to give a foundation for the extension of studies. One of the attributes of a good educator is the ability to infect the student with the educator's own enthusiasm so that the student will go on to higher things. In issues of safety (DC circuits) does not the flow of electrons become important?

Doesn't the fact that there are so many students confused, point to a re-think as to how the subject is taught? Because it has *always* been, it is not necessary that it *has* to be: there is progress. It is people such as your good selves who can influence the future. It seems all too easy for authors to give confused explanations of a subject and get it published. I believe that too often experts are not good enough communicators, and with the introduction of students having to pay for their courses, that the situation will change and University students will be far less tolerant.

Martin Baxter, via the Net

Since this E-mail letter was actually addressed to the authors of Teach-In, *it is only right that they should reply:*

As far as we are concerned, physics is a branch of electronics, and not the reverse. It is possible to discuss and demonstrate the action of electronic components without exploring the minutia of atomic physics. We could easily go into as much depth on the background "physics" as you like, and a whole lot more besides, if we thought it was appropriate, but we happen to think it isn't, as far as the *Teach-In* syllabus is concerned.

Concerning the description of which direction current flow actually takes, a covering paragraph was included in Part 1 about real-time "electron flow" purely to help engineers and technicians from other branches of science who will have been taught a "classical" model different from the conventions used in electronics theory.

In fact, there is never an exact truth in physics, chemistry or engineering. There is simply a model or representation of sufficient detail to describe and analyse the current experiment or application being considered.

Firstly, the unit of charge, its polarity and the relationships defining electric and magnetic fields, and their units of measurement, are defined as a part of the *SI Common Units of Measurement*. Electrical current is also included in the SI definitions with positive current flow from a positive potential to a negative potential. These SI units provide a common language of definitions enabling concepts to be easily communicated between all technologists.

The nature of carriers of charge in solids and in vacuum are separate but related issues. There are several models for the representation of charge carriers in vacuum. For example, the common low mass one, normally negatively charged (but some have been observed with positive charge). We have two different ways of describing the electron's properties – the "particle" model and the "wave" model and they are both valid: each model being more or less applicable depending upon the application or experiment being studied.

We like to believe the behaviour of charge carriers in solids is simple. For example, in metals, negatively charged electrons flow through a packed lattice of positively charged ions. We might seem to confirm this using, say, the Hall effect. This is where the application of a constant magnetic field orthogonal to the direction of charge carrier flow in a solid, produces a potential orthogonal to both the magnetic field and electron flow. This is used as a sensing method for magnetic fields.

For most metals, the results of such an experiment produce potentials consistent with the flow of negative charge carriers, but NOT ALL! In particular, zinc and cadmium produce potentials consistent with the flow of positive charge carriers. Are these still electrons or positrons?

As far as we are concerned, current is defined as the flow of positive charge from the positive potential to the negative potential. **It is an international standard** which everyone understands in electronics and accepts when describing electrical properties. The detailed particle descriptions of solids are described by other commonly accepted conventions. You will find this convention is used universally by academic engineers and it is the method adopted globally in all forms of technical data and circuit operation theory.

The Teach-In Authors

As Compere of this Column, I feel obliged to make a further observation. It is not up to those who teach a subject such as electronics (ourselves included in this description) to independently change the conventions which have been established by International agreement (SI). That way lies anarchy and confusion.

Where disagreement in interpretation exists, then certainly the alternative viewpoint should be highlighted, but not to the exclusion of the accepted argument. Irrespective of the validity of the non-orthodox argument, the orthodox view is the one which, in this case, industry expects engineers to conform to. Those who enter industry equipped with non-orthodox views are likely to be faced with having to relearn their subject in order to express themselves in terms of the concepts as understood by their colleagues.

Until such time as International bodies decree that a definition should be changed, the accepted view should be taught as standard. Irrespective of the enthusiasm generated (and we applaud and encourage enthusiasm), it would be irresponsible of any educator to teach otherwise.

PIPES, VIBES AND HISTORY

Dear EPE,

I found the letter from K.C. Toh of Malaysia (*Readout* April '98) rather intriguing. I remember that, way back in my student days, I used a Kundt's Tube (is the spelling right?) sprinkled with Lycopodium powder to measure the nodes and anti-nodes of a sound wave travelling down the tube.

Perhaps K.C. Toh might consider amplifying the sound from his transistor radio so that it sets the piping to vibrate, thus loosening the adherent properties. It might, though, loosen any joints as well and the mending of these could keep him occupied for some considerable time!

S. Fox,
Epping, Essex

Probably!

Your queried spelling is correct – my Timetables of Science *says that August Adolph Eduard Eberhard Kundt devised in 1866 a method for measuring the speed of sound in different gases by analysing the patterns that sound waves cause in a fine dust scattered inside a tube filled with the gas being investigated. Herr Kundt was born in Schwerin, Germany, 18 Nov 1839 and died in Israeldorf 21 May 1894.*

From the same source, I notice that in 1894 two other notable physicists died, Heinrich Hertz and Hermann von Helmholtz. In the same year, J.J. Thomson announced he had found the velocity of cathode rays to be much lower than that of light (you may recall it was he who discovered the electron, in 1897).

MORE ON BYTES

Alan Winstanley, our Circuit Surgeon, has E-mailed in the following:

To add further weight to your definition of a byte, the *Microsoft Press Computer Dictionary* says "Abbreviation of BinarY TErm. A unit of data, almost always consisting of 8 bits ...". Microsoft know a thing or two about computers!

This dictionary is particularly good because it mixes in Internet, computers and electronics very well.

Thanks Alan. I'm still waiting for readers to enter the fray on this subject, raised in Readout *May '98.*

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, most issues from the past five years are available. An index for the last five years is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price.

DID YOU MISS THESE?

JAN '97

PROJECTS ● Earth Resistivity Meter, Part 1 ● Psycho Rat ● Theremin MIDI/CV Interface, Part 1 ● Mains-Failure Warning.
FEATURES ● Ingenuity Unlimited ● Build Your Own Projects, Part 3 ● Circuit Surgery ● Interface ● Net Work – Internet News ● PCS32 Storage 'Scope Interface Review.

FEB '97

PROJECTS ● Pacific Waves ● How To Use Intelligent L.C.D.s, Part 1 ● PsiCom Experimental Controller ● Earth Resistivity Meter, Part 2 ● Theremin MIDI/CV Interface, Part 2.
FEATURES ● Ingenuity Unlimited ● Build Your Own Projects, Part 4 ● Circuit Surgery ● Interface ● Net Work – Internet News.

MARCH '97

PROJECTS ● Simple Dual-Output TENS Unit ● Video Negative Viewer ● Tri-Colour NiCad Checker ● How To Use Intelligent L.C.D.s – 2 ● Oil Check Reminder.
FEATURES ● Interface ● Ingenuity Unlimited ● Build Your Own Projects, Part 5 ● Digital TV – The Reality ● Circuit Surgery ● Net Work.

APRIL '97

PROJECTS ● 418MHz Remote Control System ● Midi Matrix ● Puppy Puddle Probe ● PIC-Agoras Wheelie Meter – 1.
FEATURES ● Interface ● Ingenuity Unlimited ● Digital TV and MPEG2 ● EDWin NC Software Review ● Circuit Surgery ● Net Work.

MAY '97

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FEATURES ● TEACH-IN '98 – An Introduction to Digital Electronics–3 ● Circuit Surgery ● Ingenuity Unlimited ● Alternative and Future Technologies–2 ● Net Work – The Internet ● *Free* – Giant PIC Data Chart.

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M5/98

8051-BASED EEPROM MICROCONTROLLERS

COLIN MEIKLE

Much used in industry, 8051-type microcontrollers are now available in EEPROM variants suited to the hobbyist user.

USING a single chip microcontroller can greatly simplify your design, while adding flexibility and additional functionality. This can easily be seen from the widespread use of PIC microcontrollers.

The 8051 family of processors, though, is amongst the most widely used microprocessor in industry, although its use in hobby electronics has so far been somewhat limited. This article gives an introduction to the family, with particular emphasis on the 2051 and 1051 EEPROM (Electrically Erasable Programmable Read Only Memory) variants. An accompanying article explains how a low-cost programming and development system for these two devices can be constructed.

INTRODUCTION

Developing code for an 8051 microcontroller without an In-Circuit Emulator (ICE) can be difficult and slow. Consequently, to develop code without an ICE, some form of re-programmability is required. This normally means using windowed EPROM (Erasable Programmable Read Only Memory) devices, which are expensive and require time to erase with ultra-violet (UV) light before they can be reused.

There are various ways to get round this when using an 8051. For example, an EPROM can be programmed with a monitor program which, via the serial port, loads external NVRAM (Non-Volatile Random Access Memory) with the program mapped into code space. However, most methods add complexity to the hardware and/or put restrictions on the code.

Recently, however, Atmel have introduced variants of the 8051 which have made microcontroller development very simple. These overcome the reprogrammability problem by implementing Flash ROM on the processor. This eliminates the need for an external EPROM, and gives "instant" reprogrammability to the developer. Atmel use the term PEROM (Programmable and Erasable Read Only Memory) to describe the devices, although the term EEPROM is equally valid.

These microcontrollers are therefore ideal for low cost development of microcontroller projects. Development systems can be put together very cheaply, giving you access to a very flexible and powerful family of processors.

8051 FAMILY VARIANTS

The 8051 family covers an enormous number of variants, well outside the scope of this article. Although only a small subset is discussed here, there is a great deal of commonality between devices. Code written for one particular device is portable between different manufacturers and different variants.

Intel introduced the 8051 back in the early '80s, following on from their MCS-48 family of processors. Although the family has grown greatly, the basic 8051 is still very popular. A summary of the most popular devices is shown in Table 1.

The table shows only a very small selection of the devices available. Note that the 80x and 87x devices have multiple manufacturers, whilst the 89x devices are manufactured by Atmel. This article concentrates on the latter devices.

The 80C51/2 are of little use to the experimental hobbyist as they are One Time Programmable (OTP) devices. You can, though, get ROM-less versions, 80C31/2 and add your own EPROM. This is cheap but unless you need large amounts of memory, defeats the purpose of a single chip microcontroller.

The 87C51/2 get round this problem as they have on-board EPROM. However, you still need to erase them with UV every time you wish to reprogram them. They are also expensive, so keeping a supply of blank ones is not cheap!

Table 1. Popular 8051-variants

Device	ROM	RAM	Timers	Interrupt	UART	I/O	Pins	Other
80C51	4K OTP	128 bytes	2	5	yes	32	40	
80C52	8K OTP	256 bytes	3	6	yes	32	40	
87C51	4K EPROM	128 bytes	2	5	yes	32	40	
87C52	8K EPROM	256 bytes	3	6	yes	32	40	
89C51	4K EEPROM	128 bytes	2	5	yes	32	40	
89C52	8K EEPROM	256 bytes	3	6	yes	32	40	
89C1051	1K EEPROM	64 bytes	1	3	no	15	20	Analogue comparator
89C2051	2K EEPROM	128 bytes	2	5	yes	15	20	Analogue comparator

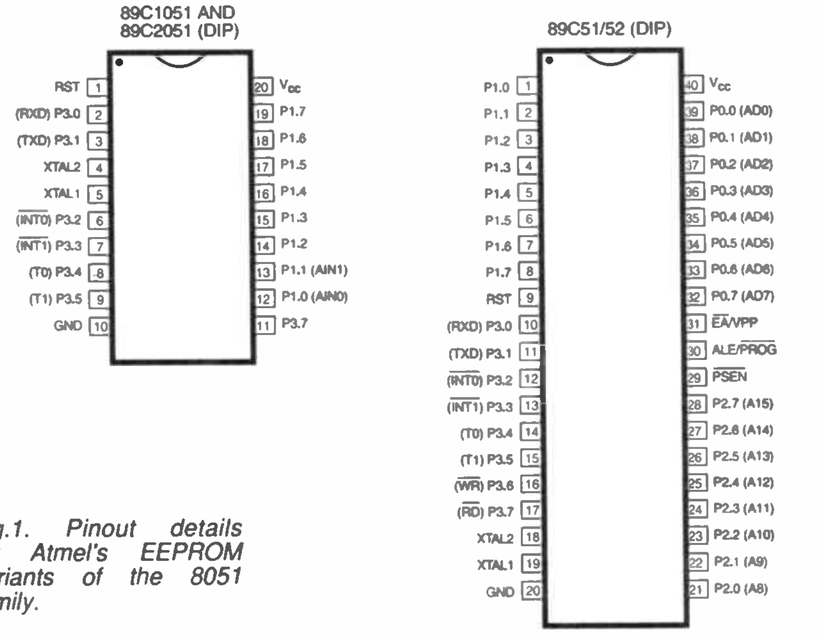

Fig.1. Pinout details for Atmel's EEPROM variants of the 8051 family.

This leaves the Atmel 89x processors. These devices have on-chip EEPROM, allowing instant reprogramming, which is ideal for a development environment (they are also relatively inexpensive). The latest devices released will actually allow you to reprogram them while they are still on the printed circuit board (p.c.b.).

Atmel's 89x variants of the 8051 are the AT89C51, AT89C52, AT89C1051 and AT89C2051. Their pinouts are shown in Fig.1.

All four devices retain most of the 8051 features, such as the UART (Universal Asynchronous Receiver/Transmitter), although the number of I/O (input/output) pins on the 1051 and 2051 devices is reduced.

The latter devices also have a 2-input analogue comparator, which is not found on the standard 8051. Because of their size, functionality and low cost, these two microcontrollers are an ideal starting point for small projects.

8051 ARCHITECTURE

The architecture of the basic Atmel 8051 core upon which all the variants are based, is illustrated in Fig.2.

Some ports also function as the address and data buses when the processor uses external memory and others have alternative functions, e.g. external read/write strobes. The details are covered in Atmel's data sheets.

If you have never used an 8051, the memory structure may appear slightly confusing. First, the program memory and data memory have separate address space (*as have PIC microcontrollers, Ed*). In addition to the two separate address areas, memory can either be internal or external. Memory organization is shown in Fig.3.

In total, 64K bytes of program and data memory can be addressed. However, to use 64K of program memory, external memory will have to be added (internal memory sizes vary, the maximum available is 32K, although 8K or 16K are normal).

For external memory accesses, the processor uses different strobe signals to access program and data memory (see Fig.2). Signal line PSEN is used to access program memory, and lines $\overline{RD}$ and $\overline{WR}$ are used to access data memory.

The EA pin on the processor determines if external or internal program memory will be used. Note that when the internal program memory range is exceeded the processor will automatically look for external memory, regardless of the EA pin.

Program memory is fairly simple, you can either use internal or external, but you cannot use both at the same address. Data memory is different, for one particular address, up to three separate locations can exist.

Again referring to Fig.3, in the range 00H to FFH both internal and external memory can exist and can be used. From 80H to FFH an additional area of memory exists in some devices, the 89C52 for example. This is referred to as the indirect memory area. Therefore, in this range there are three separate data areas.

Only part of the internal RAM is available for general-purpose use, as registers and ports are also mapped into this region.

To differentiate between the memory areas, the processor uses different instructions and addressing modes. Some examples are shown in Listing 1.

This may seem confusing, but if you do not use external memory then things are simpler. Also, if you store your data in the lower 128 bytes of RAM (00H to 7FH), both direct and indirect addressing can be used to access it.

PORTS

The 8051 has four 8-bit ports, each of which is bi-directional and bit addressable, i.e. each individual port bit can be changed without affecting the other bits. The ability to change individual bits or the whole port in one instruction is a very useful feature.

Each port has slightly different characteristics, as described in more detail later. The ports are accessed in the same way as the internal RAM, although they can only be accessed by direct addressing. They appear in the upper 128 bytes of the internal RAM (80H to FFH), called the Special Function Register (SFR) area. An example of accessing them is given in Listing 2.

The final command in Listing 2 also

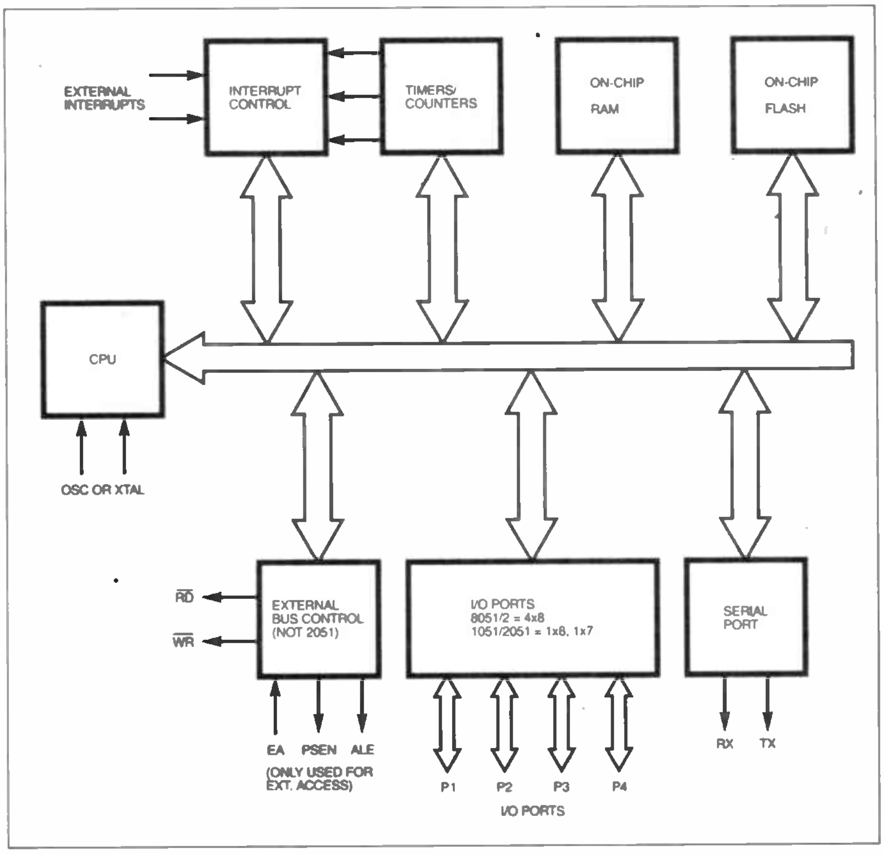

Fig.2. Basic core of the 8051 family.

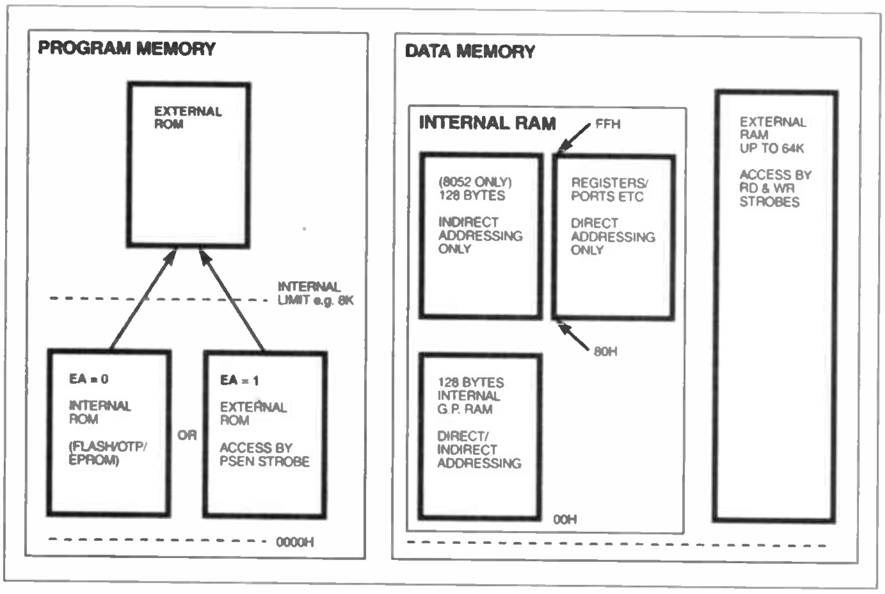

Fig.3. Memory organisation within the basic 8051.

sets the port as an input. The port pins are pulled high by internal pull-ups (see later under Port Structure).

INSTRUCTION SET AND REGISTERS

The instruction set has all the usual commands you would expect, it also has a range of bit operations, so that individual bits can be manipulated. Only 16 bytes of the general purpose RAM are bit addressable, 20H to 2FH. Most of the special function registers, e.g. I/O Port, are bit addressable.

Instructions are one, two or three bytes long and most take one or two cycles to complete. A cycle is 12 oscillator periods, therefore, with a 12MHz clock, most instructions take 1µs or 2µs.

There are four banks of eight general purpose registers (each eight bits wide). These registers are mapped to the bottom 32 bytes of internal RAM. The eight registers are numbered R0 to R7. All four banks of registers are available. However, only one bank of registers is normally used (Bank 0).

The other banks are normally used for interrupt service routines. Two of the registers (R0 and R1) are used for indirect addressing. These are the only two registers that can be used for indirect addressing.

The Accumulator (A or ACC) is a multi-purpose register which is used by a large number of instructions. Usually, the result of an instruction will be placed here. The B register is only used by the divide and multiply instructions. It can also be used as a general purpose register.

The data pointer (DPTR) is the only usable 16-bit register. It is commonly used to hold or point to the address of a data location. Since it is the only 16-bit register, it also finds many other uses.

The stack pointer is used by the PUSH/POP and CALL instructions. The default location for the stack pointer is 07H, which is the same location as register Bank 1. So, to use the other three banks, the stack pointer must be moved to an address above the register banks, e.g. 20H.

The stack pointer is incremented each time a PUSH or CALL instruction is executed and, therefore, can use a large amount of memory. Care must be taken to ensure the stack does not overwrite the data storage. A common practice is to set the stack pointer as the last (highest) data storage address.

DESIGNING CONSIDERATIONS

There are a few features of the hardware you must understand before you start designing.

If you have not written your code yet, you will not know how much program or data memory you will require. This is a problem if you want to start designing your hardware before the code is written.

There is some flexibility, though. If you target a device with 4K ROM you can move up to a device with 8K if your program does not fit. For data memory you can upgrade from 128 bytes to 256 bytes, although you should remember that you do not have access to all of this memory.

You must allow space for registers and the stack – this does not leave a huge amount! Therefore you must think carefully if you plan to only use internal memory. Adding external memory later will add extra components to your design and, more importantly, will normally use up Port 0 and Port 2 for the address and data buses. The available I/O pins will, therefore, be greatly reduced, which may result in a re-design of your p.c.b. and probably a rewrite of your code.

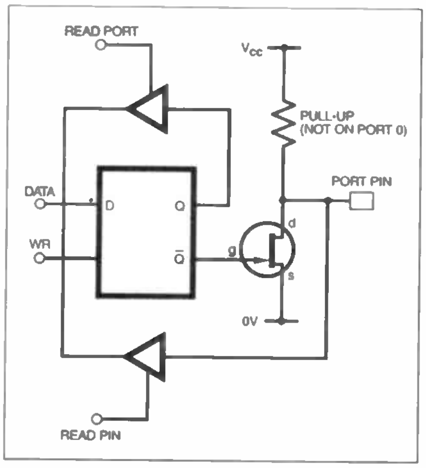

Fig.4. Typical port structure.

PORT STRUCTURE

All ports are bi-directional and each consists of a latch, input buffer and output buffer, see Fig.4. The output stages of Ports 1, 2 and 3 are simply open-drains with weak internal pull-ups; Port 0 does not have the pull-ups (Atmel 1051/2051 variants have pull-ups on Port 1 bits 2 to 7; bits 0 and 1 do not).

As a result, Ports 1 to 3 can sink 1.6mA but only source 25µA, without external pull-ups. Port 0 is open collector so you must remember to add external pull-ups. Because of the low drive capabilities, the ports can only drive

LISTING 1. Example codes

1. MOVC is used to get values from program memory (often used for look-up tables):

```
MOV   DPTR,#1000H   ; load DPTR
                    ; (data
                    ; pointer
                    ; register is
                    ; 16-bit)
CLR   A             ; set the
                    ; accumu-
                    ; lator to
                    ; zero
MOVC  A,@A + DPTR   ; get byte
                    ; from
                    ; program
                    ; memory at
                    ; location
                    ; 0 + 1000H
```

2. Write 05H to Port 1 (address 90H) – Direct Addressing:

```
MOV   90H,#05H
```

3. Write 05H to address 90H in indirect RAM – Indirect Addressing:

```
MOV   R0,#90H     ; move 90H
                  ; into register
                  ; R0
MOV   @R0,05H     ; move 05H
                  ; to address
                  ; pointed to
                  ; by R0
                  ; (90H)
```

4. Write 05H to address 90H in external RAM:

```
MOV   R0,#90H
MOV   A,#05H
MOVX  @R0,A   ; move A (05H) to
              ; external location
              ; pointed to by R0
              ; (90H)
```

LISTING 2. Examples of port access

```
SETB  P3.0      ; set Port 3 bit 0 high
CLR   P3.0      ; set Port 3 bit 0 low
MOV   P3,#0FFH  ; set all 8 bits of Port 3
                ; high.
```

CMOS inputs (fewer than four inputs, without external pull-ups).

To configure a port as an input, simply write a 1 to the port, this will turn the output transistor off (see Fig.4). However, the internal pull-ups on Ports 1 to 3 are still active, hence these ports will still source current as inputs.

Note that when configured for external memory access, Port 0 and Port 2 are configured differently so that they have a higher drive capability.

PERIPHERALS

The different variants of the 8051 have different internal peripherals. There is a huge range of devices offering many different internal peripherals such as analogue to digital converters (ADC), pulse width modulation (PWM) outputs, real-time clock (RTC) etc. The basic 8051 core offers one UART, two timer/counters and 32 I/O lines.

For your microprocessor circuit to be of any use, you will require to interface to external components. The simplest way to do this is to use the I/O pins to directly control the device. Alternatively, you can memory map devices so they appear as external memory. You would normally only do this, though, if you are using the processor in external mode (as there are fewer I/O pins available).

Common examples of circuits for driving devices from the I/O pins are shown in Fig.5.

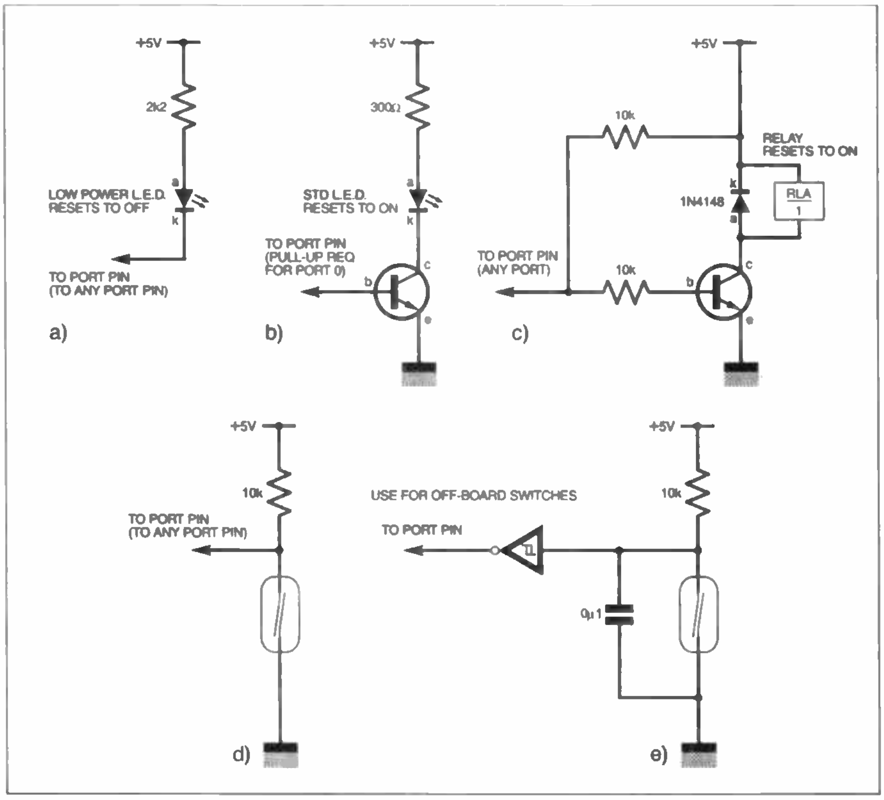

Fig.5. Examples of I/O drive circuits: (a) low current l.e.d., (b) buffered l.e.d., (c) relay drive, (d) simple reed relay, (e) improved reed relay.

