EVERYDAY

PRACTICAL ELECTRONICS

APRIL 1997

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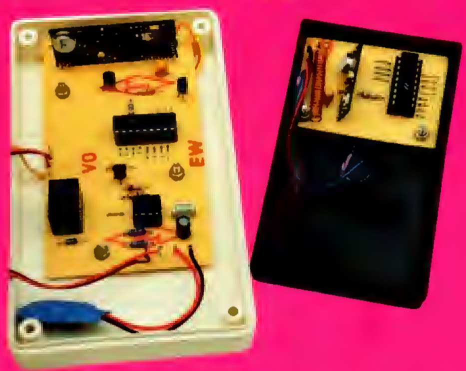
FREE! INSIDE GREENWELD 1997 CATALOGUE

418 MHz Remote Control System

Legal Transmitter/Receiver for a wide range of applications



PIC-Agoras

A computer for almost any wheeled vehicle
Measures and interprets angular rotation

MIDI Matrix

Stop swapping leads with this switching unit

MPEG 2 Digital Television

We unravel the technicalities

The No. 1 Magazine For Electronics Technology & Computer Projects

9 770262 361072 04

Ingenuity Unlimited, Circuit Surgery, New Technology Update, Innovations

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

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

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

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

DIVINING RODS £3.99 a pair! ref EF111

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

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

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

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

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

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

SURVEILLANCE TELESCOPE Superb Russian zoom telescope adjustable from 15x to 60x! complete with metal tripod (imposible to use without this on the higher settings) 66mm lense, leather carrying case £149 ref BAR69

WIRELESS VIDEO BUG KIT Transmits video and audio signals from a minature CCTV camera (included) to any standard television! All the components including a PP3 battery will fit into a cigarette packet with the lens requiring a hole about 3mm diameter Supplied with telescopic aerial but a piece of wire about 4" long will still give a range of up to 100 metres. A single PP3 will probably give less than 1 hours use. **£99** REF EP79 (probably not licensable!)

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

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

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

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

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

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

9 WATT CHIEFTAN TANK LASERS

Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for 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

TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20" (glass not included) includes full instructions. £12 ref TW1.

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

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

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

THOUSANDS AVAILABLE RING/FAX FOR DETAILS!

MAGNETIC CARD READERS (Swipes) £9.95 Cased with flyleads, designed to read standard credit cards! they have 3 wires coming out of the head so they may write as well? complete with control elctronics PCB. just £9.95 ref BAR31

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

COIN OPERATED TIMER KIT Complete with coinslot mechanism, adjustable time delay, relay output, put a coinslot on anything you like! TV,s, videos, fridges, drinks cupboards, HIFI. takes 50p's and £1 coins. DC operated, price just £7.99 ref BAR27

ZENITH 900 X MAGNIFICATION MICROSCOPE Zoom, metal construction, built in light, shrimp farm, group viewing screen, lots of accessories. £29 ref ANAYLT.

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

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

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 2 line, 99x24mm £2.99 ref SM1623A
20 character 2 line, 83x19mm £3.99 ref SM2020A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

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

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

SOLAR COOKERS Comprehensive guide to building solar powered cookers, includes plans, recipes, cooking times etc £7 ref SBC1

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CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, D base, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £8 ref lot 97 3.5" disks

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

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

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

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

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

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

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

Check out our WEB SITE full colour interactive 1997 catalogue
http://www.pavilion.co.uk/bull-electrical

IBM PS2 MODEL 150Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. **£9.95** ref EP67

1.44 DISC DRIVES Standard PC 3.5" drives but returns so they will need attention **SALE PRICE £4.99** ref EP68

1.2 DISC DRIVES Standard 5.25" drives but returns so they will need attention **SALE PRICE NOW ONLY £3.50** ref EP69

PP3 NICADS Unused but some storage marks. £4.99 ref EP52

GAS HOBS AND OVENS Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob **£19** ref BAR316. Basic small built in oven **SALE PRICE £59** ref EP73

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc £99 ref EF112.

PASTEL ACCOUNTS SOFTWARE, does everything for all sizes of businesses, includes wordprocessor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (01342-326009 try before you buy!) **SALE PRICE** £9.95 ref SA12. SAVE £120!!!

PC PAL VGA TO TV CONVERTER 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

YUASHA SEALED LEAD ACID BATTERIES Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH at just £6 ref LOT7.

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

PROJECT STRIPPERS Small cased UNITS ideal for stripping, lots of useful goodies including a smart case 120X150X50mm with feet etc , and lots of components. **SALE PRICE JUST £10 FOR FIVE** REF MD1 or a pack of 20 for £19.95 ref MD2.

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit **SALE PRICE JUST £4.99** REF SA27

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

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 **REF: MAG17**

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

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. **SALE PRICE £12.99** REF SA18

MEGA POWER BINOCULARS Made by Helios, 20 x magnification, precision ground fully coated optics, 60mm objectives, shock resistant caged prisms, case and neck strap. £89 ref HPH1

GIANT HOT AIR BALLOON KIT Build a 4.5m circumference, 1.8m high 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.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £25 **REF: MAG15** 12v psu is £5 extra **REF: MAG5P2**

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2 km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £37.00 pr **REF: MAG30**

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £18 REF: EF62 (kit) Transmits to any FM radio. Built and tested version now available of the above unit at £45 ref EXM34

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

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £14.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. **SALE PRICE £4.99** REF SA24.

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

MIXED GOODIES BOX OF MIXED COMPONENTS WEIGHING 2 KILOS YOURS FOR JUST £5.99

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties. £24.95 ref R/7.

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

HYPOTHERMIA SPACE BLANKET 215x150cm aluminised foil blanket, reflects more than 90% of body heat. Also suitable for the construction of two way mirrors! £3.99 each ref O/L041.

NICAD CHARGERS AND BATTERIES Standard universal mains operated charger, takes 4 batts + 1 PP3, £10 ref PO11D. Nicads- AA size (4 pack) £4 ref 4P44, C size (2 pack) £4 ref 4P73, D size (4 pack) £9 ref 9P12.

LENSTATIC RANGER COMPASS Oil filled capsule, strong metal case, large luminous points. Sight line with magnifying viewer. 50mm dia, 86gm. £10.99 ref O/K604.

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor. BS approved. Price is £21.95 ref EP31

TALKING WATCH Yes, it actually tells you the time at the press of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £7.99 ref EP26.

RUBBER COATED HELIOS Binoculars, 10 x 25, fully coated optics. £45 ref RP1, same spec but nitogen filled and waterproof £75 ref RP2

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence! Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones Detects X, K, and Ka bands, 3 mile range, 'over the hill' 'around bends' and 'rear trap facilities. micro size just 4.25"x2.5"x.75", Can pay for itself in just one day! £89 ref EP3.

3" DISCS As used on older Amstrad machines, Spectrum plus3's etc £3 each ref BAR400.

STEREO MICROSOPES BACK IN STOCK Russian, 200x complete with lenses, lights, filters etc etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue

SECOND GENERATION NIGHT SIGHTS FROM £748

RETRON Russian night sight, 1.8x, infra rad lamp, 10m-inf, standard M42 lens, 1.1kg. £349 ref RET1

LOW COST CORDLESS MIC 500' range, 90 - 105mhz, 115g, 193 x 26 x 39mm, 9v PP3 battery required. £17 ref MAG15P1

BULL ELECTRICAL
250 PORTLAND ROAD, HOVE, SUSSEX . BN3 5QT. (ESTABLISHED 50 YEARS).
MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3.50 P&P PLUS VAT.
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PLEASE ALLOW 7-10 DAYS FOR DELIVERY PHONE ORDERS WELCOME (ACCESS,VISA, SWITCH, AMERICAN EXPRESS)
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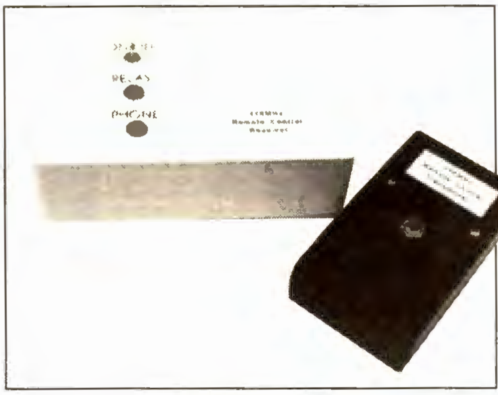

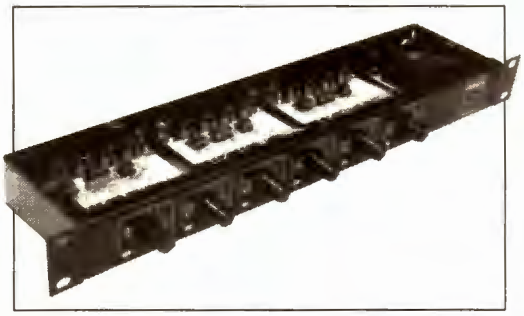

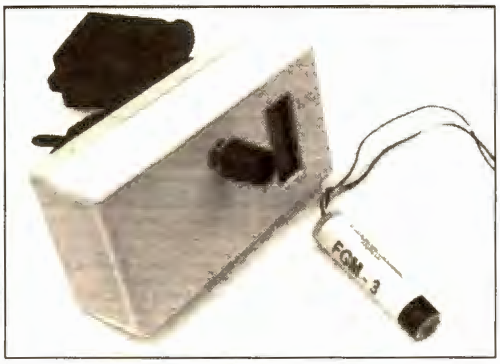

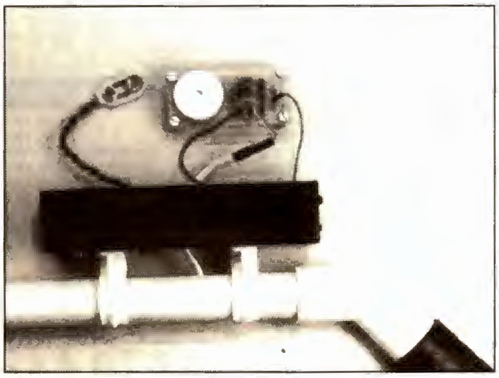

Projects and Circuits

Series and Features

Regulars and Services

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Our May '97 issue will be published on Friday, 4 April 1997. See page 263 for details.

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THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

LOW COST PC's -

SPECIAL BUY
'AT 286'
40Mb HD + 3Mb Ram

LIMITED QUANTITY only of these **12Mhz HI GRADE 286** systems Made in the USA to an industrial specification, the system was designed for *total reliability*. The **compact case** houses the motherboard, PSU and EGA video card with single **5¼" 1.2 Mb** floppy disk drive & **integral 40Mb hard disk drive** to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition complete with **enhanced keyboard, 640k + 2Mb RAM, DOS 4.01 and 90 DAY Full Guarantee.** *Ready to Run !*
Order as HIGRADE 286 ***ONLY £129.00*** (E)

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£19.95
Wordperfect 6.0 for Dos - when 3½" FDD option ordered	£22.50
NE2000 Ethernet (thick, thin or twisted) network card	£29.00

LOW COST 486DX-33 SYSTEM

Limited quantity of this 2nd user, supurb small size desktop unit. Fully featured with standard simm connectors 30 & 72 pin. Supplied with keyboard, 4 Mb of RAM, SVGA monitor output, 256k cache and integral 120 Mb IDE drive with single 1.44 Mb 3.5" floppy disk drive. Fully tested and guaranteed. *Fully expandable*
Many other options avaiable - call for details. Only **£399.00** (E)

FLOPPY DISK DRIVES 3½" - 8"

5¼" or 3½" from only £18.95 !

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are ***BRAND NEW*** or removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported on your PC)

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
3½" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
8" **Shugart 800/801** 8" SS refurbished & tested	£195.00(E)
8" **Shugart 810** 8" SS HH *Brand New*	£195.00(E)
8" **Shugart 851** 8" double sided refurbished & tested	£250.00(E)
Mitsubishi M2894-63 8" double sided *NEW*	£275.00(E)
Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

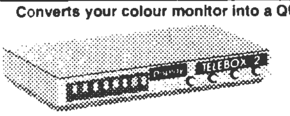
HARD DISK DRIVES

End of line purchase scoop! *Brand new* **NEC D2246** 8" 85 Mbyte drive with **industry standard SMD interface**, replaces Fujitsu equivalent model. Full manual. Only **£299.00 or 2 for £525.00** (E)

3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95(C)
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv.)RFE	£59.95(C)
3½" **CONNER** CP3044 40mb IDE I/F (or equiv.)RFE	£69.00(C)
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3½" **WESTERN DIGITAL** 850mb IDE I/F ***Brand New***	£185.00(C)
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95(C)
5¼" **HP 9754B** 850 Mb SCSI RFE tested	£89.00(C)
5¼" **HP C3010** 2 Gbyte SCSI ***differential*** RFE tested	£195.00(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)
Hard disc controllers for MFM , IDE, SCSI, RLL etc. **from**	**£16.95**

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
*CABLE COMPATIBLE **

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. The composite video output will also plug directly into most video recorders, allowing reception of **TV channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies VHF and UHF **including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor or **desktop computer video systems.** For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

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 reception Telebox MB should be connected to a cable type service. Shipping code on all Teleboxe's is (B)

DC POWER SUPPLIES

Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock Call for info / list.

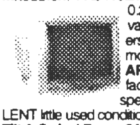
IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK
6,000,000 items EX STOCK
For ***MAJOR*** **SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST**

VIDEO MONITOR SPECIALS

One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

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 **Only £119** (E) **Order as MITS-SVGA**
VGA cable for IBM PC included.
External cables for other types of computers CALL

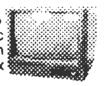
As New - Used on film set for 1 week only!! 15" 0.28 SVGA 1024 x 768 res. colour monitors. Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

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 £95** (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)



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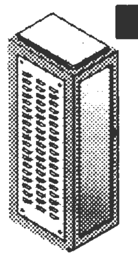

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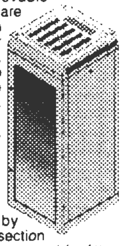

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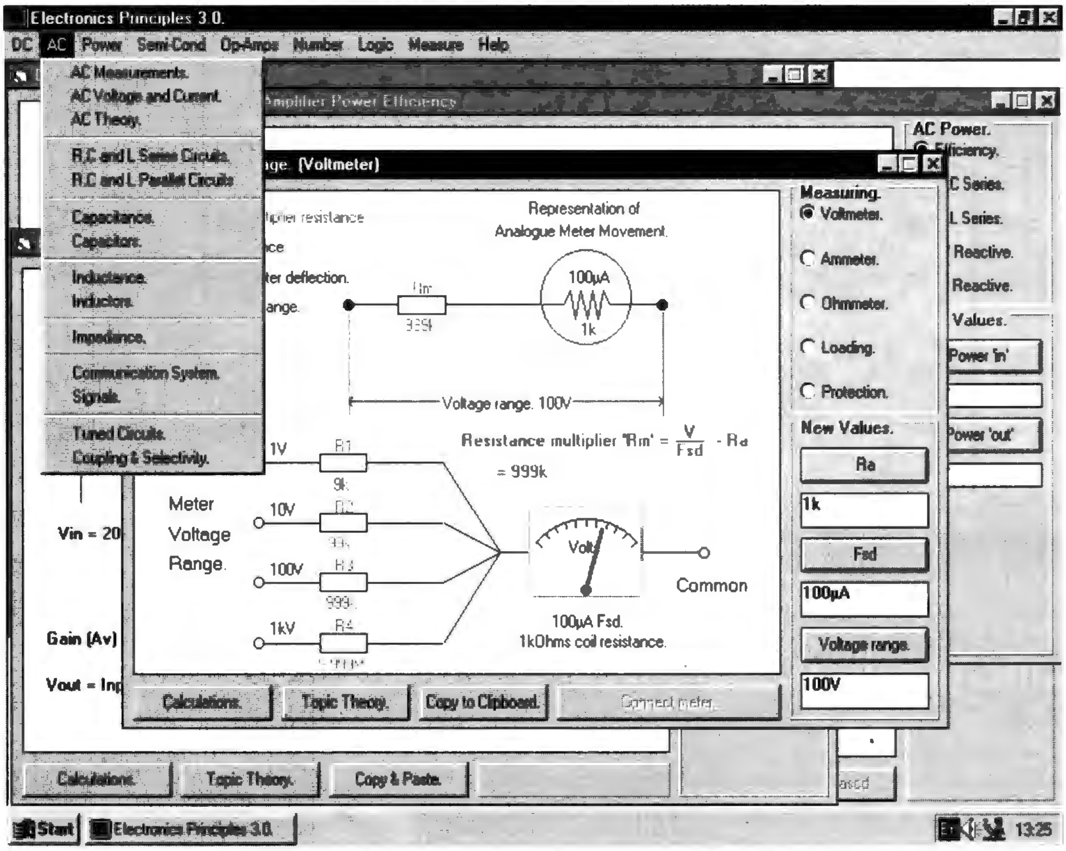

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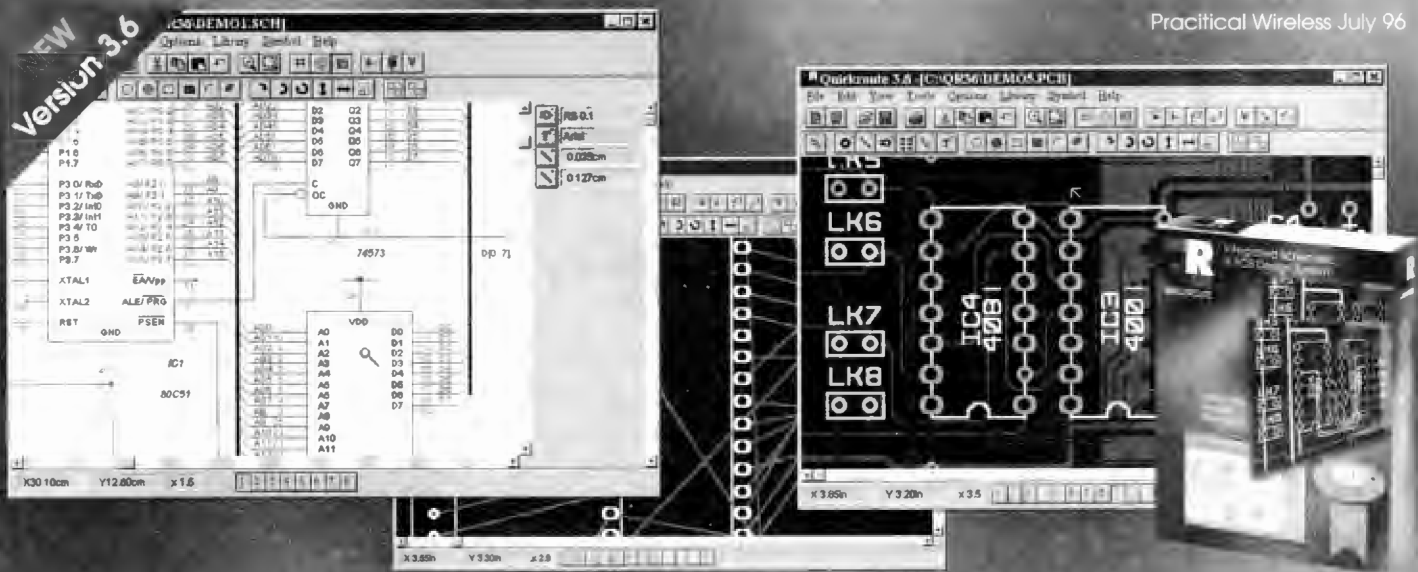

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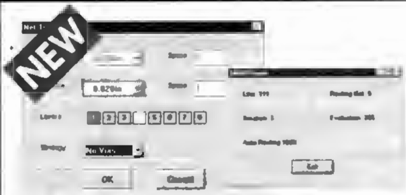

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SMARTRoute is a new 32-bit autorouter from Quickroute Systems rated in ' category A' by Electronics World (Nov 96). SMARTRoute plugs straight into Quickroute 3.6, automatically updating Quickroute' s menus with new features and tools.

