ELECTRO MUSIC • RADIO • DISCO • ENVIRONMENTAL

No. 92

FULL SOR

AUGUST 1995 • £2.10

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ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

Measuring the World's UV radiation – the sobering facts!

Multi-Strobe a pulsating project for you to build

Revitalise the 'lost art' of short wave radio receiving with a Regenerative World Band Receiver

Control your electronic equipment with the Telephone Activated Switch and Timer

Make it Funtime – build a mega exciting Sound Generator Project

New Series: The Art of Electronic Music

AUGUST 1995
VOL 14. No. 92

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WESTERN SOUND GENERATOR 4
For fans of Cowboys'n'Injuns everywhere, this fun project provides six 'Wild Western' sound effects, ranging from 'hoss' noises, through to a selection of firearms being discharged, even a bugle fanfare! Just the ticket for children's toys, parties and games, or for use in amateur dramatic productions.

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You can gain added benefit from your telephone, by using this project to control the switching on and off of appliances remotely, even from the other side of the world, by means of 'phoning through to your designated telephone, and making it ring a specified number of times in accordance to a code which will only be known by you – and best of all, its use won't break any laws in doing so!

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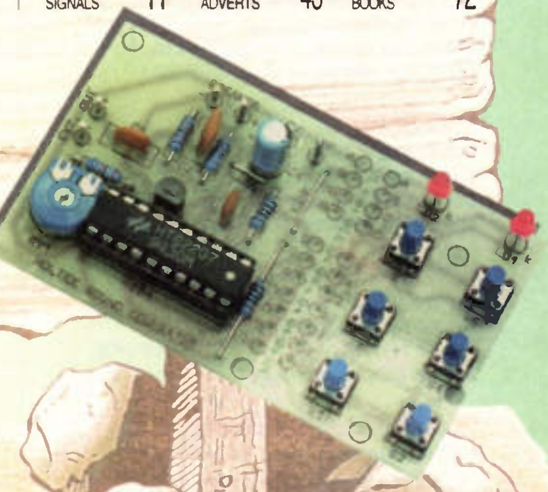

ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue of *Electronics!* This issue marks an important milestone in the history of *Electronics*; similar to when I took over from Roy Smith as Editor in 1991. The October 1991 issue also marked the change from bi-monthly to monthly publication. It is now my turn to vacate the Editor's Chair and hand *Electronics* into the capable hands of Robin Hall.

Robin joined the editorial team of *Electronics* in time for the February 1994 issue and has been a very valuable member of the team ever since. Robin recently took on the role of Assistant Editor, preparing him well for the transition to Editor. I am sure that Robin, with the assistance of Maurice Hunt and the rest of the team, will guide *Electronics* through the exciting years ahead, to bring you details of technological developments within the sphere of electronics as they happen.

I have now moved into a new role within Maplin, forming part of a new Product Group Management team. Together with my new colleagues we will be working to develop Maplin's product range to even dizzier heights than previously thought possible! You will see the results of our work in the pages of the new Maplin Catalogue, published later this year, and this very magazine – watch this space!

I would like to express my thanks to everyone involved in *Electronics*, both 'behind the scenes' and, of course, all you readers out there! *Electronics* wouldn't be what it is without your loyalty – thank you! All that now remains is for me to hand over to Robin.

Thank you, Robert, for your very kind words, I hope to keep up the high standard of *Electronics – The Maplin Magazine* that yourself and Roy Smith have set. Myself and Maurice (pictured right and left respectively) attended the Waters & Stanton Open Day recently, and it was very gratifying to come across so many subscribers to the Magazine. It is pleasant to meet our readers and discuss various topics and problems, which is not always

possible with the large amount of work involved in the running of the magazine. Further attendances at other venues are planned, later in the year. The next will be at the Southend & District Radio Society's Radio and Computer Rally to be held locally at the Cliffs Pavilion in Westcliff, Essex on 10th September. The Southend Club are celebrating their 75th year, having been formed in 1920, the year that two daily programmes were sent over the air from the Marconi works at Chelmsford. In 1923, the club was licensed to use 5QK, and in 1946, this was changed to G5QK. In 1926, the club was instrumental in setting up a complete wireless receiving system at the Victoria Hospital in Westcliff. Another complete installation was set up at Southend General Hospital in 1932, which included 135 pairs of headphones, 40 pillow phones, 20 loudspeakers and miles of cable. During the Second World War, various club members were involved in such activities as receiving encoded German messages and spy catching – it is believed no such activities are being carried out by any members of the club at present. . . .

This month, there is a varied range of four interesting projects for you to build. These consist of the Western Sound Generator, based on a super chip with six different sound effects from the Wild West programmed into it, such as rifle, gun and cannon shots, and with the cavalry coming to the rescue with a bugle fanfare. Then there is the practical Call Code Switch which enables devices (particularly mains driven devices) to be switched just by ringing the 'phone where the Call Switch is located within 'earshot' of the 'phone. The first part of a brilliant project for use at discos and other, more technical applications, is on offer, in the shape of the Multi-Strobe, which has facilities more associated with very expensive professional units, and for Short Wave Listeners, there is a regenerative receiver using modern devices, but a mixing method first used in the early radio sets, and brought up-to-date.

Features this month, include Flash EPROMS by Ian Poole, Low Energy Personal Computers by Frank Booty, Ultra-Violet Radiation by Douglas Clarkson, and Yesterday's Electricity by Stephen Waddington. We also have the start of a new series by Richard Wentk.

Additionally, there is the second part of Noise by John Woodgate, and the conclusion of Coupled Cavity Speakers by David Purton.

So, from your new Editor, and everyone here at *Electronics*, here's wishing you an enjoyable read!

ABC CONSUMER PRESS

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project The ratings are as follows:

1 **Simple** to build and understand and suitable for absolute beginners. Basic of tools required (e g . soldering iron, side cutters, pliers, wire strippers and screwdriver) Test gear not required and no setting-up needed

2 Easy to build, but not suitable for absolute beginners Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing

3 Average Some skill in construction or more extensive setting-up required

4 Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required

5 Complex High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring Recommended for skilled constructors only

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Kits, components and products stocked by Maplin can be easily obtained in a number of ways

Visit your local Maplin store, where you will find a wide range of electronic products

If you do not know where your nearest store is, Tel: (01702) 552911 To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

Write your order on the form printed in this issue and send it to Maplin Electronics, P O Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order or Credit Card

Telephone your order, call the Maplin Electronics Credit Card Hotline on (01702) 554161

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Full details of all of the methods of ordering from Maplin can be found in the current Maplin Catalogue

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Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17 5% (except items marked NV which are rated at 0%) and are valid between 7th July and 31st August 1995 errors and omissions excluded. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (01702) 556001 between 9 00am and 5.30pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (01702) 553935; or by writing to: Customer Technical Services, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17 00
£25 00 to £39 99	£24.00
£40.00 to £59.99	£30.00
£60.00 to £79.99	£40.00
£80 00 to £99.99	£50.00
£100 00 to £149 99	£60.00
Over £150.00	£60.00 minimum

Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read – your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

Write to: The Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex, SS6 8LR, or send an e-mail to AYV@maplin.demon.co.uk

TECHNOLOGY WATCH!

with Keith Brindley

As you read this, Microsoft is currently in the process of officially launching Windows 95 – the new generation of its operating system software. Microsoft expects this single piece of software to sell in its millions from the very start. It probably will of the 100 million or so IBM-compatible PC owners, the majority are expected to move across to Windows 95 over the next few years. As such (even if only, say, 60% upgrade to Windows 95) the operating system will be the single most successful piece of software ever sold by Microsoft in terms of revenue earned. Only MS-DOS itself will have sold more in terms of numbers.

But how soon should you consider moving to Windows 95? Microsoft says that Windows 95 can run on as lowly a PC as a 386 with only 4M-bytes of RAM. Well, yes it does, but that does not necessarily mean that you should rush out to buy Windows 95 if that is your PC's configuration. With only 4M-bytes of RAM your PC will rely heavily (well, almost totally) on using *virtual memory* – that is hard disk space utilised by the PC's microprocessor to act as a sort of RAM. But virtual memory is very much slower than *real* RAM and this tells in your PC's operational speed after installing Windows 95. In fact, a racehorse-like 386 with 4M-bytes of RAM running Windows 3.1 feels like a veritable nag under Windows 95.

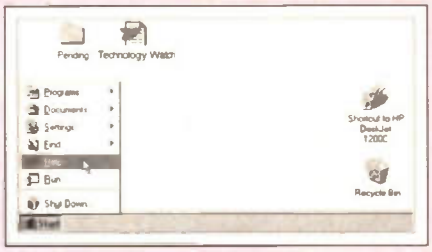
From personal tests I have undertaken on a 486 running at 33MHz, using Windows 95 in its beta versions, it is RAM which makes all the difference. Upgrading from 4M-bytes to, say, 8M-bytes of RAM makes the machine much more responsive and while not as fast as it seemed under Windows 3.1, at least liveable. With just 4M-bytes of RAM I would sooner be running Windows 3.1. But there again given the option, of course, I would sooner be running a Mac (but that is a different story, and I think I have made my point of view known on this respect before in this column). [Run OS2 Warp on the PC Keith and see the difference, Ed.]

Naturally, I am not telling people *not* to upgrade to Windows 95. All I am saying is that the upgrade cost is not necessarily just the cost of the new software. You might find you need significantly more RAM if your machine Is currently memory-challenged. Bear this in mind!

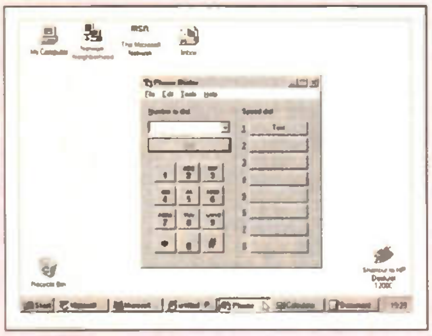
Given that, what are the benefits of upgrading to Windows 95? Well, first off, Windows 95 is a true operating system unlike earlier versions. Windows 3 and all its predecessors and ancestors are merely programs which run on top of the MS-DOS environment – itself the actual operating system. Windows 95, on the other hand, controls the PC directly. If you still run MS-DOS programs (some business software and many games are DOS-based) then you'll do this through Windows 95, rather than the other way around with earlier Windows versions.

Because of this, Windows 95 Is much better at handling the microprocessor. Some measure of pre-emptive multi-tasking is enabled, and 32-bit operation is possible. Some other technical advantages result, too.

In user terms, however, the best advantage Windows 95 has over earlier versions is the improved graphical user interface (or GUI – pronounced *gooey* – as its known). The whole computer becomes somewhat more easy to use, as a standardised logical interface takes over the running of the machine. A new arrival is the Taskbar along the bottom of the screen, featuring the Start button. Clicking here opens a hierarchical menu structure from which you can access programs, utilities, accessories, documents and so on (including the shut down procedure for turning the PC off – seems daft to me to call it the START button when you are wanting to shut down!).



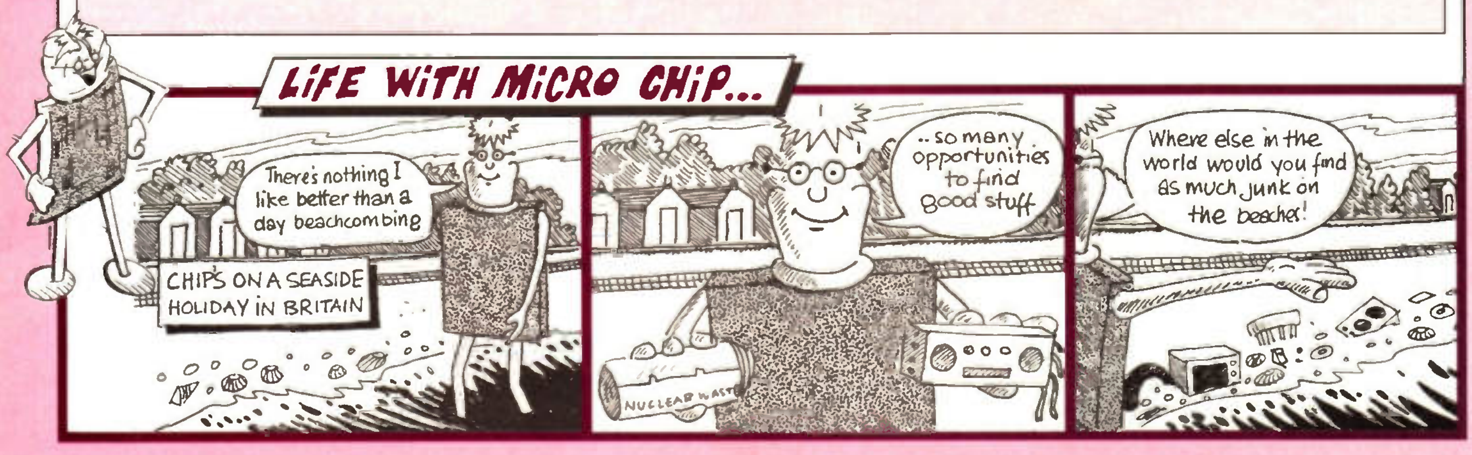
There are also buttons on the Taskbar representing every program which is currently running. Clicking on a program's button brings that program to the front of the desktop. So, if you have say 6 applications simultaneously on the go, each with their own open windows, and cannot locate a window from a particular application in among them all, just click on the application's button on the Taskbar to bring it foremost.



In earlier incarnations of Windows, File Manager was the only real graphical method of a user controlling locations of files and directories on the computer's hard drive. Program Manager (which created the PC's computer Desktop, was pretty much controlled by the software – the user did not have much say). Windows 95, on the other hand, allows you to control files and *folders* (yes, Microsoft has capitulated and resorted to the Mac's way of thinking about directories) directly from the Desktop through View windows. Just double-click a folder to open a window showing what is in it. Double-click a file to launch the application and view the file, or double-click another folder inside a folder to open another window showing what is in *that*. Drag files and folders from one folder to another to move or copy them. It is straightforward and simple and long overdue.

Finally, IBM-compatibles can have some of the features enjoyed for four or five years by users of other computing platforms – and that has got to be good news.

The opinions expressed by the author are not necessarily those of the publisher or the editor.



HT82207 SOUND GENERATOR

Recreate the sounds of the Wild West in your home, or give added realism to playing at Cowboys 'n' Indians, with this sound generator, which gives six authentic Western sounds, and all without a horse or six-shooter in sight. Giddey-up hoss, Yeeahargh!

KIT AVAILABLE (90030) PRICE £7.99

1 PROJECT RATING

FEATURES

- ★ Six Realistic 'Wild West' Sound Effects
- ★ Snap-off PCB Design
- ★ On-board Amplifier
- ★ Low Operating Voltage and Standby Current
- ★ Alternately Flashing LEDs

Design by Nigel Skeels
Text by Maurice Hunt and Nigel Skeels

APPLICATIONS

- ★ Toys, models and games
- ★ Sound effects for amateur dramatics or films
- ★ General amusement
- ★ Novelty door announcer

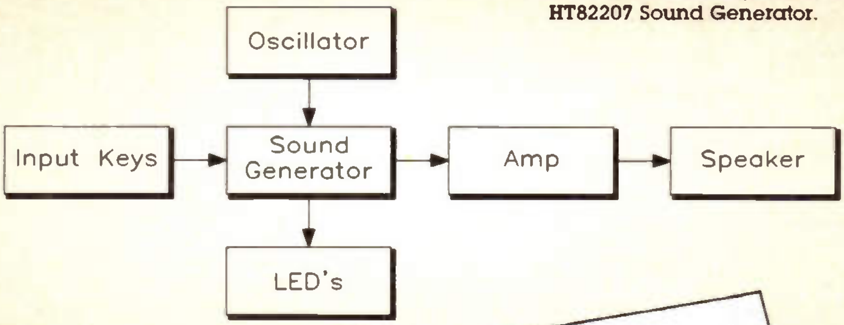
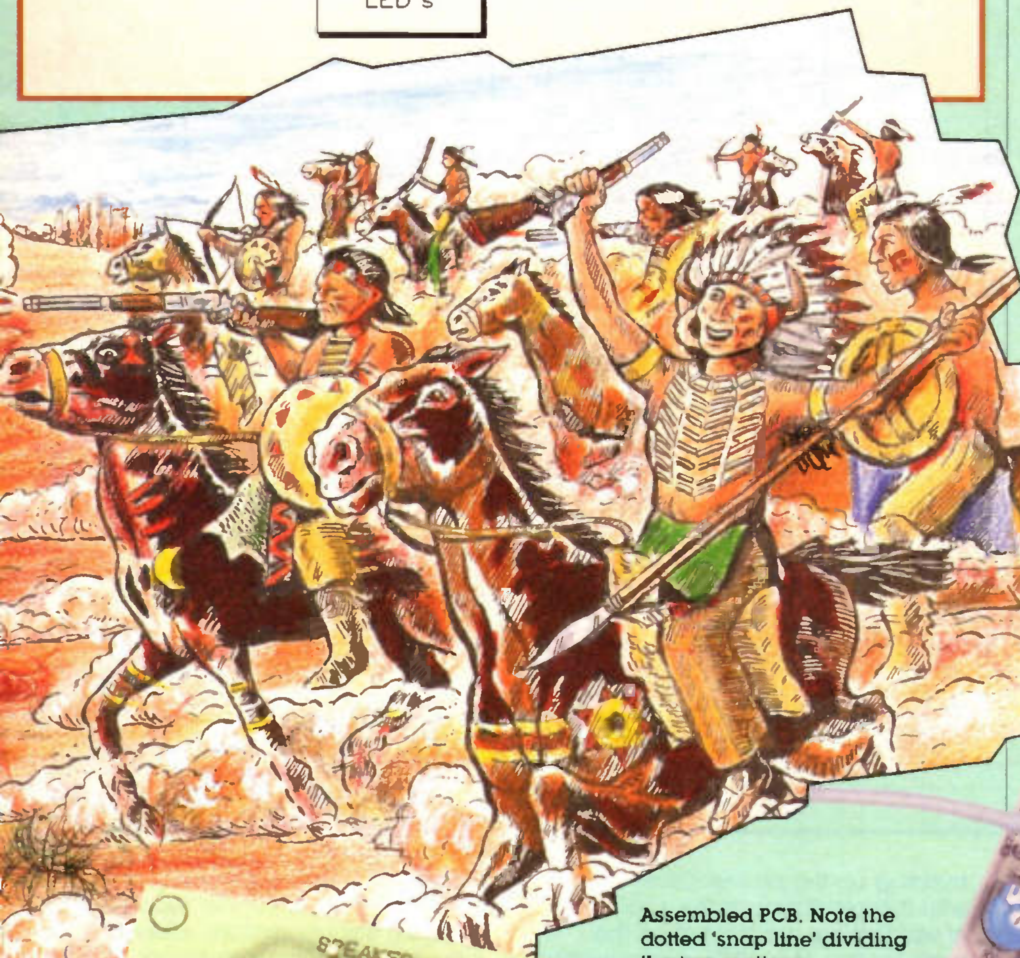
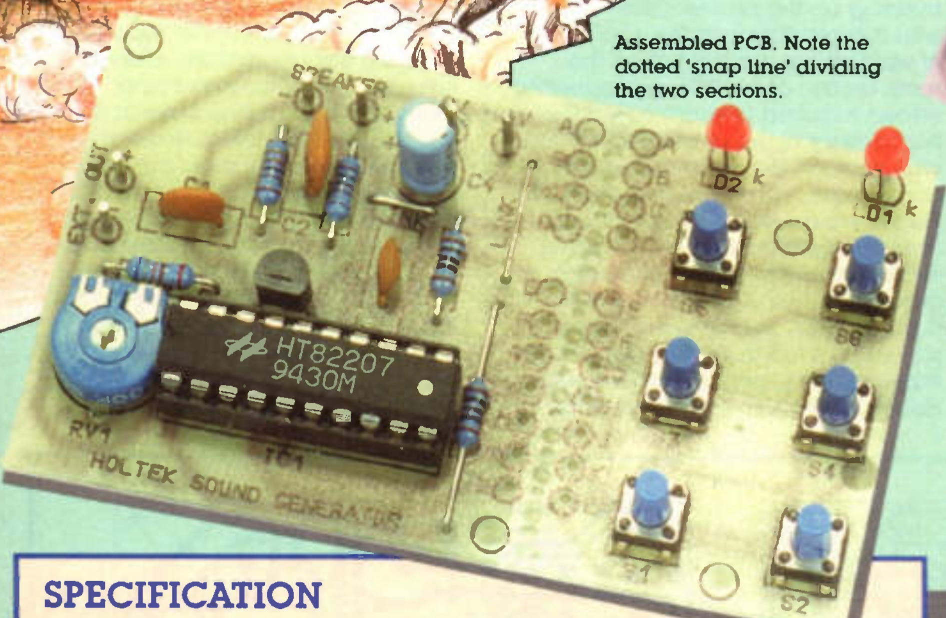


Figure 1. Block diagram of the HT82207 Sound Generator.

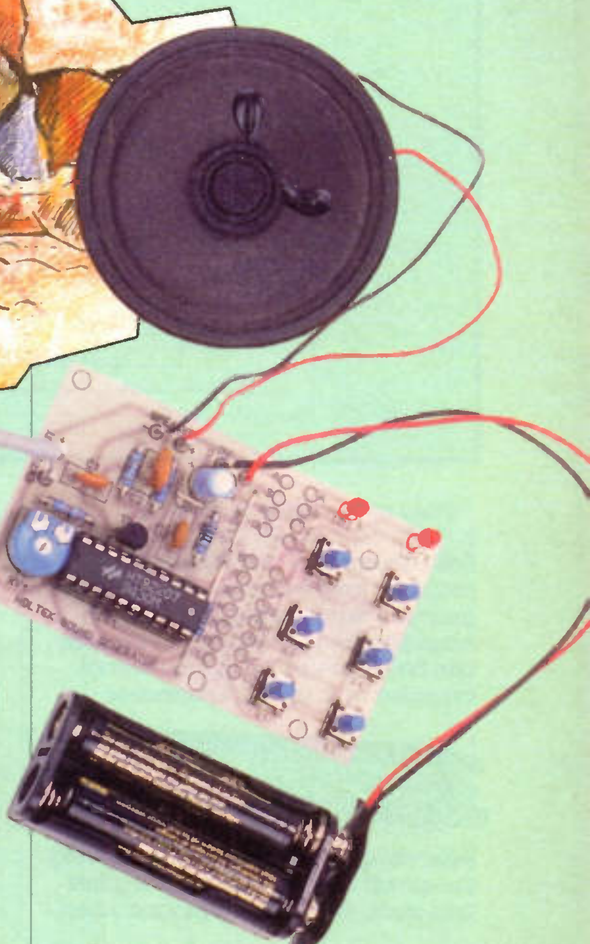


Circuit Description

This is a relatively simple circuit, consisting of two main parts, the block diagram of which is shown in Figure 1 and the circuit diagram, in Figure 2. IC1 is the HT82207 Western sound generator chip, and TR1 acts as the output amplifier for powering the speaker. There are eight sounds stored in the memory, but two of them are repeats and, therefore, have not been catered for in this design. Table 1 shows the sounds that are available, in response to the button being pressed. To achieve an output from the sound generator, one of the key pins 4,5,8,9,11 or 12 is taken low (to logic 0). Note that attempting to activate more than one sound effect at a time, will result in only one sound being selected, and the sounds are not cascadable automatically with this circuit.



Assembled PCB. Note the dotted 'snap line' dividing the two sections.



Assembled PCB unit sounder and batteries (2 × Alkaline AA) connected

SPECIFICATION

Operating voltage:	2·4 to 3·6V DC (2 × 1·5V AA cells)
Operating current (maximum):	97mA
Standby current:	0·01μA
Output impedance:	8Ω loudspeaker (driven by on-board amplifier)
PCB dimensions:	75 × 45mm

S1: HORSE WHINNYING
S2: HORSE GALLOPING
S3: PISTOL FIRE
S4: RIFLE FIRE
S5: CANNON SHOTS
S6: BUGLE FANFARE

Table 1. Sounds generated in response to button being pressed.

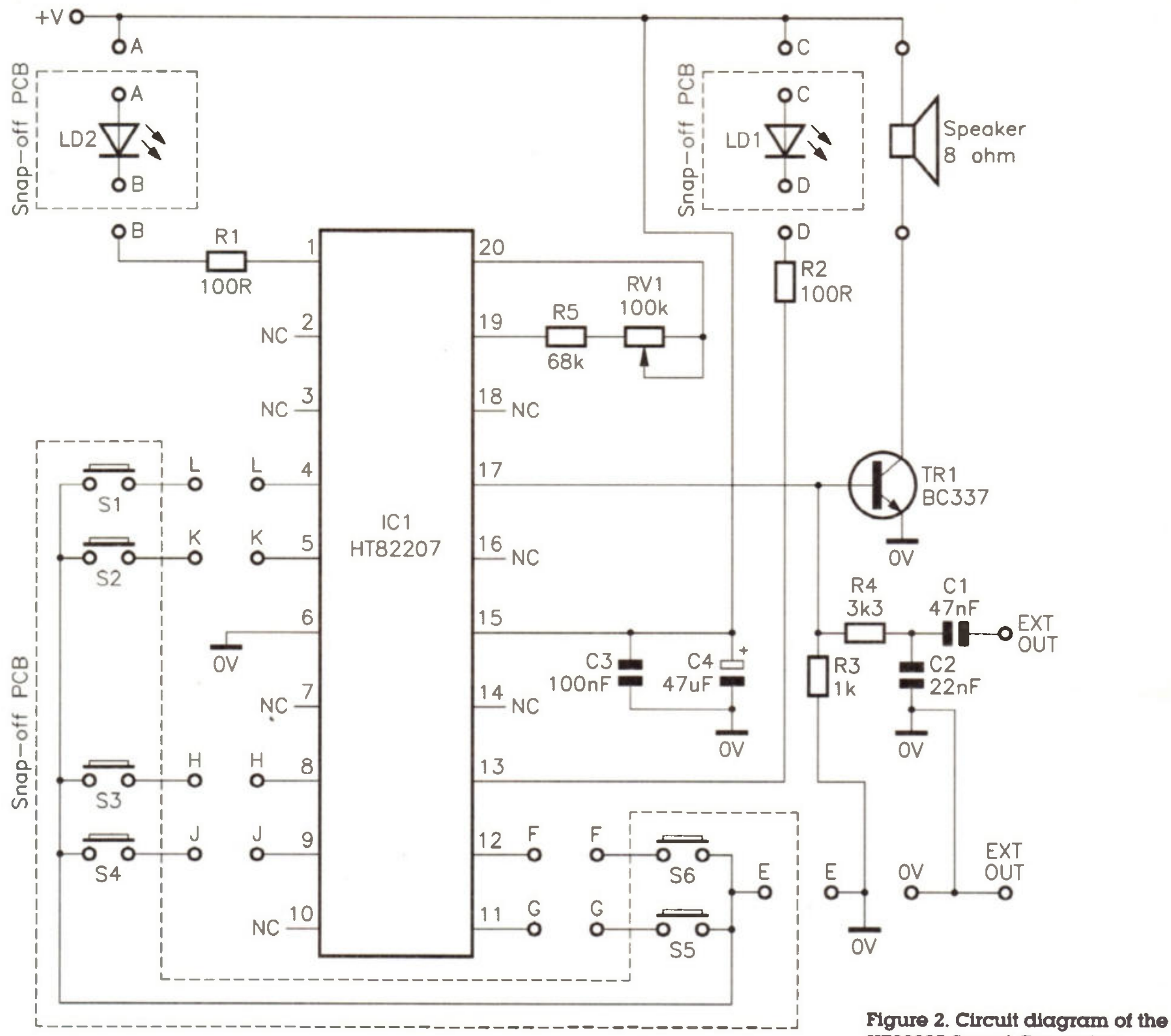


Figure 2. Circuit diagram of the HT82207 Sound Generator.

Other connections to the chip, include the two LED outputs that flash alternately, and the external amplifier feed terminals, allowing far greater volume (using your chosen amplifier/speaker combination) than can be achieved using the internal amplifier and small loudspeaker.

PCB Construction

Reference to Figures 2 and 3, showing the circuit diagram and PCB legend and track, will be of assistance when building up the project. Commence with the installation of the wire links, of which there are just two on the main section of the PCB, and a further eleven required to interconnect the two sections of the snap-off PCB if you want to have the switch/LED panel at an angle, but adjacent to the main board. Alternatively, 11-way ribbon cable could be used between these sections, to allow remote-mounting of the sound selector switches and flashing LEDs. Twenty-two PCB pins should be fitted in the two sets of holes labelled A to L, prior to soldering the ribbon cable onto these pins. Note that when 'snapping' the PCB, use a scalpel to cut the tracks running between the two sections, otherwise there is a risk of the remaining sections of track being lifted as the sections are separated. However, if you do not want to 'snap' the board, the eleven wire links are not required, since the sections are interconnected by the PCB tracks. Next, solder in the DIL IC holder, with its pin 1 identifier notch the correct way round, so that it is adjacent to the potentiometer. Mount the resistors R1 to R5, ceramic capacitors C1 to C3, and electrolytic capacitor, C4, ensuring its correct

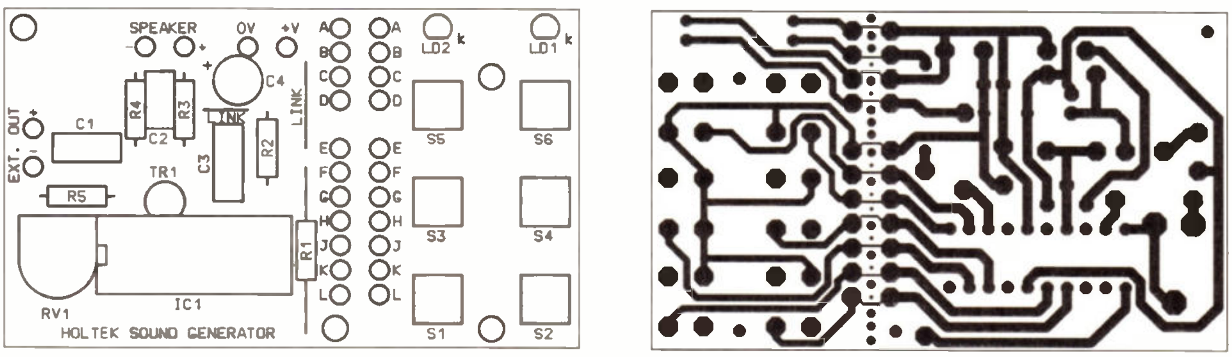


Figure 3. PCB legend and track.

polarity. Then, fit transistor TR1, and the cermet potentiometer, RV1, followed by the six PCB-mounting push switches, and the two LEDs, again, ensuring their correct polarity. Finally, fit the PCB terminal pins, and solder connecting cable, such as Zip, or bell-wire, between the PCB and the chosen power supply and speaker/amplifier, as required for the particular application. Thoroughly check your work for misplaced components, solder bridges, whiskers, and dry joints. When the PCB has been fully assembled, and preferably before snapping the PCB into two sections (if you plan to), clean all the flux off the underside, using a suitable solvent. The IC should be inserted into its socket last of all, since it is a static-sensitive CMOS component.

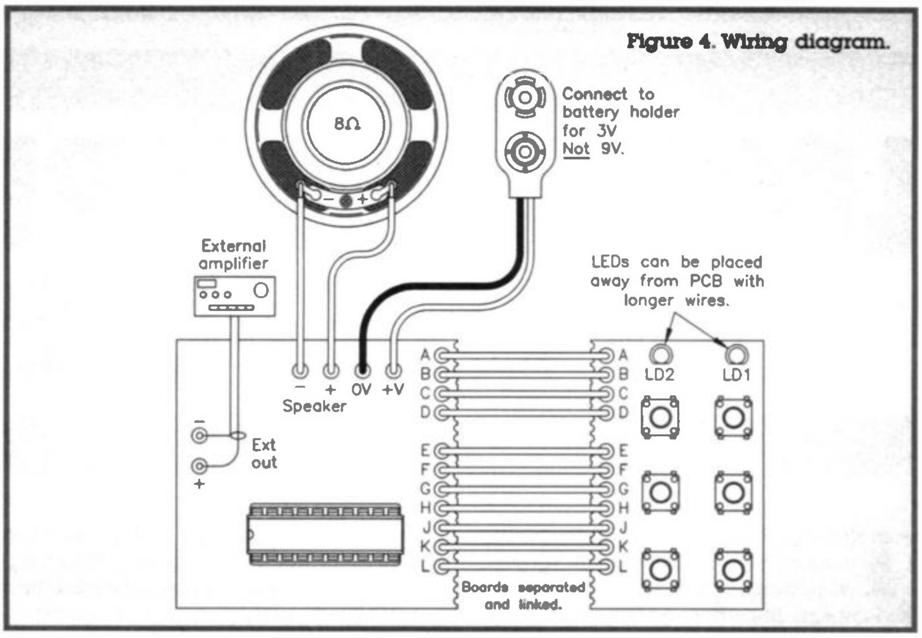


Figure 4. Wiring diagram.

Testing

Figure 4 shows the wiring diagram for this unit. With a suitable speaker or amplifier/speaker combination connected to the board via the output terminals, apply the power supply as specified, and press each of the six push switches in turn, which should result in a different 'Western' sound being produced with each button tried. Additionally, the two LEDs should flash alternately ('flip-flop'). The speed of the on-chip oscillator, and hence speed of the sound and LED flashing rate, is adjustable by means of potentiometer RV1, and should be preset as required. If nothing happens, turn off and recheck that the unit is assembled correctly, and that the right type of loudspeaker/amplifier combination is being used – it is best to test the board with just an 8Ω impedance, small speaker connected directly to the board before trying it out using a separate amplifier. If this fails, test the loudspeaker, by briefly connecting a low voltage supply (1·5V maximum) across its terminals, whence a click should be heard, confirming that the speaker is OK. Still doesn't work? Check that the IC is installed correctly in its socket. (Believe it or not, this mistake has been made before, even by experienced constructors!). The simplicity of this project means that there is not much opportunity for errors to occur in assembly. However, if the LEDs flash but no sound is emitted, it is likely to be the transistor TR1 that is at fault, rather than the IC. If, on the other hand, you get the sounds, but no flashing LEDs, then check that they have been inserted the correct way round, as per the printed outlines on the PCB.

Operation

Simply press the appropriate button to activate the circuit into emitting 'Wild Western'-style sound effects and alternately flashing LEDs. The standby current of the unit is very low, so the batteries could be left permanently connected, without detrimental effect on their lifespan, although a switch could be added into the supply lead if desired. Remember, the circuit has a maximum supply voltage rating of 3·6V, so do not accidentally connect a 9V battery to the (optional) PP3 battery clip, otherwise IC1 will be ruined. It is worthwhile putting a warning label in the battery compartment of the unit's housing, particularly if it is a child's toy, stating an appropriate alert to this criterion! E

HT82207 SOUND GENERATOR PARTS LIST

RESISTORS (All 0·6W 1% Metal Film)			
R1,2	100Ω	2	(M100R)
R3	1k	1	(M1K)
R4	3k3	1	(M3K3)
R5	68k	1	(M68K)
RV1	100k Horizontal Preset Potentiometer	1	(UH06G)
CAPACITORS			
C1	47nF 16V Ceramic Disc	1	(YR74R)
C2	22nF 50V Ceramic Disc	1	(BX01B)
C3	100nF 16V Ceramic Disc	1	(YR75S)
C4	47μF 16V Electrolytic Radial	1	(YY37S)
SEMICONDUCTORS			
IC1	HT82207	1	(AE11M)
TR1	BC337	1	(QB68Y)
LD1,2	3mm LED (Red)	2	(WL32K)
MISCELLANEOUS			
	Single-ended PCB Pin 1mm (0·04in.)	1 Pkt	(FL24B)
	20-pin DIL Socket	1	(HQ77J)
	PCB	1	(90031)
	Instruction Leaflet	1	(XV39N)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)		
Miniature Loudspeaker, Type 578	1	(WB09K)
PCB Mounting Switch, Type 105B	6	(KR90X)
2 × AA-Size Battery Box	1	(YR60Q)
PP3 Clip	1	(HF28F)
Alkaline AA Battery	2	(JY48C)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As 90030 (HT82207 Sound Generator)
Price £7.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1995 Maplin Catalogue
HT82207 Sound Generator PCB **Order As 90031**
Price £2.49

LOW ENERGY PERSONAL COMPUTERS

by Frank Booty

THERE are few people who consider the running costs of office equipment such as personal computers (PCs), printers and copiers, since they assume them to be either negligible or uncontrollable. In fact, they are neither.

UK businesses use some 6·5 million PCs and computer terminals, 2 million computer printers and 300,000 photocopiers. Between them, these consume more than 1,000MW of power, at an annual cost of £500 million. This is half the entire output of a modern coal-fired or nuclear power station, or enough electricity to supply a million people.

Another factor to consider is air-conditioning. Most of a PC's energy is dissipated as heat. Air-conditioning, where installed, already accounts for the bulk of the electricity used in offices. Yet air-conditioning equipment is only around 30% efficient, so it costs three times as much to get rid of the PC's waste heat as it cost to power it in the first place.

There are two basic solutions to the problem. The first involves reducing the amount of energy used by the equipment, either by using low-energy components, or by turning down or switching off certain components when not in use.

Some foreign governments have passed environmental legislation, mandating or recommending energy-saving features. The US Environmental Protection Agency's Energy Star programme was launched in 1992, and will become mandatory in 1995. It specifies that PCs must have a standby mode, using less than 30W (including display). Sweden's Nutek standard for displays is voluntary. It states that displays should reduce to below 30W within five to 60 minutes of inactivity, with three seconds to restore the image, and reduce to below 8W after a further 70 minutes.

Spurred on by this rash of initiatives, and by the need to differentiate their products from those of rivals by adding extra features, PC manufacturers began to introduce energy-efficient models in 1993. The list is an ever-growing one, and includes companies like Apricot, AST, IBM, ICL, Siemens Nixdorf and Virgin's daughter company, Virgin Euromagnetics.

However, in the UK, interest in these machines has been limited. Taking a straw poll of large organisations which have won awards for their energy-saving or environmental policies (e.g., Wakefield Health Authority, Northumbrian Water, ICI and BT), reveals a lukewarm enthusiasm for the concept – but scant effect on purchasing policies. One explanation is that PC buyers have so many other features to consider, such as build quality, performance, compatibility and the financial stability of the manufacturer, that energy efficiency comes too far down the list to be of concern.

Price also plays its part. Early models carried a premium of up to 50% more than the equivalent non-energy-saving PCs. But in the long term, buyers can expect to pay only 5 to 10% extra for energy-efficient PCs (that is just £50 to £100 on a £1,000 machine, and the electricity saving should outweigh this over the lifetime of a PC, which would cost about £50 a year to run, if left permanently switched on).

The alternative solution is to convince users to switch off PCs or terminals when not in use. Research by the Building Services Research and Information Association (BSRIA), found that many office workers are only occasional users of computers, who *could* switch them off when not in use. This was made up of nearly half of managent staff, up to half of engineering workers, a third of administrative staff, and up to a third of accountancy workers. Even continuous users of computers go home in the evening and at the weekend, and yet they often still leave the machines switched on permanently.

If a person is given the responsibility to go round at peak times and ask people to switch off their PCs if they are not using them, the savings would be dramatic. In 1992, Thames Water saved 10% of the £¼million electricity bill for its head office, a 15-storey tower block. That is £25,000 just for someone taking a walk round the building now and then.

Some inexperienced or badly trained users still think that they will lose all their work, if they switch off the computer or terminal. It is important to reassure them that they will not, as long as their work is saved to disk.

The complexity of today's computer systems also acts against energy efficiency. The time it takes to log users back on to the system and restart programs may make users reluctant to switch off their machines. This has always applied to mainframe and mini-computer systems, and the increasing tendency to connect PCs on networks causes similar problems.

Working it Out

The BSRIA research found that an average PC or mainframe terminal uses about 120W, rising to nearly 200W for the most power-hungry models (which tend to be older designs, not necessarily more powerful computers). Large (17 or 20in.) displays increase the power consumption. Laser printers consume about 100W (150W maximum).

The load was found to be almost constant, regardless of whether the computer or printer was working hard or idling. Although laser printers consume a lot more power when actually printing, these peaks are so short that they scarcely affect the overall energy con-

Worst-case power demands of office equipment

Type	Power Demand (W)	Nameplate Ratio
PC (including CRT display)	187 (116)	70 (46)
Mainframe terminal	160	60
Laser printer	150 (98)	20 (15)
Dot-matrix printer	67	31
Fax	38	25
Electric typewriter	38	40
Modem	20	–
Overhead projector	300	99
Slide projector	350	100

1. Nameplate ratio = actual power demand ÷ nameplate rating × 100.
2. PC and laser printer figures in brackets are averages; sample size too small to produce averages in other categories.
Figures courtesy the Building Services Resource and Information Association (BSRIA).

Table 1. Worst-case power demands of office equipment. The worst items are not those that have a generally higher rating, but the items that are left on the longest, like computers and photocopiers.

sumption. Manufacturers' nameplate ratings tend to reflect the power surge when the equipment is switched on, and overstate the average power consumption. A PC typically uses only half its rated power, and a laser printer only 15%.

According to the report, the energy consumption of a photocopier varies according to usage. A copier in a print room may be in use 80% of the time and consume about 65% of its stated power. The same machine in a typing pool may be used 40% of the time and consume more than 40% of its nameplate rating, while in a general office, it may be used only 10% of the time, consuming less than 30% of its rated output. Nameplate ratings for copiers vary between 1,000 and 2,500W.

BSRIA estimated the highest (worst case) densities of electrical equipment from a survey of 74 offices, as follows: PCs/computer terminals – one per worker; laser printers – one for every three workers; copiers, fax machines and modems – one for every 20 workers.

The usage of PCs is expected to grow, so that most office workers will use a PC for up to 90% of the time, by the year 2000, and fax machines may increase to one per five workers (although fax attachments for PCs may make standalone fax machines redundant). In the longer term, copier density may drop to one per 50 workers.

Energy check list
1. Turn PCs, terminals, printers and copiers off at night and weekends (but it may be better to leave older equipment permanently switched on, to avoid damage – consult a supplier if in doubt).
2. Turn off the display when a PC is not in use during the day (this also reduces eye strain, and prevents a stationary image damaging the surface of the screen).
3. It is more efficient to make multiple copies on a photocopier or high volume printer, than on an office printer.
4. Turn down central heating, if computers are installed.
5. Educate computer users to feel responsible.
6. Reassure users they will not lose data, if they save their files before switching off.
7. Electricity companies make a surcharge (Maximum Demand Charge) for the highest half-hour's usage every billing period – find out when this is and try to reduce consumption.
8. Do not buy PCs with a lot of expansion slots that will never be used.
9. The more careful users are, the less there is a need for special energy-saving PCs.

Table 2. Energy check-list. Use this check-list to help minimise the cost of electricity by reducing wasted energy from equipment that is not being used. Turning off monitors when computers are not used is a great way of saving energy.

Pros and cons of energy-saving PCs	
1. Lower fuel bills (PC and air- conditioning).	Slightly higher prices (10% or less).
2. Cooler offices (less waste heat).	Time lag while components are reactivated (display, disks etc).
3. Prolonged equipment life.	Performance penalty (of PCMCIA).
4. Space saving (smaller PCs, thin TFT displays).	User hostility (users may need re-educating).
5. No need to upgrade power capacity.	Fits in with 'green' business aims.

Table 3. Pros and cons of energy saving PCs. Most energy saving computers shut down items of hardware like storage devices. This is a trade-off as you are saving energy, but at the expense of access time to data held on the device.

Energy Savings

Computer manufacturers and software houses have started to build energy-saving features into their products, as described below:

Display screens: The biggest consumer of power in an office PC is the cathode ray tube (CRT) monitor – also known as the visual display unit (VDU) – which accounts for half the rated power consumption (100 to 150W). The low-energy alternative is TFT technology (essentially a flat-screen LCD type display) which is already familiar in colour portable PCs. This uses less than 20W and has other advantages: it is only 2in. thick (a CRT is 15in.), the picture does not flicker, and there are no radiation emissions. IBM is one manufacturer who launched a low-power desktop system with a TFT display (the PS/2-E series) which it claims operates at only 60W.

However, TFT is much more expensive (the displays world is driven by the mass-market TV industry – currently the orders per annum stack up as 75:25 in favour of TVs, so the computer fraternity lives off the TV sector). Until the cost of TFT comes down, energy-saving CRT monitors are available, with three stages of power saving:

1. *Screen blanking*. After 3 to 30 minutes (preset by the user) of non-use, the display is blanked, reducing power consumption to 80% of normal. If the user touches the keyboard or mouse, the picture returns instantly.
2. *Standby*. After another 3 minutes or so, the picture generating circuits are switched off, reducing power consumption to 10% of normal. It takes about 3 seconds to restore the picture when a key is pressed.
3. *Power save*. After another 5 to 60 minutes, the remaining circuits are switched off, reducing power consumption to 7%. Restoring the picture takes as long as switching on from cold (about 10 seconds).

Monitor manufacturer Eizo, already sells such monitors, and ICL markets a range of PCs which incorporate the same features. Eizo claims that power saving can prolong the useful life of its monitors by up to 50%.

Processor: The processor chip accounts for about 10% of the PC's energy. This can be cut by a third by using 3·3V chips instead of the usual 5V, and Intel, Advanced Micro Devices, Digital and other chip makers are introducing low voltage versions of their processors. Lowering the clock speed of the processor also reduces power consumption and will not be noticeable for keyboard-intensive tasks, like word processing. This can be done by using the 'turbo' button which is fitted to some PCs already, but future models are likely to have it as a matter of course.

However, the processor's main role in energy saving is to reduce the power used by the rest of the PC. The technique began on portable PCs, where prolonging battery life makes energy saving a major issue. Intel, which designed the processors which power IBM-compatible PCs, produced the SL chipset, for example.

This has built-in power management features (known as System Management Mode or SMM), which switch off the display, disks, connector sockets and other components when the PC is not in use. The user can preset the time delay before this happens, or disable power saving altogether. The SL can also suspend the whole system – the contents of the processor and memory are preserved, so the PC can be reactivated without losing the work currently in progress (which would not be the case if it was switched off). A 'hibernating' PC uses a fraction of its full power rating.

Intel is committed to producing SL versions of all its processors. IBM has developed similar chips (the 386SLC and 486SLC), which are already used in some of its PS/2 models. ICL's PowerMaster PCs use a proprietary design which can switch off the disks when not in use.

Software: An SL processor switches off the display, disks, etc. after a period of inactivity. Murphy's Law dictates that this will happen just as you need them again. To counter this, Intel and PC software company Microsoft, have developed Advanced Power Management (APM), software which tries to second-guess when the user will need certain components. For example, a word processor which automatically saves work to disk every 10 minutes will know how to fire up the hard disk a few seconds before this, and switch it off again afterwards, or a communications program will activate the socket to which the modem is attached. Portable PCs from Dell and Zenith already support APM, as does Microsoft's graphical operating software, Windows 3.1. Applications software will doubtless follow.

Cooling fan: PC power consumption is in a vicious circle – because they generate so much heat, PCs have to be cooled by a fan, which in turn uses power itself. Some small network station PCs (such as the Siemens-Nixdorf PCD-4L) have no fan. Other systems, like the ICL PowerMasters and all Hewlett-Packard and Viglen models, have variable-speed fans, controlled by a thermostat. Since the fan is the noisy element in a PC, a fanless model is virtually silent.

Expansion: This is the great unknown of PC power consumption. The ability to add extra components (disks, CD-ROM, tape drives, internal modems, faster graphics, sound and video controllers, etc.) is potentially very useful and (trade press and market analyst) reviewers will add Brownie points to PCs with good expansibility. In practice, few buyers actually use all their expansion slots and drive bays, especially now that many PCs have built-in network connectors. Yet, PC manufacturers have to allow for expansion when specifying fans and power supply units.

Apricot for example, allows an extra 25W for each expansion slot. The PC does not use the 25W until a card is installed. But the less energy a PC is using, the less efficiently the power supply operates. A 100W power supply working at near capacity is about 80% efficient. Fit a 200W unit in the same PC in case the user adds some expansion cards, and efficiency drops to 50%, wasting energy and producing more heat.

The best solution is to build as much as possible (i.e. graphics, network connector, disk controllers, etc.) into the main circuitry of the PC, and use PCMCIA technology for adding further components. PCMCIA was developed for portables, and has credit card sized units which use far less power than expansion cards. Siemens-Nixdorf's PCD-4L has the option of PCMCIA slots, and they are standard on IBM's new low-energy range.

However, PCMCIA is slower and more expensive than standard expansion cards. Of the two standard technologies, IBM's Microchannel Architecture (MCA) uses between half and two thirds the power of the older ISA (or AT bus) standard. E

NEXT issue

There are more terrific projects and features heading your way in next month's super issue of *Electronics – The Maplin Magazine*, including:

PROJECTS

PC TELETEXT DECODER CARD AND TUNER

The PC Teletext Decoder Card, which, with (an optional project) the PC Teletext Tuner, will enable PC users to download and store Teletext information. The program for controlling the operation is Windows based.

FARMYARD SOUND GENERATOR

The Farmyard Sound Generator is from the same stable as the Western Sound Generator. Can you identify the animal not normally resident on a UK farm?

THE MAINS POWER SWITCH

The Mains Power Switch is a handy project for the home, used for switching mains appliances, but make sure you read the mains safety warning first.

CW FILTER

For the radio amateur or short wave listener, there is the CW Filter. This is for fitting into a short wave receiver which does not have a suitable filter already fitted, and provides enhanced reception of the weaker CW signals.

FEATURES

Features include an informative new series A Practical Guide to Modern Digital ICs by Ray Marston. Also, continuing instalments of ongoing series, including Part 2 of Music Synthesis by Richard Wentk, and Part 3 of Noise by John Woodgate. A behind-the-scenes look at Eurotunnel by Alan Simpson. It is hoped to have a competition linked to this article. Also, Secure Information, by Frank Booty, asks just how secure do you think the files on your computer are? Find out, and be prepared to change your policies, especially if you have particularly sensitive data. Recycling Batteries by Stephen Waddington, provides an interesting insight into reusable batteries. IEEE-488 Explained by Ian Poole, describes the ins and outs of this type of data bus. Plus, there is the interesting and thought-provoking Collision Earth by Douglas Clarkson. Up to now, we have assumed that most of the debris left behind in the formation of the solar system had become captured with only occasional close encounters with comets, meteors and minor planetoids, but this view must now be changed in the light of material evidence to the contrary. Hopefully though, nothing too earth-shattering will occur to prevent you from reading all this and the regular items in your next issue of *Electronics*.

All this, plus all your favourite regulars as well!

Reserve a copy at your newsagents or take out a subscription NOW to avoid disappointment!

ELECTRONICS – THE MAPLIN MAGAZINE

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE.

Stray Signals

by Point Contact

he doesn't feel a thing, though as the work progresses there is an unmistakeable smell of pork crackling – no wonder cannibals used to describe the results of their culinary efforts as 'long pig'.

Such luxuries as temperature-controlled irons where unheard-of when PC started soldering, the Henley 60W spade bit model being the norm.Though one of those only came later, after a lot of saving up; my first iron was one you poked into the fire to get it hot! But when PC first got interested in radio, just after the Second World War, he was the grateful recipient of many old components from the battery sets using 2V valves of pre-war days. Like some of the kits you see advertised for beginners nowadays, that was strictly a case of "positively no soldering needed", everything being connected up with screw terminals.