GETTING STARTED

The only way to really learn about these devices is to use them. Before you start, though, you will need a few things: an assembler for assembling your code, a programmer to program your devices and then you require some hardware to start playing with.

To buy a professional development system would cost several thousand pounds. However, using the Atmel devices and the circuits in the accompanying constructional article, you could collect together a DIY system for under £100.

Note, though, that you need access to a PC-compatible computer. Then you need the Atmel data book, or data sheets for the chosen processor. The data can also be downloaded from the Web or obtained on CD-ROM.

There are three languages you can use to program the 8051:

1. Assembler

It may seem to some that it might be easier to start with a high level language, such as C. However, writing code in assembler will give you a good understanding of the 8051 architecture, which is essential to be able to get the most efficient code.

The best *free* one the author has found is the Meta Link ML51, available on the Philips web site and on the Atmel CD-ROM. There are numerous others available, but this one is probably the best you'll get without paying money.

2. PLM

The PASCAL-like language PLM is a possibility, and is easier to program in than assembler. However, you may be better with a high level language like C.

3. C

You may already have some knowledge of C, which will make writing code simpler and quicker. It also has the advantage of being more readable and portable than assembler and PLM, but you must remember the limitations of the processor you are using, e.g. very limited data memory and possibly code space. Therefore, you must be careful when writing your code.

Well written C can be just as efficient as hand written assembler (particularly for RAM usage). Badly written code can very quickly use up your ROM/RAM.

If you only want to use the 2051/1051 devices, you can get a code-restricted version of the excellent Keil Tools, although you can only compile 2K of code with it. This is not a problem, though, as you only have 2K of ROM on a 2051. The tools are otherwise unrestricted.

If you want to know more about C for the 8051 get the "C Primer" free from the Equinox web site. A freeware C compiler, written by Sandeep Dutta, is available from the Web.

As mentioned, you should start writing code in assembler (at least until you understand the architecture). Another good reason for this is that there are several freeware assemblers available. Some of these are very good and will quite likely satisfy all your needs.

The re-programmability of the Atmel processors makes the need for an In-Circuit Emulator (ICE) less of a necessity. However, you will still need some sort of debugging environment. Commercial ICEs are expensive, but an alternative is to use a CPU simulator (a software program that emulates the functionality of the CPU and memory) and again you can find freeware versions.

An excellent shareware one can be found on the Philips Web site (SIM51). It is in German but this is not really a problem as you can easily work out the controls.

You can also buy cheap in-circuit reprogramming modules, which allow you to reprogram your processor without removing it from the circuit (about £100 to £125 from Equinox).

Finally, you will need to program your processor. A programmer suited to the 2051 and 1051 devices is described in the accompanying constructional article.

DATA AND SOFTWARE SOURCES

The Web is the best place to get information. You can get source code data sheets and, most usefully, free tools. Getting access to the Web need not be a problem: if you do not have personal access, places such as libraries etc. now offer access.

Another good source is the Atmel Microcontroller CD-ROM. It contains a good assembler, all of the data sheets you'll need and some interesting application notes. It is worth getting; if you have trouble getting one you can buy one from Farnell.

Here are some useful web addresses:

Online Tutorial

A very good introduction to the 8051 family of processors can be found at:

www.8052.com.

Datasheets

You can get data sheets in various electronic formats from the Web or get a printed copy from a distributor. For electronic copies try:

http://www.atmel.com/ and
ftp://ftp.intel.com/ - /pub/mcs51

Assembler

There are numerous assemblers available but the Metal-Link assembler is very good. You can get it from:

ftp://ftp.philipsmcu.com/ - /pub, or **http://www.philipsmcu.com/assemblers-.html** (other goodies here, too),

or from the Atmel CD-ROM.

Simulator

A simulator is essential if you are learning. The first one below is in German (DOS-based), the second one is a nice looking Windows simulator:
SIM51: from the above Philips site or Atmel CD-ROM, or

SIM8052D, from:
http://www.vaultbbs.com/sim8052/ or **http://www.8052.com**

C Compiler

At the time of writing, the following C compiler was in a Beta phase of testing. It is free with no restrictions:

SDC by Sandeep Dutta, from:
http://www2.netcom.com/~sandeepd

There is an evaluation version of the KEIL compiler at:

www.keil.com/demo/ek51

This an excellent compiler and debugger. The "Lite" version is sold with many Atmel development systems, from Equinox and Farnell, for example.

Real Time Operating system

For a more advanced real time operating system, try:
www.iotasys.com/8051/software.htm

Devices and Programmers

Equinox – devices, programmers, development systems, and more:
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Now read the AT89C2051/1051 programming article on page 432.

SHOP TALK

with David Barrington

Simple SW Receiver

A single-gang Jackson type 0), air-spaced, 365pF tuning capacitor for the *Simple SW Receiver* project will set you back about £15 (**Maplin**, code FF39N). However, it is not essential to use the specified tuning capacitor as any "air-spaced" type having a maximum value of around 300pF to 400pF will suffice here: provided, of course, it will fit into the case. You could try contacting **Bull Electrical (☎ *01273 203500*)**, **ESR Elec. Components (☎ *0191 251 4363*)** or **Greenweld Elec. Components (☎ *01703 236363*)** who sometimes offer, surplus to requirements, tuning capacitors at a much reduced price.

We came up with two sources when searching for the specified Toko r.f. transformers. From Maplin, codes FD03D (KANK3334R – 5MHz to 15MHz), FD02C (3333R) and FD04E (3335R). Toko's main distributor in the UK, **Cirkit (☎ *01992 448899*)**, stock codes 5MHz to 15MHz, 35-33340 (KANK 3334R); 1·6M to 5MHz, 35-33330 (KANK 3333R) and 15MHz to 30MHz, 35-33350 (KANK 3335R).

Although the article specifies a 3·5mm stereo jack socket for the Headphones output, and not being able to find an easy source for a stereo *insulated* type, we suggest readers opt for a "moulded body (with plastic bezel)" 6·35mm jack socket and if necessary use a 3·5mm adaptor plug between the socket and the headphones. Most of our component advertisers should have such an adaptor.

The case chosen for the prototype model is one from a range of blue/grey, hammer finish, two-piece metal instrument cases stocked by Maplin, code XY45Y.

EPE Mood Changer

Just a couple of items could cause local shopping problems when gathering together the parts for the *EPE Mood Changer*. The OP296G and OP279G dual op.amps are fairly new additions, designed for rail-to-rail operation, and do not appear in many component advertisers lists. The ones in our model came from **Maplin**, code NP22Y (OP296G) and NP18U (OP279G).

As stated in the article, a source for the air-cored output coil was initially a problem until the friendly washing machine engineer suggested a 230V a.c. solenoid valve coil. Further enquiries revealed that these valves are readily available as service spares (Hoover), with a single solenoid coil on a valve costing less, it is claimed, than £9. The coil used had a d.c. resistance of about 4 kilohms. You could, it is suggested, also try your local scrapyard, where they might be even cheaper.

Do not forget to specify a "log" type when ordering the subminiature potentiometer. The small printed circuit board is available from the *EPE PCB Service*, code 193.

Finally, please heed the warning panel about the use of the *EPE Mood Changer*. Although this project does not "flash lights" into the eyes, it is generating brainwave frequencies which could possibly trigger a reaction. If any of the symptoms described are experienced, you are advised to consult your doctor immediately.

Reaction Timer

Most of the components needed to build up the *Reaction Timer* are RS components and any local *bona-fide* RS stockists should be able to order them for you. Alternatively, they can be purchased through **Electromail** (☎ *01536 204555*), their mail order outlet.

The red/green tri-colour l.e.d., used for "triggering" the response time, is a Siemens common cathode type LU5351-JM and is available from the above source, quote code 578-294. On this device the shortest lead is the red anode and the centre lead common cathode. Other 60mA to 20mA tri-colour l.e.d.s, such as the one offered by Maplin (YH75S), may have differing leadouts, typically green anode shortest lead, cathode centre (long) and red anode medium length.

For the extra outlay, it is probably worth purchasing the specified handheld box incorporating a display window. The one in the prototype is a Vero box (75-227911D) and carries the RS code 584-595. A battery box for the case can be ordered as 584-918 (deep).

When selecting the 7-segment dual display, it is important to choose one that has its pin line-up across the top and bottom of the device, when looking at the display underside. We understand the author purchased his from Electromail, code 247-2788.

So far, we have not been successful in finding an 18-pin d.i.l. socket with a 0·6in. pitch. We suggest readers use individual socket strips or, better still, cut a 0·3in. 18-pin i.c. socket *lengthwise* and solder the two halves on the stripboard.

The pushbutton switch (320-988), transistors (296-116) and battery holder (594-628) came from the above mentioned company. Most of our component advertisers should also be able to offer suitable alternatives.

A ready-programmed PIC16C55 is available (*Mail Order Only*) from **PH Research, 32-34 School Lane, Swavesey, Cambridge, CB4 5RL** for the sum of £11 (add £1 for overseas orders). Tel/Fax: **01954 200411.** E-mail: **paul@ph-research.prestel.co.uk**

For those who wish to do their own programming, the software is available on a 3·5in. disk from the Editorial Offices – see PCB Service page. If you are an Internet user, it is available *Free* from our FTP site:
ftp//ftp.epemag.wimborne/co.uk/pub/PICS/Reaction.Timer.

AT89C2051/1051 Programmer

A ready-programmed ISP2032 controller chip for the *AT89C2051/1051 Programmer* is available direct from the designer (Mail Order Only): **Colin Meikle, 9 Coldstream Drive, Strathaven, Lanarkshire, ML10 6UD.** Make cheques payable to him. The price, inclusive of UK postage, is £12. (For overseas orders add £1).

You can also contact the author via E-mail at:
colin.meikle@virgin.net.

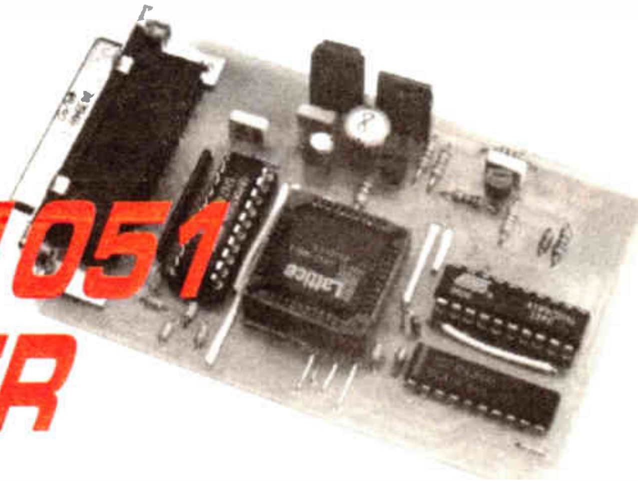
Software for the programmer and test board, including that for the ISP2032 controller, is available from the *EPE* Editorial Office on a 3·5 inch disk, order as PIC-Disk 1. See *EPE PCB Service* page for postage charges.

The software is also available *Free* from the *EPE* Web site:
ftp://ftp.epemag.wimborne.co.uk/pub/8051/programmer.

The only component that could cause sourcing problems is likely to be the *through-hole* 44-pin PLCC socket. This is currently listed by **Maplin**, code JH40T, or **Farnell** (☎ *0113 263 6311*), quote 484-386. All the connectors, other sockets, MAX232 RS232 driver chip and microcontrollers should be generally available.

The two printed circuit boards are available from the *EPE PCB Service*, codes 194 (Main) and 195 (Test), see page 468.

ATMEL AT89C2051/1051 PROGRAMMER



COLIN MEIKLE

Add 8051-family facilities to your designing armory.

ATMEL AT89C2051/1051 processors are members of the 8051 family and are extremely useful and versatile microcontrollers. These processors contain flash Programmable and Erasable Read Only Memory (PEROM), and can be reprogrammed over 1000 times. Reprogramming takes seconds without the time consuming UV-erasure step associated with EPROM based microcontrollers. They are 20-pin devices.

In the accompanying article *8051-Based EEPROM Microcontrollers*, general aspects of the 8051 family were discussed, including the 2051/1051.

We now describe a simple programmer for programming the latter devices, and follow on with the description of an experimental board with which to use them.

The programmer is designed to operate from the parallel port of a PC-compatible computer. The associated software is DOS-based, allowing the programmer to be used with almost any fairly modern PC.

However, for the programmer to work in all modes, the computer's parallel port requires to be set up for 8-bit bi-directional mode (sometimes called PS/2 mode). You can normally change the setting via the PC's BIOS settings (i.e. the set-up procedure during the PC power-up or reset). You should check your computer manual on this point. Also see later.

The hardware and software for this design is loosely based around that described in the Atmel Application Note (see the Atmel data book, data CD or web site).

Although the implementation is different (particularly that of the hardware), the hardware and software should be interchangeable with that described in the Application Note. Note that the 40-pin devices (AT89C51/52) are not supported by this programmer.

PROGRAMMING MODES

The 2051/1051 devices can be programmed in various modes, as described presently. These modes are selected by applying control signals to pins P3.3 to P3.7, as shown in Fig.1 and Fig.2.

Read Signature Bytes

The devices each have three pre-programmed bytes which identify them:

Byte 1: Identifies the manufacturer. 1EH signifies ATMEL
Byte 2: Device type. 21H for 2051 and 11H for 1051
Byte 3: Programming voltage. FFH for 12V devices

Write Code Data

The Write Code Data process fills the internal PEROM with the code. Before this process can begin, the contents of the PEROM must be erased (in the erased state all the internal locations will read back as FFH). The erasing is done electrically on the programming board. UV-erasure is not needed.

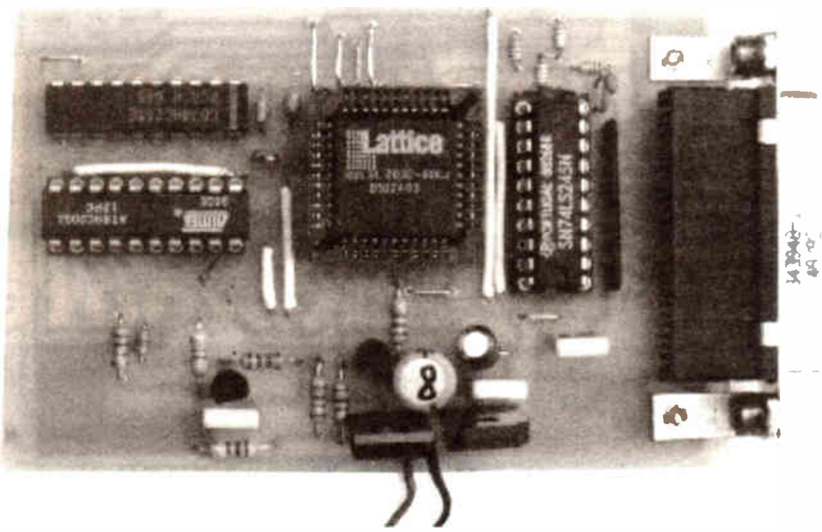
During programming, an internal counter keeps track of the current address. When the sequence is started the counter is reset to 0000H. After a location has been programmed the internal counter is advanced by one, until the complete array is filled.

Chip Erase

In the Chip Erase mode the entire PEROM array and its two lock bits are erased. Previously programmed locations require to be erased before they can be reprogrammed. The entire array should read back with FFH if the device is blank.

Read Code

The contents of the PEROM can be read back from the device, providing



AT89 DEVICES
offer an excellent alternative to PICs when more advanced command and control structures are needed.

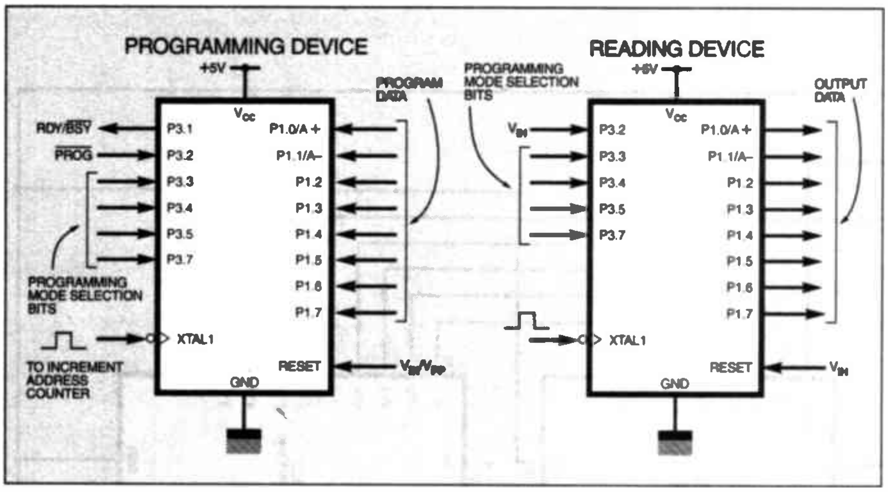


Fig.1. Signal routing for programming and reading the AT89C2051/1051 devices.

MODE	P3.2/PROG	P3.3	P3.3	P3.4	P3.5	P3.7
WRITE CODE	12V	↓ ↑	L	H	H	H
READ CODE	H	H	L	L	H	H
WRITE LOCK 1	12V	↓ ↑	H	H	H	H
WRITE LOCK 2	12V	↓ ↑	H	H	L	L
ERASE	12V	↓ ↑	H	L	L	L
SIGNATURE	H	H	L	L	L	L

Fig.2 (left). Mode selection logic for the AT89C2051/1051 devices.

See SHOP TALK Page

Lock Bit 2 is not set. Reading back the contents of the device is useful for programming verification, and for copying devices when you do not have the programming file.

Write Lock Bits

The contents of the PEROM array can be protected by programming the lock bits. Lock Bit 1 prevents further programming of the device. Lock Bit 2 prevents the contents of the array being read from the device, thereby preventing copying of devices or disassembly of the code.

CIRCUIT DESCRIPTION

The hardware for the programmer provides the interface between the PC's parallel port and the device being programmed, as well as the correct programming voltage for the device. The timing for each of the programming cycles is controlled by the software running on the PC.

The circuit diagram for the programmer is shown in Fig.3. All of the decoding and control is done inside IC3, which is a pre-programmed Programmable Logic Device (PLD).

An LS245 transceiver (IC1) buffers the data signals as some PC I/O (input/output) cards have strong pull-ups on the parallel port, therefore the programmer needs to be able to source a reasonable amount of current.

The HC240 buffer (IC5) isolates the control signals to the device being programmed (this is required during the power-up sequence).

The programming voltage requires to be switched between 0V, 5V and 12V. These voltages are provided by an LM317T adjustable regulator (IC4). Transistors TR1 and TR2 are used to switch between the voltages.

SOFTWARE DESCRIPTION

Timing for all of the programming cycles is done in software. In order for the software to be system-independent, the PC's timer is used to generate all the delays.

The software is based on that described in the Atmel Application Note. However, a number of changes and improvements have been made. Most notably the software can read both binary and Intel hex file formats. (Note that the software can support Intel hex files which have out-of-sequence addresses, unlike some hex to binary conversion utilities.)

The software gives the following facilities:

- ERASE DEVICE: Erase the entire device, including lock bytes
- READ SIGNATURE: Display device identity bytes
- PROGRAM: Program device with specified file data
- PROGRAM LOCK: Disable device programming and reading
- VERIFY: Read device and verify against specified file
- SAVE: Read device and save as a binary file.

CONSTRUCTION

Component and track layout details for the printed circuit board (p.c.b.) are shown in Fig.4. This board is available from the *EPE PCB Service*, code 194.

The p.c.b. contains some small tracks and pads, therefore, if you are making your own board, take care when drilling the holes for the components. Use the correct drill size for each component (0·8mm for IC1, IC3, IC5, transistors, resistors and capacitors; 1·2mm for IC2 and IC4; 1mm for the connectors). If you have to desolder any components, use the minimum amount of heat as tracks could lift easily.

AT89C2051 Features

- Compatible with MCS-51™ Products
- 2Kbytes of Reprogrammable Flash Memory. Endurance: 1,000 Write/Erase Cycles
- 2·7V to 6V Operating Range
- Fully Static Operation: 0Hz to 24MHz
- Two-level Program Memory Lock
- 128 × 8-Bit Internal RAM
- 15 Programmable I/O Lines
- Two 16-Bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial UART Channel
- Direct L.E.D. Drive Outputs
- On-Chip Analogue Comparator
- Low Power Idle and Power Down Modes

COMPONENTS

Resistors

R1 to R4	10k min. 0·125W (4 off)
R5, R11	2k2 (2 off)
R6, R9	1k (2 off)
R7	270Ω
R8	100k min. 0·125W
R10	4k7
R12	1k min. 0·125W
R13	100Ω
RM1	10k 9-way s.i.l. resistor module

All resistors 0·25W unless stated.

Capacitors

C1	82p ceramic plate, 0·1in pitch
C2, C3, C6 to C8	100n ceramic plate, 0·2in pitch (5 off)
C4	47µ axial elect. 10V
C5	47µ axial elect. 25V

Semiconductors

TR1	BC549 *npn* transistor
TR2	BC557 *pnp* transistor
IC1	74LS245 octal transceiver
IC2	7805 +5V 100mA regulator
IC3	ISP2032 pre-programmed controller (see text and *Shop Talk*)
IC4	LM317T adjustable regulator
IC5	74HC240 octal buffer/transceiver
IC6	89C2051 microcontroller (see text)

Miscellaneous

SK1	25-way D-type connector, female, p.c.b. mounting

Printed circuit board, available from the *EPE PCB Service*, code 194; 20-pin d.i.l. socket (2 off); 20-pin ZIF socket, 0.3in wide (see text); 44-pin PLCC socket; 14·5V to 18V power supply, 200mA d.c.; parallel cable, 25-way male to 25-way male; small heatsink clip for IC2.

Approx Cost Guidance Only £35
excl. power supply and cables

Make sure you insert the links before any other components, noting that one link goes under IC3.

The layout contains two sizes of resistors, the standard size and the miniature 0·125W type. If you have trouble finding miniature resistors, you could mount a standard resistor vertically. Make sure the orientation of the resistor module (R14 to

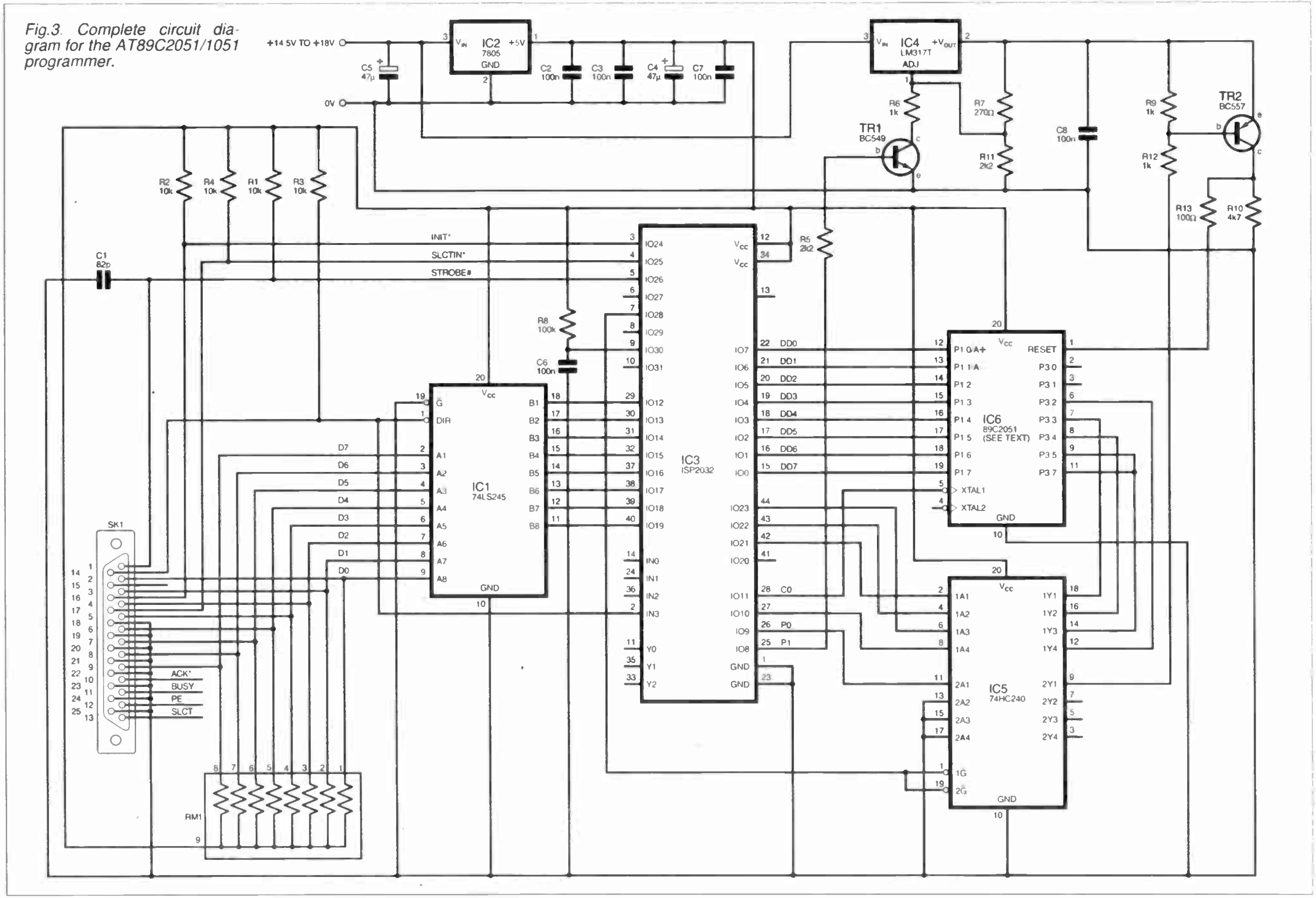


Fig.3. Complete circuit diagram for the AT89C2051/1051 programmer.

R21) is correct, denoted by a dot on the package alongside pin 1.

Position IC6 is for a ZIF (zero insertion force) socket into which the device to be programmed is inserted. Note that ZIF sockets are larger than a normal 20-pin socket and you may have to mount it in an ordinary i.c. socket to ensure that it is clear of the other components.

Standard i.c. sockets must be used for IC1, IC3 and IC5.

Take care when soldering the socket for IC3 as the pads and tracks are very close together. Also note the orientation of the socket, indicated by its slanting corner.

The two regulators, IC2 and IC4, should be mounted vertically and the metal tabs should face in towards the board. A small heatsink may be required on the 5V regulator IC2, although this was not required on the prototype.

Make sure that the housing for the 25-way D-type connector (SK1) is grounded at one of the mounting points. Connection to the PC is made via a standard 25-way printer cable with male D-type plugs at both ends.

The programmer requires a supply of between 14·5V and 18V d.c. at 200mA. It is recommended that a small commercially manufactured plug top power supply is used.

Housing the programmer in a suitable enclosure has been left up to the reader – it is not necessary to do so. Note that if you wish to house the board, ZIF sockets with long leads are available, allowing the socket to protrude through the top of a box.

TESTING

Before attempting to program any devices, check that:

- all links are in place
- there are no solder shorts on the board
- all polarised components are orientated correctly (pin 1 of IC3 is indicated by a dot)

If everything looks fine, apply power to the board, without a device in the IC6 socket and without the cable to the PC attached. Measure the current, it should be approximately 100mA. If not, switch off the power and recheck everything.

USING THE PROGRAMMER

Referring to your computer manual, ensure that the computer's parallel port is set-up for 8-bit bi-directional mode.

If the parallel port is a plug-in I/O card, you may have to change the jumper or switch setting on the card. If your card cannot be set for bi-directional mode, you can still program devices, but the read back (verify and read signature) functions will not work. However, I/O cards are cheap, so you could buy a new card.

Once you have set up the port, you are ready to program a device.

Plug the cable into a free parallel port on your PC (LPT1 and LPT2 are supported by the software). From a DOS prompt, run the PROG51 program. You will have to tell the program which port to use, either LPT1 or LPT2, e.g. type **<prog51 1> for LPT1**.

The program should be run before plugging in the programmer, so that the parallel port is reset into an inactive state.

