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No. 99

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Britain's Best Selling Electronics Magazine

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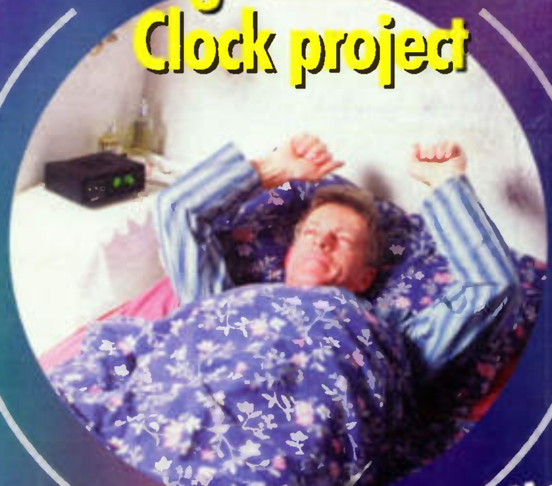

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MARCH 1996
VOL 15. No. 99

IN THIS ISSUE...

PROJECTS *FOR YOU TO BUILD!*

FEATURES *ESSENTIAL READING!*

REGULARS *NOT TO BE MISSED!*

FROM THE EDITOR . . .

Hello and welcome to this month's issue of *Electronics!* There is an intriguingly varied assortment of interesting and educational projects to read and build this month, all with different degrees of complexity. We also have informative articles on EMC and Optical Materials, and of course, all our regulars.

Competitions

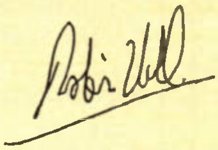
We are pleased to announce that our lucky prize winner for the BT Tower Competition is W. J. Henry BSc MBCS of Belfast in Northern Ireland. A table for two at the Top of the BT Tower has been reserved for Saturday, 20 April 1996. A long distance to travel for a meal perhaps, but then, this is a rather exclusive restaurant, with a fantastic revolving view across London!

This issue includes another competition, this time there are five copies of Laurie Anderson's latest CD.

Next month, we will be printing the names of the lucky winners of some of our other great competitions – so to the many who entered, keep your eyes peeled!

Electronics' Centenary Issue!

Be sure not to miss your next bumper copy of *Electronics* – our 100th issue! Containing an even greater selection of projects, articles and features than usual, and in celebration of this milestone event in the history of Britain's Best-selling electronics magazine, there will be an exciting Internet Competition, and best of all, a fabulous **FREE Computer Booklet**, worth in excess of £2, showing all the steps involved in building up and upgrading your own tailor-made PC, saving much of the expense involved in purchasing a ready-built version. So as not to be disappointed in the predicted stampede to obtain copies of this historic edition, order your copy now!



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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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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.

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Kit Retail Price	Standard Servicing Cost
up to £24.99	£17.00
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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

3 PROJECT RATING

KIT AVAILABLE (90075) PRICE £18.99

LIGHT SEQUENCER SOUND-TO-LIGHT ADAPTOR

Design by Chris Barlow
Text by Chris Barlow and Maurice Hunt

FEATURES

- ★ Sound-responsive or manual speed control
- ★ Speed indicator
- ★ Microphone or external audio input
- ★ Audio AGC system

APPLICATIONS

- ★ Disco light sequencer
- ★ Sound-responsive Christmas tree light controller

IMPORTANT SAFETY NOTE

It is important to note that mains voltage is potentially lethal. Full details of mains wiring connections are shown in the Light Sequencer article (see Issue 84), and every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit, which should never be operated with the box lid removed. Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article. If you are in any doubt as to the correct way to proceed, consult a suitable qualified engineer.

The Light Sequencer Sound-to-Light Adaptor described in this article is designed to provide an easy-to-build and straightforward to install add-on for the popular Christmas Tree Light Sequencer kit (95076), featured in *Electronics*, Issue 84. In its normal application, driving Christmas tree lights, this project is capable of driving three separate channels of lights, with up to 100W per channel. This offers the potential to control many sets of Christmas tree lights. However, when expanded to provide a higher power-handling capability, the unit can drive up to 400W per channel, making it ideal for driving more powerful lighting arrangements, such as disco lights.

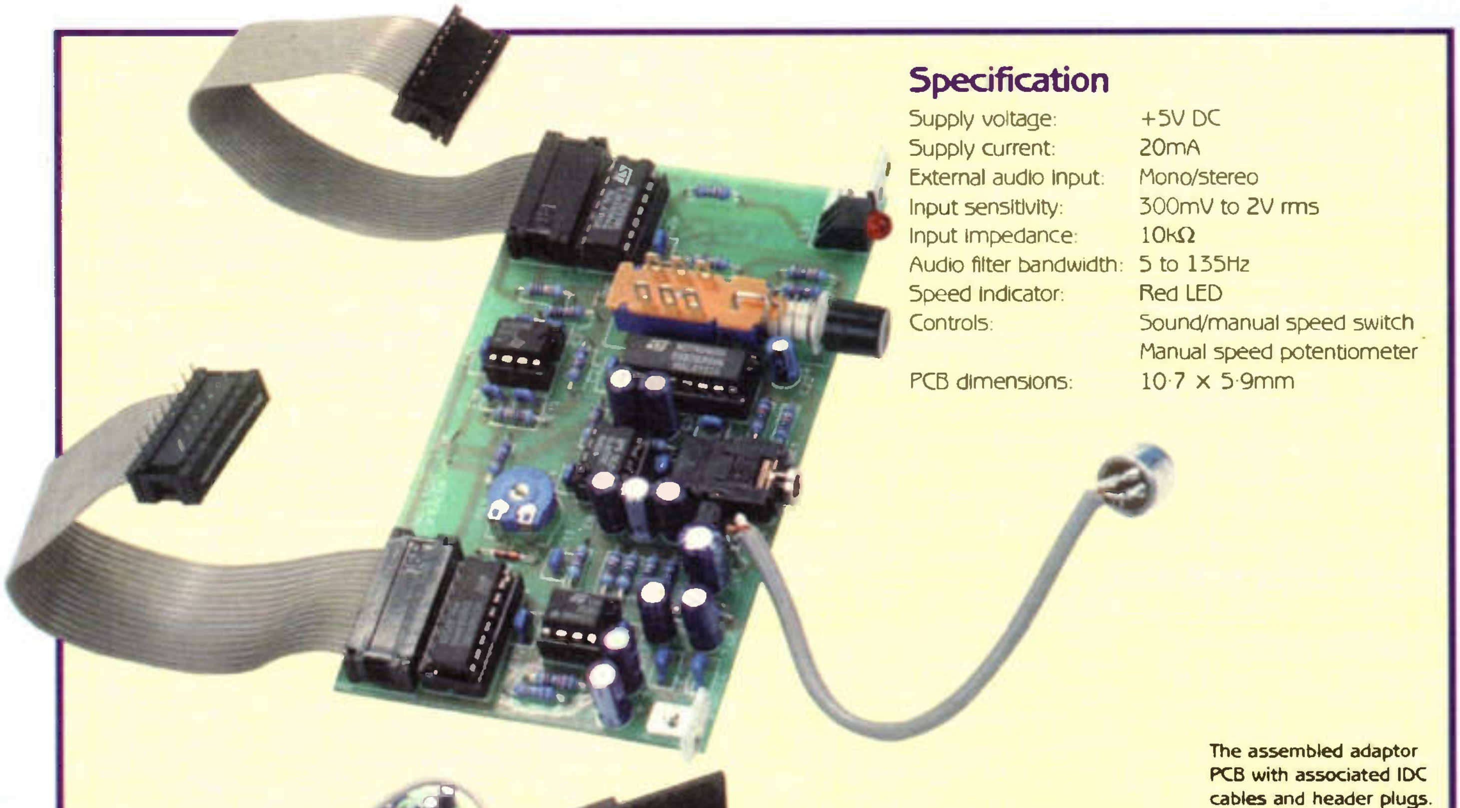
The original Light Sequencer only had a manually-controlled pattern speed. The majority of disco light sequencers have some kind of automatic sound-controlled speed function and it is this feature which is added by the adaptor, thus flashing the lights to the tempo of the music. This greatly enhances the atmosphere of a disco or party, which is why this type of lighting has been utilised to its full potential in nightclubs and discotheques for many years, and remains as powerful an incentive as ever to get on down and boogie!