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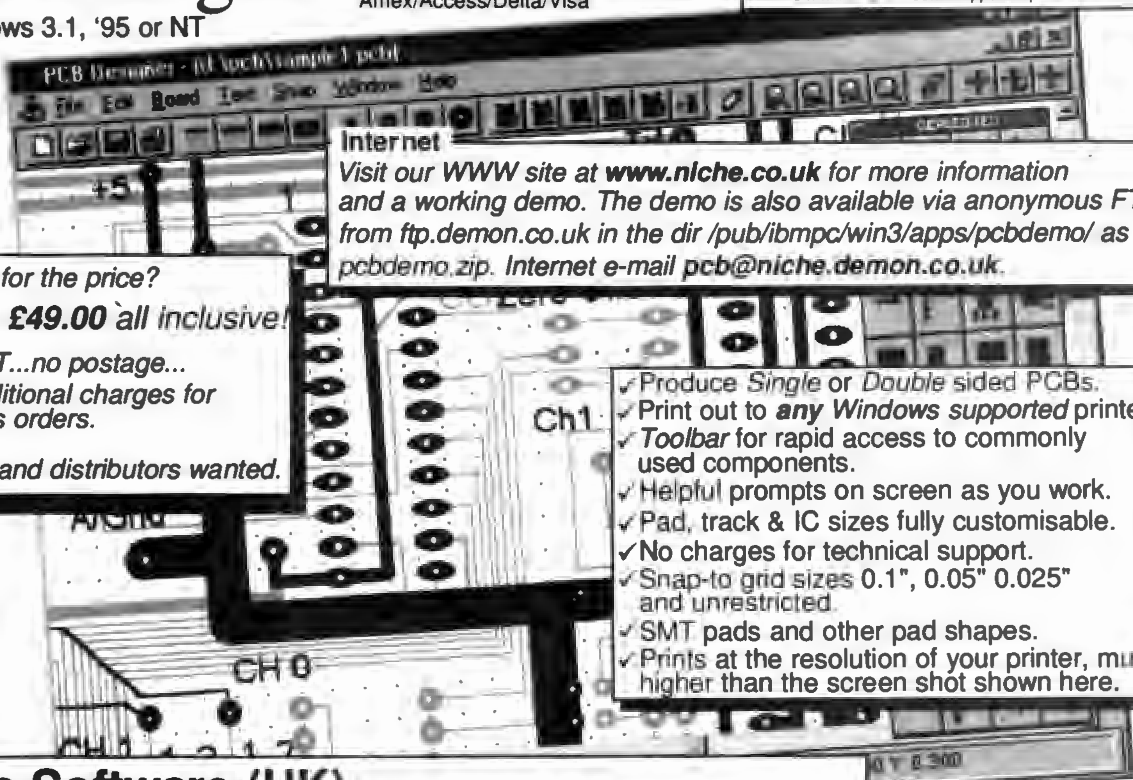

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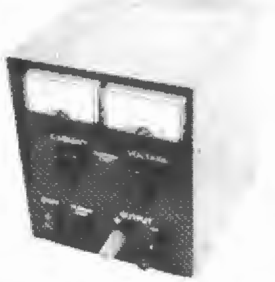

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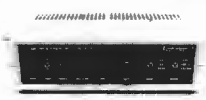

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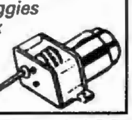

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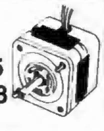

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Power Supply £3.99

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★ Chip is pre-programmed with demo display ★

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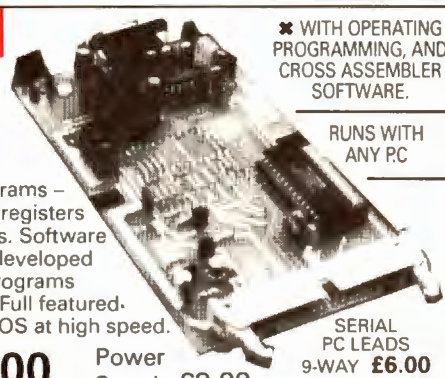

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EL2030CN	£5.67	ULN2003	£0.52
ICL7106	£2.95	ULN2004A	£0.48
ICL7611DCP	£1.06	ULN2803	£0.90
ICL7621	£1.70	ULN2804A	£1.64
ICL8038	£4.89	ULN2806	£1.20
ICM7555	£0.36	XR2206	£5.37
ICM7556	£0.98	ZN414Z	£1.16
L165V	£3.98	ZN416E	£1.99
L272M	£1.86	ZN1034E	£3.11
L293E	£4.35	**EPROM's**	
L297	£6.37	2716	£4.74
L298	£6.99	2732	£4.84
L6219	£4.48	2764-25	£4.20
LF347N	£0.46	27C64-25	£3.44
LF351N	£0.43	27C010	£5.74
LF353N	£0.42	27128-20	£4.08
LF356	£0.84	27C128-20	£4.08
LM301A	£0.25	27256-20	£4.85
LM308N	£0.58	27C256-20	£3.68
LM311N-8	£0.32	27C512	£3.42
LM318	£0.98	**RAM**	
LM319N-14	£0.90	4164-15	£1.90
LM324	£0.24	6116-10	£1.53
LM335Z	£1.52	6264-10	£3.16
LM339N	£0.24	41256-10	£2.80
LM348N	£0.31	62256-10	£4.22
LM358N	£0.27	511000-8	£8.54
LM377	£2.57	514256-8	£6.80
LM380N	£0.88	**A/D Converters**	
LM381N	£2.64	**Data Acquisition**	
LM386	£0.79	AD420AN	£25.38
LM392N	£0.79	AD557JN	£8.75
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LM709T	£0.79	AD775JN	£18.48
LM733	£1.04	AD7226KN	£25.69
LM748CN-8	£0.37	AD7528JN	£8.63
LM759CP	£3.38	AD7545AKN	£14.04
LM1458	£0.37	AD7828KN	£20.33
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LM3900N	£0.72	ZN425E	£5.94
LM3909N	£1.76	ZN426E	£3.13
LM3914	£2.30	ZN427E	£9.25
LM3915	£2.70	ZN428E	£5.94
LM13600	£1.66	ZN448E	£7.50
LMC660CN	£2.16	**Voltage**	
LMC6032IN	£1.55	**Regulators**	
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LP324N	£0.67	7808	£0.50
LP339N	£0.73	7812	£0.38
LT1013CN8	£2.99	7815	£0.38
LT1014CN	£10.20	78L05	£0.23
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MAX222CPE	£5.06	78L24	£0.39
MAX232CPE	£1.80	78S05	£0.98
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MAX485CP	£2.58	78S15	£0.98
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MAX635ACP	£4.99	7912	£0.30
MC1488	£0.39	7915	£0.38
MC1489	£0.39	7924	£0.38
MC3302	£0.56	79L05	£0.23
MC3340P	£1.60	79L12	£0.23
MC4558P	£0.36	79L15	£0.28
MV601DP	£2.97	79L24	£0.30
NE521N	£6.39	ADM666AN	£3.44
NE531	£1.47	L200CV	£1.30
NE555N	£0.25	L296	£6.87
NE556N	£0.36	L387A	£3.24
NE565	£1.84	LM2940CT	£2.30
NE566N	£0.90	LM317T	£0.50
NE567N	£0.39	LM323K	£2.84
NE571N	£2.47	LM334Z	£1.35
NE592	£0.62	LM337T	£0.68
NE5532N	£0.60	LM338K	£5.52
NE5534N	£0.64	LM723	£0.29
NE5539N	£4.35	LP2950CZ	£2.70
NE5560N	£2.31	REF01CP	£3.44
OP07CN	£1.42	REF02CP	£4.66
OP27CN	£2.90	REF12Z	£1.28
OP77GP	£2.36	REF195GP	£4.72
OP90GP	£3.11	REF25Z	£1.24
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OP113GP	£3.44	TL431CP	£0.45
OP176GP	£2.09	ZN423	£1.55
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OP200GP	£5.60	**Diodes**	
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OP282GP	£2.27	1N4001	£0.06
OP283GP	£5.20	1N4002	£0.07
OP290GP	£5.40	1N4003	£0.07
OP297GP	£5.74	1N4004	£0.07
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RC4136	£1.00	1N4007	£0.08
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SG3524N	£0.96	1N4149	£0.06
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SSM2017P	£3.38	1N5404	£0.11
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SSM2141P	£4.21	1N5407	£0.14
SSM2142P	£6.40	1N5408	£0.15
SSM2143P	£3.78	BA157	£0.10
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TBA800	£0.70	BA159	£0.10
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BRY39	£1.30	BC178	£0.18
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2N1711	£0.26	BC182	£0.11
2N1893	£0.29	BC182A	£0.11
2N2218A	£0.28	BC182B	£0.12
2N2219A	£0.25	BC182L	£0.08
2N2222A	£0.18	BC182LB	£0.08
2N2646	£1.12	BC183	£0.08
2N2904A	£0.25	BC183L	£0.08
2N2905A	£0.25	BC183LB	£0.08
2N2907	£0.20	BC184	£0.08
2N2907A	£0.20	BC184L	£0.08
2N2926	£0.16	BC186	£0.33
2N3053	£0.27	BC204C	£0.72
2N3054	£0.85	BC206B	£0.72
2N3055	£0.58	BC207B	£0.74
2N3439	£0.62	BC208	£0.72
2N3440	£0.50	BC209A	£0.72
2N3702	£0.09	BC212	£0.08
2N3703	£0.10	BC212L	£0.08
2N3704	£0.10	BC212LB	£0.08
2N3705	£0.10	BC213	£0.08
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2N3771	£1.44	BC213LC	£0.08
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2N3820	£0.66	BC237B	£0.09
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2N5551	£0.11	BC307	£0.10
2N6107	£0.60	BC308	£0.10
2N6491	£1.58	BC319C	£0.13
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2SD1730	£1.44	BC327-25	£0.10
AC126	£0.44	BC328	£0.10
AC127	£0.50	BC328-16	£0.10
AC128	£0.40	BC337	£0.10
AC187	£0.48	BC337-25	£0.12
AC188	£0.48	BC338	£0.10
ACY17	£3.84	BC338-25	£0.10
		BC348B	£0.14
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BC463	£0.29	BF244	£0.35
BC478	£0.32	BF244B	£0.40
BC479	£0.32	BF244C	£0.35
BC490	£0.24	BF257	£0.33
BC516	£0.22	BF259	£0.33
BC517	£0.17	BF337	£0.40
BC527	£0.20	BF355	£0.38
BC528	£0.20	BF423	£0.13
BC537	£0.20	BF451	£0.19
BC546B	£0.08	BF459	£0.33
BC546C	£0.08	BF469	£0.36
BC547B	£0.09	BFX29	£0.29
BC547C	£0.09	BFX84	£0.31
BC548C	£0.08	BFX85	£0.32
BC549C	£0.10	BFY50	£0.30
BC550C	£0.10	BFY51	£0.25
BC556A	£0.08	BFY52	£0.28
BC557B	£0.08	BS107	£0.21
BC557C	£0.08	BS170	£0.23
BC558C	£0.08	BSW66	£1.35
BC559C	£0.08	BU126	£1.32
BC560A	£0.09	BU205	£1.41
BC560B	£0.09	BU208A	£1.24
BC637	£0.21	BU326A	£1.40
BC638	£0.21	BU500	£1.54
BC639	£0.21	BU508A	£0.98
BC640	£0.21	BU508D	£1.44
BCY70	£0.22	BU526	£1.74
BCY71	£0.20	BU806	£1.06
BCY72	£0.20	BUT11A	£1.30
BD124P	£6.86	BUT11AF	£1.30
BD135	£0.21	BUX84	£0.78
BD136	£0.21	IRF540	£1.26
BD137	£0.23	IRF740	£1.80
BD138	£0.22	MJ2501	£1.60
BD139	£0.25	MJ3001	£1.80
BD140	£0.25	MJ11015	£2.45
BD150C	£0.82	MJ11016	£2.56
BD165	£0.42	MJE340	£0.40
BD166	£0.35	MJE350	£0.48
BD187	£0.39	MPSA05	£0.14
BD201	£0.40	MPSA06	£0.12
BD202	£0.40	MPSA13	£0.12
BD203	£0.40	MPSA42	£0.17
BD204	£0.40	MRF475	£7.28
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BD225	£0.42	TIP30C	£0.37
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BD237	£0.32	TIP32C	£0.41
BD238	£0.44	TIP33C	£0.72
BD240C	£0.37	TIP41A	£0.44
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BD244A	£0.53	TIP47	£0.48
BD244C	£0.53	TIP48	£0.62
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BD536	£0.65	TIP3055	£0.70
BD581	£0.62	VN10KM	£0.48
BD597	£0.92	ZTX300	£0.16
BD646	£0.52	ZTX500	£0.16
BD648	£0.52		
BD650	£0.53		
BD707	£0.42		
BD708	£1.04		
BD807	£0.80		
BDX32	£1.78		
BDX33C	£0.56		
BDX34C	£0.50		
BDX53C	£0.47		
BDX54C	£0.50		
BF180	£0.31		
BF182	£0.31		

No Minimum Order Value

SAMEDAY DESPATCH

Quality Components

μF	Electrolytic Radial 16v	25v	40v	63v	100v	Electrolytic Axial 16v	25v	40v	63v	100v	250v	450v
0.47	---	---	---	£0.05	---	---	---	---	---	---	---	---
1.0	---	---	---	£0.05	£0.05	---	---	---	£0.13	---	---	£0.22
2.2	---	---	---	£0.05	---	---	---	---	£0.13	---	---	£0.30
4.7	---	---	£0.05	£0.05	£0.05	---	---	---	£0.13	---	---	£0.41
10	£0.05	£0.05	£0.05	£0.05	£0.09	£0.12	---	£0.12	£0.13	£0.17	£0.40	£0.51
22	£0.05	£0.05	£0.05	£0.07	£0.11	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	£0.05	---	£0.05	---	---	---	---	---	---	---	---	---
47	£0.05	£0.05	£0.07	£0.10	£0.19	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	---
100	£0.06	£0.06	£0.10	£0.13	£0.26	£0.14	£0.16	£0.19	£0.26	£0.44	---	---
220	£0.08	£0.09	£0.13	£0.25	---	£0.19	£0.20	£0.27	£0.39	£0.48	---	---
330	£0.09	---	£0.19	---	---	---	---	---	---	---	---	---
470	£0.12	£0.17	£0.24	£0.33	---	£0.24	£0.28	£0.43	£0.53	---	---	---
1000	£0.15	£0.33	£0.34	---	---	£0.33	£0.43	£0.59	£1.08	---	---	---
2200	£0.27	£0.55	£0.70	---	---	£0.53	£0.66	£1.11	£1.55	---	---	---
3300	---	£0.94	---	---	---	---	---	---	---	---	---	---
4700	£0.67	£1.05	---	---	---	£0.86	£1.11	---	---	---	---	---

Ceramic Mini Disc
1.0,1.2,1.5,1.8,2.2,2.7,3.3,3.9,4.7,5.7,6.8,8.2
1.0pF to 22nF 100V £0.06
47nF & 100nF 50V £0.07

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10,22,33,47 and multiples.

10pF to 100nF 100V	£0.10
220nF 100V	£0.14
330nF 100V	£0.16
470nF 100V	£0.22
1.0μF 100V	£0.29

Full Technical Specification available

Resistors - Please State Value Required

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½W Carbon Film 5%	E12 Series	1Ω-10M	£0.02 Each, £0.95 per 100
1W Carbon Film 5%	E12 Series	1Ω0-10M	£0.07 Each, £3.90 per 100
2W Carbon Film 5%	E12 Series	1Ω0-10M	£0.12 Each, £5.99 per 100
2.5W Wirewound 5%	E12 Series	0Ω1-220Ω	£0.23 Each

per 100 of one value only

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Multiturn, 19mm Long, End Adjust.	E3 50Ω-2M0 0.5W	£0.64 Each

Potentiometers - Please State Value Required

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Dual Gang - ¼" Shaft, 20mm Dia.	1K0-2M2 Linear	£1.62 Each
Dual Gang - ¼" Shaft, 20mm Dia.	1K0-2M2 Logarithmic	£1.71 Each
Switched - ¼" Shaft, 20mm Dia.	1K0-2M2 Linear	£1.56 Each
Switched - ¼" Shaft, 20mm Dia.	1K0-2M2 Logarithmic	£1.69 Each
PCB Mount, Splined Shaft, 16mm Dia.	470Ω-1M0 Linear	£0.42 Each
PCB Mount, Splined Shaft, 16mm Dia.	470Ω,4k7,100k,1M0 Log	£0.42 Each
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Dual PCB, Splined Shaft, 16mm Dia.	10k,50k,100k,500k Logarithmic	£0.85 Each

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COMPLEXITY

Everyday news on new high tech. instruments lands on my desk; as equipment gets more and more complex and relies more on large-scale dedicated chips, it seems that there is less that the hobbyist can build. You only need to read the *MPEG2 Digital Television* feature in this issue to realise how complex such a system will be. There is no way that most modern equipment can be built by the hobbyist for less than the cost of buying the ready-made unit, whether it is hi-fi, TV, video, computers or communications equipment like mobile phones or amateur band transceivers. So how do we continue to pursue our hobby?

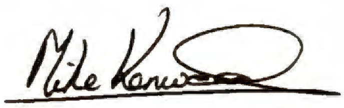
There are still plenty of unusual projects that can be built by the hobbyist for less than commercial items – mainly because there is only a small market for them, or because they are new ideas and prices have not yet fallen. This issue is an example of such projects. On the very simple side is the *Puppy Puddle Probe* – it's easy to build, useful and demonstrates some very simple electronics well. Rather more refined is the *Midi Matrix* which solves a very real problem, for those with MIDI set-ups, in an elegant way, relatively inexpensively.

TAKE YOUR PIC

The other side of the coin is demonstrated by our *PIC-Agoras* project. You can buy a bike computer for much less, but *PIC-Agoras* is very versatile, can be tailored to use with a wide range of wheel sizes and could even be adapted to measure say skateboard speed. While you *could* compare it with a commercial bike computer it can be used for a variety of tasks which are well outside the capabilities of any commercial product.

If you want a job within the electronics industry – maybe designing some of those highly complex systems I mentioned earlier – then you must start somewhere. Our simple projects, *Teach-In* series and other educational items have led many a reader into a rewarding career in electronics.

I believe there will always be room for the electronics hobbyist and a need for our type of magazine, even in today's computer dominated world. What could be more satisfying than building your own equipment, just for the sake of it? Maybe it will never compete on price with commercial products but the pleasure, knowledge and satisfaction gained are well worth the effort. Perhaps the word that best describes our hobby is *Ingenuity*.



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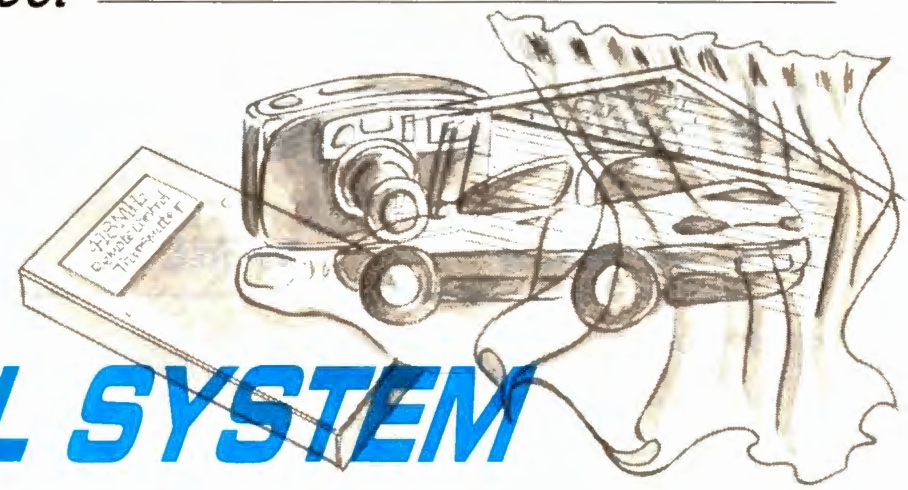


418MHz REMOTE CONTROL SYSTEM

ROBERT PENFOLD

You do not need a licence to use this coded transmission and reception control system, and it's easy to build using pre-aligned modules.

THE frequency of the 418MHz Band has been allocated to licence-exempt radio links, and its main use is probably for remotely switching intruder alarms on and off. It is open for use in other applications though, and there must be many potential uses for this type of radio link.

Transmission powers are very low, however, and only simple aerials are permitted at the transmitter. This limits the maximum operating range to about 100 to 200 metres in open terrain, or about 30 metres if the signal has to pass through buildings. While this precludes the use of 418MHz links in some applications, there are many situations where this sort of range is perfectly adequate.

For example, a camera remote control system is normally used over a range of about five to 100 metres. "Wireless" serial data links for computers also operate over a similar range.

It is not practical for the home constructor to produce 418MHz radio equipment, as it would not be possible to get the equipment approved by the radio authorities. On the other hand, it is possible to produce systems based on ready-made transmitter and receiver modules which have DTI approval, and meet the relevant standards.

Ready-made 418MHz modules are not exactly "dirt cheap", but prices have fallen to the point where they are now a practical proposition for the average electronics experimenter. The basic remote control system featured here uses commercially produced 418MHz transmitter and receiver modules that provide an operating range of up to about 100 metres in open terrain.

The use of ready-built modules means that the completed system requires no setting up or alignment of any kind, and **it can be used legally without having to obtain an operating license.**

SYSTEM OPERATION

The block diagram of Fig. 1 helps to explain the way in which the system functions. The transmitter is the more simple of the two units, and the transmitter module itself is basically just an oscillator and a lowpass filter to give a "clean" output signal. The very low power levels involved here do not warrant the use of a power amplifier stage.

Some simple audio processing at the audio input prevents any form of over-modulation. The type of modulation used is wide band frequency modulation (w.b.f.m.), which is the same type that is used for Band II broadcast transmissions.

On the face of it, the transmitter can consist of nothing more than the transmitter module, a battery, and a pushbutton to provide on/off switching. In reality such a basic system would be vulnerable to frequent spurious operations.

The problem is simply that there is only one channel available. A system that relies on basic switching of the carrier will be activated by the carrier wave from any nearby 418MHz transmitter. Your remote controlled curtains (or whatever) could operate every time a neighbour switches their car alarm on or off!

The solution to the problem is to transmit a digitally encoded carrier signal, and to have a receiver that will only respond to a correctly coded signal. Special chips to provide the encoding and decoding are readily available. The transmitter chip is fed with a 12-bit binary code, which gives a choice of 4096 different code combinations. The 12-bit code is converted to a form of serial signal which is at a low enough baud rate to be handled by the 418MHz transmitter and receiver modules.

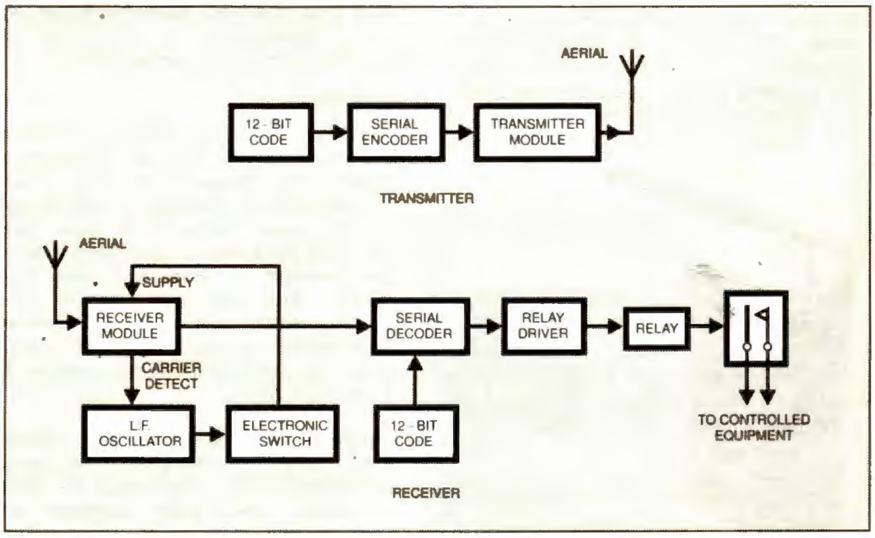


Fig. 1. The 418MHz Remote Control System block diagram.

At the receiver, the decoder converts the serial signal back into 12 bits of parallel data, and compares the decoded signal with the 12-bit binary pattern on its inputs. Provided the same 12-bit code is used at the transmitter and the receiver, the two codes will match, and the decoder chip will set its output terminal high.