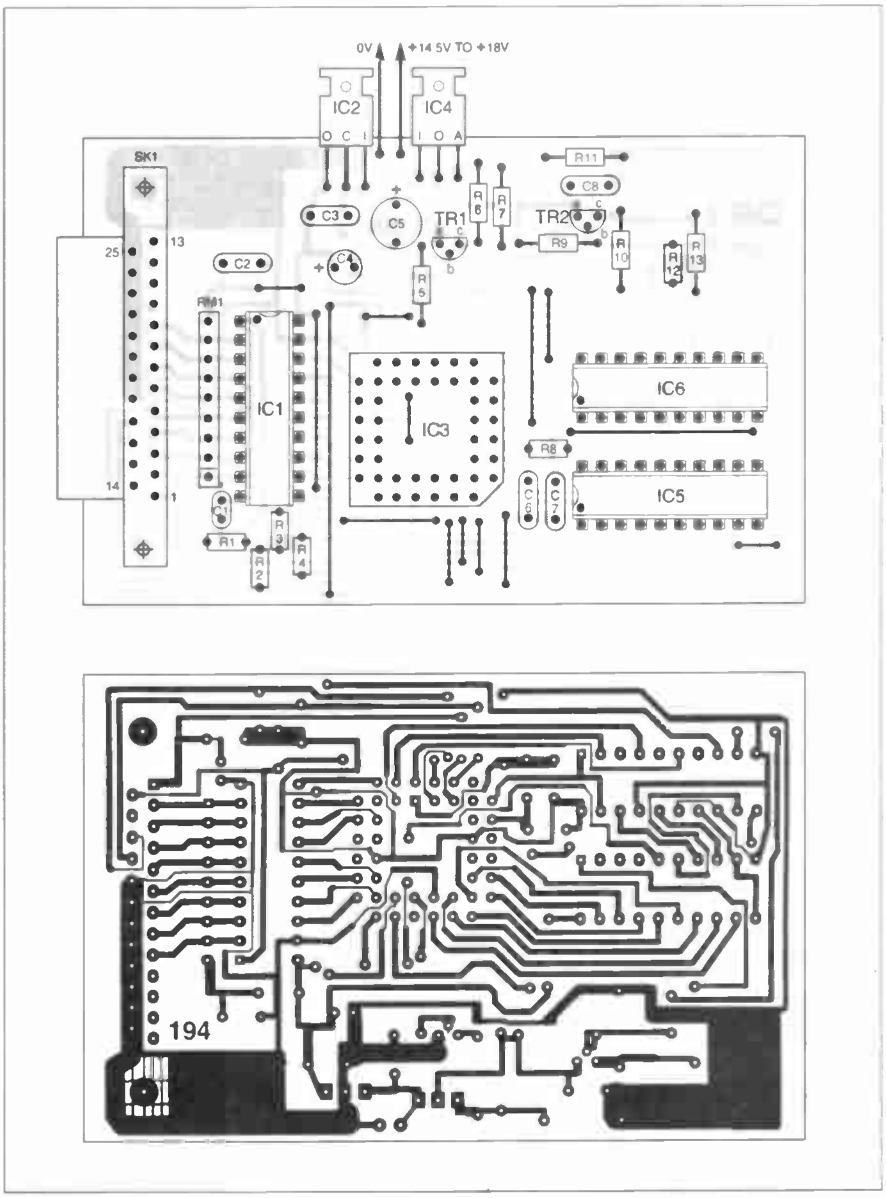
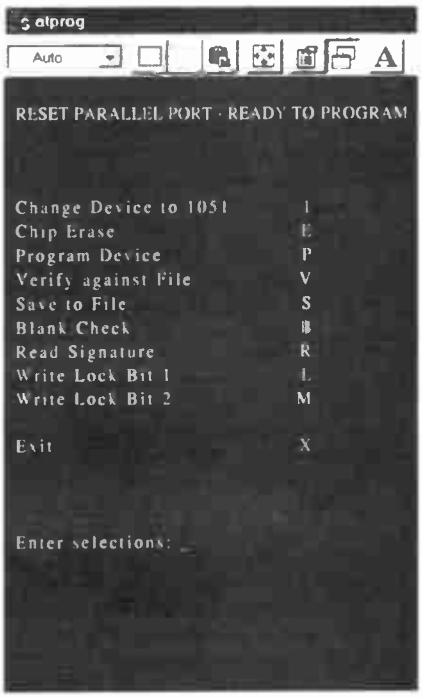


Fig.4. P.C.B. component layout and full size copper foil track master for the 2051/1051 programmer.

Fig.5 (below right). Main menu for the programming software.



Now plug the cable into the programmer, put the device to be programmed into the ZIF socket and apply power.

The programmer's power must always be switched off before inserting or removing a device.

When you run PROG51, you should be presented with the screen example shown in Fig.5.

By default, a 2051 device is selected. You can change manually by selecting "1" for 1051 or "2" for 2051: the first line of the menu will change accordingly.

If you have a device in the socket then the type can be automatically selected by pressing "R" in order to perform a "Read signature" command. This will display the signature bytes, device type and automatically set the correct device type.

To program a device, select "P". You will now be prompted for a filename and file type. The type can be either binary or Intel hex. The latter are ASCII files and normally have the extension .HEX. If possible, you should use Intel hex files as the software will do more checking on them.

The device will be erased before

programming – you cannot program over just part of it.

To verify a device, select "V". Again you will be prompted for a filename and type. If there are any discrepancies between the device and the file, they will be shown.

ERROR MESSAGES

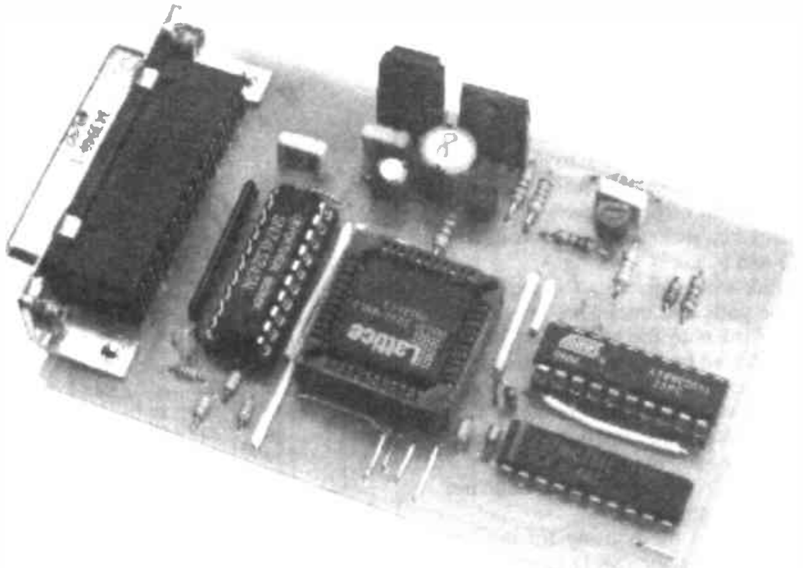
When you first test the programmer, you should try reading the signature bytes. If you get back FFH, FFH, FFH for the signature there are a number of possible causes. The recommended actions are to:

- check cables and power to the board
- check you are using the correct port
- check your board for errors
- check your BIOS setting (the port needs to be bi-directional)

If you are convinced that everything is OK, try programming a device and testing it in your application. If it works but an FFH signature has not been received, your parallel port is not bi-directional (it may not support bi-directional mode or may be incorrectly set up).

When using Intel hex files you may receive one of the following messages:

- *Address out of range*: your programming file contains addresses outside the 1K or 2K limit, e.g. your program is too big. (Note: most assemblers/compilers will not warn when you exceed the limits)



- *Check Sum Error*: your file is corrupt

You have the option of ignoring these errors but your device probably will not work as expected.

For binary files there is no checking.

If you receive any errors during a verify option, you should check the supply voltage to the programmer.

Note that if you do experience noise problems, e.g. with long cables (more than two metres), corruption is more probable when reading data back and the device will probably be programmed satisfactorily.

EXPERIMENTAL TEST BOARD

A simple test bed for 2051/1051 program development

THE circuit diagram for a simple test board on which to experiment with your programmed 2051/1051 devices is shown in Fig.6. All the port pins are free for you to play with.

In Fig.6, the microcontroller is shown as IC1. Crystal X1 is nominally a 12MHz device, although other frequencies could be used.

Access to IC1's I/O pins P1·0 to P1·3 and Reset is via socket SK3. Pins P1·0 and P1·1 can be used as analogue inputs, with resistors R8 and R9 providing a 2·5V reference level for IC1's internal comparator. The Atmel databook gives one way of creating a simple analogue to digital converter (ADC) by using the comparator.

IC1's pins P1·4 to P1·7, P3·4, P3·5 and P3·7 are routed to connector PL1 which is intended to allow a standard intelligent liquid crystal display (l.c.d.) to be connected.

The l.c.d.'s contrast may be adjusted using preset potentiometer VR1.

Four light emitting diodes (l.e.d.s), D1 to D4, can be controlled by pins P1·4 to P1·7. The pins need to be taken low (0V) to turn on the l.e.d.s. Resistors R2 to R5 limit the current flow.

A 4-way on/off slide switch module (S1) is included, allowing control logic levels to be user-set on pins P3·0 to P3·3. The switches set the pins low when closed.

An RS232 I/O control is included in the shape of IC2 and SK1. The RX and TX lines are via IC1 pins P3·0 and P3·1. An RS232 port allows communications to a PC via a terminal emulation program. It is suggested that you obtain a data sheet for the MAX232 RS232 driver when you purchase the device.

Power to the circuit should be supplied at 5V, via connector TB2. Capacitors

COMPONENTS

See SHOP TALK Page

Resistors

R1 to R6	1k (6 off)
R7	270Ω
R8, R9	10k (2 off)
R10	100k

Potentiometer

VR1	1k 15-turn preset, vertical mounting

Capacitors

C1	10μ elect. radial, 10V
C2	47μ elect. radial, 10V
C3, C4, C9	100n ceramic plate, 0·2in pitch (3 off)
C5, C6	1μ5 elect. radial, 15V (2 off)
C7, C8	22p ceramic plate, 0·1in pitch (2 off)
C10, C11	10μ elect. radial, 25V (2 off)

Semiconductors

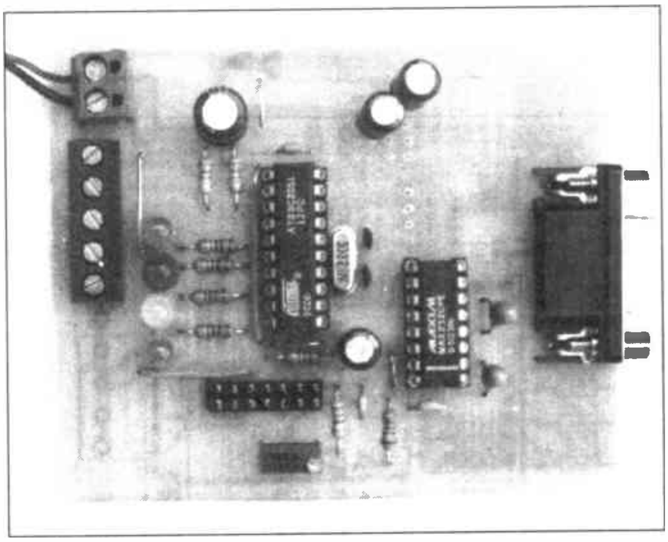
D1 to D4	red l.e.d. (4 off)
IC1	Atmel 1051 or 2051 microcontroller for programming (see text)
IC2	MAX232 RS232 driver

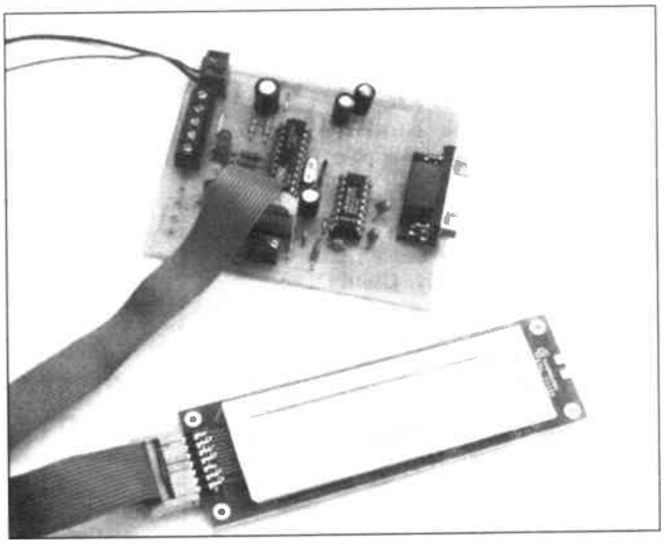
Miscellaneous

SK1	9-pin RS232 socket, p.c.b. mounting
PL1	14-way pin header
TB1	10-way terminal block, p.c.b. mounting
TB2	2-way terminal block, p.c.b. mounting
S1	4-pole make-break slide switch, p.c.b. mounting
X1	12MHz crystal (see text)

Printed circuit board, available from the *EPE PCB Service*, code 195; 2-line 16-character l.c.d. (optional); 14-pin d.i.l. socket; 20-pin d.i.l. socket; connecting wire; solder, etc.

Approx Cost Guidance Only £24 excl. l.c.d.





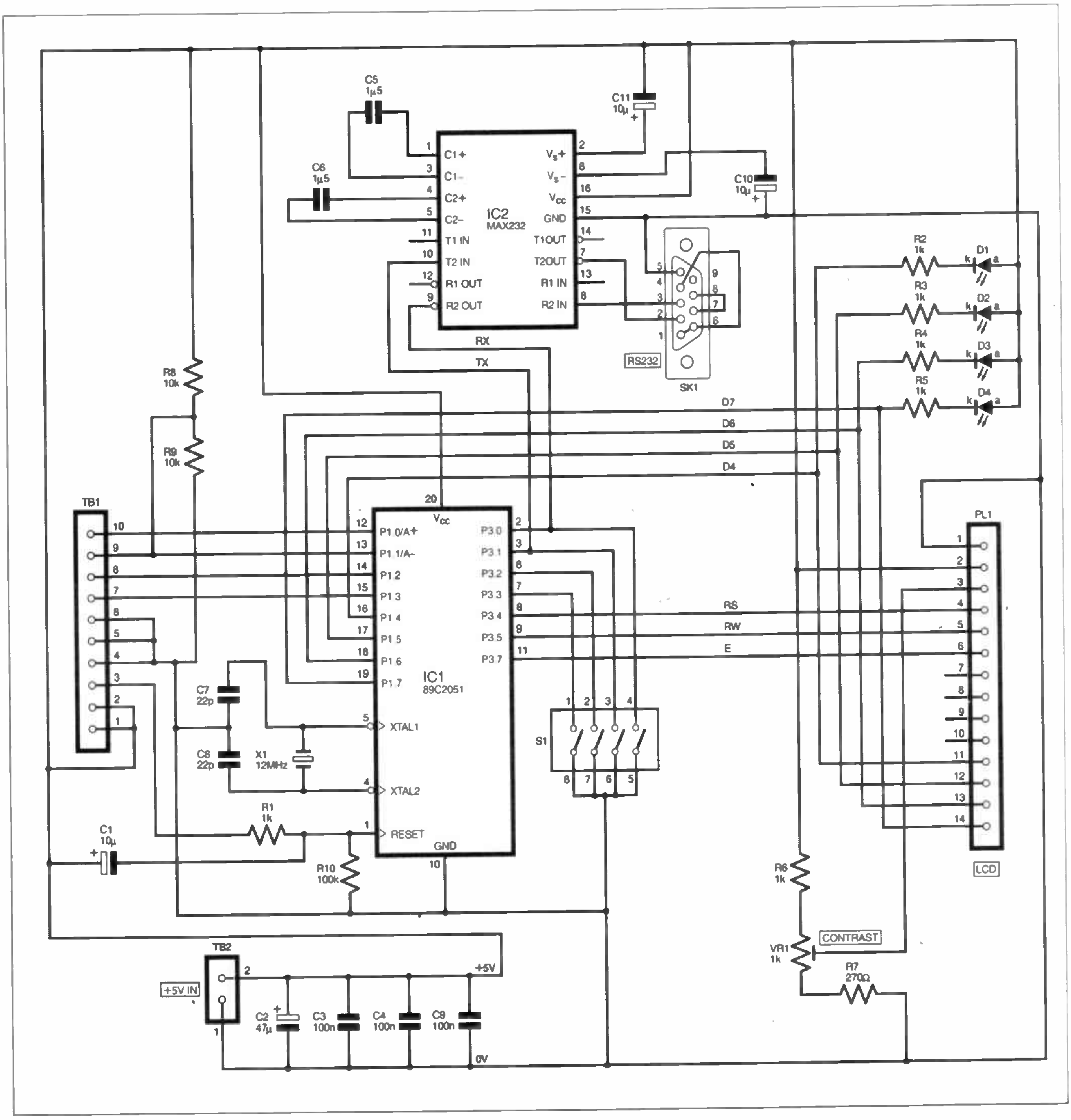


Fig.6. Circuit diagram for the Experimental Test Board.

C2 to C4 plus C9 provide power line decoupling.

CONSTRUCTION

A printed circuit board for the experimental circuit is available from the *EPE PCB Service*, code 195, and its layout details are shown in Fig.7.

Assemble the board in any order you wish, but make sure that all components are positioned correctly. Use d.i.l. sockets for the i.c.s and, perhaps, for switch S1, although this may be mounted directly on the board if preferred.

The p.c.b. has space for a 16-way header for the l.c.d. Positions 15 and 16 are not normally used, therefore populate a 14-pin header in positions 1-14.

Note that the p.c.b. has an area containing a group of unused holes – these allow you to temporarily mount other components on the board when you are testing your own applications. They can otherwise be ignored

RESOURCES

Software for the programmer and test board, including that for the ISP2032 controller, is available from the *EPE* editorial office on a 3·5 inch disk, order as PIC-Disk 1. See *EPE PCB Service* page for postage charges.

The software is also available free from the *EPE* Web site: **ftp://ftp.epemag.wimborne.co.uk/pub/prog2051**

Additionally, see the accompanying introductory article for information on other resources you need for designing and programming with 8051-based microcontrollers.

The ISP2032 controller is available as a pre-programmed device direct from the author: Colin Meikle, 9 Coldstream Drive, Strathaven, Lanarkshire, ML10 6UD. Make cheques payable to him. The price, inclusive of UK postage is £12.

You can also contact the author via E-mail at **colin.meikle@virgin.net**.

GREENHOUSE CONTROLLER

Next month, in a separate article, we describe a Greenhouse Controller which shows a practical example of an AT89C2051 microcontroller being used in a specific application. You can use your programmer to program it!

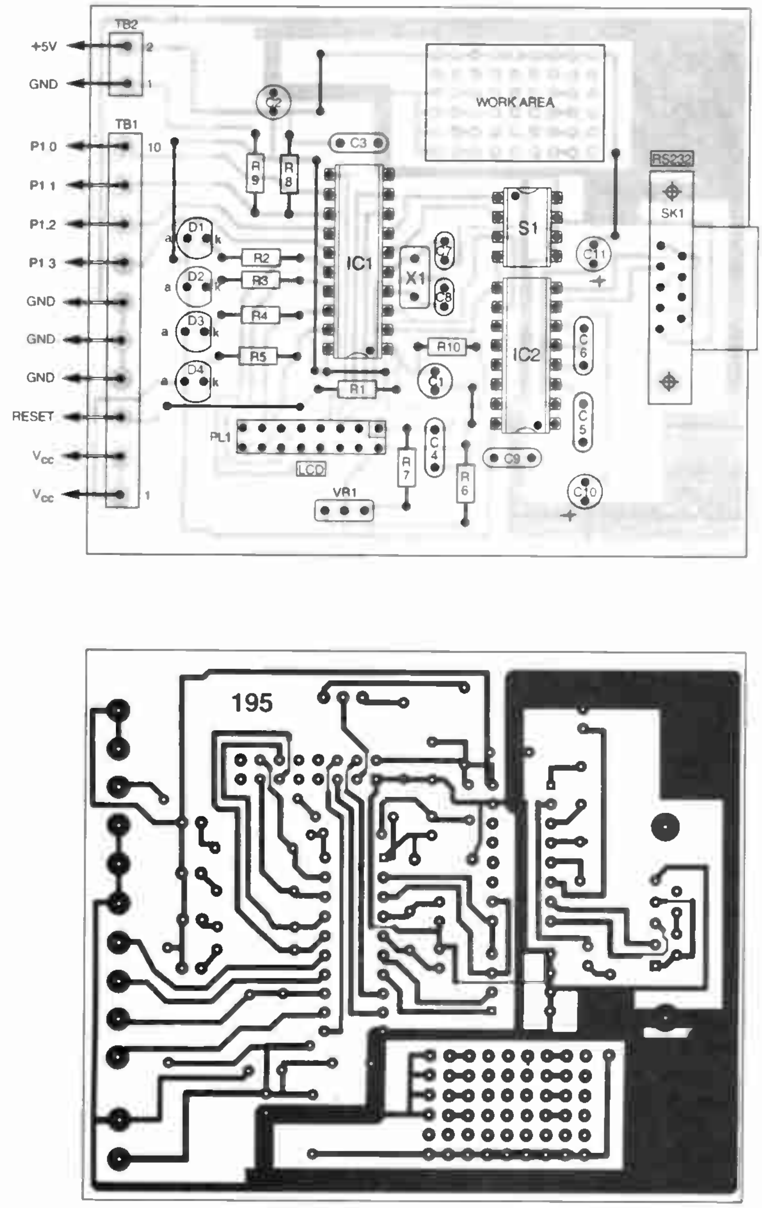
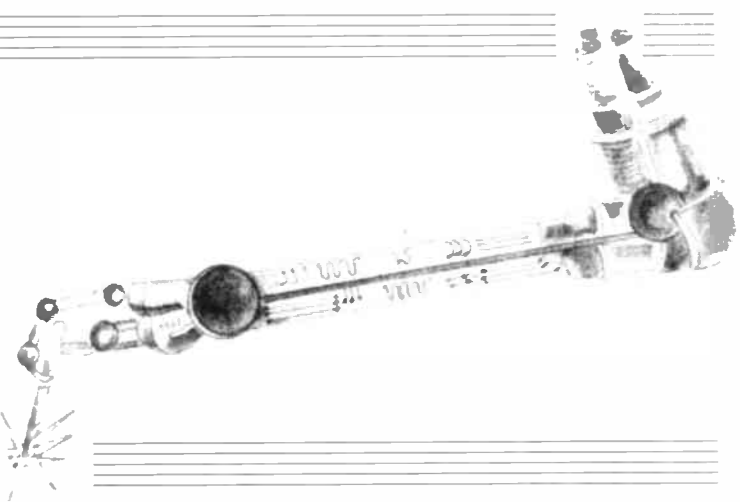


Fig.7. P.C.B. component layout and full size copper foil track master for the Experimental Test Board.

Regular Clinic



CIRCUIT SURGERY

ALAN WINSTANLEY

Co-surgeon Ian Bell rounds off his discussion of switch input multiplexing techniques, and we help America to find some Antex spares. Not to be out-done, a reader in Spain needs some scary-sounding semiconductors, too! More news on the* Teach-In *Micro Lab printer routine and we comment on the hazards of potentially-irritating solder fumes.

Scanning switch matrices

In last month's *Circuit Surgery*, fellow surgeon Ian Bell of the University of Hull investigated a sequential solution to a problem posed by Mr. P. Tanablan of Malaysia (see April '98 issue), namely, how to count the number of switches operated by a class of pupils when they each enter the classroom. We saw previously how a parallel-in serial-out (PISO) shift register formed another solution although it still needs a large number of chips to form a 100-input shift register.

A more practical way, continues Ian, is to connect the switches in a matrix. This has a set of row "wires" and a set of column "wires". The switches are placed at the intersections and each switch shorts a particular row to a particular column when "on". Fig. 1 shows a 3 by 3 switch matrix, it should be easy to see how this would extend to 10 by 10 to cover 100 switches. To "scan" the matrix we could put a logic 1 on each column in turn and look for 1s appearing on the rows. For a keyboard, we need to decode the row and column signals to work out exactly which key was pressed but for our application we only need to know if each switch has been pressed or not.

There is a slight complexity with the scanning in that we cannot drive the other columns to 0 when they do not have the 1 on them. If we did this, then pressing two keys at once would short out the driver's outputs. There are a couple of solutions to this: we can either use diodes to isolate the columns, or use a "scanner" which puts a 1 on one column and a high impedance on the others. In both cases we need pull-down resistors on the rows.

An outline schematic for a matrix-scan based solution to the 100 switch counting problem is shown in Fig.2 (see next page). The column scan is controlled by a BCD counter connected to a CMOS analogue multiplexer/demultiplexer with its single input tied high. The BCD number selects each column wire in turn to be connected to 1, while the others remain isolated. At the end of each column scan (column 9) the counters' terminal count (TC) output is active and enables the row counter to increment by one. The row counter also drives an analogue multiplexer whose output is the key sequence, as in Fig. 4 of May '98 *Circuit Surgery*, which we require. Specifically, if a key is pressed the output of the row multiplexer will be high for the clock cycle during which the corresponding column and row are selected.

The key sequence is used to enable a counter in a similar manner to Fig.5 of last month, again using the opposite clock edge to the scanning. As this circuit scans continuously, rather than once under manual control, we need to automatically reset the counter each complete scan cycle. This could potentially increase the complexity

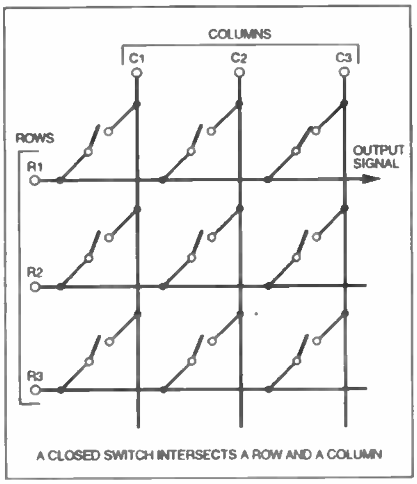


Fig.1. 3 by 3 switch matrix.

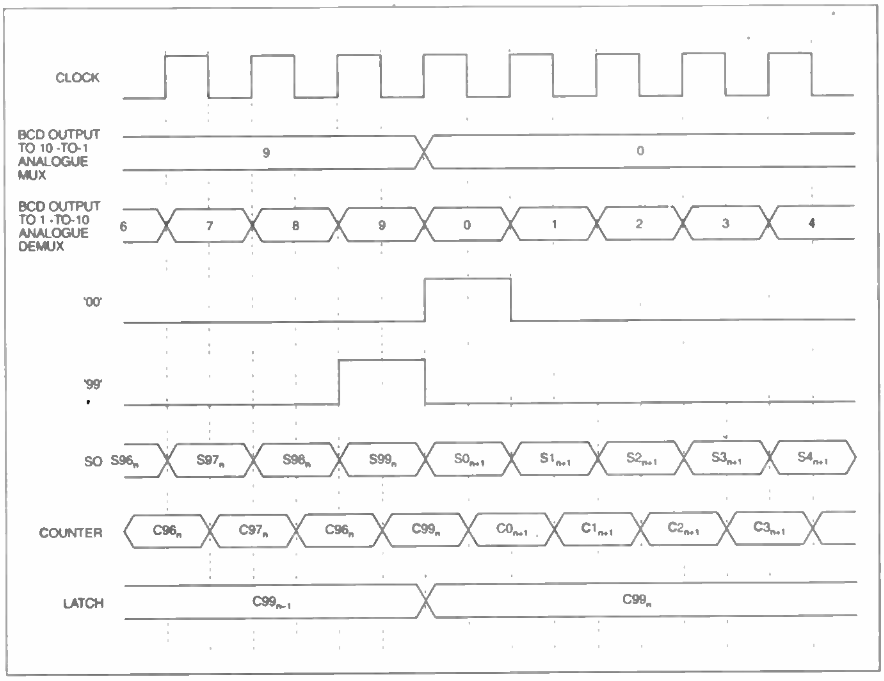


Fig.3. Timing diagram for circuit of Fig.2 (above right).