Circuit Description

In addition to the block diagram detailed in Figure 1, the circuit diagram is shown in Figure 2, and reference to these will be of assistance when following the circuit diagram, or with fault-finding of the completed unit, should this be necessary.

Sound is detected by an electret microphone insert, MC1, which is connected to the PCB terminals P1 and P2. The DC bias for both MC1 and TR1 is provided by R3. TR1 is configured as a low-noise emitter-follower, used to provide a suitable input for MC1 and a low impedance signal source required by the input of IC3. Audio signals from TR1 pass through C2 and the switch section of a 3·5mm stereo jack socket, JK1. This socket is used to directly connect external mono/stereo audio signals into the unit. The mono/stereo signals are mixed and attenuated by R1 and R2, then pass through C3 to the input of IC3.

IC3 is an SL6270 Voice Operated Gain Adjusting Device (VOGAD). It is designed to accept small signals and provide an essentially constant output signal from an input covering a range of 50dB. Its low impedance signal input is on pin 5 and R5 is used to inhibit oscillation at the onset of limiting. The attack and decay characteristics of the VOGAD are set by the RC timing components R7 and C5 on pin 1 of IC3. The output from the VOGAD preamp stage (IC3 pin 2) is coupled via capacitor C8 to the input of the main VOGAD amplifier, at pin 7. The low frequency (LF) response is determined by the value of C8, with the high frequencies (HF) restricted by C9 placed between the input and output connections (pins 7 and 8) of the main VOGAD amplifier. The combined LF and HF response has been tailored to favour the heavy bass beat found in most disco music. The final processed audio signal from pin 8 is fed via C10 to the input of the next stage of the circuit, IC4b. The +5V required to power IC3 is applied to pin 3, which is decoupled to 0V ground by C6 and C7, thus removing any supply noise. Pin 6 is used as the common ground return for all the elements within the device.



Specification

Supply voltage:	+5V DC
Supply current:	20mA
External audio input:	Mono/stereo
Input sensitivity:	300mV to 2V rms
Input impedance:	10kΩ
Audio filter bandwidth:	5 to 135Hz
Speed indicator:	Red LED
Controls:	Sound/manual speed switch
	Manual speed potentiometer
PCB dimensions:	10·7 x 5·9mm

The assembled adaptor PCB with associated IDC cables and header plugs.

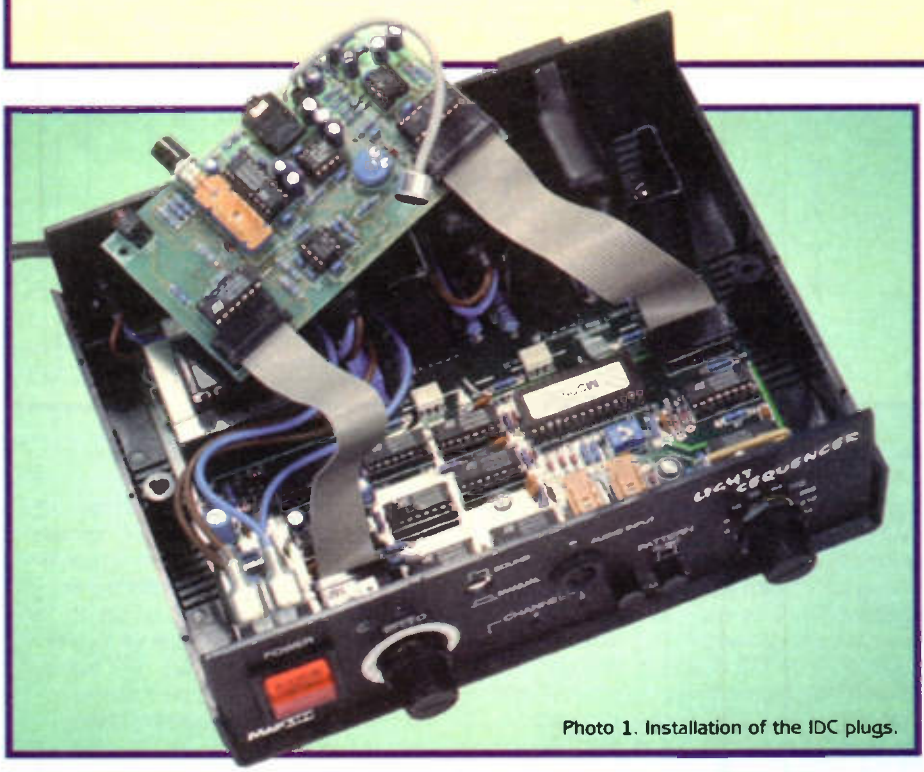


Photo 1. Installation of the IDC plugs.

IC4b is used to increase the positive voltage swing of the audio signal. The gain of this stage is set by the combined values of R9, R10 and RV1. Diode D1 is used to restrict the negative swing of the signal, with C11 restricting the overall HF content. IC4a is used to generate a DC bias voltage which is applied to IC4b and sets the slow pattern speed when no audio signals are present. The voltage reference applied to the input of IC4a is derived from the two resistors R11 and R12, which form a potential divider. The op amp is merely used as a zero gain buffer to provide a low impedance output which is then decoupled by C16 and C17.

The amplified audio signals, with DC bias from IC4b, are directly connected to the input of IC5, which forms a two-stage low-pass filter. The first and second stage of the low-pass filter is configured as a 2-pole Chebyshev active filter. The first consists of IC5b, R13, R14, C18 and C19. The second consists of IC5a, R15, R16, C20 and C21. Most of the disco music beat information is