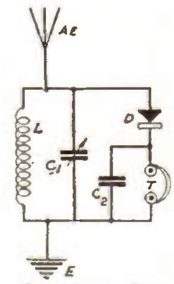


Fig. 16 (a)—A simple crystal-detector receiver

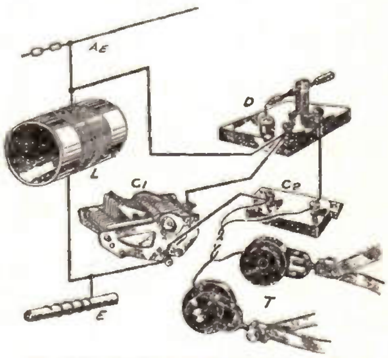


Fig. 16 (b)—Pictorial representation of the simple receiver shown in Fig. 16

Holiday Time is Here Again

Many full-time employees, get holidays with pay, and some electronics companies give as many as 25 days leave. Unless a company closed its premises down for a fortnight in the summer, it is usually left to the employees wishes. The remaining days can be used individually, or used for a second break, perhaps a winter skiing holiday. PC quite often used to take half days (which did not officially exist but were possible in those departments where the manager was willing to turn a blind eye to the practice), walking off site boldly at fifteen minutes past midday – a precise half day. A half day on a Friday always seemed very good value to PC, one woke up on Saturday morning thinking "I wasn't at work yesterday, and I haven't got to go tomorrow either" – it felt like a three day break. But walking out at twelve fifteen looked the more odd since lunch time in our particular department was as late as 1p.m. to 2p.m., due to the need for two sittings in the limited accommodation of the canteen.

They Got it Wrong Again

One is constantly coming across gaffs made by ad men and others; those made by ad men are usually merely mildly amusing, but some of the others less so.

For instance, the Japanese (who are well aware that they are the cleverest people in the world, and who therefore would not dream of learning a foreign language from anyone other than another Japanese) are famous for the funny English in instruction booklets for TVs, videos or whatever. It even extends to the names of well-known companies; apparently SONY was originally meant to be "Sonny boy" or Sonny Jim". And in a different business altogether, General Motors surely did not foresee the sales resistance their NOVA model experienced in Spain, where "No va" means "(it) don't go!".

One of the more serious gaffs, however, is that made by the CCIR (the Committee Consultatif Internationale Radio) in a classic example of the left-hand not knowing what the right-hand is doing. Digital TV is doubtless coming, and already, much television equipment in studios operates digitally. CCIR Recommendation 601 is the world standard for digital television pictures in studio centres, and defines the sampling rate for the luminance analogue component as 13·5MHz, twice the sample frequency of the two chrominance colour difference components. If the digital standard is extended to satellite broadcasting, there is the prospect of myriads of receivers containing circuits operating at 13·5MHz. Now, pulse waveforms as in sampling circuits are rich in high harmonics, and the ninth harmonic of 13·5MHz is 121·5MHz, a frequency already allocated as an international distress channel. One cannot pretend that a single TV set, especially well inland, poses any threat, but the effect of thousands of sets all radiating energy at 121·5MHz, even at a low level, is unknown; it could raise the background noise level at distress channel receivers, with possibly unfortunate results.

Sold(i)ering On

Like many (possibly most) electronic engineers nowadays, PC uses a temperature-controlled soldering iron. In fact, he usually has two on the go, one with a fine point for surface mount and general circuit work, and one with a blunter chubbier oblique cut bit for soldering to ground planes, essential if you work at RF. My preferance is for a grade 7 tip, i.e. one that runs at 700 degrees Fahrenheit or about 357 degrees C, though a colleague swears by using grade 8. He says that the higher temperature means less time needed to make a joint, so that probably overall less heat is pumped into the component and the semiconductor itself, as distinct from its lead, actually stays cooler. PC's irons are equipped with the usual wet sponge for cleaning the tip, but like many an old timer, he cannot get out of the habit of cleaning the tip with a quick dab with his left forefinger. So quick indeed

In fact, PC's first set looked very much like this month's illustration, which is Figure 16a and 16b from *The Manual of Modern Radio*, by John Scott-Taggart of Gray's Inn, Barrister-at-Law, Fellow of the Institute of Physics, Associate Member of the Institution of Electrical Engineers, Membre de la Society Francaise des Electriciens etc. etc., published by the Amalgated Press in 1933.

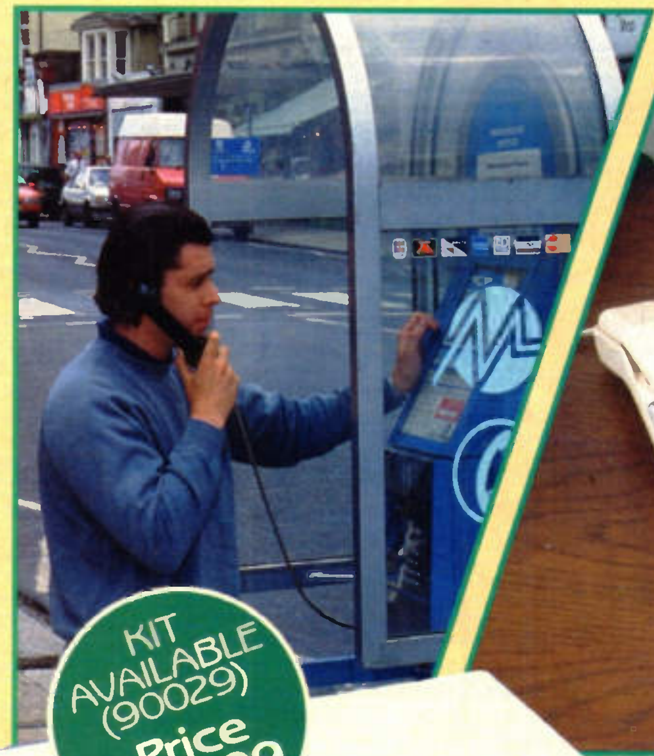
Yours sincerely,

Point Contact

The opinions expressed by the author are not necessarily those of the publisher or the editor.

CALL CODE

Telephone Activated Switch and Timer



Please note that the box shown is not included in the kit and must be purchased separately.

FEATURES

- ★ Remote switch on/switch off
- ★ No direct connection with telephone line
- ★ 42 different codes, abuse of system almost impossible
- ★ Adjustable bell signal detector
- ★ Built-in timer ★ Relay output

Text by Alan Williamson and Mike Holmes

Until now it was not so easy to switch on and off remote apparatus: a solution using a radio transmitter and receiver is not only expensive and unreliable over very long distances, but also requires a transmitting-licence.

Another solution, using special apparatus connected to the telephone line, is more reliable, but can be rather expensive as well.

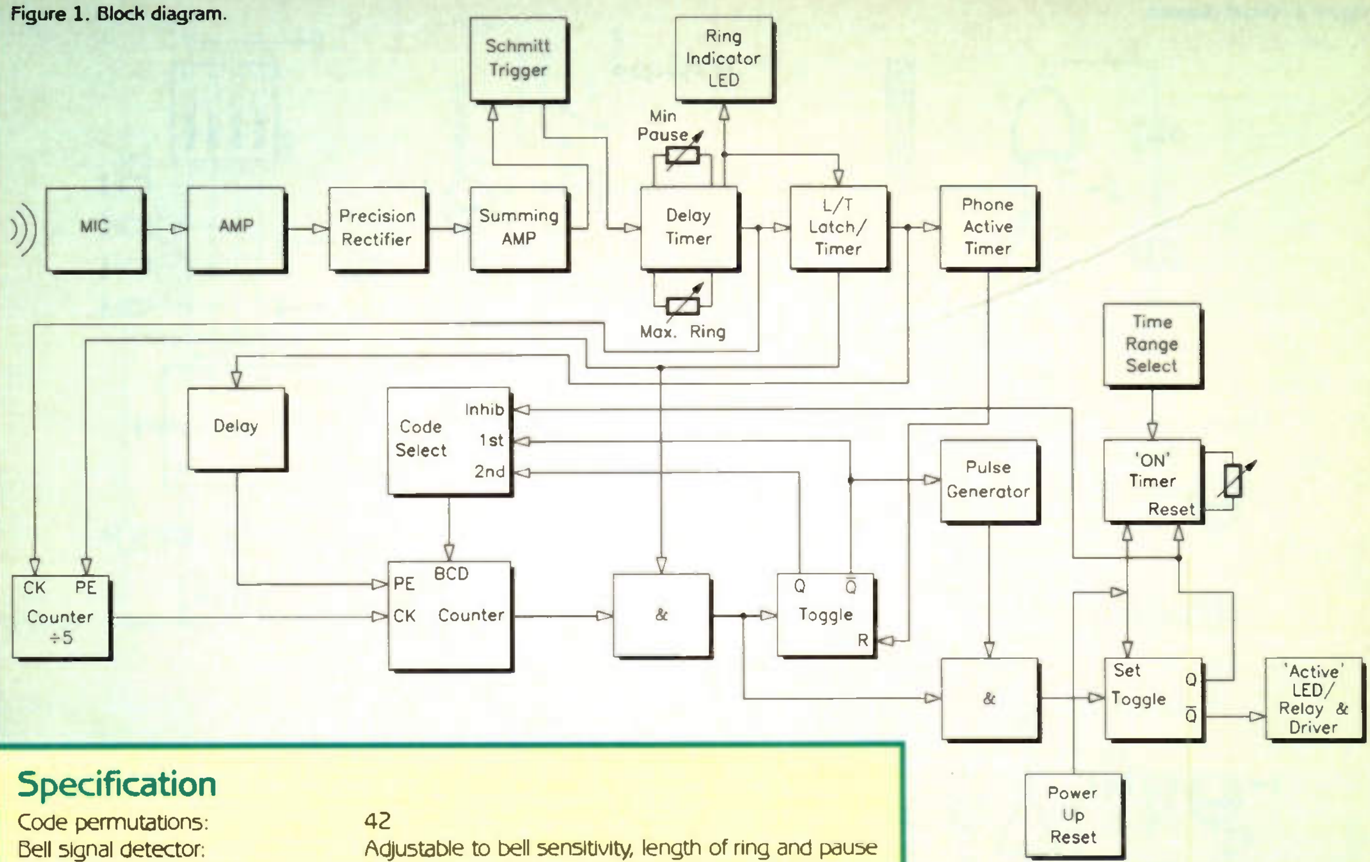
In either case, do-it-yourself kits are out of the question because an inspection of every module by the appropriate authorities would be required.

THIS remote control system, however, requires no permission at all as there is no direct connection to the telephone line, only an audible one. Moreover, it is sparing on your budget: its use is free, even when you are at the other side of the globe, because the telephone only needs to ring, no actual communication is established at this time.

The device can be coded making it reliable, and able to switch the output off using the telephone.

The on-board timer has a multitude of uses. For instance, suppose you intend to 'get away from it all' and spend the weekend at your 'country retreat'. To make it nice and comfortable on your arrival, you use the 'phone to activate the central heating before you leave. However, unfortunately your boss asks you to attend a very important conference, and you forget to call your country residence to turn

Figure 1. Block diagram.



Specification

Code permutations:	42
Bell signal detector:	Adjustable to bell sensitivity, length of ring and pause
Timer range:	3 seconds to 56 hours
Relay output rating:	50V DC, 28V AC/3A maximum (resistive load)
Supply voltage:	12V regulated
Supply current:	90mA maximum
Standby current (Output turned off):	5mA typical
Dimensions:	140 × 73 × 30mm

off the heating. No problem. Thanks to the built-in timer, the module will automatically turn off the heating after the predetermined time.

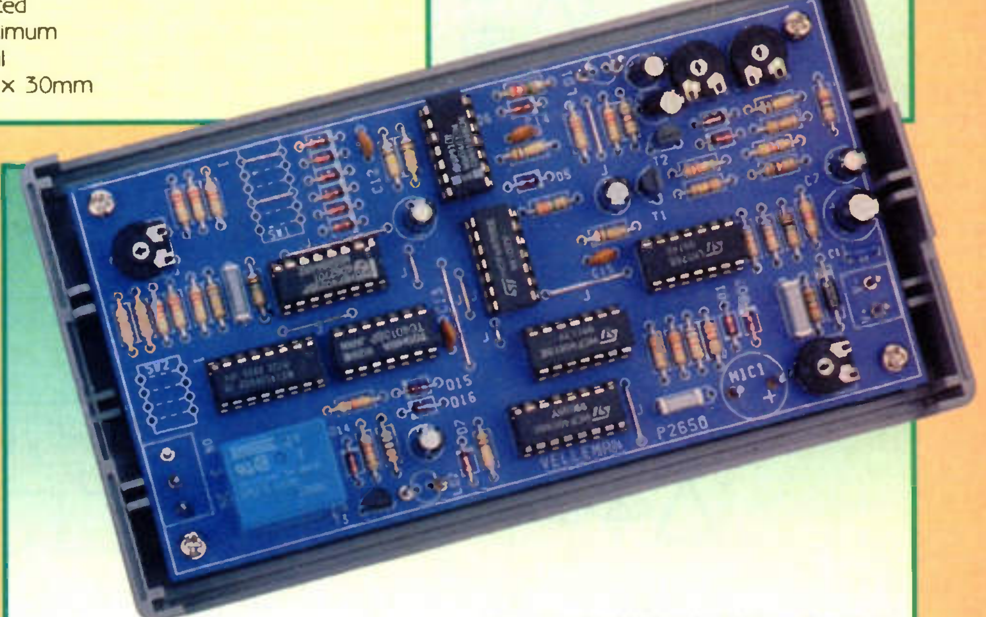
The module can also be used for security purposes. For example, if you go away on holiday and want to turn the lights on and off at irregular times (so the house does not look deserted), the timer can be set for 2 hour intervals and the occasional 'phone call to turn the lights on will achieve the desired 'occupied' effect.

Other uses could include starting the microwave oven before leaving the office in the evening, so that your supper will be ready when you arrive home, etc. It is also possible to turn off the module by simply calling the two ring code numbers in reverse. It is therefore advisable to choose two different numbers to prevent accidental reactivation or deactivation. This is explained in detail in the section 'Setting the 'Ring' Code'.

There are three factors that determine whether the sound received by the microphone is a valid ring or not – these are volume, duration of ring and the pause between the two coded rings.

The microphone should be situated as close as possible to the telephone bell as this allows the sensitivity to be reduced, preventing pick-up of spurious noises.

Ideally, the project should be fitted into a suitable box to allow the 'phone to be placed on top of the enclosure (see Optional Parts List). The microphone should be fitted to the top of the enclosure, situated at a point directly underneath the bell.



The assembled Call Code PCB in optional box.

Circuit Description

The block diagram is shown in Figure 1, with the complete circuit diagram shown in Figure 2. IC1a is configured as an inverting amplifier with a gain of 40dB (100 times), and is used to amplify the microphone signal output.

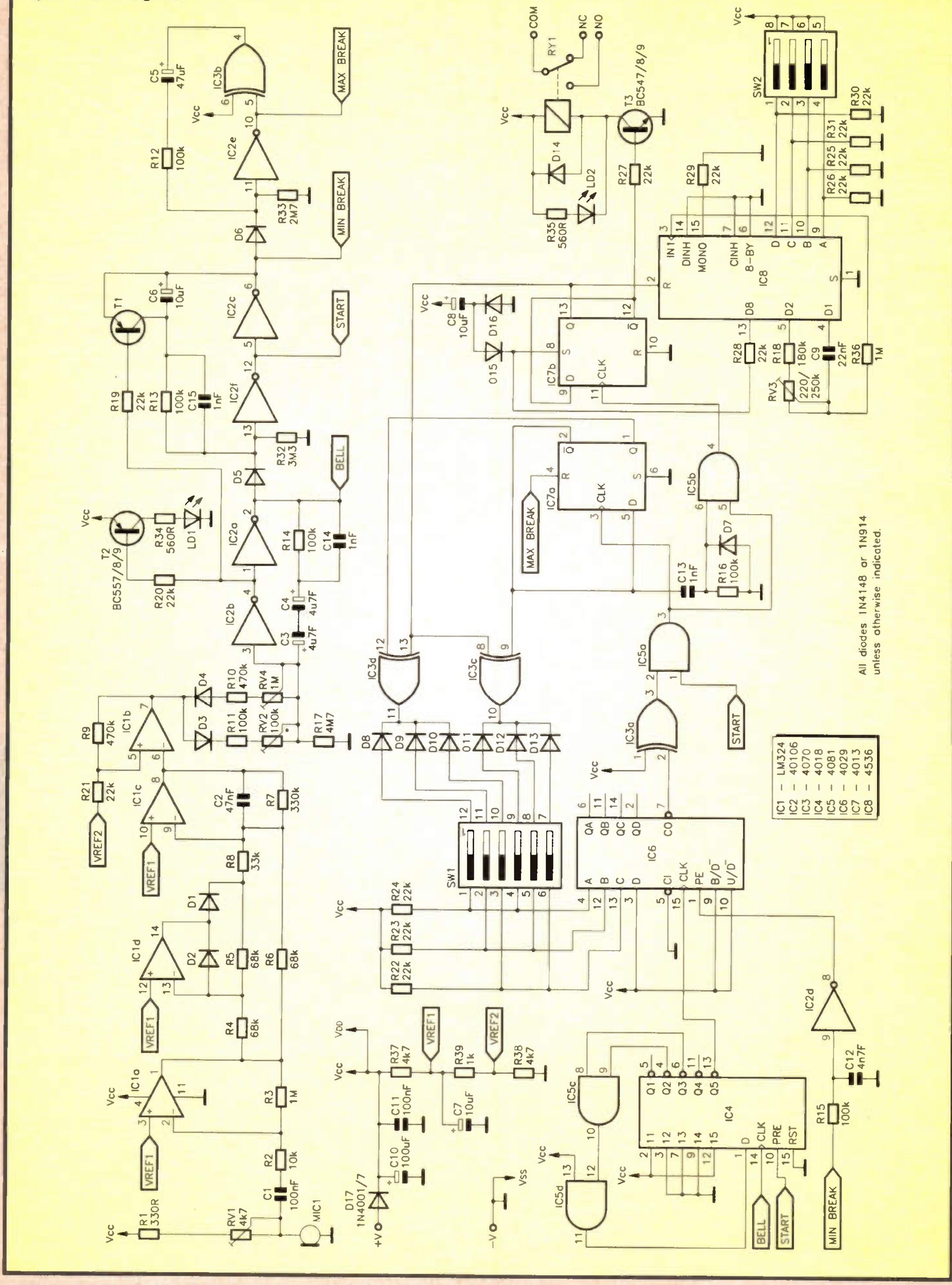
IC1d is configured as a 'precision rectifier', which permits only positive going halves of the amplified microphone signal to go on to IC1c. The stage maintains signal integrity by eliminating the diode forward voltage drop that normally results from using rectifiers. This is achieved by including them within the feedback loop of the op amp (hence 'precision').

IC1c is used as a summing amplifier and inverter, combining the rectified signal with the amplified signal from IC1a, producing a succession of close spaced, negative going half cycles. The output of IC1c will normally be at DC VREF1, but in response to an input signal, the resultant mean output of IC1c will swing towards 0V.

IC1b is used as a Schmitt trigger. An input voltage below VREF2 will cause IC1b output to change to +Vcc, and an input voltage *above* the reference will cause the output of IC1b to change to 0V.

IC2a & b together form a delay timer of sorts. A high output from IC1b will begin to charge C3 & C4, this is the 'normal' (inactive) state. Electrolytics C3 & C4 behave as one capacitor; placing them

Figure 2. Circuit diagram.



in series 'back-to-back' forms a single bidirectional component that is not dependent on specific polarity, unlike a single electrolytic.

After a preset time (determined by RV2) the output of IC2a will switch high. When IC1b switches low (on receipt of a 'ring' signal), the output of IC2a will remain high for a time determined by RV4. IC2c & f form a latch/timer. While C6 is held short circuit by transistor switch T1, the inverters function as a bistable latch; with C6 in circuit, they become a timer. IC2e & IC3b form a start-up reset timer for IC7a, similar to IC2c & f.

IC4 is a presettable divider counter, which is made to divide by 5 with the addition of IC5c & d. It is directly initiated by the bell detector circuitry (IC2), and the reason for its inclusion is that the apparatus at the other end of the line may ring one time less or one time more than the tones you hear. For this reason a margin of ±2 rings is added by the action of IC4, so that while the actual number of rings required is four, say, the control logic will respond to a range from 2 to 6 rings. Consequently the ring code numbers are organised in multiples of 5 (see also Table 1).

IC6 is a binary or decade up/down counter set in a binary count up mode. Switch bank SW1 is used to set the first and second ring pattern codes by pre-loading a binary number into the counter. The Exclusive OR gates IC3c & d select either the first or second ring code. In very basic form, the SW1 position is set up with wire links only, this is how the kit is supplied. A 6-way DIL switch can be used instead, allowing for the 'program' to be changed at will, but will have to be purchased separately (see Optional Parts List).

IC7a & b are 'D' type flip-flops, wired up as 'T' (toggle) type flip-flops. IC7a changes over after the first ring code to prepare IC6 to recognise the second ring code, according to the settings on SW1. If no second code is received, then this flip-flop is reset by the IC2 time-out circuit, so that it is not 'stuck' waiting for code 2.

IC8 is a programmable timer, with switch bank SW2 selecting the 'ON' time range (see also Table 2). The preset RV3 adjusts the oscillator speed and is therefore used as the adjustment between the selected 'ON' time range. Again, a 4-way DIL switch can be used in place of hard-wired links for flexibility of use.

SW1 Settings			'Ring' Code	No. of Rings	
SW1-4 SW1-1	SW1-5 SW1-2	SW1-6 SW1-3	First dial Second dial	Min.	Max.
1	0	0	4	2	6
0	1	0	9	7	11
1	1	0	14	12	16
0	0	1	19	17	21
1	0	1	24	22	26
0	1	1	29	27	31
1	1	1	34	32	36
0 = Open or DIL switch off.			1 = Link or DIL switch on.		

Table 1. Setting the 'ring' code pattern.

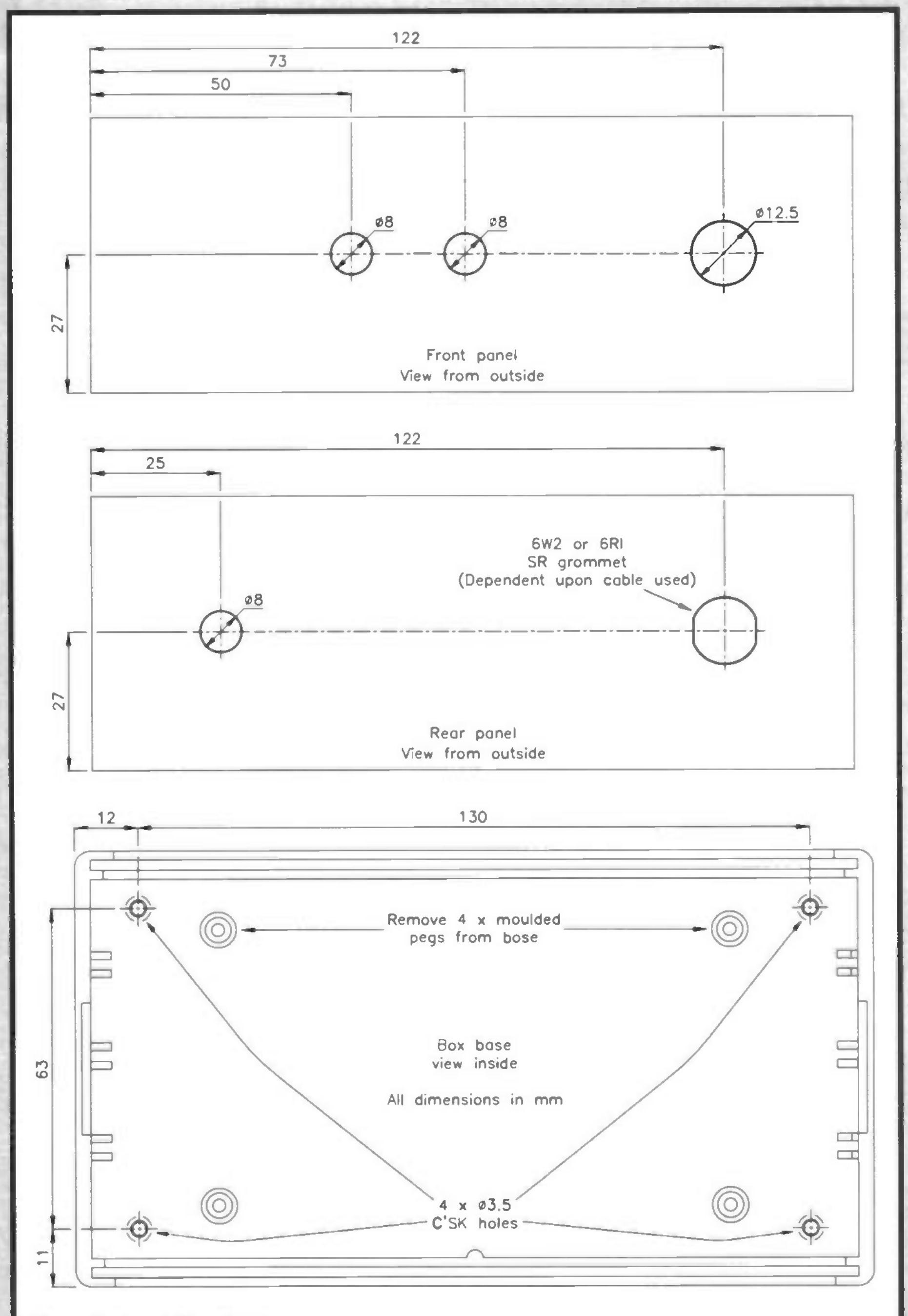


Figure 3. Box drilling details.

Operation Overview

The ringing of the 'phone will be picked up by the microphone, which will then be amplified, rectified, summed and squared. The next stage of processing determines if the signal is of a long enough duration, if so, IC4 is clocked. The pause between the rings will load IC5 with a fixed binary number, while IC6 is loaded with the first code.

Further rings will be counted by IC6 until the appropriate number has been received, whereupon the Carry Output of IC6 will be active. Too many rings, and the carry out will become *inactive*.

The 'phone must then be hung up to allow IC2c & f to reset, this will then clock IC7a via IC5a. This in turn will select the second 'ring' code, which is then latched into IC6 on the next ring.

If the pause between 'phoning the first and second codes is too long, the timer formed from IC2e & IC3b will reset IC7a, as implied earlier, which means that the first ring pattern must be used again.

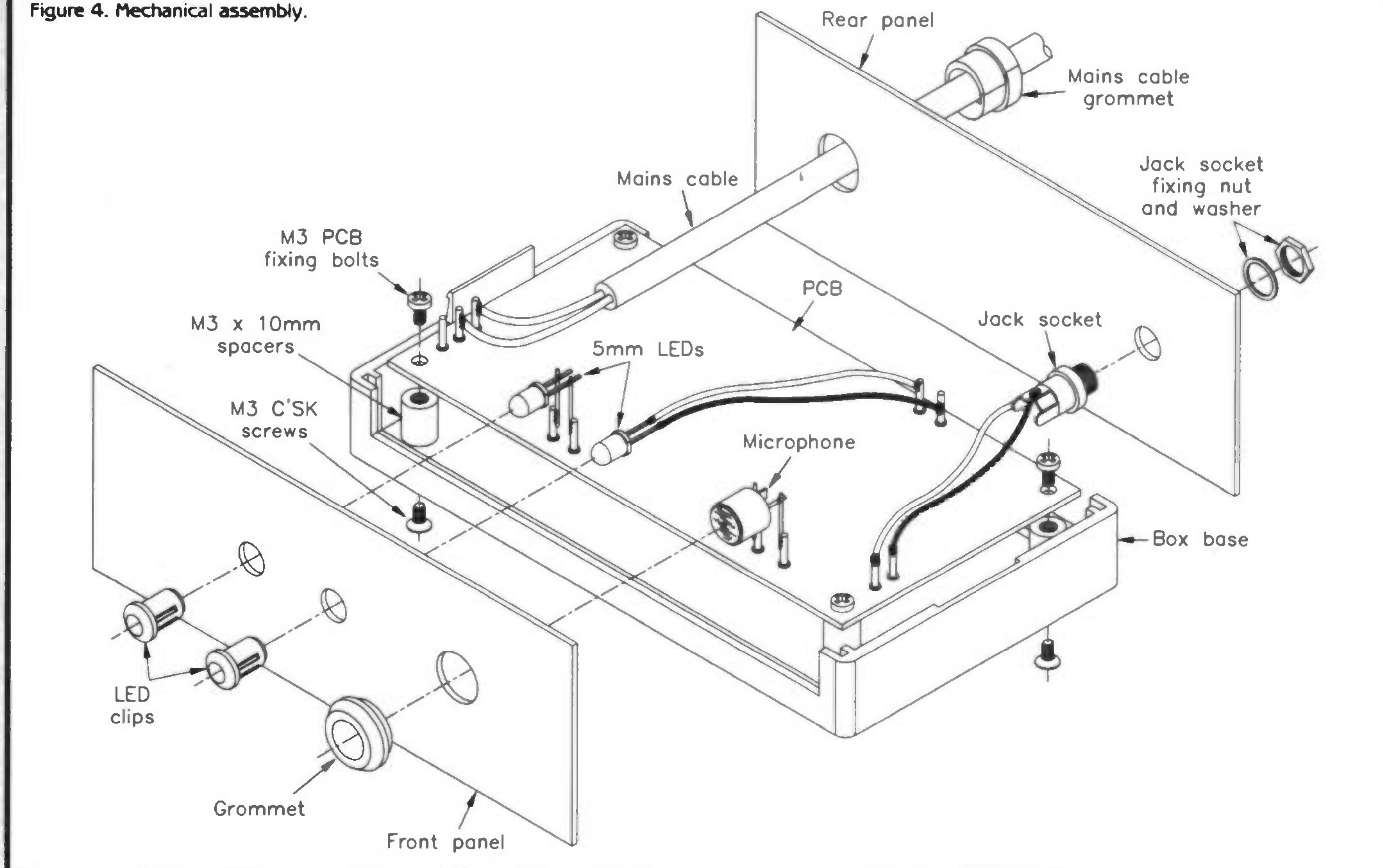
Once the second ring pattern activates IC5a, IC7a will once again toggle. This produces a pulse through C13 and clock of IC7b (via IC5b), and activates the relay and LED LD2 (via transistor T3), and starts the programmable timer (IC8). Once IC8 has timed out, the output will reset IC7b.

Construction

Constructing the kit is dealt with in more detail in the instructions supplied with the kit, but it is worth making a note of the following:

It is easiest to begin with the smallest components first, working up in size to the largest. Insert and solder all the PCB pins from the track side, similarly the wire links. Be careful to correctly orientate polarised devices, i.e. electrolytic capacitors, diodes, transistors. For electrolytics, always insert the lead opposite to that identified by a stripe and (–) legend on the body of the capacitor into the PCB hole marked (+). For diodes, identify a band around one end of the body, which indicates the cathode, and align it to the white marker on the PCB diode legend.

Figure 4. Mechanical assembly.



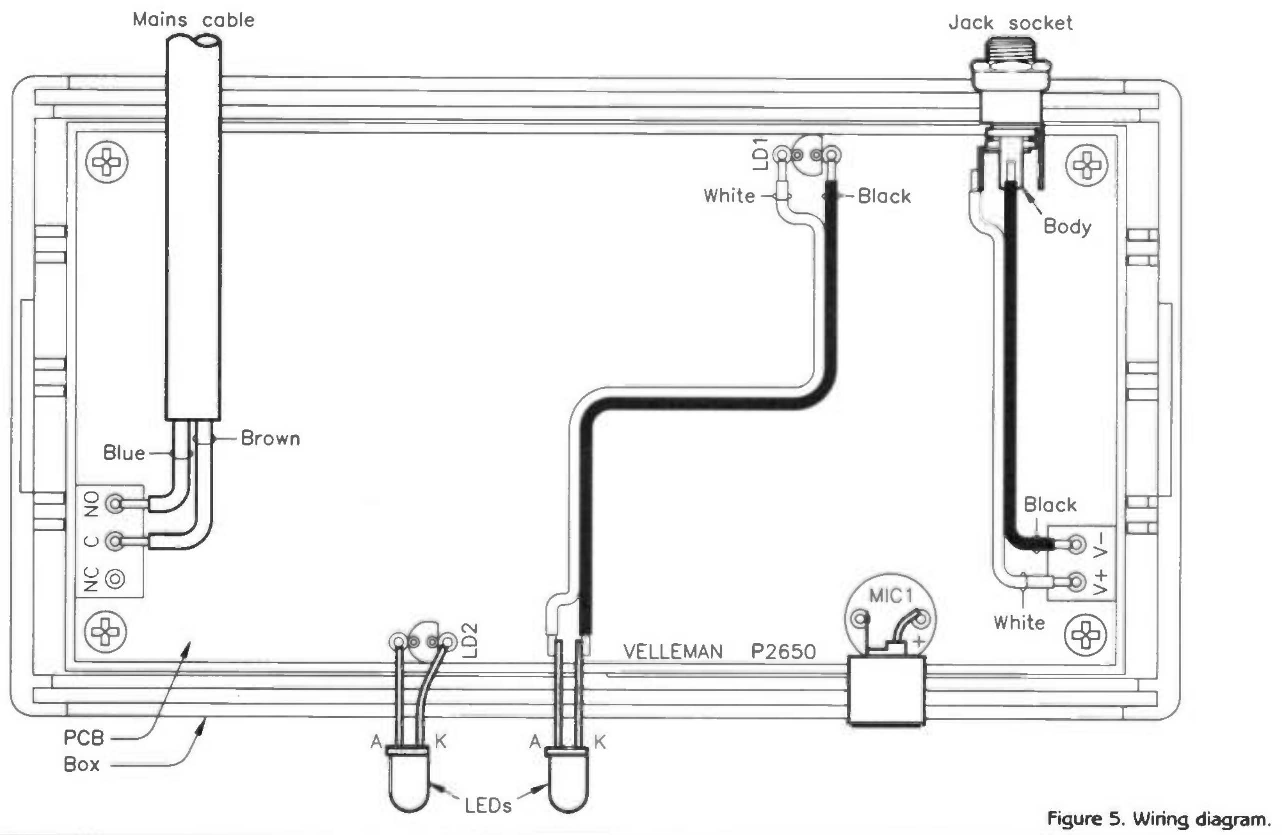


Figure 5. Wiring diagram.

For transistors, simply align the shape of the plastic body to the shape on the legend and insert all three leads through the PCB. Be careful when soldering, as semiconductors can be damaged by heat. If unsure, allow short cooling periods between soldering operations. ICs are rarely soldered directly and, in this case, DIL sockets are used which are fitted to the PCB first.

The ICs should be inserted into their sockets last of all.

The basic kit is supplied in PCB form only, but should be housed in a suitable box, such as LL09K (see Optional Parts List). Drilling details for this box are shown in Figure 3, while the hardware to go with it, making a fully working unit, is shown in Figure 4 (again see Optional Parts List).

After the PCB has been built, it is mounted in the box base using M3×10mm plastic threaded spacers. Four of the supplied screws can be used to fix the PCB to the spacers, but use countersunk M3 screws to fix the spacers to the base. LEDs should be mounted with the aid of 5mm LED clips, and a 9·5mm i/d grommet is used to secure the microphone in position in the front panel (see Optional Parts List).

More precise wiring details are shown in

Figure 5. Use black and white hook-up wire to connect the 2·5mm power jack socket, on the rear panel, and LD1 on the front panel. The size of the strain relief grommet on the rear panel depends on whether you intend to use twin-core or 3-core mains cable for connection to the internal relay.

Setting the 'Ring' Code

Refer to the SW1 table for setting the number of 'rings' to activate the module. The first and second 'ring' codes used in the test set-up for SW1 are '4' & '1'.

Fit the links (or 6-way DIL switch FV44X, see Optional Parts List) for the first and second codes.

Testing, Adjustment and Use

The 'pause' ('ring ring', pause, 'ring ring') time is not adjustable, however, the circuit does have a large tolerance, with a safety margin of ±2 rings built into the circuit.

NOTE: when listening to the ringing tone of a telephone, the apparatus at the other end of the line only rings during the pause that *you* hear, it is therefore possible that the telephone bell may be ±1 ring than the number of rings heard from the receiver.

The actual minimum and maximum pause times will depend upon the supply voltage. Other influencing factors will be the characteristics of the ICs supplied, which will vary between manufacturers and even from batch to batch.

The minimum 'pause' time is equal to the time elapsed from the end of the last 'ring' to the switching 'on' of the relay and LD1 (which will be approximately 30 seconds). If you wish to find the maximum time, rub the microphone (to generate noise), and observe the voltage at pin 4 of IC7, which will rise to 10V. The maximum 'pause' time will be the time that it takes for the voltage to decay to 0V.

Please note that mains voltage must not be directly switched using the on-board relay RY1! If mains power switching is required then alternative methods must be used, e.g., using the optoisolated Zero Crossing Switch Kit LP55K, as shown in Figure 6a. In this case, relay RY1 must be omitted and links fitted in its place as shown in the diagram. The opto-switch PCB is connected as illustrated, and on the opto-switch PCB TR1 and R2 are omitted, and a link fitted between two of the PCB holes for

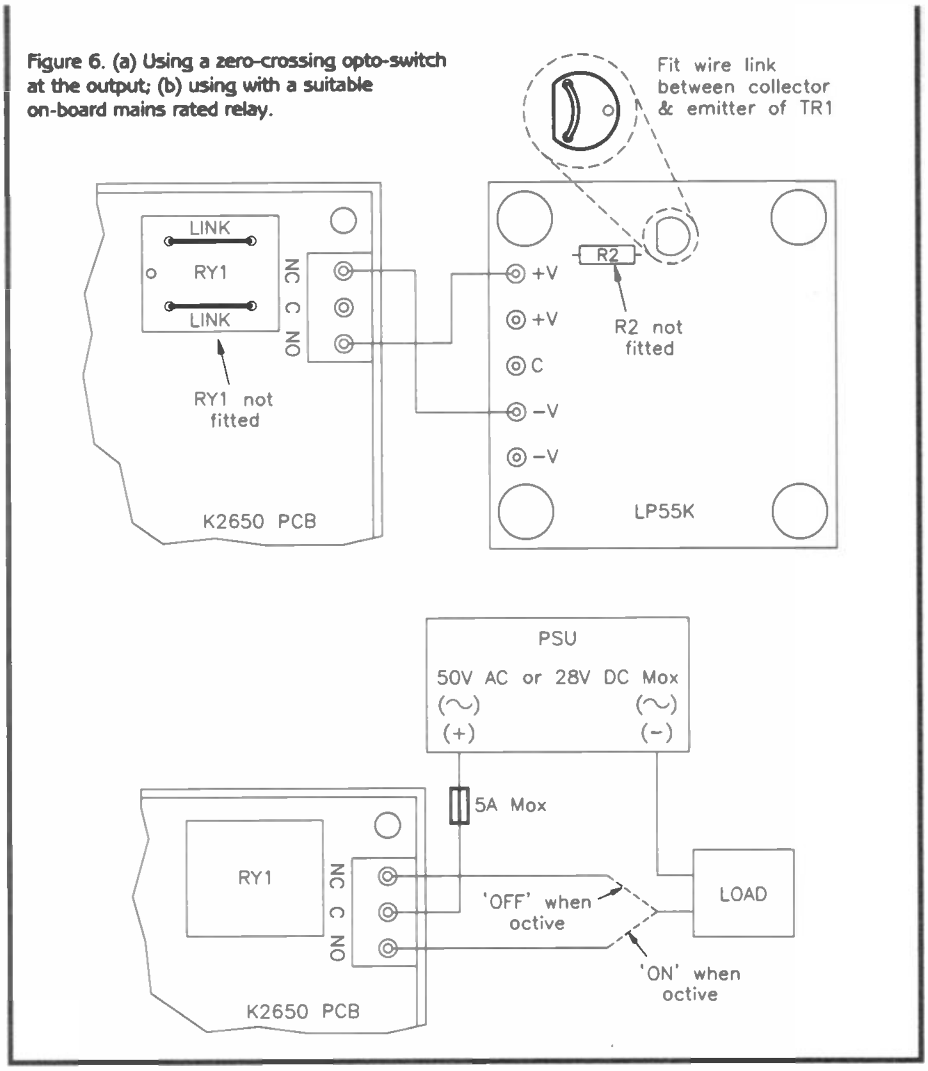


Figure 6. (a) Using a zero-crossing opto-switch at the output; (b) using with a suitable on-board mains rated relay.

TR1 as shown. See Leaflet XK38R for details about building and using this kit.

If a mains switching relay is required then Figure 6b must be followed. Here RY1 controls an external circuit including separately provided PSU, with ratings within the limits of RY1 and the Call-Code PCB, (note the inclusion of a protective fuse). RY1 can then control 'LOAD' as either normally off or normally on, depending on which PCB pins you select on the Call-Code PCB. 'LOAD' can be another relay with mains rated contacts and a minimum gap between connections of 5mm.

It is impossible to go into too many details about applications suggested by Figure 6b, as there are too many permutations and uses; these are best left to experienced constructors, *especially* where mains power is involved.

To make it easier, Mains Relay Switch Kit LU10L, can be utilised as shown in Figure 6c. Again omit RY1 and replace with links, and the Mains Switch Kit will use the same 12V supply as Call-Code.

Preliminary Testing

Set all presets to centre travel (12 o'clock). Connect a 12V DC supply (preferably regulated) to the module and switch on; both LEDs should be extinguished; wait a minute or two for the circuit to settle before beginning tests.

The test requires 4 'rings' then a pause of $1^1/_2$ minutes followed by a further 4 'rings'. Approximately 30 seconds after the second set of 4 rings, a click from the relay will be heard and the relay indicator LED (LD2) will illuminate; approximately 5

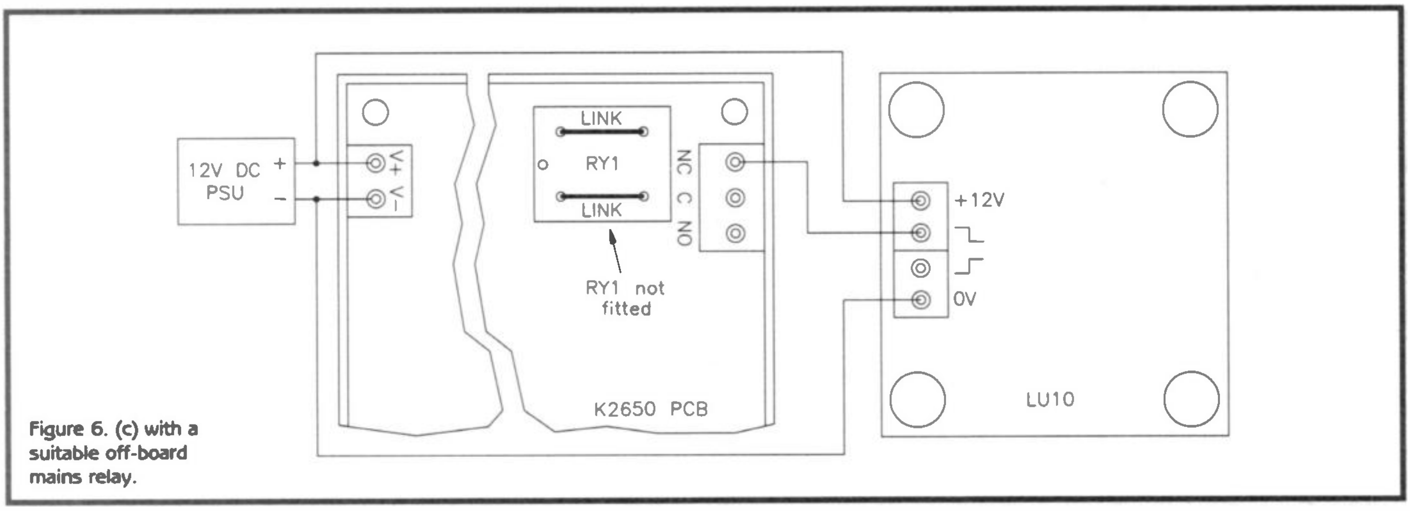


Figure 6. (c) with a suitable off-board mains relay.

seconds later the relay will drop out and the LED will extinguish.

To emulate the 'ring' of the telephone, 'rub' your finger over the microphone long enough for LD1 to illuminate then stop (minimum ring time); wait until the LED extinguishes (pause time), then 'ring' again and carry on with the sequence.

Setting the Timer Duration

First set the adjustment range for RV3 by fitting links (or optional quad DIL switch FV43W); see Table 2 for timer duration periods, then set the actual duration by adjusting RV3.

Final Adjustment

Set the desired code using SW1 (refer to Table 1). The links (or switches) 4, 5 & 6 determine the *first* code (number of rings) and links 1, 2 & 3 determine the *second* code.

You will now need to telephone a friend; ask them to 'phone you back, but explain that you will not be picking the 'phone up to answer for a minute or two; or you can use the ring-back bell-test facility, if you know the number used at your local exchange.

Once the adjustments have been made; answer the 'phone and thank your friend.

SW2 Settings				Time Range
1	2	3	4	
0	0	0	0	3 to 7 seconds
0	0	0	1	6 to 14 seconds
0	0	1	0	12 to 28 seconds
0	0	1	1	24 to 56 seconds
0	1	0	0	48 to 112 seconds
0	1	0	1	1·5 to 3·5 minutes
0	1	1	0	3 to 7·5 minutes
0	1	1	1	6·5 to 15 minutes
1	0	0	0	13 to 30 minutes
1	0	0	1	26 to 60 minutes
1	0	1	0	15 to 120 minutes
1	0	1	1	102 to 239 minutes
1	1	0	0	3·5 to 8 hours
1	1	0	1	7 to 16 hours
1	1	1	0	14 to 32 hours
1	1	1	1	27 to 64 hours
0 = Open or switch off.				1 = Link or switch on.

Table 2. Setting up the timer duration adjustment range for RV3.

Adjust RV2 (maximum ring duration) until LD1 illuminates halfway through a ring signal; adjust RV4 (minimum pause time) until LD1 extinguishes halfway through the 'ring', pause (ensure that the LED does not 'blink' between the double-ring, i.e. 'ring ring', pause, 'ring ring'). The sensitivity of the microphone should be set slightly higher than minimum and is adjusted by RV1.

CALL CODE PARTS LIST

RESISTORS All 1/4W (Unless specified)			
R1	330Ω	1	
R2	10k	1	
R3,R36	1M	2	
R4-R6	68k	3	
R7	330k	1	
R8	33k	1	
R9,R10	470k	2	
R11-16	100k	6	
R17	4M7	1	
R18	180k	1	
R19-31	22k	13	
R32	3M3	1	
R33	2M7	1	
R34,R35	560Ω	2	
R37,R38	4K7	2	
R39	1k	1	
RV1	5k Small Horizontal Preset	1	
RV2	100k Small Horizontal Preset	1	
RV3	220k Small Horizontal Preset	1	
RV4	1M Small Horizontal Preset	1	
CAPACITORS			
C1	100nF 250V	1	
C2	47nF 250V	1	
C3,C4	4µ7F 50V	1	
C5	47µF 16V	1	
C6-8	10µF 35V	3	
C9	22nF 400V	1	
C10	100µF 16V	1	
C11	100nF 63V	1	
C12	4n7F Ceramic Disc	1	
C13-15	1nF Ceramic Disc	3	
SEMICONDUCTORS			
D1-16	1N4148 (or 1N914)	16	
D17	1N4007	1	
T1,T2	BC557B	2	
T3	BC547B	1	
IC1	LM324N	1	
IC2	CD40106BE	1	
IC3	CD4070BE	1	
IC4	CD4018BE	1	
IC5	CD4081BE	1	
IC6	CD4029BE	1	
IC7	CD4013BE	1	
IC8	CD4536BE	1	
MISCELLANEOUS			
J,SW1	Wire Jumpers	10	
LD1,LD2	5mm LED (Red)	2	
MIC1	10mm Electret Microphone	1	
RY1	12V DC 3A Relay	1	
	14-pin DIL Socket	5	
	16-pin DIL Socket	3	
	PCB	1	
	PCB Pins	10	
	Instruction Leaflet	1	
OPTIONAL (Not in Kit)			
SW1	6-way 12-pin DIL Switch	1	(FV44X)
SW2	4-way 8-pin DIL Switch	1	(FV43W)
	Regulated 12V Adaptor	1	(BZ83E)
	Moulded Plastic Box Type 212	1	(LL09K)
	5mm LED Clip	2	(YY40T)
	Twin Core Mains Grommet 6W2	1	(LR49D)
	3-Core Mains Grommet 6R1	1	(JH23A)
	M3 × 10mm Plastic Spacers	1 Pkt	(FS36P)
	M3 × 6mm Countersunk Screws	1 Pkt	(BF36P)
	9·5mm i/d 12·5mm o/d Grommet	1 Pkt	(JX63T)
	2·5mm Panel Power Socket	1	(JK10L)
	Black Hook-up Wire	1 Pkt	(BL00A)
	White Hook-up Wire	1 Pkt	(BL09K)
	Twin 3A Mains Cable (Black)	As Req	(XR47B)
or	Twin 3A Mains Cable (White)	As Req	(XR00A)
or	3-Core 3A Mains Cable (Black)	As Req	(XR01B)
or	3-Core 3A Mains Cable (White)	As Req	(XR02C)
	Mains Opto-switch Kit	1	(LP55K)
	Mains Relay switch Kit	1	(LU10L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order As 90029 (Call Code Kit) Price £22.99

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

@Internet

FirstClass Client Update

A few months back, we looked at the first of the FirstClass bulletin boards which had got themselves on air on the Internet as sites which you can trip to if you have a copy of FirstClass Client 2.6. The version number is critical, as it is only version 2.6 which has the necessary TCP/IP tools to allow this.

Basically, you log on to your Internet provider in the usual PPP or SLIP way, then you run FirstClass Client and give the bulletin board IP number in the standard set up, making sure you have the TCP/IP preferences file set up correctly.

When we first looked at this new method of using the Internet, there were only a couple of boards which had been launched, but there have been several additions to the team since then. The current list is given in the table on this page, and you can see there is a wide variety. World surfing from the USA (boards like *California Lip Service* in, yes, California) to Japan (*Paradigm Online* in Tokyo) is but a log-in away.

One of our favourites has to be *digitalNATION*, based in Washington DC in the USA. To call *digitalNATION* a bulletin board is a bit of an understatement, really – find out for yourself. To access any of these, you will need to locate a copy of the FirstClass Client software (often found on computer magazine cover disks) for your computer. Mac and PC versions are available.

Many FirstClass boards have their own settings files. A FirstClass settings file defines the interface to the board, and can contain many screens, sounds and accessories unique to the board itself, and which add to the effects of intercontinental thrill-seeking on the Internet. As you log on to a new board, it is worthwhile downloading the settings file (if there is one, it will be stored somewhere on the board's many file areas) and using it the next time you log on.

While FirstClass is still very much a small part of the Internet, a veritable David to the World Wide Web's Goliath, it is still a fascinating venture. In effect, you can log on to bulletin boards worldwide and pick up the local news, look, feel, sights and smells, all for a local telephone call.

As you will see if you spend a little time surfing these boards, there is a definite dearth of FirstClass boards in the UK. Well, let's be blunt, there's none! Maybe it is a problem with the cost of full-time Internet access (which, face it, is considerable) and maybe it's a matter of not having enough users to make such a BBS financially viable. More likely it is a combination of both, and this is a distinct pity. FirstClass is the friendliest BBS interface around, and frankly, is a good Internet one too.