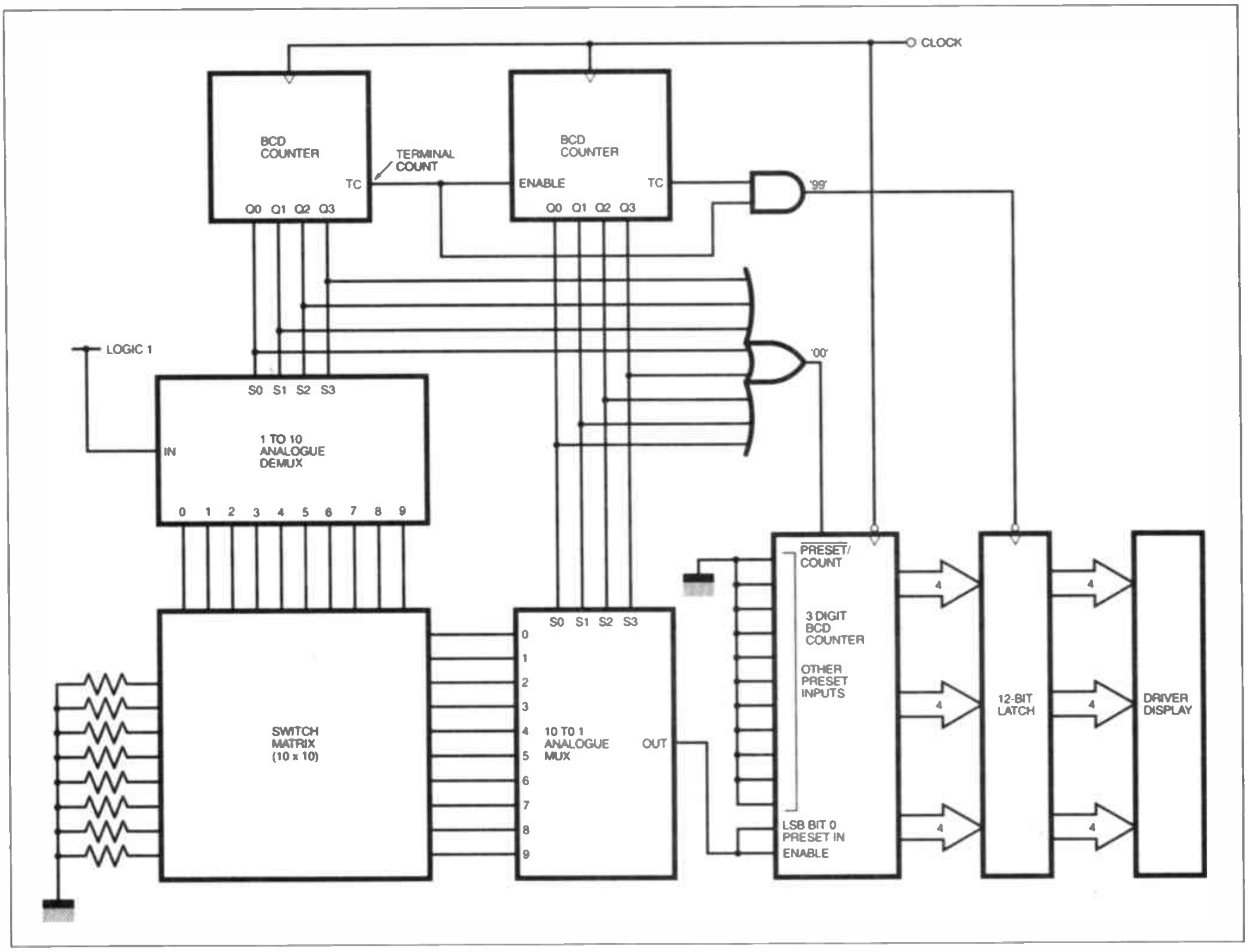


Fig.2. Matrix-scan based system to drive a display.

if we had to stop scanning for one clock cycle, but we use a trick to get round this.

The counter is preset to either 0 or 1 depending on the state of switch 0, which is the first to be scanned. Afterwards the counter is enabled by the key sequence as before. The preset/count (P/C) control of the counter is used to achieve this. Fig.3 is a timing diagram in which S97n, for example, is the value of switch S97 on scan cycle *n*, whilst C97n represents the value of the counter after switch S97 has been processed in scan cycle *n*.

The continuous counting also means that the counter only holds the result for one clock cycle (after key 99 has been scanned), so we must latch the data into a register connected to the display. As the counter is clocked on the negative of the clock we can clock the latch on the positive edge. This signal can be derived from the TC outputs of both counters, as in Fig. 2, assuming that they are glitch-free.

For the benefit of anyone wishing to develop a practical circuit, the multiplexers could be 4067s, and the counters type 40160, and for the latch and display decoder/driver the 4511 could be suitable. In fact, if binary counters were used to drive the scanner multiplexers the system could be expanded to count 256 keys.

Finally, thanks for an interesting question and I hope that this and the previous articles helped explain the practicalities and problems of providing combinational and sequential solutions. *Ian Bell.*

Antex: True Brit

From the USA, ***Mike Porter*** asks by E-mail for help refurbishing his faithful Antex soldering iron:

Alan, I have had an Antex soldering iron for about 15 years which has been a workhorse and very dependable. I am trying to locate a source for tips and a replacement power cord. I did an Internet search on "Antex" and "solder" and came up with your web site. If you have any information, I would greatly appreciate it.

Antex is a famous British-made brand of soldering equipment: I own several. If you want to import from the UK, then several suppliers sell Antex spares but you could try Farnell Components who have an outlet in the United States (try **enquiries@farnellcomponents.com** first) and they may be able to help. Alternatively Antex invite you to contact them directly and they'll be happy to help you:

Antex (Electronics) Ltd., 2, Westbridge Industrial Estate, Tavistock, Devon, PL19 8DE, UK. Tel. + 44 1822 613565. Fax +44 1822 617598.

Internet users, don't forget to check our Basic Soldering Guide which is fast becoming the standard on-line reference, with everyone from schools and colleges to American air conditioning plants bookmarking it! See **http://www.epemag.wimborne.co.uk/solderfaq.htm.**

High Voltage Components

Another sourcing problem, this time from ***Colin Rodker*** who hails from Spain and asks for help tracking down some rather scary-sounding parts:

Alan, can you help me to locate the following components:

ECG 247: 100V 12A power Darlington transistor
ECG 527A: 15kV diode
JAQ-15KMY0103: 0.01F 15kV capacitor
RFC 250H
50kilohm potentiometer.

Unfortunately I can't usually handle component sourcing queries unless they relate to *EPE* projects which are less than five years old. However, suitably intrigued, I set to work. I had never heard of any of those semiconductors but courtesy of the Internet, several sources pointed me to **www.ecgproducts.com**. "ECG" parts are a universal replacement line, ECG being part of Philips Semiconductors. They claim that their master replacement semiconductor guide cross references over 4,000 devices to over 294,000 industry part numbers.

As far as I could see, no ECG-prefixed parts were listed in any of the mainstream catalogues which exist in our own market. The semiconductors sound like TV replacement lines (the 527A is, I'm told, a solid state rectifier for the TV second anode). I couldn't find that capacitor, but the RFC and potentiometer are standard types.

In cases like this, access to an Internet browser and a search engine (e.g. *Alta Vista*) is invaluable so that you can locate distributors (if you don't have access yourself, maybe a friend can help). There are thousands of manufacturers with comprehensive data all available by the web.

My *Net Work* A-Z Index also on the *EPE* web site, contains scores of electronics-related URLs and is a good starting point for a component search. (My thanks to those readers in the USA and UK who helped locate ECG Products. We guessed Colin is in the scary world of fixing TVs, or building a plasma sphere!)

Desoldering Fumes, HASAW and COSHH!

My thanks to correspondent ***Ant. Astley*** who comments on the requirement for desoldering fume extraction: Ant. writes by E-mail:

Apropos the Teach-in '98 *series and the section on soldering and safety; for most of my life I've had a very bad throat and cough problem which is greatly aggravated by solder fumes and may well be caused by a lifetime of soldering. I now use a Weller fume-extraction iron, powered by an old vacuum cleaner, it obviously works well because the condensate in the pipe gets bad enough to block it completely. It's no great encumbrance to work with, and it helps me enormously.*

There are also various fans and filters available but I felt that this was probably the best option. I hope you can find room for this information, a mention by you may help someone avoid a great affliction . . .

Regards, Ant. (GW0AJA).

On anything but the quickest jobs I personally clear the air using a bench-top fume displacer, of the fan-box type containing a charcoal-impregnated filter fronting an extractor fan. I realise these are a luxury item for many hobbyists, but in my view they are essential for anything other than occasional soldering. They are remarkably effective albeit a bit bulky and noisy at close quarters (drowning out the Surgery radio at the same time). A soldering iron tends to smoke for many seconds after being replaced on the stand (while the flux burns off), but my fume extractor fan draws it all in, no problem. More serious or advanced hobbyists should seriously consider purchasing one.

For pin-point effectiveness you probably can't beat an iron-mounted fume extractor tube which Ant. uses. These extract the fumes at the point of emission, but the extractor pumps are costly because they are designed for continuous industrial use. You can easily spend £400+ (US$660) on the relevant kit, which is completely beyond the reach of home users. Improvising with a vacuum cleaner sounds novel, but I think the noise would drive me nuts! (It conjures up quite an image though, Ant!) If anyone could manufacture a small extractor pump station to adapt to a soldering iron tube, costing say £40-50, they would probably be on to a winner.

As a home-brew idea, you could try improvising using, say, a surplus d.c. fan salvaged from a computer power supply, and maybe some aluminium corrugated hose (sold by car spares shops, as it's used on air inlet ducting) can be bent to shape to form a mini duct, positioned near to the area of soldering. You could try to obtain some optional carbon-black impregnated foam to filter the inlet, and just exhaust the fan to atmosphere. At least it will divert the fumes away and help prevent irritation.

Co-incidentally, flicking through a Greenweld Electronics leaflet, I spotted a plastic ABS box with large circular cutouts to accept a 115mm fan. This rang a bell, as it appears to be similar to the housing used to contain my bench-top fume displacer, so you could buy a box and attempt to fit it out with a suitable mains fan, outlet grill and inlet filter, hopefully at a reasonable saving. The box measures 220mm × 150mm × 63mm. Contact Ian at Greenweld Electronics on 01703 236363. (Their ref. X6834; Ian tells me that they have quite a few in stock.)

Danger Warnings

Industrial users have well-defined statutory requirements to safeguard the health of all employees and sub-contractors, as defined in the Health & Safety At Work Act (HASAW), and my experience tells me that HSE Inspectors usually stare daggers at anything which moves, smokes or smells. The chances are that occasional users wouldn't need any form of fume extraction to be fitted, but it would almost certainly be the case for continuous production use.

The Health & Safety Executive produce many free booklets, and your local office will be listed in the phone book. Also check the major catalogues (e.g. the Farnell Industrial Catalogue) for HSE books and information as a starting point before embarking on statutory Risk Assessments, which themselves are mostly common- sense.

Still on the subject of safety at work and all things chemical, if you are managing any form of professional chemical applications in the UK (e.g. applying adhesives or lube, or using aerosols, etchants or fluxes), you will probably also know about the COSHH Regulations – the Control of Substances Hazardous to Health, in respect of which you must, amongst other things, obtain an appropriate Material Safety Data Sheet (MSDS) from all suppliers of classified products. Obtaining one does not constitute a Risk Assessment under HASAW legislation, though.

MicroLab

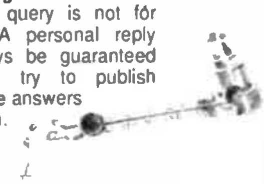
Finally this month, in case you missed my pointer in my *Net Work* Internet column (January 1998), users of the *Teach-In MicroLab* should check the MicroLab web page, where its designer Geoff MacDonald has uploaded the details needed to add a printer. **See www.pan1c.demon.co.uk/Microlab** (that's pan-one-c) for details. All the demonstration routines are there too, together with an updated EPROM listing.

If you're looking for a practical introduction to microprocessors, then our 6502-based training system could be for you. Check the advertisement of Magenta Electronics for kit details, and our book *Teach-In No. 7* is also available from the *Direct Book Service*. This book describes the construction and use of our Mini Lab and Micro Lab and offers a good practical foundation in electronics and microprocessors.

●More readers' queries, circuits and comments next month.

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk.** Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.



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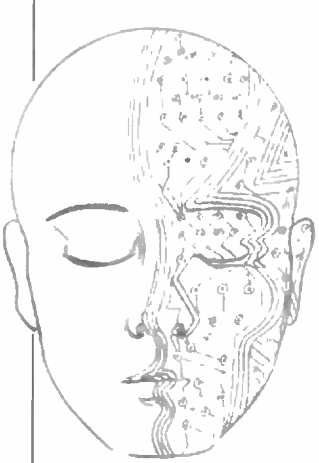
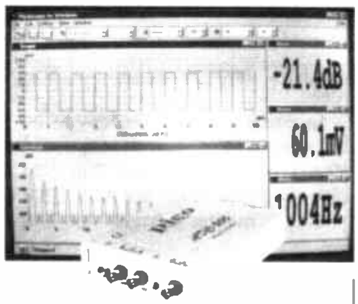


Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. They could earn you some real cash **and a prize!**



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Digital Sinewave Generation – sines of the times

THE outline circuit suggested in Fig. 1a represents an auto-reversing 4 bit counter centred around a 4029 Up-Down counter chip. The carryout signal is used to trigger count reversal via the inverter and D-type flip-flop (a type 4013, for example). The circuit uses an R-2R network which acts as a D/A converter. When clocked, it produces a linear bi-directional "staircase" which can be considered as a triangular waveform. Such waveforms can be rounded off to give a good approximation of a sinewave but there is another approach: the "slope" of the triangular waveform is determined by the clock frequency, so what happens if we alter this in synchronism?

Using a single 4 bit counter, 16 voltage levels are produced, with 15 "steps" or increments. If we increase the clock frequency from count 0 to 8 and then decrease it from count 8 to 15, the waveform produced will be much nearer to a sinewave.

The circuit shown in Fig. 1b uses another 4029, this time configured as a 3 bit auto-reversing up/down counter. Here up/down clocking is controlled in conjunction with AND gate IC3 and an RS flip-flop, such as a type 4043. It is clocked by a CMOS 7555 oscillator via *npn* transistor TR1, which may be any small signal type.

The three outputs of the counter bleed extra current into the timing circuit via the resistors R2 to R4. As a result of this, the clock period shortens in a non-linear fashion until the period after count 7. From count 8 to 15, the period again lengthens. The generator then changes its direction of count to give a mirror image of the waveform and the cycle then repeats.

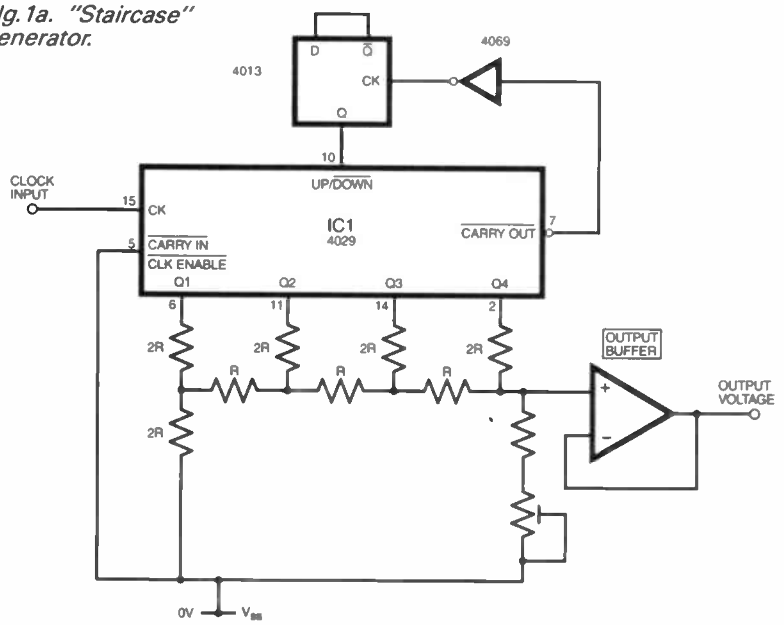
Some suggested resistor values are as follows: R1 – 330k, R2 – 200k, R3 – 75k and R4 – 33k. If we make RB equal to 1k, the periods are not too difficult to calculate and if C1 is 10nF we get the following periods: 0 – 2·07ms, 1 – 0·866ms, 2 – 0·432ms, 3 – 0·334ms, 4 – 0·205ms, 5 – 0·179ms, 6 – 0·147 and 7 – 0·132ms.

This gives us a total of 4·365ms for 90°, and thus a total sine wave period of 17·46ms, and a frequency of 57·27 Hz.

Everything is of course proportional to capacitance so changing the capacitor to 1n2 would produce a period of 2·095ms and a frequency of 477·3Hz. Note the voltage drops across the diodes have been ignored.

A. E. Whittaker, Walton, Stone, Staffs.

Fig. 1a. "Staircase" generator.



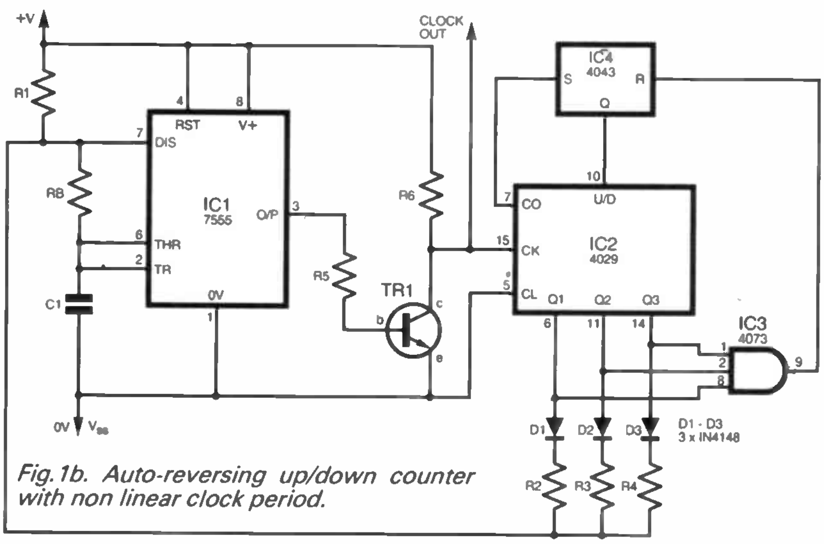


Fig. 1b. Auto-reversing up/down counter with non linear clock period.

A.C. Ripple Active Rectifier – climb those peaks

THE circuit shown in Fig. 2 arose from a need to track down 50Hz hum on an old record deck using just a multimeter. It will take an input signal of any amplitude and measure the peak a.c. on the signal. It is also easy to build.

It has a 270k minimum a.c. input impedance with a near infinite impedance at d.c. This arises from the decoupling circuit at the input, the a.c. current which is passed being developed across the input resistor. The input section can be considered as a simple potential divider arrangement – the capacitor has an impedance (capacitive reactance, Xc) of $1 / (2\pi f C)$, in this case about 16kohm / frequency – thus presenting an almost infinite impedance to d.c., and about 320 ohms to 50Hz, and less to higher frequencies.

This is then precision half-wave rectified (positive-going) by incorporating a diode D1 in the feedback loop; the op.amp IC1a automatically compensates for its built-in voltage drop. The storage capacitor C2 is then charged up to this voltage at a rate determined by the maximum output current of the op.amp.

The capacitor must also be able to discharge down to any new lower a.c. signals. The main route will be through whatever is being used to measure the voltage at the output – in my own case, a d.c. multimeter. The capacitor will discharge almost completely in about 5CR seconds, C being C2 (10µF) and R being the impedance of the multimeter. In the case of an analogue meter this will be quite quick (100kilohms per volt) but around fifty seconds for a 1Mohm digital multimeter. Other routes include leakage through the capacitor itself and through the op.amp.

The final result is a circuit of suitably high input impedance, which is quick to detect the peaks but slow to discharge. It can be tailored to have a slower rise-time by adding a resistor just before C2 capacitor, and quicker to decay by adding a resistor in parallel with it.

The choice of an LF353 dual op.amp for IC1 is not particularly critical as the second op.amp only maintains a virtual ground (quite accurately) for the signals. In this way a split-rail is easily achieved from a single battery. The supply range is that allowed by the op.amp (e.g. 9V to 30V) and the a.c. signal can go typically to within 1V of the supply rails. The circuit can be tested by monitoring some audio from a personal stereo.

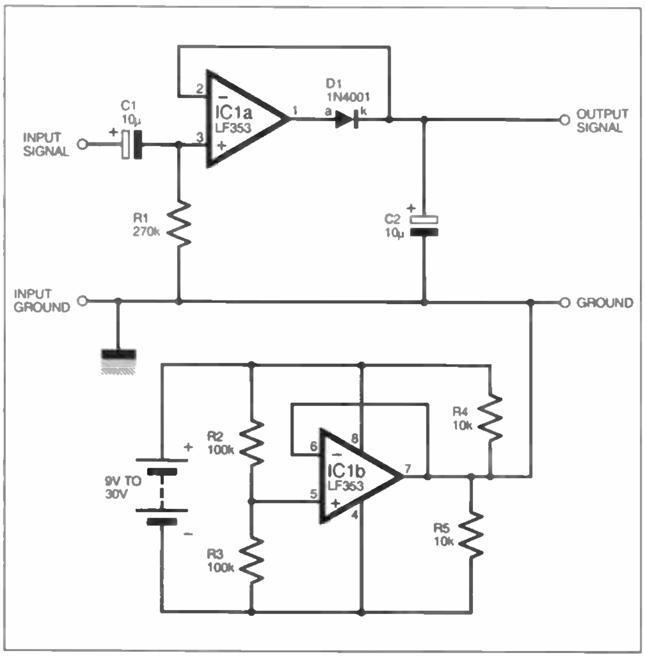


Fig.2. A.C. ripple active rectifier.

Richard Hunt, Diss, Norfolk.

Typewriter Word Counter – no word processor needed

FOR anyone who needs the convenience of a word counter but cannot justify the cost of a word processor or PC, the simple circuit of Fig. 3 will enable an inexpensive l.c.d. counter module (e.g. Maplin FS13P, or similar) to be connected to a traditional manual typewriter. TR1 and TR2 form a bistable latch. Pressing the typewriter's space bar closes S2, turning TR2 and TR3 off. The signal to the counter goes low. Then pressing any letter key closes S1 and turns TR1 off. This holds TR2 and TR3 on, and sends a positive edge to increment the counter reading.

This signal remains high until the word is complete, when the latch is reset by another operation of the space bar. Switch S3 is closed to disable the counter when desired. Note that the space bar needs to be pressed before making a carriage return, so as to separate the last word on the line from the first word on the next.

Since the latch is unaffected by switch bounce or imperfect contact, S1 and S2 can be quite crude in construction. In the original prototype, the circuit board was bolted to the typewriter frame under the carriage and earthed to it. Two lengths of 22 s.w.g. tinned copper wire were soldered to the board and bent to make contact with the space bar and carriage movement levers. The circuit can be powered from the 1.5V battery in the counter module – the current drain is so low that no on/off switch is needed, and this arrangement has proved entirely satisfactory over several years.

N. Jewell, Ilfracombe, Devon.

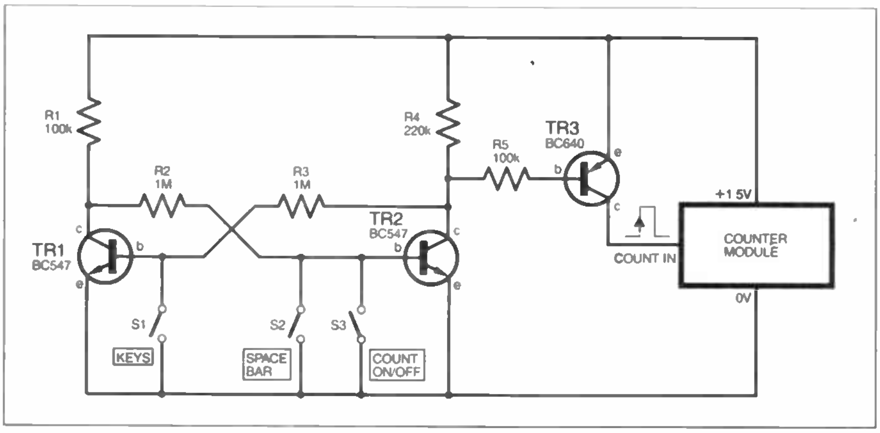
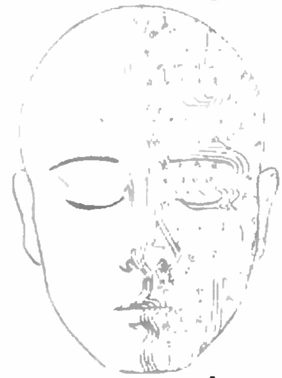


Fig.3. Typewriter word counter circuit.



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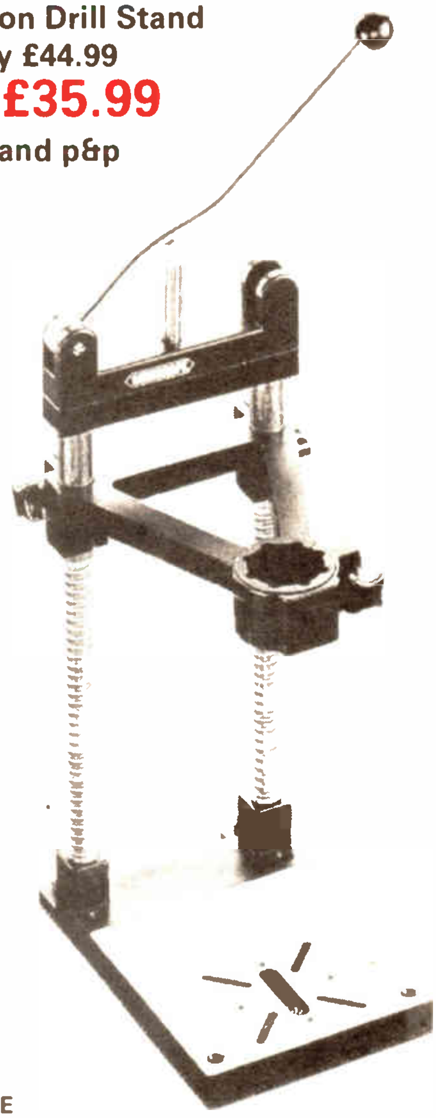

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An Introduction to DIGITAL ELECTRONICS

Ian Bell, Rob Miles, Dr. Tony Wilkinson, Alan Winstanley

TEACH-IN is a series designed to support candidates following City and Guilds (C&G) 726 Information Technology, with reference to the following specific syllabuses: ***7261/301 Introductory Digital Electronics, *726/321 Elementary Digital Electronics, *726/341 Intermediate Digital Electronics.**

Even if you are not undertaking the City and Guilds syllabus, there is much to be learned from *Teach-In*.

Lab Work

Throughout *Teach-In*, attempts are made to involve the student with practical "Lab Work" experiments and demonstrations, and complex mathematics will be avoided unless really necessary – and even then, plenty of help is to hand! We make a point of identifying practical components in special sections of *Teach-In*, so that you will learn to recognise parts.

Part Eight: BUSES AND COUNTERS

WE NOW embark on an in-depth look at the design of counters, but first we investigate a real-world application of bus based data transfer.

Back on the Buses

The word *bus* is often used to refer to the connection between the devices in a digital system, providing connection to the various memory and processor components.

Faversham Wills Household Command System

Lord Faversham Wills has been extremely pleased with his "butler priority system" which was installed in his mansion. (See Part 5 – "Priority Encoders and Majority Gates".)

However, he now wishes to extend the system so that anyone wishing to use the services of the various staff can inform them of the required services in advance. He (or any of the members of his family) can request an ironed copy of *The Times* from the butler, or a soufflé from the cook, by simply pressing the appropriate buttons on the command console in the hall. This is linked to a number of display consoles in the staff quarters around his mansion.

The first thing which had to be decided was the command codes for the system. After a protracted staff meeting to introduce the "Faversham Wills Household Command System" the following standards were established:

The Butler can perform the following functions (function numbers are expressed in binary):

00 Fetch the newspaper (*The Times*)
01 Fetch a cup of tea (Earl Grey with a slice of lemon)
10 Fetch a double whisky (single malt of course)
11 Have the rest of the day off

The Cook can perform the following functions:

00 Make Breakfast
01 Make Lunch
10 Make dinner
11 Have the rest of the day off

The Chauffeur can perform the following functions:

00 Bring the car to the front of the house
01 Wash the car
10 Put the car away for the day
11 Have the rest of the day off (perhaps with Cook)

The staff agreed that these were just the first of many different tasks that they may be asked to perform, but they insisted on no more than 256 different task codes (and a hefty raise each)!