This technique does not absolutely guarantee that the system will be free from spurious operations, but unwanted activation of the receiver can only be caused by a nearby transmitter using the right one of the 4096 codes, and the same method of serial encoding. This is unlikely to occur in practice, but if necessary the code number can be changed to one that is free from interference.

The receiver module is relatively complex, and it is actually a form of double conversion superhet receiver. Its sensitivity is good, with an input of 0·5µV giving a 20dB signal-to-noise ratio. The receiver has three outputs, one of which is an audio output. This is useful for monitoring the transmitter, but is otherwise unused.

The main output is a processed audio signal which provides a "squared" version of the audio signal that can directly drive the serial input of the decoder chip. When a suitable signal is received, the output of the decoder goes high, switching on a relay via a simple driver circuit. A pair of relay contacts then closes and activates the controlled equipment.

When the signal from the transmitter ceases, the serial decoder no longer receives a valid signal, and its output goes low again. Therefore, the relay is only switched on while the transmitter is switched on.

CONSERVING BATTERIES

Since the receiver module only consumes about 13 milliamps from a 6V supply, battery operation is possible. As the receiver may be required to operate for very long periods, a lower current consumption would be preferable though. This can be achieved by pulsing the receiver module under standby conditions, rather than having it run continuously. This mode of operation is made possible by the third output of the receiver module, which can operate an external switching transistor when a carrier signal is detected.

The basic idea is to have a low frequency oscillator which controls the power to the receiver module via an electronic switch. The module is switched on and off several times a second, and in this case it is switched at a rate of about 25 times per second. A crucial factor here is that the "on" time is made something under one tenth of the "off" time.

With the receiver module turned off for the majority of the time its current consumption is greatly reduced, and is typically a little over one milliamp. The overall current consumption of the circuit is a little higher at around two milliamps, but this is low enough to give over 1000 hours of continuous operation from each set of four HP7 size batteries.

Of course, this pulsed method of operation only operates properly if the receiver

Completed Receiver and Transmitter

latches in the "on" state once a signal is received. This latching is provided by the "carrier detect" output and the switching transistor it controls. It would be preferable if the latching was provided via the output of the decoder. Then the receiver would only latch on when a valid code number was received, rather than when any carrier signal was picked up.

Using the decoded output tends to slow things down though, possibly giving a perceptible delay between the transmitter being activated and the relay contacts closing. Using the carrier detection method there is still a delay through the system, but it is too short to be apparent to the user, and will not be significant in most applications.

TRANSMITTER CIRCUIT

In Fig. 2 is shown the circuit diagram for the 418MHz Remote Control Transmitter, which is based on a Radio-Tech TXM-418-A transmitter module. This module requires a supply potential of between six and 12 volts, and here a 9V battery supply is used.

Switch S1 is the on/off control, and C1 is the supply decoupling capacitor. The aerial is a simple home constructed helical type, which gives good performance despite its very small size.

The serial encoder chip is an HT-12E (IC1). This has a built-in clock generator that requires only one discrete component, which is timing resistor R1. The serial output at pin 17 of IC1 can directly drive the modulation input of the transmitter module. The audio input of the transmitter has built-in lowpass filtering, etc. that prevents any out-of-band signals being radiated.

Pin 14 of IC1 is taken high to inhibit transmission on the serial output, or low to enable it. In this application, IC1 must produce a serial signal whenever the transmitter is switched on, and pin 14 of IC1 is therefore permanently connected to the 0V rail. The required 12-bit binary code is hard-wired via link wires on the printed circuit board. Each address input must be connected to a high ("H") or low ("L") terminal on the p.c.b.

Typical current consumption of the transmitter is about 11 milliamps, but it can be as high as 16 to 17 milliamps. A PP3 size battery is adequate to power the circuit despite this relatively high consumption, because the transmitter will normally be used only in very short and intermittent bursts.

REMOTE CONTROL TRANSMITTER

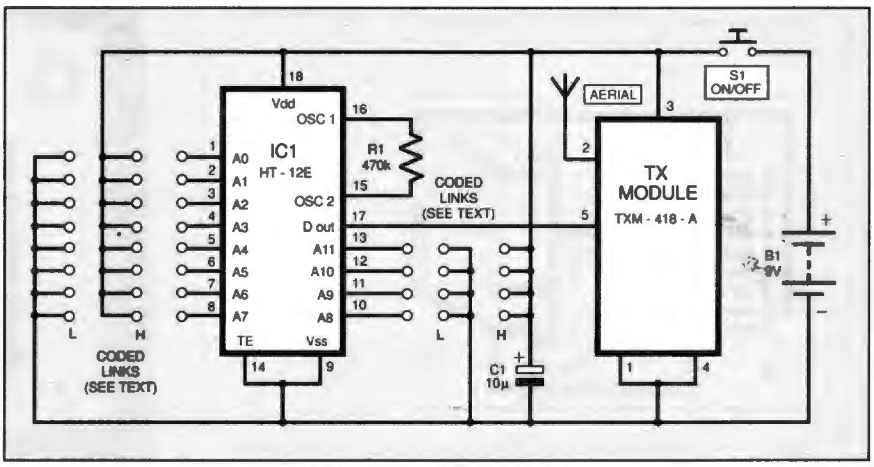


Fig. 2. Circuit diagram for the 418MHz Transmitter.

TRANSMITTER CONSTRUCTION

Details of the transmitter printed circuit board are provided in Fig. 3. This board is available from the *EPE PCB Service*, code 142.

Although this board is very simple, there are several points that are worthy of amplification. IC1 is a CMOS device, and accordingly it requires the usual anti-static handling precautions. Use a holder for IC1, and do not fit it into place until the unit is otherwise complete. Try to touch the pins as little as possible when fitting IC1 into place, and keep it well away from any likely sources of static electricity (computer monitors, static-prone carpets, etc.).

The binary code used on the prototype is 000000001111, and this is the code shown in Fig. 4. Obviously you can use any one of the 4096 available codes, but make sure that every common ("C") pad is connected to *either* a high ("H") *or* a low ("L") pad. If there are problems with interference from other 418MHz transmitters once the system is "up and running", there should be no difficulty in rewiring one of the links to try a new code. Remember to temporarily remove IC1 from the board while the change is made.

Capacitor C1 must be a high quality component that will work well at high frequencies. It can be either a tantalum capacitor or a high quality radial electrolytic type. A "bog standard" electrolytic might not give good performance in this application.

The transmitter module is mounted on the board vertically, and due to its asymmetric base it will only fit the right way round. Fit four single-sided solder pins to the board at the positions where connections will be made to switch S1 and the battery clip.

COMPONENTS

TRANSMITTER

See SHOP TALK Page

Resistor
R1 470k 0·25W 5% carbon film

Capacitor
C1 10µ high quality radial elect., or tantalum, 25V

Semiconductor
IC1 HT-12E 12-bit serial encoder

Miscellaneous
TX TXM-418-A 418MHz transmitter module (Radio-Tech).
S1 push-to-make switch
B1 9V battery (PP3 size)

Printed circuit board, available from the *EPE PCB Service*, code 142; plastic case about 105mm × 61mm × 28mm; PP3 type battery connector; 18-pin d.i.l. socket; 24 s.w.g. (0·56mm) enamelled copper wire for aerial; wire; solder, etc.

Approx Cost Guidance Only £25 excluding Batt.

AERIAL

To remain within the regulations, the transmitter must only be used with a simple aerial that does not provide gain. This gives a choice of three basic types which are helical, whip, and loop. These each have their advantages and drawbacks, but for most purposes a helical aerial is probably the best choice. It offers reasonable efficiency together with small size. In fact a helical aerial is small enough to be mounted on the p.c.b., just like any other component.

The aerial is home constructed, and it merely consists of 26 turns of 24 s.w.g. (0·56mm diameter) enamelled copper wire wound on a temporary 3·5mm diameter former (e.g. the shank of a 3·5mm twist drill). The coil should be about 25mm long initially, but once the system is working it can be expanded and contracted in an attempt to find the optimum length.

Leave a few millimetres of excess wire at one end of the coil to form a leadout wire, and scrape the insulation from this lead using a modelling knife or miniature file. "Tin" the leadout wire with a small amount of solder, and it should then connect easily and reliably to the printed circuit board.

Ideally, the aerial should be mounted where it is well clear of any metal objects, but this is not really possible if the transmitter is to be kept reasonably small. More than adequate performance seems to be obtained even with the aerial in close proximity to printed circuit tracks and other pieces of metal. However, the transmitter will not work with the aerial within a metal case.

CASE

The prototype transmitter is housed in a small plastic box having a built-in compartment for the PP3 size battery. At about 105mm × 61mm × 28mm this case is somewhat larger than is really necessary, but it is still quite "pocketable". The printed circuit board is mounted on the top half of the case, at the opposite end to the battery compartment, using 6BA or metric M3 nuts and bolts. Use short spacers or extra nuts between the case and the board, or the board might distort and crack as the mounting nuts are tightened.

Switch S1 is mounted on the top panel of the case so that it fits into the vacant area between the battery and the circuit board.

To complete the transmitter, wire the battery clip and S1 to the four solder pins, and fit IC1 into its holder. To be within the regulations, the transmitter must have a label affixed to the case which has the wording "MPT 1340 W.T. Licence Exempt" (see Fig. 4). The lettering should be no less than two millimetres high.

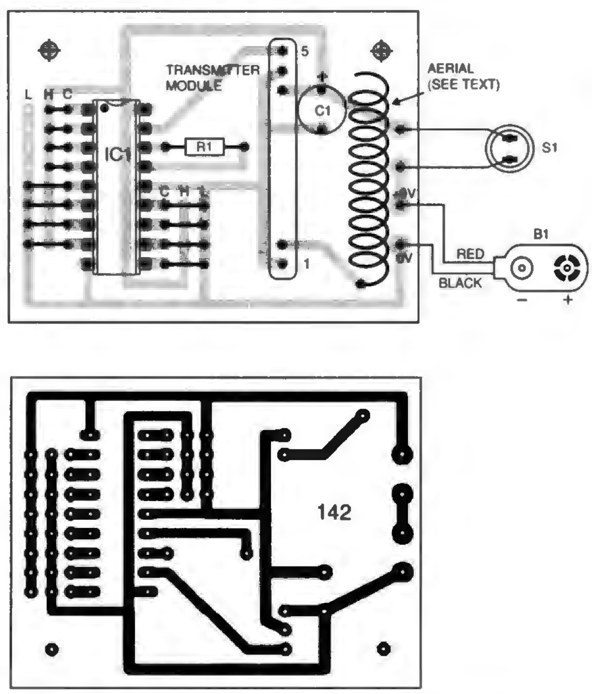
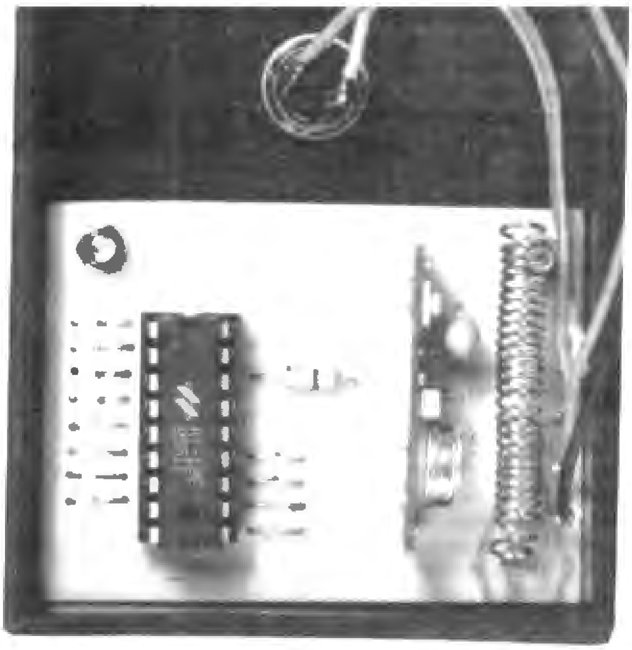


Fig. 3. Transmitter printed circuit board component layout, interwiring and full size copper foil master.

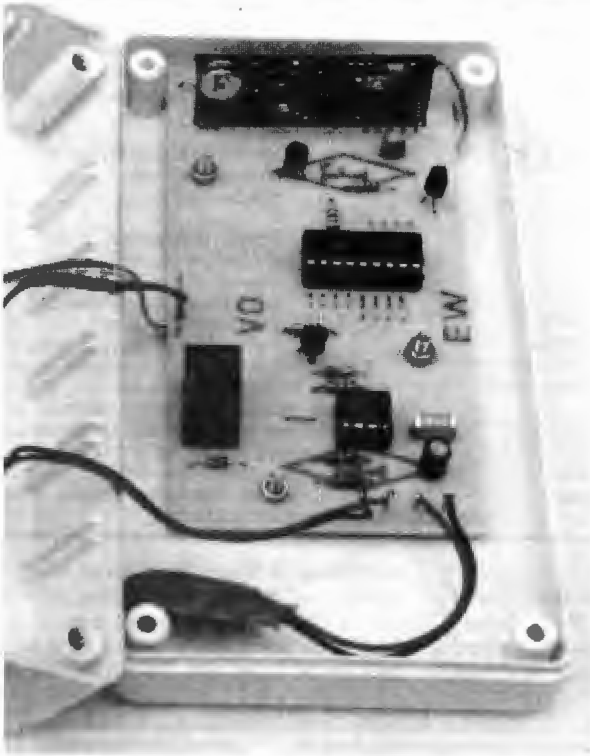
MPT 1340
W.T. LICENCE
EXEMPT

Fig. 4



Layout of components on completed Transmitter board.

REMOTE CONTROL RECEIVER



The completed Receiver board mounted in the base of the case.

RECEIVER CIRCUIT

The circuit diagram for the 418MHz Remote Control Receiver appears in Fig. 5. This circuit is based on a Radio-Tech applications circuit for the SILRX-418-A receiver module.

As with the transmitter, the aerial is a simple helical type. On the output side of the receiver module, the demodulated audio signal is fed direct to socket SK2. The audio signal can be monitored using a crystal earphone, *but no other type of earphone or headphone should be connected to SK2*.

The "squared" audio signal at pin 7 of the module is fed direct to the serial input at pin 14 of IC1, which is the decoder chip, type HT-12F. This has a built-in clock oscillator which requires only one discrete component, which is timing resistor R2.

Like the encoder, the decoder has the 12-bit binary code set via link wires on the p.c.b. Pin 17 of IC1 goes high when the correct code is received, and this turns on the relay via transistor TR1, used as a common emitter switch. Diode D1 is the usual protection diode which suppresses the high reverse voltage spikes which would otherwise be generated across the relay coil each time it switched off.

IC2 pulses the supply to the receiver module via switching transistor TR3, and the decoupling network comprised of resistor R3 and capacitor C2. The output of IC2 is high while capacitor C3 charges via resistors R4 and R5, and low while C3 discharges through R5 and an internal transistor of IC2. The charge time is therefore about eleven times longer than the discharge time.

Transistor TR3 and the receiver module are switched on during the discharge periods, which gives the required power saving. When a carrier is detected, IC2 latches with its output low, so that TR3 and the receiver module are held switched on. IC2 must be a low power version of the 555 timer, since a standard 555 would consume nearly as much current as it would save!

Transistor TR2 is switched off when a carrier is detected, which results in IC2 latching with its output low due to the coupling through R6 which takes the reset input low. Power is then supplied to the receiver module continuously. Normal standby operation is resumed when the carrier ceases, and TR2 switches off again.

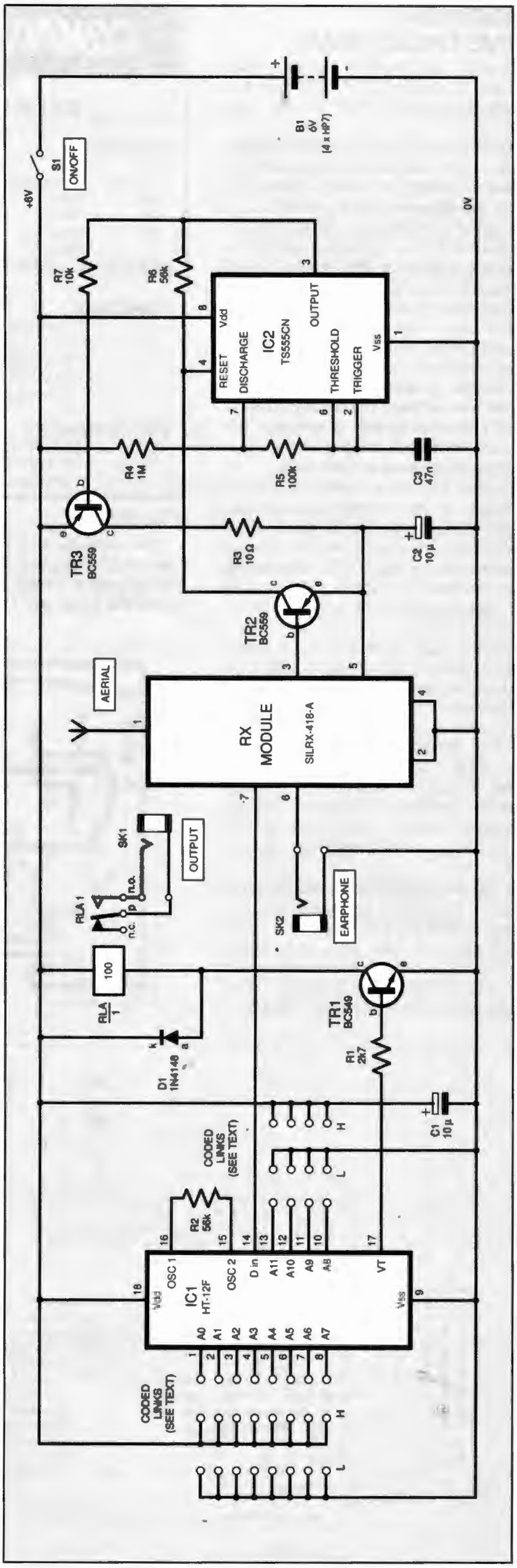


Fig. 5. Complete circuit diagram for the 418MHz Remote Control Receiver.

RECEIVER CONSTRUCTION

Details of the Receiver printed circuit board are shown in Fig. 6. This board is available from the *EPE PCB Service*, code 142.

Both IC1 and IC2 are CMOS devices, so use sockets with them and observe the standard handling precautions. Note that IC2 has the opposite orientation to IC1.

The aerial is identical to the one used in the transmitter. Capacitor C2 should be a tantalum type or a high quality radial electrolytic. When adding the twelve links to set the code number for IC1, make sure that the code used exactly matches the one used on the transmitter. Fig. 6 shows the link-wires for the 000000001111 code used on the prototype system. Do not overlook the ordinary link-wire just above IC2. The receiver module is mounted vertically on the board, making sure its pins are fully pushed down into the board.

The relay can be mounted on the circuit board in the normal way provided the specified component is used. From the electrical point of view, the receiver should work using any 6 volt relay that has a coil resistance of about 100 ohms or more, plus suitable contacts for its intended application.

However, alternative relays are almost certain to have a different pin configuration, and are mostly much larger than the specified relay. This would make it necessary to mount the relay on the case and hard wire it to the printed circuit board. Unless there is a good reason for using an alternative relay it is definitely advisable to use the specified component. This has changeover contacts rated at 2A at 24V d.c. or 240V a.c. (1A with an inductive load).

Be careful to fit diode D1 the right way round. Getting this wrong could result in damage to both D1 and TR1. Once all the components and links have been added, complete the board by fitting single-sided solder pins to take the hard wiring. "Tin" the tops of the pins with plenty of solder.

COMPONENTS

Approx Cost Guidance Only £32 excluding Batts.

RECEIVER

Resistors

R1	2k7
R2, R6	56k (2 off)
R3	10Ω
R4	1M
R5	100k
R7	10k

All 0·25W 5% carbon film

See SHOP TALK Page

Capacitors

C1	10µ radial elect., 25V
C2	10µ high quality radial elect., or tantalum, 25V
C3	47n polyester (7·5mm lead spacing)

Semiconductors

D1	1N4148 signal diode
IC1	HT-12F 12-bit serial decoder
IC2	TS555CN low power CMOS 555 timer
TR1	BC549 *npn* transistor
TR2, TR3	BC559 *pnp* transistor (2 off)

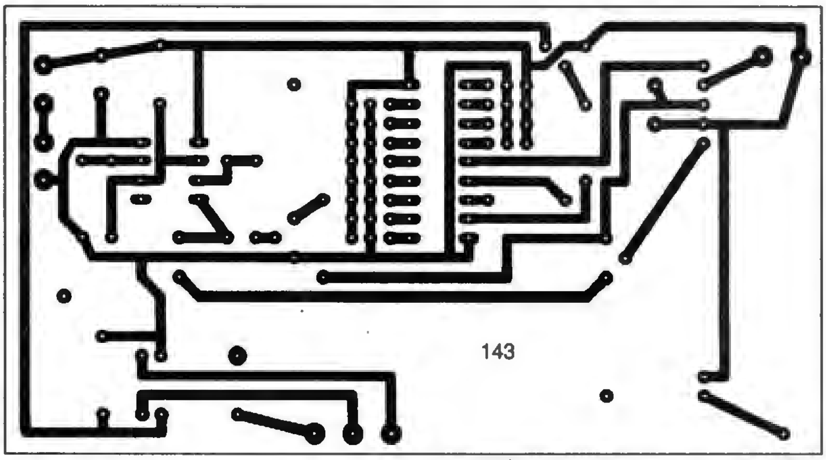
Miscellaneous

RX	SILRX-418-A 418MHz receiver module (Radio-Tech)
SK1, SK2	3·5mm jack socket (2 off)
B1	6V battery (4 × HP7 size cells)
S1	s.p.s.t. min. toggle switch
RLA1	6V 100Ω coil, single changeover contact relay

Printed circuit board, available from the *EPE PCB Service*, code 143; plastic case about 143mm × 82mm × 44mm, 8-pin d.i.l. socket, 18-pin d.i.l. socket; plastic holder for 4 × HP7 size cells; battery connector (PP3 type); 24 s.w.g. (0·56mm) enamelled copper wire for aerial; wire; solder, etc.