Name;	Domain;	IP Address;	Port;
AMDA	allinz.uni-linz.ac.at	140.78.5.56	3000
AMUG (Arizona MUG)	fc.amug.org	204.62.193.11	3000[*]
AMUG (Atlanta MUG)	atlmug.org	170.140.31.1	3000
Bitstream Underground	bitstream.mpls.mn.us	204.73.77.17	3004
BlackBoard	bboard.blackbox.or.at	193.170.155.5	3000
California Lip Service	lips.com	204.31.61.42	3000
Calpark	calpark.crai.lt	138.41.202.243	3004
Cyberden	cyberden.com	199.4.111.11	3000
designOnline	fcserver.dol.com	204.95.49.2	3000
digitalNATION		204.91.31.64	3004
Emerald OnRamp	emerald.route66.net	198.145.80.4	3000[+]
The Familiar Spirit	necronomi.com	198.6.114.252	3004
Gay BBS		198.145.80.4	3000
Infinet	shakti.txinfinet.com	204.96.111.157	3000
IST-Linz	istmail.padl.ac.at	193.170.67.250	3000[*]
MacChoice	lt4.lasertone.com	198.70.208.4	3000
MacLair	maclair.computize.com	199.1.198.31	3000
Magic Online	gandalf.magic.mb.ca	204.112.14.6	3000
Magnet	magnet.at	193.80.248.21	3000
Metnet	stevem.opi.mt.gov	161.7.104.96	3000
MityMac	macsbbs.spk.wa.us	204.212.113.2	3000
Mt. Parnassus	fc.delphic.com	204.30.14.3	3000
N.E.T.	firstclass.northcoast.com	199.4.102.21	3000
NP1.COM	np1.com	204.139.8.2	3000
Online Zone		204.182.40.1	3000
Paradigm Online	paradigmonline.or.jp	202.33.54.66	3000
Paradise	blkbox.com	198.64.53.173	3000
Red Inter Apple	ria.pue.udlap.mx	140.148.1.9	3004
Rete Civica Municipale	ghost.dsi.unimi.it	149.132.120.68	3004
SoftArc Online		198.133.37.10	3004
StarNet Online		204.178.185.2	3000
TerraX	terrax.spk.wa.us	199.79.239.40	3000
TogetherNet/TGF Tech		204.97.123.70	3000
WCA Academy	marathon.wca95.org	193.45.142.40	3000

[*] use guest/guest for username/password
[+] use blank/blank for username/password

Institution of Electrical Engineers Secure WWW Site

Members of the IEE with access to the Internet can find up-to-date details of the Institution's programme of Learned Society Events, Publishing and Information Services, and much more, at the Institution's World Wide Web site.

Contact: **http://www.iee.org.uk**

Press Association

As with the majority of Web sites, it is often frustrating to discover that they are local to the USA. It is refreshing, therefore, to discover that one of the freshest Web sites on the Internet belongs to the UK-based Press Association. The Press Association pages offer an up-to-the-minute round-up of news and weather reports, as well as information on sports events, TV and other PA services, such as a photo library and data design service. The pages offer links to other news and information related pages. To use the service, you have to register (for free) before entering. This is to enable PA to monitor site usage.

Contact: **http://www.pa.press.net/secure.html**

CompuServe's Free Web and Access Software

CompuServe users have struggled to get access to dial-in-points, and help lines have been permanently engaged since the company opened its networks to the World Wide Web last month. The popularity of the new World Wide Web service has been unprecedented. The good news is that CompuServe is building in measures to cope with the increased demands.

The new Web access service is open to CompuServe's global membership through a direct Point-to-Point Protocol (PPP) connection and a new piece of software, called NetLauncher. Net Launcher has two components: SPRY Mosaic and the CompuServe Internet Dialer. SPRY Mosaic is an easy-to-use interface that links Windows users to pictures, sound and video on thousands of Web services and databases. Custom hotlists, helper applications and context-sensitive help make the Web manageable, even for novices.

CompuServe Internet Dialer is the mechanism for Windows users to establish a direct PPP connection, using SPRY Mosaic, another Web browser or any other Winsock-compatible application.

For Windows users, accessing the Web is simple. NetLauncher builds on

technology developed by CompuServe and SPRY, to provide everything necessary to explore the Web at the click of a mouse button. For Windows users who prefer to use another browser, the CompuServe Internet Dialer facilitates a fast, direct connection to the Internet. When the user exits the browser, the dialer automatically disconnects and ends the CompuServe session. To use the dialer, a member must have installed the CompuServe Information Manager for Windows (WinCIM), version 1.3 or later, or CompuServe Navigator for Windows.

Contact: CompuServe, Tel: (01734) 391064.

3D Graphics from Silicon Graphics

Silicon Graphics have introduced new 3D enhancements to their Web site.

Contact: **http://www-europe.sgi.com**

Instrumentation Information

National Instruments has established a World Wide Web server to give users access to the volumes of information which the company holds, to assist in the development and configuration of instrument devices.

Contact: **http://www.natinst.com/**

Site Survey
– the month's destinations

Two sites of interest this month. First is the *digitalNATION* FirstClass bulletin board in Washington DC. This was one of the first FirstClass BBSs to get up and running on the Internet, and its latest settings file (version 4) is quite something to behold.

Our second site is on the University of Warwick's WWW server, and is a wired magazine run by students at the uni. The URL to hop to is: **http://www.csv.warwick.ac.uk/~maurj/index.html**

The site is called *RetroActive Baggage and other derivative nonsense* and is an electronic reprint of the students' dead-tree publication of the same name. It is a neat example of electronic publishing at its most fundamental, which gives a glimpse of what is to come on the Internet, as more and more publications get themselves wired.

by Richard Wentk

The ART of Electronic Music

Part I – An Introduction

Over the last couple of decades, electronic music systems have really come into their own. It is probably true that most popular music is electronically generated now, and from humble and relatively crude beginnings the synthesizer has become a powerful and expressive instrument.

But how does a synthesizer work? And how are the different sounds created and shaped? Later on in this series we'll be looking at some of the latest examples of synthesizer technology, and discovering just how close synthesizers have come to creating accurate realistic-sounding simulations of acoustic instruments. This month though, we'll start with a look at the properties of sound, and also at the origins of synthesizer technology.

The Art of Noise

Any musical sound has three distinguishing characteristics, namely; pitch, loudness and tone colour (also called timbre). In air, sounds are propagated by sound pressure-waves spreading out from a source, rather like ripples on a pond. The perceived pitch of a sound depends directly on the frequency of the waves, the loudness depends on their amplitude, and the tone colour depends on their shape. These characteristics of sound are illustrated in Figure 1. Human hearing extends from a range of about 20Hz to 20kHz (see Note 1), the top limit reducing rapidly with age and excessive exposure to loud music. In terms of loudness, the human ear can cope with a dynamic range of over 120dB – a range that is only just being approached by the very latest digital recording and sound reproduction systems.

Tone colour cannot be quantified easily, although in technical terms sounds have a distinctive tone quality because of a mix of extra frequencies, called harmonics, on top of the main pitch, which is known as the fundamental; see Figure 2. Each harmonic is a sine wave, and when added to the others in the mix it helps define the wave shape of the sound. It is this mix that gives the ear and brain the information required to distinguish between the various types of musical instruments.

Fourier Transform Analysis

A useful mathematical technique, called the Fourier Transform, can be used to analyse tone colour precisely. The Fourier Transform can take a periodic wave shape and produce a list of the component harmonics in much the same way that light is split into colours when it passes through a prism. These ingredients completely define the wave shape; in fact, applying the inverse transform results in a perfect copy of the original wave – Figure 3 clarifies this effect.

In theory, it should be possible to analyse any sound in this way and then recreate it perfectly. Unfortunately, this isn't yet possible with the current level of computer technology. Acoustic instruments use a range of mechanical processes to create their sounds, and these invariably include 'chaotic' and other processes which add an element of randomness and unpredictability to real sounds. This is one reason why acoustic instrument sounds are so

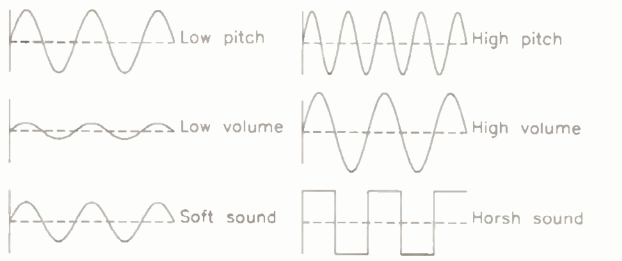


Figure 1. Pitch, volume and tone quality define how a sound is perceived.

Figure 2. Any repeating waveform can be analysed as a mix of sine wave harmonics.

A synthesizer and associated equipment.

interesting to the human ear – there is always something surprising going on! Electronic systems don't yet have the processing power to accurately model these effects, and so designers have had to resort to much cruder methods to create practical instruments.

Early Attempts

The earliest methods were very crude indeed. In the 1950s, before commercial synthesizers became readily available, composers often resorted to using studio test equipment to create electronic tones. In practice this often meant painstakingly multitracking sine waves to tape, to create an interesting harmonic mix. This took a very long time, and also raised problems of tuning and control. As a result, only a few dedicated and immensely patient composers, such as Karlheinz Stockhausen and John Cage, were able to create music in this way.

The earliest synthesizers were an attempt to tackle this problem. The most important innovation was the simple but elegant idea of *voltage control*, which was invented – more or less simultaneously – by Bob Moog, Alan Pearlman, Donald Buchla and their co-workers in the early 1960s. Voltage control meant that a circuit could be controlled remotely with a voltage, as well as directly from the front panel. The big advantage of this scheme was that now synthesizer circuits could control each other, making it possible to add some measure of automation to electronic sounds.

In order to understand exactly how these early machines worked, it is well worth taking a closer look at the facilities they

Continued on page 25.

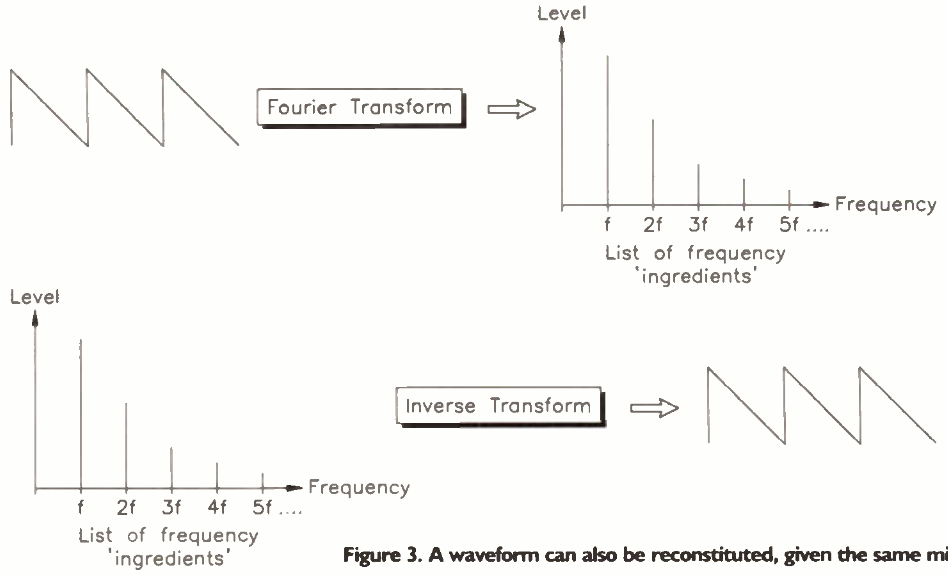


Figure 3. A waveform can also be reconstituted, given the same mix.

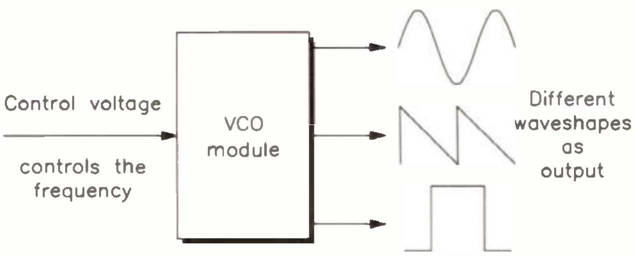


Figure 4. A VCO module – the input voltage controls the pitch. The output is a set of repeating wave shapes.

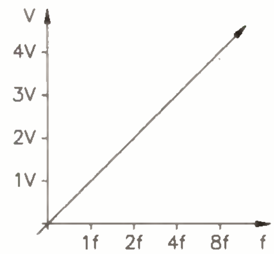


Figure 5. The standard VCO control setting of 1V/octave. As the voltage goes up by 1V, the pitch of the output doubles.

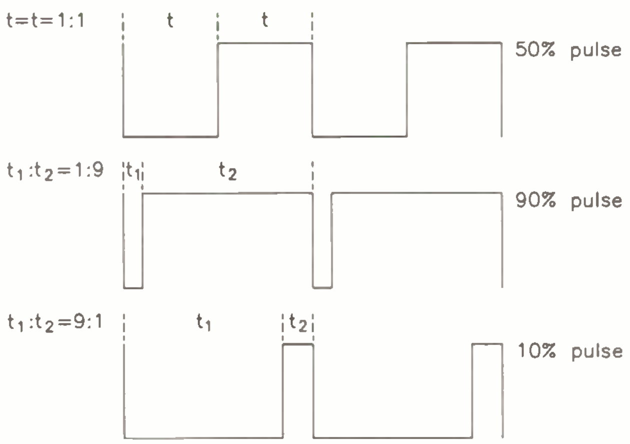


Figure 6. Pulse width modulation used to create a new wave shape from the original square wave shape. Although the diagram cannot show this, the wave shape can be changed dynamically.

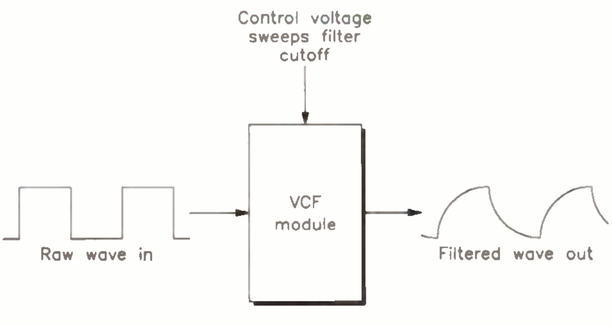


Figure 7. The VCF module is used to sweep through the frequency spectrum and remove unwanted harmonics.

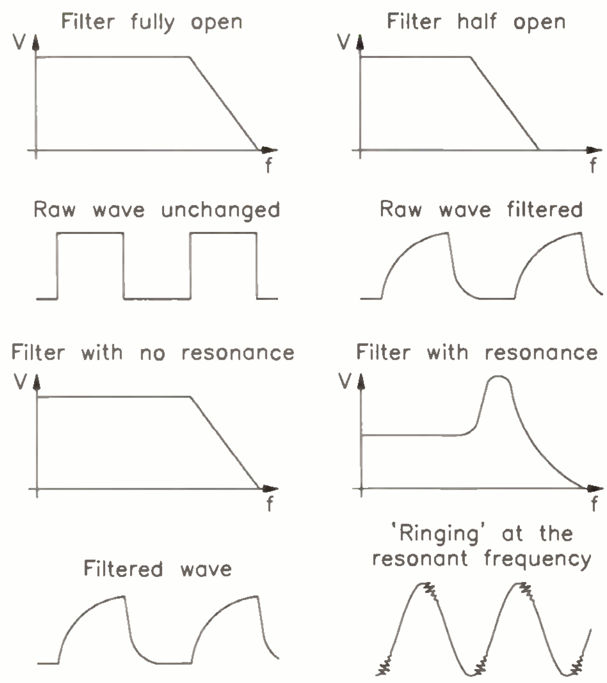


Figure 8. Adding resonance creates 'ringing' at the filter's resonant frequency, and makes the sound much more electronic and artificial.

MEASURING ULTRA•VIOLET RADIATION

BY DOUGLAS CLARKSON

Ultra-Violet (UV) radiation has, in recent years, attracted considerable attention from both the scientific community and the en-vironmental lobby. This has been prompted by the depletion of the ozone layer, primarily over the south polar regions and, to a lesser extent, over the northern polar region. With changing social habits and lifestyles, exposure of UV to the population has increased considerably – both of natural UV, and also from man made sources.

There are other even more critical points of balance in the eco-systems of the world. Crop harvests, and the very plankton in the sea, which determines so much of the food chains of the oceans, are significantly influenced by levels of UV radiation. One of the key aspects of UV radiation is measurement. This article looks extensively at the measurement aspects of UV radiation and identifies conventional and developing methods of UV radiation detection.

There are, however, numerous 'tricks of the trade' in UV measurement – hints and tips known to equipment manufacturers. Also, points of contact for optical components are not widely known. Some details are provided.

Types of Ultra Violet Radiation

Ultra violet radiation is banded into UVA, UVB and UVC, according to definitions of Table 1. The definition of UVB as far as 320nm is realistic as will be seen later, where the contributions at various wavelengths to the reddening of the skin is considered. The atmosphere effectively blocks out all UVC radiation.

The Concept of UV Measurement

In the measurement of UV radiation, systems can, on the one hand, give detailed information of levels in, for example, 1nm bands of wavelength, such as provided by a spectrum analyser, or provide a single numeric value, from a representative spread of wavelengths. A system of the first type can be obtained for around £10,000, while the more basic system may cost only £50.00 in parts and materials.

The principle of the diffuser/cosine corrector shown in Figure 1, indicates the basic components of the simpler measurement device. The key components are the diffuser/cosine corrector, filter structure, and photosensor. Photons of radiation incident upon the corrector are refracted, so that they register within the sensing system. Thus, photons are counted with equal weight, no matter what their initial angle of incidence. Most simple detectors do not have such a cosine corrector. A useful material for such cosine correctors is PTFE (Teflon), which is highly transmitting in the UV region.

Such corrections can be important for measurements of natural UV radiation, where a large component of UV is scattered from clouds and also the blue sky. Figure 2 shows a range of responses of various detectors, some with cosine correction, and some without. Clearly, this can account for differences between detection systems.

UV Filter Systems

The filter system used with the UV detector can take many forms. One of the cheapest forms of filter is derived from glass of specific formulations. An extensive range of glasses is provided by Hoya, and another is provided by Schott glass. Two main types of glass filter are available – cut filters and transmission filters. The so-called cut filters 'cut in' at specific wavelengths. Thus, in the Hoya range, UV-28 has an approximate 50% transmission at 280nm and UV-30 has an approximate 50% transmission at 300nm. These 'cut in' filters are useful for determining the short wavelength transmission of a filter combination.

The range of transmission filters allow transmission of a specific range of wavelengths. The standard configurations UV-330, UV-340, UV-350 and UV-360, correspond to peak transmissions at specific corresponding wavelengths. This combination of cut and transmission filters allows configuration of a range of wavelength responses when used with suitable photodetectors. The typical responses attainable with such filters is, however, generally broad band where the width of the filter is typically greater than 20nm. In trying to resolve much narrower bands of wavelength, e.g., 2nm, which would be useful in measuring UVB wavelengths between 300nm and 320nm, such filter glasses offer little, if any, help.

One option which has been variously investigated is to 'subtract' two spectra, where each signal is obtained with a discrete filter/photodiode combination. This form of difference spectra has been investigated most extensively, in order to provide a response which mimics that of the so-called Diffey curve, as depicted in Figure 3. This is the form of the response which measures the so called erythemal dose to the skin from UVB radiation. Examination of the curve shows why it is so difficult to manufacture a filter which provides a similar response curve.

Figures 4a to 4d show a range of filter glass, Gallium Phosphide (GaP) photodetector spectral combinations. In Figure 4a, using a UV-22, with transmission down to short wavelengths, the response is dominated by that of the GaP detector. In Figure 4b, UV-32 is added with UV-330, so that the UV-32 determines the short wavelength cut off, and UV-330 the long wavelength cut off. In Figure 4c, shown is the difference of two different signals, one from UV-28 and the other from UV-30. This can be used to obtain some information about UVB levels. In Figure 4d,

Band of UV	UVC	UVB	UVA
Range (nm)	200 to 280	280 to 320	320 to 400

Table 1. Series of World Health Organisation definitions of UV ranges in nm.

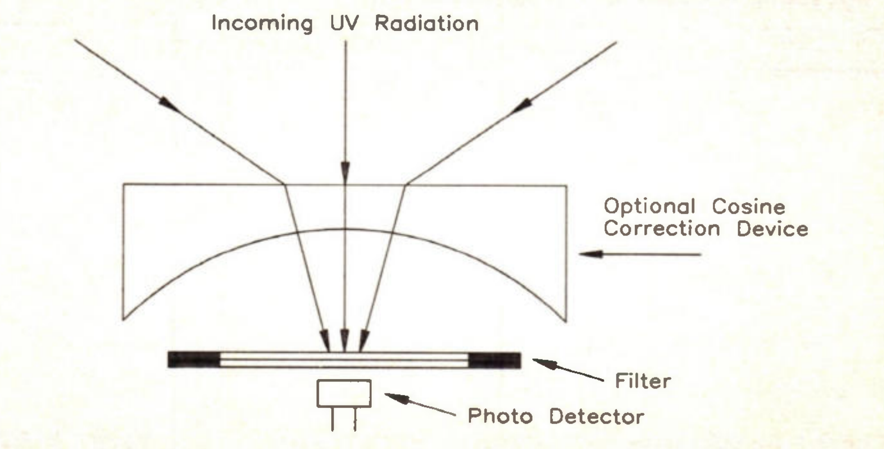


Figure 1. Basic design of single photodetector UV unit.

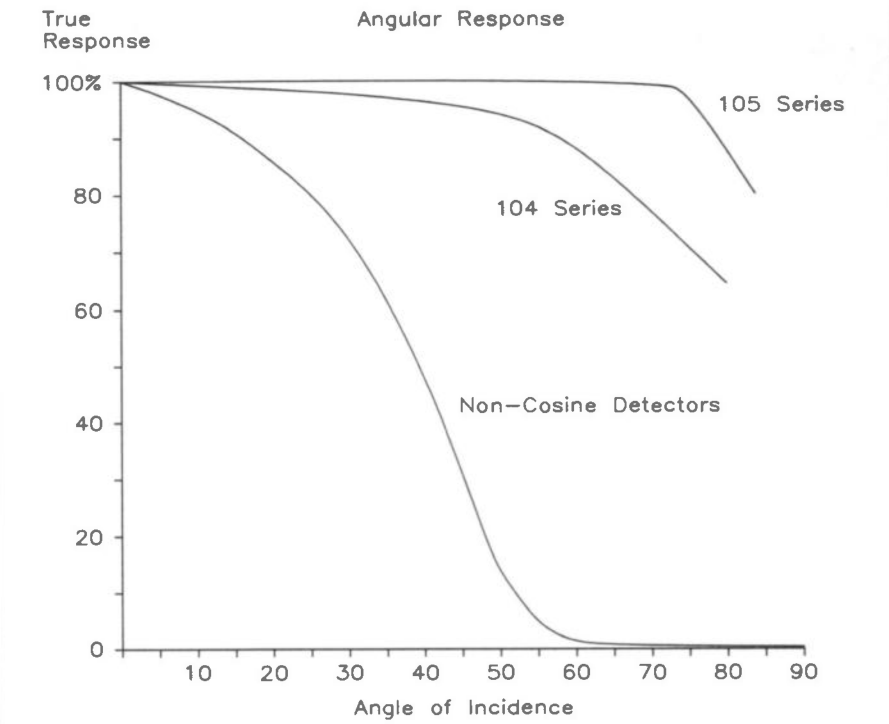


Figure 2. Angular sensitivity properties of specific UV detection systems (courtesy Macam Photometrics Ltd.).

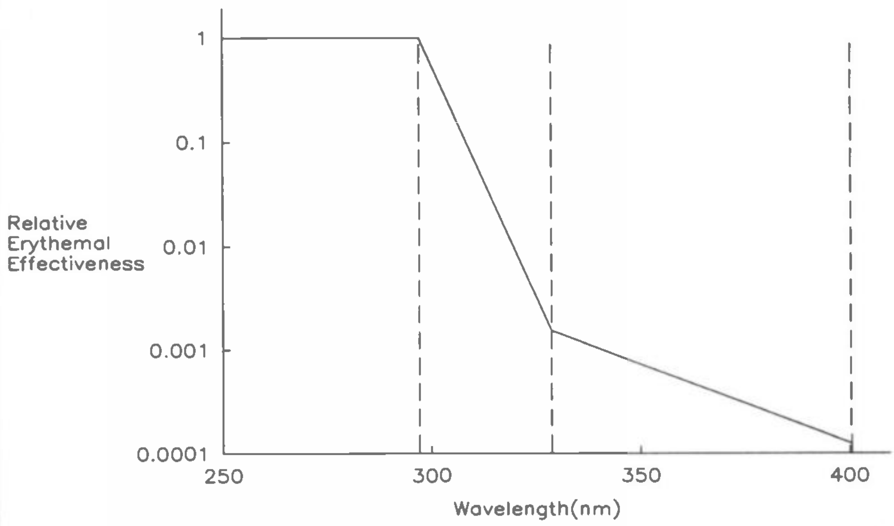


Figure 3. Skin erythemal response curve (Diffey Curve): The response changes rapidly from unity around 298nm to 0·001 at 330nm.

the response obtained from UV-34 and UV-330 is indicated. This gives a useful broad peak of sensitivity around 360nm.

Such filter glasses are relatively cheap; cut sections of 1cm in diameter can usually be obtained for around £2 per piece. The glass can be cut in different thicknesses, to give varying levels of attenuation. The data shown in Figure 4 is for 2·5mm thick Hoya glass. The use of narrow band filters, as the name implies, relates to the use of filters which transmit much narrower bands of wavelengths. These are usually available in 0·5in. and 1in. diameter, and also 1in. square. Such filters find extensive use in laboratory equipment, for measuring light levels of specific wavelengths.

Figure 5 shows the typical, much narrower, wavelength response of an interference filter. The key parameters of such a filter are the bandwidth at 50% transmission (Full width half maximum, FWHM), the blocking transmission, and the peak transmission. Table 2 indicates typical values of UV transmission filters. Such components, however, are relatively expensive – at least £60 per item. Thus, it is relatively expensive to incorporate an array of such filters into UV monitoring equipment. Also, such filters can be prone to ageing from high levels of UV radiation, and can absorb water vapour, which changes spectral response if layers of the filter are not adequately sealed.

There is generally increasing peak transmission with increasing wavelength. This is not very helpful, since it is often the shorter wavelengths where low levels of intensity are required to be measured. There is also the problem of angle of incidence of the incident radiation. The wavelength response of a specific filter will only be appropriate for incident rays at near normal incidence. This imposes limitation on geometry of detection. Typical values of wavelength shift at 5° and 10° (for normal incidence on a 500nm centre wavelength filter) are 1nm and 4nm, respectively.

Another consideration is the blocking value of the interference filter. This is the transmission at wavelengths remote from the band pass of the filter. Usually, this will have a value of 0·01%, although higher specification 0·001% types are available. While this would seem to be appropriate relative to a peak band-pass transmission of say 50%, it is possible to add considerable contributions from the blocking range of wavelengths, if the spectral content in these wavelengths is significant.

Thus, for a spectrum with a relative spectral content of 20% of maximum at the FWHM value of say, 7nm (0·7 relative signal units), a spectra of 100% signal over a 300nm extent at 0·01% blocking will contribute 0·03 relative units, or 4·3% of the peak signal. Where, for example, such filters are being used to measure transmission through specific wavelengths, precautions should be taken to minimise the effect of the breakthrough at blocking wavelengths remote from the transmission wavelengths. This can be achieved by means of limiting the initial spectrum, by means of choice of light source or by using an additional filter (e.g., glass type), so that light from blocking wavelengths is minimised. While these filters typically have a nominal diameter, such as 1in. or 0·5in., the so-called clear aperture – the area within which the filter actually operates – is typically around 90% of this. There are, therefore, a broad range of considerations in the design of such optical systems.

Refraction and Diffraction in UV Detection

The reason for using filters is to modify the set of wavelengths passed to a detector for measurement. This is the method used by low-cost 'compact' measurement systems. As any expert in light/UV measurement will state, by far the best (but certainly the more expensive) solution is to choose a technique in which the light is split up spatially into different wavelengths. Figure 6 shows how this can be undertaken by using a prism, shown in this case with equal 20cm sides. The fundamental optical law used is Snell's Law (or that of Descartes, of France), which states that:

$$n = \frac{\sin\theta_i}{\sin\theta_r}$$

Where;

θ_i = Angle of incidence
θ_r = Angle of refraction
n = Refractive Index

Most of the time in optics, it is required that optical materials will treat all wavelengths of light in a similar fashion, e.g., in lens optics. In using the prism to split up light, however, exactly the opposite effect is required. A high value of dispersion – the variation of refractive index with wavelength – is required.

If the performance is investigated of a specific prism, with sides of prism 20cm and all angles 60°, as shown in Figure 6, then for an incident beam at A (at angle of incidence

45°), the prism refracts each wavelength to a slightly different extent. For a specific silicate glass with a high dispersion between (say) 300 and 320nm of 1·1% (mean refractive index 1·47) the radiation is refracted to points approximately 3mm apart on the lower axis line at R. In order to resolve the erythemal component of UVB radiation, measurement is required in approximately 2nm bands, which would mean that sensitivity would be required in 0·3mm wide photosensors. This poses no potential problem for a linear array of, for example, 128 pixels of size 0·05 × 2·5mm with extended UV sensitivity. Such devices, such as Hamamatsu S-5, N-MOS type S3901, are expensive, however.

Some of the inherent problems of such devices are absorption, especially at lower wavelengths, and the changing path length for different wavelengths which in turn will alter transmission levels through the prism. There is also the problem of non-linearity in the dispersion properties of the prism material. So on paper, the dispersive prism provides some advantages, but in practice, problems in uniformity of optical properties of such materials at present, restrict the usefulness of the technique.

Diffraction Grating Systems

Almost all spectrum analysis systems make use of diffraction gratings for splitting up light into its various spectral components. In the case of UV measurements, there is often the particular problem for measuring low levels of radiation. As in any measurement system, there is always the problem of 'signal to noise'. In systems where light is split into spectral components, there is the problem of stray light interference, where light from a background of wavelengths can swamp the signal derived from detecting light of a specific wavelength at low intensities. Most spectrum analysers use a set of double grating devices for UV, in what is known as a double monochromator, as shown in the diagram in Figure 7, and the interior of a specific model (Bentham DM150) is shown in Photo 1. With appropriate optical configuration, the UV spectrum can be analysed in 1nm steps. The light is split once, and the remaining light split again, to improve stray light rejection.

Photo-Detectors

A broad range of detectors is available for measurement of UV radiation. Commonly-used devices include the UV-enhanced Silicon photodiode, Gallium Arsenic Phosphide (GaAsP) and Gallium Phosphide (GaP) photodiodes. Figures 8a to 8c indicate representative responses for the various devices. Figure 8a shows higher sensitivity, whilst Figure 8b shows flatter response between 300nm and 400nm. Figure 8c has zero response above around 550nm, which is an advantage in several applications. The GaP type, while presenting a lower sensitivity than the Silicon variety, has the useful property that the response ceases above around 550nm. Some filter glass elements (such as Hoya UV-330) have a transmission above 700nm, and so the incorporation of a GaP device will not require any additional filter to block above 700nm when such glass is used.

Continued on page 28.

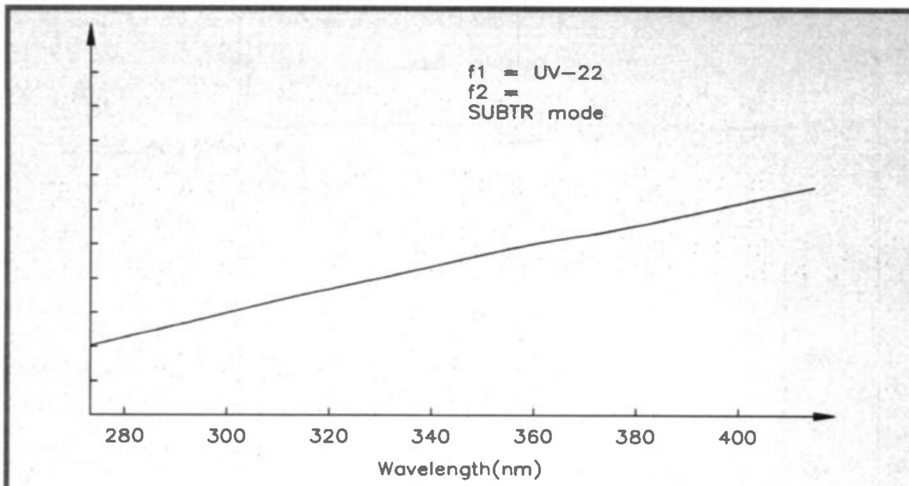


Figure 4a. UV-22 (cut) with GaP photodiode.

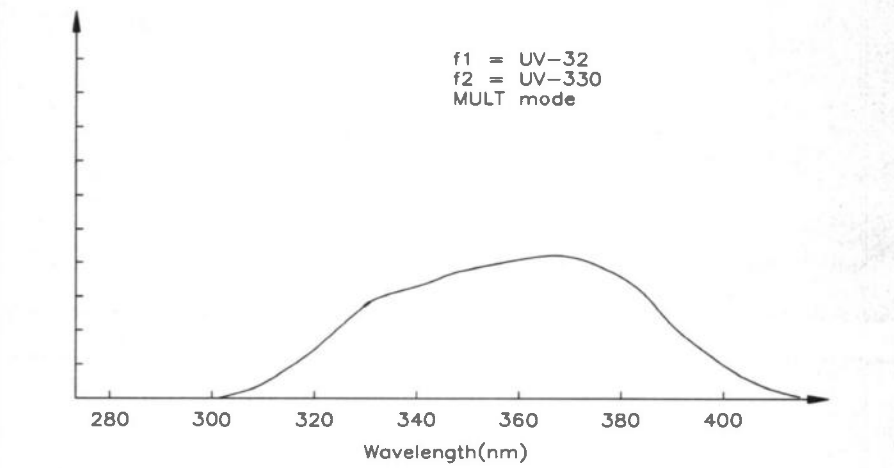


Figure 4b. UV-32 (cut) and UV-330 (transmission), with GaP photodiode for 2·5mm thick glass.

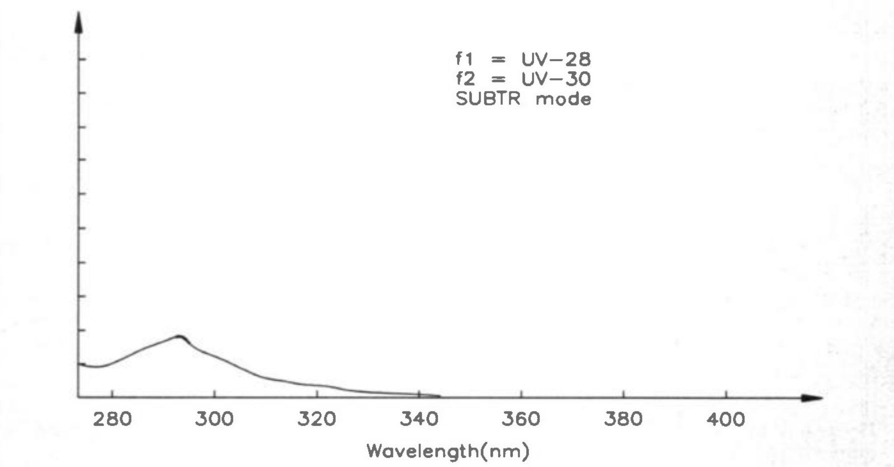


Figure 4c. Difference signal of UV-28 (cut) with GaP, and UV-30 (cut) with GaP.

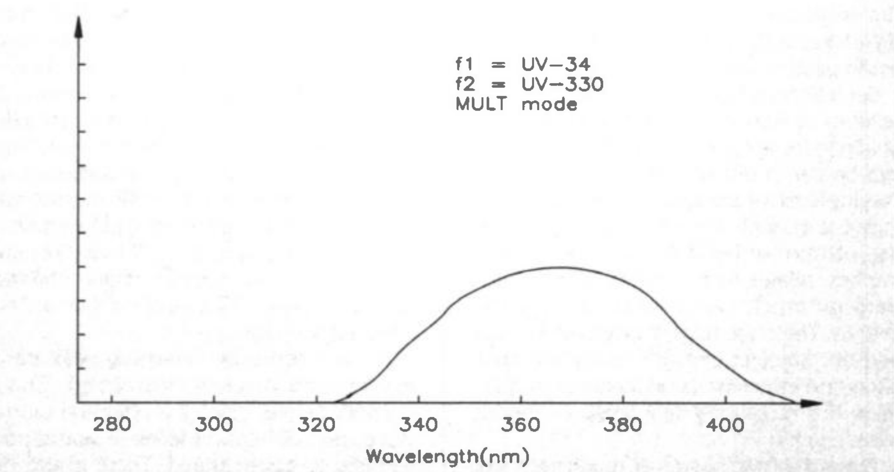


Figure 4d. UV-34 (cut) and UV-330 (transmission), with GaP photodiode for 2·5mm thick glass.

offered. Early synthesizers were *modular* – they were made of lots of different kinds of circuits that had to be connected by hand before any sound could be generated. In theory there were two different kinds of modules. Every circuit used a voltage swing for both input and output, but only some circuits – the sound generators and modifiers – were directly in the signal path. The others, known as modulators, were used as automatic control voltage sources that defined the way a note developed and changed. In practice the divisions were easily blurred. There was nothing to stop an adventurous user from connecting circuits back into themselves, or linking them in a chain, or doing other things that the designers probably never dreamed of!

Synthesizer Building Blocks

Let us take a closer look at the different kinds of circuits. As a general note it is worth remembering that most practical circuits include some form of control voltage mixer stage, usually of the virtual earth variety to prevent impedance matching problems. This makes it easy to use more than one control voltage source at the same time, and hence create much more interesting and realistic sounds. Many modules also include audio mixer stages as well, sometimes with a separate gain control for each input. The individual sections of a synthesizer system are outlined below.

Voltage Controlled Oscillator

Perhaps the most important circuit of all is the Voltage Controlled Oscillator (VCO), as shown in Figure 4. A VCO takes a voltage output from a keyboard, or from any other circuit, and turns it into a pitched repeating wave shape. A master tuning control sets the master tuning of the module, and then as the user plays up and down the keys, the pitch of the oscillator follows. The standard setting here is known as 1V per octave – as the voltage goes up by one volt, the pitch of the oscillator doubles; Figure 5 illustrates this. In practice though, early oscillator designs were notorious for drifting away from this ideal, and for drifting out of tune in general!

Most VCOs can produce one or more wave shapes, sometimes simultaneously. The sine wave is one popular option, as are other harmonic-rich wave shapes such as sawtooth, triangle and pulse waves. These shapes are static, so later VCO designs include extra features which add movement to the raw sounds. The easiest, if not quite the cheapest, way to do this is by adding more oscillator circuits. This can create a very lush and rich sound. Different oscillators can be tuned slightly apart to thicken the sound slightly, or can be set at musical intervals to create a very big and fat sound indeed. Another popular technique is called Pulse Width Modulation (PWM), see Figure 6. The mark-space ratio of the square wave output can be swept in real time, changing the harmonic mix and adding an interesting dynamic to the sound.

Voltage Controlled Filter

Because raw oscillator sounds are too static and overpowering for most applications, the next step is to add some filtering. This is done with a module known as a Voltage Controlled Filter (VCF), shown in Figure 7. Here the voltage control is used to sweep the cut-off frequency of the filter in real time. Most filters are of the low-pass variety, with either a subtle sounding 12dB/octave or a much sharper and fatter 24dB/octave cut-off. Other filter types, such as high-pass, band-pass and notch varieties are also used.

It is perhaps the use of the VCF that gives synthesizers their distinctive sound quality. Most filters come with a resonance feature which 'peaks' the sound around the cut-off frequency, indicated in Figure 8. This makes the sound distinctively electronic and 'wet'-sounding, and also sounds similar to the human vocal tract – hence the vocal-like nature of some synthesized sounds. But there is more to filter design than cut-off and resonance. Many musicians are now going back to traditional instruments because the latest crop of digital machines simply cannot duplicate that elusive 'fat' sounding musical quality, that was available on the early designs. Filters designed by Robert. A. Moog are particularly well respected, even though in electronic terms they are surprisingly crude by modern standards.

Voltage Controlled Amplifier

Once the sound has been filtered, it is passed onto a voltage controlled amplifier circuit. This time the control voltage controls the volume of the sound, as Figure 9 shows. Different acoustic sounds have very different volume contours. A percussion sound for example has a very short, sharp and tight volume curve that makes the

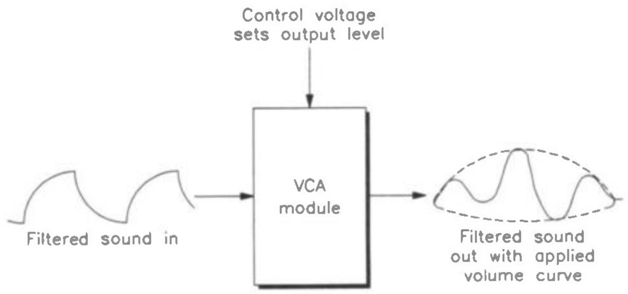


Figure 9. The VCA module sets the level of the final sound, and can add a dynamic level curve.

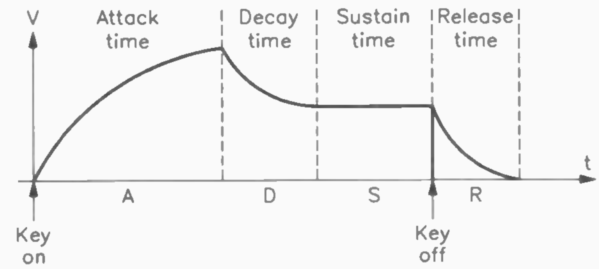


Figure 10. The ADSR envelope generator is used to create a voltage contour that shapes each note.

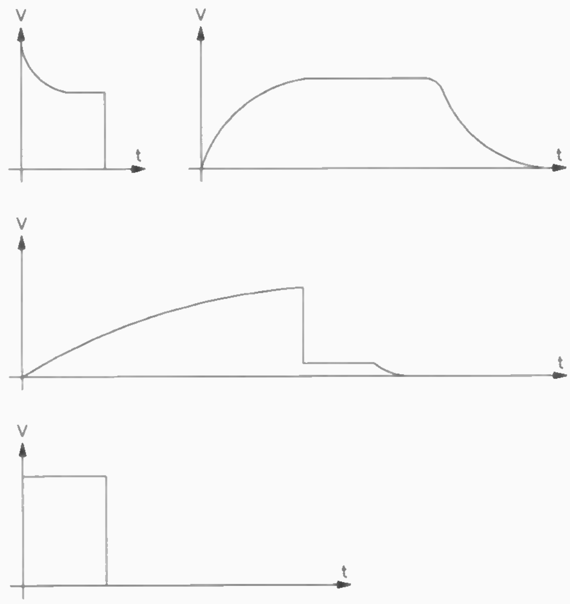


Figure 11. Just a few of the envelope shapes possible with an ADSR envelope generator.

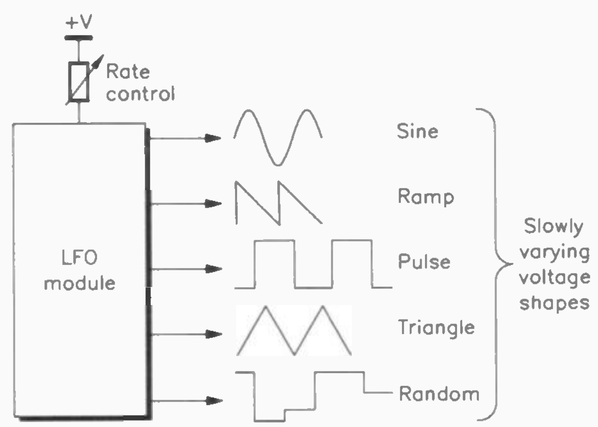


Figure 12. The LFO module creates a range of slowly varying voltage shapes.

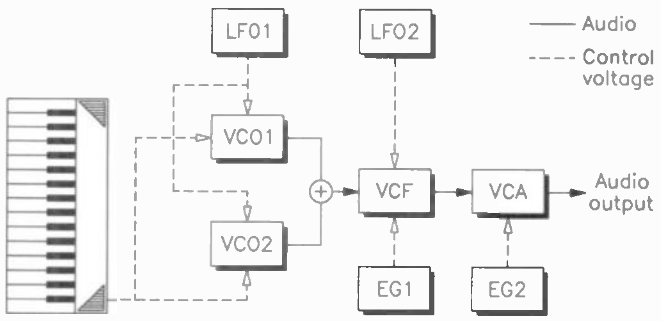


Figure 13. The standard prepatched synthesizer circuit. Most synthesizers are based on this design.

sound snap, while something like a flute has a much softer and gentler curve. The VCA circuit is used to add volume changes that can duplicate either of these effects, and others besides.

Envelope Generator

To simulate the volume curve itself, a modulator circuit called an Envelope Generator (EG) is used. This creates a voltage curve that varies predictably throughout the course of a note. Most EGs are of the four stage Attack, Decay, Sustain and Release (ADSR) variety, as Figure 10 highlights, which splits the sound into an initial attack transient, a static level which is held while a note is held down, and a release phase which starts when the note is released. By changing these four settings a range of complex and interesting curves can be produced. This kind of EG can easily simulate all the loudness contours that are created by real instruments, as well as creating other completely unnatural and synthetic effects, the waveforms of which are shown in Figure 11. Because EGs are modulator circuits, they can also be connected to circuits other than VCA. A common application is to use an EG to sweep the filter while a note is playing. This creates a range of 'wah' and 'ooh' effects, depending on the settings used. Another application is to link the EG to the control input of an oscillator. This creates siren-like effects as the note rises or falls in pitch dramatically while the note is held.

Low Frequency Oscillator

The other frequently used modulation circuit, shown in Figure 12, is the Low Frequency Oscillator (LFO). An LFO produces a slowly varying, repeating waveform with a frequency anywhere between around 0·01Hz and 100Hz. Most LFOs offer a choice of wave shape, including sine, triangle, ramp, pulse and even random shapes. LFOs have many uses. Some of the most popular include adding vibrato – that slight musical pitch wobble that acoustic players add to make their music more interesting – and auto-wah effects. Other effects are also possible, including auto-panning, which can bounce a sound between the left and right speakers. Again, the exact effect an LFO has depends on which module it is connected to.

Modern Synthesizer Techniques

Although modular synthesizers are wonderfully flexible, they are also very time consuming to use. Creating new sounds can take a very long time. So the next step in synthesizer evolution was the design of the prepatched machine. This includes a useful selection of modules which are already connected together. The user can change the panel settings, and perhaps some of the connections using panel switches, but most of the layout is preset.

In fact almost *all* modern synthesizers are now prepatched – the basic layout outlined in Figure 13 has not changed for over twenty years. Although the technology has moved on dramatically – modern synthesizers use Digital Signal Processing (DSP) to create their

Photo 1. A traditional synthesizer: Sequential Circuits Pro-One. © Copyright 1994 Stuart Baynes Photography, all rights reserved, used by permission.

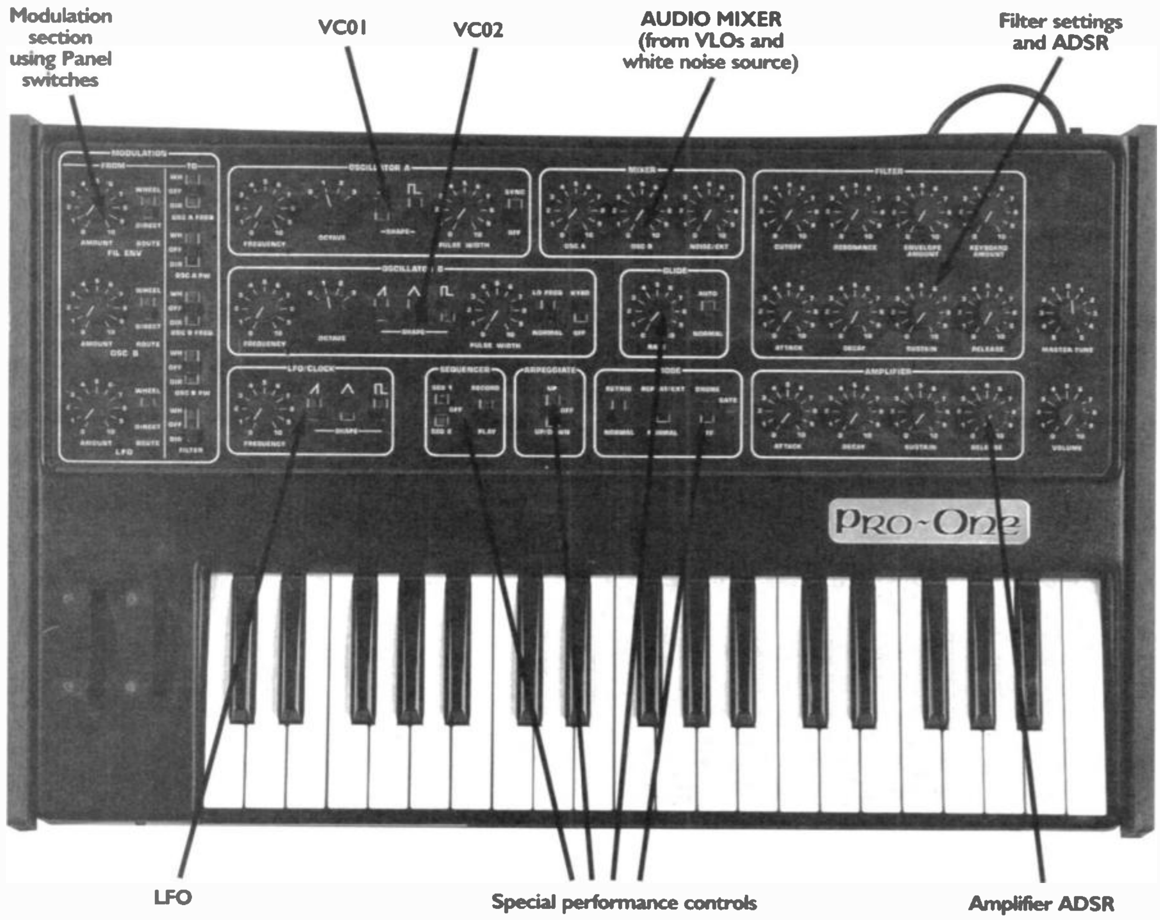


Photo 2. The front panel layout of the Pro-One. © Copyright 1994 Stuart Baynes Photography, all rights reserved, used by permission.

sounds, instead of the discrete analogue circuitry of old – the basic outline of a prepatched machine has stayed more or less constant, with a few interesting exceptions which we will be covering later in the series.

Photos 1 and 2 show how it all comes together in practice, and depict a synthesizer known as the Sequential Circuits Pro1, which was designed over ten years ago and discontinued when Sequential Circuits (one of the early synthesizer pioneers) went out of business. This old design, however, is still selling well today, because it is one of the last machines made where users can change the sound by reaching out and changing a panel control. Photo 2 shows the layout of the front panel controls; it can clearly be seen that the controls fall neatly into logical groups as indicated by the legend.

Notes

(1). Rupert Neve, one of the most respected designers of mixing desks in the music business, is a firm believer in the idea that sounds well above 20kHz can still be perceived. At his demonstrations he is known for playing a very high frequency sine wave (well over 10kHz) through a studio quality sound system, and then switching it to a squarewave. In theory any harmonics in the squarewave should be inaudible. In practice many people can hear the change quite easily. Many CD mastering studios include – and often use – equipment which can effect these very high-frequency sounds.

Further reading

Musical Applications of Microprocessors, Hal Chamberlin, Hayden.
The *Keyfax* Series, Julian Colbeck, Making Music Publications.

Further Listening

Isao Tomita, RCA records – Isao Tomita specialises in colourful electronic transcriptions of music of the classical nature that are highly recommended to anyone who would like to know just what traditional synthesizers really can sound like!
Tangerine Dream, Virgin Records – For those people with more of an interest in rock music, Tangerine Dream produced what is perhaps the definitive series of synthesizer albums in the early 1970s. The live albums – *Ricochet* and *Encore* – are particularly recommended.

What's On?

Electric Music Goes Under the Hammer

A Vintage Electric Musical Auction to be held at Star House, Sandford, Devon on 2 July, is already attracting interest from buyers in Europe, America and Japan.

The Auctioneers are keen to hear not only from buyers, but also from individuals who might have items to sell. According to the auction coordinator Paul Forrest, "If readers have old music projects tucked away we want to hear from them. You may be surprised to find that a well built synthesizer (particularly a modular type) is actually worth a fair bit of money."

Indeed a full Digisound rack of twelve modules might be worth over £500. Even spare chips such as Curtis and SMMs are increasingly being purchased for high sums. Items subjected for auction at the time of going to press included Hammond Model A, BA Player and Hammond Novachord organs, a Simmons drum module, a Yamaha GX1 and a Minitronic early electric piano.

Contact: Vintage Electric Musical Instrument Auctions, Tel: (01363) 774627.

UK Embedded Systems Show

Worldwide chip sales were up 40% in 1994, and a further increase of 25% is expected this year according to industry analysts Dataquest. While this ramp-up is being driven by PCs shifting from business applications into the consumer market, there is another class of microprocessors emerging.