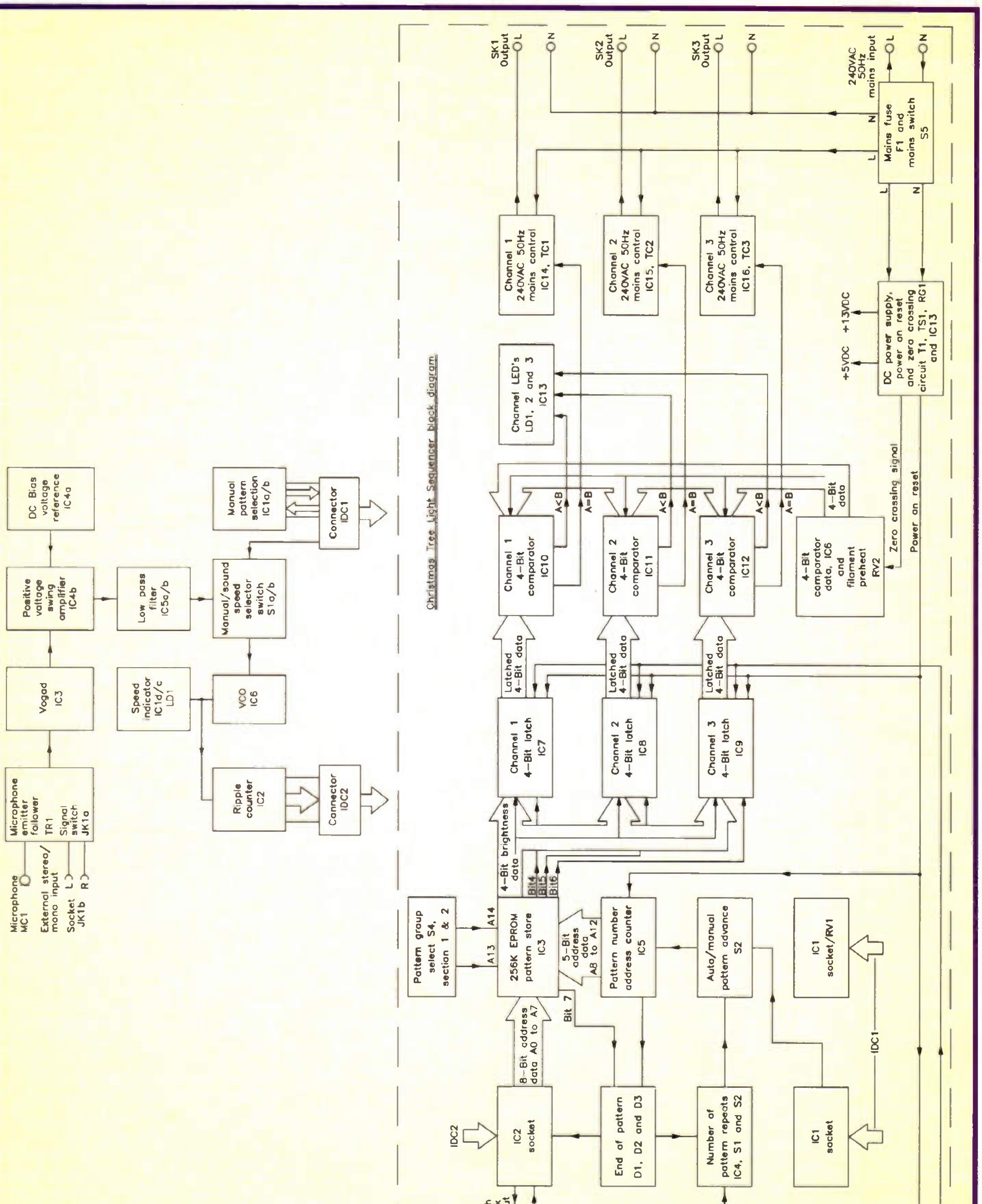


Figure 1. Block diagram of the Light Sequencer Sound-to-Light Adaptor.

contained in the lower frequencies, so the cut-off frequency of the low-pass filter is set to approximately 135Hz. The filtered audio signal from pin 1 of IC5a now enters, via D2, the 'MANUAL/SOUND' pattern speed selector switch, S1a and S1b.

When the push switch, S1, is in the 'out' position it selects the audio signal. This positive signal will rapidly charge C22. However, this capacitor discharges at a slower rate determined by the value of R18. This has the effect of smoothing out the speed variation of the music beat. When S1 is pushed 'in' it selects a manually controlled speed variation. This is achieved by a potential divider using R17, R18 and the original speed control, RV1, on the Light Sequencer project (LT69A). The connection to RV1 is made by using an insulation displacement connector (IDC) cable. The cable has a DIL IDC header at each end. One end is soldered directly into the adaptor PCB at IDC1 with the other plugging into the Light Sequencer PCB in place of IC1. This IC, a 4093, is transferred to the adaptor PCB at its IC1 position.

The positive voltage charge across C22 is used to control IC6 a Voltage Controlled Oscillator (VCO). This voltage is applied to pin 9 and the more positive the higher the output frequency will be on pin 2. The frequency range of IC6 is set by the values of C24, R20 and R21. The output of this IC drives two separate circuits, the speed indicator IC1 and the ripple counter IC2.

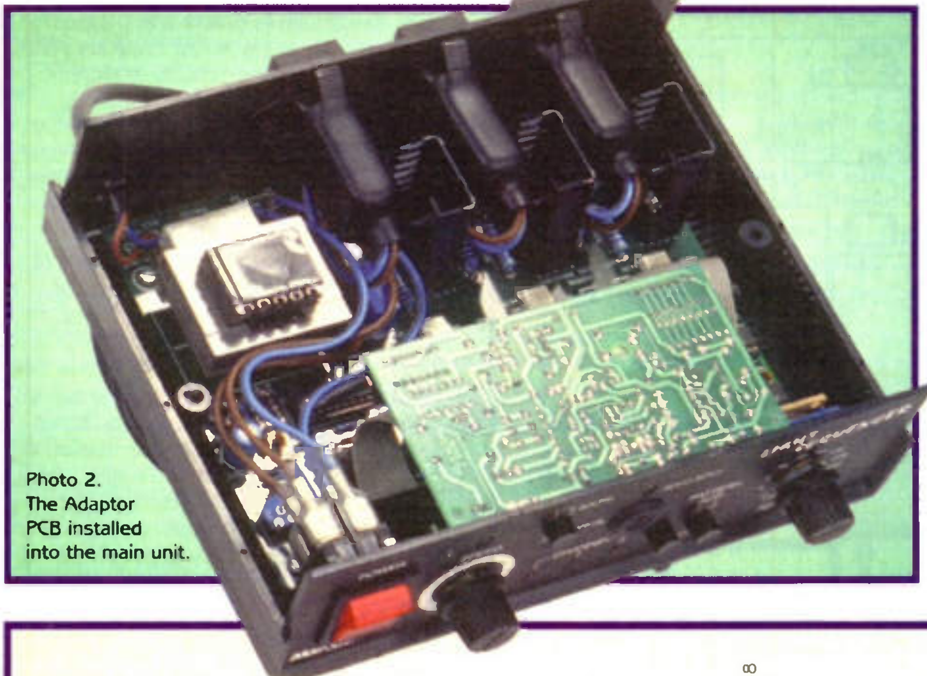


Photo 2. The Adaptor PCB installed into the main unit.

IC1d is used as an inverting buffer which drives the R-C network formed by R19 and C25. This produces a narrow pulse from the square wave output of the VCO IC6 and IC1c is used to switch the LED, LD1. As the frequency of the VCO increases the light intensity of LD1 appears to increase proportionally. IC1a and IC1b are not used by the adaptor, but are required by the main christmas tree light sequencer circuit. All the connections to these two NAND gates go directly to IDC1 which is plugged back into the main circuit board via the DIL holder where IC1 normally resides. IC1 is transposed to the adaptor board, to the position marked 'IC1' on the legend, surprisingly enough. This provides the manual one-shot pulse used to advance the pattern selection.

IC2 receives the square wave output from the VCO, IC6, on its clock input (pin 10). This chip is a 12-stage ripple counter,