CASE

Any medium size plastic case should comfortably accommodate the receiver. Do not use a metal case as this would screen the aerial and prevent the unit from working at all. The printed circuit board is mounted on the rear panel using 6BA or M3 fixings. Fit it well to one side so that there is sufficient space left for the battery pack on the other side. Switch S1 and the



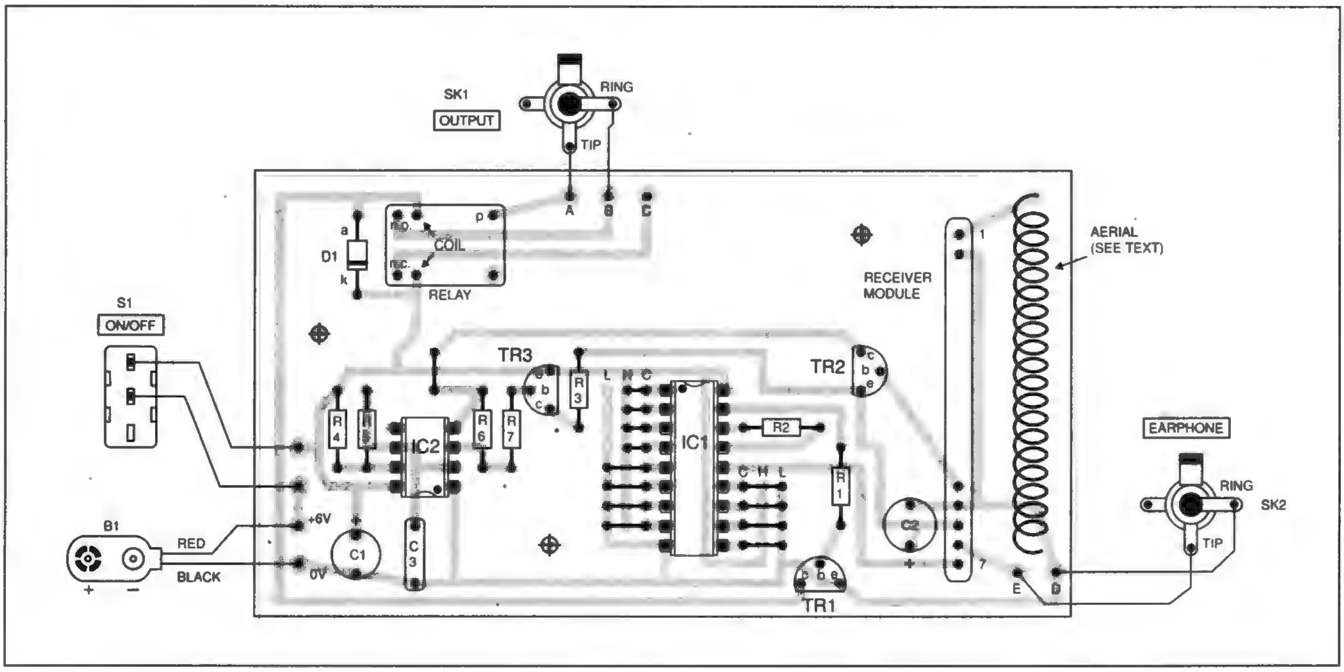


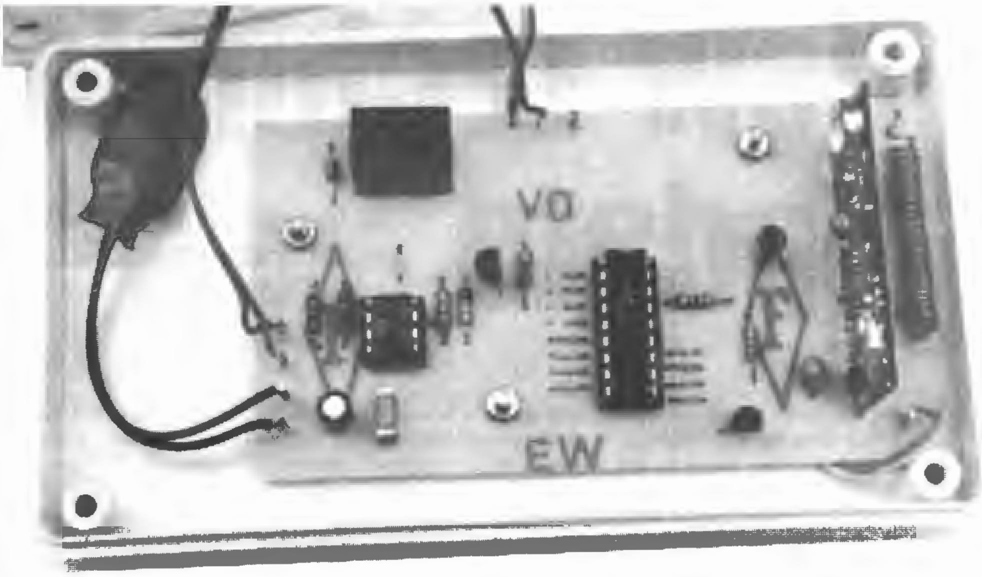
Fig. 6. Receiver printed circuit board component layout, interwiring and full size copper foil master pattern (top).

two sockets, SK1 and SK2, are mounted at any desired places on the front panel, but make sure that they are positioned well clear of the battery pack.

To complete the receiver, add the small amount of hard wiring. This is also shown in Fig. 6. The method of connecting socket SK1 to the relay contacts shown in Fig. 6 is correct if normally open operation is required (i.e. the relay contacts are normally open, and they close while switch S1 at the receiver is closed).

If normally closed operation is needed, connect SK1 to pin "C" on the circuit board instead of pin "B". To complete the unit add the battery connector, which is a standard PP3 type.

Note that in this form the receiver should only be used with battery powered equipment, such as a camera. It should only be used with mains powered equipment if it is constructed and installed by someone with the requisite knowledge and experience, and it must conform to the normal safety standards.



Layout of components on the completed Receiver board. Note that the aerial "lead" on the far right is soldered to the p.c.b. at one end only.

IN USE

As the transmitter and receiver modules are pre-aligned, the completed system should work immediately over a reasonable range. For operation over distances of up to about 10 or 20 metres there will probably be no need to "tweak" the aerials for optimum results.

For operation over longer ranges, it might be necessary to expand/compress the aerials in order to optimise performance. This is really just a matter of using trial and error, but monitoring the audio output signal of the receiver can be helpful. A strong signal gives a "clean" sounding "buzz" having a low background "hiss" level. Weak reception produces a rougher sounding "buzz" with a generally higher background noise level.

For operation at short ranges, the relative orientations of the two aerials seems to be unimportant. At longer operating distances the aerials should both be more-or-less vertical.

Remember that the range of the system will be reduced if it is used within buildings, but the signal from the transmitter seems to be able to penetrate several average internal walls. In this respect a radio control system is far superior to an infra-red type, which cannot operate through anything opaque.

ACKNOWLEDGEMENT

The author thanks Radio-Tech Ltd. for their helpful cooperation with regard to the transmitter and receiver modules used in this design. They are also offering these devices at a specially discounted price to *EPE* readers, see *Shop Talk* page.

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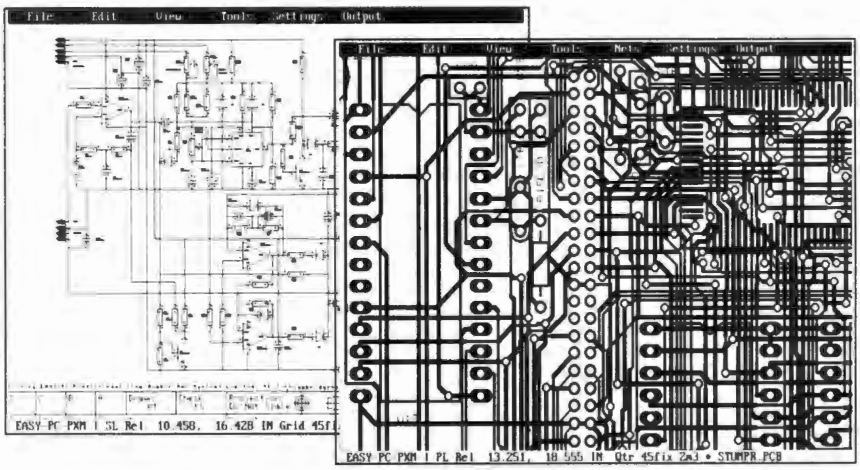

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New Technology Update

As the search for better VDU materials becomes more concentrated, the F.E.D.s seem to have an answer – Ian Poole reports.

IN THE field of electronics, it is often the case that an idea cannot be fully exploited because there is not a complete understanding of the way in which it works. This may appear surprising in view of the enormous advances which have been made in our knowledge of science in recent years. However, as new developments are made, often new principles are involved and time is required before they are fully understood.

It has been the case many times in the past, that an electronic device has been made to work and fulfil a valuable function without a full understanding of its operation. Thermionic valves represent a very good example.

In the early days of their existence it was thought that valves needed a small amount of gas inside their glass envelope for them to be able to operate correctly. Only when an American named Langmuir proved that these gasses were not needed, were fully evacuated or "hard" valves produced and their performance improved by a considerable degree.

The "cat's whisker" was another fine example of an effect which had been noticed and put to good use. However, it took many years before the physics behind it was understood, and progress could be made on making semiconductor diodes in a much more reliable way.

Phosphor Performance

The same is true today about the understanding we have about the way in which materials like phosphors emit light. Although much is known, there is still a lot we do not understand.

Even though these phosphors are the cornerstone upon which the cathode ray tube (c.r.t.) depends, there is still much to be learnt about the mechanics behind this useful phenomenon. Unfortunately, research into material physics is not easy, and can be very costly. Nevertheless it can bring large rewards, especially if new devices can be made in large quantities.

Obviously the limitations in our knowledge of these phosphors has not limited their use in c.r.t.s. Currently, they are still the most widely used type of display, with hundreds of millions of them being manufactured each year.

However, it has brought about a number of problems when they have been used in other applications. In order to make them emit light, large voltages and relatively high powers are needed. Domestic televisions require several kilovolts. The higher the voltage, the brighter the picture can be made.

As most televisions are powered from the mains, this does not present a real problem. However, when small battery powered units are required, this brings far more stringent requirements in terms of power consumption. It is clearly not viable to have a small battery powered unit which consumes the levels of power required by a c.r.t.

L.C.D. Performance

Even though c.r.t.s are not being used in small battery powered pieces of equipment, the new phosphor field emission displays (f.e.d.s) are growing in popularity and are being used increasingly. Although l.c.d.s (liquid crystal displays) can be used in many applications, they have a number of limitations.

They do not perform well in conditions of high ambient light, and sometimes they require the use of a back-light, a factor which itself uses significant amounts of power. They also do not operate at low temperatures, and even at ambient temperatures they have a very slow response time. They are also far too slow for television applications.

Another problem is the small viewing angle. Combined, all of these limitations mean that the l.c.d. is not going to achieve widespread acceptance for applications like television, even though they are used in vast quantities for many other applications, including laptop computers.

However, anyone using a laptop will soon see the shortcomings of the l.c.d., although its low power consumption means that it is the only viable option. If a display with a better performance and lower cost could be devised, the returns on any investment would be vast. Not only would it be used in many computer applications, but if it could be used for televisions this would bring another vast market within its reach.

Investigating F.E.D.s

As a result of the power constraints, it has become more important to investigate methods of improving the efficiency of phosphor f.e.d. displays. As the efficiency of the displays is primarily governed by that of the light conversion, this has recently come under close scrutiny now that a new development initiative has been launched. Funded by the American Government, Sandia Laboratories in Albuqurque, New Mexico are undertaking the research, and they have started to make progress and make some interesting discoveries.

When commencing their study, the researchers decided to concentrate on just one material, a zinc oxide based phosphor. This reduced the number of variables, and allowed the basic theories and methods to be tried on just one substance. Any results could be extended to other materials at a later date, as the same basic principles apply.

The studies showed that light is emitted from areas where there are surface defects, such as missing oxygen atoms. This indicated that the light emission is purely a function of the surface.

Previously it had been thought that the thickness or density of the material had an effect, but this is not the case. Working along these lines, the researchers have changed the chemistry of the test material to alter the surface and they have successfully increased the luminescence.

Laser information

Much of the crucial information about the light emission has been gained from an instrument called a photo-thermal deflection spectroscope. Using this, samples of the phosphor have a liquid introduced into them.

As the mixture is heated, the reflection of a laser beam is noted. The degree of deflection for a given amount of heat passed into the mixture enables a measurement of the optical absorption of the material to be made.

This research will pay large dividends with phosphor based f.e.d.s.. Optimising the phosphors will enable them to operate with much lower voltages, possibly down to less than 0·5kV. This is a considerable reduction when compared to the voltages which were previously required.

It will mean that f.e.d.s will be used in a variety of applications where they may have been too power hungry before. They will be ideal for use in commercial laptop computers. If the f.e.d. can gain a significant foothold in this market it may also start to catch on in other areas as well.

Although there is still more work to be undertaken, the project has already made a valuable contribution to display technology. It is also likely that as different aspects of the phosphors are monitored and investigated, improvements in other areas may be made. Any improvement in our understanding of the way in which these phosphors emit light will enable them to be used more effectively, and give better products for the future.

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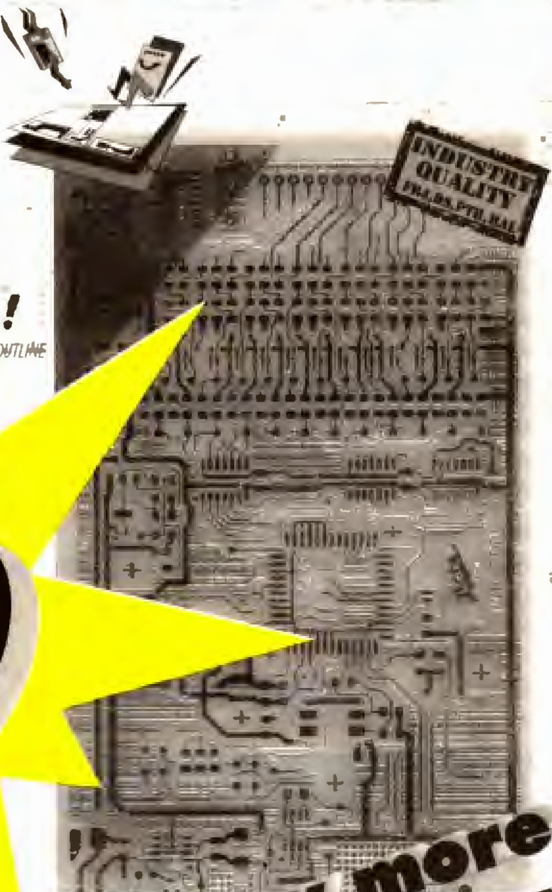

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Innovations

A roundup of the latest Everyday News from the world of electronics

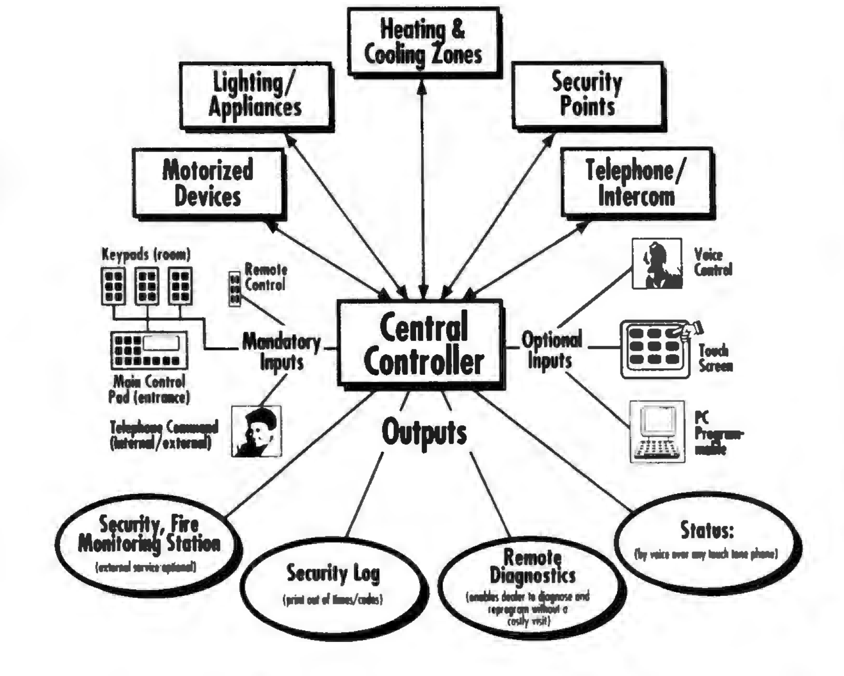
THE BUTLER DID IT!

Alexander, the electronic butler in the IntelliHome automated home control system, can be held responsible for almost everything – *by Hazel Cavendish*

THE internationaly-famous French architect Le Corbusier was the first man to suggest that a house should be "a machine for living", yet no-one so far has put this concept into totally practical effect. Now an Aberdeen Scot called Charles Davidson and his partner Jack McLaughlin have introduced their electronically-inspired IntelliHome to England in a £1,000,000 show house in Surrey, due to open to the public soon. This house claims to have the most extensive fully-automated voice-activated system in the British Isles.

In August last year *EPE* included Davidson's original "Thinking House" in the *Innovations* round-up of *Marvels for the Millennium*. Its success has been taken up by one of England's leading house builders in the South and a similar system is being developed for pubs and shops. Considerable interest is being shown by European builders.

Davidson believes his new system will become standard in new homes throughout Britain in five years, as he has devised a way of manufacturing it so economically that a householder is likely to recover the cost of the system in the first couple of years, through impressive economies in heating and lighting.



IntelliHome integrated control system.

BUTLERIAN REVOLUTION

The 1997 IntelliHome is based around an electronic "butler" which Davidson calls Alexander. The basic voice-activated system, with around 60 functions, costs about £1,500, although the really sophisticated versions for luxury homes with swimming pools and music rooms can cost up to £70,000.

Security is possibly the most important part of the system. Alexander will call the emergency services and a nominated neighbour if there is a break-in, and if someone comes to the door when the owner is away, Alexander transfers the call to the owner's mobile phone, so that he can speak to the visitor over the intercom, giving the impression that he is at home. It is even possible to send a video image of the caller to him if he is abroad, so he can tell Alexander whether or not it is safe to admit the caller.

Alexander's video surveillance system has many unique and highly secure design features. It consists of a video panel to which four cameras are connected. A slave video panel can also be connected to allow up to eight cameras to be controlled. A remarkable economy is achieved through the wiring, which requires no special tools and has been developed to utilise standard burglar alarm wire, making installation costs nominal. It should be possible to fit cameras to wherever wires have been run to detectors.

Alexander keeps a careful eye on the weather and the thermometer, and can make sure the dimmer switches are used when the house is unoccupied and the heating kept low, with resultant economy saving. One of Alexander's features is that the owner can phone him for confirmation that the heating is turned up to eliminate danger of burst pipes, and that the electric blanket will be on when he returns!

EVEN THE MENIALS

Even plants and pets are catered for. Plants can be watered in an owner's absence, and dogs and cats be fed automatically from special compartmentalised dishes. There is also an electronic rake which cleans out the cat's litter tray and leaves the detritus sealed in a plastic bag!

In homes having a swimming pool, spacious lawns and elaborate gardens, outside chores can also be assisted. Alexander can be told to maintain the swimming pool, filtering and vacuuming it twice daily, and other such operations. He can also ensure that lawns are watered daily in summer, except when it has rained, and hanging baskets are watered twice in 24 hours.

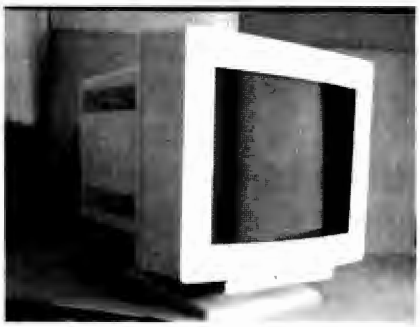
"As far as I know," says Mr Davidson, "Nobody has ever put so many devices under one roof before. We have created a sophisticated wiring infrastructure as the base of the system. Every room in the house can be wired so that from anywhere the occupants will have access to video, audio, telephone, computer links, automation control, temperature control, security system and access control.

BUTLERING GRANNY

Three new developments – described as "stand-alone" products – comprise a unique security lamp called ShadowGuard, which uses a variety of effects to create the illusion of occupancy, a revolutionary digital CCTV system, recording onto a computer hard disk, which includes a neighbourhood watch function, allowing householders to monitor each others' homes, and an "intelligent" wall socket. The latter can be switched on and off from anywhere in the world by touch-tone telephone.

Whilst the full-scale IntelliHome is designed to answer the needs of the very rich, the very busy and the very powerful, in its simpler version it could revolutionise many ordinary lives. Last year, Scottish Homes asked Charles Davidson's company to create a "Granny-friendly home" in a sheltered complex, and a major Sheltered Housing charity has asked for a pilot scheme for disabled people, which, if adopted, should allow many to live on in their own homes with the aid of the most helpful items of the new technology. Such schemes can be programmed according to individual requirements, and by the use of the fool-proof voice-activated system which any user can quickly understand.

What a Picture!



A FAMILIAR scenario for many electronic enthusiasts and small business: you're fed-up with trying to do CAD, DTP or graphics work on that 15-inch monitor, but cannot afford the dosh to get a larger one!

Well, there seems to be light at the end of the tunnel for you – Barry Eudall of BBA Ltd has developed a way of running Sparc Station monitors on a standard 486 or above PC, using any 1Mb or greater graphics card. Available in 17-inch and 20-inch versions, and costing just £225 and £325 respectively (plus VAT), these superb second-user monitors come with a three month return-to-base warranty.

Performance-wise, they will reach XVGA level, 0·26 dot pitch, 1024 × 768 resolution at 70 or 75 cycles in Windows 3.1, 95 or NT (all DOS applications must be run within Windows). It's a serious electronic designer's dream!

Furthermore, there is even a technical hot-line available to help you, should you experience any problems with installation.