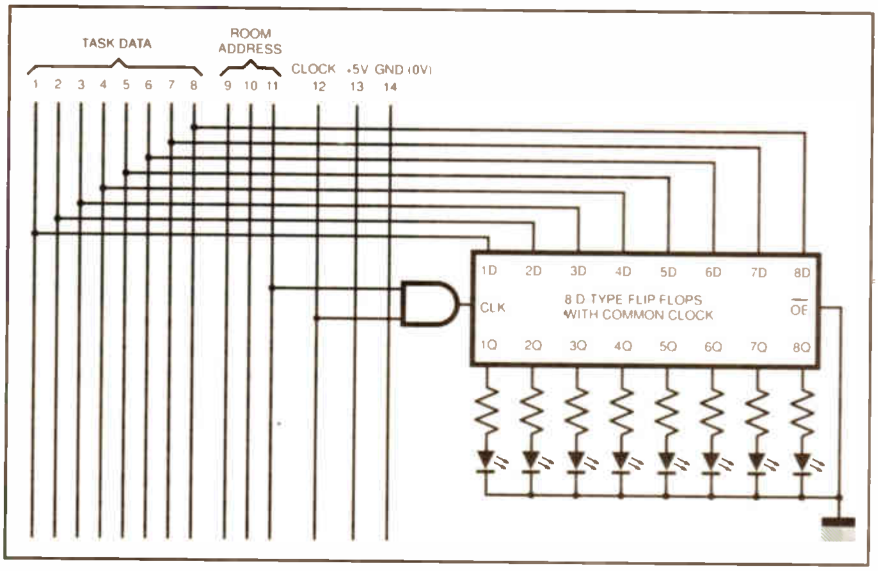


Fig.8.1. Command display circuit diagram.

Chain of Command

Having decided on the code for the tasks to be performed Lord Faversham must now consider how the signals are to be sent to each person. He has in mind sending the commands around his entire residence, and has sensibly purchased a large drum of 20-core wire.

Initially the wire will link the butler's pantry, the kitchen and the garage, but the long term plan is to connect every room (all 60 of them!). What he must now do is decide what signals to send down each core to perform the signalling.

From his knowledge of binary he realises that eight signals must be used to send the code value and so eight wires must be used for this. He also needs signal wires to indicate the recipient of his request and a clock signal to latch the data into the display.

He is starting with three members of staff, so he assigns the signals thus:

8 wires for the data
3 wires to indicate where the message is to go (one each for Butler's Pantry, Kitchen and Garage)
1 clock signal which is used to latch the data into the display
1 ground wire.

To send a command to a particular destination the signal for that room must be asserted. The clock wire is then driven to latch the command into the display device. Fig.8.1 shows the design for a command display station, with Fig.8.2 giving the timing of the signals to display a command.

At this point Lord Faversham Wills realises that he has two problems. First, if he wants to network the entire mansion he doesn't have enough cores in his wire (he would need a wire for each of the 60 rooms)! Second, he has no way of knowing if a particular request has been received and is being acted on.

However, being an inventive chap he reasons thus: "I will never need to send a message simultaneously to more than one member of staff at a time, and so I can use my signal wires to hold a binary bit pattern to indicate where the message is to go".

This means that he can get away with far fewer wires to indicate the message destination (for 64 rooms he would need just six wires). The convention that is to be used in the household is as follows:
01 Butler's Pantry; 10 Kitchen; 11 Garage.

These signals form the "address bus" of our household command system. Each station must respond to a unique address pattern on this bus.

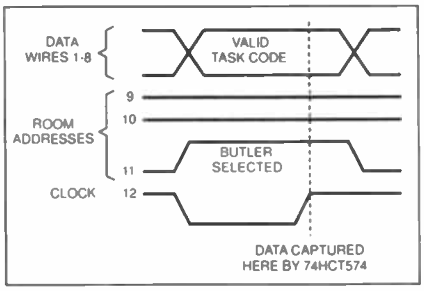


Fig.8.2. Command timing diagram.

To find out the progress of each task Lord Faversham Wills must negotiate the use of extra equipment in each room. The staff must return some sort of progress code, for example:
00 Waiting for a message; 01 Started working on the task; 10 Finished the task; 11 Unable to start the task.

This means that the data bus is being used to send information in two directions, from the command console to the display ("I would like a cup of tea") and from the display to the console ("The kettle is on the hob"). There is no problem with using the data bus in this way, provided that the systems at each end are aware of their role during a data transfer.

To make this *bi-directional* use of the data bus possible we use two synchronised clocks. One of these is used to send the data (Write $\overline{WR}$ clock) and the other allows Lord "F" to receive a reply (Read $\overline{RD}$ clock). Note that the connections to the data bus must also be made using *tri-state* buffers. (See Part 7 for details of tri-state).

House Commands

The cable connections and circuit diagram for the entire Household Command System are given in Fig.8.3 and the timing diagrams for the read and write operations are given in Fig.8.4. The cable connections are as follows:
C1 to C8 bi-directional data bus
C9 to C16 address bus
C17 $\overline{WR}$ - clocked low by Lord F to send a command out
C18 $\overline{RD}$ - clocked low by the recipient to send a reply back
C19 5V power supply
C20 Ground wire

The bottom portion of Fig.8.3 shows the control console with latches to display the Progress code, set the Task code and set the Room address code respectively. The large NAND gate in the centre of the diagram performs the address decoding in a particular station (in this case the Butler's).

Note that we are showing the decoding for station number 1, which means that all the address bits other than the lowest one (C9) must be inverted before being

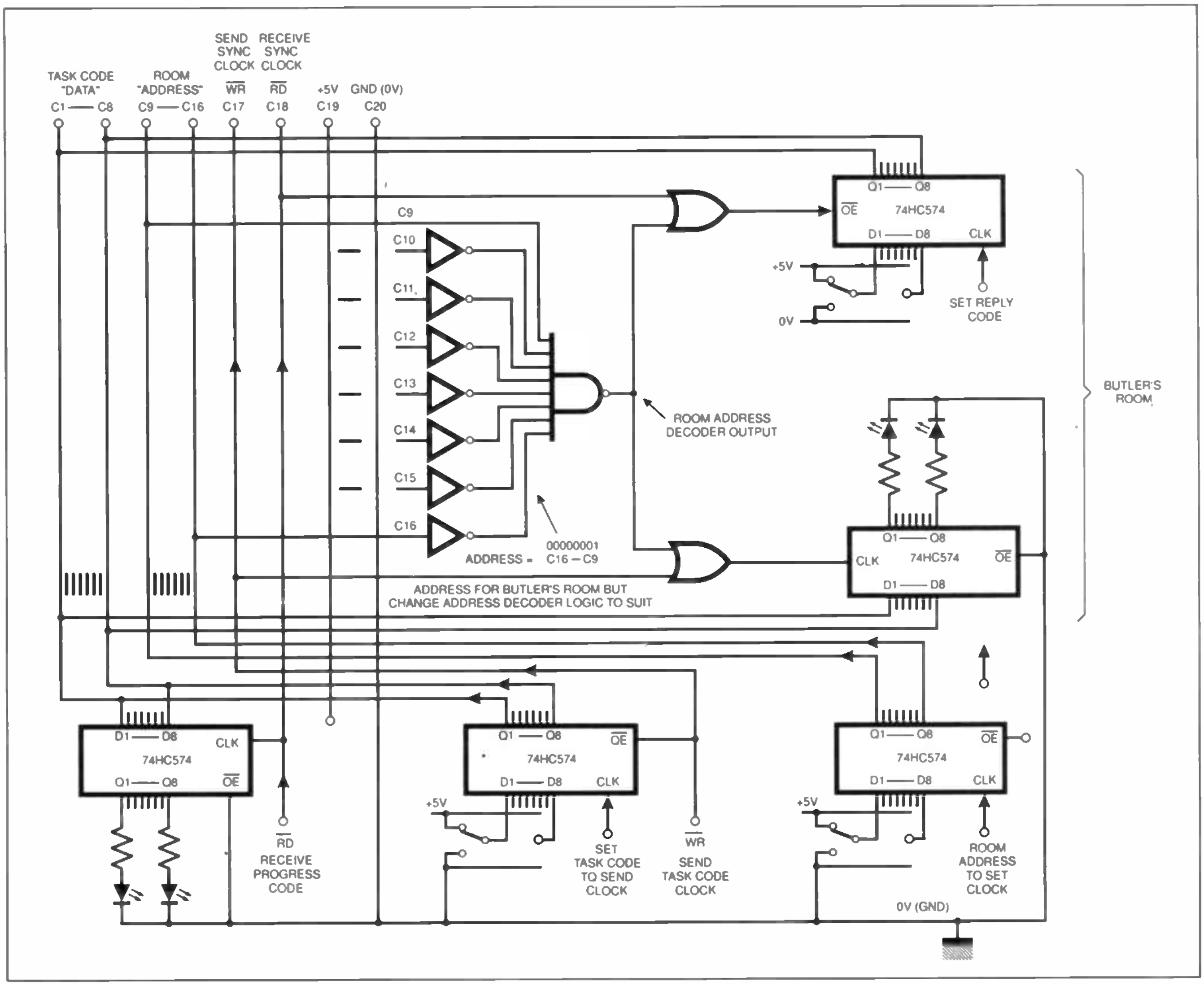


Fig.8.3. Circuit diagram for the Faversham Wills Household Command System.

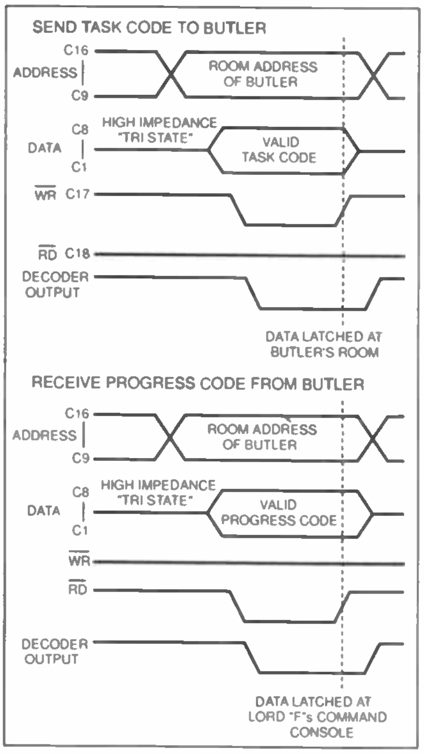


Fig.8.4 Read and Write timing diagrams for the Household Command System.

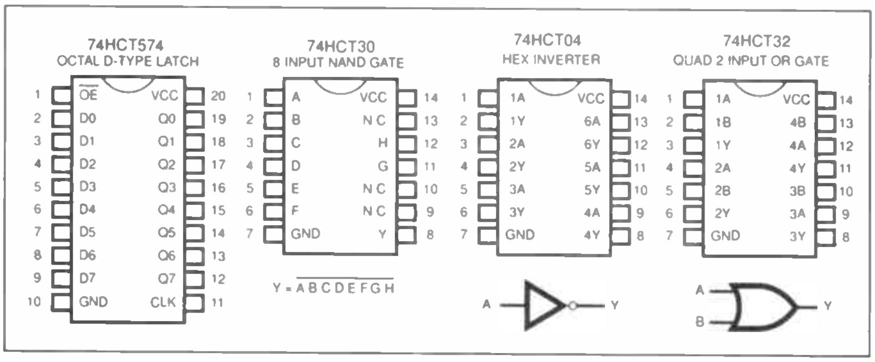


Fig.8.5. Pinout details for the chips used in the Household Command System circuit.

fed into the NAND. The address selection signal is then passed through OR gates with the READ signal to select a latch with the reply information on it and is also ORed with the WRITE signal to select the latch which drives the command display

The diagram does not show the circuit for the de-bounced clock signals (these were described in Part 7), they are used to ensure that the clock signals have nice clean edges.

The pinouts for the chips used in the "Household Command System" are shown in Fig.8.5. We are not actually proposing that you build one (or that anyone in your household would feel disposed to respond to it if you did) but we think that you will find it useful to study the system and convince yourself that it would work!

As a further exercise, you may find it interesting to consider how we could change the system so that room address 0 (not presently allocated) could be used as a "broadcast" address to summon all the staff to a meeting. This would require changes to the address decoding logic in each station.

Real Life Buses

The Faversham Wills Household Command System looks very like the collection of signals which is used inside a computer to transfer data between the various components. The computer itself will store and retrieve data held at particular addresses. To do this it must use a set of data signals (the ***data bus***) and a set of address signals (the ***address bus***).

The number of signals in the data bus determines the size of the packet of *data* which is transferred around the system. The number of signals in the *address* bus determines the number of addressable locations available.

Early microprocessors had 8-bit data buses and 16-bit address buses. The wider your data bus the more data you can process at a time. The wider your address bus, the more memory locations your computer can contain. Computers based upon the Pentium processor have a 64-bit data bus and 32-bit address bus.

One other trick which is played to reduce the number of pins on a microprocessor is to send the data and the address signals down the same signal wires. This is called an *address/data bus*. All that is needed is an extra signal, often called ***ALE*** or ***Address Latch Enable***, which is raised when the processor is generating an address value.

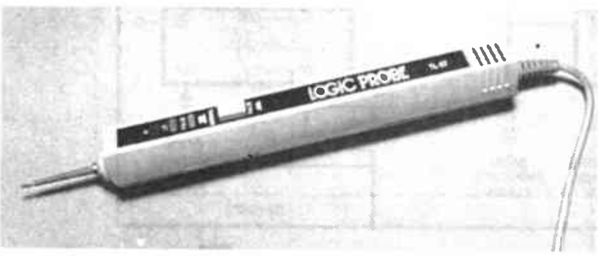
Check Out: Logic Probes

A simple but very useful item of test equipment is the hand-held *Logic Probe*. These are specially designed to work with logic signal voltages, and they enable the user to determine whether a high or low logic signal is being detected. It should be remembered that there are certain voltage limits which define what a "high" and a "low" signal may be, and a logic probe is usually designed to work within these limits and interpret them correctly.

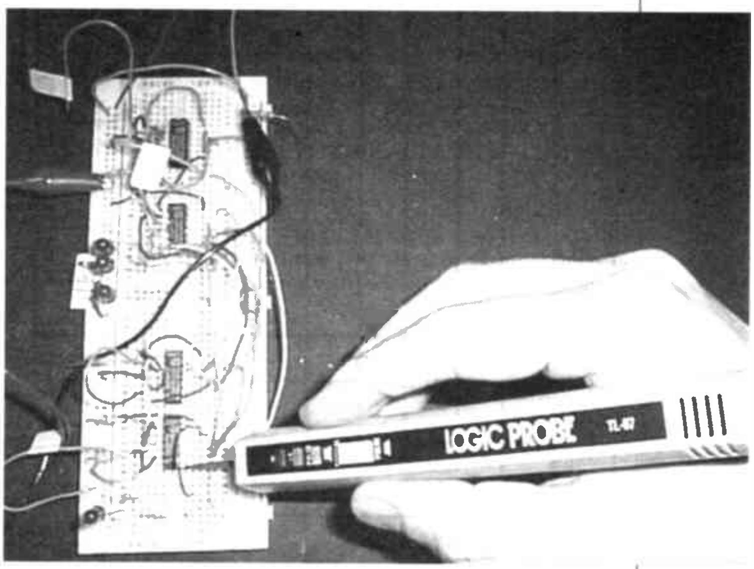
They may be powered from the circuit under test, so a pair of crocodile clips will be provided for the probe to be hooked to a 5V supply on the board. Logic indications can be provided by both an l.e.d. and an audible tone generator within the probe. The simple type in the photographs uses a low-frequency tone for "logic low" and a higher tone for logic high. This is a great way of monitoring logic levels without needing to read and decipher a visual display, although it also indicates high or low via coloured l.e.d.s. More advanced types may interconnect optionally with an oscilloscope display.

Usefully, some logic probes also have a "pulse" mode for detecting "edges", i.e. when a logic signal changes state. This can be indicated by a brief audible beep which is triggered for a preset time. Thus, very brief pulses or glitches can sometimes be detected (see Lab Work 8 for an example) as the logic probe will act as a "pulse stretcher" and generate an audible tone accordingly.

A *Logic Analyser* is a much more expensive item of test equipment which is used for detecting, storing and displaying logic signals. Multi-channel types can monitor several signal streams at once.



A useful piece of test equipment is the Logic Probe. The lead is terminated with a pair of crocodile clips.



Using a logic probe to checkout our Lab Work exercise. The croc. clips are across the supply lines.

Accountable Circuits

In the **Lab Work** at the end of the previous part we asked you to build a pair of 2-bit Binary Counters, one *asynchronous* and the other *synchronous*. We will now consider counting circuits in more detail and highlight the differences between the two circuits you built. However, we will first explore how we can arrive at the designs for these circuits.

A counter circuit is limited in terms of the maximum number it can count to. For straightforward binary counters if we have *n* bits we can count to $2^n - 1$. For example, if n=3 the maximum number is 7. There are a total of 2^n possible values the counter can hold, including 0.

Most digital counters go to 0 after the maximum count, something we are in fact familiar with in everyday life. For example, the odometer in a car returns to zero if you go far enough ("driven round the clock"). Our measurement of time works in a similar way. If it is 22:00 (24 hour clock) and we add 6 hours we get 04:00 not 28:00. In mathematics calculation using numbers which "loop around" like this is called ***modulo arithmetic***.

We can explicitly define the output from a 3-bit binary up counter by writing out all the numbers in sequence as shown in Fig.8.6a.

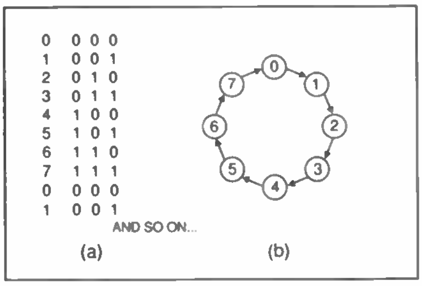


Fig.8.6. A 3-bit binary up counter (a) outputs, (b) state diagram.

We can show the modulo counting more clearly by using a diagram as in Fig.8.6b. Such diagrams are called *state diagrams*. Each circle is a state and represents a certain combination of 1s and 0s in the circuit's memory (i.e. in the flip-flops). The circuit stays in a state until something causes it to change (typically a clock edge) at which time it jumps to the next state as indicated by arrows on the diagram.

Now look at the 3-bit binary count in Fig.8.6a. You should be able to spot some patterns in the bits. For example, whenever a bit changes from 0 to 1 (i.e. a negative edge occurs on that output from the counter) the *next* most significant bit changes state as shown in Fig.8.7

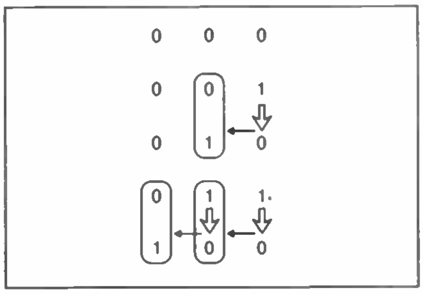


Fig.8.7. A 1→0 transition on one bit causes the next significant bit to toggle.

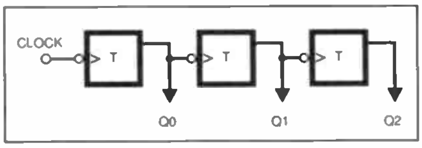


Fig.8.8. Asynchronous 3-bit binary counter using toggle flip-flops.

The least significant bit (LSB) toggles with every clock input (i.e. each time the counter counts up by 1).

This observation can lead us to the idea of connecting the output of one toggle flip-flop to the negative edge clock of the next toggle flip-flop in the counter as in Fig.8.8. We can implement the toggle flip-flop either with a D-type, with D connected to $\overline{Q}$, or with a JK flip-flop, with J=K=1 (see Fig.8.9).

Note that both these circuits give us an *asynchronous* counter in that the counter bits do not all change at the same instant. For the higher bits to change the signals from the lower bits must travel across the circuit.

This is in contrast to a *synchronous* design, in which all the bits would change to the next value at exactly the same time. We will look at synchronous counter designs in a moment, but first here are some asynchronous counter chips.

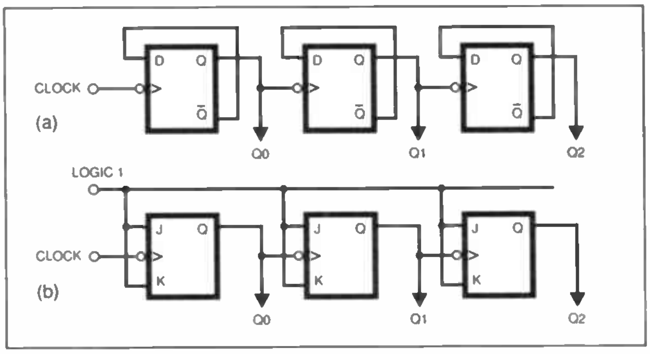


Fig.8.9. Asynchronous 3-bit binary up counters (a) using D-types, (b) using JKs.

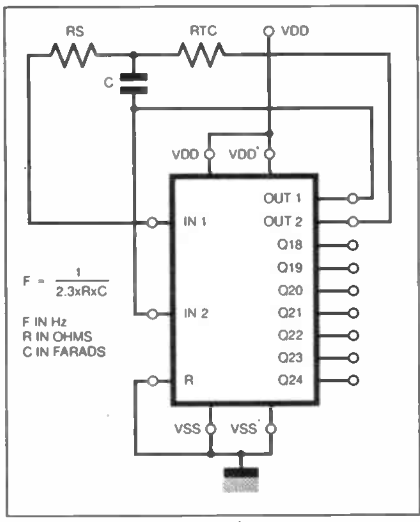


Fig.8.11 (above). Circuit for an RC oscillator circuit using a 4521 frequency divider i.c.

Fig.8.10 (right). Using the 4521 24-stage frequency divider i.c. to produce a crystal oscillator circuit.

Asynchronous Counter Chips and Dividers

The 4020 i.c. is a 14-bit asynchronous counter chip, however the second and third bits are not connected to the chip pins. The 4024 i.c. is a 7-bit asynchronous counter. The 4040 is a 12-bit asynchronous counter.

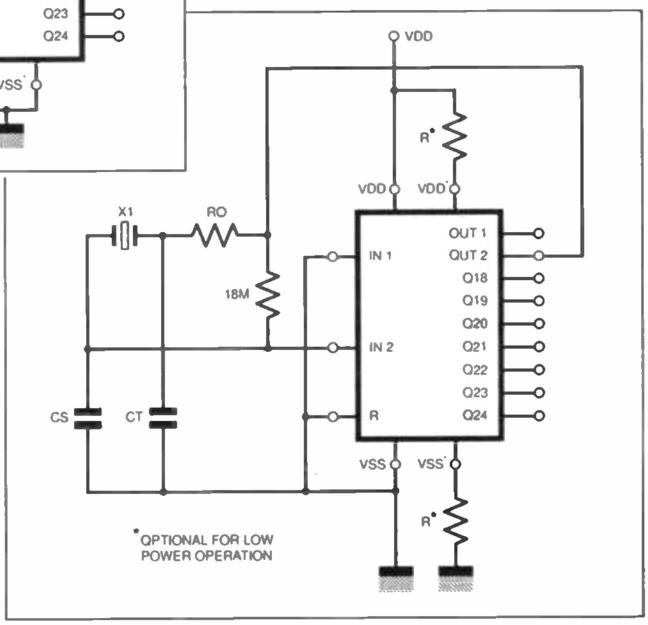
The 4521 is a 24-stage frequency divider in which the 18th to 24th bits are available at the output pins. The maximum division is by 16777216. The 4521 i.c. also features circuitry which enables an *RC* (resistor/capacitor) or crystal oscillator to be built as an input to the counter. These circuits are shown as Fig.8.10 and Fig.8.11.

Note that the formula for the *RC* oscillator (given on Fig.8.11) is approximate and the frequency will vary with temperature and supply voltage. Graphs which give this variation are available in manufacturer's data sheets.

The 74292 i.c. is a 30-stage programmable frequency divider based on Fig.8.8 but with additional logic to control where the clock input is fed into the counter chain. This allows digital selection of a number of different frequency divisions, i.e. we could connect a latch to the division selection pins and electronically set the speed of the output.

Synchronous Counters

If you look again at Fig.8.6a you should be able to see another pattern in the



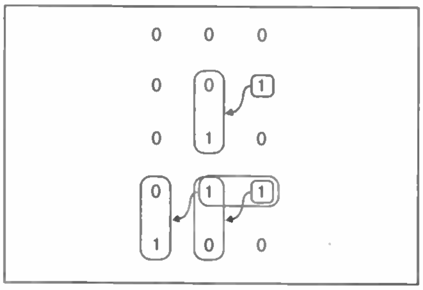


Fig.8.12. When all lesser significant bits are 1 the next significant bit will toggle at the next clock input.

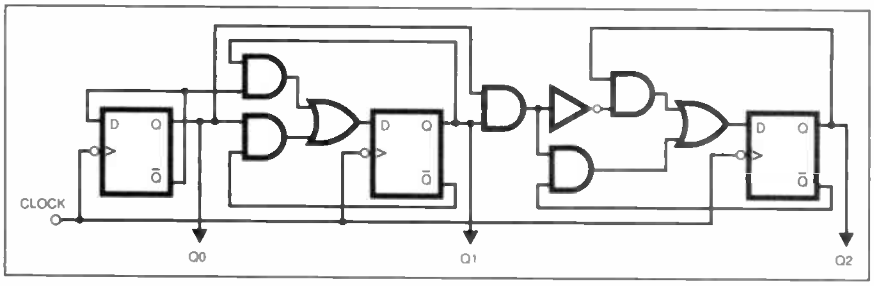


Fig.8.14. A 3-bit binary synchronous up counter using D-type flip-flops.

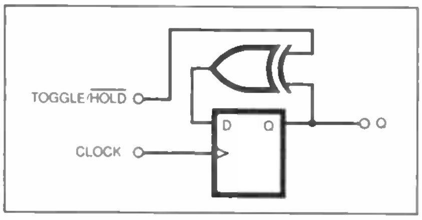


Fig.8.15 (right). Yet another toggle/hold circuit.

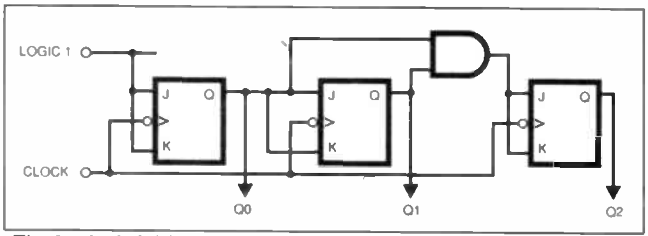


Fig.8.13. A 3-bit synchronous up counter using JK flip-flops.

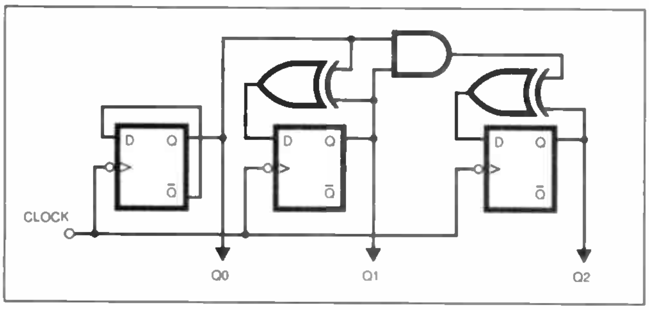


Fig.8.16. Another 3-bit binary synchronous up counter. This one uses the toggle/hold circuit of Fig.8.15

binary sequence. Notice that bit toggles whenever all lesser significant bits are 1 (see Fig.8.12). The least significant bit always toggles.

From this observation we can derive the logic for a synchronous binary up counter. We can use JK flip-flops with J and K connected together to obtain a toggle/$\overline{\text{hold}}$ function.

The first stage always toggles so the J and K of the first flip-flop are connected to logic 1. The second bit (Q1) toggles if the first bit (Q0) is 1 so we connect Q0 to J and K of the second flip-flop.