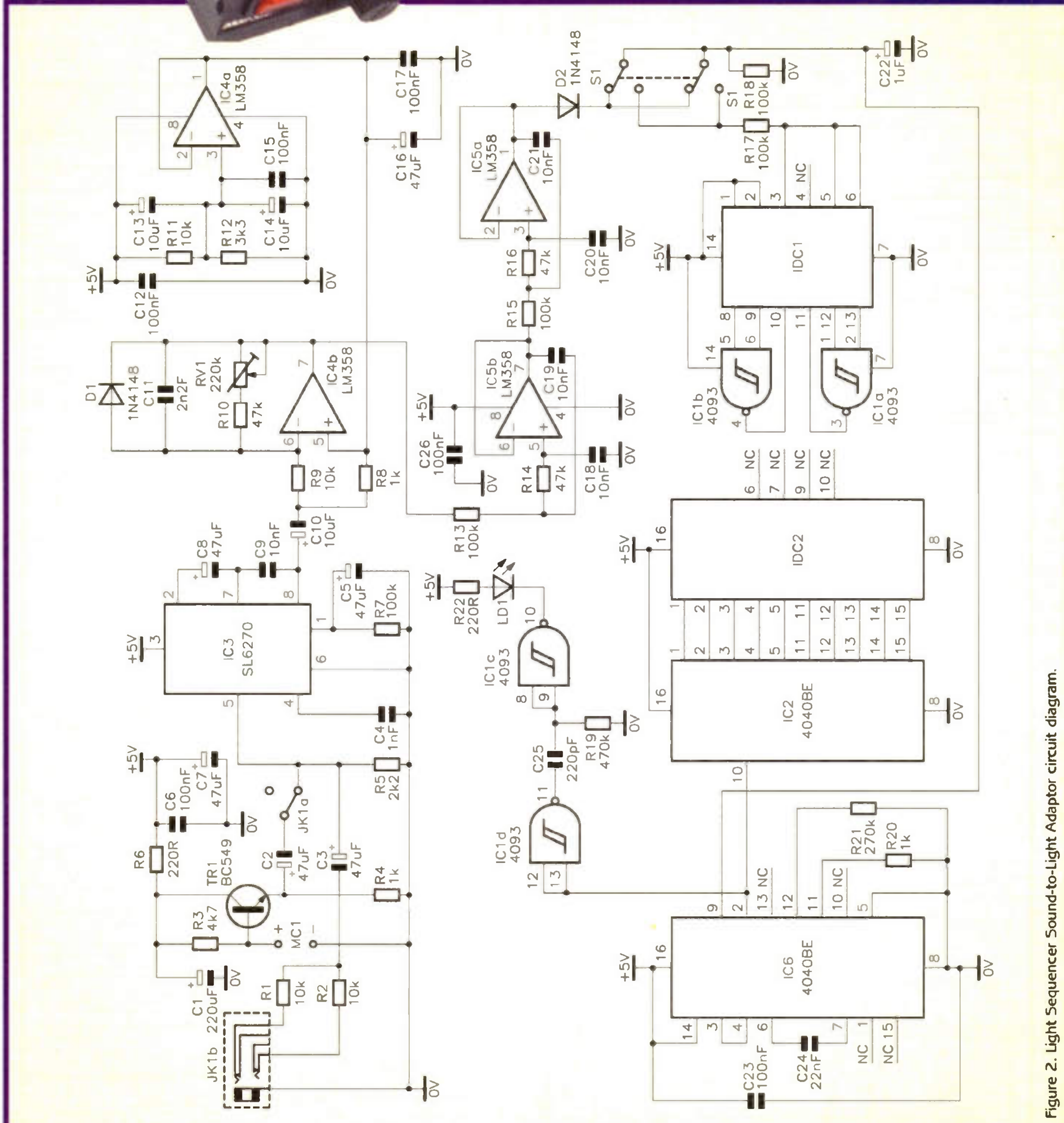


Figure 2. Light Sequencer Sound-to-Light Adaptor circuit diagram.

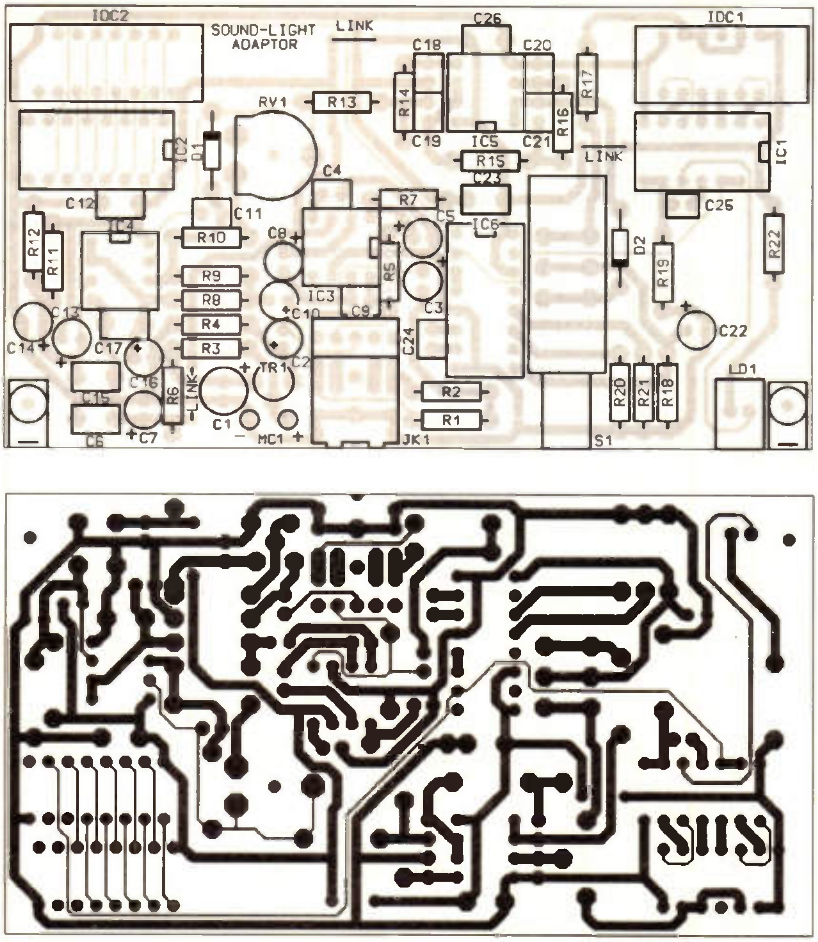


Figure 3. PCB legend and track.

Rear view of assembled unit in recommended optional box.

which is used to generate the 8-bit code required to sequence through a selected light pattern. The output connection from IC2 is made by using another IDC cable. One end is soldered directly into the adaptor PCB at IDC2 with the other end plugging into the Light Sequencer PCB in place of IC2. This IC, a 4040, is transferred to the adaptor PCB at its IC2 position.

The +5V DC power and 0V ground required by the adaptor circuit is taken from the Light Sequencer via the IDC connections. This supply has additional decoupling capacitors C6, C7, C12, C23 and C26.

PCB Construction

Construction is relatively straightforward, the components being mounted onto a single-sided board. Refer to Figure 3, showing the PCB legend and track diagrams. Assemble the board in order of ascending component size, taking care to ensure that polarized devices such as electrolytic capacitors and semiconductors are correctly orientated, in accordance with the printed legend. Plug the ICs into their sockets last of all, taking suitable antistatic precautions. Refer to the Circuit Description section for details of transposing IC1 and IC2 from the main board to the adaptor PCB.

Figure 4 shows the mounting details of the fixing brackets and components IDC1, IDC2, LD1, S1, and JK1 to the adaptor board. Note that the latter three items must be fitted flat to the board, so that they align with the front panel holes. The two IDC cables are available as ready-made items – refer to the Parts List. Having completed the board assembly process, thoroughly check your work for errors such as misplaced components, solder bridges, whiskers and dry joints, etc. Finally, clean excess flux off the board using a suitable solvent.

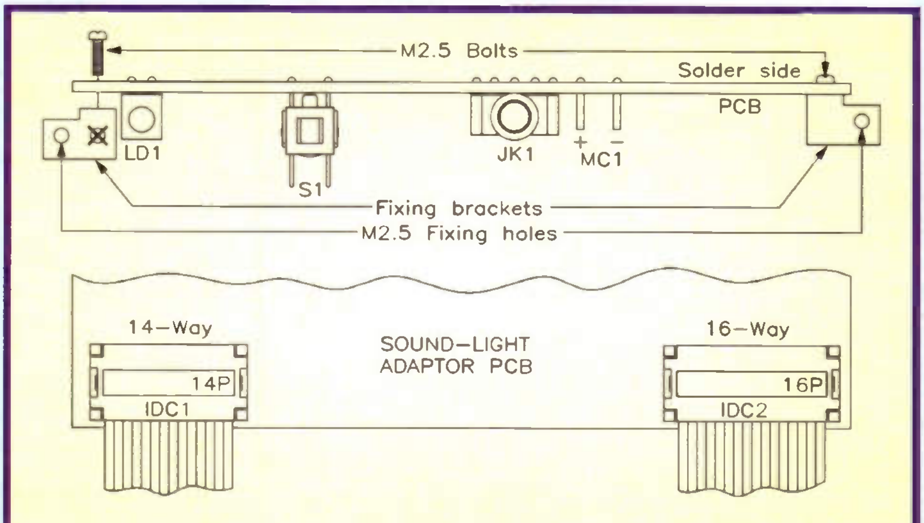


Figure 4. Component mounting details.