So, give BBA a ring on 01664 482600 and give your eyesight a rest, with no more tunnel vision. Alternatively, write to BBA at 22 Granville Road, Melton Mowbray, Leicestershire LE13 0SN.

Internet Satellites

"SATELLITES have the potential to take the information superhighway to every corner of the globe," enthuses Science and Technology minister, Ian Taylor. "In the long run, they could make using the Internet faster and cheaper and enable it to be accessed from any point on the planet, no matter how remote."

Mr Taylor was commenting on the announcement of a programme to encourage industry to come up with new ways to deliver multimedia services via satellite. Under the Satellite Multimedia Applications Demonstration Programme (SMADP), which is being sponsored by the British National Space Centre (BNSC), consortia will be invited to put forward proposals on how to provide information technology services more efficiently.

"A frequent complaint from Internet users is how long it takes to locate the information they are looking for." We whole-heartedly agree!

BIDDING-UP DIGITAL TV

IAN TAYLOR, Minister for Science and Technology has welcomed the substantial bids the Independent Television Commission has received for multiplex licences for digital terrestrial TV.

"The receipt of bids", he says, "marks a major step in our development of a new digital environment in the UK. The real commercial interest now evident gives the lie to all Jeremiahs and the prophets of doom who said that DTT would be of no commercial interest."

"It is now up to the ITC to select the winning bids and for the competition authorities to consider any issues arising out of those bids. Whatever the outcome, the future for Digital in the UK is one we can look forward to with confidence."

A new free telephone hot-line to up-date callers with details of information technology opportunities across the UK went live on 1st February. The hot-line – 0800 456 567 – is part of the government's *IT For All* campaign which is intended to take the mystery out of information technology and help banish technophobia in Britain by giving hands-on opportunities to see what IT can do. This commitment to technology is welcomed; all to often the opposite seems to have prevailed.

MINI PIC-CHIP

MICROCHIP'S revolutionary 8-pin microcontroller family – the world's smallest – now includes devices with advanced analogue-to-digital features. The PIC12C671 and PIC12C672 8-bit one-time-programmable (OTP) microcontrollers enable intelligent features to be integrated into mechanical designs. They will compete directly with 4-bit microcontrollers (yes, 4-bit technology still has its place), but offer significantly enhanced performance.

The advanced features include an on-chip ADC and two analogue channels. Respectively, the two chips have 1024 and 2048 words of program memory, plus 128 bytes of user RAM. They also provide six multiplexed I/O pins, 4MHz on-chip oscillator, 35 single-word instructions, and other usual features that you would expect to find on a PIC.

For more information, contact Arizona Microchip Technology Ltd., Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks, Sl8 5AJ. Tel: 01628 851077. Fax 01628 850259.

KANDA MINI-PICS IT

KANDA System's Professional Universal PIC programmer will now program the new 8-pin 12C5xx series of microcontrollers. This is in addition to the 16C5x. 16C6x, 16C7x, 16C8x and 17C4x series (18-pin, 28-pin and 40-pin variants).

The intuitive windowed menu system allows access to all the processor features (unlike many low-cost units) and will work with code produced by any standard assembler or compiler, including C and Basic, and, Kanda tell us, MPASM and TASM as well.

This programmer normally retails for £169 but, for *EPE* readers, it is being offered at only £99 (excl. VAT), *and you will be given a free 8-pin processor.*

For further information on their range of products, contact Kanda Systems Ltd., Unit 11, Glanyravon Enterprise Park, Aberystwyth, SY23 9ZZ. Tel: 01974 282570. Fax 01974 282356. E-mail **Sales@Kanda-systems.com.**

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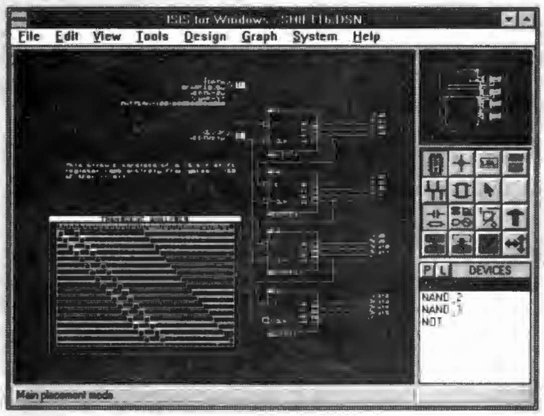

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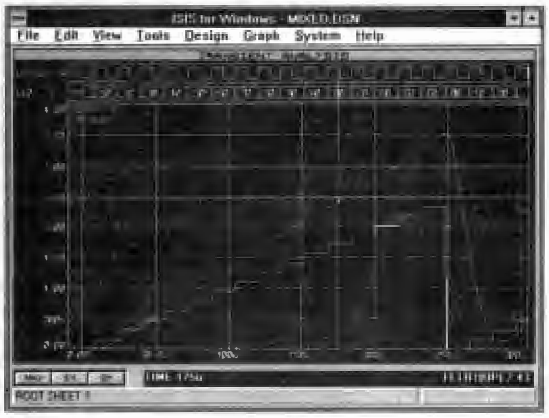

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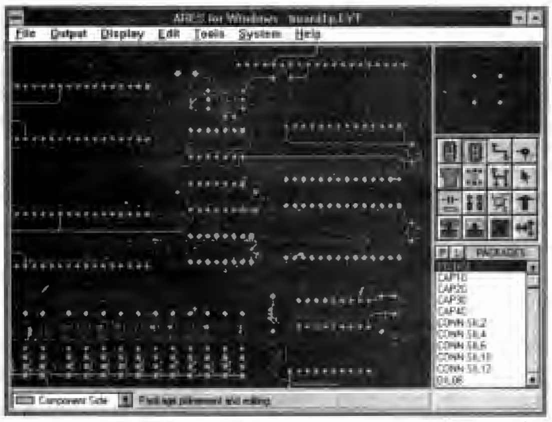

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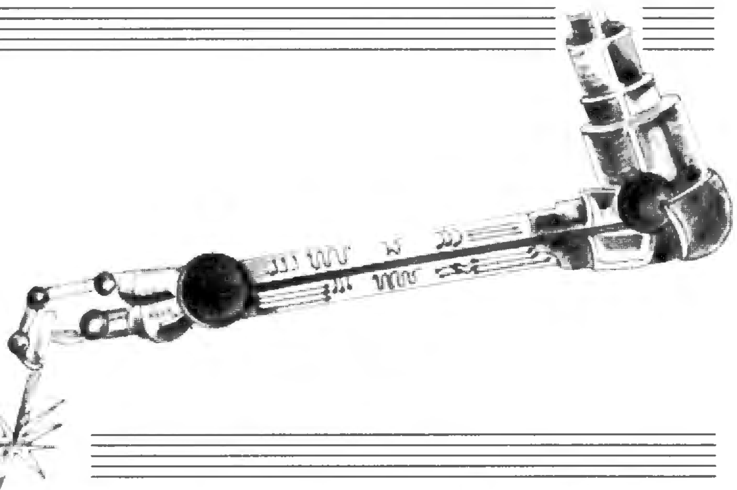


ALAN WINSTANLEY

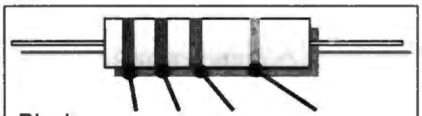
This month, the Readers' Help Desk manned by our regular 'Surgeon' helps with bizarre CMOS behaviour and takes resistors apart – literally!

Resistor Puzzle

OUR regular round-up of comments, queries and readers' questions starts with a puzzler concerning resistor types. We also get to grips with 4 and 5 band resistor codes. ***Jonathan Stott of Tamworth, Staffs.*** asks:

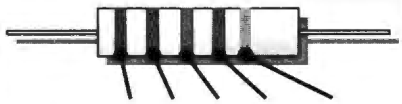
Dear Alan, I am 16 years old and enjoy making some of the projects in EPE. *A question recently arose which I hope you can help answer: what is the difference between carbon film and metal film resistors? One seems to be able to buy a wider range of resistances in metal film ranges. Is it all right to use metal film resistors even if carbon film types are specified in the Components List? Thanks for your help!*

Well Jonathan, **carbon film** resistors are the most popular choice because they offer a good balance between cost and performance. They are made by depositing a "carbon film" onto a ceramic body, which is then trimmed to the required ohmic value by cutting a spiral groove. They are a good, cheap and cheerful choice for most projects. Snip one in half and you will see the ceramic centre, coloured white; scrape off the surface paint and with luck you'll reveal the spiral resistance band underneath! Carbon film resistors are typically painted beige or brown and show four colour bands. The four-band code is straightforward and for the benefit of beginners it is shown in Fig. 1.



Black	0	0	1	-
Brown	1	1	10	-
Red	2	2	100	-
Orange	3	3	1k	-
Yellow	4	4	10k	-
Green	5	5	100k	-
Blue	6	6	1M	-
Violet	7	7	10M	-
Grey	8	8	-	-
White	9	9	-	-
Gold	-	-	-	5%
Silver	-	-	-	10%

Fig. 1. Four-band resistor code example: yellow-violet-orange-gold = 47,000 ohms (47k) 5%.



Black	0	0	0	1	-
Brown	1	1	1	10	1%
Red	2	2	2	100	2%
Orange	3	3	3	1k	-
Yellow	4	4	4	10k	-
Green	5	5	5	100k	-
Blue	6	6	6	1M	-
Violet	7	7	7	10M	-
Grey	8	8	8	-	-
White	9	9	9	-	-
Gold	-	-	-	-	5%
Silver	-	-	-	-	10%

Fig. 2. Five-band resistor code example: yellow-violet-black-red-brown = 47,000 (47k) 1%.

Metal film are superior to carbon types because an alloy film is deposited as the resistive material. This produces a high stability resistor with low "noise" and close tolerance, but this is only important in sensitive circuits and the improvement will not be at all noticeable in most projects. Metal film resistors are typically coloured blue or grey and will have five colour bands to represent the resistor value. The five band code is given in Fig. 2.

See how four bands are used to determine the code whilst a fifth band is the tolerance. Note that Maplin's "Min Res" metal film 0·6 watt resistors are 1% tolerance, but the ordinary four-band code usually applies, they say, and if a fifth (red) band is shown, this may be an indicator of the resistor's *temperature coefficient* (see later), not the tolerance. Confusing!

Being Tolerant

The tolerance of a resistor is an indication of its accuracy. A 100 ohm 5% resistor could in practice be anything between 95 to 105 ohms. As far as the resistor values themselves are concerned, these are grouped into **preferred values** and most *EPE* constructional projects use the **E12** range, the most basic and widely available set of values used. These are based on 1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8 and 8·2 and their multipliers (100 ohms, 1·0 kilohms, 10 kilohms, etc.). Sometimes, "unusual" resistor values crop in circuits which are not of the E12 preferred range, and this worries novices who are unaccustomed to such peculiar values. For instance, you may see a *200 ohm* resistor rather than a more customary *220 ohm* (E12) value.

Fear not. The reason is often that the circuit designer may well be a professional or advanced constructor who simply works with the E24 preferred range! At his disposal he will have the following **E24** values: 1, 1·1, 1·2, 1·3, 1·5, 1·6, 1·8, 2·0, 2·2, 2·4, 2·7, 3·0, 3·3, 3·6, 3·9, 4·3, 4·7, 5·1, 5·6, 6·2, 6·8, 7·5, 8·2, and 9·1. Note the extra values available! So he may well have picked a 200 ohm resistor simply because that's what was around at the time.

In some cases (perhaps it's part of a voltage reference or biasing network), the resistor value is critical and will have been chosen for a specific reason. Such resistor values may be highlighted by the fact that the designer may specify a close tolerance (metal film) 1% type, so it is then best to stick with that value and not stray from the published design.

As often than not, though, you can substitute a near-value resistor (220 ohms, say) and in many examples this will not make any difference to your circuit. Don't be put off by those "funny" values which you may see from time to time, but check to see if there is a particular reason why such a part was specified in the design.

There are also even wider ranges of resistors available in the **E48** (48 values) and **E96** (96 values) ranges, which are only of interest to professionals and circuit developers. The far greater number of values available implies that closer tolerances are required, and metal film technology is therefore more appropriate, that's why there are seemingly more metal film than carbon film resistors on sale. For the technically orientated, British Standard BS 2488: 1966 (equivalent to IEC 63) is the *Schedule of preferred numbers for the resistance of resistors and the capacitance of capacitors for telecommunications equipment.* Yes, the same scheme of preferred values applies to capacitors, too.

Other factors which a designer would sometimes take into account include the "tempco" – **temperature co-efficient** – an indication of how much the value is likely to drift up or down when the temperature changes. This is expressed in terms of parts per million (ppm) per °C, and metal film resistors offer superior performance in this respect (50ppm compared with 200-500ppm for carbon film types). There is an excellent reference to this and those "E" values in the book *Newnes "Electronics Toolkit"* by Geoff Phillips (ISBN 0-7506-0929-X), which is a handy source of data.

To answer your final question, there is technically nothing to be gained by using metal film resistors if carbon film are specified in Components Lists. When funds are restricted, I recommend gradually building up a "resistor kit" – 5% 0·25W carbon film resistors are perfectly adequate for hobbyists' needs – perhaps purchasing ten or twenty of some of the most popular values each time you place an order. I simply store them in re-sealable poly bags, with a large bag holding each E12 value (as listed earlier), and smaller bags within containing the resistors themselves.

Internet users may be interested in two freeware resistor colour code programs available from our FTP site at **ftp://ftp.epemag.wimborne.co.uk/pub/software. Resistor.zip** is a simple, neat 3-colour code display – type in the value to see the colours, or click to select a colour and see the resistance value computed. **Rescalc.zip** deals with 5-colour band types. Both programs run under Windows 3.x or Windows 95.

For readers who do not have Internet access, we can provide both these freeware files on an IBM-PC floppy disk for the sum of £2·50 (UK) which covers copying, mailing, postage and handling.

Redundant Pins Become Static-prone

An avid *"Ingenuity Unlimited"* contributor, the ***Rev. Thos. Scarborough*** of Cape Town, South Africa asks several questions in a recent letter: *"Why should unused pins of i.c.s be tied high or low, and what are the consequences of failing to do so?"* And another similar question cropped up in an Internet newsgroup recently:

"I'm just getting into electronics, and was working on a project when I noticed that my NAND gate (2-input quad 4011 CMOS chip) was not working properly. To test it out, I wired a basic circuit where one input always had power, and the other is connected to power via a pushswitch. The output was connected to an l.e.d. Theoretically, the l.e.d. should stay on unless the button is pressed. It sort of did this, but when I released the button, it remained off. I also noticed it would come back on again if I gently tapped the circuit."

CMOS technology was originally known as COS/MOS (Complementary-Symmetry Metal-Oxide Semiconductor) and was pioneered at the RCA Laboratories in Princeton, New Jersey in the early 1960s. RCA Solid State announced the first commercial COS/MOS series in 1968, nearly thirty years ago.

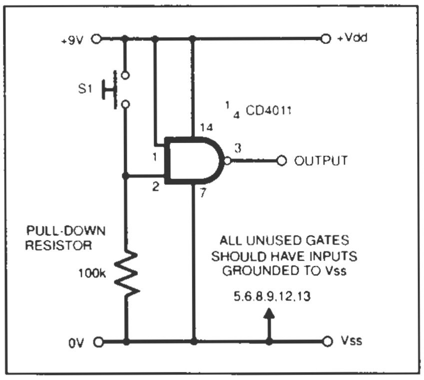


Fig. 3. A pull-down resistor is essential to prevent the input (pin 2) from "floating".

RCA utilised new on-chip *complementary p*-channel and *n*-channel MOS "transistors" in their new COS/MOS gates. These transistors are perhaps better thought of as "capacitors" since they are formed from an extremely thin sandwich of metal oxide and i.c. substrate acting as capacitor "plates", separated by a dielectric of silicon dioxide. The device works by transferring *charge* between the gate's internal CMOS "capacitors". Unlike a bipolar device, no noticeable input current flows, and instead the gate is purely voltage controlled.

Consequently, the MOS transistors are formed using extremely thin layers of oxide which are highly prone to damage by static electricity discharges. CMOS gates have a very high input impedance (10^{12} ohms or more) and contain an input-protection circuit consisting of a diode network which (one hopes) will shunt away any excess voltages created through the accumulation of static, or the application of excessive signal voltages or noise.

However, it's easy for a human body to acquire a charge of 10-20,000eV (electron volts) purely by walking on a nylon carpet, and this is sufficient to destroy a CMOS device if you discharge yourself into the chip. Hence we pin our hopes on anti-static precautions (wrist straps, etc.) and we hope that those built-in diodes will catch anything else; in fact the diodes provide protection up to about 4kV, less on older devices.

When building circuits which contain CMOS logic, it is best to ground any unused pins to 0V (V_{ss}). This equally applies to the input pins of *unused gates*. Failure to do so can force the CMOS transistors to move into their linear region, rather than acting as simple on-off switches. This causes larger currents to flow and results in faulty or erratic operation of the gate, or possibly the entire chip.

Our anonymous Internet friend also made the subtle mistake of keeping an input pin "floating" or unconnected to anything. A **pull-up** or **pull-down** resistor should always be used on CMOS inputs to prevent the CMOS transistors from partly conducting. In this example, he should hook a pull-down resistor, say 100k or so, between the pin and V_{ss}, remembering that the switch itself is connected to the input pin and positive rail ($+V_{dd}$). The resistor biases the pin to one supply rail or the other, see Fig. 3.

The very act of "tapping" the chip with a finger may have contributed to the CMOS gate's bizarre behaviour because he may have introduced further static or helped to shunt some of it away. I have witnessed odd behaviour with a counter chip which would display a seven-segment figure randomly when a finger was placed nearby. The cause was static accumulation on some unused pins of the counter!

With bipolar devices, it perhaps isn't compulsory to use biasing resistors but in many situations it is a wise precaution as it helps the stability of the circuit. The 555 timer shown in Fig. 4 has pull-up resistors on the trigger and reset pins, to prevent erratic operation.

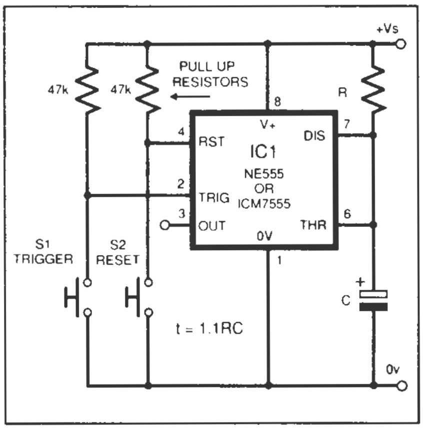
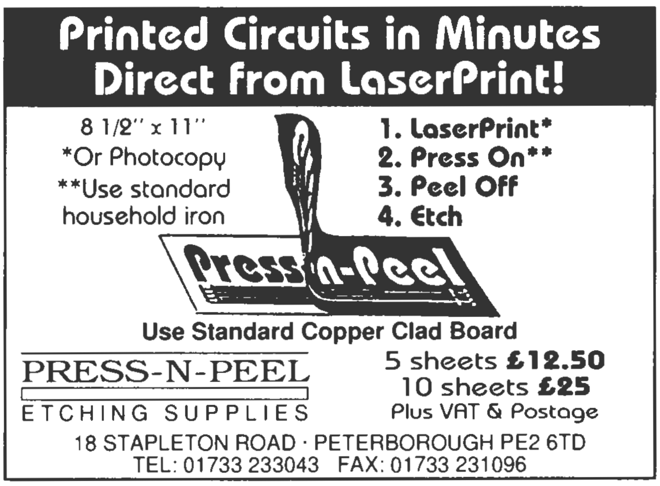
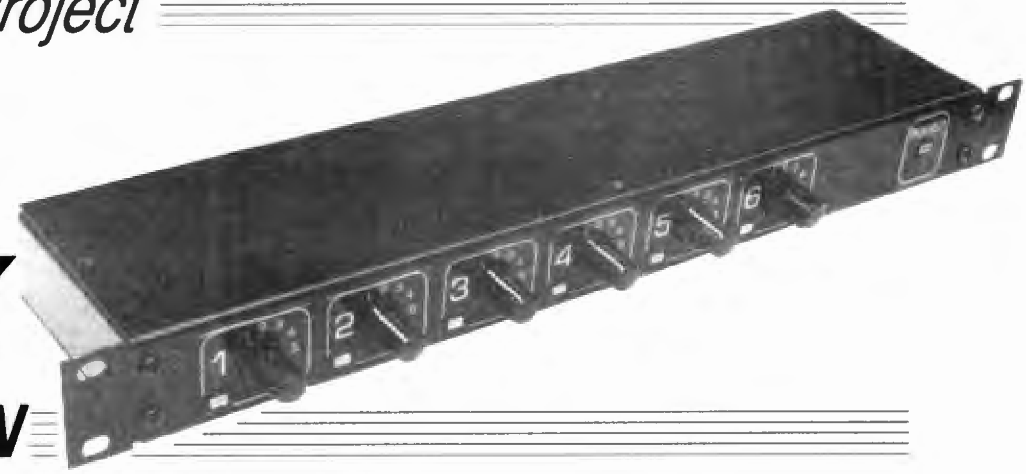


Fig. 4. Pull-up resistors are used to bias the trigger and reset pins to the positive rail.

If you have any questions 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.** We cannot guarantee a personal reply but will endeavour to offer help where possible.





MIDI MATRIX

NEIL JOHNSON

Eliminate the hassle of constantly replugging your MIDI gear with this six-channel switching unit.

MODERN electronic music systems rely on the Musical Instrument Digital Interface (MIDI) to connect together synthesizers, drum machines and computers. Unfortunately, even the most basic amateur electronic music system requires a reasonable amount of MIDI cabling. Before long, the swapping of MIDI cables between units results in a spaghetti jumble of cables and plugs.

The MIDI Matrix was designed to solve the cable swapping problem, using the "telephone exchange" principle – lots of signals coming in, lots of signals going out, and just a few switches providing interconnections between the two in any configuration required.

This project is aimed at any electronic musician, amateur or professional, who has even the remotest need to frequently change MIDI cabling arrangements. Once all your MIDI signals are connected to this unit you can forget about rummaging around the back of your synthesizers and modules to change your leads – with a twist of a switch, this unit can alter your MIDI layout *instantly*.