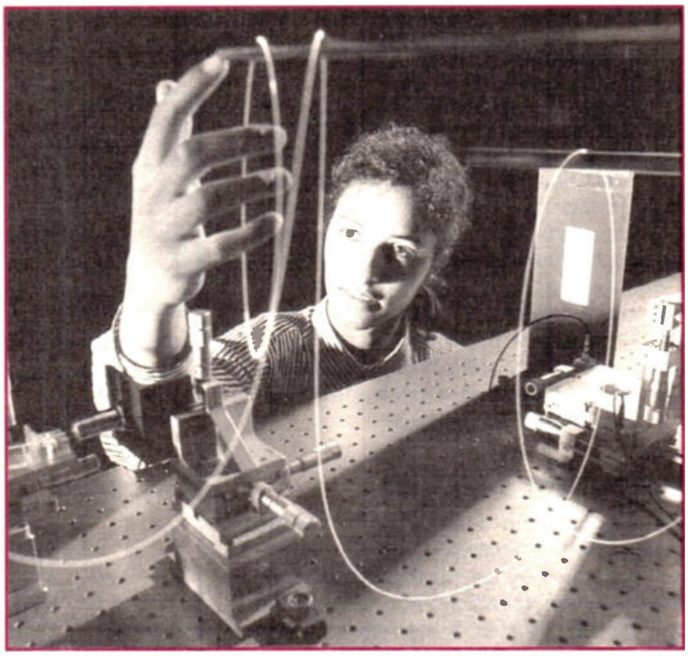
As the Embedded Systems Show at the London's Barbican last month demonstrated, embedded RISC microprocessors are becoming big business. These devices are typically very small, yet offer 32-bit capability combined with excellent code density, keeping system costs to a minimum.

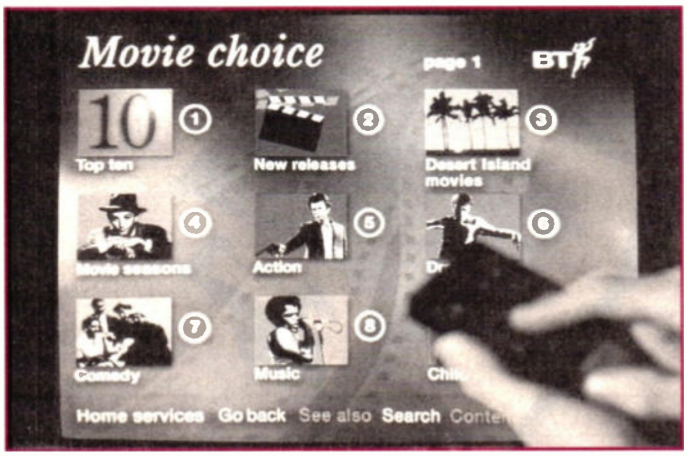
Minimal power consumption is an additional advantage which devices like the ARM family of microprocessors are able to offer. Combined with high processing power and low cost, this makes the processor ideal for embedded applications.

The microprocessor, once the domain of the high power mainframe is finding applications in diverse areas such as mobile communications, games machines, household consumer products such as microwaves and washing machines, smart cards and remote networking products. The list goes on and on. Indeed the latest BMW to hit the street is said to contain no less than 12 microprocessors, equivalent to eight desktop PCs worth of processing power.

Among the names at the Embedded Systems Show were IBM and Motorola with cut-down versions of their Power PC. Hitachi showed off its one-year old SH-3 already claimed to be the best selling embedded RISC microprocessor having been designed into Sega's Saturn game machine.

Competition to secure design wins is fierce. The feeling at the Embedded Systems Show was that the next shift in the market will be towards set top boxes. This is an ideal space for embedded RISC where high performance, coupled with low cost is essential.





Surf the Net at the Science Museum

The Science Museum has boarded the Superhighway and opened its doors to invite members of the public to surf the net. The exhibition which will run for three months is sponsored by BT and Oracle, with PCs provided by HP and Internet access supported by the Institute of Science and Technology Janet network.

Access to the exhibition is free and unrestricted allowing visitors to explore the Internet on their own terms. Touch screen terminals explain how to access the World Wide Web, as well as access News Groups, and how to send electronic mail.

The exhibition also gives visitors an opportunity to experience Video-on-Demand, and Interactive Television services via a set-top box provided by Online Media.

If you prefer not to leave the comfort of your own home, it is possible to visit the exhibition via the World Wide Web. The Web tour includes all the features of its real-life counterpart including a demonstration of television on demand.

Tel: Science Museum, Tel: (0171) 938 8000, **http://www.nmsi.ac.uk**

Exhibitions Power Weekend Activity

Stuck for something to do at weekends? Perhaps you are fed up with your latest project and want to get outdoors. Well with this in mind, and summer supposedly well on its way, this month we have been up North, to take a look at a couple of industrial exhibitions which profile the extremities of the electricity generating industry.

Whether or not you agree with nuclear energy, the Sellafield Visitors Centre at Seascale in Cumbria is well worth a visit. Computer simulations, audio-visual displays and interactive models provide a fascinating, albeit biased insight into the nuclear industry, while guides are on hand to explain aspects of the Sellafield site in detail.

Contact: The Sellafield Visitors Centre, Tel: (019467) 27027.

Opening-times: Open all year, April to October daily 10:00 to 18:00, November to March daily 10:00 to 16:00. (Closed 25 December). Admission: Free.

Heading further North and moving to the opposite end of the power industry, the Pitlochry Hydro-Electric Visitor Centre is based around an exhibition which shows how electricity is brought from the power station to the customer. Here visitors are allowed access to the main dam, to view one of the station's turbines through a viewing gallery. A second viewing chamber provides access to the dam's salmon ladder allowing visitors to see the fish as they travel upstream to their spawning ground.

Contact: Pitlochry Hydro-Electric Visitor Centre, Tel: (01796) 473152. Opening-times: Open April to October, daily 9.40 to 17:30. Admission: Adults £1.50, Children £0.60, Concessions £1, Family Ticket £3.

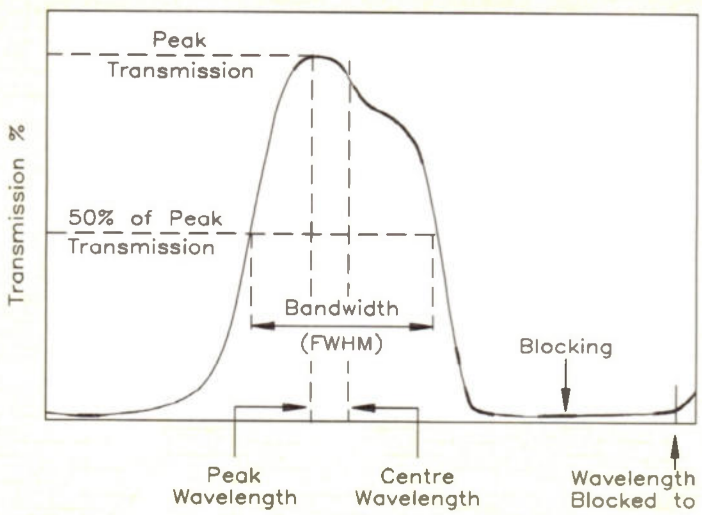


Figure 5. Typical response of interference filter (courtesy of Ealing Electro-Optics plc).

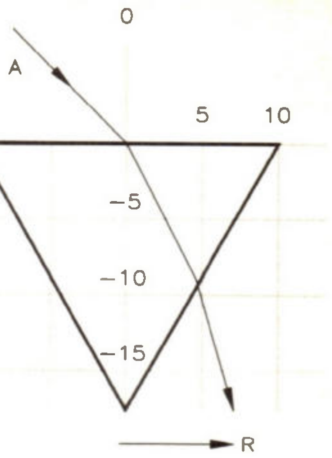


Figure 6. Function of prism in splitting up light; configuration shown for a prism of sides 20cm.

Between 300nm and 400nm, the GaP response is linear with increasing wavelength. The GaAsP response is flatter between 300 and 400nm than the other detectors. The GaP device is therefore ideal to use with interference filters, where contributions from blocking wavelengths wish to be minimised. Figure 9 indicates the typical response of two commercially available GaP detectors with integral filter windows. The G5842 is a particularly useful and cost-effective device, which is used primarily for UVA measurements and is available as a compact flat package.

Detection Circuits

Figure 10 shows a standard circuit for the measurement of photodiode signals. The current generated by the photodiode is translated to a proportional voltage circuit by the operational amplifier. It is possible to estimate the levels of current which photodiodes can generate. Sensitivities are listed in A/W (Amps per Watt). For an average intensity of 1mW/cm2 for a die of detector 1mm square, the total intensity incident on the detector is 10μW. Assuming a sensitivity factor of 0·1A/W, the current generated would be 1μA.

Each detector device has an associated 'Dark Current' – a current that flows with no incident illumination. Typical values for quality devices are between 10 and 50pA. The operational amplifier used to amplify the photodiode output signal should ideally incorporate adjustable offset, to allow setting of zero output voltage for zero incident illumination. Where low-level signals are being measured, it is appropriate to use detectors with large die areas to enhance the signal-to-noise ratio.

It is important, however, to realise that while natural UV levels will be relatively stable, sources of artificial UV almost always will not be. For example, the light output from UVA sun beds (a form of fluorescent lighting) will usually vary at a frequency of 100Hz. There are a number of circuit options to provide a 'smooth' signal from such alternating light fields, the simple option being to use some form of electronic filtering. An interesting solution, however, is to use a precision integrator device, such as the Burr Brown ACF2101. The device is controlled by conventional TTL circuitry to, for example,

Centre Bandwidth wavelength (nm)	Peak FHWM (nm)	Blocking transmission (%)	fraction (%)
260	10	15	0·01
300	10	15	0·01
320	10	20	0·01
340	12	38	0·01
360	10·6	38	0·01

Table 2. Typical Characteristics of Band-pass Interference Filters.

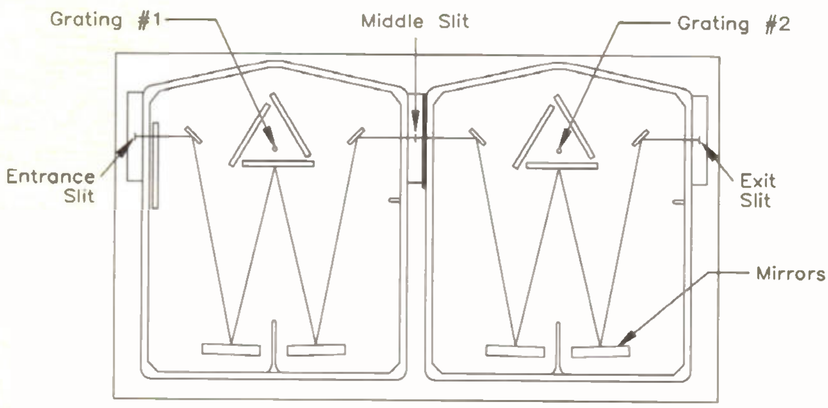


Figure 7. Optical path with a double monochromator (courtesy Bentham Instruments Ltd.).

Photo 1. Inner view of DM150 double monochromator (courtesy Bentham Instruments Ltd.).

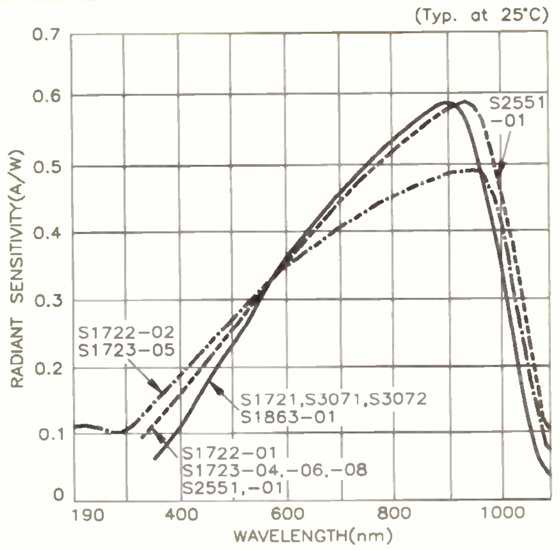


Figure 8a. Relative response of UV enhanced Silicon photodiode.

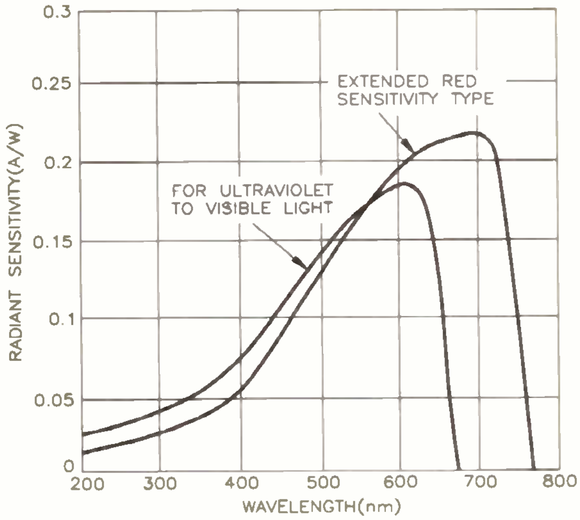


Figure 8b. Relative response of GaAsP photodiode.

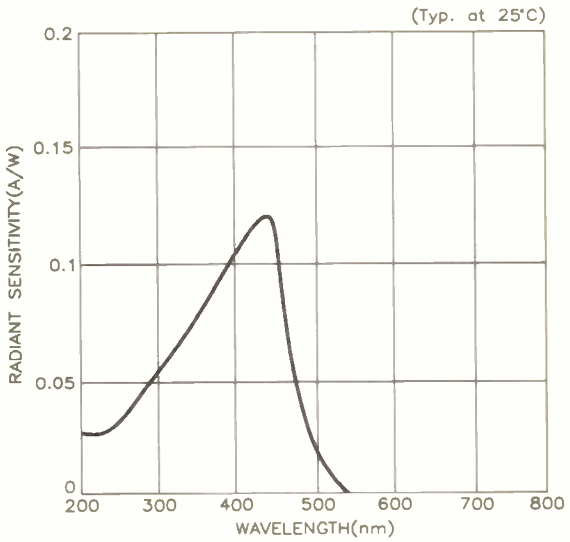


Figure 8c. Relative response of GaP photodiode (courtesy Hamamatsu Photonics Ltd.).

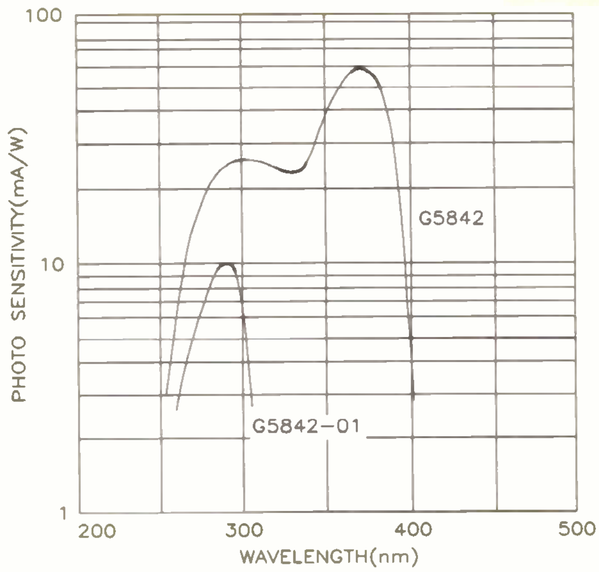


Figure 9. Wavelength response of two Hamamatsu devices – GaP units, with integral filter windows (courtesy Hamamatsu Photonics Ltd.).

Figure 10. Simple electronic circuit for measurement of photodiode signals.

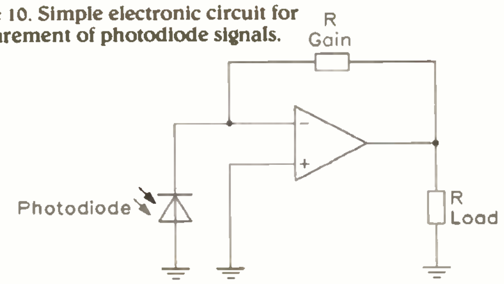


Photo 2. Compact design of modern UV meter electronics (courtesy Macam Photometrics Ltd.).

set zero (discharge capacitance), integrate and hold values. This option allows a number of output cycles to be integrated without aliasing, provided that the sample time is a whole number of alternating cycles.

Using the relationship:

$$V_{out} = \frac{I_{input} \times dt}{C}$$

Where:

I_{input} is the input current
dt is the time of integration
C is the integrating capacitor

Values of V_{out} can be calculated. For example, with C = 10nF and dt = 0·25s, values of output voltage in relation to input current are as per Table 3.

V_{out} (V)	I_{input}
0·0025	0·0001
0·025	0·001
0·25	0·01
2·5	0·1

Table 3. Response of the Burr Brown ACF2101 Precision Integrator.

Such a device has the capability to allow measurement of extremely low currents. As can be seen in Table 3, an input current of a 100pA corresponds to an output voltage of 2·5mV. The ACF2101 has an internal precision 100pF capacitance for each channel, which can be selected using a specific configuration. However, where larger currents are required to be integrated, then a separate external capacitor can be included in each circuit, as shown in Figure 11a (DIP package). Figure 11b indicates logic control signals for reset, integrate and hold.

For a measurement time of 2·5 seconds (longer integration time) and a (smaller) value of capacitance of 1nF, a current level of 1pA would register as a voltage signal of 2·5mV. In an application with a band-pass filter with 1mW/cm2 incident, 2·5% of spectrum transmitted in 5nm bandwidth, detector sensitivity of 0·1A/W (area 1mm2) and with 20%

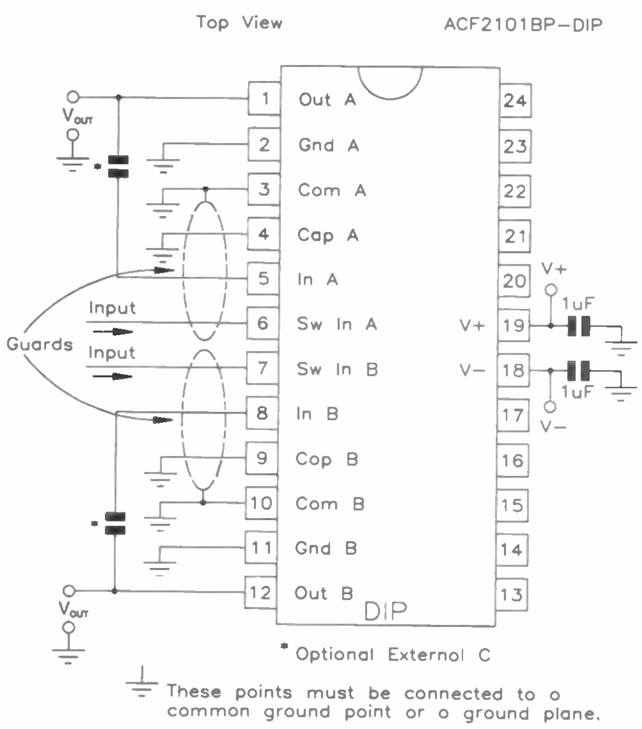
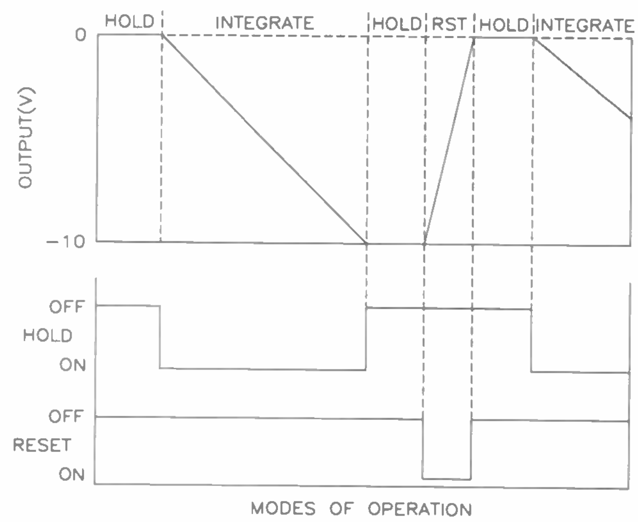


Figure 11a Precision integrator with external capacitance.



SWITCH	MODE OF OPERATION Integrate	Hold	Reset
Hold Switch	ON	OFF	ON/OFF
Reset Switch	OFF	OFF	ON

ON: Switch shorted; Logic 0 input.
OFF: Switch open; Logic 1 input.

Figure 11b. Control logic for precision integrator (courtesy Burr-Brown (UK) Ltd.).

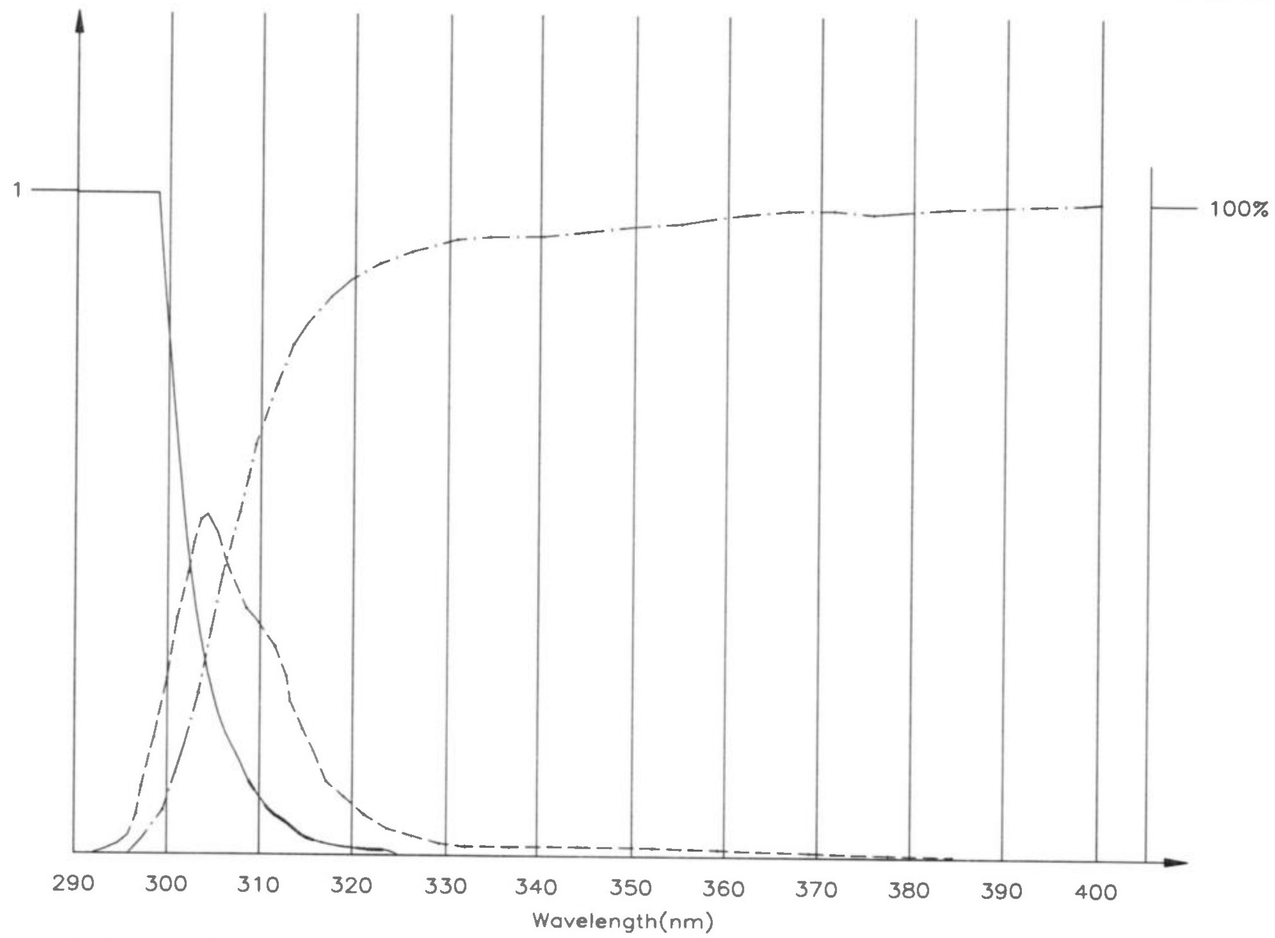


Figure 12. Graph showing how the Diffey action spectra (——) modulates the relative UV signal to an erythemal dose contribution (— —), and how the cumulative dose increases with wavelength (—·—).

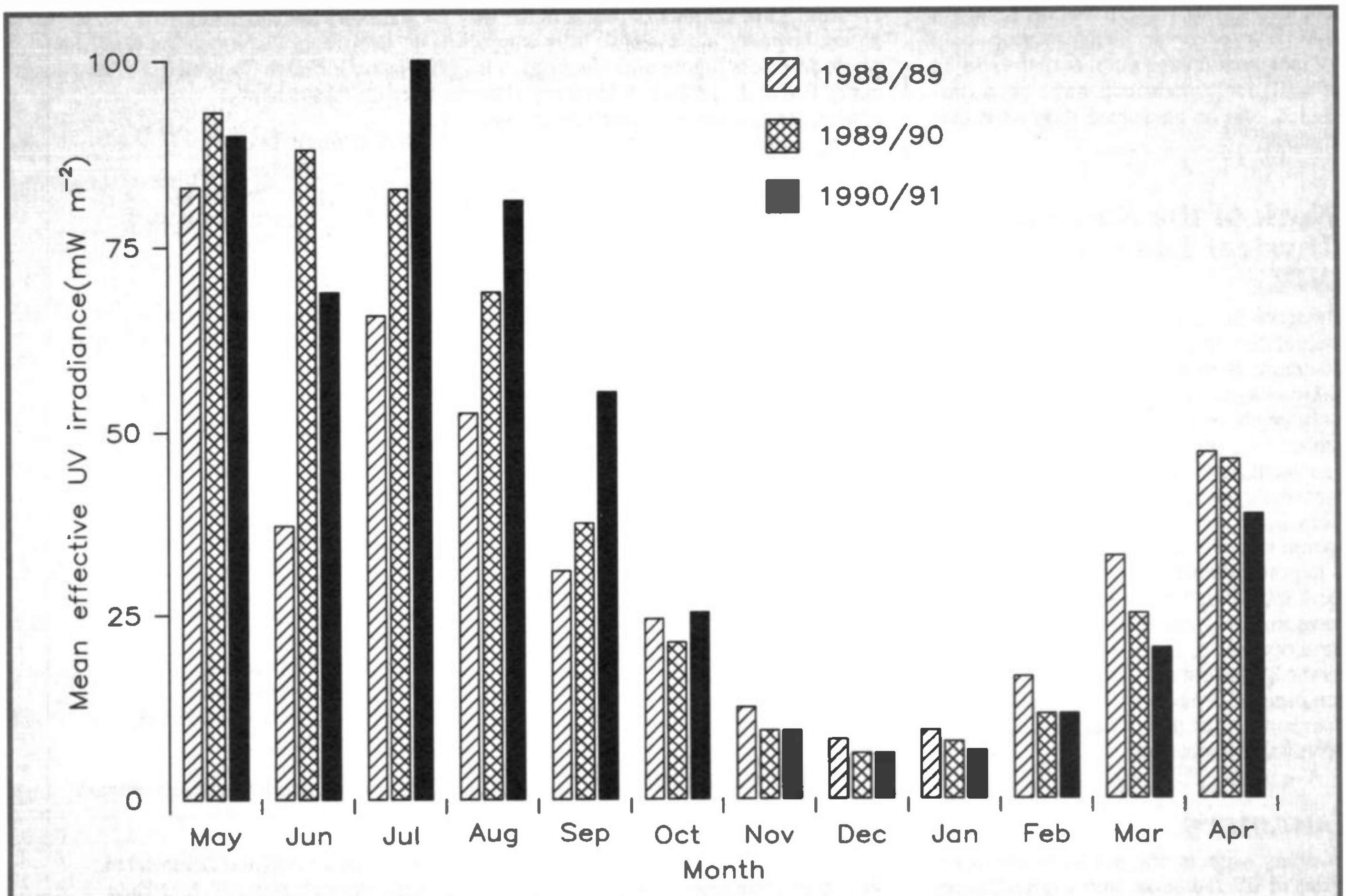


Figure 13. Solar measurements at Chilton, Leeds and Glasgow (mean, as at 12:00 GMT) 1988-1992, in UVR effective units of mW/cm² (courtesy NRPB).

transmission in pass band, the current generated would be 0·005μA (5nA). At a sample time of 0·25s with a 10nF capacitance, the measured signal would be 0·125V. This confirms that typical measurements with UV photodiodes will necessitate measuring currents between nA and μA ranges.

If this integration approach is compared with a standard current to voltage detector, such as that shown in Figure 10 with a 1MΩ gain resistance, the output signal would be 5mV – a factor 25 times smaller than that with the precision integrator. Clearly, there is also some advantage in using time as a kind of amplification factor. Photo 2 demonstrates the typical compact size of modern UV meters, which provide for a range of output measurements and filter options.

Measuring the Erythemal Dose

Part of the problem, however, in measuring the effective dose associated with shorter wavelength UVB radiation, is that the associated action spectra changes rapidly in value with wavelength. As a specific example, while the response is flat up until 298nm, its value falls to 10% by 308nm, to 1% by 319nm, and to 0·1% by 339nm. This poses considerable problems in measurement of erythemal dose using conventional filters.

It is also important to appreciate the difference between measuring the erythemal dose, weighted by the skin action spectra, and the energy within a specific wavelength extent in conventional units of mW/cm². It is useful, for example, to calculate contributions to the erythemal dose from a typical summer UV spectra with significant UVB content. Figure 12 shows how the Diffey action spectra (green) modulates the relative UV signal to an erythemal dose contribution (blue), and how the cumulative dose increases with wavelength (black). In the example of the specific spectra listed, 50% of the erythemal dose is achieved by 307nm, 75% by 312nm, and 80% by 320nm.

There has been considerable effort expended in trying to create a filter which has the appropriate erythemal response. Such a filter would transmit the shorter wavelengths and tend to block out the longer wavelengths. As the calculations show, however, the response of the filter is most critical between 298 and 320nm. Interference filters would be appropriate only with narrow bands around 2nm wide in the rapidly changing wavelength range between 298 and 309nm. Table 4 indicates a possible set of interference filters that would be appropriate. Such filters would be expensive to manufacture as individual items, and not really practical options. One specific filter which has been developed commercially for this application is used in the Robertson-Berger detector. Its response is a reasonable approximation to the erythemal response curve.

Filter centre wavelength (nm)	FWHM (nm)	Approximate contribution (%)
297	4	7·3
301	2	7·6
303	2	12·8
305	2	13·9
307	2	11·0
309	2	9·7
312	4	15·6
317	6	10·2
323	6	2·8
330	8	2·2
340	10	2·0
350	10	1·6
370	20	1·9
390	20	1·4

Table 4. Functional set of interference filters for Erythemal Dose measurement. The contributions above 330nm are less significant compared with those in 2nm bands around 305nm (contributions are weighted by the Diffey response curve).

Work of the National Radiological Protection Board (NRPB)

In the UK, considerable work has been undertaken by the National Radiological Protection Board at Chilton, Oxfordshire, in developing equipment for the measurement of UV radiation, and initiation of programmes for UV monitoring at key sites. Measurements are now being collected at Chilton, Leeds, Glasgow Lerwick (Shetland), Kinloss (Morayshire) and Camborne (Cornwall). Work is also progressing with extending measurements to two sites in Greenland and one in Galway, Ireland. It is hoped that this will provide detailed information about patterns of UV radiation in the northern hemisphere.

Figure 13 shows values for the mean monthly UV effective irradiance in recent years, at the NRPB at Chilton, at 12:00 GMT. There is a considerable variation between seasons, and also a variation from year to year for a specific month. The NRPB is also a useful point of contact for information about UV radiation. A large number of the NRPB's At-a-Glance broadsheets have been distributed, and an associated slide set is also available.

Work of the National Physical Laboratory (NPL)

The work of measurement of UV relates to traceability, in accordance with National Standards. Extensive facilities exist at NPL, to calibrate light sources over a broad range of wavelengths of ultra violet, visible, near infra-red and far infra-red radiation. Recently, new facilities have been commissioned for measurement of, for example, UV levels from lamp sources and also spectral response of UV detectors. Such work at NPL is important, since it provides a foundation for an increasingly important sector of optical measurements and standards, and for the development of measurement equipment for the 'global' market. This is why the maintenance and development of National Standards within the UK has such significant economic importance.

Summary

In many aspects, the accurate measurement of UV radiation, and especially, the action spectra in relation to the effect on personal exposure, is something of a challenge. A considerable number of pieces of the UV jigsaw, however, are available – by way of photodetectors, filters and electronic circuitry. Part of the problem is knowing where to access such items, and how to design measuring equipment which measures relevant parameters.

Photodetector and filter technology is also in a phase of relatively rapid development. It is likely that cost-effective solutions to many of the inherent problems of UV measurement will be found with emerging technology; watch this space! It is difficult to cover in adequate depth, all of the topics relevant to UV radiation and its measurement. However, the sources of further information listed will help fill some of the gaps. E

Further Information

National Radiological Protection Board,
Chilton, Didcot, Oxon OX11 0RQ
Tel: (01235) 831600

National Physical Laboratory,
Teddington, Middlesex
Tel: (0181) 977 3222

Hamamatsu Photonics,
Lough Point, Gladbeck Way,
Windmill Hill, Enfield, Middlesex EN2 JA
Tel: (0181) 367 3560

Macam Photometrics Ltd.,
10 Kelvin Square, Livingston EH54 5PF
Tel: (01506) 37391

Photonics Marketing Ltd.,
86 Gloucester Place, London W1H 3HN
(Agents for Hoya Corporation; filter glasses)
Tel: (0171) 935 5918

UQC (Optical) Ltd.,
99-101 Cambridge Road,
Milton, Cambridge CB4 6AT
(Stockist of Schott filter glasses)
Tel: (01223) 420329

Ealing Electro-Optical plc,
Greycaine Road, Watford WD2 4PW
(Suppliers of interference filters, etc.)
Tel: (01923) 242261

Further Reading

A Guide to Spectroradiometry
Available from:
Bentham Instruments Ltd.,
2 Boulton Road, Reading RG20 NT1
Tel: (01734) 751355

Guide for Spectroscopy
Available from:
Instruments SA (UK) Ltd.,
2-4 Wigton Gardens,
Stanmore, Middlesex H17 1BG
Tel: (0181) 204 8142

The Development of Instrumentation for UV Hazard Monitoring
Available from:
Able Instruments and Controls Ltd.,
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Noise! What is it, and Why?

PART TWO

by J. M. Woodgate B.Sc.(Eng.), C.Eng., M.I.E.E., M.A.E.S., F.Inst.S.C.E.

In Part 1, we discovered that electrical noise is caused by the random movement of current carriers, usually electrons, and the interesting properties of noise, including the spectrum (noise voltage or current in a narrow bandwidth as a function of the centre frequency of the band) and the probability distribution. The latter is a function which tells us how likely it is that the instantaneous value of the noise falls within a specified range. Thermal noise, due to the movement of atoms and electrons simply because they are warmer than absolute zero, has a Gaussian, or 'normal', probability distribution. Although this function looks complicated as a mathematical expression, many of its properties are quite simple. For example, the chance of the instantaneous value of a Gaussian noise signal being more than 3 times the rms value is less than 1 in 300. Noise which has a uniform spectrum on a linear frequency scale is called 'white noise'. 'Pink noise' has a uniform spectrum on a logarithmic frequency scale, and is used mostly in audio and electroacoustics.

Noise in Semiconductors

As opposed to many of the ancient sources from which I extract my material, it seems better nowadays to start with semiconductors and leave valves (tubes) till later. Why ancient sources? Why not the latest textbooks? Well, where do you think those authors get their material? Besides, going back to the time when theories were developing, gives much insight into good, and not so good, approaches to the subject, and the places where misunderstandings are likely to occur. Furthermore, I try to work from basic principles towards useful results, and basic physics doesn't change (in most of the areas affecting electronics) nearly as much as does the implementation of its results in the engineering of devices and products.

Noise in Ordinary Diodes

If a simple semiconductor diode is reverse biased, it passes a small leakage current. This small current, however, consists of a vast number of electrons. For example, 1μA corresponds to a flow of $1{\cdot}6 \times 10^{13}$ electrons per second *on average*. It is the random fluctuations in this number which form the *shot noise component* of the leakage current. The rms value of this current, I_N, is given by the Schottky formula:

$$I_N = \sqrt{2qI_{dc}B}$$

Where q is the charge on an electron, $1{\cdot}6 \times 10^{-19}$ coulombs, I_{dc} is the DC leakage current, and B is the bandwidth in which the noise is measured. Shot noise isn't named after an English version of Professor Schottky's name, but in fact, refers to a mechanical example of white noise, which is the sound of steel shot falling on an inclined hard surface. The electroacoustic instrument makers Brüel & Kjær used to make a noise source for microphone calibration using this technique. An extreme condition, in which the formula is not valid, is the case where the current is very low indeed, such as can occur in photomultiplier tubes and video camera tubes at very low light levels. Under these conditions, the arrival of individual electrons at the output can be observed, and instead of having a Gaussian distribution, the noise is in the form of individual, identical pulses.

The Schottky equation also applies to a forward-biased diode, provided that the forward current greatly exceeds the leakage current, I_0. At low values of forward current I, the exponential component and the leakage component are of similar magnitude:

$$I = I_0[\exp(qV_{dc}/kT) - 1]$$

where V_{dc} is the forward bias voltage, k is Boltzmann's constant, equal to $1{\cdot}38 \times 10^{-23}$ JK^{-1} (joules per kelvin) and T is the absolute temperature (i.e. the Celsius temperature plus 273). Each component of the current then contributes an independent shot noise current according to the Schottky equation. These add 'rms-wise' (the total current is the square root of the sum of the squares of the individual currents), to give:

$$I_N = \sqrt{2qBI_0[\exp(qV_{dc}/kT) + 1]}$$

In particular, when $V_{dc} = 0$,

$$I_N = 2\sqrt{qI_0B}$$

If we differentiate the general equation for diode current with respect to V_{dc}, and then set $V_{dc} = 0$, we find that:

$$I_0 = \frac{kTg_0}{q}$$

Where g_0 is the small-signal AC conductance of the diode with zero bias voltage. If the diode is biased well on, so that the forward current is much greater than the leakage current, the Schottky equation tells us that the mean square shot noise current is:

$$\bar{i}_N^{\,2} = 2qBI$$
$$= 2qBI_0\exp(qV_{dc}/kT)$$

However, if we use the Nyquist equation from Part 1, we find that the noise in a real conductance, g, equal to the small-signal conductance of the diode at that current (having, of course, a resistance equal to $1/g$) is:

$$\bar{i}_N^{\,2} = 4kTBg$$
$$= 4I_0qB(qV_{dc}/kT)$$

Which is twice as great. This is really true: the noise current in an ordinary semiconductor diode with fixed forward voltage bias (or the noise voltage across the diode with fixed forward current bias) is *half* the thermal noise value. There are other instances where resistances (not physical resistors) prove to be less noisy than the Nyquist equation would predict.

Zener and Avalanche Diodes

You may have noticed that the words 'ordinary diode' appear in the previous section. This is because other sorts of diode behave differently, or more precisely, they have extra noise-producing characteristics. To begin with, we have to recall that the term 'Zener diode' as commonly used, actually covers both true Zeners and what should be called avalanche diodes. True Zeners have breakdown voltages of less than 4·5V, and conduct in the reverse direction by the quantum-mechanical tunnelling of electrons through the potential barrier. This reverse current does not include any extra noise component. However, diodes with breakdown voltages above 6·7V break down because the leakage electrons move fast enough to knock further electrons out of their association with particular atoms, and thus induce them to join in the large-scale current flow. Since these electrons can themselves displace more electrons, the effect is called 'avalanche breakdown', and it is VERY noisy.

Continued on page 50.

MULTI-STROBE

This is a complete, self-contained mains powered strobe lamp project, which includes a custom designed metal housing. The housing includes reflector, perspex front window and a universal bracket mounting, allowing the unit to be mounted at any angle, and with all necessary holes pre-punched. The basic module includes the familiar type of variable-rate flasher timer, with controls mounted on the rear panel.

3 PROJECT RATING

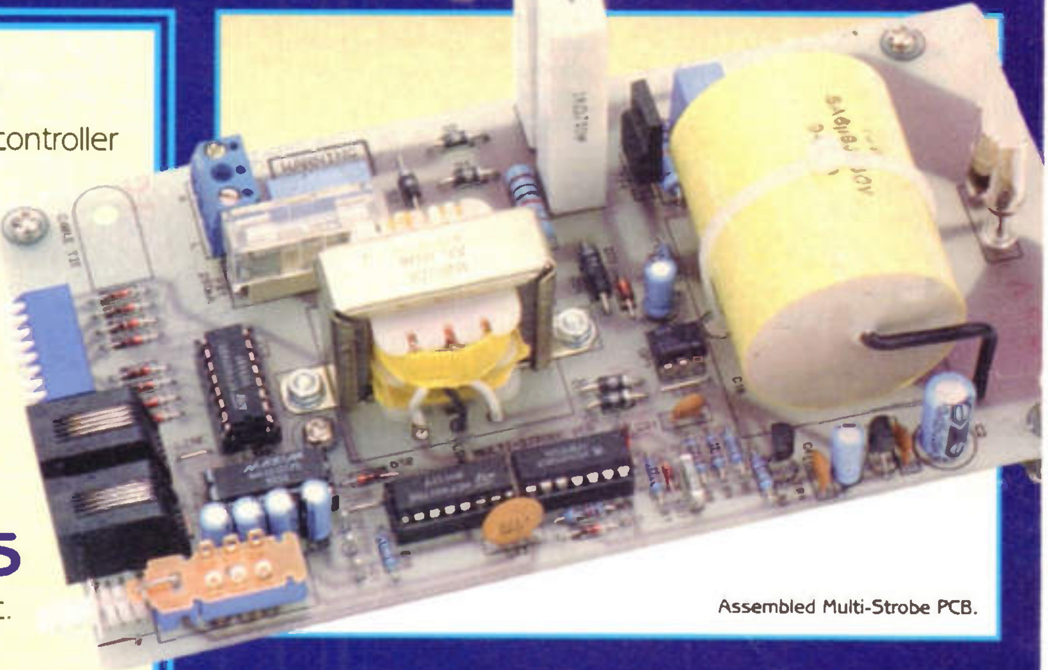
Part One

FEATURES

- ★ On-board variable speed controller
- ★ Bright light output
- ★ External control direct and via RS232 line
- ★ Strobes can be 'daisy-chained' together
- ★ Group control for selected strobes in a chain
- ★ Metal housing with pan and tilt fixing

APPLICATIONS

- ★ Entertainment, discos, etc.
- ★ Lighting/special effects
- ★ Photographic flash
- ★ Scientific and educational uses
- ★ Machine diagnostics, industrial applications



Assembled Multi-Strobe PCB.

Design by Alan Williamson

Text by Alan Williamson and Mike Holmes

IMPORTANT SAFETY NOTE:

Because the finished unit is housed in a metal case with integral mains supply, Class 1 construction techniques must be employed; the case and metalwork of the mains transformer must be earthed. Connection to the mains supply must be via a 3-core mains lead and conventional 3-pin plug.

Every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit. Safe construction of the unit is entirely dependent on the skill of the constructor.

For your safety, it is important that insulation is applied to all the exposed mains connections.

On no account must power be applied to the circuit with the lid removed from the box, as mains voltage is potentially lethal. The mains must, therefore, always be treated with the greatest respect.

Other precautions and steps necessary to comply with published safety standards must be employed to ensure safety of the user and servicing personnel.

If in any doubt as to the correct way to build or use this unit, seek advice from a suitably qualified engineer.

In addition the strobe can be remote controlled either by a simple active-low voltage input or ground switch (pins 3 & 4, SK1 & 2), such as from a totally independently powered timer, or from a more sophisticated type of controller such as a computer, via an RS232 compatible serial data input (this will be dealt with in Part 2). A second socket (convenient 4-way telephone style connectors are used) allows further strobes to be connected together in a 'daisy-chain'. The data is buffered from one strobe to the next, so in theory the total number connected is limitless, with no overloading of the serial data source.

The serial data input method takes the familiar form of a packet of eight data bits, and each strobe can be preset (with a DIL switch on the rear panel) to respond to any one data bit. Multiple strobe units can be organised into groups, that is, several strobes triggered by one data bit, the remainder being arranged in other bit dependent combinations. If a computer is used as the common controller, very sophisticated effects are possible where software can have precise control over each group.

Remote control is preferred in stage and discotheque lighting situations, where units may be mounted in inaccessible places.

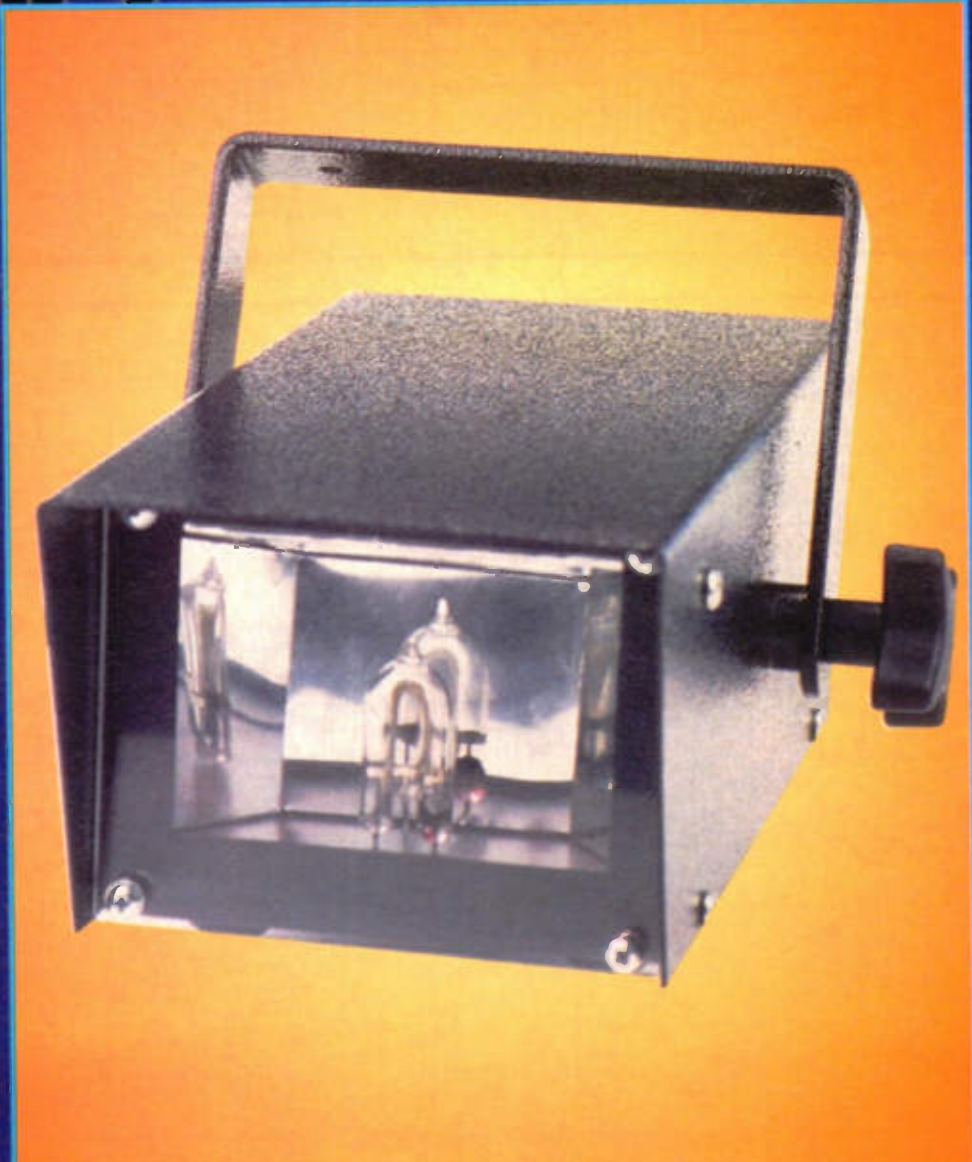
Specification

Main Unit

Mains supply:		220 to 240V AC
Maximum current at maximum flash rate:		85mA
Flash rate:		0·5Hz to 20Hz (20Hz max.)
Energy per flash:		0·4 Watts
Max. power consumption:		20 Watts
Connections: SK1	pin 1:	RS232 Clock input (±30V max)
	pin 2:	RS232 Data input (±30V max)
	pin 3:	Ground switch input TTL/CMOS
	pin 4:	Ground 0V
SK2	pin 1:	RS232 Clock output (±9V into 3k)
	pin 2:	RS232 Data output (±9V into 3k)
	pin 3:	Ground switch input TTL/CMOS
	pin 4:	Ground 0V

External Oscillator

Supply voltage:		+6·5V DC to 12V DC
Maximum current:		2mA at 12V DC
Oscillator frequency:		0·5Hz to 20Hz
Output sink current:		90mA
Maximum output switching voltage:		5V DC (with LD1 & R15 fitted) 30V DC (without LD1 & R15 fitted)
Connections: SK1	pin 1:	NC (unused)
	pin 2:	NC (unused)
	pin 3:	Output
	pin 4:	0V



Completed Multi-Strobe Unit

Circuit Description

The block diagram, Figure 1, illustrates the basic layout of the circuit, and the different ways in which it can be triggered. The group at top left, enclosed within the dashed line, comprises the remote battery powered controller, essentially a variable-speed trigger timer. It communicates to the main strobe unit via SK1, the RS232 serial link, as would any other remote triggering device which conforms to the RS232 standard.

The internal timer oscillator is built on a 'daughterboard' that comes attached to the main PCB, and needs to be snapped off (shown enclosed in dashed box at bottom right of Figure 1). When assembled it is mounted to the rear panel of the enclosure.

The complete circuit diagram is shown in Figure 2. The power supply for the strobe tube is derived *directly* from the mains supply and is, therefore, potentially lethal, see separate panel about mains safety precautions.

PSU and Output Stage

With reference to the circuit diagram, the electrically dangerous components (if you touch them while the mains is connected!) are confined to all those on the primary side of T1, including those associated with triac TI1. Optoisolator OP1 isolates this area from the input and driver stages (more on this later).