The third bit (Q2) toggles when both Q0 AND Q1 are 1 so we use an AND gate to obtain this function, connecting its output to the J and K of the third flip-flop. We arrive at the circuit shown in Fig.8.13.

We are not restricted to using JK flip-flops to build our counter, although they conveniently contain the logic to implement the toggle/$\overline{\text{hold}}$ action we need. To use D-types we need to add the toggle/$\overline{\text{hold}}$ logic (see the previous part for further discussion on this topic).

We can use the circuit in Fig.7.14 from Part 7 in place of the JKs to give the counter in Fig.8.14. Note that the first flip-flop simply needs D connecting to $\overline{Q}$ as it always toggles and that we have dropped the inverter connected to flip-flop two as we can use the first flip-flop's $\overline{Q}$ output instead.

In Part 5 (Fig.5.7d) we saw that an XOR gate acted as a controlled inverter (i.e. invert/don't invert the data). We can use this to obtain yet another toggle/$\overline{\text{hold}}$ circuit as shown in Fig.8.15.

Using Fig.8.12 leads to another version of our counter, shown in Fig.8.16.

Many Ways of Counting

You may be wondering why we have bothered showing you so many versions of the same circuit. There are a couple of important points to be made here:

First, the asynchronous and synchronous version are fundamentally different and we will be going into this in more detail in a moment.

Second, the synchronous counters in Fig.8.13, Fig.8.14 and Fig.8.15 are fundamentally the same. In fact, if you work out the Boolean functions for the values loaded onto each Q output after a clock edge you would get the same equation.

If you feel confident, try this out by writing the equations for the D inputs of each flip-flop in Fig.8.14 and Fig.8.16 in terms of the Q outputs of the counter. You will have to manipulate the equations using the rules given in Part 5 to prove that they are the same.

An important point to learn here is that the logic function of a circuit should be seen as a separate issue from the particular way in which it is implemented. The implementation may be important or even very important as it may influence such factors as cost, size, speed and power consumption. However, it may simply be a matter of using what happens to be available (a constraint often imposed on the hobbyist).

While considering our collection of counters it is worth noting that in practice they would probably have Reset inputs to set them to zero. We have not shown these to simplify the diagrams while discussing the count logic. To wire the Reset (for all versions) simply connect all the flip flop's reset inputs together and connect them to the POR (Power On Reset), reset switch or other control signal as required.

Synchronous and Asynchronous

Having seen that the asynchronous counter can be built using flip-flops alone whereas the synchronous one requires additional gates you may be wondering why we have expended so much effort on the synchronous circuit. The difference is a matter of timing. The timing diagram in Fig.8.18 shows the outputs from a 2-bit

Callout – Flip-Flop Timing

Like the gates we described in Part 6, flip-flops have a propagation delay – the time it takes for data to appear on the outputs after the flip-flop is clocked. The delays may be different for the Q and $\overline{Q}$ outputs. For asynchronous inputs, such as resets, separate propagation delays must be specified. As with gates all these delays may be different for high to low and low to high transitions at the output.

In addition to propagation delays and rise and fall times clocked flip flops have two important timing parameters which are not applicable to gates. These are the setup and hold times and are illustrated in Fig.8.17. The data (D, JK, T/H or other synchronous inputs) must be stable (unchanging) for the *setup* time before the clock changes and must remain stable for the *hold* time after the clock changes.

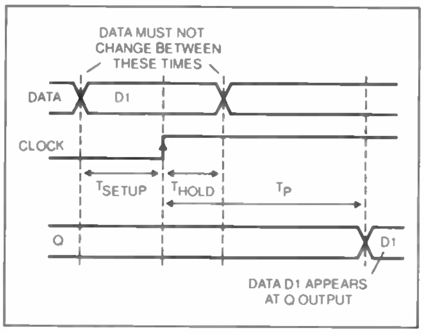


Fig.8.17. Flip-flop setup, hold times and propagation delay.

Check Out: Dip and Rotary Switches

Part One of *Teach-In* introduced a variety of familiar switches which are used on control panels or similar, to enable users to adjust the operation or settings of an apparatus.

One more complex variety of switch is the thumbwheel, in which a thumb-operated rotary dial can be operated to provide a dial-in selection. This could be used to select, say, a frequency setting or other numerical control. They may have a range of features including end-stops (to prevent numbers higher than a particular numeral from being dialled), and decimal, hexadecimal (base 16) or BCD outputs. Some even have 7-segment l.e.d. displays. Thumbwheel switches are snap-in panel-mounted using end cheeks on each side, and several can be banked together.

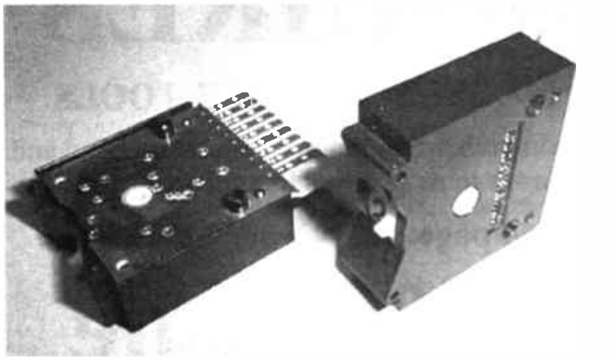
Sometimes it may be necessary to preset some circuit settings on a once-only basis (e.g. during testing or setting-up). This may not necessitate big, panel-mounted switches and something at circuit-board level may be more appropriate, especially if low-level signals are involved.

Dual-in-line package ("d.i.p." or "d.i.l." switches) are used on printed circuit boards as a way of providing tiny switching systems which may only need to be used occasionally or even only once. Examples are seen on computer boards, where the manufacturer presets certain features, and the end-user can alter the settings by operating the relevant combinations of d.i.p. switch.

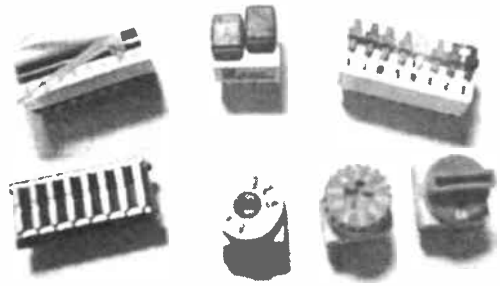
D.I.L. switches are also useful as a neat way of incorporating switching systems into a breadboard circuit. The switches are usually made with the same "pitch" (matrix dimensions) as an ordinary dual-in-line integrated circuit so they will insert directly into a breadboard or p.c.b. with no external wiring being needed.

Choose from several styles: slider, lever, piano key and rotary types are common, with slide-over contacts being the standard. Some d.i.l. switch ranges include BCD or hexadecimal (base 16) output patterns, which can be useful in logic circuits. Sliding types are colour coded to help identify the switch levers.

"Programmable d.i.l. headers" are used where you want to hard wire a contact setting on a once-only basis. These are dual-in-line packages featuring internal wires that can be snipped with wire cutters. These could be used for entering codes or circuit settings customised for a particular application and the header is then plugged into a board as a small programmable module.



A typical "thumbwheel" switch. Using end cheeks on each side, they can be banked together.



A selection of d.i.l. and rotary p.c.b. mounting switches.

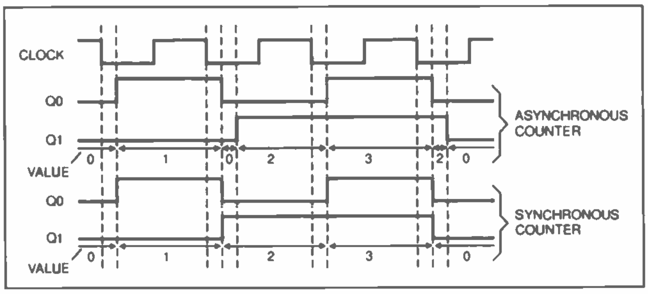


Fig.8.18. Timing diagram for asynchronous and synchronous counters.

asynchronous and a synchronous binary up counter.

Both circuits are negative edge clocked. Note that the circuit in Fig.8.8, the asynchronous counter must use negative edge triggered flip-flops but the circuit in Fig.8.13, Fig.8.14 and Fig.8.16 could use either edge triggers, as long as all their flip-flops were the same type.

The nature of the asynchronous counter is such that changes "ripple" through from the clock input, stage by stage towards the most significant bit. Each change is delayed by the *propagation delay* of the flip-flop with respect to the previous bit.

The unfortunate consequence of this, apart from the slow reaction time of large asynchronous counters, is that the outputs go through a series of indeterminate values before settling down to the correct state. This is shown in Fig.8.18 where it can be seen that an extra "00" is output as the counter changes from 01 to 10 (1 to 2) and an extra "10" as it changes from 11 to 00 (3 to 0).

This timing diagram shows the outputs of the synchronous counter changing at exactly the same time. In practice there would be some difference due to the *variation* in propagation delay between the flip-flops – but this would normally be considerably smaller than the propagation delay itself. If all the flip-flops are of the same design, on the same chip, at the same temperature and have the same load the variation should be very small.

The problem with the relatively long duration of the unwanted outputs from the asynchronous counter is that they may cause false triggering of other circuits, particularly if these circuits are clocked from gates connected to the counter's outputs. This is illustrated in *Lab Work*.

Full synchronous circuits may require more gates than simple asynchronous versions but do not suffer from problems due to intermediate outputs from circuits as they change state. The clock speed is chosen so that the whole circuit has time to settle down before the next active clock edge arrives.

The ripple effect in large asynchronous counters makes them relatively slow, however asynchronous logic is not always slower than synchronous logic. It is possible to design large asynchronous circuits which always start the next activity as soon as the current one is finished. Unlike sequential circuits they do not have to wait for the clock. This provides high speed operation as there is no "idle time".

Another advantage of asynchronous circuits is that their flip-flops only get clocked when absolutely necessary (i.e. when they have to change state) whereas in synchronous circuits they will get clocked much more frequently. This means that asynchronous circuits can be designed which consume less power than their synchronous equivalents.

Advanced asynchronous design like this is a specialist subject well beyond the scope of this series. Such circuits are designed to not only produce the correct functional outputs but also to indicate when they have finished processing and have the output ready. This approach overcomes the intermediate value problem we discussed for the simple asynchronous counter.

Despite its faults the asynchronous counter is a useful circuit, particularly for dividing high frequencies, as we described earlier.

In the next *Teach-In* we continue our look at the ups and downs of counters. Now have a look at the **Lab Work** section and build up the Counter/Monitor demonstration circuit.

The *Teach-In* writers are delighted to receive your comments, feedback and queries. You can write to us at *Teach-In* c/o the Editorial address, or E-mail **Teach_In98epemag.demon.co.uk.**

LAB WORK 8

Objectives: To demonstrate the difference between a synchronous and asynchronous counter. Construct a simple counter/monitor circuit to detect glitches in the count sequence of an asynchronous counter.

IN THE previous *Lab Work*, we constructed a simple 2-bit counter, introducing both asynchronous and synchronous types. The asynchronous counter of Lab Work 7.4 has the clock input of a flip-flop driven by the output of a preceding latch. However the synchronous counter (Lab 7.5), has both clocks driven simultaneously by the same clock signal.

When observing the bit pattern on the counter's display l.e.d.s (see Lab Work 7, Figs. 7.27 and 7.28), there seems to be nothing to distinguish between the two. In Lab Work 8, it is necessary to construct both types of counter once again, with the addition of a counter/monitor to highlight the difference between synchronous and asynchronous counters. We think you will be quite surprised when you see glitches in action!

Lab 8.1. A Clock-Cycle Monitor

A familiar-looking 2-bit Synchronous Counter centred around a 74HCT73 is shown in Fig.8.19. The count is displayed by two l.e.d.s, D1 and D2 (most significant and least significant bits), driven by inverter/buffers as usual. The counter's clock input (COUNT CLK) is "active low" so every negative-going clock edge advances the counter by one, and the two l.e.d.s will display the count. In theory, this should happen every time the COUNT CLK l.e.d. D3 extinguishes, to indicate a negative clock edge.

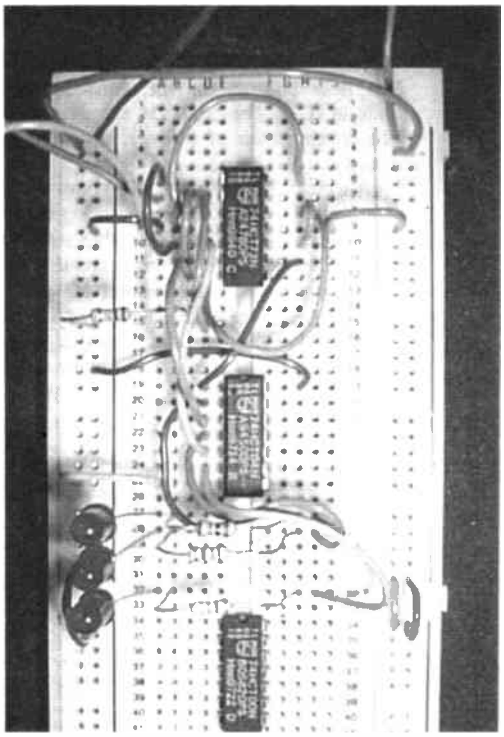
Breadboard

Assemble this Counter/Monitor using a 74HCT73 and 74HCT04 (hex inverter) on your solderless breadboard: for pinouts see next page. Position the chips at one end of the breadboard to leave plenty of space for the following Labs. Observe anti-static precautions as usual and pay close attention to the power supply connections for both chips.

Before powering up this circuit it is a good idea to temporarily pull-up any unused hex inverter inputs (pins 9, 11, 13 of IC2) with a 100k resistor, although all the inverters will be used in the next Labs. Temporarily pull-up the COUNT CLK junction with a separate resistor too.

Quick Check

You can briefly check the operation by powering the circuit. The l.e.d.s will illuminate, and the display will change when negative clock signals are applied, although because the clock isn't debounced, the counter display will be erratic. Now power down and remove any temporary pull-up resistors. The terminal labelled COUNT CLK will next be used as a "probe input" for the following experiments. *Remember that when the display on D1 and D2 advances, this signifies that a negative clock signal has been received by this counter.*



Assemble the Counter/Monitor on the breadboard first.

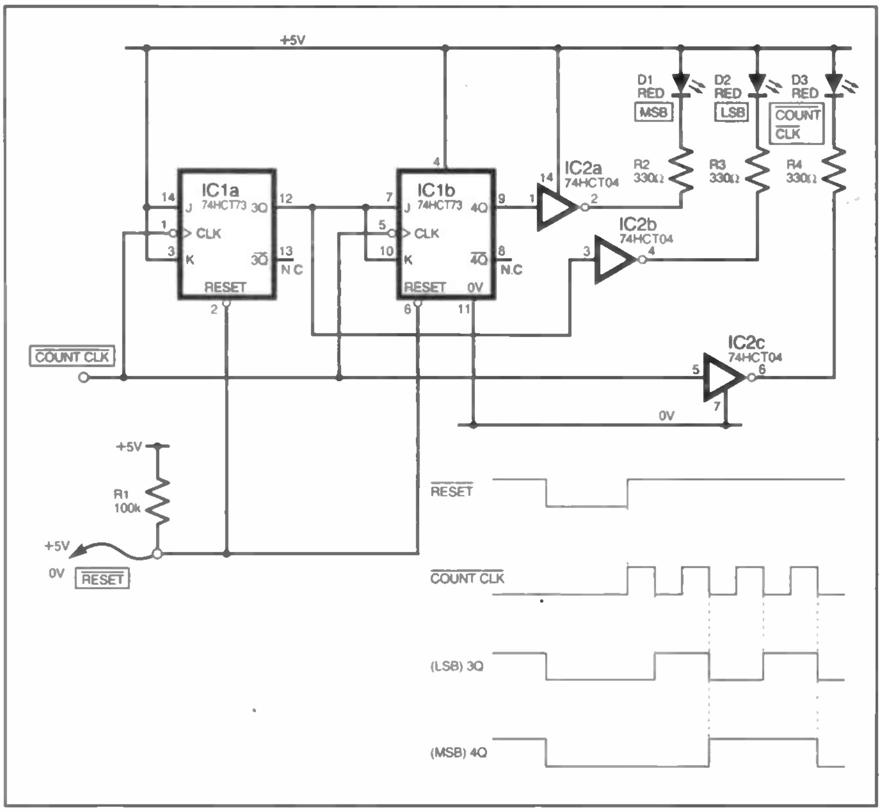


Fig.8.19. Construct this 2-bit Synchronous Counter to count clock pulses. Use RESET first, before commencing counting, and link COUNT CLK to the next two demonstrations.

— You Will Need —

Resistors
- 330 ohm (4 off)
- 100k (5 off)
- All 0·25W 5% carbon film

Semiconductors
- 74HCT73 dual JK flip-flop (2 off)
- 74HCT04 hex inverter
- 74HCT00 quad dual-input NAND

Miscellaneous
- red l.e.d. (4 off); solderless breadboard; interconnecting wire; 5V d.c. regulated supply; optional logic probe

• It's a good idea to label two flying leads as $\overline{RST}$ and C.CLK to help identify them later. Perhaps place a suitable small label next to the l.e.d.s too.

Lab 8.2 Asynchronous Counter Glitch

A second dual flip-flop (IC4) wired as an Asynchronous 2-bit Counter (see Lab Work 7.4) is shown in Fig.8.20. A debounced clock signal is generated by two NAND gates, IC3a and IC3b which form a bistable latch. The clock output also drives a fourth l.e.d. D4, labelled CLOCK. This indicates when IC4 has been clocked. (We found it handy to mark relevant wires and indicators with small adhesive labels.)

Instead of monitoring this counter's output sequence with two l.e.d.s as in Lab 8.19, both the 1Q and 2Q outputs have been ANDed together, using two spare inverters (IC2d and IC2e) and IC3c, a spare NAND gate. Now, whenever the 2-bit output from the counter is "00", this will generate a logic 0 clock signal at IC3c output, and it is ***this*** detected signal that will be counted by the monitor circuit of Lab 8.19.

Construct this 2-bit asynchronous counter and clock circuit on your breadboard. As before, a flying lead is used as the clock, and this toggles between R8 and R9 to advance the counter formed by IC4. (Note R6 is a pull-up for the unused NAND gate in IC3). The l.e.d. D4 simply signifies the transmission of a clock signal to IC4 counter.

An ideal 2-bit counter will count 00, 01, 10, and 11 before starting over again (see Lab Work 7.4). We are detecting and using its ANDed output (IC3c) to generate a logic 0 signal whenever the counter 1Q and 2Q outputs generates 00. It obviously takes four clock cycles to count this sequence, so you would expect to see "00" being generated once every four clock counts. It is l.e.d. D3 which denotes a logic "00" being generated.

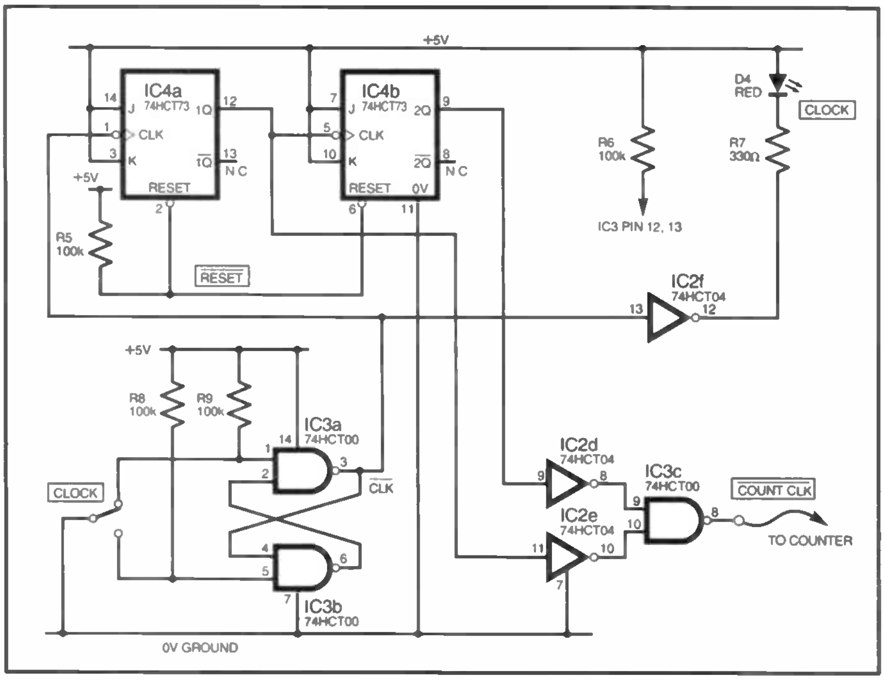


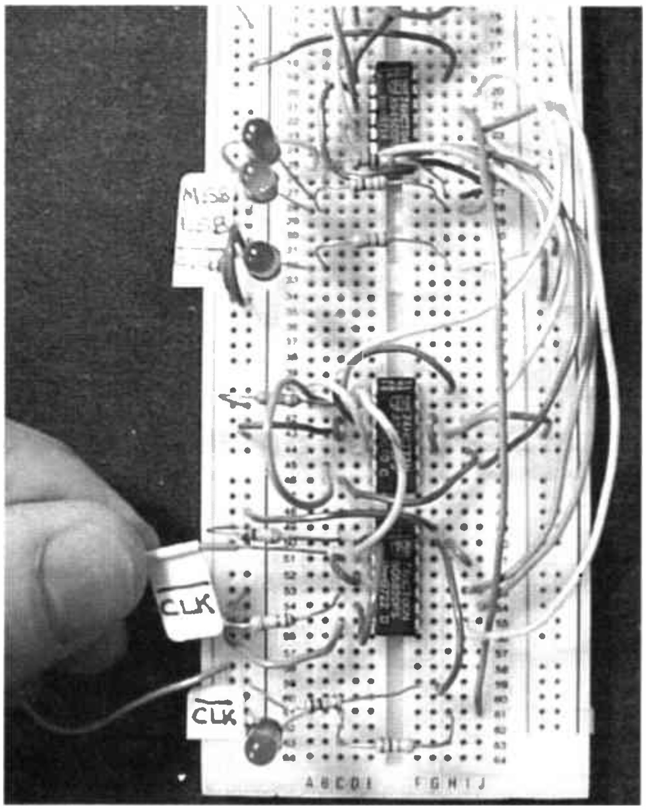
Fig.8.20. Assemble this Asynchronous 2-bit Counter, and link the $\overline{\text{Count CLK}}$ output to the clock counter of Fig.8.19.

After assembling and checking, power up the circuit and apply a reset signal to IC1 using the $\overline{RST}$ flying lead. By toggling the clock wire between R8 and R9, the CLOCK l.e.d. D4 should alternate. The display of the counter/monitor of IC1 should advance every time D3 extinguishes (negative clock edge). Try to observe the operation of the counter display every time you clock it.

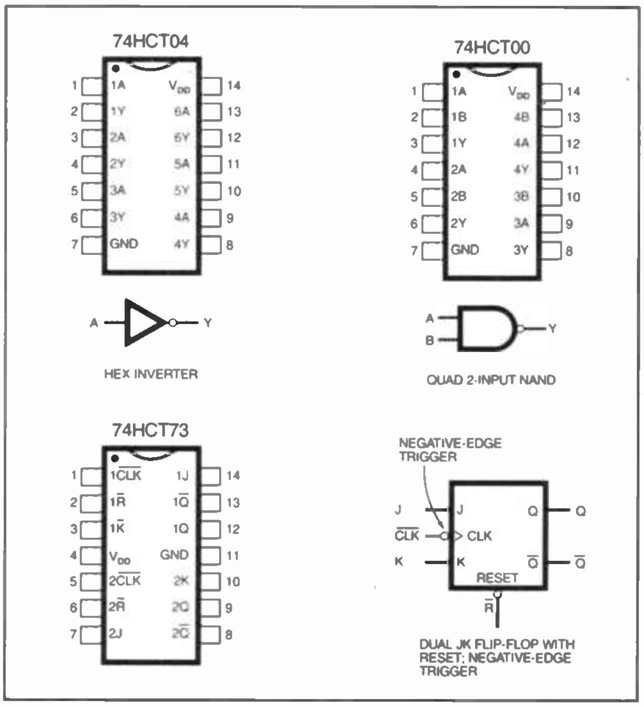
The drawback with this circuit is subtle. In fact there are two $\overline{\text{COUNT CLK}}$ pulses observed for every four clock cycles, so an extra "00" is being generated by the asynchronous counter. The only way you will observe this is to watch the counter display of D1/D2, whilst applying clock signals. Hopefully, you should see that the l.e.d. display will suddenly advance one count, even though the $\overline{\text{COUNT CLK}}$ l.e.d. remains unchanged: remember the counter/monitor will only advance when a "00" is detected.

• The asynchronous counter generates a glitch (an extra "00") during its counting sequence which can be so fast that the eye won't spot this on the $\overline{\text{COUNT CLK}}$ l.e.d. It may seem to be continuously illuminated but the counter will suddenly advance by one for no apparent reason. Even an oscilloscope may not detect it. But a logic circuit is fast enough to react to it!

• A simple ***Logic Probe*** (see main tutorial check out panels) can be used to detect pulses, which may help to reveal the



Building the synchronous/asynchronous counters, labelling the l.e.d.s and "toggling" the clock.



Pinout details for the MOS logic i.c.s used in the counter circuits.

presence of glitches in simple circuits. Depending on the type of probe, placing one on the COUNT CLK signal (pin 8, IC3c) will generate an audible signal on the probe whenever an "edge" (change of logic level) is detected – even if the signal is so fast that the COUNT CLK l.e.d. does not seem to change.

This could help you to determine why the l.e.d. display advances. The answer is that a brief glitch is being generated, which is too fast to be noticed on the l.e.d. D3 by the human eye.

Lab 8.3 Synchronous Counter

The minor modifications needed to the previous Lab to produce a Synchronous Counter are shown in Fig.8.21. Alter the interwiring of IC4, so that both clocks are

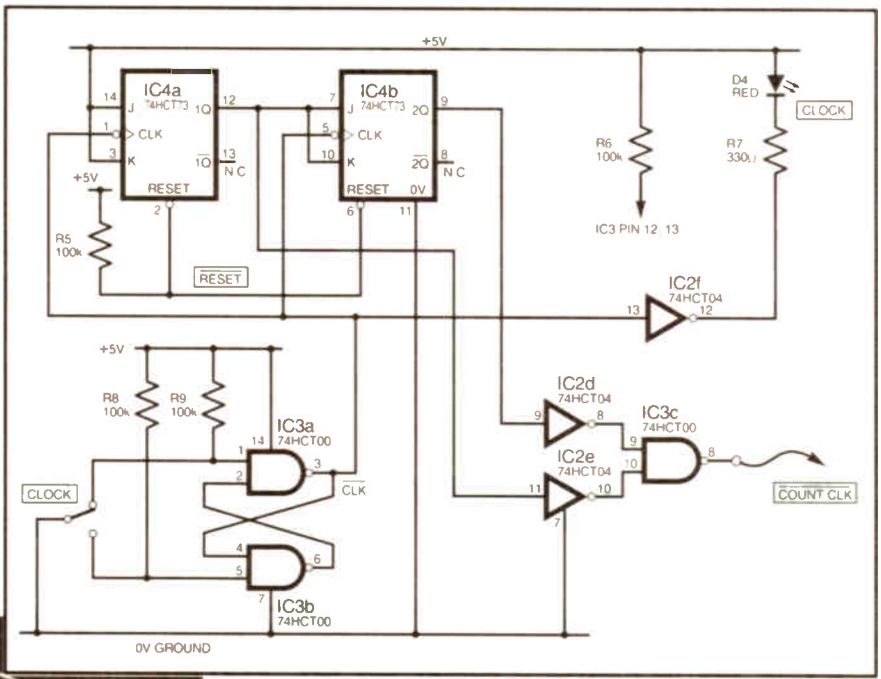
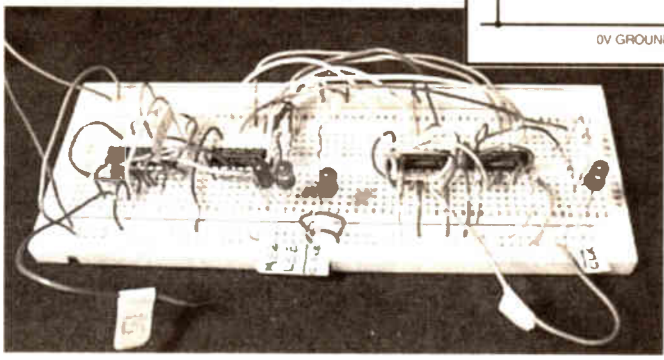


Fig.8.21. Modify the connections between IC4a and IC4b to form a Synchronous 2-bit Counter.