SYSTEM CONFIGURATION

The MIDI Matrix is built from two basic modules: a MIDI Interface module and a Power Supply Unit (PSU). The block diagram of the basic layout of the MIDI Matrix is shown in Fig. 1.

The MIDI Interface modules provide the interface between the MIDI signals and the internal electronics, transferring the MIDI signal onto one of the internal data channels. The actual signalling system used by MIDI is a type known as a current loop. Data is sent in a serial stream, similar to the common RS-232 system used by computers and terminals, using a current of 5mA to represent 0 and no current to represent 1.

The reason for this rather ancient system (current loops originated back in the days of mechanical teletypewriters) is that the standard MIDI Input circuitry must use an opto-isolator to provide electrical isolation between the transmitter and the receiver, a current of 5mA being sufficient to drive most common opto-isolators.

The purpose of the opto-isolator is to provide galvanic isolation: no direct electrical connection between the sender and receiver. This feature has two important properties, namely, electrical safety and improved noise immunity.

Of most interest to the musician is the second property – noise. Noise will get into an electrical system any way it can, and one subtle entry route is through an earth loop. As its name suggests, this is a loop of wire which is supposedly at earth potential. However, upon closer inspection you will find that the cable is joined to earth at only two points – its ends (see Fig. 2).

That earth wire loop forms a rather nice inductive loop antenna, liable to pick up all sorts of noise – mains hum, audio signals, radio signals, noisy electric motors – which will find its way into the audio signal path and ultimately into the recording equipment.

By placing an electrical barrier at the MIDI Input, we break this earth loop and prevent any induced noise finding its way, via the MIDI Matrix, into a synthesizer or mixer. It would be particularly disastrous, for example, if noise found its way into your mixer, where it would ruin your carefully crafted audio masterpiece.

Another reason for trying to keep out noise is that it could, if sufficiently strong, disrupt the MIDI data. This would cause data errors, interfering with the information between MIDI units. The effect of this would depend on what was happening at the time of the disruption. For instance, you have just waited five minutes for a long sample to download into your sampler; when the transfer process suddenly stops, the sampler says the data is corrupt and would you like to "Try Again (Yes/No/Abort)?"

Alternatively, you could be centre-stage playing your lead solo when, just as you reach the crescendo, a blip in the MIDI data signals your synthesizer to stop what it is doing and retune itself, leaving you looking like a lemon under the stage lights.

The subject of safety cannot be overstressed, especially when dealing with some musicians who seem to have a very cavalier attitude towards electricity. There are many tales of musicians who have been killed through very dodgy mains earthing circuits – one poor chap did not

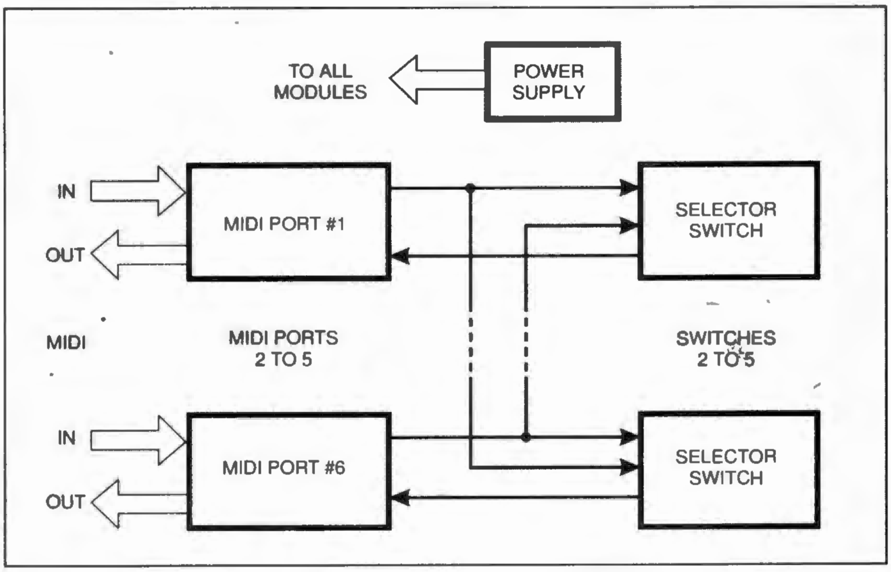


Fig. 1. Block diagram for the MIDI Matrix.

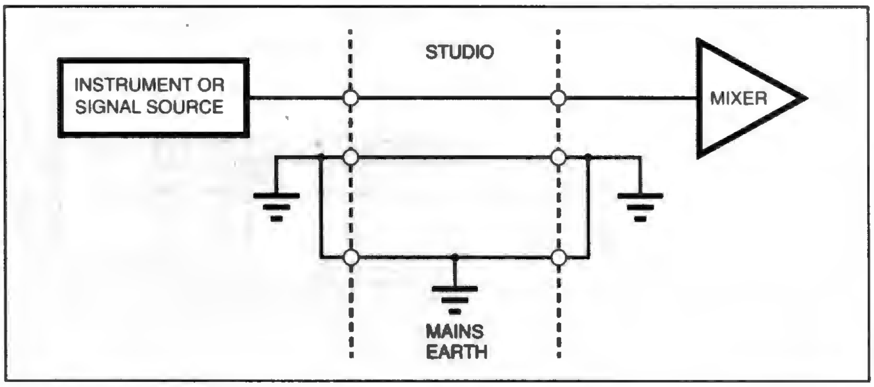


Fig. 2. Un-isolated connections between two units can create an undesirable earth loop.

realise his electric guitar was actually at mains voltage until he completed the circuit to earth through an earthed metal microphone body ...RIP

The opto-isolator specified for the MIDI Matrix has an isolation voltage rating of 2500V r.m.s., more than sufficient to block mains voltage. In the worst case, where one of the MIDI wires found itself at mains potential, the only damage to occur would be to the l.e.d. (light emitting diode) in the opto-isolator – much easier to replace a small lump of plastic than rewire a previously living, breathing musician.

Rotary Selector switches select the data channel routings. Each switch is connected to its own MIDI Out interface and can select any one of the available MIDI Input channels.

Finally, the PSU provides power at +5 volts for the complete system. For design simplicity and safety, a ready-made mains PSU module is used, together with an l.e.d. to provide power indication. No provision has been made for a power switch for two reasons, simplicity and safety (fewer components and no internal wiring at mains potential) since the MIDI Matrix will be required whenever the MIDI system is going to be used. The mains plug, of course, must be fitted with a suitably rated fuse.

HOW IT WORKS

The circuit diagram for the MIDI Interface module is shown in Fig. 3. Current flows into socket SK1, through resistor R1 and the l.e.d. in opto-isolator IC1, and back out through SK1 again. Diode D1 protects IC1 against accidental reverse connection.

When current passes through the internal l.e.d. of IC1, it shines on the light-sensitive base of a high gain transistor, and turns it on. The output of IC1 is the open collector of a second booster transistor, which is pulled high by resistor R2 when in the *off* state. The resulting digital signal is sent off-board to the Selector modules.

Resistor R3 provides a drain for the leakage current of the light-sensitive transistor, reducing the switching time of the device.

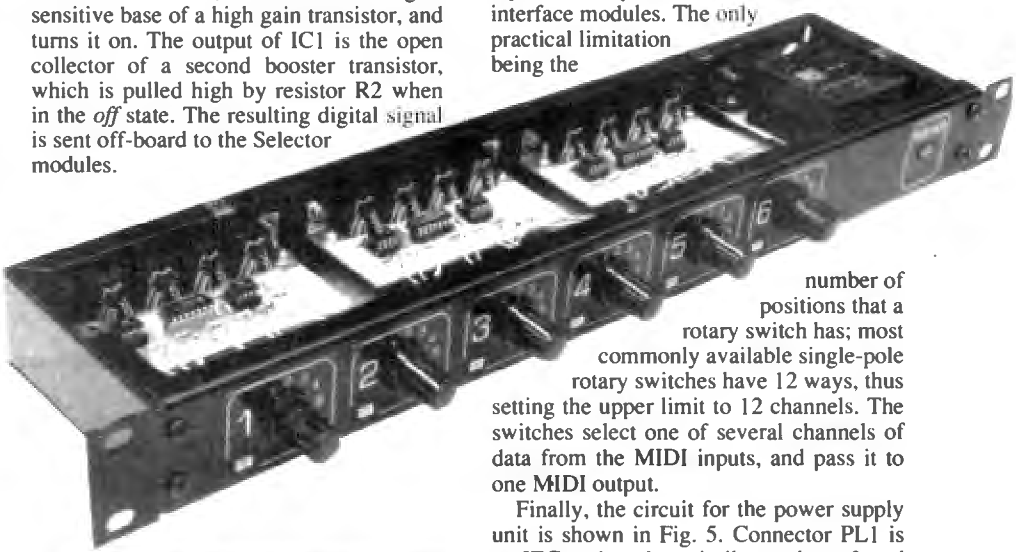
Returning signals are fed into a simple booster amplifier based on two of the inverters, IC2c and IC2d, within the hex Schmitt inverter package of IC2. Resistor R4 pulls the input high when no input signal is present, while resistors R5 and R6 complete the 5mA current loop.

Assuming a 1·7 volt drop across the receiver l.e.d. within IC1, the current flow will be:

$$I = (5 - 1{\cdot}7) / (3 \times 220) = 5\text{mA}$$

The third inverter, IC2e, together with resistor R7 and l.e.d. D2, indicate to the user whenever MIDI data passes through the output. This seemingly simple addition can save many a headache while running a MIDI system (thus speaks painful experience!).

As shown in Fig. 4, the Selector switches, S1 to S6, are of the break-before-make rotary type. Although this article describes a unit with only six inputs, it is possible to add more MIDI interface modules. The only practical limitation being the



number of positions that a rotary switch has; most commonly available single-pole rotary switches have 12 ways, thus setting the upper limit to 12 channels. The switches select one of several channels of data from the MIDI inputs, and pass it to one MIDI output.

Finally, the circuit for the power supply unit is shown in Fig. 5. Connector PL1 is an IEC mains plug, similar to those found on the back of computers and most professional electronic equipment. This feeds mains power directly into the PSU module. Indication of power is provided by l.e.d. D3, which is in series with current limiting resistor R8.

CONSTRUCTION

Ease of construction has been a main aim when designing this project. Virtually all of the components are mounted on printed circuit boards (p.c.b.s), with very minimal inter-board wiring. To reduce the

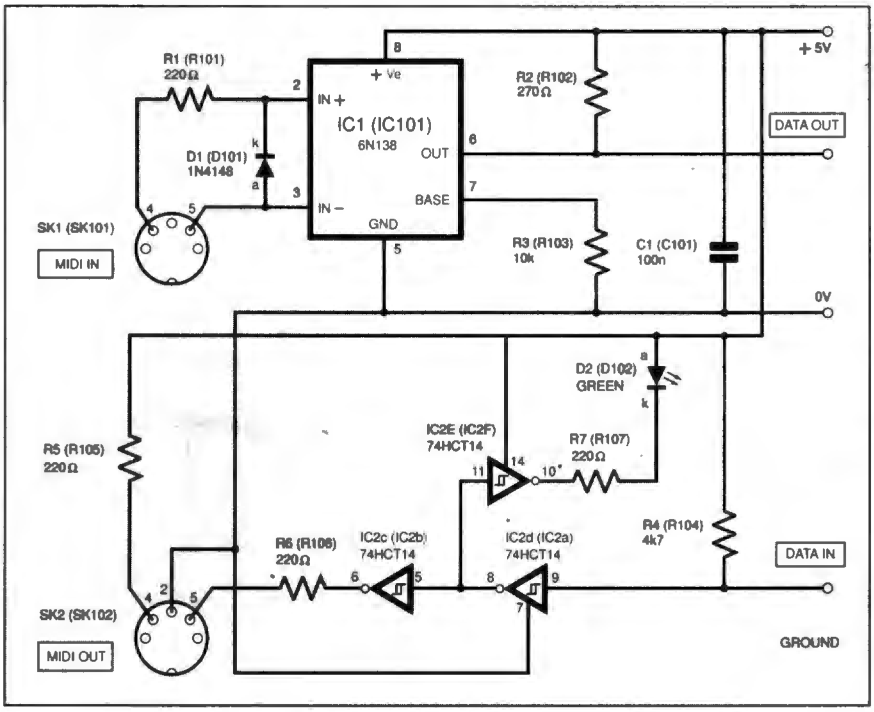


Fig. 3. MIDI Interface circuit diagram.

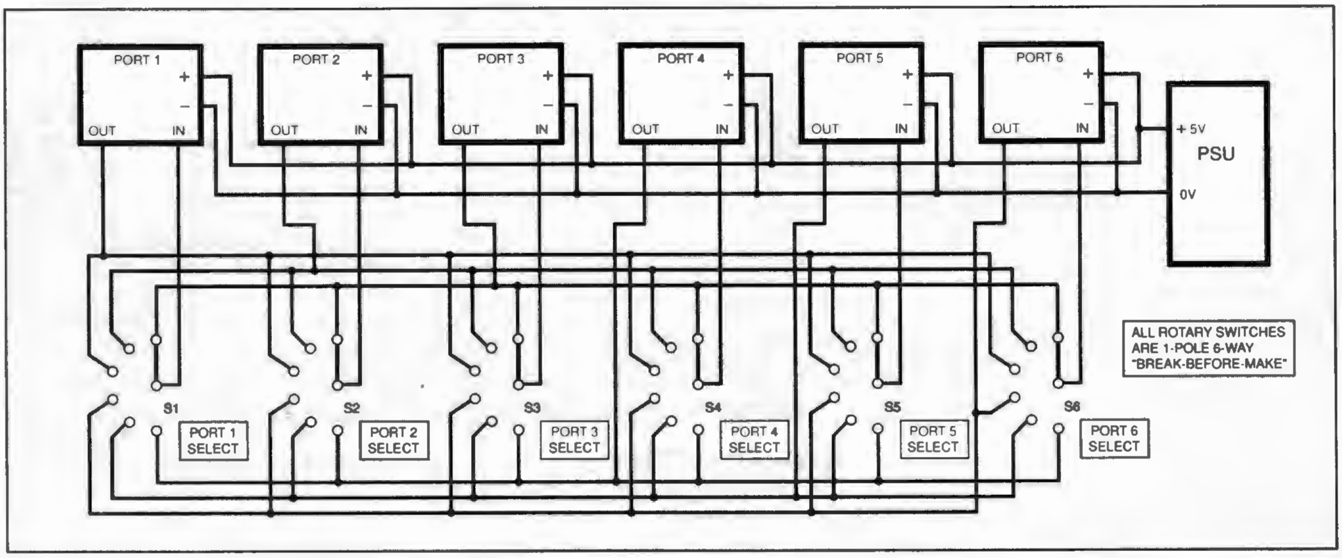


Fig. 4. Details of how the six ports are switched.

number of p.c.b.s and wiring, two complete channels are incorporated on each MIDI interface board. The boards are available from the *EPE PCB Service*, codes 147 (PSU) and 148 (Interface).

We will start by describing assembly of the PSU board, followed by the MIDI Interface board.

The PSU board is probably the simplest design you will ever come across for a mains PSU, there being only three components mounted on the board itself, as shown in Fig. 6. You only need one copy of this board. Start assembly with resistor R8, plug PL1 and then the PSU module itself. If you are going to use p.c.b. pins for the off-board terminations, they should be inserted after R8.

CAUTION: Hazardous mains voltages are present on the PSU board. Construction and assembly of this part of the project should only be done by experienced constructors. If you are in any doubt about the safety of your circuit, get it checked by a qualified electrician.

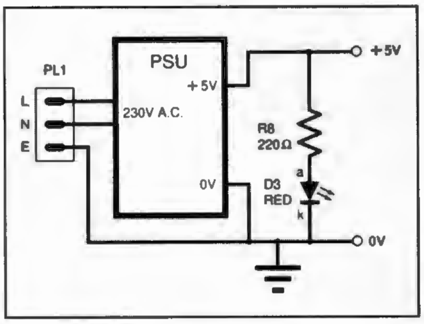


Fig. 5. Power Supply Details.

COMPONENTS

NOTE: Quantites shown for control module p.c.b. mounted components are for one module only.

Resistors

R1, R5 to R7, R101, R105 to R107	220Ω (8 off)
R2, R102	270Ω (2 off)
R3, R103	10k (2 off)
R4, R104	4k7 (2 off)
R8	270Ω

All 0·25W 5% carbon or better.

See SHOP TALK Page

Capacitor

C1, C101	100n polyester (2 off)

Semiconductors

D1, D101	1N4148 signal diode (2 off)
D2, D102	green l.e.d. (2 off)
D3	red l.e.d.
IC1, IC101	6N138 or 6N139 opto-isolator (2 off)
IC2	74HCT14 hex Schmitt inverter

Miscellaneous

PL1	IEC mains plug, right-angle, p.c.b. mounting
S1 to S6	1-pole 6-way rotary switch, break-before-make (6 off)
SK1, SK2, SK101, SK102	5-pin DIN socket, p.c.b. mounting (2 off)

Printed circuit boards, available from the *EPE PCB Service*, codes 147 (PSU – 1 off), 148 (Interface – 3 off); power supply module, mains powered, 5V d.c. 1W regulated output (see Shop Talk); case, 19-inch rack-mounting, 1/2U height; metal bracket; wire; solder, etc.

Approx Cost Guidance Only £49 excl. case

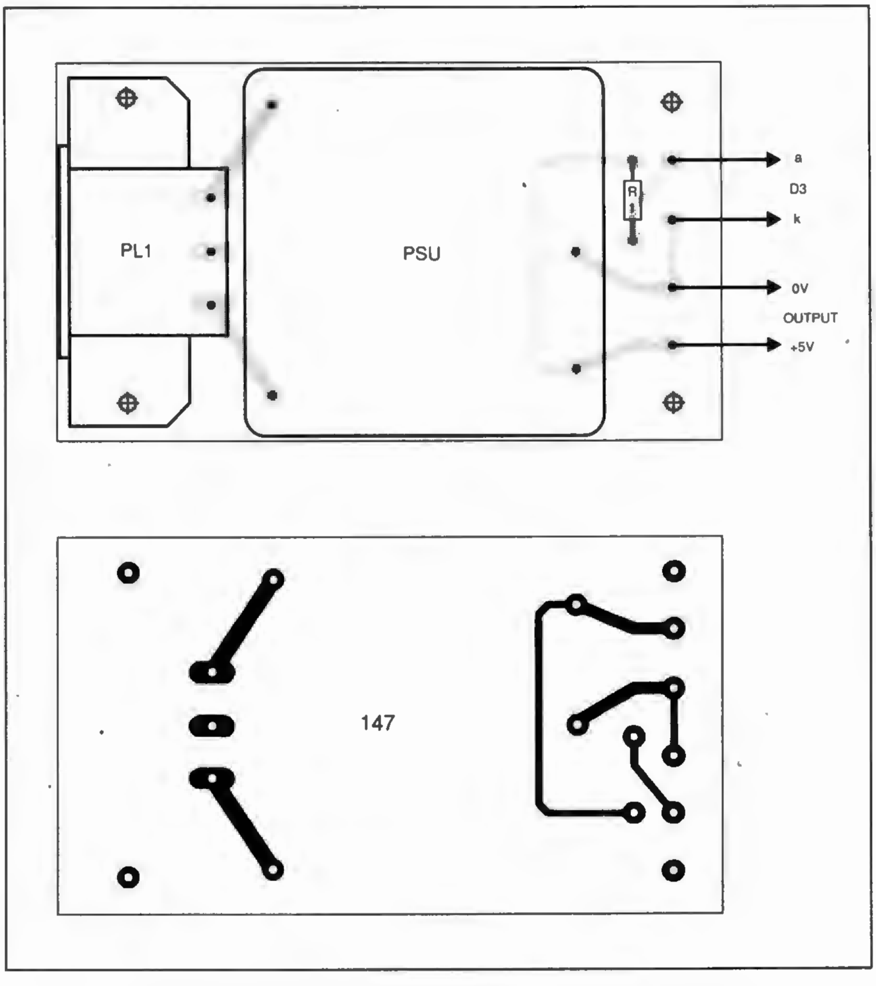


Fig. 6. Printed circuit board details for the power supply.

Two mounting holes are included on the board to secure it to the plug PL1 – *do not rely on the three solder joints to hold the board to this connector.*

Check the solder joints before gluing the cover to the board as shown in Fig. 7. This cover must be made of non-conducting material, such as acrylic (Perspex), SRBP, or fibre-glass sheet, and ensures that there is plenty of isolation distance between parts at mains voltage and the case.

Assembly details for the MIDI Interface board are shown in Fig. 8. You need one of these boards for each pair of Interface circuits, i.e. three for a 6-channel unit. Start with the d.i.l. (dual-in-line) sockets, then follow with the diodes, resistors and capacitor. Note that component numbers for the second channel, except for C1 and IC2, are prefixed by "10"; for example R1 becomes R101, D1 becomes D101, etc.

The group of four DIN sockets (SK1, SK2, SK101 and SK102) are designed to slot together to form one block of connectors. Insert them carefully into the board and solder in place, taking care to get the mating grooves properly overlapping.

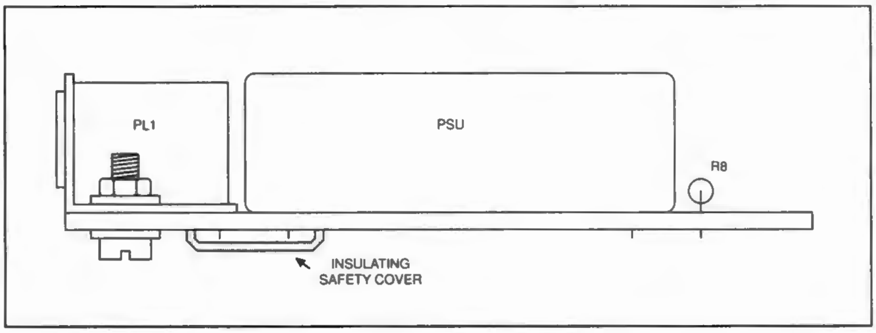


Fig. 7. Showing where the insulating cover is used on the power supply module.