FS1 is the mains supply protection fuse. The function of the capacitor C1 is to reduce noise on the mains supply and it will

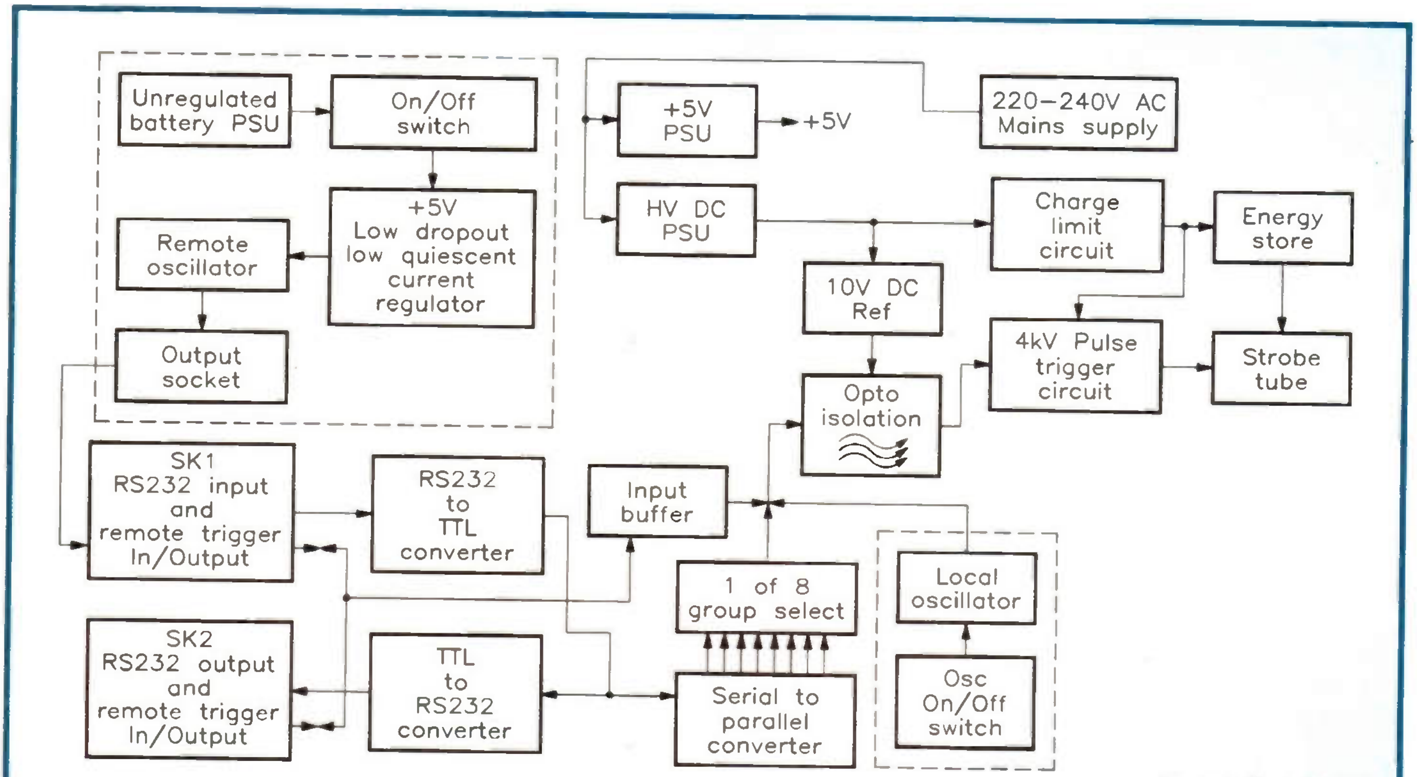
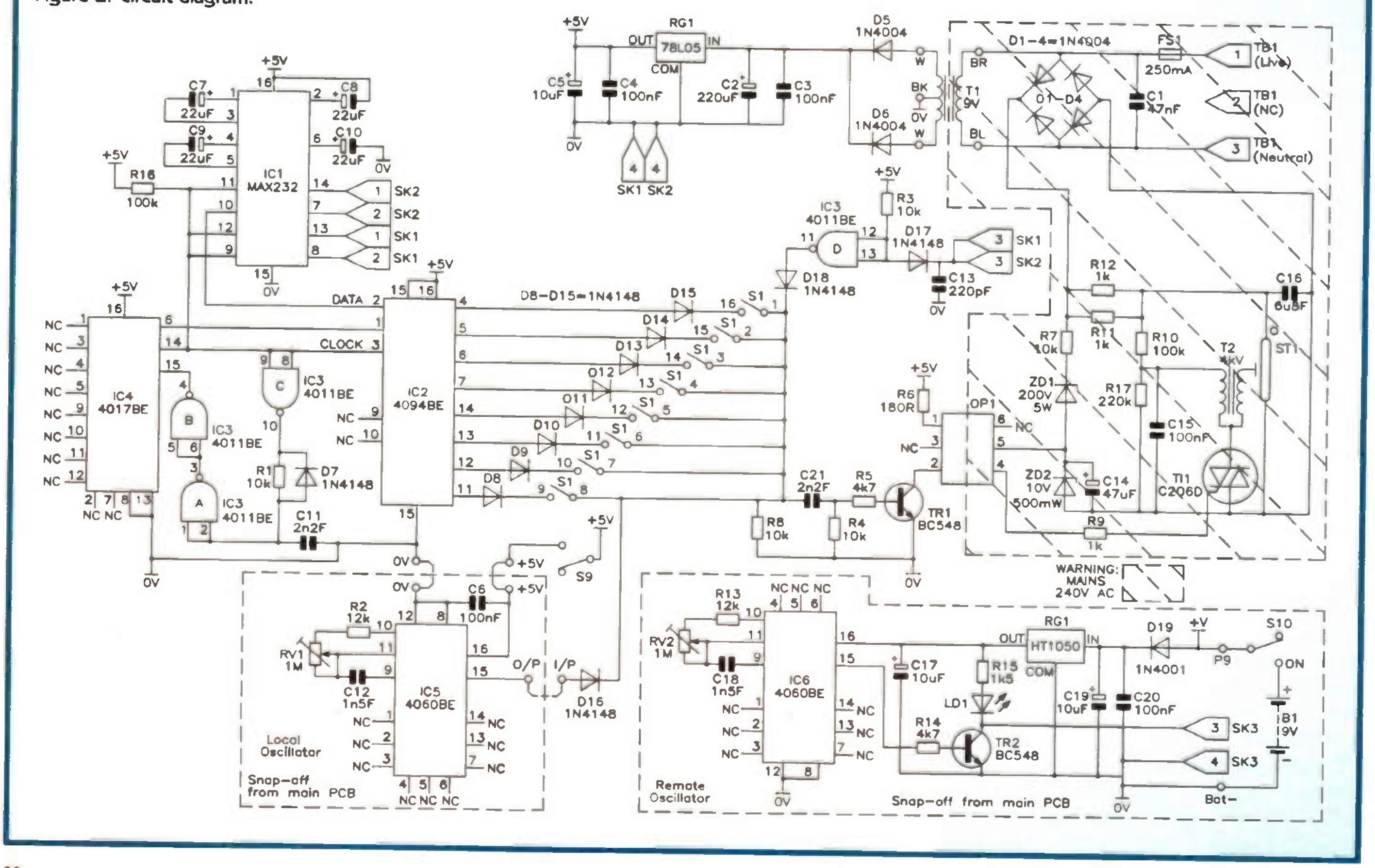


Figure 1. Block diagram.

Figure 2. Circuit diagram.



also reduce any noise spikes being fed back onto the mains supply from the short conduction pulse of the strobe tube.

A high DC voltage supply is required by the tube circuit. Diodes D1 to D4 full-wave rectify the mains to a very high potential (+320V DC peak); this voltage is stored on capacitor C16 via the resistors R11 & R12. This capacitor is the 'energy store' in Figure 1, and the charge is used up by the strobe tube when it is triggered, i.e. a capacitive discharge technique is utilised. R11 & R12 form the 'charge limit' part of Figure 1, preventing the entire supply being short-circuited through the tube.

A supply for the transistor side of the optoisolator device (OP1) is also derived from the 320V DC rail. Resistor R7 limits the current through the Zener diodes ZD1 & ZD2; without ZD1, R7 would have to be a high value, high power resistor. ZD2 prevents over-voltage of the optoisolator device and is also used as a reference.

R10 & R17 set a charge voltage of nominally 200V DC on the trigger capacitor C15. The value chosen for the resistor R10 not only limits the current through this chain but also sets maximum current flow through the triac TI1, which must fall *below* its minimum holding current after C15 has been discharged through T2.

Triggering Modes

The strobe can be triggered from three sources. These are the internal oscillator

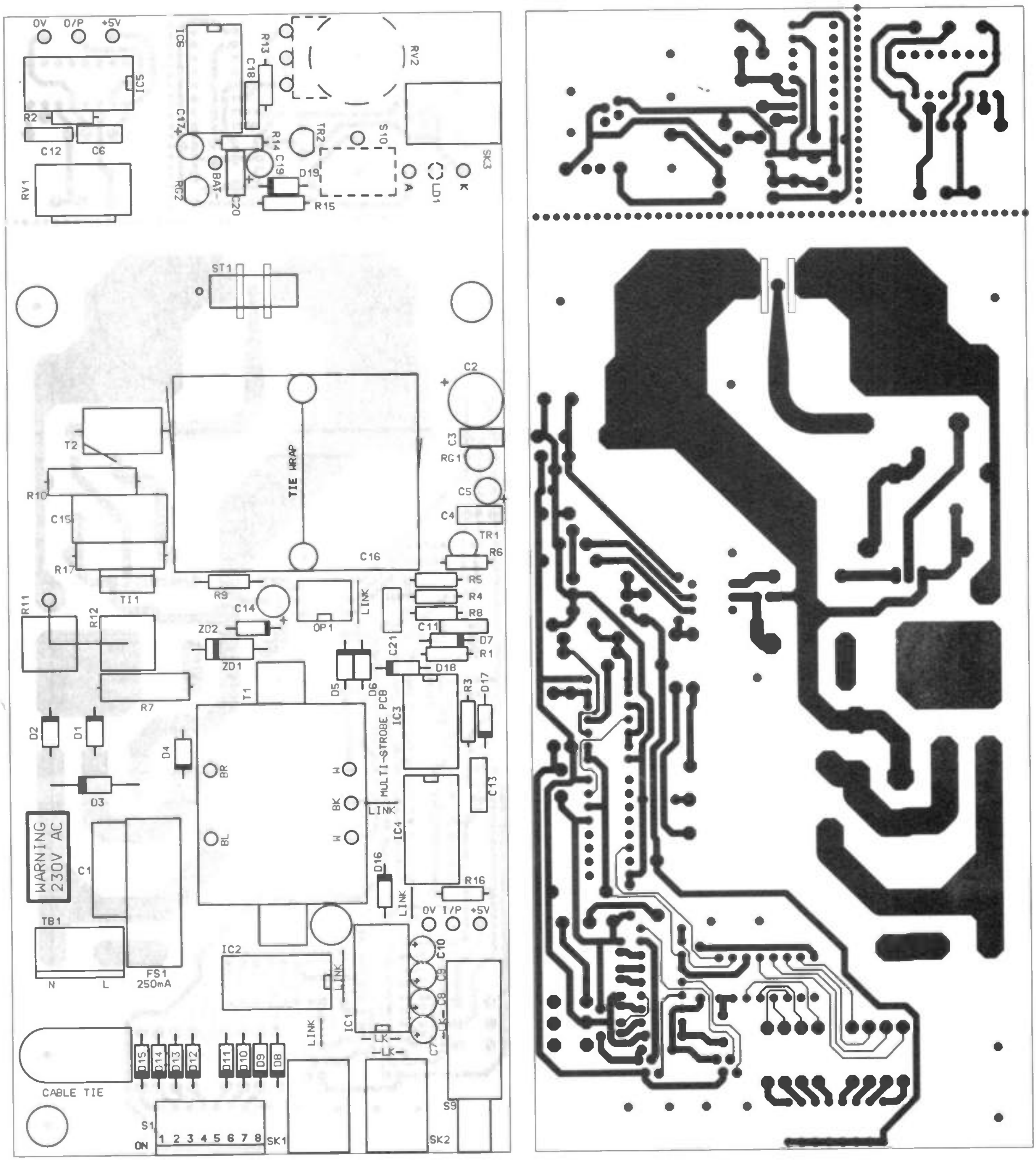


Figure 3. PCB legend and track.

on the daughterboard (IC5 and associated components), the active low external trigger input via IC3d, achieved by either connecting Pin 3 (input) to Pin 4 (0V) of SK1 or SK2, or from the external RS232 input, also via SK1.

Any of these methods will cause the common connection at the junction of R9 & C21 to go to a logic 1 state. This is communicated as a positive going pulse to the base of the transistor TR1 by C21 & R5. C21 & R4 behave as a simple monostable, while R9 discharges C21 as the input changes state, ready for the next pulse. As TR1 turns on, it will illuminate the LED within the optoisolator OP1; this will switch on the optocoupled transistor and feed current into the gate terminal of the triac TI1.

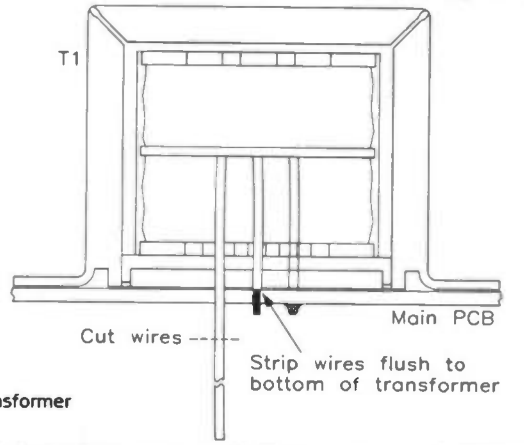
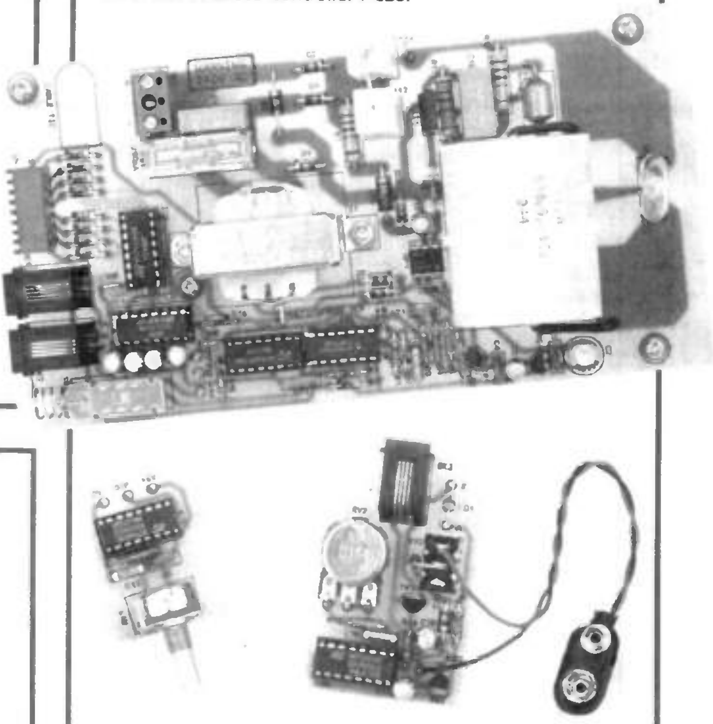


Figure 4. Mains transformer lead modifications.

The assembled Multi-Strobe main board, Internal Oscillator/Timer and Remote Controller PCBs.



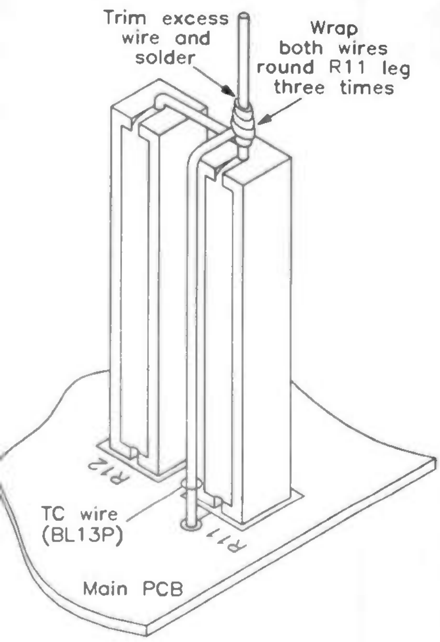


Figure 5. Fitting the 10W wirewound resistors R11 & R12.

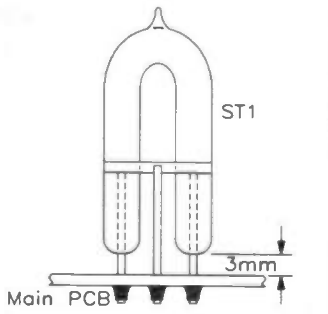


Figure 6. Fitting the strobe tube.

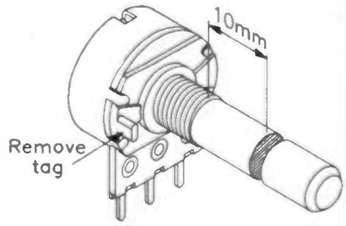


Figure 7. Modifying the 'speed' potentiometer for the timer PCB.

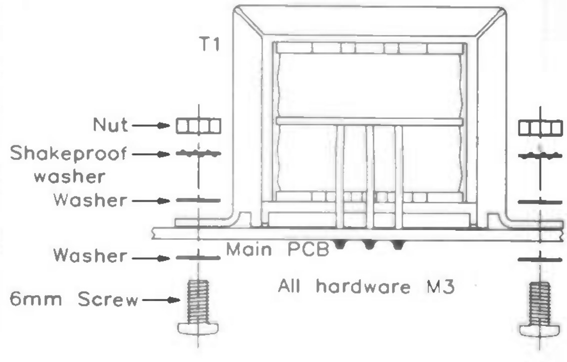
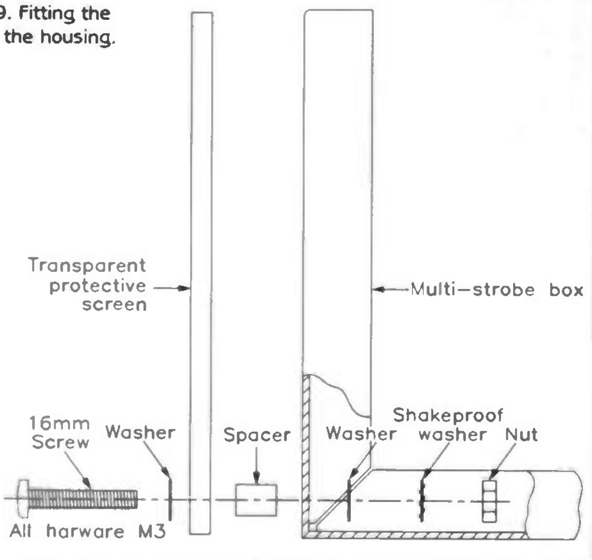


Figure 8. Mounting the mains transformer onto the PCB.

Figure 9. Fitting the filter to the housing.



The assembled Multi-Strobe PCB fitted in supplied case.

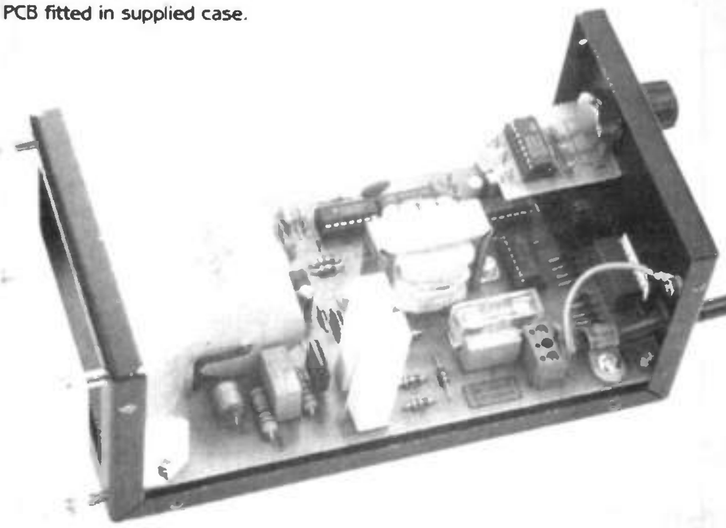
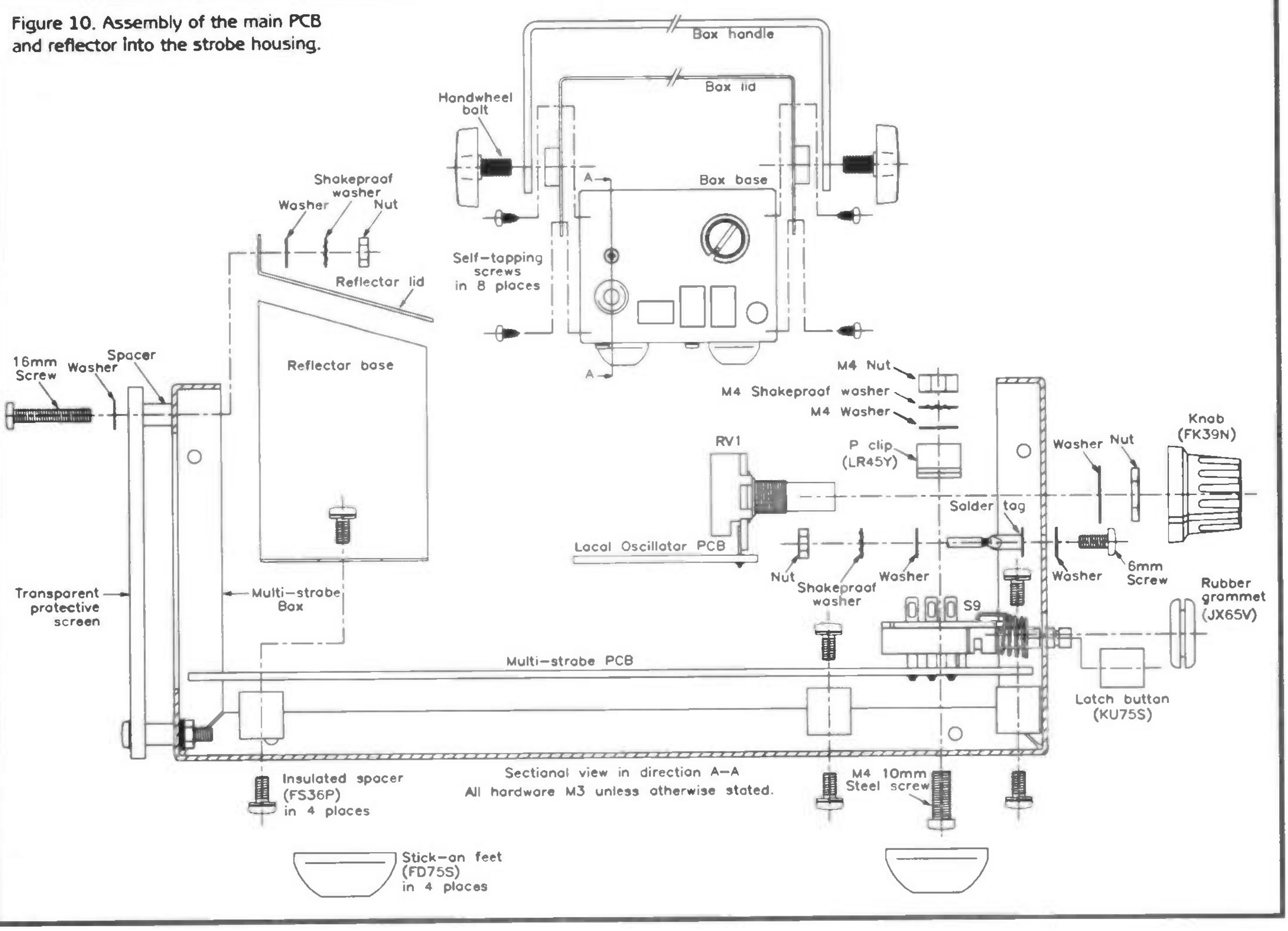


Figure 10. Assembly of the main PCB and reflector into the strobe housing.



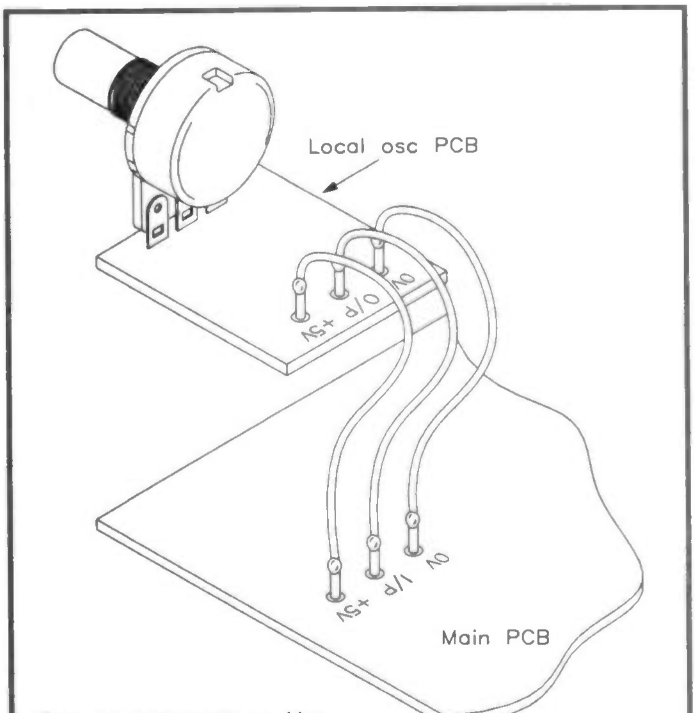


Figure 11. (a) low voltage wiring.

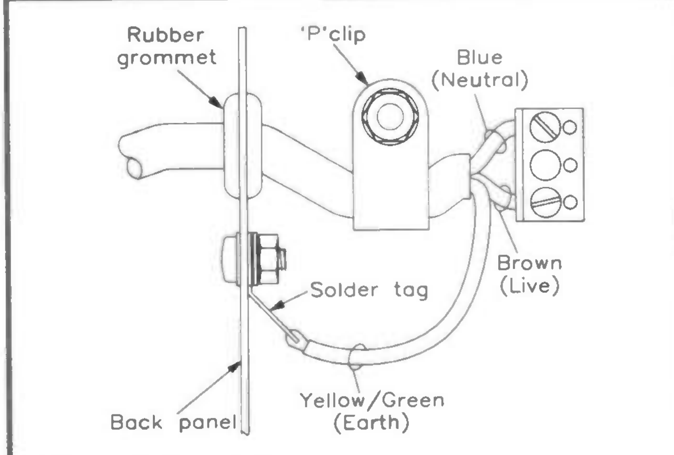


Figure 11. (b) Mains wiring.

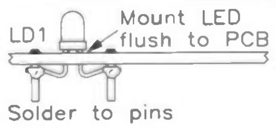


Figure 12. Remote Controller – LED fitting.

The triac will then conduct producing a pulse from C15. The trigger transformer will then step up the 200V pulse to 4kV, which then ionises the xenon gas within the strobe tube. The xenon will then become conductive, C16 will then discharge through the tube and rip electrons off the xenon molecules. A light photon is produced each time an electron returns to its stable state, the tube emitting a brilliant white light.

RS232 Control Channel

SK1 (as previously mentioned) is the RS232 input socket, with IC1 converting the RS232 clock and data signal levels (–10 to +10V) to TTL logic levels (0 to +5V). IC1 also acts as a line driver buffer by converting the TTL signals back to RS232 levels, which are available at SK2. This allows 'daisy-chaining' of the strobes, thus reducing the typical 'rat's nest' of connections to a single run of cable between the controller and strobes.

The TTL serial data output of IC1 is converted to parallel data by IC2, an 8-bit shift register, where the data is applied to pin 2 while the clock is applied to pin 3. The clock signal is received as a gated 8-bit frame, which is also applied to the network of IC3a, b, c and R1, C11 & D7 (a frame sync separator) and IC4, a decade counter.

The 7th clock pulse, applied to pin 14 of IC4, activates pin 6 which enables the 'strobe input' of IC2. The 8th clock pulse, when applied to the shift register, will transfer and latch the 8 data bits on the outputs of IC2.

The frame sync separator (R1, D7 & C11) 'strips out' the high frequency frame data bits by slowly charging C11 via R10 and quickly discharging via D7, therefore IC3 a & b are only allowed to change state *between* the clock frames. This resets IC4, in readiness for the next frame.

Internal Controller Timer

IC5 is the local ('internal') oscillator formed from a 4060, a combined CMOS 14-stage divider and oscillator. The frequency of this is determined by C12, R2 & RV1. The final output frequency is taken from the 10th division stage (divided by 1024). This is a preferred method for generating low-frequency oscillations accurately, as a higher frequency oscillator is more stable. S2, which will be located on the rear panel along with 'speed' control RV1, can be switched out to defeat the internal oscillator and allow remote control triggering.

Remote Controller Timer

IC6 is also a 4060 forming the *optional* remote-control timer oscillator. The components required to build this will have to be bought separately if this item is required; they are not included in the kit. They include R13-15, RV2, C17-19, C20, D19, LD1, TR2, IC6, RG2, SK3 and switch S10. See Optional Parts List. A suitable box and battery are also required. Also the PCB is an integral part of the main PCB and will have to be 'snapped' off whether it is used or not.

With IC6 serving the same function as IC5, transistor TR2 is used as a current buffer at the output of the oscillator. In use, output pins 3 & 4 (of SK3) connect to pins 3 & 4 of the strobe socket SK1 or SK2. The second socket enables 'daisy-chaining', allowing up to 200 strobes to be controlled at the same time.

LED LD1 is used as the oscillator visual 'speed' indicator. RG2 is a special 5V regulator with a low quiescent current of 3·5μA and a low dropout of 100mV, ideal for battery powered applications. A standard 78xx type regulator would draw more quiescent current than the load circuit it is powering!

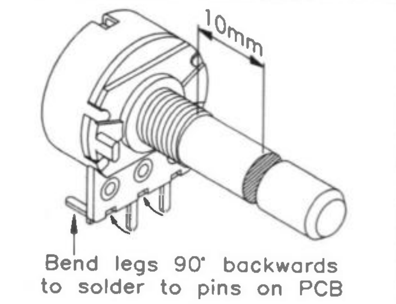


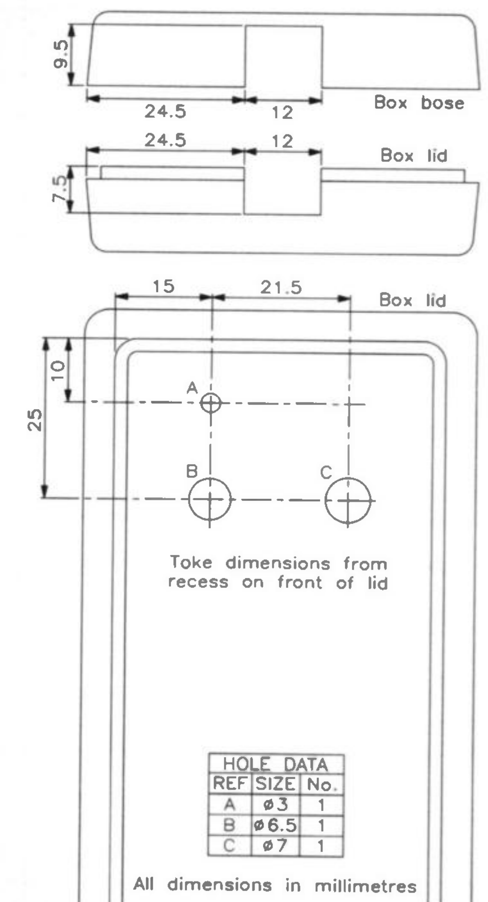
Figure 13. Remote Controller – potentiometer modification.

Construction

Construction is fairly straightforward and applies to all PCBs, refer to the PCB legend Figure 3, and the Parts List. The best way of working is to begin with the smallest components first, working up in size to the largest. Insert and solder all the PCB pins from the track side. Be careful to correctly orientate polarised devices, i.e. electrolytic capacitors, diodes, transistors, regulators, ICs, the optoisolator device and strobe tube. For electrolytics, always insert the lead *opposite* to that identified by a stripe and (–) legend on the body of the capacitor into the PCB hole marked (+). For diodes, identify a band around one end of the body, which indicates the cathode, and align it to the white marker on the PCB diode legend.

For transistors, simply align the shape of the plastic body to the shape on the legend and insert all three leads through the PCB. Be careful when soldering, as semiconductors can be damaged by heat. If unsure, allow short cooling periods between soldering operations. ICs are rarely soldered directly and, in this case, DIL sockets are used which are fitted to the PCB first. The ICs should be inserted into their sockets last of all. Even modern CMOS types are at some risk from static damage.

Some components need special attention. NOTE, for example, that a socket for



HOLE DATA		
REF	SIZE	No.
A	ø3	1
B	ø6.5	1
C	ø7	1

Figure 14. Remote Controller – box drilling details.

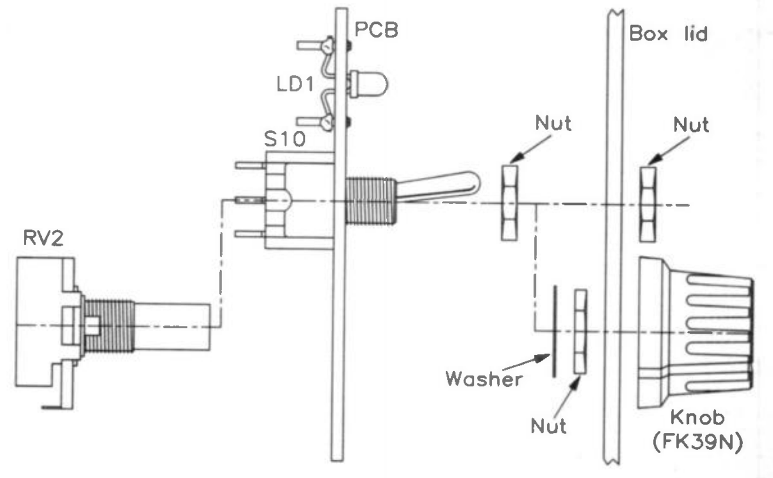


Figure 15. Remote Controller – mechanical assembly of PCB, RV2 and switch S10.

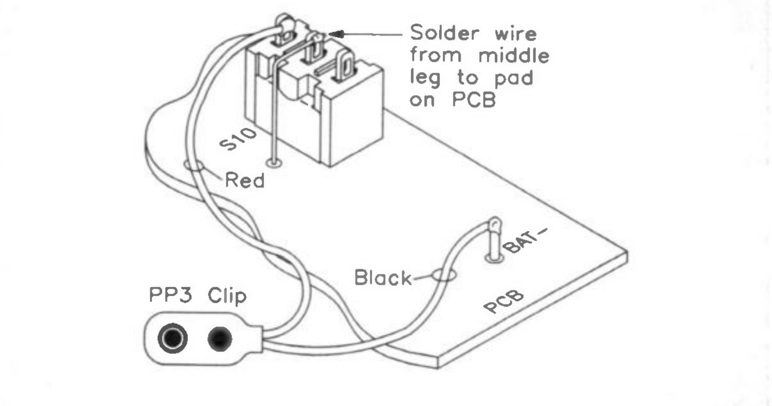


Figure 16. Remote Controller – wiring the battery to the PCB and switch S10.

the optoisolator has not been supplied *intentionally*, and therefore should *NOT* be fitted into a socket. It must be soldered directly with the usual precautions pertaining to semiconductors.

The following Figures refer to modifications of special components prior to fitting: Figure 4 shows how to prepare the mains transformer leads (T1) by cutting them short to fit into the PCB holes, with the insulation stripped from the ends.

Figure 5 shows the fitting of the 10W resistors after both R11 & R12 have been installed and soldered onto the PCB, cut the top lead of R11 back to approximately 5mm. Next, wrap the top lead of R12 three times around that of R11, trim and solder. Fit a length of tinned copper wire between the PCB hole beside R11, and the top of R11, wrap three times, trim and solder.

Figure 6 shows the correct height of the strobe tube above the PCB. Note also that C16 is retained on the PCB by a self-adhesive pad *and* a plastic tie-wrap, and that its leads are offset to reach the PCB holes.

When fitting the PCB mounted screw terminal blocks and telephone sockets (TB1, SK1 & SK2), ensure that they are pressed flush onto the PCB.

On the internal timer PCB, cut the spindle of RV1 back to a length of 9mm (measured from the end of the threaded boss), and remove the locating tag on the body (see Figure 7). The mains transformer, T1, is fitted onto the main PCB as shown in Figure 8.

Now thoroughly check for misplaced components, solder whiskers bridges and dry joints. Finally, clean all the flux from the PCB track side using a suitable solvent.

Final Assembly

Fit the module into the enclosure, Figures 9 & 10 show the procedure. Figure 9 shows how to fit the reflector to the PCB and the front filter ('glass') assembly to the case,

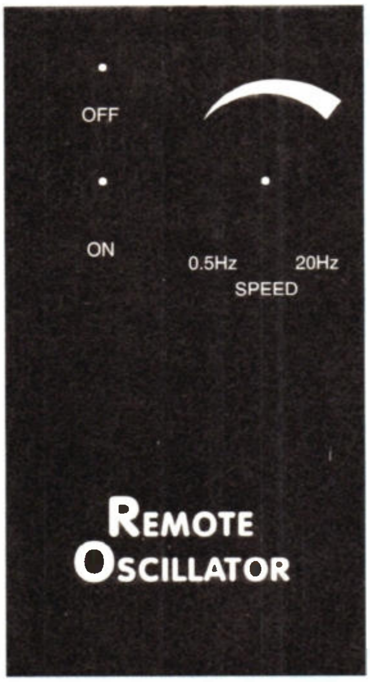


Figure 17. The Multi-Strobe Remote Oscillator label.

and then the PCB and reflector (Figure 10).

Figures 11a & 11b are the low-voltage and mains side wiring diagrams respectively. In Figure 11b, make sure to fit the green/yellow earth wire to the rear panel using the screw, tag-washer, shake-proof washers and nut as shown. Do not omit the grommet, and secure the mains cable to the PCB using the 'P' clip.

Figure 11a shows how the internal timer 'daughterboard' is wired to the main PCB, if used. Connect the PCB pins '+5V' to '+5V', 'O/P' to 'I/P' and '0V' to '0V'. The timer PCB is secured to the rear panel by the nut and washer of the on-board potentiometer RV1.

Before finally fitting the lid to the enclosure, *double-check EVERYTHING!*

Testing

To test the unit, fit a 13A plug (with a 2A fuse) to the mains lead. Turn the potentiometer on the rear panel to minimum (fully anticlockwise), and check that *all* the 'piano' style DIP switch levers are in the 'OFF' position (if fitted).

Connect the mains plug to a 13A outlet socket and switch on the supply. Push the switch on the rear panel to the 'ON' position, and the strobe should flash approximately once every 2 seconds. Turn the 'speed' control clockwise, and the flash rate will increase. With the control at maximum travel, the flash rate will be approximately 20Hz (20 flashes per second). Note, however, that prolonged operation at high speed could shorten the life of the tube.

The Remote Controller

Basic assembly of the Remote Timer Controller PCB is much the same as already described, except for the special considerations illustrated in Figures 12 to 16. The RED power-on indicator LED should be mounted at the correct height as shown in Figure 12, note that the leads are connected to the adjacent PCB pins.

Figure 13 shows how the leads of the 'speed' potentiometer (RV2) are modified prior to mounting onto the PCB. Figure 14 gives box drilling details for the suggested plastic case, and Figure 15 shows overall mechanical assembly including the position of toggle switch SW10. The battery clip leads are wired to the PCB and SW10 (Figure 16). Figure 17 shows the Remote Oscillator Label.

Continued on page 49.

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CRYSTAL PALACE & DISTRICT RADIO CLUB. Meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, G3DSC, Tel: (0181) 6995732 or Bob Burns G3OOU Tel: (01737) 552170.

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY. For details of meetings, Tel: (0181) 902 3390 or write to 87 Oakington Manor Drive, Wembley, Middlesex HA9 6LX.

THE LINCOLN SHORT WAVE CLUB meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. For further details contact Pam, (G4STO) (Secretary) Tel: (01427) 788356.

MODEL RAILWAY ENTHUSIAST? How about joining 'MERG', the Model Electronic Railway Group. For more details contact: Paul King, Honorary Secretary, 25 Fir Tree Way, Hassocks, West Sussex BN6 8BU.

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SEEMUG (South East Essex Mac User Group), meet in Southend, every second Monday of each month. For details Tel: Michael Foy (01702) 468062, or e-mail to mac@mikefoy.demon.co.uk.

SOUTHEND & DISTRICT RADIO SOCIETY meets at the Druid Venture Scout Centre, Southend, Essex every Thursday at 8pm. For further details, contact: P.O. Box 88, Rayleigh, Essex SS6 8NZ.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent. TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information. Contact: Eric W. Wiltsher, TESUG, Rio House, Stafford Close, Ashford, Kent TN23 2TT. England.

WIRRAL AMATEUR RADIO SOCIETY meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the the 1st and 3rd Wednesday of every month. Details: A. Seed (G3FOO), 31 Withert Avenue, Bebington, Wirral L63 5NE.

WIRRAL AND DISTRICT AMATEUR RADIO SOCIETY meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson, (G0JZP) on (0151) 648 5892.

WINCHESTER AMATEUR RADIO CLUB meets on the third Friday of each month. For full programme contact: G4AXO Tel: (01962) 860807.

AARS (Aberdeen Amateur Radio Society) meets on Friday evenings in the RC Hall 70 Cairngorm Crescent, Kincorth. For further details contact Martin GM0JCN Tel:(01569) 731177.

THE (WIGAN) DOUGLAS VALLEY AMATEUR RADIO SOCIETY still meets on the first and third Thursdays in the month from 8.00pm. The Hesketh Arms, Shevingtom Moor, Shevington, Wigan. For further details contact D. Snape, G4GWG, QTHR, Tel: (01942) 211397 for further details.

These descriptions are necessarily short. Please ensure that you know exactly what the kit is and what it comprises before ordering, by checking the appropriate issue of *Electronics* referred to in the list.
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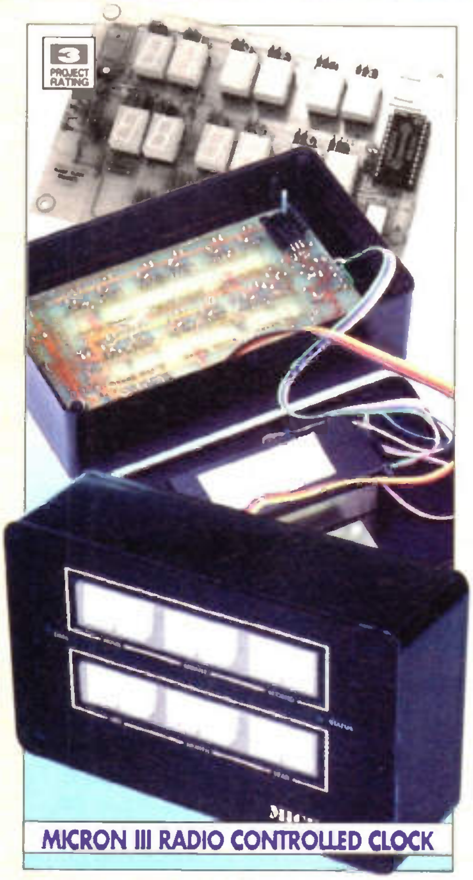
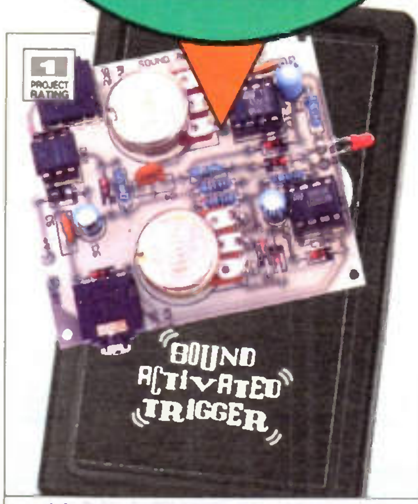


MICRON III RADIO CONTROLLED CLOCK

The right time all the time! Used in conjunction with the Rugby Clock Receiver (LP70M), this radio-controlled timepiece receives ultra-precise date and time data from the MSF transmitter in Rugby which it shows on a bank of 12 seven-segment displays. Other features include automatic Leap Year and British Summertime correction.
Order as: LT03D (Micron III), **£47.99** B1. Details in *Electronics* No. 88, April 1995 (XA88V); LP70M (Rugby Clock Receiver), **£22.99**. Details in *Electronics* No. 47, November 1991 (XA47B).

FOX WIRELESS ALARM UPGRADE

Upgrade your Fox Wireless Burglar Alarm to use the Maplin XP03D, fully tamper-proof, External Bell Box with battery back-up. The kit contains all the necessary connectors, and details of the simple wiring modifications. Please note that the Maplin 'Get-You-Working' Service is not available for this project.
Order as: LU09K, **£1.49**. Details in *Electronics* No. 89, May 1995 (XA89W). XP03D Assembled Polycarbonate Bell Box (not included), **£42.99** C5.



SOUND ACTIVATED FLASH TRIGGER

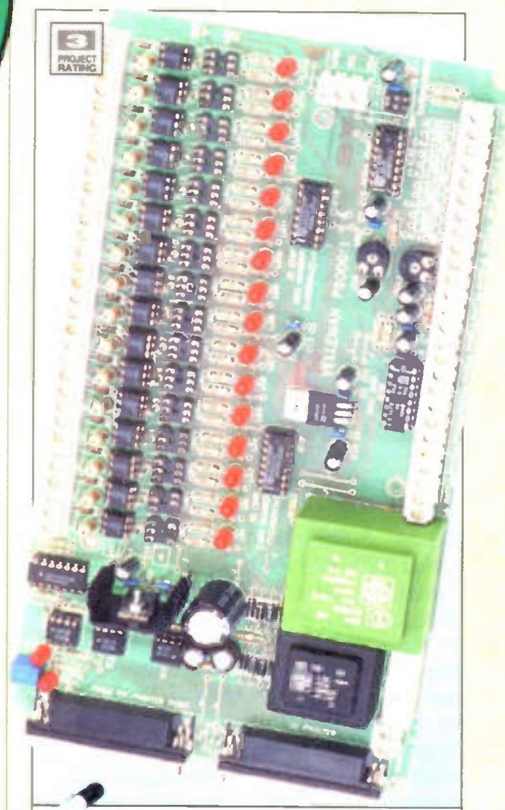
Produce exciting pictures of darts bursting balloons, bullets passing through light bulbs etc., with this inexpensive flash trigger. The sound of mum's best bone china hitting the floor triggers the unit which operates your flash-gun in time to photograph the bits whilst still in mid-air.
Order as: LT86T, **£14.99**. Details in *Electronics* No. 88, April 1995 (XA88V).

SUPER SCAN HF/VHF ACTIVE AERIAL

Improve your scanner's reception with this active, broadband aerial. The aerial supplied with most scanners is perfectly adequate for local reception, but a significant improvement can be made in the reception of long distance (DX) and weaker stations by using a fixed, active aerial like the Super Scan. (Plastic aerial housing and PSU box not included in kit.)
Order as: LT27E, **£29.99**. Details in *Electronics* No. 89, May 1995 (XA89W)

VOICE VANDAL

Create your own distortion effects and 'alien' voices with this entertaining audio project. Both music and voices can be 'vandalised' by pitch changing, clipping and echo effects. Ideal for plays, amateur dramatics or just for fun. Dad's Max Bygraves collection will never sound the same again! (Case not included in kit.)
Order as: LT82D, **£29.99**. Details in *Electronics* No. 89, May 1995 (XA89W).



COMPUTER INTERFACE BOARD

Unleash your computer's power by allowing it to communicate with the outside world. This fully optoisolated interface is suitable for IBM compatibles and simply connects to the printer port, while still allowing the printer to be used. Features include: sixteen inputs/outputs; eight 6-bit analogue outputs; one 8-bit precision analogue output and four 8-bit analogue inputs.
Order as: VF54J, **£84.99**. Details in *Electronics* No. 88, April 1995 (XA88V).

RS232 SERIAL LINE TESTER

Troubleshoot RS232 equipment quickly and conveniently with this battery powered, hand-held tester. The tester produces a short RS232 message and is ideal for checking terminals, printers, and other serial equipment, as well as their interconnecting data cables.
Order as: LT83E, **£32.99** A1. Details in *Electronics* No. 89, May 1995 (XA89W).

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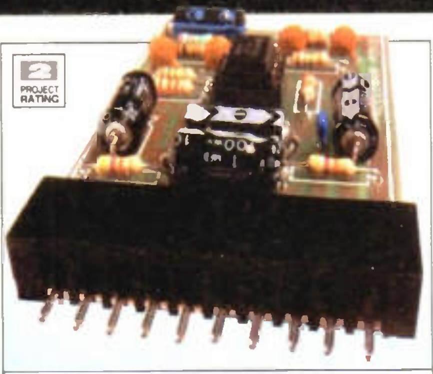
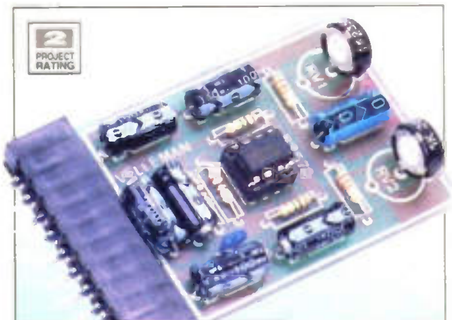


STEREO RIAA CORRECTION PREAMP

Many modern power amplifiers no longer have RIAA corrected inputs suitable for moving-magnet or moving-coil cartridges. If you, like many others, have a substantial vinyl record collection, but want to update your amp, then this project is a must.
Order as: 90014, **£7.99**. Details in *Electronics* No. 90, June 1995 (XA90X).

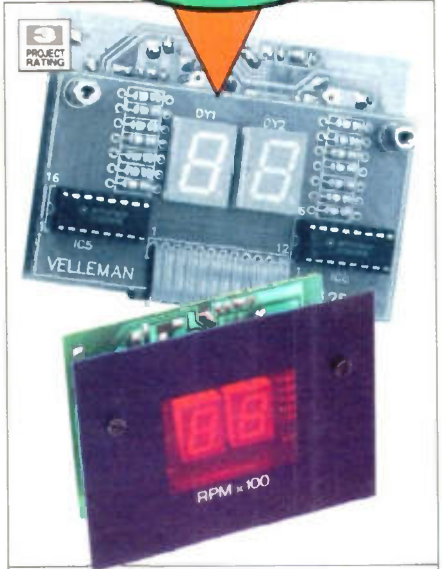
INTERACTIVE DOORBELL

Ring the changes with this novel doorbell project! Up to 16 seconds of sounds or speech can be recorded, for playback when the door bell is pressed. Greet your friends with a warm welcome, or your mother-in-law with a suitable insult! (Case not included in kit.)
Order as: 90023, **£39.99**. A1. Details in *Electronics* No. 91, July 1995 (XA91Y).



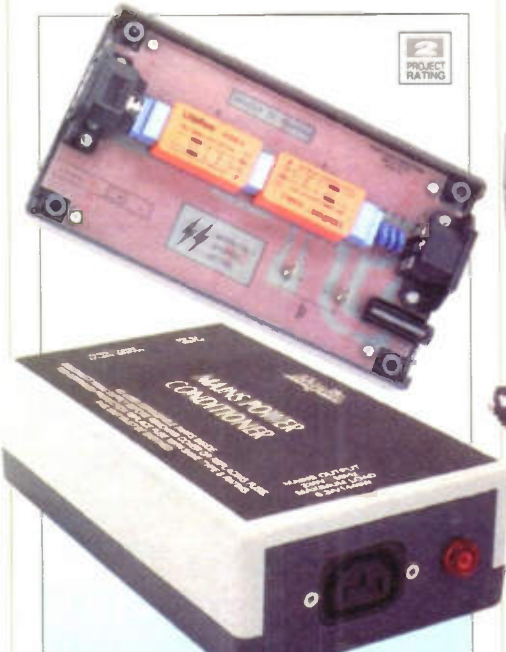
UNIVERSAL STEREO PREAMPLIFIER

This inexpensive stereo preamplifier is suitable for all sorts of applications where input signals are too small or too large for direct connection to a power amplifier. The unit requires a power supply of between 10 to 30V DC and is compatible with other featured modules enabling you to build a complete stereo preamplifier system.
Order as: 90022, **£7.99**. Details in *Electronics* No. 91, July 1995 (XA91Y).



DIGITAL TACHOMETER

This digital 'rev-counter' is a very practical 'bolt-on-goody' for older or base specification, negative earth cars. The Digital Tachometer can allow you to set up idling speeds accurately, and drive your car at its optimum engine speeds for maximum acceleration, power or economy.
Order as: 90013, **£25.99**. Details in *Electronics* No. 90, June 1995 (XA90X).

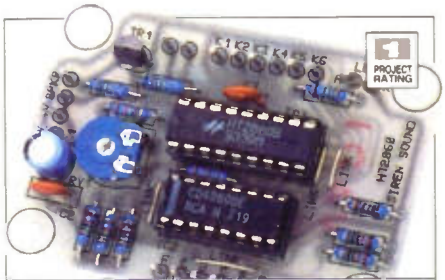


MAINS POWER CONDITIONER

No, it won't make piles of towels all soft and fluffy, but it will help to remove spikes, transients and noise from the mains supply, which could otherwise upset sensitive equipment like computers, TVs, Hi-Fis, test gear and communications equipment.
Order as: 90019, **£32.99** A1. Details in *Electronics* No. 91, July 1995 (XA91Y).