Completed Counter demo module.



wired together, and IC4b J and K inputs are connected to 1Q, the output of the first latch.

It should now be seen that for every clock signal applied, there will be only one COUNT CLK pulse for every four CLK pulses. Every time the COUNT CLK l.e.d. extinguishes, the binary count advances by one and no glitch is generated in the counting pattern.

In **Lab Work 9:** We return to investigate digital counters and their applications.

Constructional Project

REACTION TIMER

PAUL HACKETT

PIC your time to test your reactions. Will provide hours of fun!

EVERYONE likes to believe they have quick reactions; some would even argue their reactions are still quick even after a drink or two. With this reaction timer all will be revealed, but be warned! Trying to improve your reaction time can be very addictive, especially when with a group of people competing against each other.

COLOURFUL REACTION

The Reaction Timer has a single pushswitch for both initiating the test and measuring the reaction time. The first press of the switch initiates the test, and this is indicated by a tri-colour light emitting diode (l.e.d.) changing from red to green.

After a random delay period the l.e.d. changes back from green to red. For a quick reaction time to be recorded, the switch should be pressed again as soon as possible after the l.e.d. returns to red.

After the switch has been pressed a second time, the reaction time is displayed on a four-digit, 7-segment, l.e.d. display. The measurement is shown in milliseconds (ms) with a resolution of 0·1ms. If the switch is not pressed within 999·9ms (almost one second), the message "HELP" is displayed.

REACTION TIME

Reaction time is the time it takes to react to something, whether it be a sound, pain, or in this case, an l.e.d. changing from green to red. In more precise terms, it is the *elapsed* time from an event to the point at which a decision is made to act. It should not be confused with response time, which is what the Reaction Timer described in this article actually measures. Since most people talk about their reactions, and not their responses, it seemed more appropriate to use the name Reaction Timer rather than Response Timer.

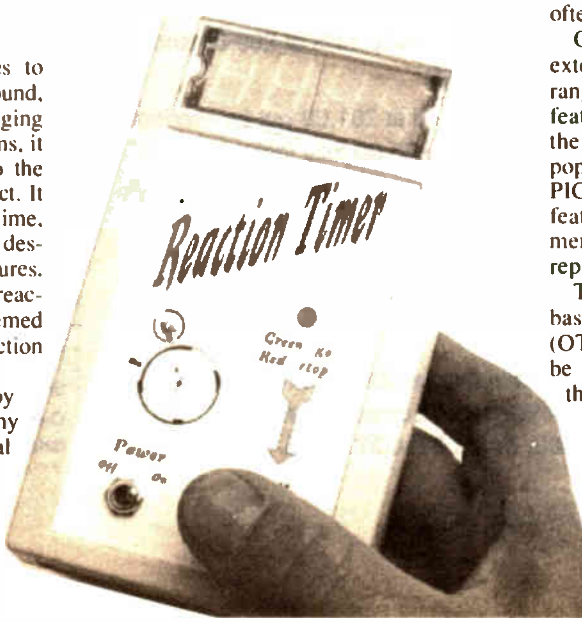
The Reaction Timer has been used by numerous people for fun, but not for any serious research. However, the general findings are that response times do vary between individuals and improve with practice. The average response time is around 200ms and the fastest around 150ms.

From those intending to do serious investigations using the Reaction Timer, the author would be interested to learn of the results. See the *Shoptalk* page for address details of where to send them – E-mail preferable.

To understand response time and the factors that may affect it, it is best to consider the process of what actually happens. The process can be broken down into a sequence of events, all of which take time to complete.

The first is when the l.e.d. changes colour from green to red, and the eye has to detect it. The signal from the eye is then transmitted to the brain. Only when it reaches the brain can the thinking process begin.

Finally, a decision to act is made – the reaction – and a signal is sent from the brain to the muscles in the hand. The muscles then respond to the signal and the button is at last pressed. The microcontroller then does its bit and displays the response time on the display.



Some of the known factors that influence response time are; age, fatigue, alcohol, and drugs. It should also be pointed out that the response time for each of our senses is different. There is no reason why the Reaction Timer could not be modified to produce sound to investigate this.

CIRCUIT DETAILS

The full circuit diagram for the Reaction Timer is shown in Fig.1. The main components are the PIC microcontroller IC1 and the 7-segment displays, X2 and X3.

The design is based on the PIC16C55-XT from Microchip. This device was one of the first of a family of low cost microcontrollers that offered designers the ability to put intelligence into products where cost had once dictated otherwise. Whilst the PIC16C55 has its limitations being a low-end microcontroller, the things that can be achieved with it are often outstanding.

Over the years Microchip has added extensively to its microcontroller product range, many devices offering increased features at costs not much more than the PIC16C55. One device that is very popular with the home enthusiast is the PIC16C84, not necessarily because of its features, but the fact that its program memory is EEPROM. This allows it to be reprogrammed many times.

The PIC16C55 on the other hand is basically a One Time Programmable (OTP) part that means it can only be programmed once. However, what the PIC16C55 does have over the PIC16C84 is an extra port of I/O (input/output) lines, and this is what is required for the Reaction Timer project.

OSCILLATOR CONFIGURATION

For most designs the *RC* oscillator configuration is quite often satisfactory, and also the cheapest solution. However, the Reaction Timer is intended to measure time, relying totally on the frequency accuracy of the oscillator to do this. This therefore rules out the low cost *RC* option.

If the displayed times are to mean anything, then the use of a crystal or ceramic resonator is necessary. A 4MHz crystal X1 has been used in the model. Whichever is used, the parallel resonant frequency of the chosen device should be 4·00MHz, unless, of course, the software is modified to suit an alternative frequency.

Whilst a crystal will provide the best absolute accuracy, the use of a ceramic resonator is just as satisfactory and also slightly cheaper. Most ceramic resonators have an initial frequency accuracy of ±0·5% at 25°C. This equates to an absolute accuracy of ±1·0ms for a typical reaction time of 200ms. It should be pointed out that the repeatable accuracy, at a given temperature, will be significantly better; the limiting factor being the resolution of the display, ±0·1ms.

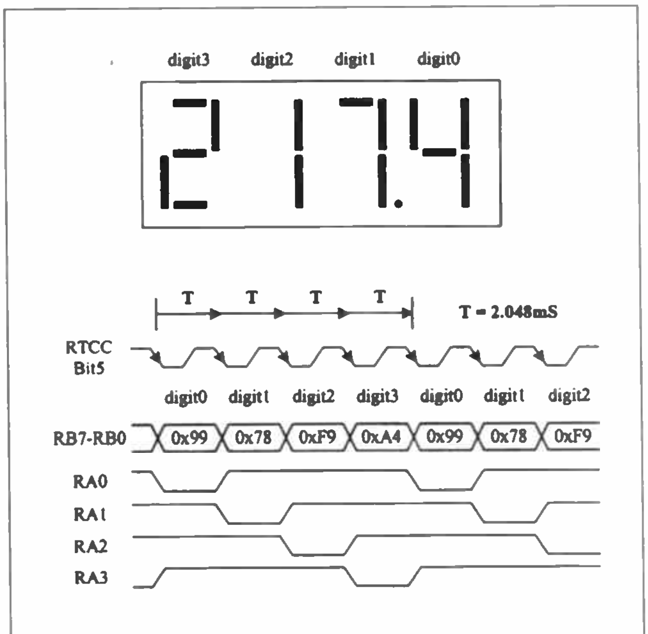


Fig.2. Display multiplexing.

ON DISPLAY

The measured reaction time is displayed using a four-digit, 7-segment, l.e.d. display. The display is made up by using two, dual-digit, modules X2 and X3. Whilst a four-digit version is available, the cost is more than that of the two dual modules.

Each digit of the display comprises of eight enunciators, seven for the segments, and one for the decimal point. The anodes (a) of the enunciators are connected together within the display, and the term *common anode* is therefore used to describe it.

A common anode type display was chosen so that the micro IC1 could drive the cathodes (k) directly. This is because the micro's I/O lines can sink more current than they can source. The dual digit module only has 18 pins presented to the outside world since the anodes are connected internally within the display: one anode and eight cathodes per digit.

Due to the limited number of I/O lines available from IC1, the display has to be multiplexed. By multiplexing, we only require 12 I/O lines, compared to 32 if the display was to be driven statically.

The common anodes, one per digit, are driven by transistors TR1 to TR4. Each transistor acts as a switch and is able to source the high current necessary to illuminate all eight enunciators at once.

Transistors TR1 to TR4 are controlled by IC1 via resistors R2 to R5, which define the base currents. The chosen value of 1·5 kilohms (1k5) for the resistors ensures that sufficient base current (approx. 2·5mA) flows to keep the transistors fully saturated when supplying maximum current.

The controlling I/O lines RA0 to RA3 of IC1 (pins 6 to 9) are configured as outputs by the software. A logic 0 on one of the lines will switch the corresponding transistor on, whereas a logic 1 will switch it off. When multiplexing the display, only one of these lines will be low (logic 0) at any one time: the other lines all being high (logic 1) – see Fig.2.

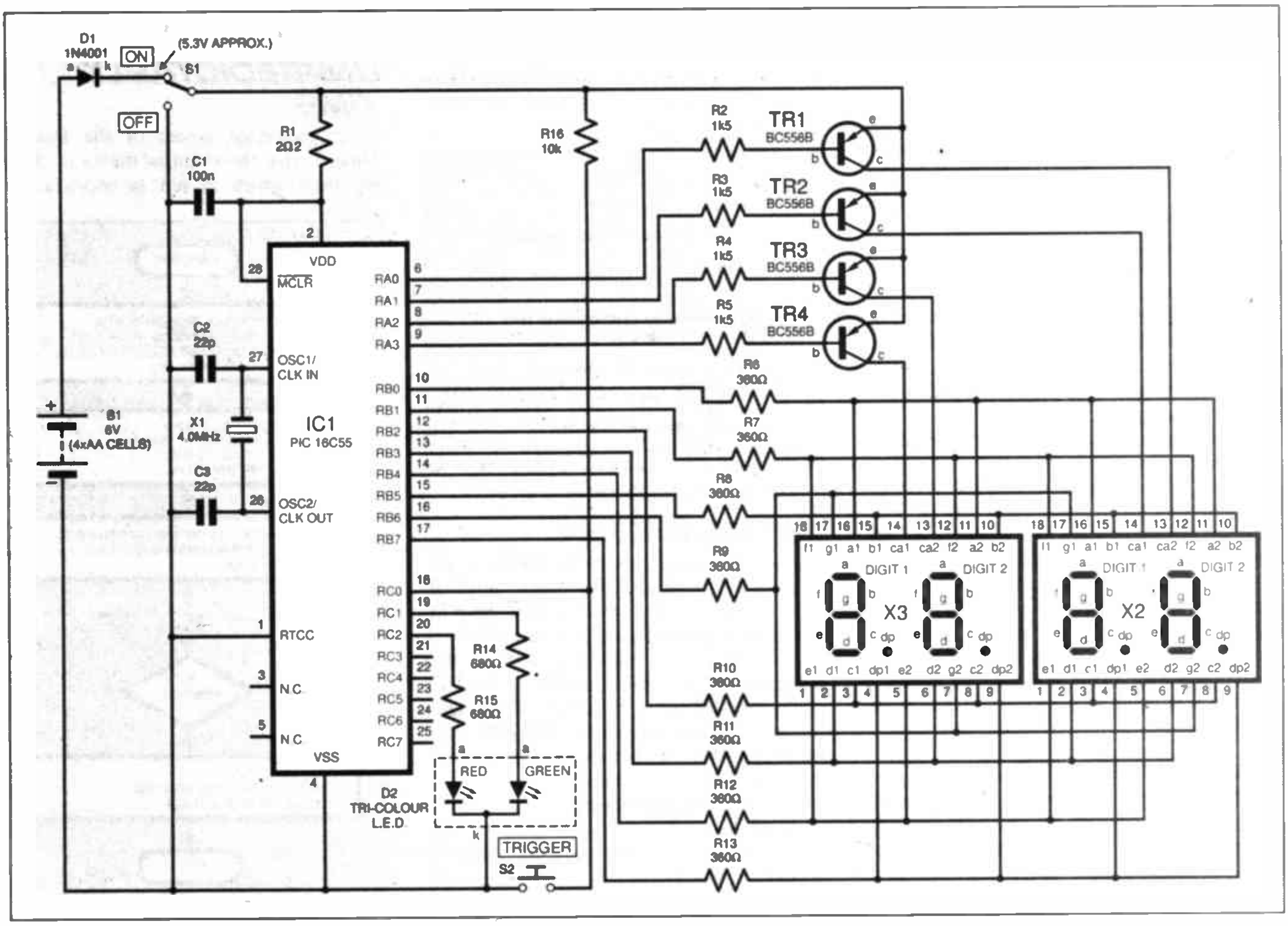
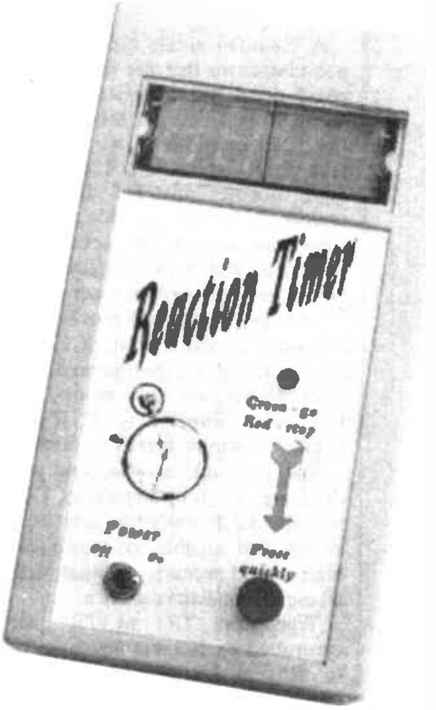


Fig.1. Complete circuit diagram for the Reaction Timer.



The segments and decimal point of each digit are connected together and are driven, via resistors R6 to R13, from IC1's I/O lines RB0 to RB7 (pins 10 to 17); these being configured as outputs by the software. Resistors R6 to R13 set the current through each segment to approximately 20mA. Since the display is 1:4 multiplexed, the average current through a segment will be around 5mA. To illuminate a segment, the corresponding RB pin of IC1 should be driven low.

TRI-COLOUR STIMULUS

The red/green tri-colour l.e.d., used as the stimulus for measuring the reaction time, is driven from IC1's port C at pin 19 and pin 20. I/O line RC1 drives the green anode via resistor R14 and RC2 drives the red anode via R15. These pins are configured as outputs by the software and are driven high to illuminate the l.e.d.s. The common cathode of the l.e.d. is connected to the 0V line.

Resistors R14 and R15 limit the current through the l.e.d.s to approximately 4mA. Whilst not used for this project, yellow can be achieved by driving RC1 and RC2 high at the same time.

Response time is recorded by means of S2; a momentary action, press-to-make, switch. The switch is connected between 0V and IC1's I/O line RC0 at pin 18. The line is configured by the software as an input and is therefore high impedance.

Resistor R16, connected between the positive supply and RC0, acts as a pull-up to define the non-pressed state of the switch as being high. The micro therefore looks for a high to low transition on RC0 as the indication that the switch has been pressed.

POWER SUPPLY

The project is powered from a 6V supply; provided by four AA 1·5V battery cells connected in series. Also in series with the supply is diode D1. This acts as a polarity protection device by ensuring no current flows should the battery pack be connected the wrong way.

Taking into account the voltage drop across D1, the circuit typically runs from 5·3V. Finally, a single pole double-throw switch S1 is used to turn the Reaction Timer on and off.

The supply current, in the main, is governed by the displays X2 and X3. With all digits illuminated – a display reading of 888·8 – the supply current is around 100mA. In order to ensure a long battery life, the Reaction Timer shuts down if switch S2 is not pressed for 25 seconds.

In shut down mode the display is blanked, the red/green l.e.d. extinguished, and the micro (IC1) put into sleep mode. In this state, the supply current is tens of micro-amps.

To restart the Reaction Timer, it must first be switched off and then back on using switch S1. The wiring of S1 is such that when it is switched to the Off position, the voltage on capacitor C1 is quickly discharged through resistor R1. This ensures that when it is switched back to the On position, the internal power on reset function of the micro operates correctly.

SOFTWARE

One of the advantages of using a micro like the PIC16C55 is that the software is fairly simple to understand. This is because the instruction set is small, only 33 instructions, and not much configuration is required to get it up and running. For those with little or no knowledge of software and assembly language, this project is possibly a good place to start learning.

The software is explained using both flow charts and snippets of the assembly code. This is more than adequate to get a good understanding of how it works. For those who wish to delve further, then there is no better place to look than the commented source code.

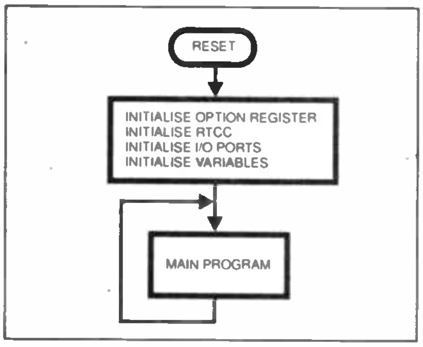


Fig.3. Initialisation flow chart.

INITIALISATION

As with most programs, there is an initialisation routine and a main program loop. As can be seen from the flow chart in Fig.3, the initialisation is fairly simple.

Apart from the variables used in the program and the configuration of the I/O ports, there is only one register that really needs to be configured; the OPTION register. The value written to this register sets the prescaler to 32 and assigns it to the RTCC. The resulting internal configuration is shown in Fig.7.

The initialisation also sets the value in RTCC to zero, but this is not essential and is only done to be thorough. It is always good practice to initialise variables, even if there is no need for it.

The remainder of the initialisation is fairly self explanatory. The two instructions shown below are those used to initialise the OPTION register.

```
MOVLW   000100B    ; Configure option register
OPTION      |||-     Prescaler for rtcc = 1/32
            |----    Prescaler assigned to rtcc
           |-----    rtcc signal edge = +ve
          |------    rtcc signal source = Internal
```

MAIN LOOP

The main program performs two basic functions; driving the display and measuring reaction time. These functions are totally separate and are described in full below.

The software to drive the display is written as a state machine that is synchronised to bit 5 of the RTCC register – see Fig.4. The state machine has four states corresponding to the four digits of the display.

Each time a negative transition of RTCC bit 5 occurs, the next digit of the display is driven and the state of the state machine changed. The result is that each digit of the display is illuminated for approximately 2ms every 8ms – see Fig.2.

This equates to a 1:4 multiplex ratio and a refresh rate of approximately 120Hz. If the Reaction Timer is moved quickly, the display will appear to flicker and is a clear indication that it is multiplexed.

The display continues to be multiplexed until switch S2 is pressed. At this point, the software exits the state machine and enters the program that measures the reaction time (see Fig.5), during which the display is totally extinguished.

UNPREDICTABLE TIME

An important aspect of the Reaction Timer is that the event of the l.e.d. changing from green to red is unpredictable.

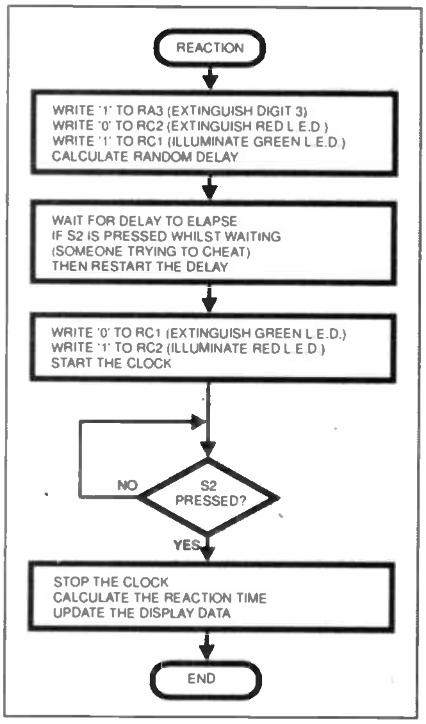
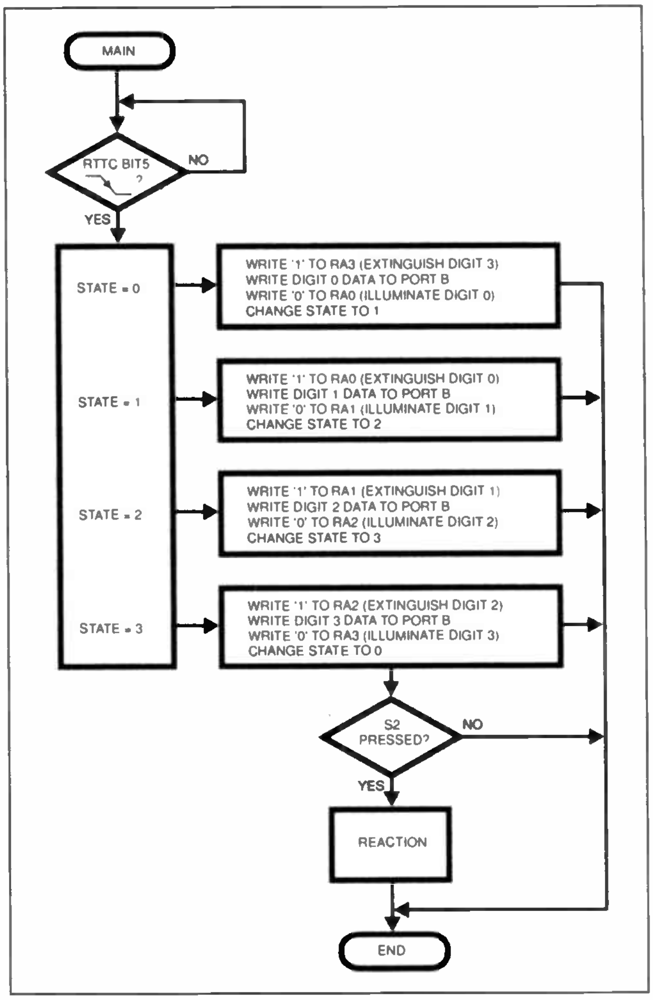


Fig.5. Software flow chart for reaction time.



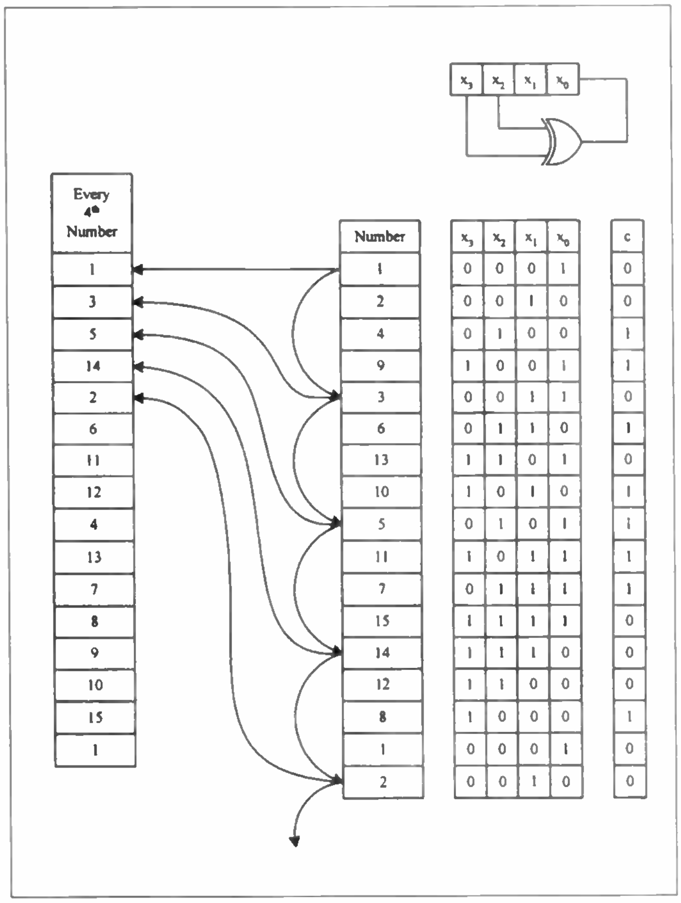


Fig.6 (above). Calculating a pseudo random number.

Fig.4 (left). Main program state machine display flow chart.

This is achieved by producing a random delay based on a pseudo random number. The pseudo random number is generated in a similar way to how it would be using discrete logic elements; a shift register and an exclusive-OR gate – see Fig.6.

Due to the feedback via the exclusive-OR gate, each left shift of the shift register results in a new number being produced. In this example, only 15 integer random numbers are generated before the sequence repeats.

To remove correlation between the numbers, the shift register is shifted four times to ensure that all the bits in the register are new. We are effectively taking every 4th number as shown in the example, Fig.6.

The fact that the sequence repeats implies that the generated numbers are not truly random, and therefore not unpredictable. However, if there are many numbers before the sequence repeats, then for a project like this, the numbers can be considered sufficiently random and unpredictable.

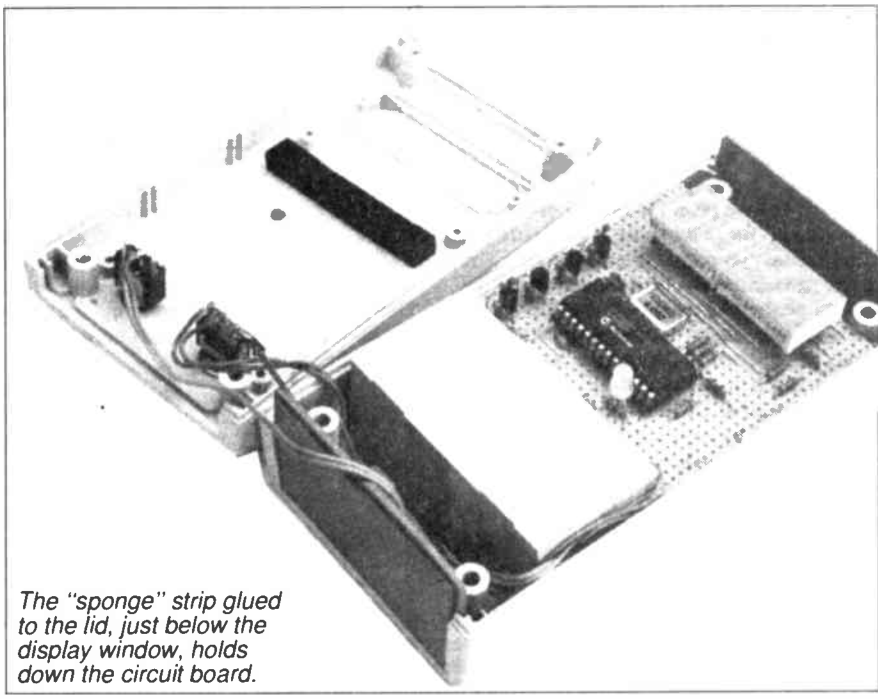
The tap positions in the software implementation are X3 and X6. These tap positions provide a sequence of random numbers between 1 and 127 before the sequence eventually repeats. In both the software and hardware implementations, the number 0 is not produced. If zero was introduced as a seed, then the random number generator would only produce zeros.

It should also be pointed out that the position of the taps is important too, and that they have not been chosen at random! There is a method of choosing tap positions using irreducible polynomials, but that will not be covered here.

Once the random number has been generated, an offset of 15 is added to it in order to set a minimum delay time. The resulting number is then used, in conjunction with the RTCC, to produce a delay ranging from 1·05 to 9·31 seconds.

During the delay, switch S2 is continually monitored to see if it is pressed. If it is, then the delay is restarted.

In an earlier version of the software this was not the case and, if S2 was pressed repeatedly, sub 100ms reaction times would sometimes be recorded. This trap has therefore been included to stop cheats who try to record fast reaction times when backs are turned.



The "sponge" strip glued to the lid, just below the display window, holds down the circuit board.

After the delay has elapsed the colour of the l.e.d. is changed from green to red and the stopwatch is started. The stopwatch is in fact the RTCC and variable RTCC1, and to start it both are loaded with zero. The variable RTCC1 is incremented, in software, on each negative transition of RTCC bit 7 – see Fig.7.