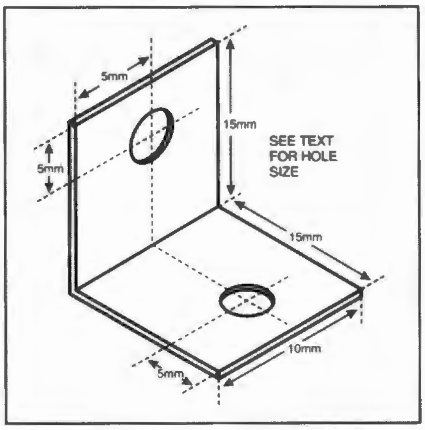


Fig. 9. Details of one of the mounting brackets.

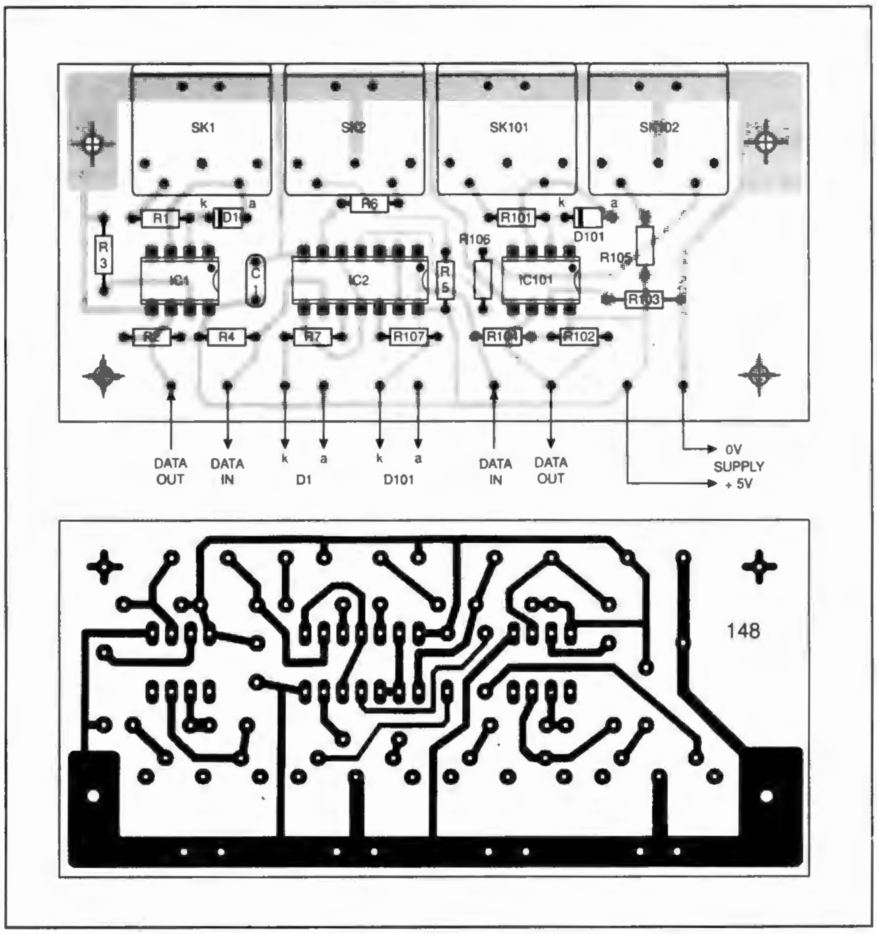


Fig. 8. Printed circuit board details for one dual-port control module.

The last parts to fix to the board are the two mounting brackets at each end. These are small metal brackets with holes suitable for 4BA bolts (or M3·5 if you prefer metric). Dimensions are shown in Fig. 9.

CASE DETAILS

The last stage of construction is to drill and assemble the case, and connect the boards together.

Simplicity has again been a major influence in the choice of the case. By using a flat-pack 19-inch rack case, only two panels require holes to be drilled in them – the front and rear panels. The layout details and control legends can be seen in the photographs.

The front panel requires thirteen holes: six for the Selector switches, six for corresponding MIDI indicator l.e.d.s, and one for the power indicator l.e.d. The rear panel is slightly more complicated with 21 holes being required. Drill the holes to allow enough clearance for the l.e.d. clips and switch-mounting nuts.

The four modules – PSU and three MIDI Interface modules – can be mounted on the rear panel using 4BA screws. As stated, the MIDI Interface modules require small metal brackets to attach them perpendicular to the rear panel using 4BA or M3 nuts and bolts as appropriate.

The PSU requires particular attention since there are dangerous mains voltages present. The following assembly details should be followed to ensure your safety.

The practical upshot of most of it is "Earth any metal which you can touch".

Begin by fixing the PSU to the back panel with two M3 screws. Then connect a piece of stout, insulated wire between the earth terminal on the mains connector (PL1) and an earth tag fixed to one of the mounting bolts. Use wire of grade 19/0·2 (19 strands of 0·2mm diameter) or greater, since in the case of a short-circuit, this wire must carry the full rupture current of the mains fuse.

The mains cable should be terminated at one end in an approved mains plug and an IEC socket at the other end. It is recommended that a ready-made cable with moulded plugs is used, since this obviates the need for any mains wiring at all. The mains plug should be fitted with a 3-amp rated fuse, sufficient to protect the cable.

Proceed with mounting the front panel and the rear panel. On one of the mounting screws place an earth tag between the front panel and the rear panel. Again using insulated stout wire, connect this to the earth terminal on PL1. Make up two more earth straps, one each for the top and bottom panels, long enough to reach the mounting screw holes.

Wiring up of the unit is fairly straightforward, and consists mostly of wires going between the MIDI Interface modules and the front panel. Begin with the wiring from the PSU module, including the front panel indicator, and daisy-chain the power leads from one MIDI Interface module to another.

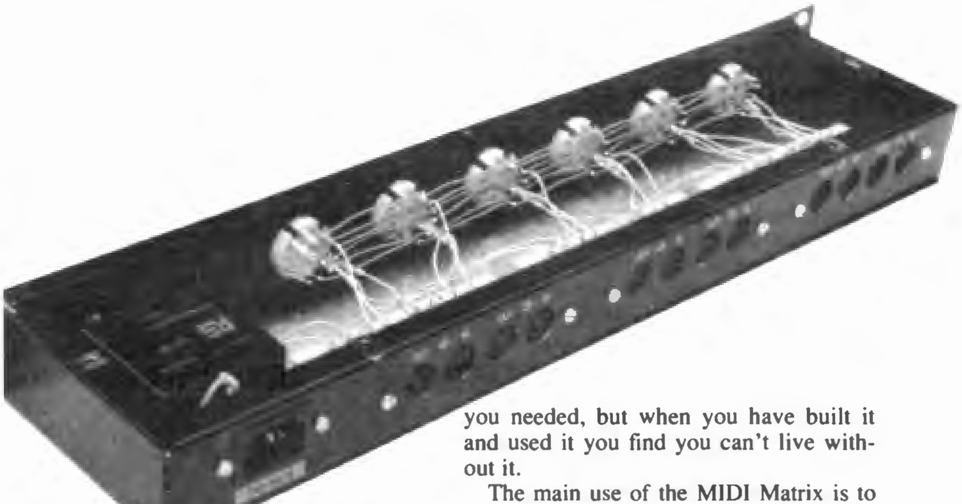
The wiring of the Selector switches consists of connecting together all the common terminals of the switches. This is best done with short lengths of PVC-covered solid-core wire. This is a slightly tedious job, there being thirty interconnections to be made. However, in practice, the repetitive pattern of interconnections helps identify any wiring errors that may occur.

The final wiring required is that between the MIDI Interface modules and the front panel l.e.d.s and Selector switches. This should be done with lengths of stranded wire, typically 7/0·2mm (seven strands, 0·2mm in diameter) or similar. Be careful to connect the l.e.d.s the correct way round. Should you accidentally get your wires crossed no harm will come to the l.e.d., but you could spend ages wondering why no MIDI data seems to be getting through!

The last task is to fit the top and bottom panels of the case. These slide on and are retained by the small screws supplied with the case.

TESTING

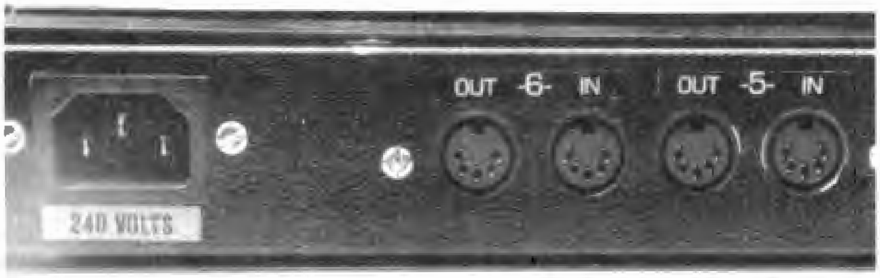
The first step in testing is to check the mains PSU. As has been clearly stated above: **take care!**



Once the PSU is up and running, check with a voltmeter that there are no voltages present on any of the inputs.

Likewise, check the outputs for any signs of untoward voltages. Operation can be quickly checked by pushing a low current l.e.d. directly into the holes of the DIN socket – cathode (k) into pin 5 and the anode (a) into pin 4. If all is okay, the l.e.d. should *not* light.

Now for the fun bit. Connect up a keyboard to one of the MIDI inputs and a synthesizer to one of the MIDI outputs. Turn everything on, select the appropriate input on the MIDI Matrix, and play a few notes. The data l.e.d. on the MIDI Matrix should flash and your synth should squawk, zzimm, boom, or whatever.



After repeating this test for the other inputs and outputs, you should now have a fully working MIDI Matrix. All that remains is to fit the unit into your studio, connect all your MIDI devices to it, and away you go, switching to your heart's desires.

As for setting up, there is none. It's just an excuse to go and have a nice cup of tea; if anyone asks you what you're doing, you can say something along the lines of "waiting for the unit to reach thermal equilibrium" (let the tea brew) before you make adjustments (add milk and sugar) to the main data switching module (get biscuit from tin), oh, and the tea's nice.

IN USE

This is one of those projects that, before you built it, you probably didn't realise you needed, but when you have built it and used it you find you can't live without it.

The main use of the MIDI Matrix is to form the heart of a small MIDI studio, where every MIDI channel passes through the unit. This greatly simplifies the wiring in the small studio, and makes alterations or additions much easier to affect (experience speaks again).

The prototype unit has certainly earned its keep since it was built, allowing rapid changes in the MIDI data path to try out new things. For example, while one computer is downloading data into a sampler, the keyboard can be controlling another synthesizer, while a second computer can be analyzing the MIDI data stream from the keyboard. Then, at the flick of a couple of switches, the whole arrangement can be changed at will.

Ease, convenience and flexibility all rolled into one unit. Marvellous!

PLUGGING MIDI

Are you aware of some of our previous MIDI projects? Since Feb '95 we have published three other MIDI designs.

Theremin MIDI/CV Interface (Jan/Feb '97)

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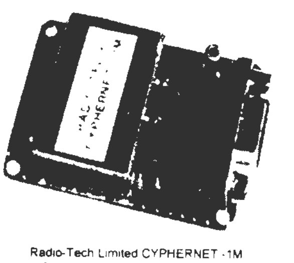

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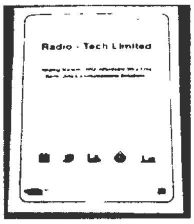

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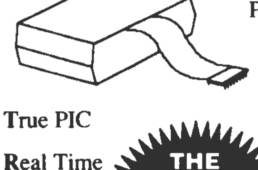

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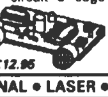

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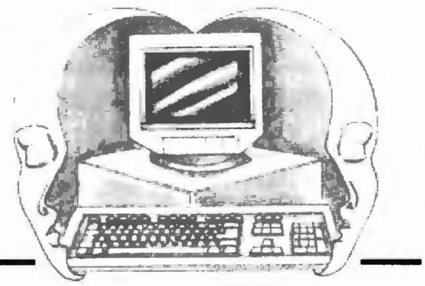
INTERFACE

Robert Penfold



FREQUENCY SYNTHESISER USING A P.L.L. AND DIVIDE-BY-N COUNTER

Last month's *Interface* article dealt with precise frequency generation using a crystal oscillator and a programmable divider chain. This method is very simple, but gives non-linear scaling. At the high end of the frequency range the output frequencies are well spread out. At the low frequency end of the range the resolution is much finer.

For some applications it is more than a little helpful to have a constant increment from one frequency to the next. This can be achieved using a standard frequency synthesis technique which utilizes a p.l.l. (phase locked loop).

With this method a crystal oscillator and divider chain produce a low frequency clock signal. The divide-by-N and p.l.l. circuits then multiply this frequency by the required factor. For example, using a clock frequency of 1kHz (kilohertz), divisions of two, three, and four through the divide-by-N counter would give output frequencies of 2kHz, 3kHz, and 4kHz.

Locking Phasers

A p.l.l. is essentially quite simple, and uses the arrangement shown in the upper block diagram of Fig.1. The input signal is fed to one input of a phase comparator, and the output of a v.c.o. (voltage controlled oscillator) is fed to the comparator's other input. The output of the comparator drives the control input of the v.c.o. via a lowpass filter.

The output from the comparator is a pulse signal, but the lowpass filter smooths the pulses to produce a d.c. control voltage for the v.c.o. The d.c. control voltage is equal to the average output voltage from the phase comparator.

If the input frequency is at a lower frequency than the v.c.o., the average output voltage from the phase comparator is very low, and the v.c.o.'s output frequency is reduced. If the input frequency is higher than the v.c.o.'s frequency, the average output potential from the comparator is high, and the v.c.o.'s operating frequency is increased. This gives a form of negative feedback loop. Provided the input frequency is within the operating range of the v.c.o., the v.c.o. will be maintained at the same frequency as the input signal, and in phase with it.

A basic frequency synthesiser consists of a p.l.l. with a divide-by-N circuit added between the v.c.o. and the phase comparator (see the lower block diagram of Fig.1). This operates in much the same way as an ordinary p.l.l., with the two input signals to the phase comparator being maintained at the same frequency and in-phase.

However, the v.c.o. has to operate at a higher frequency in order to achieve this. If there is a division by ten through the divider circuit, the v.c.o. has to operate at ten times the input frequency. Provided the limits of the v.c.o are not exceeded, the output frequency is equal to the input frequency multiplied by the division rate through the divide-by-N circuit.

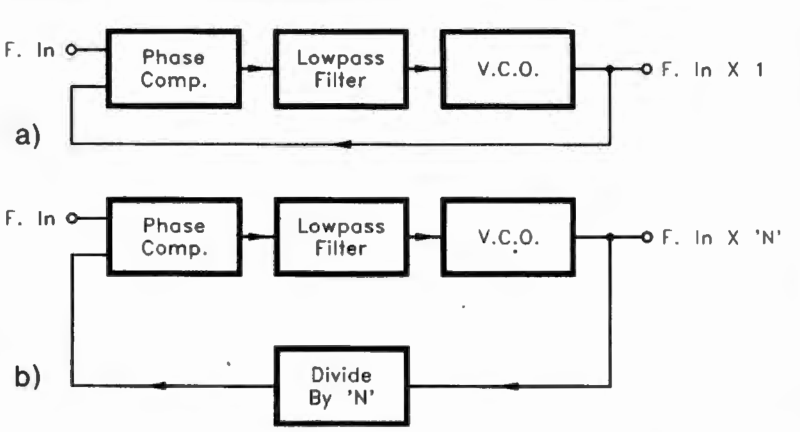


Fig. 1. (a) Block diagram for a p.l.l. (phase locked loop) and (b) the arrangement used in a basic frequency synthesiser.

Stepping Up

A block diagram for an experimental frequency synthesiser, based on the divide-by-N circuit described in last month's *Interface*, is shown in FIg. 2. A 4MHz crystal oscillator generates an accurate clock signal which is processed by a divide-by-eight counter, and a chain of four divide-by-10 counters. This gives a final clock frequency of 50Hz, which is fed to the input of the p.l.l.

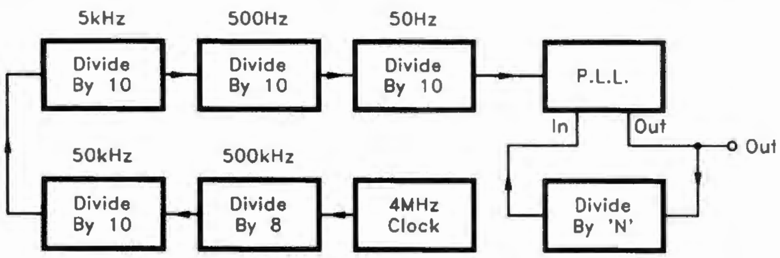


Fig. 2. Block diagram for the basic Frequency Synthesiser.

The divide-by-N counter is connected between the p.l.l.'s v.c.o. output and phase comparator input. The output frequency from the v.c.o. is therefore equal to 50Hz multiplied by the division rate through the divide-by-N circuit.

The programmable divider must include the divide-by-two stage at its output, because the p.l.l. cannot lock onto the short pulse signal produced by the 74HC161 when large division rates are used. The flip/flop produces an accurate squarewave signal that is ideal for the p.l.l., but it does of course increase the minimum division rate from two to four.

The divider therefore covers a range of four to 482, rather than two to 241. This gives a theoretical output frequency range of 200Hz (50Hz × 4) to 24·1kHz with a resolution of 100Hz.

On the face of it, the resolution should be 50Hz (i.e. equal to the final clock frequency). The reason for the inferior resolution is the divide-by-two flip/flop at the output of the divide-by-N counter.

Setting division rates of two, three, and four through the main divide-by-N circuit gives overall division rates of four, six, and eight. Divisions by odd numbers are not possible, giving a resolution of 100Hz instead of 50Hz. On the plus side, the maximum output frequency is doubled, and the inclusion of the flip/flop does not reduce the number of output frequencies available.

Frequency Synthesiser

The circuit diagram for the Divide-by-N Counter appears in Fig.3, and this is basically the same programmable divider circuit described previously, but with the oscillator stage omitted. Refer to last month's *EPE* for a full description of this circuit.

The circuit diagram for the clock and p.l.l. stages of the Frequency Synthesiser is shown in Fig. 4. Transistor TR1 is used in a conventional crystal oscillator which generates a 4MHz output signal. This is fed to the clock input of a seven stage binary "ripple" counter (IC1). In this circuit only the first three stages of IC1 are used, giving a divide-by-eight action and an output frequency of 500kHz.

Note that an ordinary 4024BE is *not* likely to work properly with a five volt supply and an input frequency of 4MHz. Its guaranteed maximum clock frequency with a five volt supply is just 2·5MHz. IC1 *must* therefore be a 74HC4024, which will operate at up to 70MHz.

The output of IC1 drives a series of four identical divide-by-10 stages. These are based on 4017BE one-of-ten decoders and decade counters.

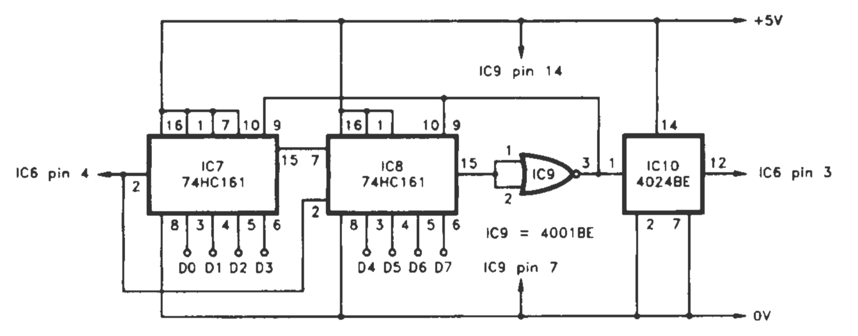


Fig. 3. Circuit diagram for the Divide-by-N Counter.

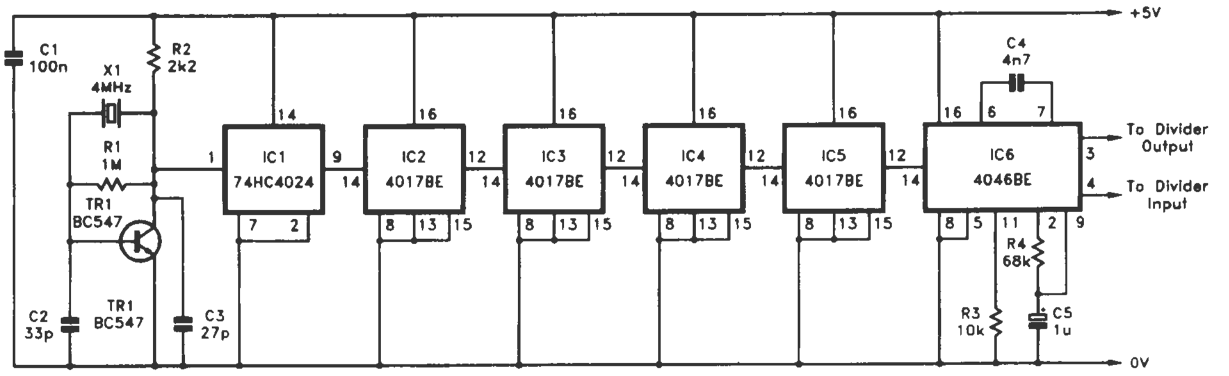


Fig. 4. Circuit diagram for the clock, divider and p.l.l. stages.

In this application only the "carry out" output at pin 12 is required, and the other ten outputs of each device are left unused. The inhibit and reset inputs at pins 13 and 15 serve no useful purpose in this application, and are connected to the zero volt (0V) rail.

A CMOS 4046BE "micro-power" p.l.l. chip is used for IC6. The only discrete components this requires are timing components capacitor C4 and resistor R3, and filter components R4 and C5. The 4046BE actually has two phase comparators with a common input terminal (pin 3), but their outputs are available separately at pins 2 and 13. The circuit will work with R4 connected to either of these outputs, but pin 2 seems to provide a slightly wider lock range in this application.

In theory, the divide-by-N counter provides a maximum output frequency that is well over one hundred times higher than the minimum output frequency. In reality the p.l.l. might not lock properly over such a wide frequency span. Some "tweaking" of R3's or C4's value should optimise the lock-in range for a given specimen of the 4046BE, but if a very wide frequency span is required it will almost certainly be necessary to cover it in two or more ranges.