ULTRASONIC DETECTOR

Bats in the belfry? Noisy mechanical bearings? Not sure if your dog-whistle works? This novel project converts ultrasonic sounds into audible sounds enabling them to be heard by the human ear. Other applications include testing of ultrasonic remote control units and ultrasonic alarm detectors.
Order as: 90008, **£39.99** A1. Details in *Electronics* No. 90, June 1995 (XA90X).

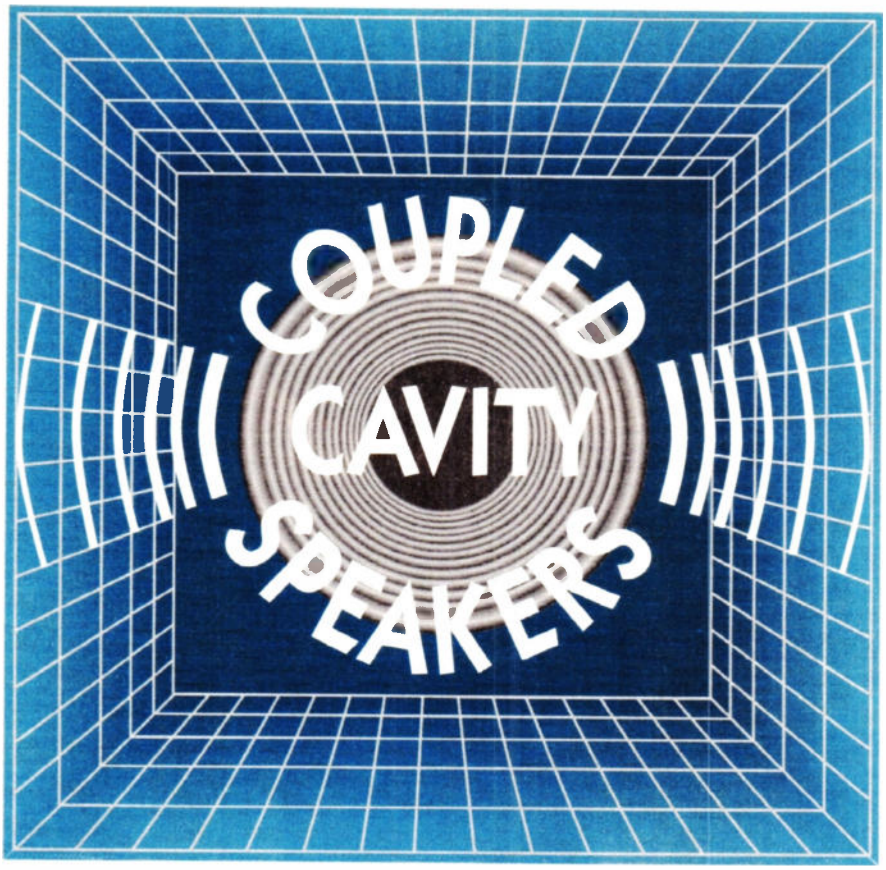


SIREN SOUND GENERATOR

Generate up to six different siren sounds for models, toys, plays, alarms, etc., with this easy-to-build project. Features include variable sound pitch, cascade mode, auto power-off, and outputs for an LED and a speaker or piezo sounder. Please note that the Maplin 'Get-You-Working' Service is not available for this project.
Order as: 90011, **£6.99**. Details in *Electronics* No. 90, June 1995 (XA90X).

CMOS ELECTRONIC CW KEYER

If Morse Code is driving you dotty, make a dash for this project! Designed for use with a paddle key, the unit produces a continuous stream of dots or dashes, depending on whether the key is pushed to the left or to the right, saving all that frantic hammering on a conventional key. (Case not included in kit.)
Order as: 90018, **£26.95**. Details in *Electronics* No. 91, July 1995 (XA91Y).



PART 3: BASS UNIT CONSTRUCTION

by David Purton

In the last two articles, we looked at the theory and benefits of this form of bass loading. In the second article, details of cabinet volumes and port lengths were provided for three designs based around the 10in. XG46A Maplin driver. I have chosen to build Design 'B', as it suits my system best(!), and would be appropriate for most 8 to 15 litre sealed box satellite speakers, with sensitivities of between 86 and 88dB/W, referred to 8Ω.

THERE are two routes available to you. If you are not a competent DIYer, I would recommend the services of a cabinetmaker. Although relatively simple (being a box with a partition, and a number of holes), some experience of working accurately with power tools is required. If, however, you are keen to build them yourself, then it's off to the DIY store you go. I have found the sheet-cutting service available at some stores to be far more accurate than that achieved by local woodyards with their ripsaws.

You will require the following tools:

- A jigsaw, with plenty of spare blades
- An orbital sander
- Preferably, a router with a radius profile.

The materials you will require are as follows:

- 12 pieces of 12mm MDF, 350 × 300mm
- 8 pieces of 12mm MDF, 579 × 350mm
- 8 pieces of 12mm MDF, 579 × 348mm
- 2·5 litres of impact adhesive (e.g., Dunlop 'Thixofix')
- 1 litre of PVA adhesive
- 1 roll of car sound-damping felt
- Ports cut from rainwater pipe.
- 1 roll of foam draught excluder
- Cabinet feet, or anti-acoustic mountings
- Paint, or chosen finish. (Maplin supply rolls of vynide covering cloth). A twin-pack auto finish, e.g., 'K-Lack' (available at all good motor factors, etc.), can be attractive, giving a good gloss 'straight from the can'.
- Primer, to suit the paint chosen.

This should come to around £75, without drivers or finish. The drivers are about £80 a pair, and it could cost up to another £40 for finish, and extra bits!

Note. A small design improvement.

If you refer to the tables of cabinet sizes and port lengths, in Part 2, you will find that lengths have been quoted for 75mm diameter ports. It is possible to use a larger diameter, L2. A larger port is less likely to 'chuff'! The following changes to the design need to be made.

Based on 100mm (4in.) pipe;

- Design 'A' changes to 123mm length
- Design 'B' changes to 122mm length
- Design 'C' changes to 157mm length

SAFETY WARNING:

(Please read the following carefully!) Medium Density Fine (MDF) is a remarkable material, in that you can machine and sand it to a very high finish. However, it is also an extremely DANGEROUS material. Under no circumstances, sand or machine in confined spaces; try to work in the open air, if possible, and ALWAYS WEAR A DUST MASK. MDF, comprising partially of compressed glue, is carcinogenic. Always follow the manufacturer's safety warnings when dealing with paints and adhesives, which may contain toxic substances, hazardous to health.

Building Your Bass Units

The performance of these units fully warrants time and care taken in construction. Mine took about a fortnight of evenings and weekends. I chose a 'lacquer black' finish though, and made a rod for my own back!

Start by matching pairs of the cut MDF. Following the instructions on the impact adhesive, bond each pair of 12mm MDF sheets together, resulting in 24mm panels. Allow them to dry and harden overnight, preferably under pressure, or held together with stretched tape, to ensure they bond over their full surface area.

Referring to the 'cut-through' diagram of Figure 1, you will see how the unit is built up. Cut all the holes before assembly. With the 'half round' router, shape the mouth of the exit port to reduce turbulence. The neatest method is to mount the exit port from the back, so externally one can only see machined MDF. I would recommend installing the driver and internal port into their internal baffle, before mounting into the cabinet.

Construct the cabinet first. With 24mm panels, I have found butt joints to be quite sufficient. Liberally apply PVA adhesive to all the required edges, and bind the cabinet together with broad masking tape or carpet tape. Stretched tape applies considerable force, and will ensure good glue joints. Please ensure that all the edges are flush, and as square as possible. Leave to harden, preferably overnight.

NB. You do not secure the back panel at this stage!

Apply adhesive to the edges of the baffle, and install, as per the Figure 1. If the panel cutters have done their job, this should be an exact fit. If it is loose, you will have to batten it with triangular section timber (triangular takes up less volume than square). Wedge something of the correct thickness under the magnet assembly, to ensure the panel stays vertical whilst the glue is setting – you know the kind of thing, a stack of books or a block of wood, etc.

If you have not already installed your exit port, now is the time! Depending on whether you have rebated the port in from the back (best) or just butt-mounted it (second best), ensure that its total length is correct. You should now be looking into a backless box, with the baffle, driver and two ports installed. Line the whole of the area of the two cavities with your car damping felt, internal baffle excluded, and leave a space for the battening to be glued to the inside of the box, onto which you will secure the back panel, (to achieve specified response, no additional wadding was required).

I like the cannon connector, as it requires one 19mm hole, and provides a good seal. Place it anywhere you choose on the back panel, but make sure it serves the drive unit's connector side! Solder good quality cable to the driver, sufficient in length to protrude through the hole for the connector. Measuring the back panel accurately, drill a ring of holes to centre on the internal battening. I would suggest five fixings for the long side and three for the short. Make your first ones near the corners, as we do not want them resonating!

Secure the back panel, making sure your cables stick through the hole, as you will not be able to fish about for them afterwards. It may be an idea at this stage to solder the cannon in place, to prevent the cables slipping back into the cabinet. Your cabinet is now structurally complete, but quite substantial in weight. Do take great care when handling, so you do not damage your back, or the cabinet.

Damage to cabinets with corners happens quite often! A styling point is to profile all the edges with the router to provide a soft-edged look, and reduce the risk of damage. With the orbital sander, and remembering the health warning, sand the whole cabinet until smooth to the touch, finishing the rounded edges with a fine sandpaper. Obviously, if you have chosen a veneer finish, rounded edges will not be appropriate.

Your cabinets are now ready for their finish, and an ideal method is to spray them. If you have a car body shop close by, it may even be cheaper, and a lot less messy, to get them to spray them for you.

Ensure that they are well primed though, as paint sinks into MDF. As ever, the preparation work is reflected in the final finish, so please ensure they have a good thick coat – lots of thin ones built up of primer, well cut back, before the final colour coats are put on. BEWARE . . . driver inside! Make sure the exit port is well covered up before painting, as drivers do not like cellulose on their cones. When you are sufficiently happy with your finish, insert the cannon, secure, and fit feet (e.g., FW19V, BK25C) or conical anti-acoustic mountings, e.g., Maplin CJ80B, CJ81C, or CJ82D.

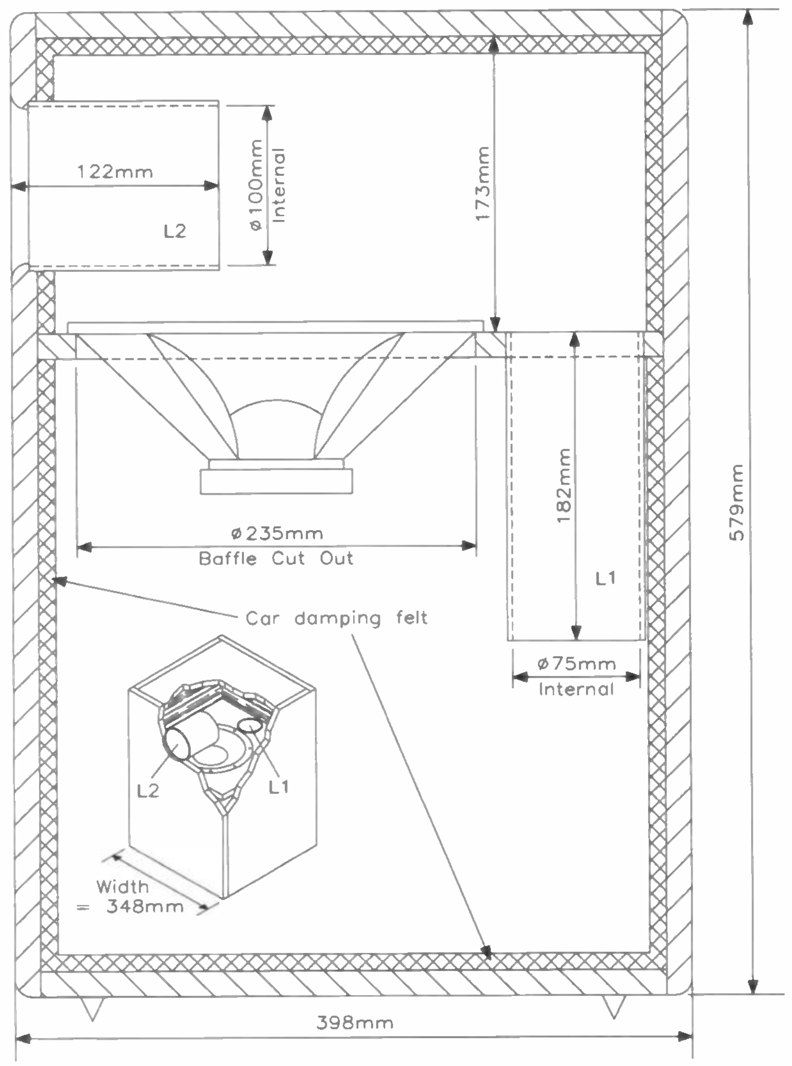


Figure 1. Cut-through diagram of coupled cavity bass unit.

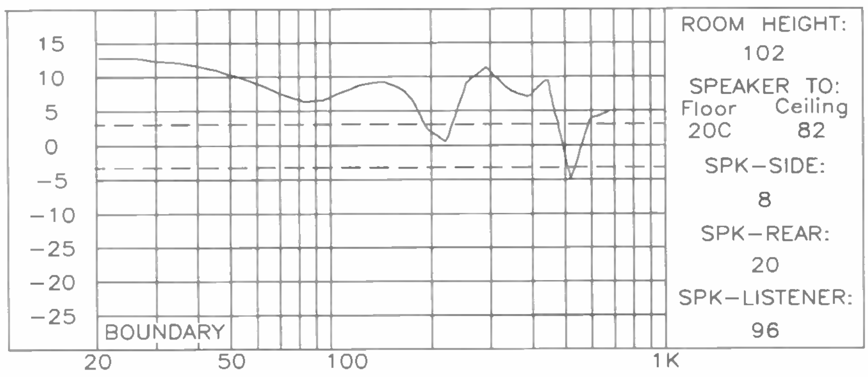


Figure 2. Boundary response plot, speaker placed close to wall.

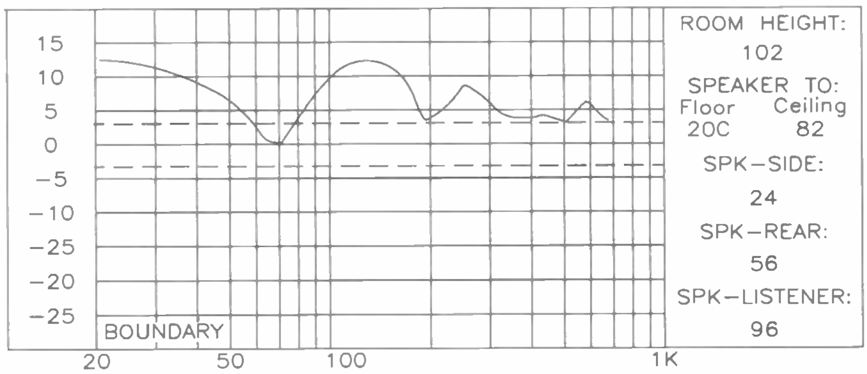


Figure 3. Boundary response plot, speaker moved away from wall.

Where Do I Put Them?

You may choose to have the port firing upwards, but their dimensions make them suitable to act as very effective speaker stands. Bass is a difficult area of the frequency spectrum to reproduce, and generally, my advice is to place them where they suit your purposes best. If you have chosen to support your satellites with them, you will actually be restricting yourself on placement. If you are a purist, you may still prefer to place the bass units where they perform best, and your satellites on open stands, in the room, to benefit sound stage and imaging.

I have been fortunate enough to access a little computer program, which demonstrates the effect of boundaries on frequency response. If you look at the 'BOUNDARY' plots of Figures 2 and 3, and remember you are only interested in frequencies of up to 200Hz, you will discover, in time-honoured tradition, that loading them close to walls does actually produce the best bass reinforcement, and the smoothest response. As the units are moved away from the back wall, suck-outs appear in the response. Remember, you are trying to optimise bass reproduction.

If you look at the graphs, and the tables offset to the right of them (dimensions in inches!), you will clearly see the effect of moving the unit away from the back wall.

Completed pair of coupled cavity speakers, with monitor above showing response curve.

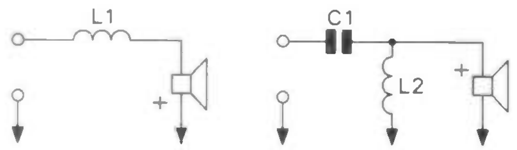
This is only intended as a simple guide, and these plots are assuming a 'simple' box-shaped room. There are many other factors involved, and as mentioned before, your own experimentation will provide the best results for you. Please also experiment with reversing the polarity of the bass units relative to the satellites. Different polarity connection will result in a different response, depending on the 'Q' and the frequency that the satellites are at their −3dB point. Alternatively, you can reduce the variables by using a crossover network.

Additional Tweaks

As indicated, bass reproduction is very dependent on room position, but it is possible to achieve a more consistent result by ensuring that it crosses over accurately to the satellites. Assuming your satellites are of a nominal 8Ω impedance, there may be some benefit in placing a 2nd order network as a high-pass filter. I enclose a circuit dia-

Continued on page 51.

Figure 4. Suggested crossover for coupled cavity bass unit and satellite speaker. Component values are: L1 = 1·5mH (low-loss ferrite core with high power handling; L2 = 5mH; C1 = 60μF. Note that the bass unit is connected in reverse polarity.



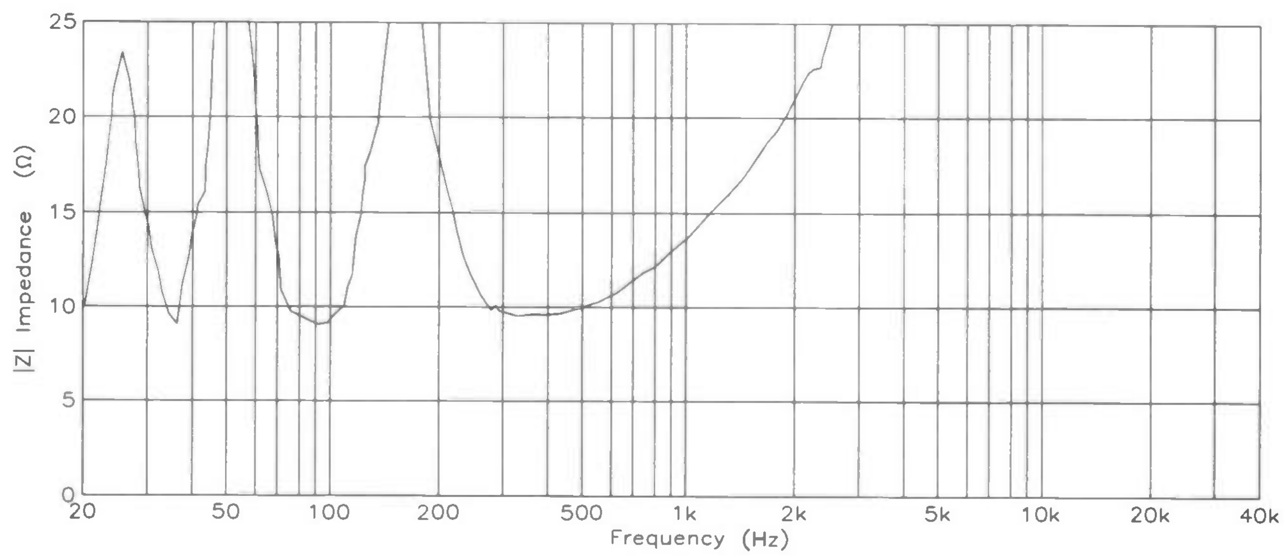


Figure 5. Impedance plot of Design 'B' coupled cavity bass unit.

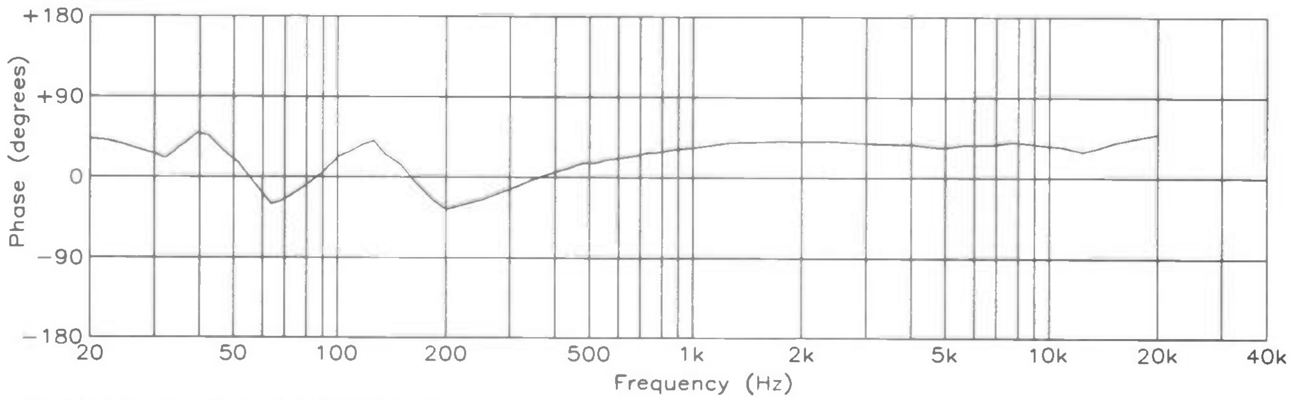


Figure 6. Phase plot of Design 'B' coupled cavity bass unit.

MULTI-STROBE – *Continued from page 43.*

MULTI-STROBE PARTS LIST

MAIN UNIT

RESISTORS: All 0·6W 1% Metal Film (Unless specified)

R1,3,4,8	10k	4	(M10K)
R2	12k	1	(M12K)
R5	4k7	1	(M4K7)
R6	180Ω	1	(M180R)
R7	10k 2W Metal Film	1	(D10K)
R9	1k	1	(M1K)
R10	100k 2W Metal Film	1	(D100K)
R11,12	1k 10W Wirewound	2	(H1K)
R16	100k	1	(M100K)
R17	220k 2W Metal Film	1	(D220K)
RV1	1M Linear Potentiometer	1	(JM76H)

CAPACITORS

C1	47nF IS Capacitor	1	(JR33L)
C2	220μF 35V PC Electrolytic	1	(JL22Y)
C3,4,6,21	100nF 50V Ceramic Disc	4	(BX03D)
C5	10μF 50V PC Electrolytic	1	(FF04E)
C7-10	22μF 25V PC Electrolytic	4	(FF06G)
C11	2n2F Poly Layer	1	(WW24B)
C12	1n5F Poly Layer	1	(WW23A)
C13	220pF Ceramic Disc	1	(WX60Q)
C14	47μF 25V PC Electrolytic	1	(FF08J)
C15	100nF IS Capacitor	1	(JR34M)
C16	6μ8F Audio Grade Polypropylene	1	(KR83E)

SEMICONDUCTORS

D1-6	1N4004	6	(QL76H)
D7-18	1N4148	12	(QL80B)
ZD1	1N5388BRL	1	(AY88V)
ZD2	BZYC10	1	(QH14Q)
TR1	BC548	1	(QB73Q)
TI1	C206D	1	(WQ24B)
IC1	MAX232CPE	1	(FD92A)
IC2	HCF4094BEY	1	(QW54J)
IC3	HCF4011BEY	1	(QX05F)
IC4	HCF4017BEY	1	(QX09K)
IC5	HCF4060BEY	1	(QW40T)
RG1	LM78L05ACZ	1	(QL26D)

MISCELLANEOUS

T1	9-0-9V Sub-miniature Mains Transformer	1	(WB01B)
T2	4kV Trigger Transformer	1	(YQ63T)
FS1	250mA Time-Delay Fuse	1	(RA06G)
SK1,2	4-way Telephone Socket FCC68 4C4P	2	(JW46A)
OP1	Optoisolator	1	(WL35Q)
TB1	2-way PC Terminal	1	(JY93B)
S1-8	8-way Piano Style DIL Switch	1	(JW76H)
S9	2-pole Latchswitch	1	(FH67X)
ST1	Xenon Strobe Tube	1	(FS78K)
	1mm PCB Pins	1 Pkt	(FL24B)
	Multi-strobe Case	1	(90017)
	14-pin DIL Socket	1	(BL18U)
	16-pin DIL Socket	3	(BL19V)
	PCB Mounting Fuseholder with Cover	1	(KU29G)
	Small Latch Button (Black)	1	(KU75S)
	20swg Tinned Copper Wire (0·9mm)	1 Reel	(BL13P)
	Stranded Hook-up Wire (Black)	1 Pkt	(BL00A)
	3-core 6A Mains Cable (Black)	3m	(XR03D)
	6·4mm Grommet	1 Pkt	(JX65V)
	203 × 2·5mm Tie-Wrap	1	(BF93B)
	Self-adhesive Pads	1 Strip	(HB22Y)
	15 × 19·5mm dia. Knob (Black)	1	(FK39N)
	Square Stick-on Feet	1 Pkt	(FD75S)
	¼in. Cable 'P' Clip	1	(LR45Y)
	M3 Solder-Tag Washers	1 Pkt	(LR64U)
	M3 × 6·3mm (¼in.) Spacers	1 Pkt	(FG33L)
	M3 Insulated Spacers	1 Pkt	(FS36P)
	M3 Steel Nuts	1 Pkt	(JD61R)
	M3 Steel Washers	1 Pkt	(JD76H)
	M3 Shake-proof Washers	1 Pkt	(BF44X)
	M3 × 6mm Steel Screw	1 Pkt	(JY21X)
	M3 × 16mm Steel Screw	1 Pkt	(JY24B)
	M4 Steel Nuts	1 Pkt	(JD60Q)
	M4 Steel Washers	1 Pkt	(JD75S)
	M4 Shake-proof Washers	1 Pkt	(BF43W)
	M4 × 10mm Steel Screws	1 Pkt	(JY14Q)
	PCB	1	(90016)
	Instruction Leaflet	1	(XV44X)
	Constructors' Guide	1	(XH79L)

OPTIONAL REMOTE CONTROLLER (Not in Kit)

RESISTORS: All 0·6W 1% Metal Film (Unless specified)

R13	12k	1	(M12K)
R14	4k7	1	(M4K7)
R15	1k5	1	(M1K5)
RV2	1M Miniature Linear Potentiometer	1	(JM76H)

CAPACITORS

C17,19	10μF 50V PC Electrolytic	2	(FF04E)
C18	1n5F Poly Layer	1	(WW23A)
C20	100nF 50V Ceramic Disc	1	(BX03D)

SEMICONDUCTORS

D19	1N4001	1	(QL73Q)
LD1	High Power 2mA Miniature LED (Red)	1	(CZ28F)
TR2	BC548	1	(QB73Q)
IC6	HCF4060BE	1	(QW40T)
RG2	HT1050 Micro Power Voltage Regulator	1	(BH68Y)

MISCELLANEOUS

SK3	4-way Telephone Socket FCC68 4C4P	1	(JW46A)
S10	Sub-miniature SPDT Toggle Switch	1	(FH00A)
	1mm PCB Pins	1 Pkt	(FL24B)
	15 × 19·5mm dia. Knob (Black)	1	(FK39N)
	16-pin DIL Socket	1	(BL19V)
	Pocket Clip Case	1	(KC95D)
	PP3 Battery Clip	1	(HF28F)
	4-core Telephone Cable FCC68	As Req.	(XS27E)
	4-way Telephone Plug FCC68 4C4P	2	(JW42V)
	PP3 Battery	1	(JY49D)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order As 90015 (Multi-Strobe Kit) Price £29.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately but are not shown in the 1995 Maplin Catalogue.
Multi-Strobe PCB **Order As 90016 Price £5.99**
Multi-Strobe Case **Order As 90017 Price £5.49**

NOISE – *Continued from page 35.*

Diodes with reverse breakdown voltages of between 4·5 and 6·7V employ both mechanisms.

The noise produced by avalanching is so great, that the diode can radiate noise into nearby sensitive circuits, such as HF radio receiver (including IF amplifiers). It is, therefore, necessary to connect a suppression capacitor across any avalanche diode in anything but an audio circuit, and it may even be necessary to include an inductor in series with the current supply, to prevent radiation from the wiring or PCB conductor. There doesn't seem to be any easy way of calculating the noise component of the avalanche current, or the noise voltage across the diode, so further analysis of this will have to wait for later in the series.

Bipolar Transistors

There are five sources of noise in a bipolar transistor:

- Shot noise in the collector current..
- Shot noise in the base current.
- Thermal noise in the extrinsic base resistance $r_{bb'}$.
- Flicker noise.
- Popcorn noise.

Of these, the first three can be calculated using the Schottky and Nyquist formulae, while the other two are due to manufacturing defects, and cannot be calculated. Flicker noise is partly due to imperfections in the crystal structure of the silicon wafer, which trap electrons randomly, and has a voltage spectrum inversely proportional to frequency down to very low frequencies indeed. For this reason, it is often called '$1/f$ noise'. Another contribution comes from minute variations in the temperature of the diode. Since the forward voltage at a given current falls by 2·5mV/K, a change of only one-thousandth of a degree produces a change of 2·5µV. Popcorn noise is due to surface contamination of the silicon, and gets its name from the audible effect when it occurs in an audio amplifier. Luckily, both flicker noise (except the part due to temperature changes) and popcorn noise, are greatly reduced by modern manufacturing techniques, and can be neglected in many applications.

Provided we restrict our analysis to the frequency range from a few hertz to $f_T/\sqrt{\beta}$ (where f_T is the transition or unity gain frequency, and β is the common-emitter current gain), the noise characteristics of a bipolar transistor can be represented by the *dependent-generator equivalent circuit* with the addition of two uncorrelated (independently random) noise sources, as shown in Figure 5.

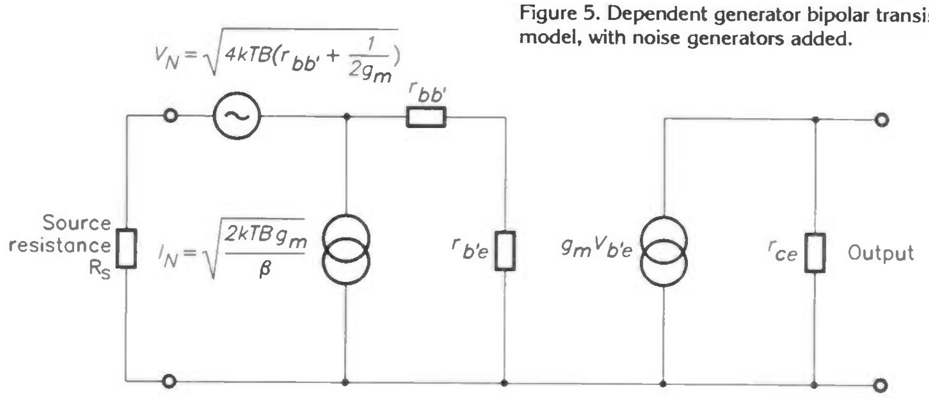


Figure 5. Dependent generator bipolar transistor model, with noise generators added.

At higher frequencies, collector-to-base feedback cannot be neglected, and the generators become partially correlated, so that their contributions tend to add arithmetically instead of rms-wise, which results in increased noise. It is possible to replace the two generators by resistances whose thermal noise is equal to that of the generator. For the voltage generator V_N, we have:

$$R_{NV} = r_{bb'} + 1/2g_m$$

by Nyquist's formula, and the resistance whose short-circuit noise current is equal to the value of the noise current generator I_N is:

$$R_{NI} = 2\beta/g_m$$

V_N is the characteristic that is usually expressed in the peculiar units of nV/√Hz ('nanovolts per root hertz'), and very little tends to be said about I_N. You can see that the 'root hertz' comes from B, the bandwidth, appearing in the expression for V_N under the square root sign.

What we are usually interested in, is the extra amount of noise that the transistor adds to the unavoidable noise produced by the source resistance R_s (see Figure 5). This is most conveniently calculated from the noise powers produced in the input resistance R_{in} (which can be assumed noiseless):

The total power is:

$$\frac{V_s^2R_{in}}{(R_{in}+R_s)^2} + \frac{V_N^2R_{in}}{(R_{in}+R_s)^2} + \frac{I_N^2R_sR_{in}}{(R_{in}+R_s)^2}$$

and the power due to R_s alone is just the first term,

so the power ratio is:

$$\frac{V_s^2 + V_N^2 + I_N^2R_s}{V_s^2}$$

and rewriting in terms of R_{NV} and R_{NI} is:

$$1 + \frac{R_{NV}}{R_s} + \frac{R_s}{R_{NI}}$$

The power ratio, or *noise factor*, F, is usually expressed as the noise figure, L_F, in decibels, which is ten times the logarithm (base 10) of the ratio. By differentiating the equation for F with respect to R_s, it is not difficult to show that F is a minimum when:

$$R_s = \sqrt{R_{NV}R_{NI}}$$

and with this value of R_s

$$F_{min} = 1 + 2\sqrt{\frac{R_{NV}}{R_{NI}}}$$

Clearly, to get low-noise performance, the current noise resistance (R_{NI}) must be much larger than the voltage noise resistance (R_{NV}). The minimum noise factor can be expressed in terms of the transistor parameters, by substituting for the noise resistances:

$$F_{min} = 1 + \sqrt{\frac{1 + 2g_mr_{bb'}}{\beta}}$$

Now we can see that a low-noise transistor should have a high β and a low $r_{bb'}$, but this can only be achieved by choosing the right type of device. However, gm is proportional to the DC collector current, I_c, in fact, it is equal to $qI_c/kT = 39I_c$ mS (millisiemens, not milliseconds!) if I_c is in mA. So, it appears that the designer can choose the collector current which gives least noise, but that turns out to be zero, which is not much use! In fact, there is very little to be gained by reducing I_c below the value that makes $2g_mr_{bb'} = 1$. It is then necessary to make R_s equal to the optimum value for that collector current. However, this is often not possible; R_s is fixed. It is then possible to choose g_m, and hence I_c, to minimise the noise, and the optimum value of g_m turns out, from the equations for RNV, RNI and F, to be $\sqrt{\beta/R_s}$.

Flicker noise can be taken into account in the design, by modelling it as an increase in the current noise below a corner frequency which is roughly proportional to collector current. So, to minimise it, first choose a device which has low inherent flicker noise, and then run it at as low a collector current as possible, remembering that both β and f_T fall at very low collector currents, and the optimum value of R_s increases.

Field-Effect Transistors (FETs)

The same pair of noise generators as for bipolar transistors, model the noise performance of FETs (all sorts) quite well, but, of course, the dependent generator model for the device itself is different. The major differences in the noise characteristics are that the ratio R_{NI}/R_{NV} is much greater, the flicker noise appears in the voltage generator, and the variation of noise performance between samples tends to be greater, especially in devices whose noise performance is not specified by the manufacturer.

Unless the source impedance is very high indeed, the effect of the current noise generator can be neglected. The voltage noise generator actually represents the effect of thermal noise current in the channel of the FET, which can be calculated from a modified Nyquist equation:

$$I_{ND}^2 = \frac{8}{3}kTg_mB$$

So the gate voltage is given by:

$$V_{ND}^2 = \frac{8kTB}{3g_m}$$

The current generator at low frequencies is due to shot noise in the gate current:

$$I_{NG}^2 = 2qI_gB$$

However, at higher frequencies, an effect known as 'induced gate noise current, I_{NDG}' occurs. This is a random motion of charge carriers in the gate, induced through the gate capacitance by the thermal noise current in the channel. Think of the effect on a parked caravan, when a juggernaut passes at speed. The effect is proportional to frequency f (equivalent to the lorry's speed), which is not surprising, as it depends on capacitive coupling:

From these, we can deduce the optimum source resistance Rs, opt and the noise factor F, at low and high frequencies:

$$I_{NDG}^2 = 4\pi^2 f^2 kTB/g_m$$

From these, we can deduce the optimum source resistance $R_{s,opt}$ andthe noise factor F, at low and high frequencies:

Noise in Integrated Circuits

Basically, there is no difference in the noise performance of semiconductors, whether they are in discrete form, or embedded in an IC. However, practical differences may arise due to process limitations, for example. It may not be possible to obtain, say, the best possible low-frequency noise performance with the same process as produces fast, high-voltage switching. There are also some peculiarities which the manufacturers tend not to talk about. For example, Zener diodes in ICs, which may not even be shown in the functional circuit, can have properties somewhat different from discrete devices, and the same can apply to some forward-biased junctions.

Noise in Valves (Tubes)

A few years ago, I would not have been writing this section on valves, and the kindly Editor would have had doubts about publishing it if I had. But times change, and those of us who are lucky enough still to have a copy of Langford-Smith have a considerable advantage in the current fascination with valves. Basically, Nyquist and Schottky still apply, and so does the two-generator model, but there are a number of other effects to consider.

At low frequencies:

$$R_{s,opt} = \sqrt{\frac{4kT}{3qI_g g_m}}$$

$$F = 1 + \sqrt{\frac{8qI_g}{3kTg_m}}$$

At low frequencies:

$$R_{s,opt} = \frac{\sqrt{8/3}}{2\pi f C_{gs}}$$

$$F = 1 + \frac{2\pi f C_{gs}}{g_m} = 1 + f/f_T$$

Noise Diodes

Valves with oxide-coated cathodes (mostly Barium and Strontium oxides) have to be designed so that the cathode emits far more electrons than the anode current draws away. The surplus electrons form a cloud or 'space charge', which protects the cathode material from damage due to electric field stresses and ions from the residual gas in the bulb. This space charge has a smoothing effect on the noise component of the anode current, so that its value is reduced to about one-third of the value given by the Schottky equation: the precise value is difficult to calculate.

However, the noise current of a vacuum diode with a directly-heated uncoated tungsten filament can be accurately predicted from the DC anode current and the Schottky equation. This is because the anode voltage can be made high enough, without danger of damaging the cathode, for the space charge to be stripped away. Under these conditions, the anode current is nearly independent of the anode voltage, and depends only on the cathode temperature. Operating in this way, the anode current is said to be 'saturated' or 'temperature-limited'. If the anode-to-cathode spacing of the diode is very small, so that electron transit-time effects can be neglected, the bandwidth of the noise current can be very high, so that such diodes were, and still are, used as calibrated noise sources for measurements of the noise performance of receivers, even at extremely high frequencies.

Triodes

Since, in normal operation, the grid current should be very small, the current generator can be neglected at low frequencies, but at high frequencies induced grid noise occurs, by the same mechanism as induced gate noise in a FET, and, to some extent, the same equation applies (with C_{gs} changed to C_{gk} to be precise). However, the electron transit time introduces a lagging component in the capacitive feedback at high frequencies, which is equivalent to resistive feedback. Also, the effective temperature of the equivalent noise resistance is the cathode temperature, which can be taken as 1,000K for oxide-coated cathodes. Noise due to this effect is partly correlated with that of the shot noise equivalent voltage generator, so the total noise increases through arithmetic instead of rms addition. The R_{NV} of a triode can be calculated from the Schottky equation, modified to allow for space-charge smoothing, the cathode temperature and the electrode dimensions, but the approximation:

$$R_{NV} = \frac{2{\cdot}2}{g_m}$$

has been widely used.

Tetrodes and Pentodes

The noise performance of these devices is complicated by two factors. At all frequencies, there is an extra noise component due to the random division of current between the anode and g_2 (or screen). This is called 'partition noise', and can be modelled reasonably accurately by increasing R_{NV}:

$$R_{NV} = \frac{2{\cdot}2}{g_m} + \frac{20 I_a I_{g2}}{g_m^2 (I_a + I_{g2})}$$

The other effect emerges at high frequencies, and is due to feedback via the inductance of the cathode lead. Not only does this feedback reduce the input impedance at the control grid, but it also results in further correlation between the noise sources, which results in an overall increase.

Next Time

In Part 3, we shall look at noise in circuits, as opposed to devices, and why negative feedback doesn't (or perhaps does) reduce noise!

COUPLED CAVITY SPEAKERS – *Continued from page 48.*

gram, shown in Figure 4, that accurately matches the responses of the two units, and I have found, running plots on various satellites, that the addition of this network has a negligible effect on loading the satellites' own internal network. As this network is designed to roll in at 180Hz, it makes almost all satellites compatible with these bass units. If you can afford Solen capacitors, they offer a cleaner sound quality.

If you choose to use a choke on the bass unit, I found that 1·5mH is the best option. This value is the largest you can use without affecting the response of the bass unit, but will improve overall system impedance, and act as a 'mush' filter should you find there is too much transmission of high frequencies through the port. PLEASE NOTE, that the bass units should be connected in reverse polarity, to ensure a flat response, and a very low DC resistance for the choke is required, such as the low-loss ferrite chokes.

Also included in this article, is an impedance plot, so those with 'NETCALC' or a similar program will be able to accurately crossover, in amplitude and phase, to their own satellites. See Figures 5 and 6. Please adhere to the health warnings, and very good luck with your project!

CORRIGENDA

ISSUE 83/NOVEMBER 1994

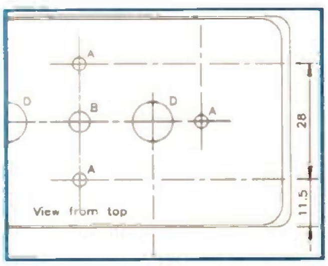
418MHz Encoded RX, page 58, incorrect text, two references to pin 2, in Helical subsection should read: A wire coil, connected directly to pin 1 of the module, and in **Whip** subsection should read: This is a wire connected directly to pin 1 of the module.

ISSUE 89/MAY 1995

Super Scan, page 15, one dimension on the right in Figure 12 PSU diecast box wrong, are given as 30·5, should read: 28 (see diagram, far right).

Voice Vandal, page 54, references to ¼in. stereo plug are wrong, in Testing subsection should read: is to plug in a connecting lead terminated in a ¼in. mono jack plug, and in **Operation** subsection should read: via leads terminated in ¼in. mono jack plugs.

Optional Parts List, page 54, knobs RN18 wrong types, should read: Knob RN15 Blue 1 FE74R, Knob RN15 Green 1 FE75S, Knob RN15 Red 1 FE76H, Knob RN15 Yellow 1 FE77J, and add, ¼in. Stereo Plug to 3·5mm Mono Socket Adaptor 1 YW34M.



KIT AVAILABLE (90032) PRICE £69.95c

The look and the feel of early day reception, of radio signals, on the short wave bands has now largely disappeared. This is mainly due to the introduction of sophisticated all singing and dancing synthesized general coverage receivers. The joy of building a short wave receiver and then the thrill of using it to receive stations has been replaced by an almost professional approach. This project hopefully will revitalise this lost art of receiving.

Text by Robin Hall G4DVJ

FEATURES

- Easy to build
- Easy to set up
- Reception of AM, CW and SSB
- Five tuning ranges

2 PROJECT RATING

Specification

DC Power source:	9V PP3 battery
Supply current min to max:	40mA to 130mA
Frequency range	
A:	3·5 to 4·3MHz
B:	5·9 to 7·4MHz
C:	9·5 to 12MHz
D:	13·2 to 16·4MHz
E:	17·5 to 22MHz
Reception modes:	CW, SSB, & AM
Rated audio impedance:	8 to 35Ω
Audio output power:	200mW into 8Ω
PCB size:	162·5 × 133mm

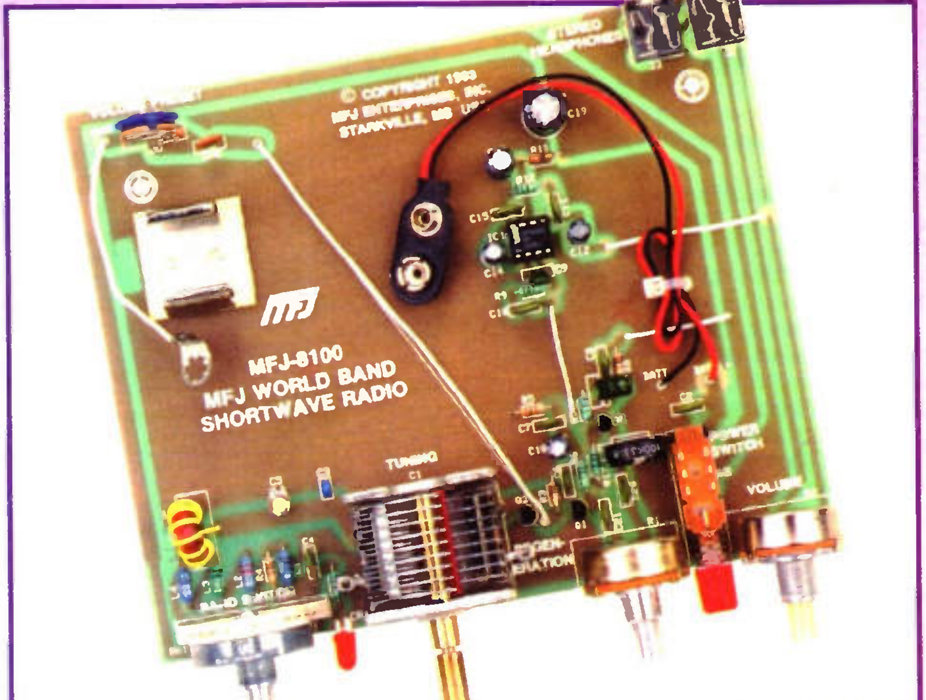
THERE are various methods available for receivers to tune to a particular frequency, capture the radio signals, demodulate and then amplify the audio signals to an acceptable level for headphones or a loudspeaker. The method employed in this receiver is known as 'RF Regeneration'. Where instead of having local oscillators (LO) and intermediate frequencies (IF), detectors and audio frequency (AF) amplifiers, the stages themselves use controlled oscillation at RF and provide the gain and correct amount of carrier to demodulate the signals, before being passed onto an AF amplifier. This method goes back to the original days of crystal set receivers, but has been updated and now benefits from modern technology and components.

Circuit Description

The block diagram is given in Figure 1, with the circuit diagram shown in Figure 2. Studying these should assist in following the circuit description, or with fault-finding if necessary in the completed unit.

The circuit is based on radio frequency regeneration, with DC feedback. The aerial is directly coupled (via R19 the rf gain control) to the source of the RF amplifier FET Q3 rather than to the tuning network. Direct coupling of Q1 and Q3 isolates the LC circuit from the aerial input, thus increasing stability. R1 adjusts the level of feedback of the detector stage Q1 and Q2. R4 reduces the Q of L1 (10μH), this is important for smoother regeneration. The bandswitch SW1, selects a combination of inductors for each band.

The variable air-spaced capacitor C1 is used to tune the main range of the receiver, with C3, and trimmer C5 fine tuning the set range.



The assembled PCB.

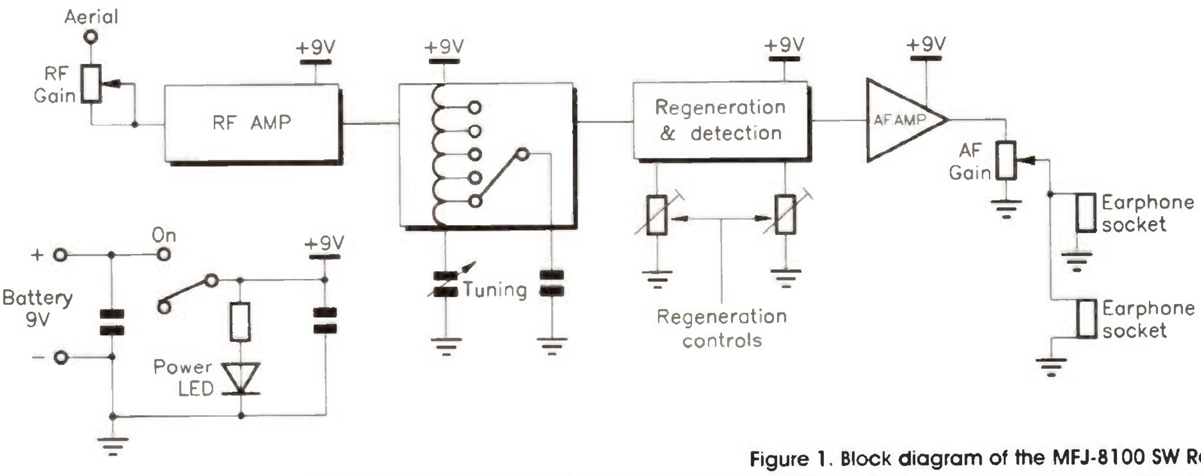
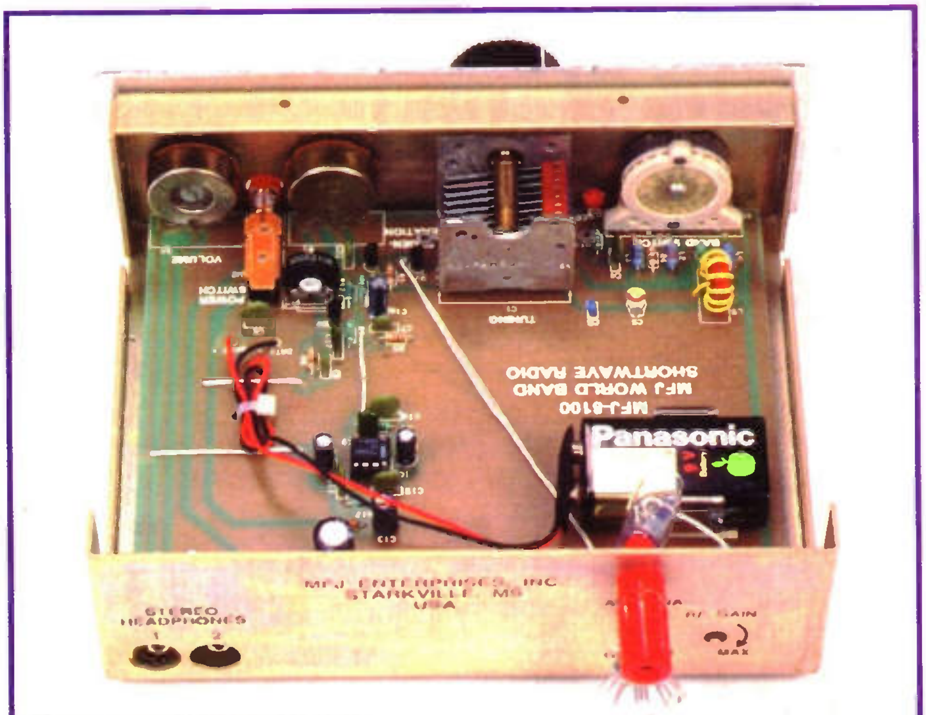


Figure 1. Block diagram of the MFJ-8100 SW Receiver.



The assembled PCB fitted in case.

The trimmer potentiometer R20 is used for smooth regeneration over the tuning ranges.

C17, C9, C10 and R9 form a low-pass filter to block RF to the audio amplifier IC1, and provides audio filtering. The audio level from the audio amplifier IC1 to the earphone/loudspeaker is controlled by R2.

Construction

PCB Assembly

This is fairly straightforward, refer to the Parts List, circuit diagram of Figure 2 and PCB legend and track of Figure 3.

There is a very good Instruction and Assembly Manual contained within the kit. If you are new to project construction, refer also to the Constructors' Guide (XH79L) for hints and tips on soldering and assembly techniques.

Begin with the smallest components, working up in size to the largest.

The inductors are encapsulated and

have a similar appearance to resistors, but the markings are on a blue body.

There are two similar potentiometers, 250Ω and 10k. For identification the 250Ω volume control has 250 stamped on it. Ensure correct identification before soldering in.

Various lengths of white wire are included in the kit. These are for wire links to be fitted onto the PCB. It is best to measure these up first before fitting, as they may not all be cut to size.

The volume control has a lug which, unless removed, will slightly offset the control when in position on the front panel. This is easily removed by snapping off with pliers (better to do this now, before the PCB is in position). If you forget to do this, the control will not sit flush against the front panel.

Before installing the air-cored variable capacitor, either cut the two front lugs off, or bend them out the way. The capacitor is mounted onto the PCB with its positioning legs passed through the PCB. When satisfied that it is sitting squarely on the PCB, solder into position. A higher power soldering iron (25W plus) will be required for this job.