Testing the Adaptor Board

The tests of the completed adaptor board can be made with a minimum of equipment. You will need a multimeter and a Light Sequencer (95076). If you have a regulated +5V DC power supply, you can test the current drawn by the unit.

The first test is to ensure that there are no short circuits before you connect the adaptor to the Light Sequencer. Set your multimeter to read OHMS on its resistance range, and connect the test probes (either way round) to pins 14 and 7 of IDC 1. A reading of greater than 3kΩ should be obtained. To test the DC current, select a suitable range on your meter that will accommodate a 100mA reading and place it in the positive power line (pin 14 of IDC 1). Connect the negative line of your regulated 5V DC power supply to pin 7 of IDC 1 and switch on, whereupon a current reading of approximately 20mA should be observed. This completes the DC testing of the adaptor, now disconnect the multimeter and power supply from IDC 1. Proceed to install the adaptor into the Light Sequencer project, as described below.

Box Preparation

The existing housing for the Light Sequencer requires some further drilling, beyond that shown in the Figures 11 to 13 on pages 16 and 17 of Issue 84, to accept this add-on project. Figure 5 provides the necessary information. Peel off the existing front panel label (if fitted) prior to drilling the holes, and deburr the holes after drilling has been carried out. The box lid must be modified in accordance with Figure 6, involving the removal of the support lugs in order to provide clearance for the adaptor board. This can be achieved using large wire cutters, followed by a scalpel to tidy up the remains.

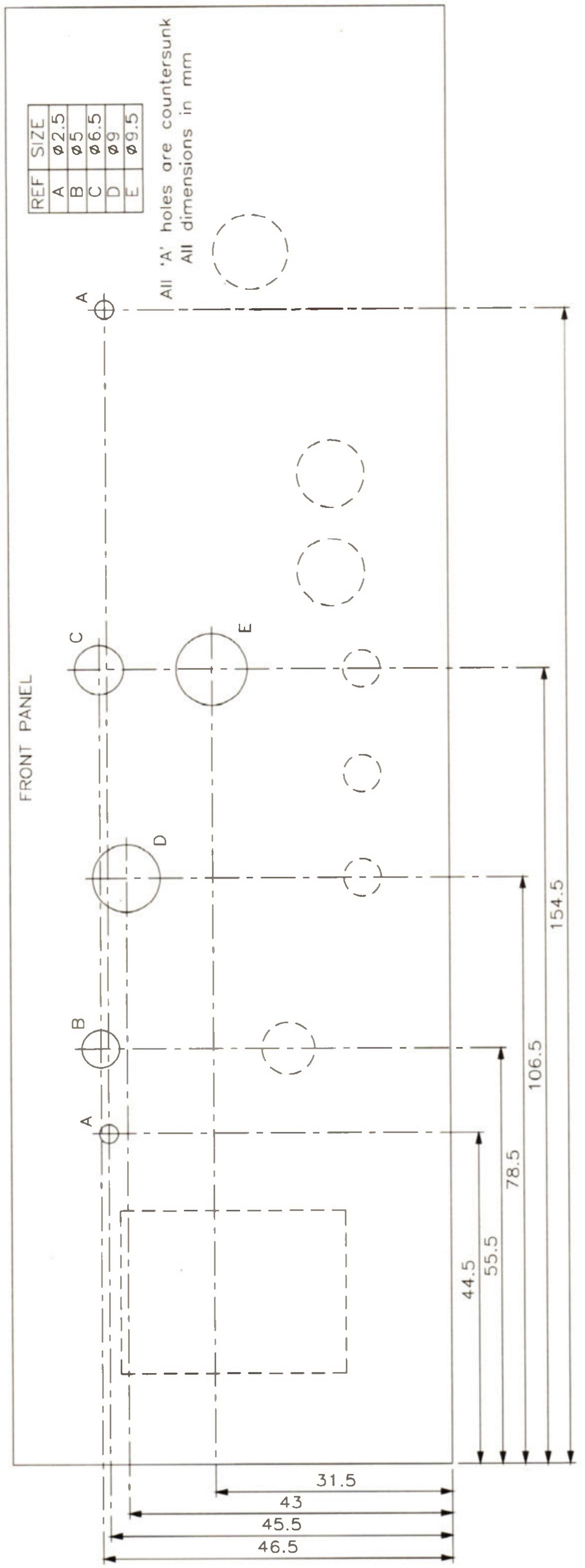


Figure 5. Box drilling details.

Final Assembly

Refer to the assembly diagram depicted in Figure 6, the photographs showing how the adaptor board is fitted into the box, and also the wiring diagram of Figure 7; naturally, the wiring to the microphone and IDC connectors should be carried out before fitting the adaptor board into the box! Photo 1 shows the installation of the IDC plugs onto the main board (these simply plug into the DIL sockets left unoccupied by the transposal of IC1 and IC2 from the main board to the adaptor PCB). Photo 2 shows the installation of the adaptor PCB into the main unit. Fix the adaptor board mounting brackets to the adaptor board with two round-headed M2·5 screws (supplied with the brackets) using the straight edge of the board as a guide to alignment, then fit the adaptor board to the front panel by means of the two M2·5 countersunk screws. Do these up tightly (but do not overtighten!), since once the label is applied, you will not have access to them. Now separate the adaptor board from the panel by undoing the round-headed PCB-to-bracket screws, wipe the panel clean and affix the front panel label as shown in Figure 8.

Punch through the hole points marked on the label with a pointed instrument, and enlarge them to match the size of the drilled hole beneath; a scalpel should be used to neatly cut away excess label at the holes for the LEDs and push switches – slight enlargement of the push switch holes using a suitable file may be necessary to allow smooth operation of the switches. Refit the adaptor board to the brackets previously fitted to the panel, and ensure that all switches operate without hinderance from the label. Plug the IDC plugs into the DIL sockets and place the microphone into the grommet in the front panel, then slide the front panel/adaptor board sub-assembly into the appropriate slots in the casing. Following testing of the unit as described below, the lid is fitted and secured using the two self-tapping screws supplied with the box.

Testing the Installed Adaptor

Do not plug the unit into the 230V AC mains supply until you have carried out the following:

1. Set the mains power switch to OFF.
2. Set the speed control fully anticlockwise – slow speed.
3. Press in the pattern select switch to select manual mode.
4. Set the pattern repeat switch fully anticlockwise – no repeats.
5. Press in the adaptor switch, S1, to select its manual speed mode.
6. On the adaptor PCB set RV1 fully clockwise.

Check that the mains lamps are wired correctly. Please refer to the mains safety warning printed in the Light Sequencer article (see issue 84) prior to carrying out further testing of the unit when powered from the mains supply. Plug the unit into the mains supply, and switch on. If all is well, then the following should occur:

1. The red neon power switch should illuminate.
2. All of the LEDs and mains lights should illuminate for approximately half a second. This is the power-on reset time.
3. If the normal group 3 patterns have been selected, then the lights should follow the 1,2,3 up/down slow pattern.

As the speed control is advanced, the pattern will accelerate and the speed indicator, LD1, will progressively become brighter until full speed is reached. Now release S1, putting the unit into its sound control mode.

To test the response of the unit to sound, you will require some disco-type music, with plenty of bass beat. The more bass components in the music, the faster the light pattern will run and the brighter the speed indicator, LD1, will become. RV1 sets the maximum pattern speed, which should be the same as the maximum speed set by the manual control on the sequencer. To compare these speeds, set the manual control fully clockwise and press the sound/manual switch (S1) in. Note the speed of the pattern, then release S1 to select the sound mode. With some really energetic disco music playing, set RV1 so that the lights run at approximately the same speed as the maximum manual setting. Note that a quick test of the unit's response to sound is to bang your hand on the desk that the unit is resting on – the faster you do this, the faster the lights should flash.