It is normal for a p.l.l. to have a relatively small initial lock range, but a much wider range once it has actually locked onto the input signal. Accordingly, the division rate through the divide-by-N counter should be set to a middle value initially so that the p.l.l. can easily lock onto the 50Hz input signal. It should then be able to track a substantial range of output frequencies.

Home Improvements

As already pointed out, in order to cover a really wide frequency span the circuit must have several operating ranges. There is more than one way of tackling this. One approach is to have a relatively high frequency range from the synthesiser, and to then use dividers to provide lower output frequencies.

For example, suppose that the synthesiser operates over a frequency range of 2kHz to 50kHz in 1kHz steps. Feeding the output to a divide-by-10 circuit would give an additional range of 200Hz to 5kHz with 100Hz resolution. Two further divisions by ten would give additional ranges of 20Hz to 500Hz in 10Hz steps, and 2Hz to 50Hz with 1Hz resolution. In this way the basic 25:1 frequency span of the synthesiser can be boosted to an output frequency range of 25000:1.

Modifying the circuit to cover a frequency span of 2kHz to 50kHz is not difficult. IC6 must have a 500Hz clock signal in order to give 1kHz resolution, and this can be achieved by omitting the last of the divide-by-10 stages.

Pin 12 of IC4 then connects to pin 14 of IC6. Also capacitor C4 must be made much lower in value at around 470p, because the v.c.o. will operate over a higher frequency range.

The alternative method of obtaining more ranges is to use different clock frequencies, and replace C4 with several switched capacitors, one for each clock frequency. This is likely to prove more difficult in practice, and is not the approach that would be recommended. There is certainly plenty of scope for experimentation though, and this method should work well enough with the right values for capacitor C4.

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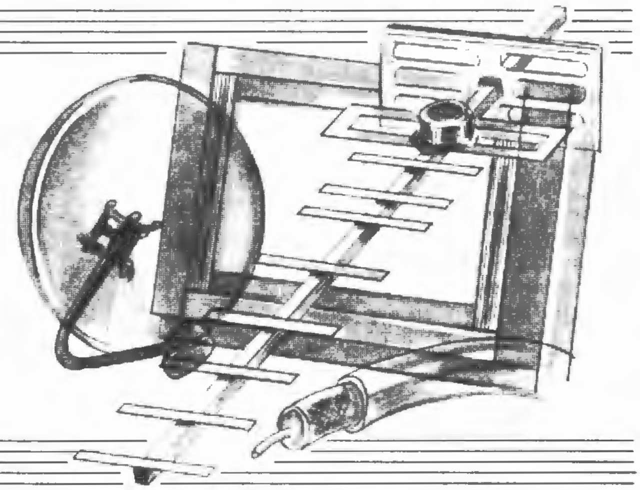
Special Review

DIGITAL TV AND MPEG2



MIKE RUTHERFORD

What is Digital TV, why all the fuss, and what on earth is MPEG2? Read on and find out!

WITHIN the space of twenty years, it has been said, all analogue forms of Radio and Television transmission could have been phased out in favour of a digital system of communication. The changes are just beginning to take place now. "Digital" is a word that is being bandied about more frequently by broadcasters, and has completely conquered the gramophone record industry in less than ten years.

This article attempts to explain the problems encountered in broadcasting television programmes in digital form, how they are overcome and what advantages accrue from going along the digital TV path.

Digital transmission of cable, satellite and terrestrial TV signals is based on MPEG2 coding, the digital compression standard set by the Motion Picture Experts Group of the International Electrotechnical Commission (IEC), and International Standards Organisation (ISO). Digital transmission of cable, satellite and terrestrial TV signals is based on this standard. Its relevance will become apparent as you read on.

ANALOGUE TO DIGITAL

The analogue system in use at present relies on exact synchronisation between camera and receiver to rewrite the transmitted picture at the point of presentation – the CRT (cathode ray tube) screen – 25 times a second. The complete picture is repeated every time, even if it contains no movement. In a digital television system the picture is created in memory and "read out" from there as a computer display reads out a graphics card.

To create a digital representation of an analogue signal requires the signal to be sampled at a high frequency, often two or three times the highest frequency present on the analogue signal. On every sampling cycle the voltage of the analogue signal is measured and turned into binary form. The principle is illustrated in Fig. 1.

For a TV picture, the result is a stream of binary data coming from the sampling process that represents the original picture dot-by-dot from top left to bottom right. A television picture is generally divided into columns and rows called pixels and lines. A pixel is a picture element.

In a 625-line picture, 576 lines are used for the picture, the remainder are blank or carry teletext data. If the aspect ratio of the picture is five units wide by four units high, you can calculate that, for equal vertical and horizontal definition, there should be 576 × 5 / 4 pixels in one line. The result is 720.

These 720 pixels have to be displayed in the time of one active line period, namely 52 microseconds, so that each pixel occupies a time of 72·2 nanoseconds. Assuming that each pixel alternately is black, then white, the highest frequency reached would be 6·9MHz. Therefore the lowest sampling frequency one could use for such a picture would be 14MHz, and, in fact, the luminance signal is sampled at 13·5MHz for MPEG2.

A colour television picture that was simply converted from its present 625-line, 25 frames per second, format into a stream of binary digits would require a bandwidth of 108MHz to transmit its 216Mbits/s (megabits per second) serial data stream. 108MHz could accommodate thirteen analogue channels – so what's the point in going digital?

THE POINT OF DIGITAL

There was very little point in going digital until broadcasting engineers began to study more closely the nature of television pictures, realising that much of the information transmitted in the analogue system was repetitive. The big advantage of the digital way was that memory could be used to store the picture, then only changes in the picture from frame to frame need be transmitted. In the receiver, the information could be used to up-date the original image in memory to make the next

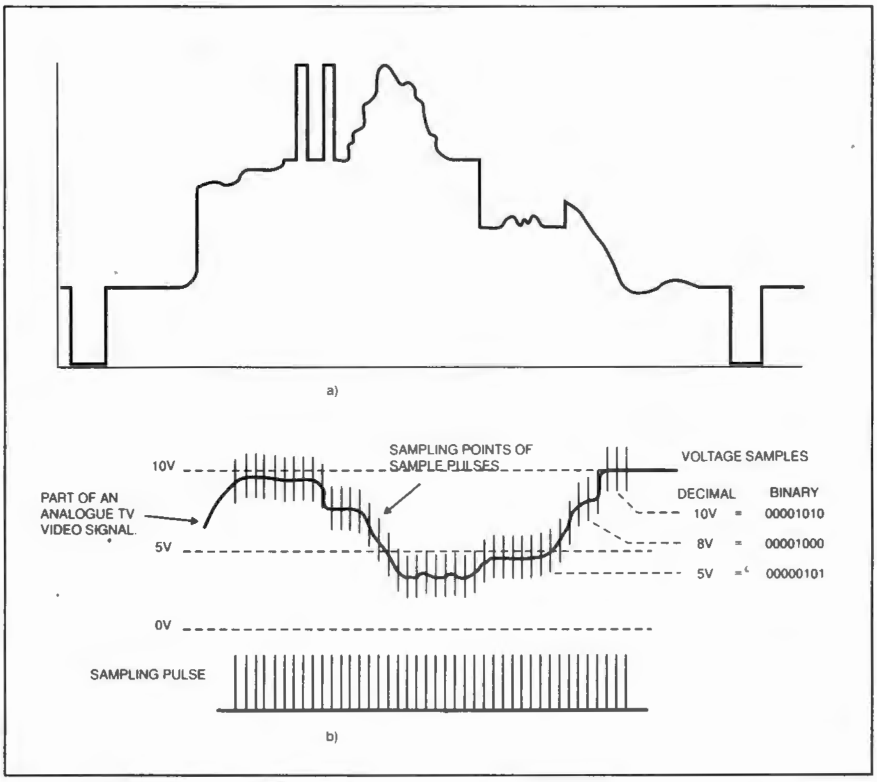


Fig. 1. (a) Typical analogue TV line, (b) analogue to digital conversion by sampling.

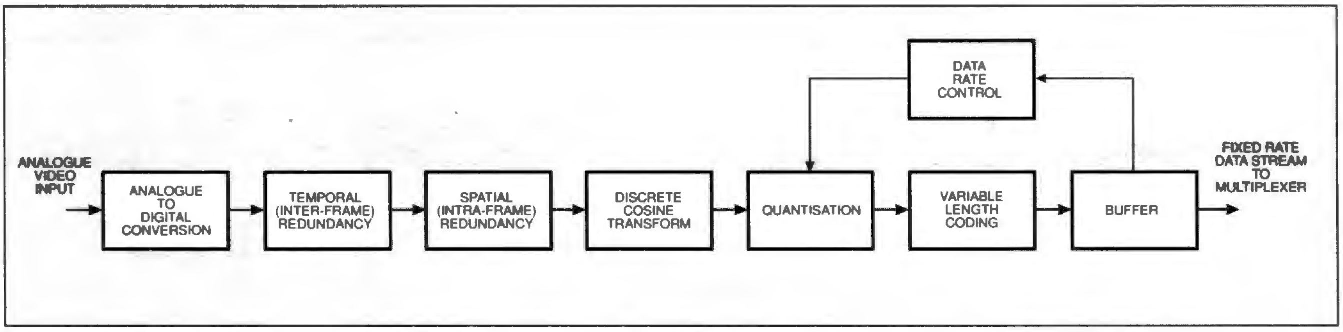


Fig. 2. MPEG2 processing stages.

frame! This is one of the bases of MPEG2, the data compression process used to transmit high-quality pictures (and sound) in a small bandwidth.

Since MPEG2 is going to feature largely in our lives in the future, it might be as well to examine its processes as a path to understanding the nature of digital TV. Between the studio console and the transmitter are seven steps of data processing that throw out repetitive data, split up the remainder into packets with identification and timing tags, and multiplex it with other television services all with sound and other data. Fig. 2 shows the seven stages of processing used by MPEG2 to achieve compression ratios of up to 160:1.

Very often the amount of redundant information in a television picture can be as high as 95%. Stage one, the analogue to digital conversion stage, samples the luminance and chrominance signals and turns them into streams of binary digits. The luminance signal is sampled at 13·5MHz and the R-Y and B-Y colour difference signals, known as Cr and Cb in their digital form, at 6·75MHz each. Eight-bit sampling will give 256 shades of grey, but ten-bit samples are more frequent in modern digital studios.

By comparing adjacent frames of a video sequence, the differences from frame to frame can be detected and these sent to the receiver to modify the picture in memory. If a still picture or, more rarely, a test card was transmitted it should be possible to send one frame and then turn the transmitter off! Unfortunately, anyone who turned his receiver on slightly late would get nothing at all, and for this reason a full frame is sent on a regular basis to allow for people channel-hopping and turning on the TV in the middle of something.

TEMPORAL REDUNDANCY

The process of discarding repetitive picture information from frame to frame is termed Temporal Redundancy and is the second stage shown in Fig. 2. Motion-picture cartoon animators use a similar process on the rostrum camera using overlays on a static background for some scenes as it avoids having to draw the same background repeatedly frame after frame.

Each frame is assembled into blocks of pixels, initially eight pixels by eight lines of luminance, then formed further into groups of four luminance blocks (16 pixels by 16 lines) with two chrominance blocks, one for Cr and the other for Cb. This larger grouping is called a macro-block, and is detailed more fully in Fig. 3.

Inter-frame comparisons are done at macro-block level. A process akin to subtraction is used to determine differences which are forwarded for more processing. The macro-blocks are assembled in sequence in exactly the same way as the original picture was scanned – left to right, top to bottom.

The assemblage of several adjacent macro-blocks into a sequence constructs what is called a "slice" (see Fig. 4). A slice forms a convenient collection of data for error-detection and correction purposes. The "slices" are assembled in sequence to compose one TV frame and a string of frames, usually twelve in

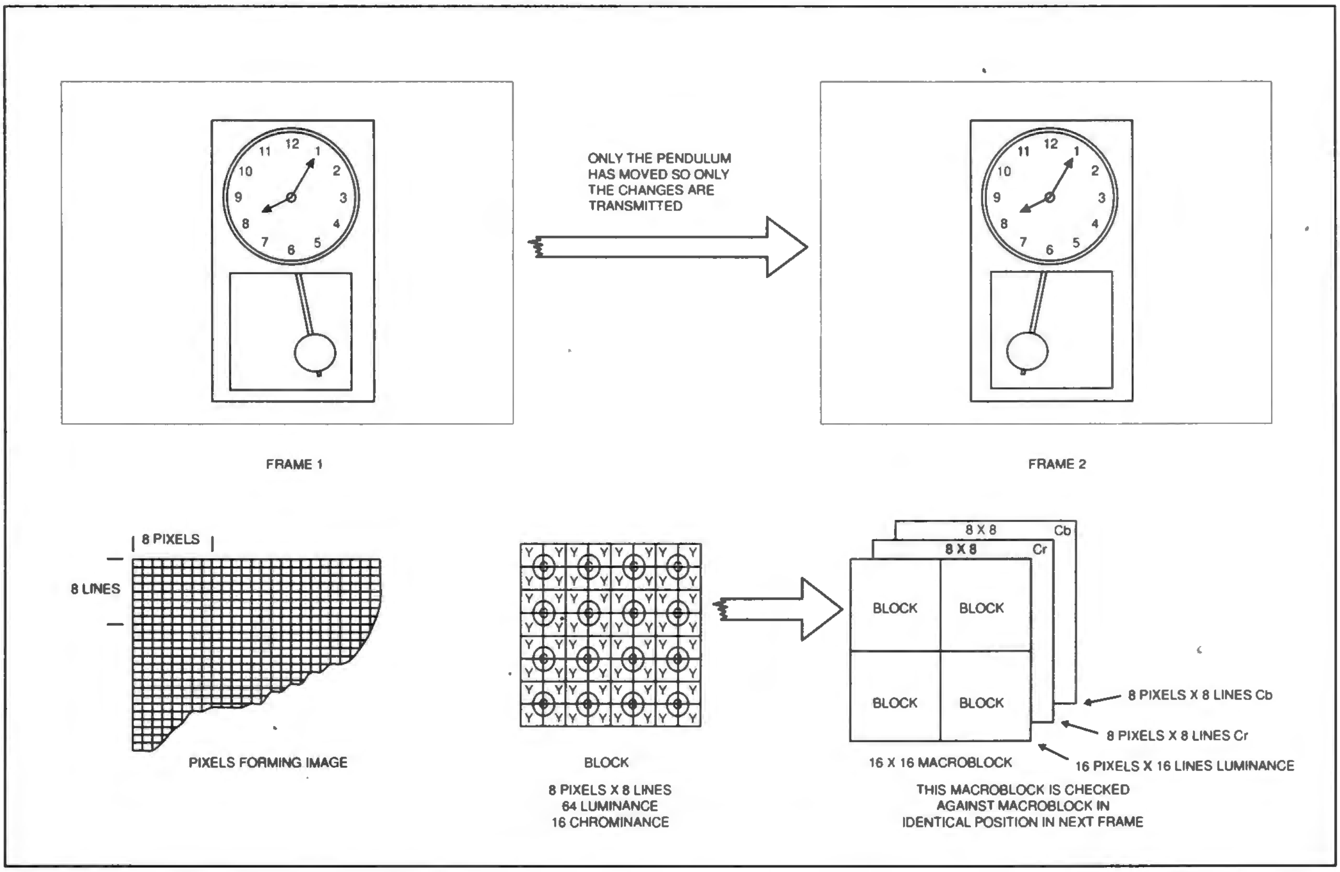


Fig. 3. Temporal redundancy – blocks and macro-blocks.

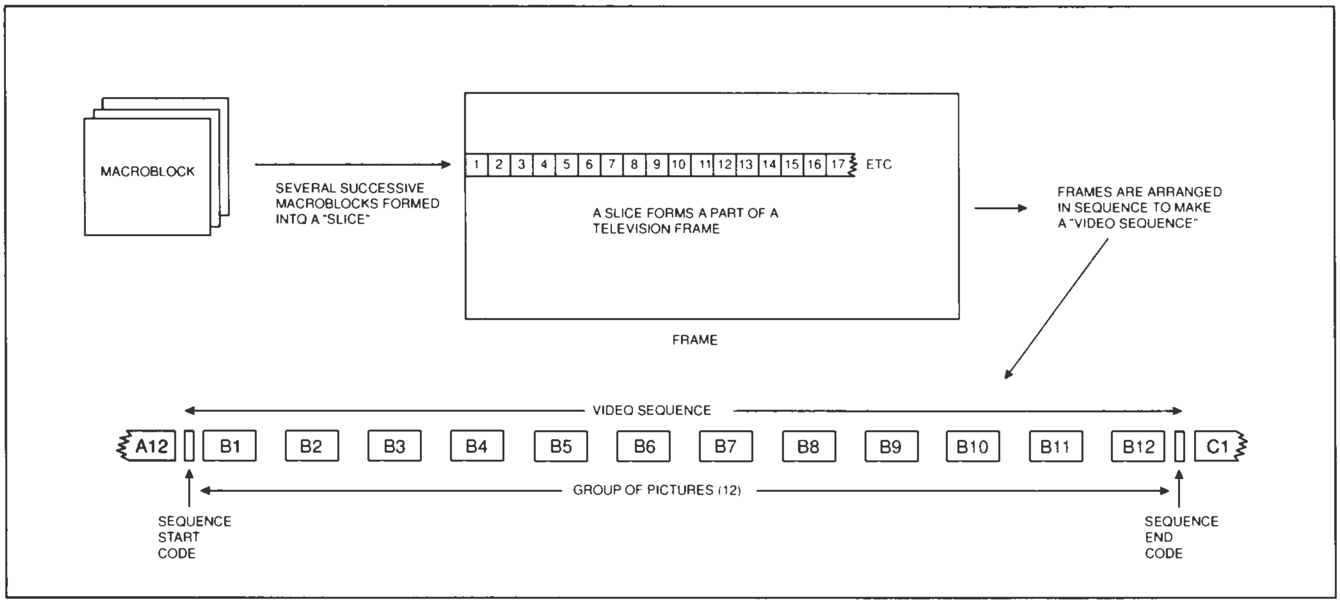


Fig. 4. A group of pictures.

number, are grouped together with appropriate identification codes and timing marks to form a video sequence. The group is a useful unit around which service identities can be determined and this makes for greater ease of editing and switching.

Next, the similarity of adjacent pixels within a frame is examined and a code sent to denote how many pixels have the same or very similar luminance and chrominance values. If, say, a whole line of picture has a luminance value of 0·6, Cr of 2·2 and Cb of 8·3, the process will say "Line 78, Pixel 1, Y =0·6, Cr =2·2, Cb =8·3, repeat 719 times".

SPATIAL REDUNDANCY

The third stage in Fig. 2 is termed Spatial Redundancy and only occurs within the boundaries of an individual frame. It is shown in expanded detail in Fig. 5. The process contributes further to the elimination of repetitive information. Further savings are made by using short codes for frequently-used code sequences and for timing and synchronising signals.

This is like the system used in Morse Code where the most frequently used letters of the alphabet have the shortest codes, for example "E" is simply a dot and "T" is just one dash, whereas "Z" is dah dah dit dit. In addition, large numbers of zeroes or ones can be re-coded, for instance x zeroes followed by y ones can be re-coded as (x, 0) (y, 1).

Large runs of zeroes are found at the end of data runs, and these are given short codes to signify the end of a data run instead. It all saves precious space, and the process is called Statistical Redundancy.

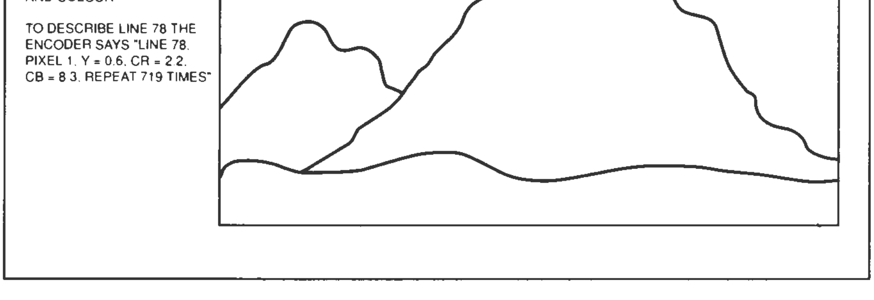


Fig. 5. Spatial redundancy.

The precise timings involved in television are an advantage when it comes to assessing the motion of a group of pixels which comprise part of a moving picture, for the accurate timing and precise positional information allows predictions to be made about blocks of pixels in motion. Macro-blocks are used for motion prediction, and the speed and direction can be calculated simply and a vector produced that describes the motion. The values of Y, Cr and Cb in macro-blocks in identical positions in successive frames can be compared and the differences used to generate a shorter code.

COSINE TRANSFORMS

Up to this point, the redundancy process is reversible, nothing of value has been lost. The next step in the sequence is a complicated mathematical process known as Discrete Cosine Transform. This is represented by stage four in Fig. 2, and expanded in Fig. 6.

The transformation is performed upon the numbers representing the luminance and chrominance values in the pixels of an 8 × 8 block. It is a conversion of the values from a time domain to a frequency domain.

It is somewhat akin to saying that a side of a square wave rises in 25 nanoseconds and that, in frequency terms, is 10 megahertz. This delivers a new set of whole numbers which are then quantised. That is to say, the numbers are "rounded up" or "rounded down" to the nearest step in a range of equal steps.

Supposing you have a set of steps that increment by 20 and you have to fit 47 into it, the nearest step is 40, so 47 is quantised to 40. If the next number in the range is 77, that is quantised to 80. The larger the steps (and the fewer), the larger the errors are. With the same numbers and steps of 5, 47 would be quantised to 45 and 77 to 75, so the closer the steps, the smaller the quantisation errors.

The quantisation process further reduces the amount of data that needs to be sent and in the MPEG encoder the quantisation process is a variable one, as will be seen later.

TRIPLE FRAMING

The MPEG process uses three types of frame (see Fig. 7), *I* for Intraframe, *P* for predicted frame, and *B* for bi-directional frame. The I frames are reference frames, they are not predicted or interpolated. An I frame is inserted into a group of pictures every twelfth spot, and serves to provide a reference for decoding to commence quickly – just under half a second. They are not subjected to the high degree of compression that B and P frames undergo.

The I frames allow channel surfers and the casual viewers who dip into and out of