Now fit the rotary band-switch onto the PCB, and when satisfied that all the legs are through (with the body of the switch sitting level on the PCB) solder in position. In all cases make sure that the components are flush-fitted, as once they have been soldered they will be extremely difficult to remove.

Winding the Toroid

This is not as bad as it sounds. Place 8-turns of the yellow wire provided through the toroid, as shown in Figure 4. The wire should be evenly spaced but not slack. Cut the appropriate amount off the ends so that the toroid can be mounted onto the PCB, tin the ends of the wires and solder in position on the PCB.

Case Assembly

There is a pre-drilled case and front panel (with associated washers and screws) included in the kit. Refer to Figure 4 which shows the exploded assembly of the PCB to the lower section of the case. When fitting the PCB into the case, slight temporary readjustment of the components may be necessary. Make sure that the LED is not trapped behind the front section (building a number of these receivers has shown that in all cases the board fits extremely well) then hold in position by the fixing screws provided.

Fit the components as indicated, to the rear section of the case, and solder the aerial wire to the metal connection of the antenna terminal.

Next fit the front panel, be especially careful when tightening the locknuts holding the front panel, as one slip might result in a nasty score mark in the brushed aluminium panel, thus spoiling your handiwork at a stroke. Fit the knobs and tighten up the grub screws where applicable.

Before fitting the main tuning dial, the pointer has to be literally forced onto the tuning capactitor's spindle (not an easy task). If you feel that you have to resort

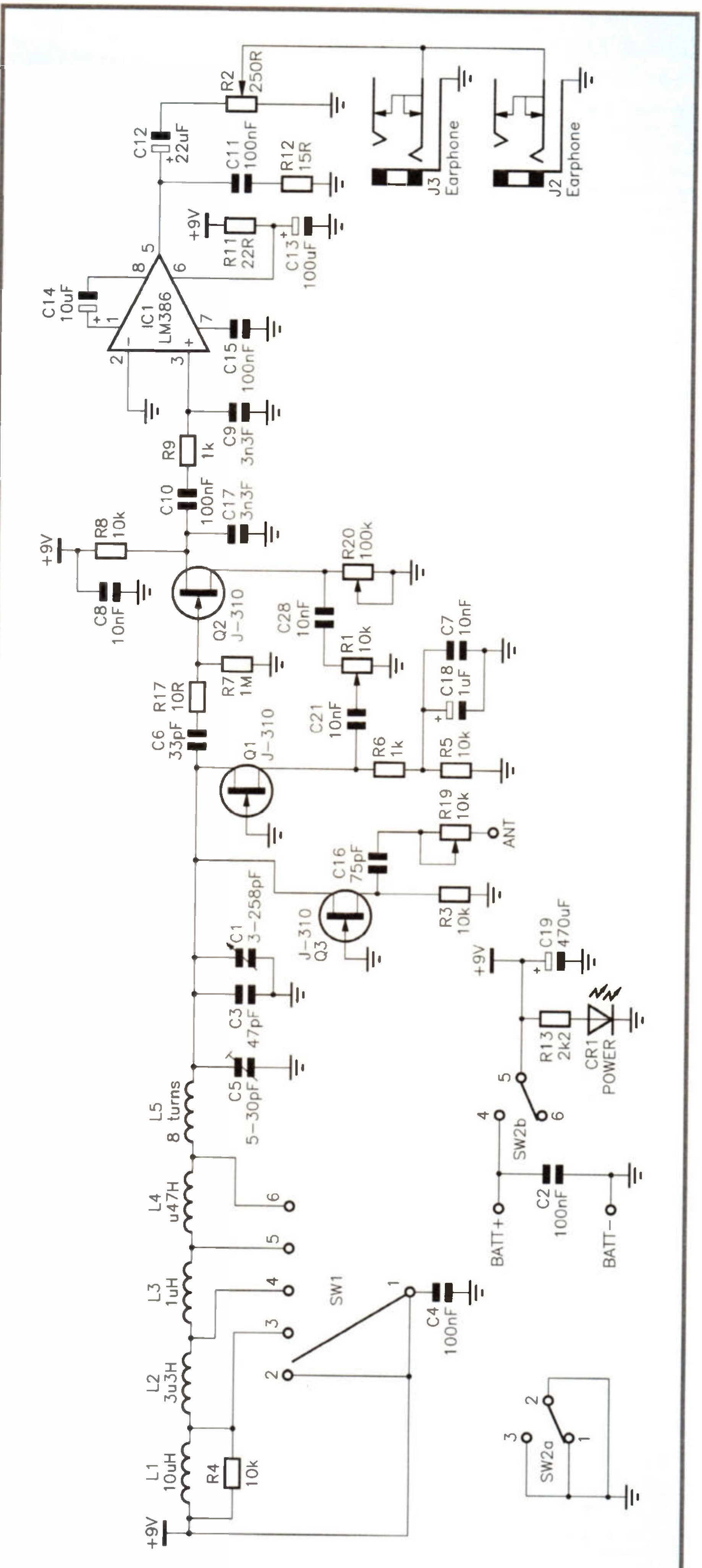
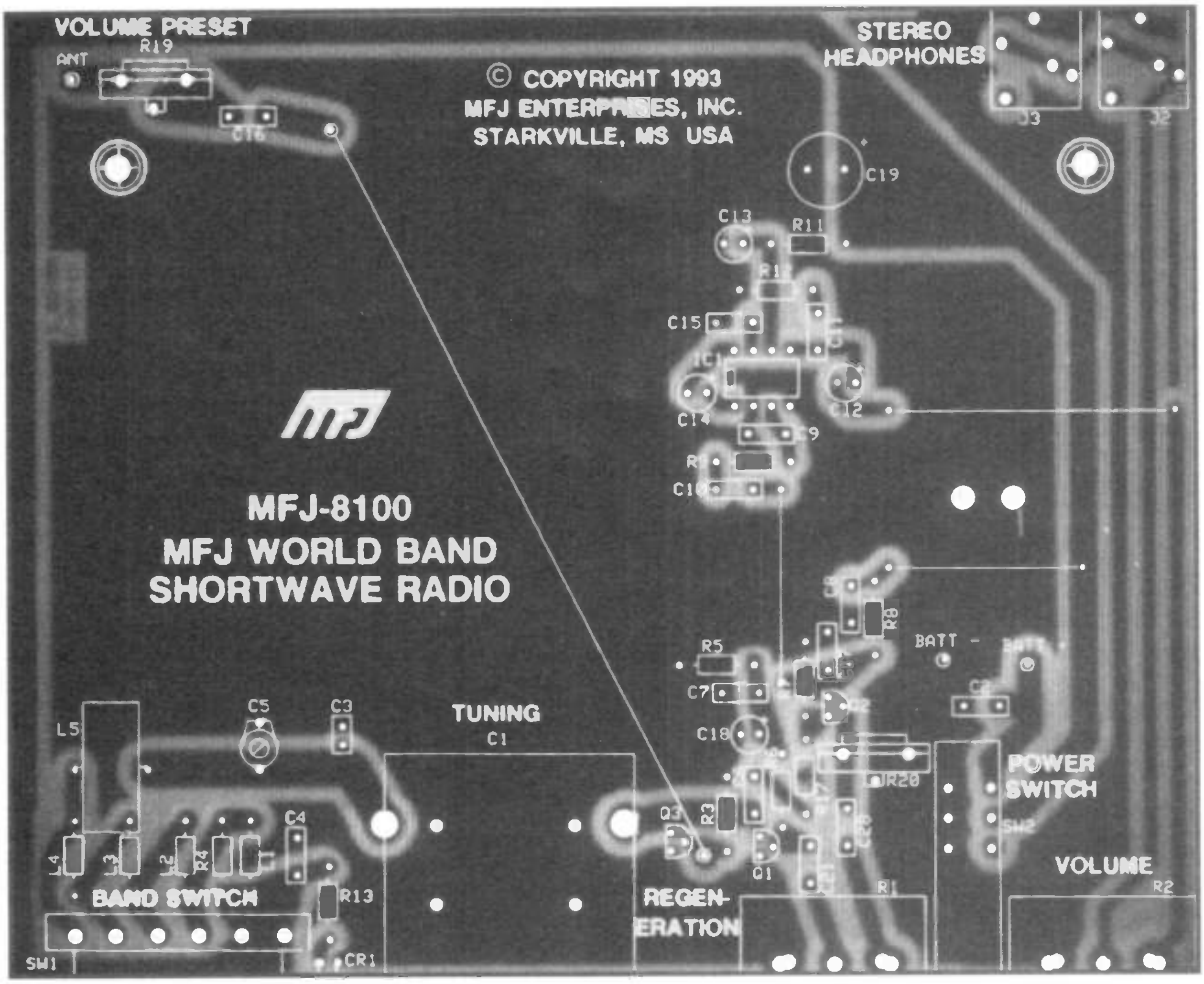


Figure 2. Circuit diagram of the MFJ-8100 SW Receiver.



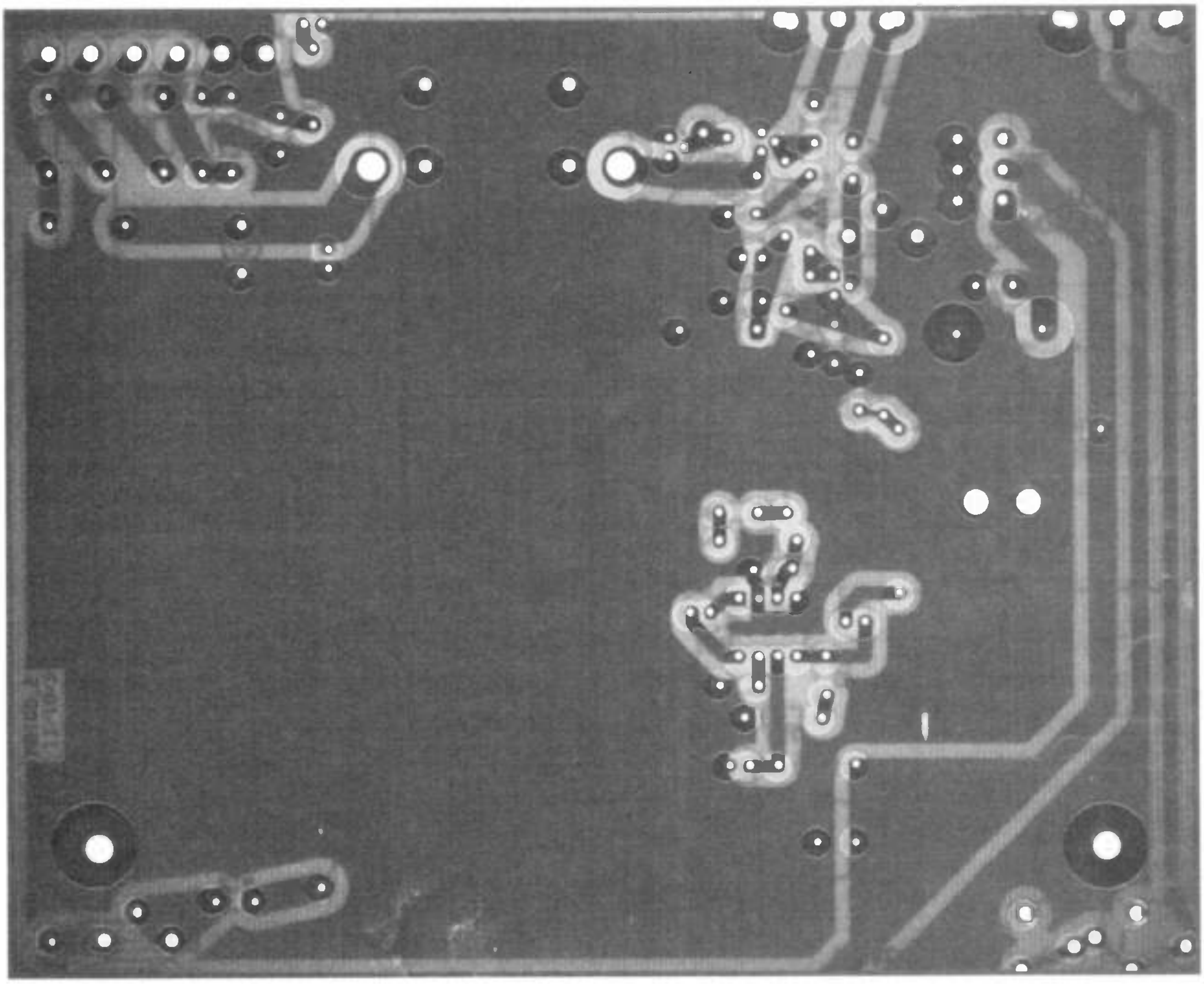


Figure 3. PCB legend and track.

to making the hole in the plastic on the pointer bigger (then be warned, the tolerance is very critical) too much will result in the pointer becoming too slack on the spindle. Once this is in position on the slow motion drive segment of the spindle then fit the main rotary knob. Adjustment of the pointer can be made so that it corresponds with the tuning limits on the front panel.

It is best to leave the top of the case off for the next stage.

Setting Up

Now the receiver PCB has been built, checked and fitted into the lower portion of the case, it is now time to calibrate the receiver. Before doing so, fit a pair of headphones, or an active loudspeaker system, and a 9V battery. If a signal generator is available that covers the range of the receiver, then this can be used to mark selected frequencies. Then with C5 the trimming capacitor, adjust the tuning so that the tuning dial is matched as close as possible to the marked frequency, carry this out for each band.

If a signal generator is not available then tests carried out with a separate receiver will have to be made. This can be used to assist in calibration of the MFJ-8100, as you will be able to pick up oscillations from the MFJ-8100 with an external receiver in close proximity, and this will indicate where the MFJ-8100 is tuned.

Finally attach a suitable aerial and earth to the MFJ-8100, and test for live signals, see Figure 5 for typical arrangements.

All around the world there are stations that send out time signal transmissions on 10, and 15 and 20MHz, such as JJY in Japan, WWVH in Hawaii and WWV in Boulder Colorado. There are other time signal stations on other frequencies, but these would have to be checked In an appropriate SW Frequency guide book.

Operation

With the receiver tested and aligned, the top casing can now be fitted and held in position by the self-tapping screws provided. Select the desired

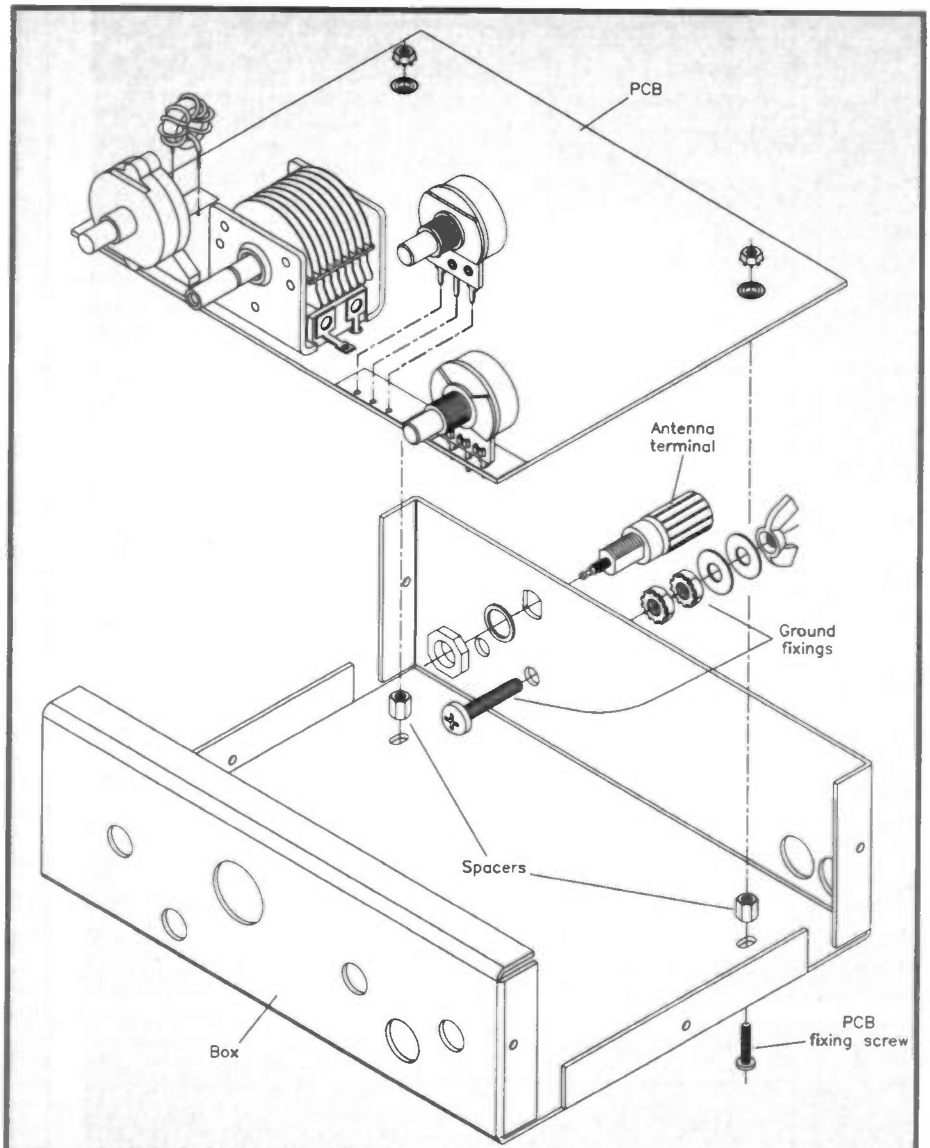
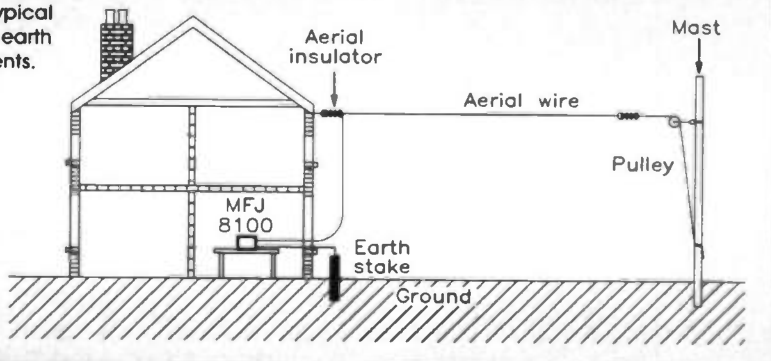
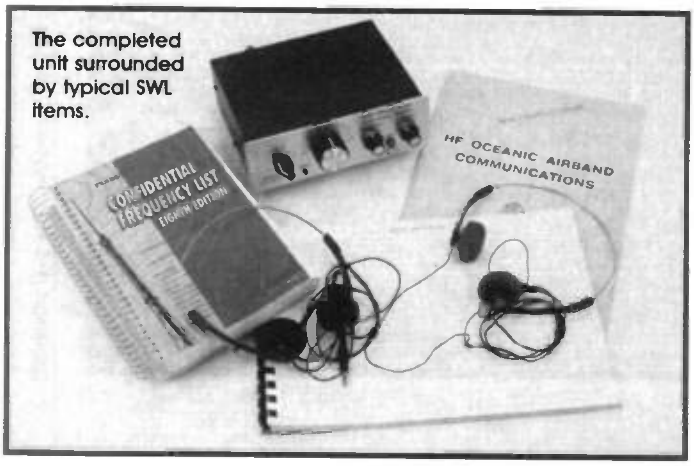


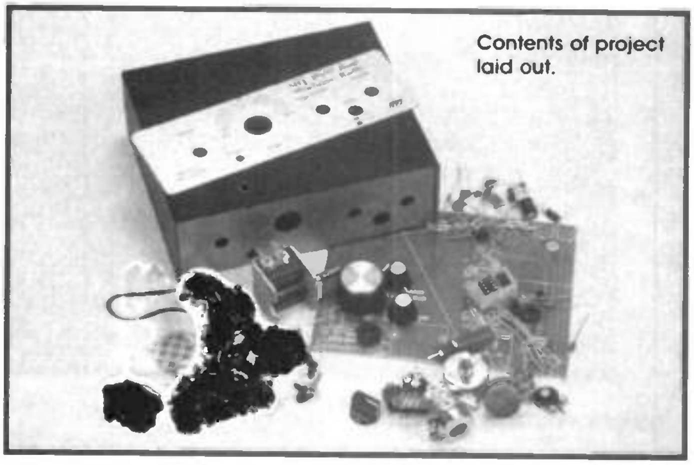
Figure 4. Exploded assembly drawing.

Figure 5. Typical aerial and earth arrangements.





The completed unit surrounded by typical SWL items.



Contents of project laid out.

band and tune in the receiver. When receiving a signal carefully adjust the regeneration control, this is very important for SSB and CW signals. The regeneration control might have to be reduced on AM signals.

Most SWL's have a room or space provided where they can carry out their hobby without interference to others, or vice versa. A desk with plenty of room for frequency guides, logbooks and QSL cards is advisable.

Table 1 shows the frequency bands that are covered by the MFJ-8100. The bands are further split into sections showing where the Broadcast, Maritime, Aeronautical, Fixed, Amateur and Time Signal stations are generally located.

References

There are many books to read on the subject of SW listening in all its forms, such as amateur radio, commercial radio, shipping, aircraft and coast stations. Reference books on frequencies are likewise plentiful.

For the budget conscious or beginner, there are books such as *Short Wave International Frequency Handbook* and *HF Oceanic Airband Communications* by Bill Laver, *Shortwave Listening Guidebook* by Harry L. Helms, and *International Radio Stations Guide* by P. Shore. For the avid enthusiast there are books such as *Ferrell's Confidential Frequency List*, the *World Radio and TV Handbook* and the *Admiralty List of Radio Signals*. There are also books which make interesting reading about the history of radio, such as *The Setmakers*, and our own booklet, *The Story of Radio* by Graham Dixey.

The frequencies of commercial SW stations are constantly changing so make sure that you get up-to-date reference books. They are generally reprinted yearly, and once you select your favourite radio stations you will find out any changes. Generally they inform the listeners of forthcoming frequency changes in the year, and publish them in their own programme or frequency guides. Radio amateurs generally move around the 'ham bands', but they do make schedules 'skeds'with other stations.

Once into the hobby it might be as well to keep a log-book. Log-books are available for radio amateurs for legal purposes, and can be used, but there are some just devoted for the SWL, with extra columns for remarks and QSL information. Failing that, a ruled exercise book is just as handy, but a lot cheaper.

Contacts

There are many clubs for the short wave listener (SWL). One nice aspect of the hobby, is QSLing, which can be applied to either the commercial or amateur radio bands. This is where the SWL sends in a signal report in a letter form or on a specially printed QSL card, either direct to the station or via the 'Bureau'.

Frequency Range	Frequency Bands														
A: 3·5 to 4·3MHz	3·5 to 3·8MHz Amateur Radio, shared with Fixed Services & Maritime Service	3·8 to 3·95MHz Aeronautical shared with Amateur Radio, Fixed Broadcasting & Services	3·95 to 4·0MHz Broadcasting shared with Fixed Services	4·0 to 4·1MHz Fixed Services shared with Maritime Service	4·1 to 4·3MHz* Maritime Service										
B: 5·9 to 7·4MHz	5·9 to 6·2MHz International Broadcasting	6·2 to 6·5MHz Maritime Service	6·5 to 6·8MHz Aeronautical Service	6·8 to 7·0MHz Special Services	7·0 to 7·1MHz Amateur Radio with International Broadcasting	7·1 to 7·3MHz Amateur Radio shared	7·3 to 7·4MHz* Fixed Services								
C: 9·5 to 12·0MHz	9·5 to 9·9MHz International Broadcasting	9·8 to 9·9MHz International Broadcasting shared with Fixed Services	9·9 to 9·995MHz Fixed Services	9·995 to 10·005MHz Standard Frequency Time Signals	10·005 to 10·1MHz Aeronautical Services	10·1 to 11·175MHz Fixed Services	10·1 to 10·15MHz Fixed Services shared with Amateur Radio	11·175 to 11·4MHz Aeronautical Service	11·4 to 11·65MHz Fixed Services	11·65 to 12·05MHz* International Broadcasting	11·65 to 11·7MHz International Broadcasting shared with Fixed Services	11·975 to 12·05MHz* International Broadcasting shared with Fixed Services			
C: 13·2 to 16·4MHz	13·2 to 13·36MHz Aeronautical Service	13·36 to 13·8MHz Fixed Services	13·6 to 13·8MHz Fixed Stations Shared with International Broadcasting	13·8 to 14·0MHz Fixed Services	14·0 to 14·350MHz Amateur Radio	14·25 to 14·350MHz Amateur Radio shared with Fixed Services	14·350 to 14·99MHz Fixed Services	14·990 to 15·01MHz Standard Frequency & Time Signals	15·01 to 15·1MHz Aeronautical Services	15·1 to 15·6MHz International Broadcasting	15·45 to 15·6MHz International Broadcasting Shared with Fixed Services	15·6 to 16·4MHz Fixed Services			
E:17·5 to 22·MHz	17·5 to 17·9MHz International Broadcasting	17·55MHz to 17·7MHz International Broadcasting shared with Fixed Services	17·9MHz to 18·03MHz Aeronautical Service	18·03MHz to 18·068MHz Fixed Services	18·068MHz to 18·168MHz Amateur Radio shared with Fixed Services	18·168 to 18·780MHz Fixed Services	18·78MHz to 18·9MHz Maritime Service	18·9 to 19·68MHz Fixed Services	19·68 to 19·8MHz Maritime Service	19·8 to 19·99MHz Fixed Services	19·99 to 20·01MHz Standard Frequency & Time Signals	20·01 to 21·0MHz Fixed Services	21·0 to 21·45MHz Amateur Radio	21·45 to 21·85MHz International Broadcasting	21·85 to 22·0MHz Aeronautical Service

* Indicates that the band in question continues outside of the range of the receiver.

Commercial radio stations on short wave normally have programmes devoted to SWLs, and quite often read out letters and reports. Amateur radio stations will always respond direct if an international reply coupon is attached to the report, or send their QSL card back via the Bureau. In this country the Radio Society of Great Britain (RSGB) run a QSL bureau. There is also the International Short Wave League (ISWL) who cater for the SWL. Many local radio clubs run a QSL postbox system, especially if they are active in competitions. E

Acknowledgment

Thanks to Waters & Stanton Electronics of Hockley for supplying the MFJ-8100 SW Receiver.

SW REGENERATIVE RECEIVER PARTS LIST

RESISTORS		
R1	10k Potentiometer	1
R2	250Ω Potentiometer	1
R3-R5,R8	10k	4
R6,R9	1k	2
R7	1M	1
R11	22Ω	1
R12	15Ω	1
R13	2k2	1
R17	10Ω	1
R19	10k Potentiometer Vertical	1
R20	100k Potentiometer Vertical	1
CAPACITORS		
C1	3-258pF (Air Spaced)	1
C2,C4,C10,C11,C15	100nF	5
C3	47pF Monolithic Ceramic	1
C5	5-30pF Trimmer	1
C6	33pF	1
C7,C8,C21,C28	10nF	4
C9,C17	3n3F Mylar	2
C12	22µF 25V Electrolytic	1
C13	100µF 16V Electrolytic	1
C14	10µF 35V Electrolytic	1
C16	75pF Disc Ceramic	1
C18	1µF 100V Electrolytic	1
C19	470µF 16V Electrolytic	1
SEMICONDUCTORS		
CR1	Red LED	1
IC1	LM386 Audio Amp	1
Q1-Q3	J310 FET	3
INDUCTORS		
L1	10µH	1
L2	3µ3H	1
L3	1µH	1
L4	470mH	1
L5	T-52-2 Toroid, 8T	1
MISCELLANEOUS		
J1	Antenna Connector	1
J2	Stereo Socket PCB Mount	1
J3	Stereo Socket PCB Mount	1

SW1	5-position Rotary Switch	1	
SW2	On/Off Latch Switch 2-pole	1	
	Large Knob	1	
	Small Ridged Knob	2	
	Heavy Duty Pointer Knob	1	
	Dial Pointer	1	
	Red Small Round Button	1	
	Terminal Post Red	1	
	Grounding Post & Wing-nut	1	
	8-pin DIL Socket	1	
	PP3 Battery Clip	1	
	PP3 Battery Mount	1	
	Inductor Wire Yellow	23cm	
	Tie-wrap	1	
	Self-tapping Screw	8	
	Hex Headed Spacer	4	
	Screw 2 x 12mm	4	
	Shakeproof Lock-nut 2mm	4	
	Solder-tag	1	
	Double-sided Tape	1	
	Stick-on Feet	4	
	PCB	1	
	Front Panel	1	
	Metal Case	1	
OPTIONAL (Not in Kit)			
	9V Alkaline Battery	1	(ZB52G)
	Loud Speaker(s) (Active)	1	(MK51F)
	Headphones (Comms style)	1	(BZ58N)
	Headphones (Walkman style)	1	(RJ96E)
	Aerial Wire	1 Pkt	(FA26D)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available in kit form only.

Order As 90032 (SW MFJ-8100 Regenerative Receiver) Price £69.95c

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

DIARY DATES

Every possible effort has been made to ensure that the information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments please contact event organisations to confirm details.

1 to 2 July. VHF Field Day Contest Weekend, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

2 July. Vintage Electric Musical Instruments Auction, Star House, Sandford, Devon. Tel: (01363) 777872.

4 July. Operating QRP, Sunbury & District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: (01787) 313212.

7 July. June Sale, Aberdeen Amateur Radio Society, RC Hall, Cairngorm Crescent, Aberdeen. Tel: (01569) 731177.

10 July. Summer Social, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

24 July. Construction Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

20 August. Evening on Air, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

27 August. East Coast Amateur Radio and Computer Rally, Clacton Leisure Centre. Tel: (01473) 272002.

2 September. Wight Wireless Rally, Arreton Manor Wireless Museum, Newport, IOW. Tel: (01983) 567665.

2 to 3 September. HF SSB Field Contest Weekend, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

5 to 7 September. International Conference on 100 Years of Radio, Savoy Place, London WC2. Tel: (0171) 240 1871.

10 September. Southend & District Radio Society, 75th Anniversary Radio & Computer Rally, The Cliffs Pavilion, Southend. Tel: (01702) 353676.

10 September. Lincoln Short Radio Hamfest, Lincoln Showground, Lincoln. Tel: (01522) 525760.

10 to 12 September. European Computer Trade Show, Olympia, London. Tel: (0181) 742 2828

10 to 13 September. PLASA – Light & Sound Trade Show, Earls Court, London. Tel: (0171) 244 6433.

12 September. Opening Night and Dayton '94 talk by Herb Asmussen OZ7SM and George Beasley G3LNS. Stratford-upon-Avon & District Radio Society. Tel: (01789) 773286.

12 to 14 September. First IEE/IEEE International Conference on Generic Algorithms in Engineering Systems – Innovations and Applications, Sheffield. Tel: (0171) 240 1871.

13 to 14 September. European Optical Communications Show, Olympia. Tel: (01425) 473535

19 to 21 September. Computers in Manufacturing Exhibition, NEC, Birmingham. Tel: (01932) 564455.

19 to 24 September. LIVE '95, Earls Court, London. Opening times: 12pm to 9pm weekdays, 10pm to 6pm weekends. Tel: First Call Ticket Agency (0171) 396 4545.

20 to 21 September. Electrical Engineering Show, Hinckley Island Hotel, Hinckley. Tel: (01732) 359990.

3 to 5 October. Electronics Data Exhibition, NEC, Birmingham. Tel: (0181) 742 2828.

Please send details of events for inclusion in 'Diary Dates' to: The News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR.

NEWS Report

Mobile DSP

Two new customised digital signal processors (DSPs) for wireless communications applications have been launched by Texas Instruments. The devices combine high performance, hard-wire functionality with specialised instruction set to implement worldwide digital cellular standards, including Global System for Mobile Communications (GSM), IS-54B, IS-136, Personal Digital Cellular (PDC), and IS-95. Contact: Texas Instruments, Tel: (01604) 663 147.

Big Teacher is Watching You

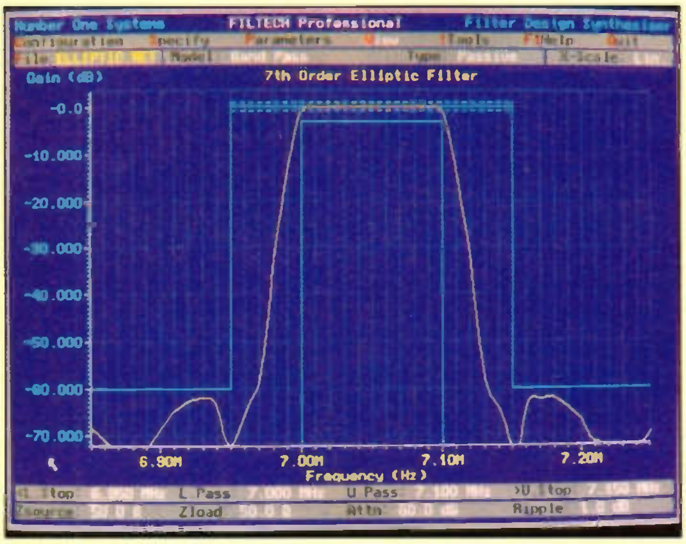
A girls' school which topped the country's league tables for truancy is installing a £25,000 video security system to keep an eye on its pupils. Staff at Whalley Range High School for Girls in Manchester believe the electronic surveillance will catch pupils missing classes or being late for lessons. Fourteen cameras trained on exits and corridors will send pictures to a central control point monitored by staff throughout the day.

Pub Payphone Prices Criticised

Consumers are paying too much to use payphones in pubs and garages, said Nigel Griffiths, Labour consumers spokesman. He claimed in a speech last month that many private payphones were fixed so that users paid as much as £1 for a call that should cost 30p.

CD-ROM Takes to the Road

A PC Card CD-ROM has been launched by Grey Cell in the UK. With a price tag of £350 the device enables CD-ROM software to be used with portable PCs equipped with a PC Card slot.
Contact: Grey Cell Systems, Tel: (0171) 831 4889.



Advanced Filter Circuit Synthesis

Filter design is perhaps the most taxing area of analogue design. Even in the UK, analogue engineers are held in high regard and are often paid considerably more than their digital counterparts. But with a new software package from Number One Systems, this could all change.

Given a frequency response and input impedance, FILTECH Professional will produce a complete design for either an active or passive filter circuit. Except it is not quite that simple. FILTECH Professional does not do away with the engineer completely, but removes the tedious and repetitive calculations, leaving the designer free to experiment.

Contact: Number One Systems, Tel: (01480) 461778.

New Chip Enables Collaborative PC Working

Voice and data over a single telephone line is enabled by a new chip set announced by Telecom Design Communications.

The Digital SVD chipset produced by Rockwell enables PC users to exchange voice and data over the phone line, in compliance with the recently developed Digital SVD Protocol Specification industry standard.

The digital SVD specification was developed by PC and modem manufacturers in order to eliminate the need for two phone lines when using collaborative PC applications such as personal conferencing.

Contact: Telecom Design Communications, Tel: (01256) 332800.

Solar Mower on Show at Chelsea

Visitors to the Chelsea Flower Show back in May were intrigued by the world's first solar-powered lawn mower, which navigates a lawn, cutting on its way without human guidance.

The mower moves around in a random pattern, using a microprocessor and sensors to prevent it from bumping into things. Sensing the lawn edges, the machine reverses and heads off in a different direction.

While the mower will operate under minimal light conditions, if the sun isn't bright enough to power the mower's internal cells, it stops and waits until they have been refreshed.

The solar mower which is not yet commercially available in the UK is expected to cost around £2,000 according to its manufacturers Husqvarna.

PC Audio Frequency Measurement

Liberty Audiosuite is an audio measurement and analysis software package that works with sound-cards based on the ADSP2115 DSP. Launched at the beginning of the month, the package is capable of measuring frequency response, time domain responses, impedances, spectra, distortion, anechoic behaviour, room acoustics and a wide variety of other characteristics of both audio frequency electronics and loudspeakers.

The system provides a choice of 14 different sample rates from 5·5 to 48kHz with MLS/FFT and sinewave capability up to 16,384 data points. Instruments included within the Liberty Audiosuite range from a distortion analyser to a dual-channel oscilloscope, and from a sinewave function analyser to a MLS-based FFT network and acoustic analyser.

Liberty Audiosuite costs £269, and requires a 386 PC, 4M-byte memory and a ADSP2115 DSP-based sound-card. Complete plug and go systems, which include a sound-card, start from £425.

Contact: Marton Music, Tel: (01282) 773198.

Mobile Giveaway

Demonstrating that mobile phones have become a consumer commodity, Logitech is giving away a Mitsubishi device together with airtime connection with every Logitech product sold throughout the Summer.
Contact: Logitech, Tel: (01334) 894 301.

Lottery Computer Aids Winners

A pocket computer, said to have won millions for lottery punters abroad, went on sale in the UK this month. Loto-Master has been a huge sales success since Quebec-based electronics genius Alex Moosz and a team of engineers spent 14 months developing it five years ago.

Isle of Wight-based DKS Distribution has bought the UK rights to the computer. Loto-Master, which will sell for £24.99, is programmed to organise a lottery player's favourite numbers into a spread of combinations to bring down multiple-number betting to an affordable cost.

Contact: DKS Distribution, Tel: (01983) 884654.

In and Out Service for Photographers

Photographic manipulation software such as Paint Shop Pro and Adobe Photoshop are fantastic pieces of software, but the final result depends very heavily on the quality of input and output facilities.

This is why a company called Colab is offering to scan images up to A3 size, or from transparencies, negatives or prints, leaving photographers free to work on the image on PC or Macintosh.

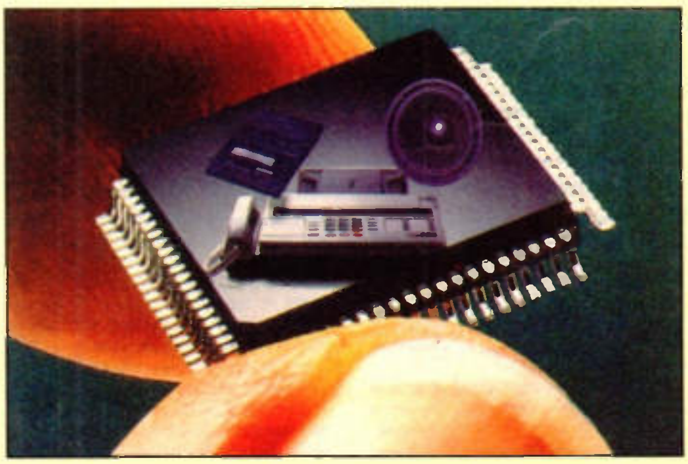
According to Colab's technical director, Robin Hartley, "Computers are becoming as much a part of the professional's toolbox as cameras and darkroom equipment."

The drawback is that few photographers can afford the investment in a high quality scanner, computer and associated software, together with a suitable colour printer.

Scans are supplied on disk or Syquest, and accepted in the same format for outputting. The cost of an output depends on the quantity, together with the format required.

For accurate cost information, contact your nearest Colab branch in Coventry, Wolverhampton, Birmingham, Cheltenham, Cardiff, Nottingham, Oxford or Peterborough.

Contact: Colab, Tel: (01203) 440 404.



E-mail for the ThinkPad

Lotus has developed an electronic mail package called Lotus cc: Mail which will be preloaded on all IBM ThinkPad computers. Through the IBM Global Network Service, ThinkPad users will be able to send e-mail messages around the world to the 90 countries with coverage. Contact: IBM, Tel: (01705) 561 780.

PC Card and Floppy Slots

The SwapBox Floppy Combo launched by SCM Microsystems combines a PC Card socket and floppy disk drive unit. This offers users a means of expanding storage, communication and networking capabilities of their PCs by providing full PC Card functionality.

The Floppy Combo SwapBox is the first product to combine a PC Card socket and 3·5in. floppy drive in the space of a standard 3·5in. bay, eliminating the need to use an additional bay for PC Card support.

The SwapBox floppy combo is available from International Microtech, SCM's UK representative priced £175. Contact: International Microtech, Tel: (01793) 784480.

Electric Vehicles on the Up

At least one million electric passenger vehicles will be in use worldwide by the end of the decade according to the industry consultancy BIS Strategic Decisions. The market growth will be fuelled by technological advancements in the storage capacity of rechargeable batteries.
Contact: BIS Strategic Decisions, Tel: 01582 405 678.

World's Fastest 1M-byte SRAMs

It is no good having a super fast microprocessor if your memory cannot keep pace. That is why the research guys at IBM have developed the world's fastest commercial CMOS based chip, enabling memory speeds down to 2·5 nano-seconds.

IBM's one-megabit synchronous static random access memory (SRAM) chips are designed for PowerPC and other high performance RISC based servers and workstations with clock speeds up to 200MHz.
Contact: IBM, Tel: (01705) 561 780.

Hitachi Move into PDA Market

Playing catch-up with Sharp and Toshiba, Hitachi is to introduce its own Personal Digital Assistant (PDA) in Japan this Autumn. The PDA will allow users to transfer data to and from PCs, while also enabling control of full remote control of an office based PC over ISDN.

Hitachi plans to use its own 32-bit SH microprocessor as the engine in the new PDA. The SH2 launched earlier this year has already been designed into the Saturn video games machine.

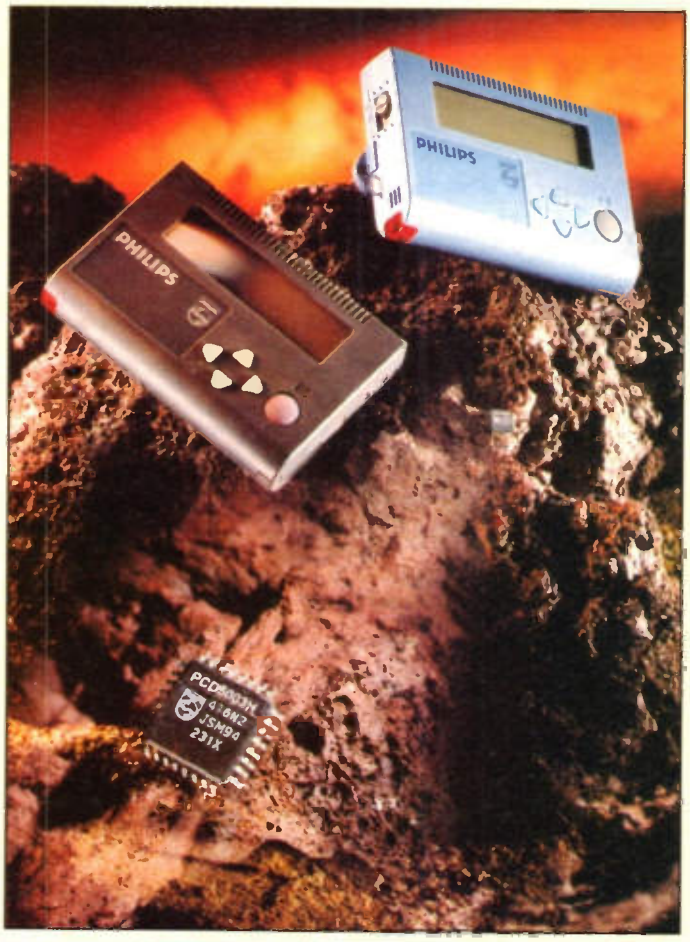
Hitachi expects to make several thousand PDAs a month at its plant in Ibaraki, Japan. The PDA is expected to retail for around US$600, comparable with the Sharp PDA portfolio.

Philips PSCSAG Decoder Enables 2400 Baud

The PCD5003 Advanced POCSAG Decoder from Philips Semiconductors requires the mere addition of a low-cost 76·8kHz crystal to support 512, 1200 and 2400 baud data transmissions. This makes it ideally suitable for the latest generation of lightweight radio pagers and personal organisers.

Featuring operation at supply voltages down to 1·5V, low overall power consumption and integral power management facilities, the PCD5003 significantly extends the pager's battery life. The ability to reprogram its on-chip EEPROM at supply voltages as low as 2·5V would enable a pager to be programmed over the air.

Advanced decoder features such as built-in digital noise filtering, 2-bit random and option 4-bit burst address error correction, plus Philips' patented Access synchronization algorithm will ensure that messages are received securely, even under fading RF signal conditions. Contact: Philips Semiconductors, Tel: +31 40 72 20 91.



Fax Software Available on CD-ROM

Delrina Corporation has announced the availability of two new CD-ROM based bundles of its market leading WinFax PRO and Communications Suite.

WinFax PRO 4.0 CD includes the world's best selling fax software for Windows, plus two thousand ClickArt images, from T/Maker Company, that can be used to enhance fax cover pages, and Pro CD Fax Book from Pro CD, Inc., a listing of over 100,000 published business fax numbers for companies in the United States and Canada.

In addition, Delrina is including Cover Your Fax I and II, a collection of over 200 humorous and effective fax cover pages. With more than half of all new personal computers shipping with a CD-ROM drive, Delrina has had phenomenal demand from customers to offer its mainstream business products on CD-ROM.
Contact: Delrina, Tel: (0181) 207 3163.

HP Gets in Bed with AMD

Hewlett-Packard and Advanced Micro Devices (AMD) are getting together to develop chip sets for pocket computers and PDAs based on the Intel 386 core. It is thought that the 486 core will not be suitable for embedding in such chip sets because of their size until 0·35 micron processes become the norm.

Tune Up Your Windows

If you feel you are not getting the best out of Windows on your PC, Win-Tuner may be able to help. The program, price £19.99 from Kimberly Computer Services, runs a 17-stage test to suggest improvements for your system. Contact: Kimberly Computer Services, Tel: (01942) 677 777.

CTI Solution Enables Isochronous Ethernet and SCSA Model

More partnerships. This time it is National Semiconductor that is getting into bed with Dialogic. The pair plan to develop an adaptor card which will connect the modular Signal Computing System Architecture (SCSA) used in computer telephony hardware to isochronous Ethernet (IsoEthernet).

Why the connection? IsoEthernet is a handy scalable solution for real-time communications. Linking computer telephony services across IsoEthernet will effect evolution applications, providing increased bandwidth and flexibility for existing Computer Telephony Integration (CTI) applications. This is likely to further the cause of video-conferencing technology and other advanced telephony services.

IsoEthernet enables real-time Interactive communications from basic voice to high quality H.320 video. It combines time-sensitive, real-time interactive data, video and telephony applications with all packet LAN applications. The technology provides 96 ISDN channels on the standard 10Base-T Ethernet channel, and has been standardised by the IEEE 802.9a committee.

SCSA is a set of open standard specifications started by Dialogic and supported by more than 260 countries. The SCSA hardware enables telephony products from different manufacturers to be integrated.
Contact: Dialogic, Tel: +32 2 725 0890.

Rural Schools Pioneer Technology Links

BT's video-conferencing technology is being used to bring together children in some of the UK's most remote schools. The initiative, announced by BT, Olivetti and Strathclyde Regional Council will link 40 schools in Argyll and Bute, including the inner Hebridean islands. Some schools are so remote that they only have two teachers, with classes made up of pupils from five to twelve years old. The project will allow pupils to link up with others of their own age, in distant schools, to participate in lessons specifically designed for their own age group.

The schools will use PC Videophones consisting of PCs fitted with BT's VC8000 communications card, Olivetti Personal Communication Computer PCC) Software and a tiny video camera. High quality moving images, pictures, voice and data are transmitted at high speeds between the schools using BT's ISDN2 network.

The pilot classroom application using the PC Videophone has been developed through on-site testing at selected schools over the last six months. As a result the full curriculum will be available to students in 40 schools throughout the Strathclyde region, regardless of their location. The pilot will be extended to a further 40 schools over the next year. Contact: BT, Tel: (0171) 356 5369.

Temperature, Pressure and Flow ADC

The MAX110 and MAX111 Analogue-to-Digital Converters (ADC) from Maxim, monitor temperature, pressure and flow, without the need for external components.

The MAX111 operates from a single +5V supply, whilst the MAX110 provides analogue inputs above and below ground when operating from dual 5V supplies.

Both devices provide two high-impedance differential input channels which can be internally calibrated for offset and gain. A serial interface simplifies interconnection, board layout and isolation. Contact: Maxim, Tel: (01734) 303388.

French First to DAB

The French have got there first. According to the French Technology Press Bureau, a company called ITIS has produced the first practical implementation of Digital Audio Broadcasting (DAB).

The new suite of products spans the full range of broadcasting needs, from radio studios – Musicam source encoding and programme multiplexing – to networks – telecommunications interfaces – and transmitters – COFDM encoding.
Contact: The French Technology Press Bureau, Tel: (0171) 235 5330.

FLASH MEMORIES - WHAT ARE THEY?

by Ian Poole

Over the past few years, a new type of memory has hit the IC market. Known as flash technology, it promises to offer many advantages over the more traditional Erasable, Programmable, Read-Only Memories (EPROMs) which are firmly established in today's electronics. However, there is some doubt about whether it will live up to all its expectations, and whether it will just be a flash in the pan.

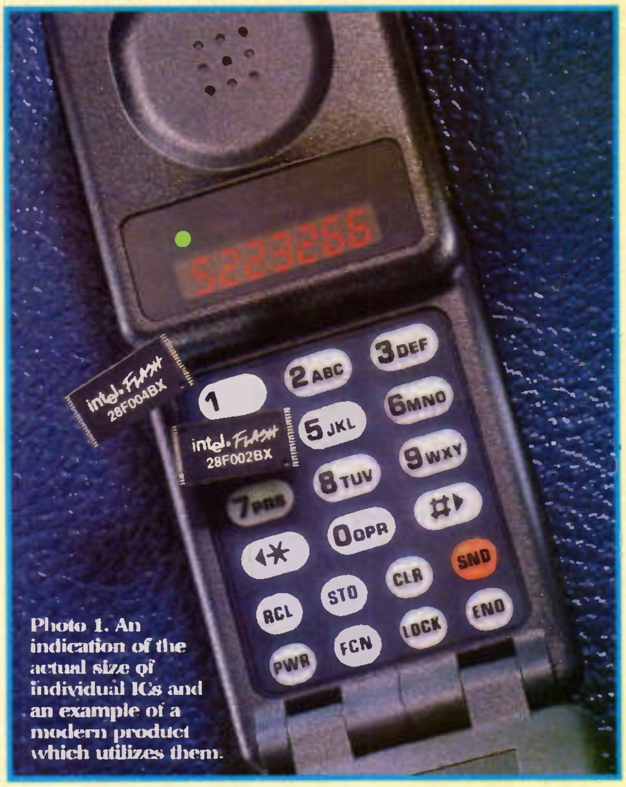


Photo 1. An indication of the actual size of individual ICs and an example of a modern product which utilizes them.

FLASH memories have been available for a number of years. Intel was one of the first companies to lead the way, taking an early decision to discontinue its EPROM manufacture. This sent shock waves through the whole of the electronics industry, and many companies found EPROMs in short supply until other manufacturers made up the shortfall in supply.

However, a company like Intel was unlikely to take such a decision lightly. Their first generation of devices ranged in density from 256K-bits through to 2M-bits, and they were rapidly adopted by the market. Flash technology continued to improve, and by 1991, Intel held 85% of the market share. Now, many more manufacturers have seen this corner of the market as being a very lucrative one. A large number of IC manufacturers have joined the flash club. AMD, Atmel, Hitachi, Fujitsu and many others are all manufacturing flash products.

Flash memories find uses in a very wide range of products. They are ideally suited to low-power applications such as notebook and portable computers, because they offer low-power consumption when compared to standard forms of memory, which they replace in a number of instances.

Not only are they finding enormous usage in computer applications, telecommunications is another large user. Cellular phones also have requirements for increasing degrees of sophistication, needing more processor control. However, this is also combined with a requirement for very low power consumption and efficient use of space. Its high density makes flash an ideal candidate for this application as well. This is particularly true for the emerging digital forms of phone system, which rely heavily on software and digital processing. Photo 1 shows an example of this.

What is Flash?