If acoustic pick up is not desired, then the audio signal can be directly injected into the unit via JK1, a stereo 3·5mm jack socket. The jack plug can be wired for mono or stereo, depending upon your individual sound system requirements. This input will accept audio signals over a wide range of levels (300mV to 2V rms), making it suitable for most sound systems. It can be obtained from the line level output of most home Hi-Fi systems, or disco mixer outputs.

If you have an audio signal generator, you can test the frequency response of the unit by injecting the signal direct into JK1. Set your generator to produce a sine wave output at approximately 500mV rms and sweep its frequency from 5 to 250Hz. From between 5 and approximately 135Hz, the lights should move quickly and the speed indicator, LD1, should be fully illuminated. As you pass 135Hz, the lights should slow down and LD1 will begin to dim. This completes the testing of the unit, and the case lid may now be fitted.

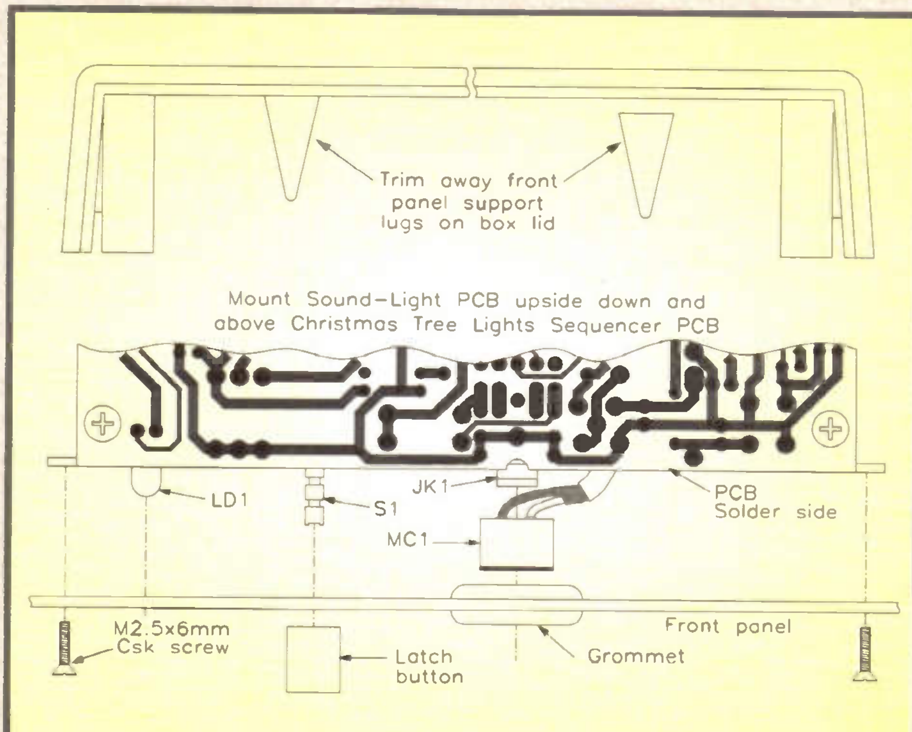


Figure 6. Exploded assembly (showing lid modification).

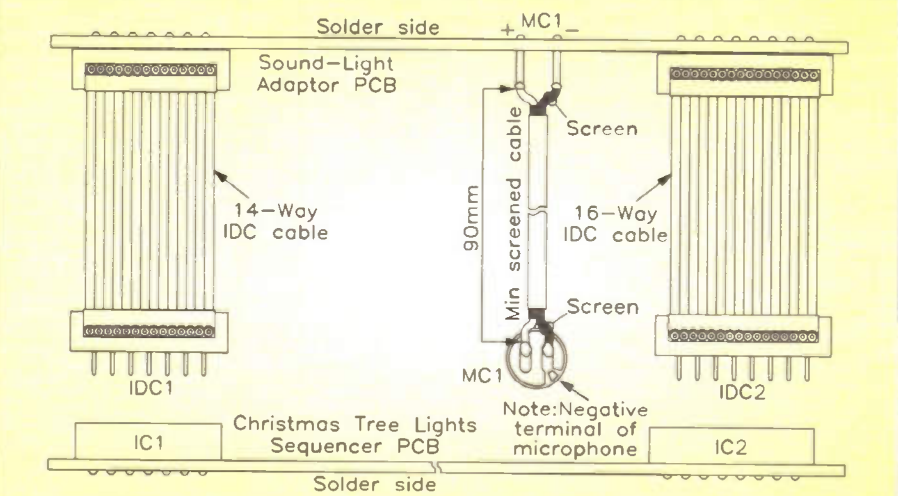


Figure 7. IDC connector wiring and general wiring diagram.

Using the Adaptor

Only operate this unit with the lid attached, and always switch off the mains supply

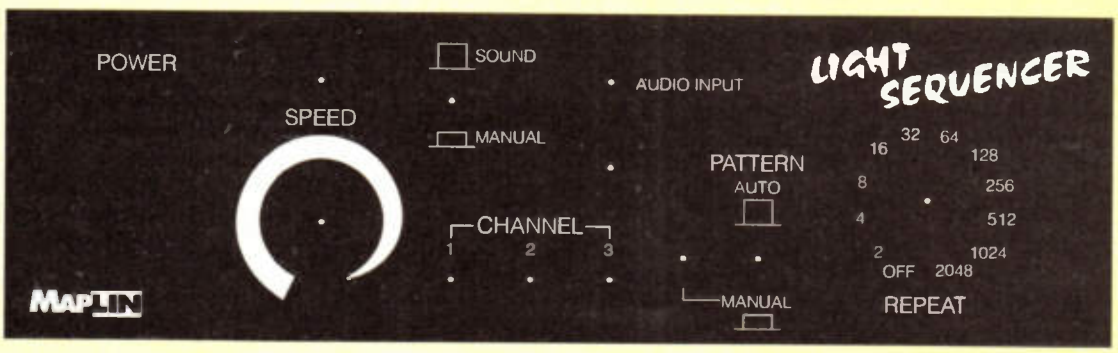


Figure 8. Front panel label, (scale 75%).

prior to removing the lid for maintenance or inspection purposes. Refer to the Light Sequencer article (issue 84) for details of connecting lamps via Euro plugs to the rear of the unit. The standard unit is capable of driving a total power loading of up to 100W per channel, whilst the expanded unit, with the beefier TRIACs installed, can handle a total power loading of up to 400W per channel.