This process continues until either switch S2 is pressed, or RTCC1 bit 7 goes high indicating an elapsed time of greater than 999·9ms. At this point, the stopwatch is stopped and the resulting time resides in the variables RTCC1 and RTCC0. Precautions are taken to ensure that if the value of RTCC changes from 255 to zero before it is copied to RTCC0, then RTCC1 is incremented to take account of it.

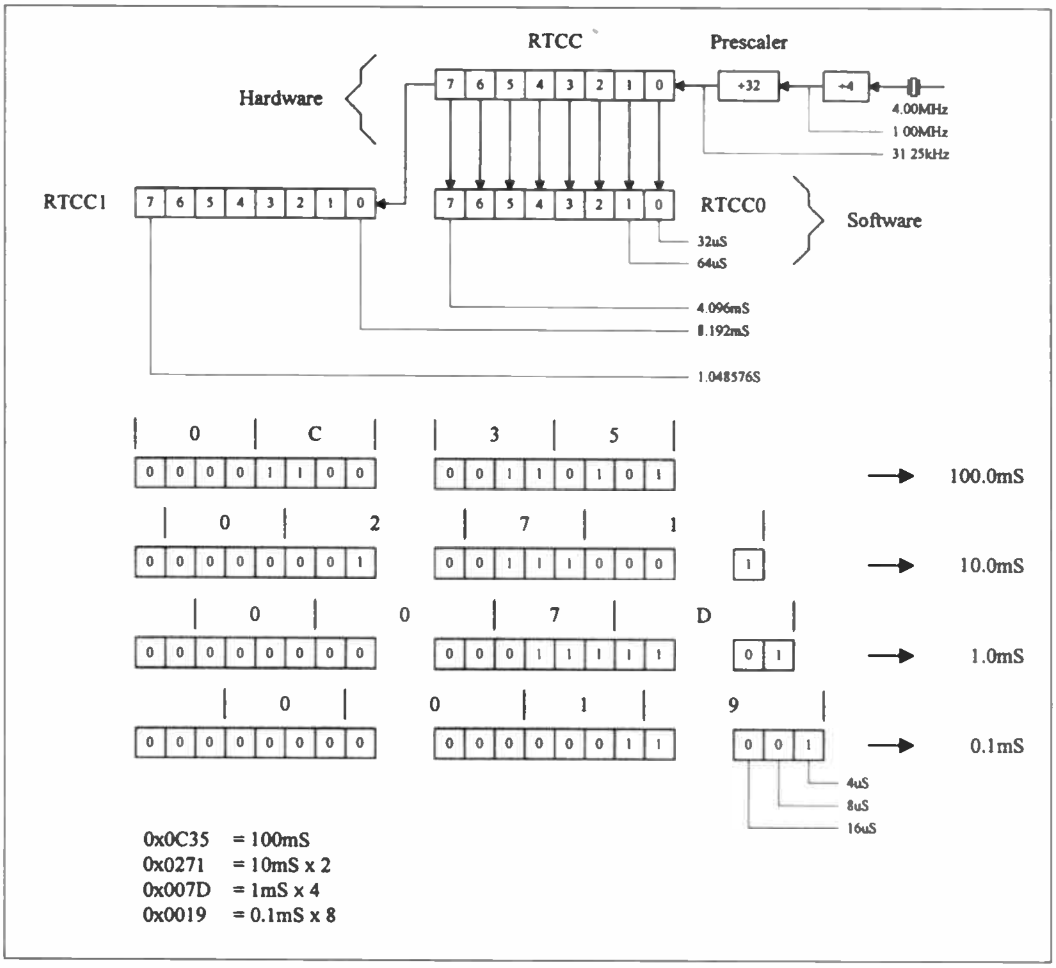


Fig.7. Calculating the reaction time.

HELP LINE

Before conversion of the binary time into a Binary Coded Decimal (BCD) format, a test is performed to see if the stopwatch was stopped due to bit 7 of RTCC1 being high. If it was, then no conversion takes place. Instead, the display variables are loaded with the appropriate seven-segment data to display the word "HELP".

The process of converting the time from binary to BCD is one of division, and is achieved using subtraction. Binary data representing 100ms is subtracted from the time in the RTCC variables, and is repeated until the remaining time is less than 100ms.

The number of times this subtraction occurs is recorded since it represents the value to be displayed in the hundred's digit of the display. If the number is greater than nine, then the reaction time is greater than 999·9ms and the word "HELP" is displayed instead. A similar process is repeated to determine the values for the other digits.

Since the data required for 10ms includes a bit beyond the resolution of the RTCC variables, a multiply by two (by shifting the data left by one place) is carried out before performing the subtractions – see Fig.7. This ensures no rounding errors occur. The same process is also used to determine the values of the other digits. Once the binary to BCD conversion is complete, the BCD data is converted to 7-segment format and written to the display variables.

Conversion of BCD to 7-segment format is performed by means of a look-up table; the BCD data providing the offset into the table, as shown below:

```
BCD_7Seg                        ; BCD to 7 Segment conversion
         ANDLW    0x0F          ; BCD < 16
         ADDWF    pc,f          ; Add BCD to program counter

         RETLW    cn_0          ; character '0' (11000000)
         RETLW    ch_1          ; character '1' (11111001)
         RETLW    ch_2          ; character '2' (10100100)
         RETLW    ch_3          ; character '3' (10110000)
```

The BCD value is first placed into the W register and the BCD conversion routine is then called. The value returned by the routine is the corresponding 7-segment data.

Care is taken to ensure that the addition does not cause a jump beyond the end of the table; hence the reason for the ANDLW instruction at the start (Note: sixteen RETLW instructions in table). Also, since the code does not test for overflow after the addition, the location of the subroutine is such that it does not cross a 256 page boundary.

SLEEP

Although there is a power on/off switch for the Reaction Timer, an automatic power down is performed in software if switch S2 is not pressed for 25 seconds. This feature has been included to save the batteries from unnecessary discharge should the Reaction Timer be accidentally left switched on.

The software for this is just after the RTCC bit 5 test in the main loop but, for simplicity, is not shown in the flow chart. However, the code that performs the shutdown is shown below just to indicate how easy the process actually is.

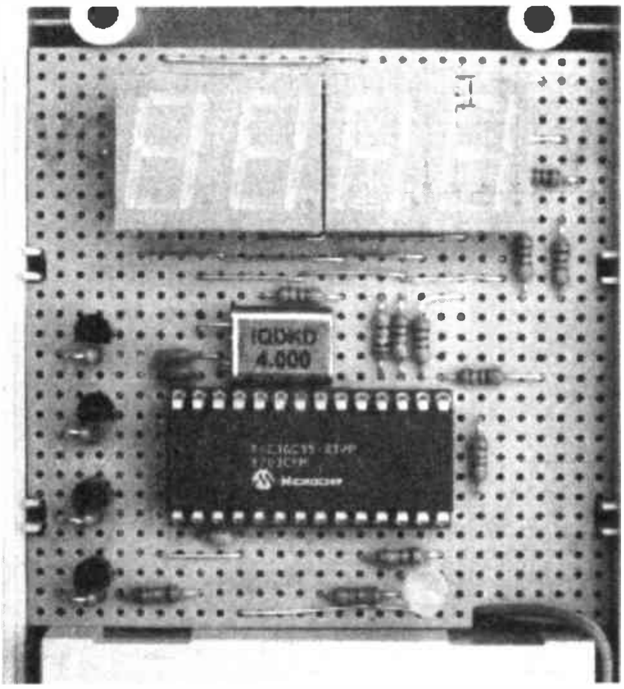
```
Shut_Down  MOVLW    0xFF     ;
           MOVWF    porta    ;
           MOVWF    portb    ; Extinguish display
           CLRF     portc    ; Extinguish red/green l.e.d.
           SLEEP             ; Goto sleep (stop oscillator)
```

SOFTWARE SOURCING

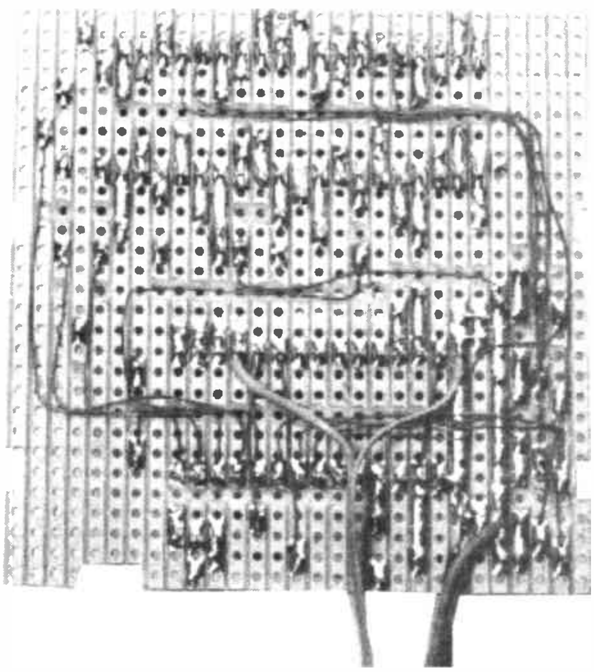
A pre-programmed PIC16C55-XT is available from the author for those readers who do not have facilities to program these parts – see *Shoptalk* page. Readers who wish to program their own PICs can obtain the software either on disk, from the *EPE* editorial office, or from our web site (there is a nominal charge for the former, but the latter is free) – see *Shoptalk* page. The web site files are in the sub-directory PIC-REACTION.

CONSTRUCTION

The Reaction Timer illustrated here has been constructed on stripboard. Although it could be converted to a printed circuit board (p.c.b.) layout, it would need to be a



Component layout on the circuit board. Note the side cutouts to allow the board to slot into the case.



Underside of the stripboard showing interwiring. The wire used is Kynar covered type used for wirewrapping.

double-sided type. It is not the intention to cover the later option here.

Whatever method of construction is used, the use of sockets for the displays and PIC microcontroller is a must. Also, the PIC should be fitted last when the completed circuit board has been thoroughly checked, taking appropriate antistatic precautions.

The stripboard component layout and details of breaks required in the underside copper tracks are given in Fig.8. Start construction by trimming the board to the required size of 29 holes by 29 copper strips using a small hacksaw.

Before mounting any components on the board, carefully make all breaks in the copper tracks using a special "spot-face" cutter or a hand-held twist drill bit of about 5mm diameter. Next you should cut out the board mounting side guide slots if the specified case is used.

As 0·6in. pitch 18-pin sockets do not appear to be sold, a standard d.i.l. socket can be cut *lengthwise*, trimmed clean, and the resulting two strips soldered in position for the dual 7-segment displays. Remember to allow enough of the pins to protrude to take the underside wiring.

Now commence mounting components on the circuit board. Begin with the wire links and d.i.l. sockets, these will help as a guide for the other compoents. Do **NOT** fit the displays or the PIC microcontroller in their holders until the circuit board and all interwiring has been completed and double-checked. Try to touch the pins of the PIC as little as possible when eventually fitting it into its holder.

Assembly of the rest of the components on the board should follow the normal procedure of starting with the lowest profile components working up to the largest. Pay particular attention to the diodes and transistors, checking to ensure they are inserted on

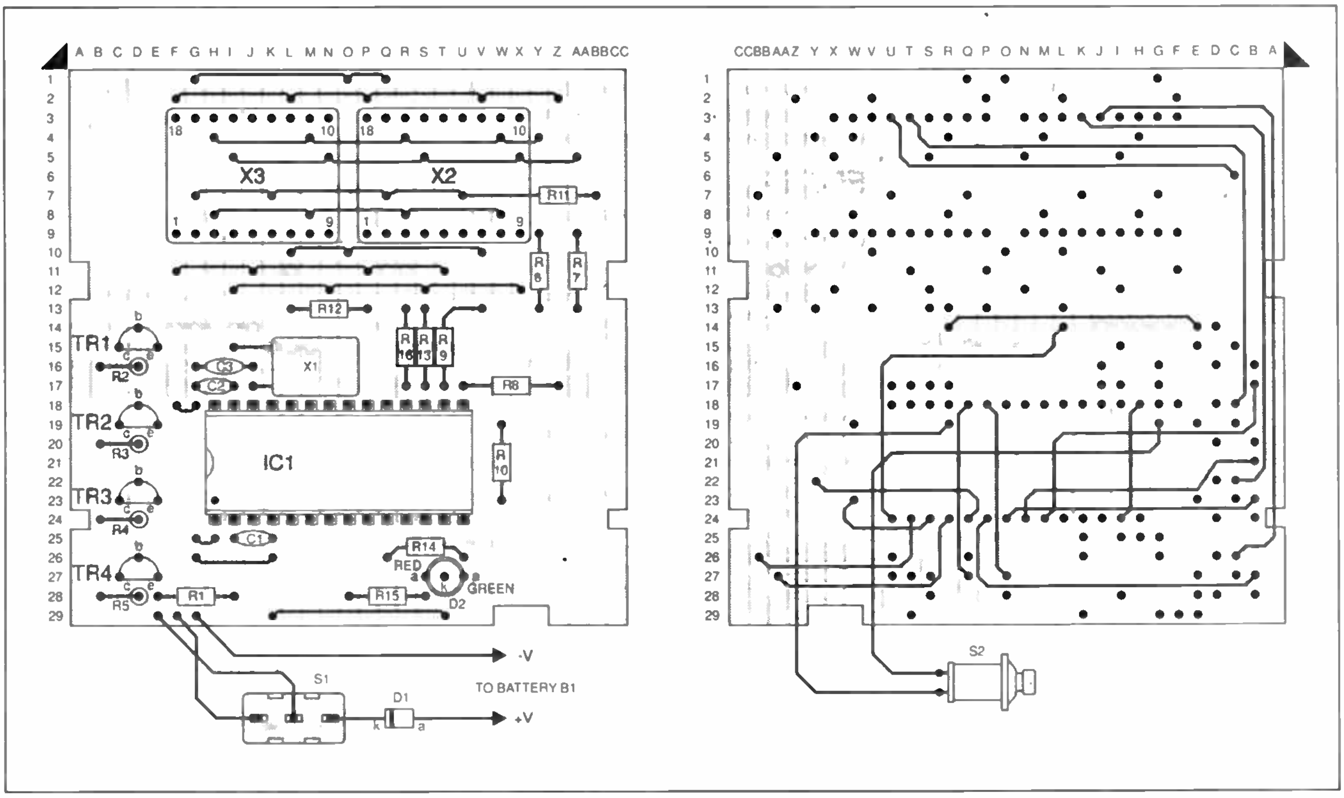


Fig.8. Stripboard component layout and wiring. Some of the interwiring on the underside is soldered ***directly*** *onto i.c. socket pins and some component leads.*

COMPONENTS

Resistors

R1	2Ω2	See **SHOP TALK** Page
R2 to R5	1k5 (4 off)	
R6 to R13	360Ω (8 off)	
R14, R15	680Ω (2 off)	
R16	10k	

All 0·25W 1% metal film

Capacitors

C1	100n disc ceramic
C2, C3	22p disc ceramic

Semiconductors

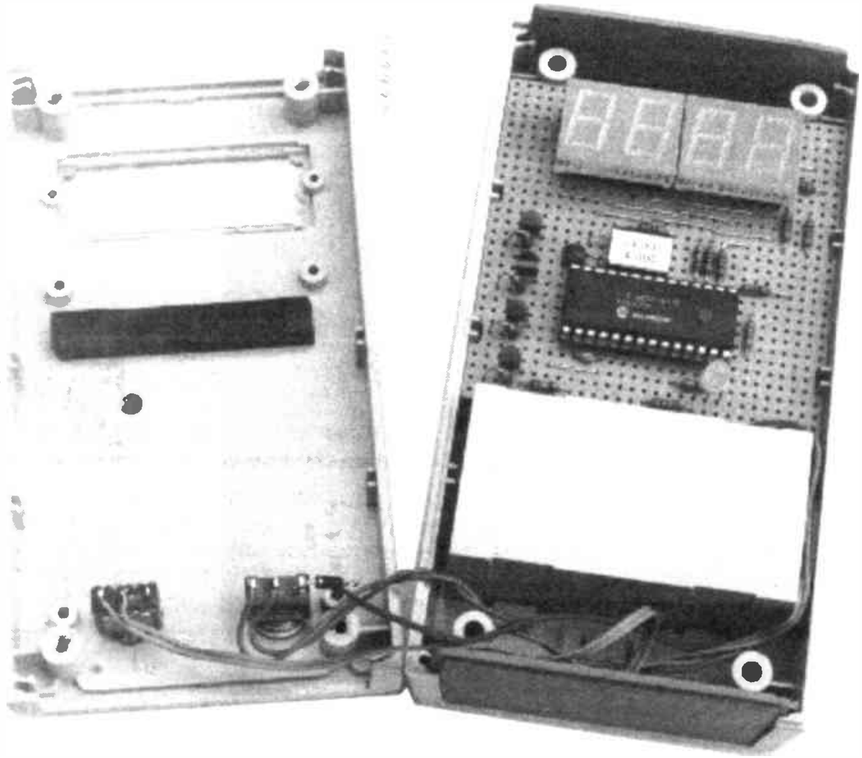
D1	1N4001 50V 1A rect. diode
D2	tri-colour l.e.d.
TR1 to TR4	BC556B *pnp* transistor (4 off)
IC1	PIC16C55-XT/P microcontroller preprogrammed (see text)
X1	4·0MHz crystal
X2, X3	dual 7-segment l.e.d. display (2 off)

Miscellaneous

S1	single-pole on/off min. toggle switch
S2	min. pushbutton switch, push-to-make
B1	6V battery pack (4 × AA cells)

Stripboard, 0·1in. matrix, size 29 holes × 29 strips; plastic case, size 150mm × 80mm × 45mm; 18-pin d.i.l. socket, 0·6in. pitch (2 off); 28-pin d.i.l. socket, 0·6in pitch; battery holder, 4 × AA (short); battery connector, with leads (PP3); Kynar covered wire; solder pins; solder etc.

Approx Cost Guidance Only £30 excluding batt.



The completed Reaction Timer. The circuit board "sits" on the rubber strips glued to the sides of the case, at a height to allow the l.e.d. to protrude through the case lid.

the board the correct way round, see Fig.8. Solder them in position as quickly as possible to avoid excessive heat.

Also at this stage, lengths of interconnecting leads should be soldered to the underside edges of the board ready for connecting to the off-board components.

CASE DETAILS

Before plugging the displays and microcontroller into their sockets it is necessary to finish off the case. If you are not using the specified case, the first task is to make the rectangular cutout for the displays. This can be accomplished by offering up the board to the case, using any board mounting holes as a guide, marking the display position on the surface of the case lid.

Next a series of small holes should be drilled just inside the markings for the cutout. The holes can then be "joined" up to leave a rough cutout. The rough edges can be filed flat to leave a neat cutout for the display window.

Rubber sponge strips should be glued to the inner sides of the lower half of the case to support the circuit board. These should be at a height to allow the "reaction" l.e.d. to just protrude through the case lid.

Finally, the holes for the two switches and the tri-colour l.e.d. should be made. As the l.e.d. is mounted directly on the circuit board, its position needs to be marked at the same time as the display window.

Complete the wiring to off-board components and insert the PIC into its d.i.l. socket. But, first double-check the board and wiring.

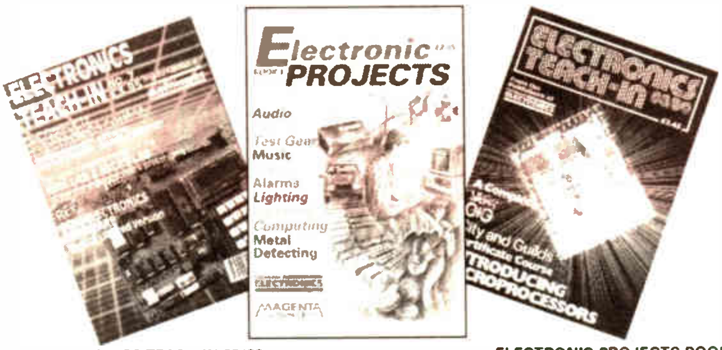
Pay particular attention to the track breaks to ensure no "slivers" of copper swarf have bridged across any adjacent tracks. This can be verified with a small magnifying glass. Also check for any "dry" solder joints, usually spotted by a discolouring of the joint.

Warning: The Reaction Timer has been designed to run from four 1·5V AA cells, wired in series to give a 6V supply. The supply to the PIC microcontroller must not exceed its maximum rating of 7·5V, otherwise you can cause serious damage. So, no 9V PP3 battery please!

If all is okay the battery pack can be connected up and power switch S1 thrown. If all is well, the display should show 0·0 and the tri-colour l.e.d. should be red.

Now the fun begins!

DIRECT BOOK SERVICE



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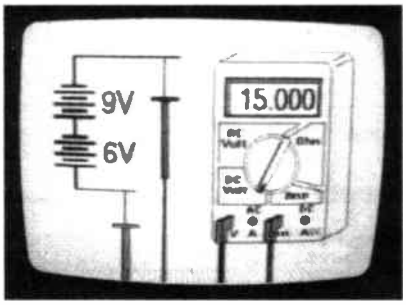

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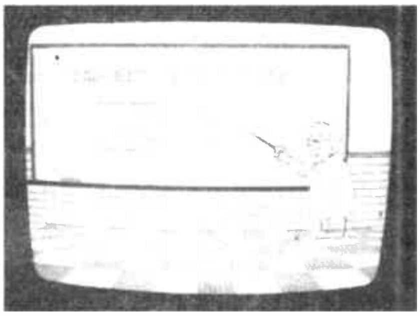

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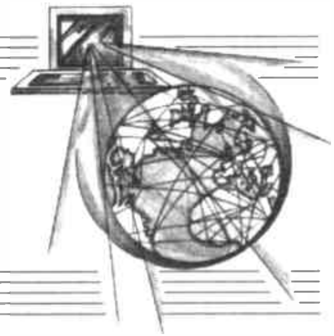

NET WORK is our monthly column written specially for electronics enthusiasts having access to the Internet. Our web site URL (**http://www.epemag.wimborne.co.uk**) contains details of the latest issue and a brief reminder about earlier editions too. You can also subscribe or renew your *EPE* subscription for up to four years (at a guaranteed fixed price), via our secure server. This month's project files are on the FTP site at **pub/PICS/Reaction.Timer and pub/8051/Programmer.**

Several readers appear to have problems using File Transfer Protocol (FTP) in order to access our FTP site. As promised in the May issue, starting this month we take time out to help you navigate around our file area. I'll be describing those relevant to Windows 95 users, but Macintosh owners may also find the following pointers useful as some of the principles apply to them, too.

FTP at the DOS Prompt

I will bet that a sizeable number of Windows 95 users are unaware they can run a "command-line" FTP session via the Internet, from their DOS prompt. Simply make a connection to the Internet (e.g. using Dial-Up Networking) then open a DOS box by clicking the MS-DOS icon. At the DOS prompt type **FTP** <return>. The C prompt will change to **FTP>** and you are ready. You will now witness a coming-together of two operating systems, because every FTP server I have ever known uses Unix. It pays to become acquainted with a few basic Unix commands, and although some are broadly similar to DOS, there are some fundamental differences not least of which is that Unix uses a forward slash "/" instead of a DOS back-slash "\". This can be a pain to begin with! Furthermore, Unix command file names and directories are case-sensitive.

The first command to enter is the URL of the FTP server. To connect to the *EPE* FTP site, you would type **open ftp.epemag.wimborne.co.uk** <return>, after which you will be asked to log in by providing a user name and password.

The vast majority of FTP sessions are performed by "anonymous FTP" so the files are freely available to everybody. Type the word "anonymous" as a log-in, and your full (valid) E-mail address as a password:

```
ftp> open ftp.epemag.wimborne.co.uk
Connected to ftp.epemag.wimborne.co.uk.
220-ftp.epemag.wimborne.co.uk FTP server (NcFTPd 2.2.0) ready.
220- Welcome to the FTP archive at
ftp.epemag.wimborne.co.uk
220- Login as 'anonymous' and give your email address as the password
220- to access our FTP archive.
User (ftp.epemag.wimborne.co.uk:(none)): anonymous
331 Guest login ok, send your complete e-mail address as password.
Password:
230-You are user #2 of 30 simultaneous users allowed.
230-
230 Logged in anonymously.
ftp>
```

At this point, you have gained access to the log-in "root" of the FTP site, from where all the sub-directories branch out. It is now necessary to navigate to the relevant folders using some arcane DOS-like commands, hitting <return> after each one: **dir** lists the contents and file data of the current directory:

```
ftp> dir
200 PORT command successful.
150 Opening ASCII mode data connection for /bin/ls.
dr-xr-xr-x  2 ftpuser  ftpusers  512 Jul 11  1995 bin
dr-xr-xr-x  2 ftpuser  ftpusers  512 Jul 11  1995 dev
dr-xr-xr-x  3 ftpuser  ftpusers  512 Jul 11  1995 etc
drwxr-xr-x 10 ftpuser  ftpusers  512 Feb  5 14:44 pub
dr-xr-xr-x  3 ftpuser  ftpusers  512 Jul 11  1995 usr
226 Listing completed.
305 bytes received in 0.05 seconds (6.10 Kbytes/sec)
ftp>
```

The "pub" (public) directory is the only one of interest. To go there, type **cd/pub** then **ls**. You will see the following Unix file structure displayed:

```
ftp> ls
200 PORT command successful.
150 Opening ASCII mode data connection for /bin/ls.
Heating
Met.office
PICS
SOUNDAC
VScope
docs
incoming
readme.txt
software
whatsnew.txt
226 Listing completed.
96 bytes received in 0.05 seconds (1.92 Kbytes/sec)
ftp>
```

To download a file onto your PC, use **get**. But first you must differentiate between ASCII (pure text) files and binary (.zip, .gif. .doc etc.) files before commencing the transfer. Type **ascii** or **binary** accordingly: *the file will be corrupted if you transfer binary files as ASCII.* For example, back in the root of the FTP server, to fetch the file **readme.txt:**

```
ftp> ascii
200 Type okay.
ftp> get readme.txt
200 PORT command successful.
150 Opening ASCII mode data connection for readme.txt (1163 bytes).
226 Transfer completed.
1197 bytes received in 0.28 seconds (4.28 Kbytes/sec)
ftp> quit
221 C-ya!
C:\WINDOWS>
```

Lastly, type **quit** to exit the FTP session (and don't forget to disconnect the modem) and **exit** to leave DOS. By default, the file now resides in the Windows directory. I'll be continuing this FTP primer next month.

Phantom of the Opera

If you are fed up of the bloat of your browser and want something less proprietary and more fun, then get Opera, a slim (1MB) but feature-rich Windows browser from Norway. Opera Software says their goal is to provide us with the best browser on the Net, regardless of market share, browser war or competitive domination strategies.

Opera has useful zoom facilities (up to 1,000%) on both text and graphics, which will be of enormous help to those who are partially sighted; it can also be navigated by keyboard only, if desired. A mail and news client is incorporated and on test, Opera 3.1 found all my Navigator and MSIE bookmarks straight away using an impressive Hotlist feature. **Http://www.operasoftware.com** is the place to go. It is priced at US$35, with a 50% discount for educational users, and you can buy on-line via SSL.

Defeated by my word count, I am placing this month's interesting links directly on the web site! Be sure to check *Net Work* on the *EPE* web site, and let me know your favourite places. You can E-mail me at **alan@epemag.demon.co.uk**.

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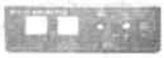

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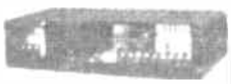

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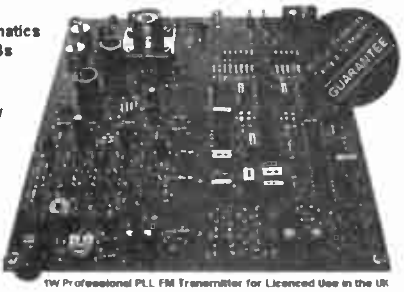

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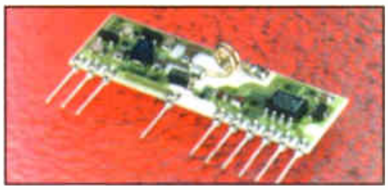

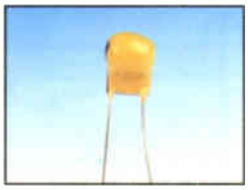

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