Flash is a form of non-volatile memory, which was born out of a combination of the familiar EPROM and Electrically-Erasable, Programmable Read-Only Memory (E^2PROM). In essence, it uses the same method of programming as the standard EPROM, and the erasure method of the E^2PROM. One of the main advantages of flash over EPROM is its ability to be erased electrically. However, it is not possible to erase each cell individually unless a large amount of additional circuitry is added into the chip. This would add significantly to the cost, and accordingly, most manufacturers dropped this approach in favour of a system whereby the whole chip, or a large part of it is block – or flash-erased – hence the name! Today, most chips have selective erasure, allowing parts or sectors of it to be erased. However, any erasure still means that a significant section of the chip has to be erased.

Structure and Operation

Flash is a high-density memory. This is brought about by the fact that each cell is made up from a single field effect transistor (FET), and it is very similar in structure to the ordinary EPROM as seen in Figure 1.

Each cell consists of the basic channel, with the source and drain electrodes separated by the channel about 1μm long, as shown in Figure 2. Above the channel, there is a floating gate which is separated from the channel by an exceedingly thin oxide layer, which is typically only 100Å thick. It is the quality of this layer which is crucial to the reliable operation of the memory. Above the floating gate, there is the control gate. This is used to charge up the gate capacitance during the write cycle.

In the case of traditional EPROMs, the memory can be erased by the application of UV light. To accommodate this, these chips have a translucent window which can be exposed to the UV light. However, this process takes upwards of 20 minutes. It also requires the chip to be removed from its circuit and placed in a special eraser, where the UV light can be contained.

The flash cell functions by storing charge on the floating gate. The presence of charge will then determine whether the channel will conduct or not. During the read cycle, a '1' at the output corresponds to the channel being in its low resistance, or ON state.

Programming the cell is a little more complicated, and involves a process known as hot-electron injection. When programming, the control gate is connected to an external supply voltage of 12V, as shown in Figure 3. The drain will then see a voltage of around half this value, while the source is at ground. The voltage on the control gate is coupled to the floating gate through the dielectric, raising the floating gate to the programming voltage, and inverting the channel underneath. This results in the channel electrons having a higher drift velocity and increased kinetic energy.

Collisions between the energetic electrons and the crystal lattice dissipate heat which raises the temperature of the silicon. At the programming voltage, it is found that the electrons cannot transfer their kinetic energy to the surrounding atoms fast enough, and they become 'hotter' and scatter further afield, many towards the oxide layer. These electrons overcome the 3·1eV (electron volts) needed to overcome the barrier, and they accumulate on the floating gate. As there is no way of escape, they remain there until they are removed by an erase cycle.

The erase cycle uses a process called Fowler-Nordheim tunnelling. The process is initiated by routing the programming voltage (which is normally 12V) to the source, grounding the control gate and leaving the drain floating, as shown in Figure 4. In this condition, electrons are attracted towards the source and they tunnel off the floating gate, passing through the thin oxide layer. This leaves the floating gate devoid of charge. Generally, the erase process is only made to last a few milliseconds. When complete, all the cells in the block are checked to ensure they have been completely erased. If not, a second erase cycle is initiated.

Continued on page 67.

The 1880s are generally accepted as being the era when the power of electricity was first harnessed usefully, when energy was first available to produce heat and light in both the home and the workplace. But much happened before then, and were it not for a couple of Italians, a bit of lateral thinking and a pair of frogs legs the Electronic Revolution might never have happened.

Yesterday's Electricity and the Creative Thinkers

by Stephen Waddington

In the February Issue (No. 86), Ian Poole outlined the early beginnings of the science we now call Electronics, before detailing the journey that led to modern-day technology such as microprocessors and very large scale integrated (VLSI) circuits. Here, we are going to hang out for a while in those early days and dabble amongst the work and minds of our forefathers, when electricity was not so much a science, but a philosophy, studied by artists and scientists alike.

Back in the early seventeenth century, the study of electricity was a glamorous and well-respected occupation, a chasm apart from the oily-rag reputation of electrical engineering as we know it today. Scientists were ingenious, almost magical people who followed impulsive ideas in the chase to discover an unchartered aspect of their field.

Greeks and the Concept of Charge

There is nothing new about electricity, it has always existed, waiting for human beings to catch on to its value. It was first discovered around 600BC, when the Greeks determined that certain substances attracted each other when rubbed. Even today, children are introduced to the concept of electrical charge through electrostatic experiments, similar in principle to the exploits of the early pioneers.

Thales is often counted as one of the first scientists, after he investigated the characteristics of amber. He noted that the properties were similar to magnetism, but could not work out how or why. Thales was born in Miletus, his precise date of birth being unknown, but the peak of his activity is dated as 585BC, the year in which he correctly predicted an eclipse of the sun.

After the findings of the early Greeks, little happened in scientific terms for a couple of thousand years. In fact, it was not until the sixteenth century that scientists first observed and quantified electrical phenomena within a laboratory.

Gilbert, Magnetism and Static

In 1570, the English scientist William Gilbert (1544-1603) studied magnetism, along with the corresponding attraction of amber and a variety of precious metals.

Gilbert published his work in the field of magnetism in 1600, in a book called *Concerning Magnetism, Magnetic Bodies and the Great Magnet Earth*. The volume, a copy of which may be consulted at the library of the London Science Museum, was welcomed as being revolutionary by the scientists of the day, including Galileo, who considered Gilbert to be the principle founder of the ex-perimental method – before the likes of Francis Bacon and Isaac Newton.

Not only did Gilbert disprove conclusively, many of the popular inaccurate beliefs about magnetism, he also outlined several new laws, such as those of attraction and repulsion. From his studies of the

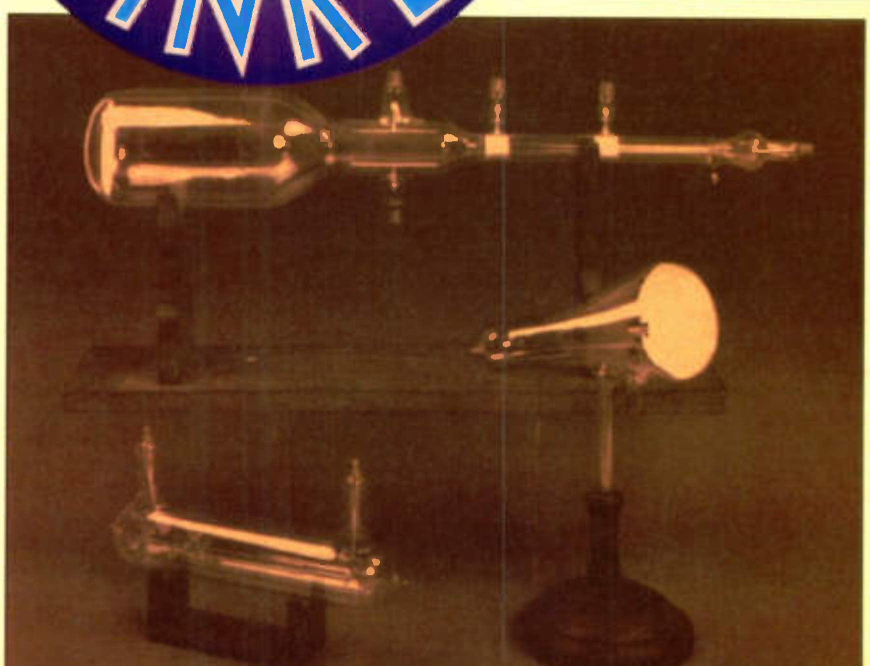


Photo 1. Crookes' tubes, used to examine cathode rays in a variety of configurations and gas pressures.

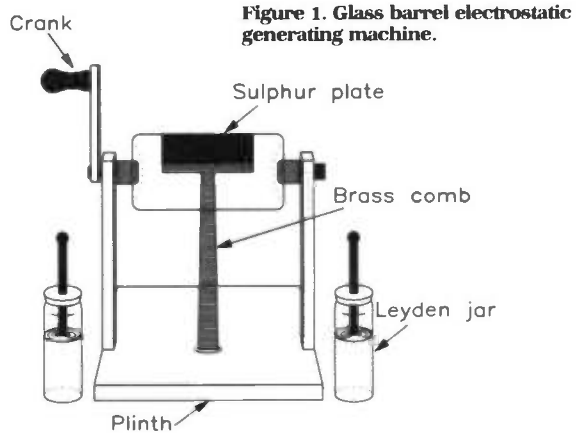


Figure 1. Glass barrel electrostatic generating machine.

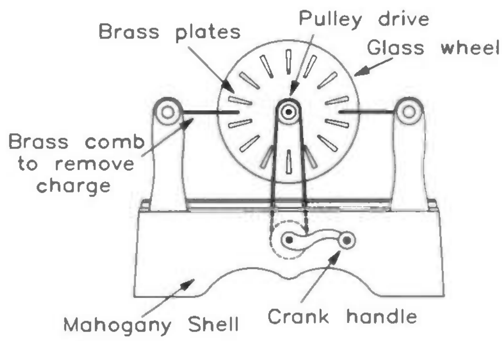


Figure 2. Wimshurst electrostatic friction machine – electricity is drawn off into Leyden jars by a brass comb.

behaviour of small magnets, Gilbert concluded that the Earth itself acts as a giant bar magnet, with a magnetic pole close to each geographical pole. So extensive were his investigations, that it was not until Sturgeon made the first electromagnet in 1825, and Michael Faraday began studies shortly after, that fresh insight was added to the subject.

Gilbert also investigated static electricity. The ancient Greeks had already discovered that amber, when rubbed with silk, attracted light objects, but Gilbert demonstrated that other substances exhibit the same effect, and that the magnitude of the effect is approximately proportional to the area rubbed. He also modified the Greek and Latin terms for amber to produce the English word 'electric', to clearly differentiate between magnetic and electrical attraction, ultimately leading to the concept of electrical charge. In 1650, half a century after Gilbert's principal work, the term 'electricity' entered the English language, used originally to describe the force of attraction.

Generating Machines

In the same year, German scientist Otto von Guericke developed a method for generating electricity in greater quantities than was possible with a piece of amber and a few precious metals. Using sulphur instead of amber as an electrostatic substance, Von Guericke produced an early generating machine. By fixing a spherical ball of sulphur to a shaft, he was able to rotate it against a fixed metallic bracket to produce a continual rubbing action.

Operated at high speeds, von Guericke's machine produced electricity, evident from evanescent sparks of light that originated from the interface between the metal plate and the rotating sulphur ball. Almost overnight, the study of this new science became the vogue. Scientists the world over focused efforts on the generation and storage of electrical charge, for practical gain.

Charge Storage

In 1745, scientists in Leyden, Netherlands, concluded that electricity could be stored in water within a glass jar, conducted in and out by using metallic wires. Leyden jars can be considered as primitive capacitors, with the water acting as a dielectric. In its early form, the Leyden jar consisted of a cylindrical glass container part-filled with water. The top end was closed with a cork, and a conductor passed through the cork into the water, with a charge being applied to the protruding nail from a friction generator. Once the electrostatic source was removed, the jar retained its charge, resulting in a shock for anyone that touched it. Some terrific shocks resulted, and according to nineteenth century texts, Leyden jars became as popular in the parlour as in the laboratory. Modern versions, often used in high school physics experiments, are somewhat different in construction, opting for a metallic instead of water dielectric, but the basic principle remains the same.

Developments from von Guericke included glass barrel machines fitted with sulphur friction pads which rubbed against a brass column as shown in Figure 1. More powerful versions were produced over a time, perhaps the most impressive being the Wimshurst-pattern electrostatic friction machine of 1876. Incorporating rotating glass plates with brass-mounted inserts and sulphur brushes, the machines were employed during the First World War to generate in excess of half a million volts to produce X-rays. A brass comb ensured that electricity could be drawn off into Leyden jars as shown in Figure 2, as the crank handle was rotated.

No-one knew what electricity was back in the eighteenth century, and it was not even clear then whether there was one type or two. As a popular diarist of the time recorded; "different electrics attracted and repelled different substances although the shocks appear to be the same".

It was by accident that a scientist in Italy, Luigi Galvani, found that severed frogs legs twitched in response to applied electricity. He also found that they responded in the same way if they were then touched by a piece of metal that was uncharged. This, coupled with the fact that human beings were also susceptible to electric shocks, indicated that electricity must have a role in the function of living organisms.

We leave it to readers to ponder on how Galvani happened to be experimenting with frogs legs in his laboratory, and what then possessed him to bring electricity into the equation. Historical references report that Galvani's interests were based on the study of the nerve structure within animals.

Early Batteries

Around the same time, another Italian, Alessandro Volta, who unlike Galvani had been consciously experimenting with electricity, found he could generate an electrical charge from a chemical reaction. He built an experimental apparatus known as the voltaic pile, comprising of plates of copper and zinc in a solution of dilute sulphuric acid, which for the first time ever, produced electricity without the need for a rubbing action.

In time, it was proved that almost any two differing metals could be used in an acid solution to form a cell, and Volta's work soon caught on. It was not long before the likes of Pappendoff, Daniell and Leclanché worked to optimise the metals used and the construction of the cell, to produce versions with improved charge capacity.

Daniell sought to improve the useful lifetime of Volta's original cell. He determined that the reason for the current diminishing rapidly was because of an effect called polarization, whereby hydrogen bubbles collect on the copper electrode, increasing the internal resistance of the cell. In 1836, Daniell proposed a new type of cell, consisting of a copper anode plate immersed in a saturated solution of copper sulphate separated by a porous barrier. The barrier prevents the mechanical mixing of solutions,

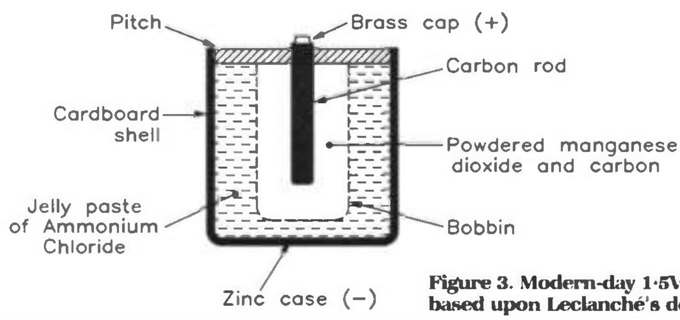


Figure 3. Modern-day 1·5V dry cell, based upon Leclanché's design.

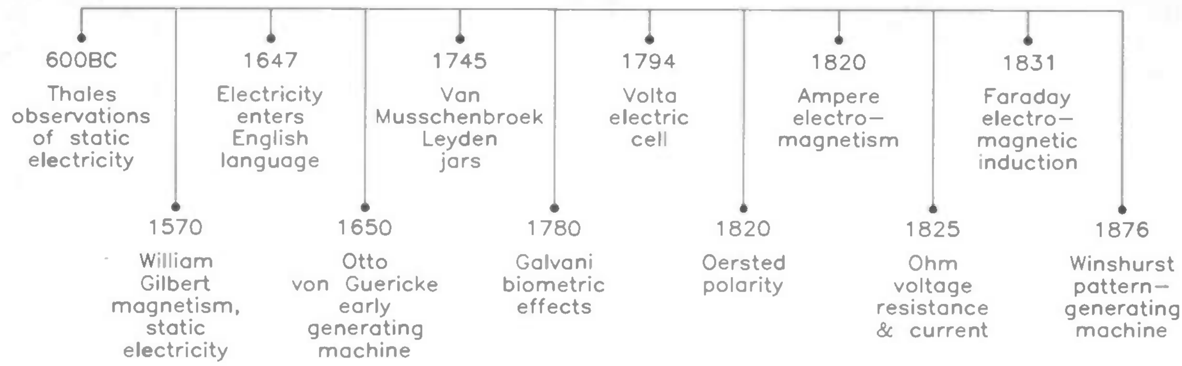


Figure 4. Historical time-line, illustrating significant events in the history of electronics.

Photo 2. A Crookes' tube, consisting of a flower painted with a variety of mineral dusts.

Photo 3. Mahogany-cased voltmeter and ammeter.

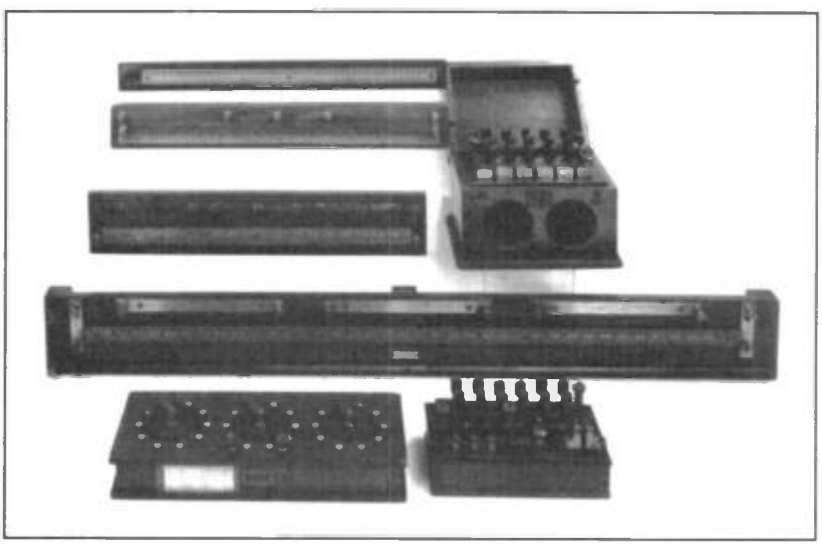


Photo 4. Substitution boxes from the nineteenth century.

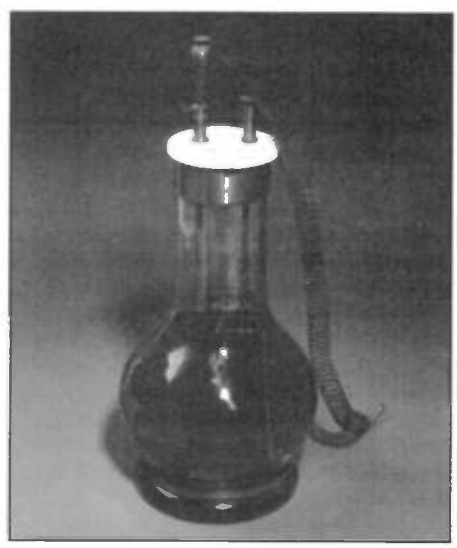


Photo 5. Pappendoff batteries.

while allowing the passage of charged ions.

When the current flows, zinc combines with the sulphuric acid, freeing positively-charged hydrogen ions as they pass through the barrier to the copper plate. Here, they loose their charge and combine with copper sulphate, forming sulphuric acid, and depositing copper onto the plate. Negatively-charged sulphate ions pass in the opposite direction, reacting with zinc to form zinc sulphate. Consequently, no gases evolve at the electrodes, and a constant current results. Daniell's cell stimulated further research into electricity and was later used as the basis of the method for electroplating.

At the time Leclanché's design was revolutionary, and even today, forms the basis of the primary 1·5V dry cell as shown in Figure 3. Here, Leclanché used a positive pole of carbon, together with a negative of zinc. These were placed in an electrolyte of ammonium chloride, with a depolarizing combination of powered manganese dioxide and carbon in a porous pot. While keeping the depolarizing mixture packed round the carbon rod, the porous pot allows ions to pass to the zinc rod.

It is at this point in history that conventional historical texts go on to describe the work of Ampère, Faraday, Ohm, Wheatstone and Stokes. While that has value – please don't get me wrong; if it were not for Faraday I would be out of a job – we are instead going to leap off at a tangent, and look at the work of a lesser-known scientist. If you are unsure of the logical progression, consult the time line given in Figure 4.

Crookes and Vacuum Tubes

William Crookes is an unsung character of the time, which is odd, since many of his instruments remain in use today. An active physicist, Crookes was the first to produce a vacuum greater than one millionth of atmosphere. As a result, he investigated the action of cathode rays in a vacuum (whilst remaining outside of the vacuum himself!), and suggested that the electrical discharge in an evaporated tube was an illumination of the lines of molecular pressures.

Crookes produced special tubes such as those shown in Photo 1 to examine cathode rays in a variety of configurations and gas pressures, and was one of the first to investigate the effect of magnetic fields on cathode rays – work that ultimately led to the development of the cathode ray tube used in televisions.

Exactly how Crookes manufactured the intricate tubes to such a high specification is today a mystery and surviving examples are extremely rare. To the indifferent observer, Crookes' tubes are often regarded as works of art, rather than items of electrical science. An aesthetically pleasing example is shown in Photo 2, which consists of a flower painted with a variety of mineral dusts, each of which fluoresces differently when bombarded with electrons, to produce a beautiful shimmering effect.

Style

But then, scientists of the day had style; there were no breadboard experiments or tobacco tin mock-ups. Instead, electrical and indeed electronic equipment, was constructed from the finest materials. Photo 3 shows an ammeter encased in mahogany, complete with matching voltmeter from Crookes' era. Attention to detail was important to the latter day scientist. Even resistance and capacitance substitution boxes, shown in Photo 4, were mahogany cased and finished with brass fixings.

While experimenting with radium, Crookes devised the Spinthariscope, an instrument for detecting radioactive alpha particles. The instrument consisted of a screen coated with zinc sulphide at the end of a tube fitted with a low-powered lens. When alpha particles, emitted from a radioactive source such as radium, hit the screen, they produce a small flash of intense light.

Perhaps the reason for Crookes' apparent lack of recognition is that his interests were far too wide. Topics covered in his published scientific papers range from chemical analysis to the manufacturing of sugar beet, and from the dyeing and printing of textiles, to the use of artificial fertilisers and their manufacture from atmospheric nitrogen.Crookes was never afraid of pursuing an idea counter to the trend of scientific opinion.

I believe we have much to learn from Crookes' approach. While a degree of focus is essential to ensure tasks are completed, an open-minded approach to unconventional ideas is also important. If like Galvani, you have a notion of an experiment, give it a try (keeping safety in mind!). Perhaps you are wondering how an operational amplifier might function if you add an unusual form of feedback loop, or how an LC filter will perform if you use a different type of capacitor. Give it a try – and if something unpredictable happens, write in and let us know.

Christie's Sale

In 1991, a sale at London auctioneers Christies, provided a rare glimpse at some of the apparatus and instruments designed and utilised by the early electrical pioneers. The Nicholas Webster collection, consisted of several hundred pieces of scientific equipment, discharge tubes and early electrical components.

Nicholas Webster was born in Birmingham, and became preoccupied with science during his years at Bishop Vesey's Grammar School in Sutton Coldfield. Employment with Griffin & George, manufacturers of experimental apparatus, fuelled his interest in scientific and philosophical instruments, and their use in education and research.

Boasting an expert standing in a wide array of disciplines, Christies is supported by a circle of historical specialists. Consequently, when Nicholas Webster decided that his collection was becoming a liability, he sought the guidance of Christies' Jeremy Collins, an authority on scientific instruments.

Commanding prices from hundreds of pounds, to several thousands, the six hundred or so items ranged from Wimshurst generators to Pappedoff batteries, as shown in Photo 5, and from the classic Maltese tube shown in Photo 1, to more elegant phosphorescent devices from Crookes' era. E

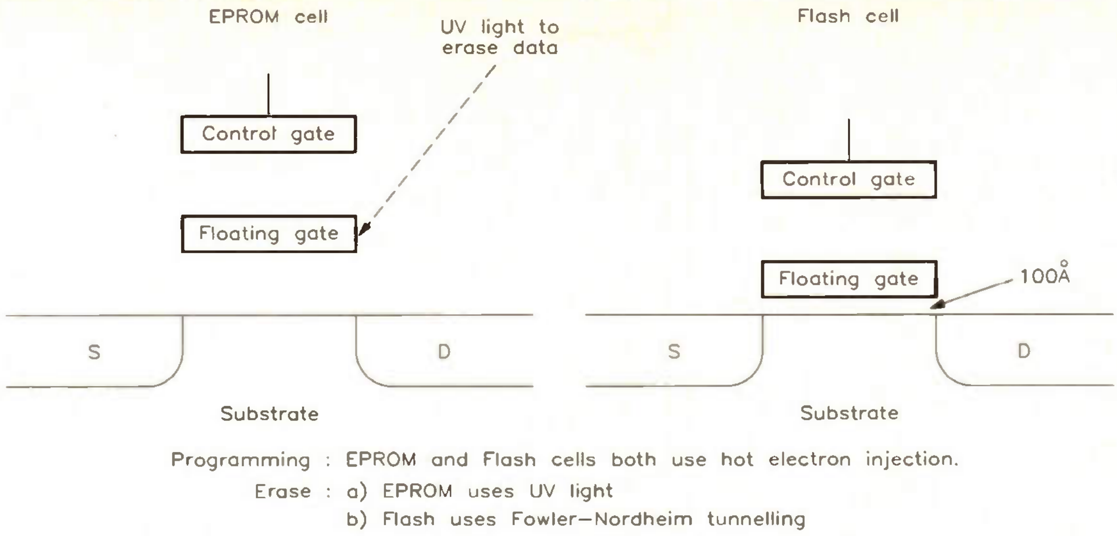


Figure 1. Comparison between EPROM and Flash cells.

Write Erase Cycles

In the early days of flash memories, one of the limiting factors in their uptake was the limited number of erase program cycles. This was caused by the destructive breakdown of the thin gate oxide layer. Some of the early examples of flash memories only had a few hundred cycles. Now the technology is vastly improved, and manufacturers are happily quoting figures in excess of 100,000 cycles, and some, around 1,000,000 cycles.

Most of the improvement has been brought about by improving the quality of the oxide layer. When samples of flash chips are found to have a lower lifetime, it is usually caused by the manufacturing process not being optimised for the oxide growth. Now, major efforts are being placed into improving the quality of the oxide, to improve the reliability and lifetime still further.

Replacement for EPROM

One of the first uses for flash memories was as a replacement for the traditional EPROM. This device has been with us for many years, and is the mainstay of embedded software. Whilst some high-volume products use Read-Only Memories (ROMs), many more use EPROMs which can be reprogrammed if any software bugs are found or other improvements need doing. Any alterations like these would render the preprogrammed ROMs useless.

Flash is now entering this market, and many people are considering using them in their mainline products for holding the embedded software. It has a number of advantages. In the first instance, it is not necessary to take the chip out of circuit. It can be reprogrammed whilst on the board, if a suitable connection is available. It is also easier to reprogram. Previously, EPROMs had to be placed under a special UV light source for twenty minutes or more. Reprogramming could then take a few minutes, depending upon the size of the memory.

Flash chips can be erased in an instant, and then reprogramming is much faster than their EPROM counterparts. Although flash chips are a little more expensive, their

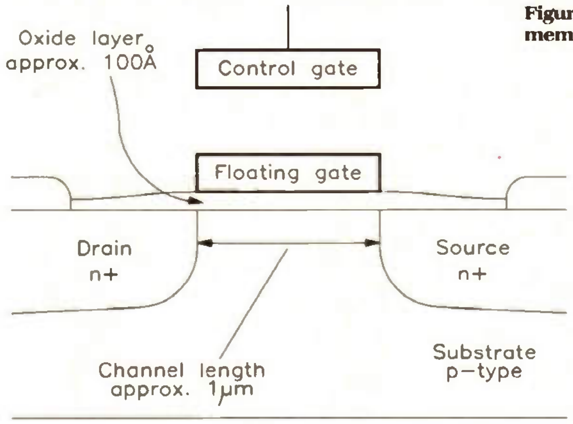


Figure 2. Basic Flash memory cell.

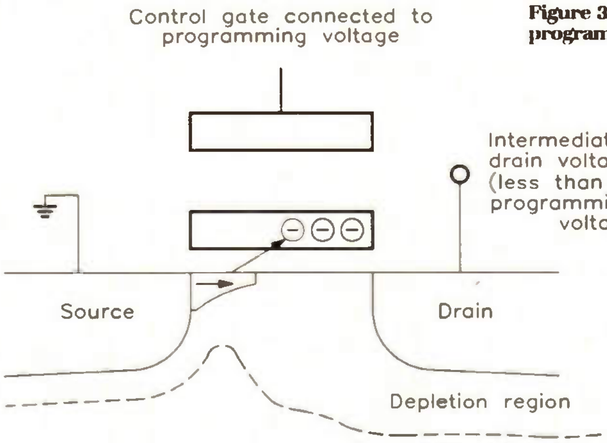
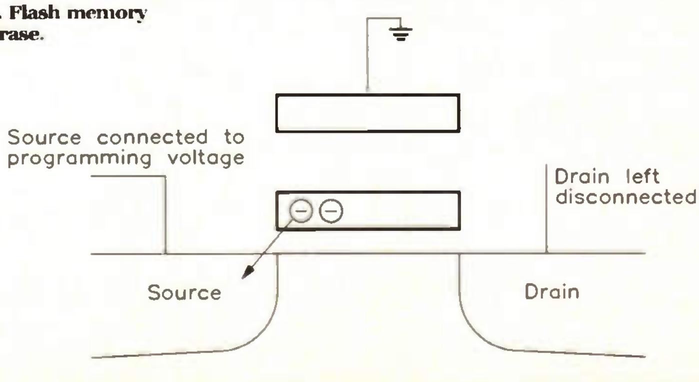


Figure 3. Flash memory programming cycle.

Figure 4. Flash memory during erase.



prices are falling with the aggressive marketing techniques of the large companies. This makes flash an even more attractive proposition for the designer, especially when the reprogramming time for EPROMs is taken into consideration.

Microcontrollers get Flash

Flash memories are not just used on their own. Manufacturers are starting to include them onto the same chips as microprocessors. Processors with EPROM memory or microcontrollers have been available for a number of years. This approach has the advantage that the chip count and size can be reduced, saving time and money.

However, putting flash memory onto a processor chip is not an easy or cheap option at the moment. It requires extra stages in the fabrication process. This obviously costs more in terms of the additional processes which need to be undertaken, and it adds a further cost penalty because of the reduction in yield. Consequently, prices are still relatively high, and the more sophisticated flash controllers are only being used by those who can afford the prices. Car manufacturers, including Aston Martin and BMW, are some of the first users of these products.

Even so, there is a healthy interest in the less powerful options. Already, the portable 'phone market is showing a growing demand for four and eight bit controllers with onboard flash memories. These are undoubtedly not the only requirements. Many more users are looking into the use of flash microcontrollers, especially if the price can be brought down to suitable levels. This will force down prices, and enable their usage to become far more widespread.

Flash Drives

In another use, flash memory modules are emerging as a compact and rugged alternative to disk drives. Some credit card-sized flash memory modules are now being marketed, which can hold several Megabytes, an example of which is shown in Photo 2. The absence of any moving parts make them faster and more rugged than any of the existing rotating drives. However, at the moment, the higher capacity flash drives are more expensive than their traditional mechanical counterparts, around twice to three times the cost for 20M-byte units. Consequently, flash drives are not taking over the whole market, being used mainly in notebook and palm-top computers, as depicted in Photo 3. Despite this, there is still a very significant market which they are starting to dominate, and it is expected that they will make inroads into the more traditional disk drive areas before too long.

In converting to a flash drive, it must be remembered that there are a number of significant differences when compared to ordinary drives. To overcome these, the controller software in the computer must take account of this. In the first instance, flash memories have to be erased in relatively large blocks. Typically, flash ICs have erase blocks varying from 512 bytes right up to 64K-bytes. It is also found that an instruction to write or erase a cell may not be complete until the command has been issued a number of times. This means that the software has to be capable of detecting this, and repeating the operation until all is correct.

A further difference is the limited number of write/erase cycles each location in the memory can endure. If the flash drive were treated as a normal memory, certain areas would quickly become unreliable because a few areas would be used far more than others. To overcome this, the controller software tries to even out the storage of new data, so that all areas of the memory are used equally in a process called wear levelling. Software is also able to detect those cells or areas which are not reliable or fully functional, and prevent any data from being written to them.

It should be remembered that ordinary mechanical disk drives have a finite life. With the wear levelling techniques incorporated in the controller software, the flash memory is very reliable, and in many instances, will exceed that of a mechanical drive. To put the reliability of a flash memory into perspective, it would take in excess of 10,000 hours (or just over thirteen months) to cycle an Intel 28F016SA (32 blocks of 64K-byte blocks) 1,000,000 times assuming it was continually erased and then rewritten. The device is specified as being able to withstand over 1,000,000 block erase cycles, provided wear levelling concepts are used.

In another development, a company called Oki have announced that they are pioneering a system of only reprogramming those locations in which the data needs to be changed. In other words, if a sequence of '0111' needs to replace '1110', only the bits at either end would need to be changed. However, it is not clear how this can be done, and the company have not released details of how they are able to achieve it, at least until the patents have been firmly filed.

Despite the current difficulties with flash technology, many manufacturers are pressing ahead with their use and manufacture. For their main use in small portable computers, their size and ruggedness are their chief advantages. As an example, a flash drive may only weigh half that of a traditional drive, and it will withstand far more rough handling, especially when in operation. Mechanical drives rely on the heads flying exceedingly close to the disk surface. This is clearly not possible when the computer is being knocked and jolted. On the other hand, a flash drive can withstand just as much rough treatment as any other purely electronic assembly, whether running or switched off. As an example of the type of products available, Intel manufacture a number of cards which are designed specifically as hard drive replacements, as shown in Photo 4. They boast storage sizes of 5 and 10M-bytes, data transfer rates of 5M-bit/s,

Photo 2. Intel Flash series 2+ 40M-byte memory card.

Photo 3. Flash ICs on a palm top computer.

and 1,000G shock resistance. All this is contained in a package which weighs only 29g and is designed to have a disk compatible interface.

With advantages like these, flash is quickly gaining acceptance into the mainstream market. Whilst only a year or so ago, flash disk drives were the domain of a few specialist companies, many of the larger equipment manufacturers are now making them. Epson, and even the giant IBM, have all started to manufacture these products.

To take the idea even further, one company, called Eurom, has developed a product that they call their 'DiskOnChip'. This is a multichip module, which also contains BIOS, hardware and firmware that make the single chip emulate a conventional disk drive, with capacities from 1M-byte up to 16M-bytes.

IC Developments

Development of flash memories is, naturally, progressing very rapidly at the moment, with the enormous possibilities for the use of these chips. One of the most pressing requirements is to increase the life. With development now under way, we should very soon see chips which can have well in excess of 1,000,000 write/erase cycles as standard.

Another problem which is encountered by flash users, is the high programming voltage. Typically, a voltage of 12V is needed, and this can be a considerable inconvenience for anyone with limited power in a portable system. New developments are looking at the possibilities of reducing the programming voltage to more reasonable levels. Other possibilities also exist, for running flash memories from the new 3·3V standard, which is establishing itself for low-power digital applications.

The other area for development is to be able to reduce the size of the blocks which have to be reprogrammed. The first flash chips required the whole of the data in the IC to be erased. Intel chips have 64K-byte erase blocks, because they maintain that the larger erase blocks result in cheaper ICs, since less additional circuitry is required. Even so, the market seems to be forcing manufacturers in the opposite direction for the convenience of only having to rewrite smaller blocks of information when only a few bytes need changing. Two companies, Sundisk and Oki, have erase blocks as small as 512 bytes, and it is likely that these figures will be even smaller before long. Perhaps single bytes could be erased before long?

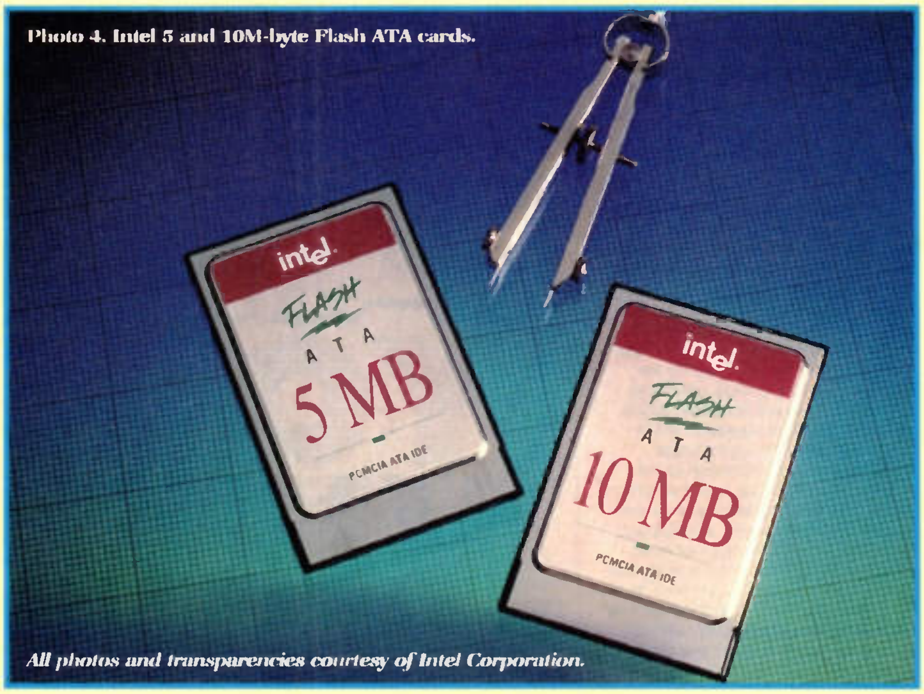


Photo 4. Intel 5 and 10M-byte Flash ATA cards.

All photos and transparencies courtesy of Intel Corporation.

Further Uses

Apart from their use as memories for computer based products, a wide number of other possibilities exist. It has even been suggested that they may be included into ASIC libraries, so that designers can put memories into their own IC designs. Even further into the future, flash technology might find its way into the world of analogue electronics. Here, the devices could be used to feed data into digital to analogue converters, allowing factory settings to be made digitally instead of by the use of trimmer potentiometers, which are notoriously troublesome.

Only time will tell if flash technology meets everyone's expectations. It is undoubtedly here to stay for many years to come, if only for the reason that many manufacturers are pushing their flash products because of their phenomenal investments. However, they do seem to be offering some very real advantages, and for this reason alone, their success seems assured. E

Glossary of Terms

ASIC	Applications-Specific Integrated Circuit
BIOS	Basic Input/Output System
EPROM	Erasable Programmable Read-Only Memory (requires exposure to UV light through a window in the IC to erase the information)
E2PROM	EEPROM Electrically Erasable, Programmable Read-Only Memory.

A readers' forum for your views and comments. If you would like to contribute, please address your replies to:

The Editor, Electronics – The Maplin Magazine P.O. Box 3, Rayleigh, Essex SS6 8LR, or send an e-mail to: AYV@maplin.demon.co.uk

Dear Editor

AIR YOUR VIEWS

Speak Up!

Dear Sir,
Firstly, I would like to congratulate you on such a great magazine – keep up the good work. I have written in because I would like to build a voice recognition system so that I could walk into a room and say "lights", and the lights would go on (à la Red Dwarf, Star Trek, etc.). It would have to consist of an EPROM which could be programmed for the necessary word or phrase using your voice. Then, a circuit is needed which, when the phrase is repeated, would match it up with the original voice pattern. If it was near enough to the original, then the circuit would switch on a triac or relay to control whatever was necessary. I have seen a few designs in books for sound- or clap-activated switches, but they could be activated by something dropping onto the floor or any loud noise, so I don't think they are very practical, and I would be very grateful if you published this letter, and really pleased if you actually came up with a design.
Oliver Lindley, Buckfastleigh, Devon.

That Sounds Familiar!

Dear Sir,
I am a 12 year old, who is very keen on electronics, and a computer addict. I think that your computer projects are great, but they all seem to be for the PC. Why don't you have some for the Amiga or other micros? A relay card would be a great start, and how about some PCB design programmes for the Amiga? I also think you should open some Maplin shops in Devon, because there aren't any. Please could you also design a circuit that could be used as a voice recognition system, and also investigate surface mount technology?
Ed Tarleton, Exeter, Devon.

What an amazing coincidence – two Devonshire folk, both requesting voice recognition systems! Such systems are now beginning to emerge for use with PCs (at a price), but a comparatively large amount of memory is required (which PCs are able to supply) to be able to record your voice, and produce an effective recognition system that takes into account a person's accent, intonation, inflexions, pitch, speed of speech, volume, etc. You have to 'teach' the computer to recognise your pronunciation of the words you wish to use. Even then, the dynamic range of contemporary systems is not particularly good, meaning that you have to speak in a closely-defined manner before the computer will recognise your voice – no use when you have a cold, for example. It would be impossible/impractical to get all of this information onto a conventional EPROM-based circuit alone – the sound bytes have to be converted into digital form, and then compressed (to save on memory space), whereupon digital signal processing (DSP) circuitry can be used to process the information. At present, this is a complicated, and expensive function to achieve. There is a good reason for most of the computer projects that appear in Electronics (and other electronics/computer publications) being for PCs, this being that these are by far, the most popular type of computer used in the home and elsewhere, so naturally, there is most demand for PC-based projects – not so long ago, it was almost exclusively BBC Micros, and ZX Spectrums that hogged the limelight! – it's all down to market forces. However, many interface boards can be modified for use with almost any computer that has 8-bit I/O ports, and the computer's operation manual will usually give information on software commands for making use of the ports. Maplin's ongoing policy of expansion means that new stores are being opened on a regular basis, and there is a possibility of one being planned for the Plymouth area. Look out for up and coming articles and projects using surface mount technology in future issues of Electronics.

S·T·A·R L·E·T·T·E·R

In this issue, Timothy Brown, Age 12, from Crawley in West Sussex, wins the Star Letter Award of a Maplin £5 Gift Token, for his letter.

Dear Editor,
I've just started buying your magazine, monthly. I have taken an interest in electronics for a long time now. I liked Bob's Mini Circuits (April 1995), because they are small and not too complicated. I also liked the Voice Vandal (May 1995). This is a bit too complicated for me to make it all, so I'm saving up to buy the kit. I enjoy the small cartoons like Life with Micro Chip and sometimes, Stray Signals. I have made a digital parallel I/O port for our Amstrad PCW computer, using buffers and latches, and connecting a speaker to it, so we can make noises. I was wondering if someone could make a circuit to improve the quality of it, as it isn't very good! I like your magazine, because it has colour pictures and you explain everything clearly. Good luck with your following issues.

Always a pleasure to hear from our younger electronics enthusiast readers, and good to hear your favourable views about the magazine. Perhaps the Star Letter prize will help boost your savings towards the Voice Vandal kit! My younger brother (Hi, Tom!) recently built one that he received for his 13th birthday, and I can reveal that he built it himself (with just a few helping hints from yours truly), and it worked first time, even though he is a comparative novice at electronics – an experienced project builder such as yourself should have no trouble making this kit! The best way of obtaining better sound quality from your interface board, would probably be to run it through a separate amplifier and larger loudspeaker (perhaps, for example, your home stereo equipment, via suitable input leads). Some form of filtering may also be a good idea, to remove annoying high-pitched clicks/hum that computers seem prone to give out – a simple low-pass RC filter, placed prior to the amplifier/speaker might do the trick.

Absolutely Chuffed!

Dear Editor,
I'm chuffed with your Chuffer (LT39N), and as for the Whistle/Horn (LT61R), it's so lifelike that everyone scampers for cover. I didn't expect the chuffer to work with my mark-space controller, as the voltage is constant to the tracks (it didn't), so envisaging some form of RC network, I put a 470Ω resistor in series with one of the track leads to the chuffer, and was pleasantly surprised when it worked, following the speed of the train perfectly. No doubt, it would work in this way with the Maplin Control-a-Train (LK64U, *Electronics*, March 1985 issue). A lot of these must have been built, as the kit is still in the current catalogue, 10 years later. I fed the chuffer, Whistle/Horn into the 1W amplifier, as suggested, and the volume was more than ample. I turned it down, following a complaint from British Rail! On the debit side, as the Whistle/Horn and amplifier has a maximum working voltage of 15V, it was a bit of a nuisance to find that the Chuffer had a *minimum* working voltage of 15V. I used a 12V sub-miniature transformer (WB02C), with a bridge rectifier and a 1,000µF electrolytic for the chuffer, which gave 15V on load, and a 9V Standard Range transformer (DH24B) with bridge and 1,000µF capacitor for the Whistle Horn and amplifier. I could have used other ways of course, but then I do everything the hard way. I have bound every copy of *Electronics* from 1984 Volume 3, and wonder why the pages of each volume cannot be numbered consecutively, as it would be a big help in finding articles, etc. One of the most useful pages in *Electronics* is the order form, but not, please, on the back of a page of text, as in the April issue! Finally, I have made the Live Wire Detector (I expect everyone in the World has by now. . .). Maybe I ought to point out that the instructions say "after fitting to the box, adjust RV1", but you cannot – there ain't no 'ole in that there PCB! There is in the Metal Detector, he whispered.
Gordon Preston, Erdington, Birmingham.

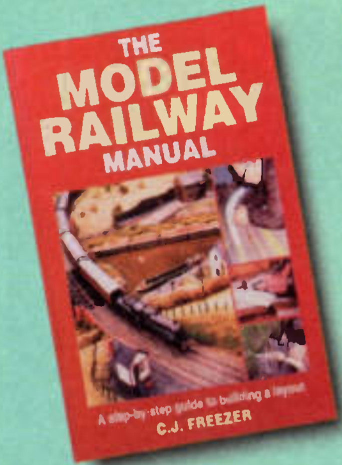
Glad to hear that you are pleased with the model train projects. Some would argue that to number the pages consecutively throughout each volume (as certain other publications do) can be rather annoying for those who prefer a more logical numerical sequence with each issue, e.g., if you know it's a 72-page issue (say) and you want to read an article on page 33, then you know to turn to roughly half way through – difficult, if the page numbers go between (say) 376 and 448, unless you're a whiz at performing calculations in your head! We generally try to keep the Order Coupon on an individual page unless space is tight as a result of us attempting to cram as much as possible into an issue! You could always take a photocopy, if you did not wish to 'lose' the page in question. Regarding the Live Wire Detector project (of a decade ago now!), well spotted, but what do you expect from what was initially, a 'free gift' PCB! And surely, having to drill an extra, unspecified hole is all part of the intrigue and fun of building up a kit, n'est-ce pas?!

Just for Starters . . .

Dear Sir,
As you are no doubt aware, but did not mention in the reply to G. A. Boyce (Air Your Views, Issue 91), the electronic type of fluorescent starter is listed in the Maplin Catalogue (RZ29G), along with the normal (glow) type (FQ07H), and these are also available from many DIY and electrical stores. The 'glow' type could be considered as being 'mechanical', as they have a moving contact, and are a later variation of the thermal starters that had a bimetal strip, operated by a heating element. The glass bulb contains a gas, which glows when a voltage is applied, and causes a bimetal strip to heat and bend, closing a pair of contacts. This then provides the circuit for the tube heaters. However, when the contacts close, the neon glow is extinguished, and the bimetal strip cools, thus opening the contacts. This closing and opening of the contacts is repeated until the tube 'strikes', and gives the prominent flickering at switch-on. When the tube is extinguished (i.e. when first switched on), there is a full 240V across the starter, but when the tube strikes, this falls to around 100V, which is insufficient to ignite the gas, so the contacts remain open. It is this repeated switching on and off of the tube heaters that helps to blacken the ends, as the heaters are often on for longer than is necessary. The electronic types provide better control, and generally far faster striking of the tube, hence the heaters are on for far less time, thus extending the tube life and reducing end blackening.
Malcolm Perry, Kidderminster, Worcester.

Thank you for your explanation of the fluorescent tube starter operation, and also to several other readers who contacted us to clarify the situation regarding these units, both types of which (normal and electronic) are indeed listed in the Catalogue – your letters have been passed on to G. A. Boyce.

All of the books featured on this page are available from Maplin Regional Stores and by Maplin Mail Order. To find your nearest Maplin Regional Store Tel: (01702) 552911 or to order call the Credit Card Hotline on Tel: (01702) 554161



The Model Railway Manual

by C. J. Freezer

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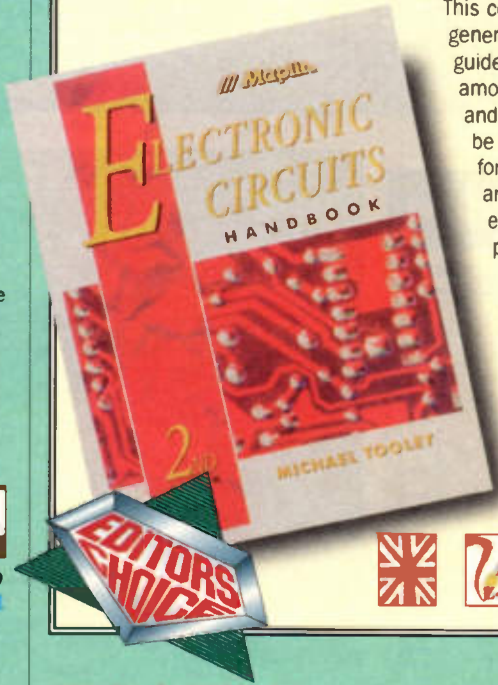
192

1994. 280 × 214mm. *Order As 90069 (Model Railway Manual) £14.99 NV A1*
Add UK carriage £1.55

MAPLIN ELECTRONIC CIRCUITS HANDBOOK 2ND EDITION

by Michael Tooley

Whether you are an electronics engineer, technician, student or simply an enthusiast working from home, the *Maplin Electronic Circuits Handbook*, written by the well-known technical author and college tutor, Michael Tooley, is the ideal book for you.
It aims to explode two common misconceptions concerning the design of electronic circuits: that only those with many years of experience should attempt to undertake circuit design, and that the process relies on the understanding and execution of advanced mathematics. Provided that one is not overly ambitious straight off, neither of these popularly held beliefs is true.
This comprehensive, generously illustrated guide provides a massive amount of information and data that will be found essential for the beginner and intermediate electronics practitioner alike.



1995. 188 × 245mm, *Order As 90072 (Maplin Elec CCTS Hbk) RRP £14.99 (For a Limited Period Only £12.95) NV A1*
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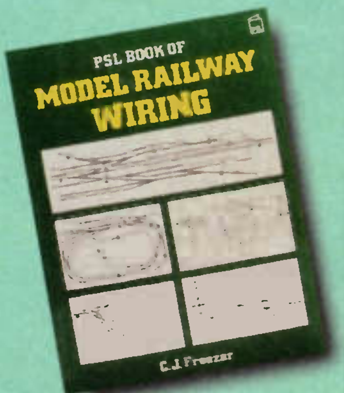
304

PSL Book Of Model Railway Wiring

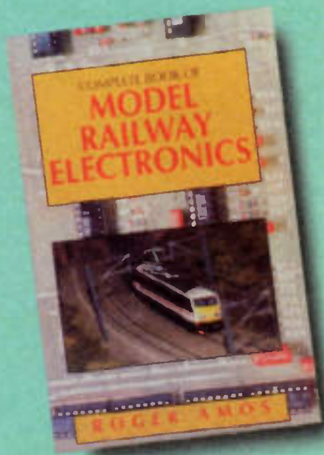
by C. J. Freezer

For the railway modeller whose aim is to achieve accurate simulation of the workings of a full-size railway system, a degree of electrical expertise is essential, yet this is perhaps the least understood aspect of the hobby. This easy-to-follow guide explains how the remote-controlled switching of the points, isolation of track sections, independent control of different locomotives, track-side lighting, cab control, etc., are all easily within the grasp of the average layman, and can be arranged simply and inexpensively, using readily available components. Even if your electrical knowledge is limited to fitting a 3-pin mains plug, this book will show you how straightforward it can be to introduce an impressive degree of sophistication and realism to your model railway, by means of a little informed track wiring.



144

1994. 238 × 179mm. *Order As 90070 (Model Railway Wiring) £7.99 NV*



Complete Book of Model Railway Electronics

by Roger Amos

Written by the author of *Practical Electronics for Railway Modellers*, which was followed by a second volume in 1985, and both books served to fuel the popularity of this branch of the hobby. This new, well illustrated and informative, up-to-date guide successfully introduces the novice electronics hobbyist and/or railway modeller to the subject of realism-enhancing electronics circuitry applications in model railways by means of a range of simple-to-build projects, which can then be followed by more advanced add-on features if it is desired. The projects deal with the basic control and detection of trains, through to logic-controlled signal systems of increasing complexity and the automatic operation of the layout, to such additional touches of realism as train and carriage lighting (including a novel method of powering the lights via the tracks but independent of the trains' power controller) and also train sound effects. The comprehensive appendices are both practical and theoretical, and the 36 projects are supported by almost 150 detailed diagrams.

255

1990. 240 × 160mm. *Order As 90071 (Model Railway Electr) £16.99 NV A1*
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