It is worthwhile having a few spare bulbs and fuses of the appropriate type to hand when using the unit, to prevent disappointment (or embarrassment!) should a failure take place while the party or disco is in full swing. However, all being well, you should be rewarded with an impressive display of sound-responsive lighting which will add considerably to the atmosphere of the event, and help tempt guests towards the dance floor! E

LIGHT SEQUENCER SOUND-TO-LIGHT ADAPTOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Specified)			
R1,2,9,11	10k	4	(M10K)
R3	4k7	1	(M4K7)
R4,8,20	1k	1	(M1K)
R5	2k2	1	(M2K2)
R6,22	220Ω	2	(M220R)
R7,13,15 17,18	100k	5	(M100K)
R10,14,16	47k	3	(M47K)
R12	3k3	1	(M3K3)
R19	470k	1	(M470K)
R21	270k	1	(M270K)
RV1	220k Horizontal Preset Potentiometer	1	(UH07H)
CAPACITORS			
C1	220µF 10V Radial Electrolytic	1	(AT31J)
C2,3,5, 7,8,16	47µF 10V Radial Electrolytic	6	(AT29G)
C4	1nF Monolithic Ceramic	1	(RA39N)
C6,12,15, 17,23,26	100nF Monolithic Ceramic	6	(RA49D)
C9,18-21	10nF Monolithic Ceramic	5	(RA44X)
C10,13,14	10µF 63V Radial Electrolytic	3	(AT77J)
C11	2n2F Monolithic Ceramic	1	(RA40T)
C22	1µF 63V Radial Electrolytic	1	(AT74R)
C24	22nF Monolithic Ceramic	1	(RA45Y)
C25	220pF Monolithic Ceramic	1	(RA37S)
SEMICONDUCTORS			
D1,2	1N4148	2	(QL80B)
LD1	PCB-mounting High Brightness Red LED	1	(CP53H)
TR1	BC549	1	(QQ15R)
IC1	HCF4093BEY	(See Text)	
IC2	HCF4040BEY	(See Text)	
IC3	SL6270CDP	1	(UM73Q)
IC4,5	LM358N	2	(UJ34M)
IC6	HCF4046BEY	1	(QW32K)
MISCELLANEOUS			
MC1	Subminiature Omni-directional Microphone Insert	1	(FS43W)
JK1	PCB-mounting 3·5mm 1-pole 2-way Jack Socket	1	(JM22Y)
S1	2-pole Latchswitch	1	(FH67X)
	Latchswitch Button Black	1	(KU75S)
	8-pin DIL Socket	2	(BL17T)
	14-pin DIL Socket	1	(BL18U)
	16-pin DIL Socket	2	(BL19V)
	PCB Pin 1mm	1 Pkt	(FL24B)
	Metal Fixing Attachment	1 Pair	(JP32K)
	M2·5 × 10mm Pozi-drive Screw	1 Pkt	(JC68Y)
	9·5mm Grommet	1 Pkt	(JX63T)
	Sound-to-light Adaptor IDC1 Cable	1	(DT16S)
	Sound-to-light Adaptor IDC2 Cable	1	(DT17T)
	Screened Cable	1m	(XR15R)
	Front Panel Label	1	(90082)
	PCB	1	(90076)
	Instruction Leaflet	1	(XV81C)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Light Sequencer	1	(95076)

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 90075 (Light Sequencer Sound-to-Light Adaptor) Price £18.99

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 1996 Maplin Catalogue.

Light Sequencer Sound-to-Light Adaptor PCB
Order As 90076 Price £2.99

Light Sequencer Sound-to-Light Adaptor Front Panel Label
Order As 90082 Price £2.49

Light Sequencer Sound-to-Light Adaptor IDC1
Order As 95074 Price TBA

Light Sequencer Sound-to-Light Adaptor IDC2
Order As 95075 Price TBA

NEWS FLASH! NEWS FLASH! NEWS FLASH!

Young Engineers for Britain 1996 –Open for entries

Young Engineers for Britain 1996, the leading competition of its type in Europe which attracts more than 1,200 entries from Britain's most ingenious students, is now open for entries.

The competition is organised by the Engineering Council in association with the Standing Conference on Schools' Science and Technology (SCSST) Young Engineers' Clubs, and a number of leading industrial companies and organisations.

Young Engineers for Britain 1996 will have the brightest and most imaginative students competing for prizes totalling £20,000. The national final will be held in London in September and the overall winner, the 'Young Engineer for Britain 1996', will receive a prize of £1,000, a trophy and £1,500 for their school or organisation.

Entry forms can be obtained from: Young Engineers for Britain, 10 Maltravers Street, London, WC2R 3ER. The closing date for entries is 29 March 1996.

Samsung to set up Major R&D Centre in Japan

Samsung Electronics Co (SEC) held a ground breaking ceremony last month for a new large-scale R&D centre in Yokohama, Japan.

The centre will focus on twelve different areas including multimedia products and systems, electronics components, telecommunications hardware, electrical products for the home, computer peripherals, software, factory control systems and materials.

Samsung Electronics established AITECH (Advanced Institute of Technology), a local R&D subsidiary in Japan, in August 1992, which has helped pave the way for expanded research operations. Samsung now plans to invest about US$130 million over the next three years to build a six-storey R&D centre (total floor space 18,800 square metres on a site of about 7,600 square metres). Construction of the state of the art facility is scheduled for completion in May 1997.

CONTENT-BASED INDEXING FOR MULTIMEDIA

by Frank Booty

This article is about information retrieval and document imaging software based on adaptive recognition technology. This technology provides information storage with automatic indexing and high-speed fuzzy retrieval, using a process that identifies patterns in the binary representations of data. One company (Excalibur) has packaged this cognitive indexing technology into C language libraries that allow software developers and integrators the ability to provide content-based retrieval features in their applications.

Imagine there is a software product that uses multiple data types in some way. Indeed, it could be a true multimedia product. Users need to be provided with a way to manage the huge and diverse amounts of data that are typical with multimedia. To succeed, the application needs to do more than just import, export and display files. The true key to managing multimedia data requires a fluid means of retrieving information, e.g., find any text files that have voice annotation comments that contain the word 'meeting'.

Although the concept of indexing and retrieval in multimedia is not difficult to understand conceptually, there are some problems. The current concept of multimedia has focused on display, not storage. But how is multimedia data indexed without losing the context that makes it multimedia? Is a user expected to manually tag, or index, or assign key words to every file? Also, will a labour-intensive process like that work for multimedia when it eventually fails in relatively simple text database systems? How can information be found that is buried in Gigabytes of data without an index of equal size and a supercomputer to parse through it?

One company (called Excalibur) has a solution to multimedia indexing and retrieval, integrating its proprietary pattern recognition technology as a library of routines into any application. This technology provides automatic, on the fly indexing and fast pattern matching retrieval, which is well suited for the multiple data types (and the huge amounts of data) that are associated with multimedia.

Promise and Challenge of Multimedia

To be able to provide a useful component in today's multimedia systems calls for a company to have an understanding of why multimedia is so promising. The challenge is to produce systems that deliver this potential power. However, what is multimedia, and what does it mean in today's software industry? Most definitions include applications in which two or more data types are used. For example, video and sound (different data types) 'played' by the computer in a synchronized manner that conveys meaning; it is a meaning that the individual parts do not communicate by themselves. This is analogous to a ballet, where dance and music (each of which could be performed separately) combine to express a more powerful message.

Finding new levels of meaning in information is the promise of multimedia. The challenge is to produce software applications that deliver this potential power. Imagine the dynamic range of communication that could include electronic mail with voice annotation, or word processing documents with 'pictures' that can play video sequences to enhance and clarify what the words say when the user clicks on the picture. Possibly even an interactive hyper-linked document that can teach the user the many dimensions of a Beethoven symphony through music, voice, text, images and animation.

Multimedia data types can be images (still or sequential), text (multilingual), and sound (voice, music). They can be colour, animated, digital video, multichannel stereo. A movie film on a laser disk would certainly qualify as multimedia by most definitions. Less in the mainstream, but equally valid in the large multimedia promise, is signal data such as spectral analysis and electrocardiograms – medical and scientific information that can be combined with other data types to provide a richer, more meaningful picture for tomorrow's information seeker.

However, all this information needs to be managed. How can users meet this challenge? In the serious multimedia models now emerging, the filing and retrieval of images, text and audio is considered a daunting task. The sheer volume of data involved prevents most of us from realising much of multimedia's potential today. After all, video sequences are really rivers of images, as are voice, signal and musical data.

Some rivers can be torrents. A typical movie lasting 90 minutes might consist of 640 × 480 pixels per frame, at 30 frames per second, which at a byte per pixel resolution, produces an awesome storage requirement of close to 50 billion bytes. Even then the resolution and depth of colour is only barely acceptable compared to the quality most are used to seeing. It would seem that the challenges facing companies that want to participate in the multimedia revolution have less to do with the actual 'playing' of data, and more to do with the taming of data.

Applications of Document Management

- Automatic message-handling systems
- Computer-aided logistical support
- Contract management
- Configuration management
- Correspondence tracking
- Customer support
- Directory assistance
- Document exploitation
- Document imaging
- Drug application tracking
- EDI support
- Electronic filing
- Electronic publishing management and retrieval
- Engineering document management
- Integrated OA
- Library management
- Litigation support
- Material safety data sheets
- Medical imaging
- Online policy and procedures
- Online technical manuals
- Patent documentation
- Research and analysis
- Software code library management

Limitations of Traditional Methods

The key need in multimedia systems is to solve the problem of how to store and how to find data (for most applications). The difficulty in multimedia is that data. How can a user establish and maintain logical 'links' among different data types, and (perhaps more important) how can a user discover creative new links?

The most serious multimedia models assume the coming of large, multi-platform databases which have the capacity to handle not only the bulk, but also the variety of multimedia data. These models are logical, but their traditional approach will not work. For example, a SQL-based approach does not take into account information that is hard to describe with a text 'label', such as sounds and images. SQL and other traditional methods are based on data processing assumptions that do not fully take multimedia into account.

The first challenge to overcome is the sheer volume of data which must be stored and processed with multimedia data. Consider the 50 billion byte movie example mentioned earlier. Even with compression techniques that can reduce image size by a factor of 100 to 1, there would still be hundreds of megabytes, filling up all the disk space. Further, today's colour compression does not come close to that ratio unless the user is willing to sacrifice quality.

The second challenge is simply the logistics of filing images. Imagine hand-labelling every separate frame of a movie with a description of its contents. The obvious approach is to label the whole movie and access it as a block.

However, what if the user wishes to access only the images which contain pictures of the Houses of Parliament, and then later, the user wanted to access only those images that contained women with blonde hair? (!) The options are limited. The user could hire a person with a good memory, or the user could make a list of the sequences with this information. This might be a good solution, assuming the hand-labelling work had to be done only once and that a large number of users could benefit from the resulting fixed, static information (everyone always wanting to find images only of the Houses of Parliament).

Another problem with any sort of human, manual labelling scheme is mind set. What does anyone really see around them? In addition to 'objects', there are abstractions of relationships between objects, and multiple dimensions of interactions. It is difficult to pre-categorise information. Some birds fly and some do not, and bats are not birds but they fly. The person who applies the labels may think more literally (or laterally) than the user who hires him/her, and the search queries the user applies will not be good matches for that person's retrieval labels. Most modern database accesses avoid this problem by narrowing the domains (contexts) rather than increasing the number of dimensions of categorisation. Although it is always possible for humans to organise this kind of data by clerical force, it seems that a more elegant and cost-effective self-organising method would be welcome. Self-organising methods, which include automatic filing for a range of possible queries, are based on the content of the multimedia information – retrieving data from the 'rivers of data' themselves. Automatic pattern recognition processing (content based indexing) can overcome most of these problems.

Cognitive Linking

What is really needed is a low-cost way to link the elements of multiple data types – a way to index information that offers more flexibility than traditional database models. A model that can handle the large amounts of data, that can automatically organise data, thus creating links, and that can enable retrieval in meaningful contexts. Content-based indexing technology (such as that from Excalibur and using adaptive pattern recognition techniques) addresses these problems. Unlike other 'content-based' retrieval schemes, which are implemented by a system of symbolic logic combined with extensive human efforts to describe multimedia data in textual ways, Excalibur's software automatically analyses and indexes the data.

This self-organising method (automatic indexing for a wide range of possible queries) is based on the content of the multimedia information – to retrieve information, it uses data from the images themselves. In many cases, where multimedia data can be reduced to generalised patterns, the software can simultaneously compress and index the data. For example, it could replace all occurrences of logos with some code that says 'XYZ logo goes here'.

If there is one integrated architecture that works on all data types, this same concept can be applied to audio or any other signal data. Content-based indexing of the musical components of a 100M-byte audio recording file could compress the data into an index and a MIDI file of a much smaller file. Because this process organises the data automatically, it means someone could hum a tune into a microphone and the computer would respond by playing a symphony that contains that tune, starting at the position where that tune is found. That would be impossible with traditional database models.

As with all aspects of multimedia, content-based indexing can be limited by the hardware that most companies have installed today. A home computer will not be able to content-index the British Library and the National Gallery, of course. Faster and faster hardware is being developed continually. Furthermore, accelerator techniques such as parallel distributed processing are capable of extending the capability of properly designed multimedia systems by several magnitudes. To establish the cognitive links that deliver the power of multimedia, a single architecture algorithm is needed that can index all types of data.

Embedding the Technology

The indexing process is called 'learning' and the search process 'searching' – these processes can be applied to each type of information in the multimedia world. To store and index, the user shows an electronic image, a stream of video images or a stream of text to a computer system – e.g., an electronic image via a frame grabber. The system automatically extracts patterns from the data and associates or 'learns' the storage location of the data and the pattern identifications. Storage locations can be frame locations for positioning of a video type, a disk sector address on magnetic or CD-ROM media, or a program address to be executed (which knows about a particular data set).

To retrieve data or 'search', the user obtains a sample image, sound bite, or text clue containing something similar to that which may be located in the database. The computer system repeats the same 'learning' process on the clue data that was used for the original data. The resulting pattern identifications associate to all stored images that contain similar images to the clue, and the videotape or disk is repositioned to the retrieval locations for those images.

This method of content-based retrieval also stimulates hyper-linked data without the intensive labour (and restrictions) of setting up such links. By selecting an object within an image of several objects, all images that contain that object can be traversed, as if the images were threaded together.

If all types of multimedia data are analysed as image data, the same storage and retrieval processing techniques apply with content-based retrieval of mixed data types. Multimedia appears to be developing in this direction, with a mix of 'visualised' audio and video data both analysed as image data.

What is pattern recognition? To illustrate the concept of the adaptive pattern recognition process, consider the example of how it works in the text domain. Ask the question: how do you find something even when you do not know what you are looking for? The content-based index drops one level below the 'word' and into the binary realm of the computer. The pattern recognition process creates a table of the repeating patterns found in the data. Each entry in the table contains the pattern ID number and a linked list of the locations in the original text where those patterns were found. These patterns (which can be long or short and occur frequently or infrequently) are not words as in traditional keyword systems.

Consider the following data:

YOUCANREADTHISSENTENCEEVEN THOUGHITRUNSTOGETHER

Because a word is a human construct and as humans, we can identify the familiar patterns (we call them words) and understand their meaning. When we index at the binary level, our neural net indexing process identifies the objective patterns in the text, image or signal data. The result is more effective than a keyword index, uses one third the space and is done automatically.

Additionally, alternate or supplementary methods can be used that initially convert the images to descriptions of key-scene objects by their use. The key-scene objects are created in text form that can be implemented in a conventional text database. Essentially, this is a multiple-layer process with content-based indexing used as the initial operation and a conventional database used in the final stage.

How Adaptive Pattern Recognition Technology Works

The information filing and retrieval software employs adaptive pattern recognition technology for reading files and for searching the database for information.

Document images are entered into the system via scanners, facsimiles or directly from disk. To add text to the system, the user selects the file to be indexed, which may be word processing, database or the OCRed contents of a document image (OCR = optical character recognition). The software then opens the file and reads its contents. As the software reads the file, adaptive pattern recognition technology automatically scans the data into an index. The resulting index is a content-base memory module that associates the patrons (binary representation) of the ASCII text with the corresponding patterns in the text file. Adaptive pattern recognition technology scans for both language patterns (e.g., English, Japanese, etc.), as well as jargon occurrences (e.g., legal, social, etc.) for easy retrieval.

To retrieve data, the user types in a clue (which can be a word or string of words) and the software quickly searches for patterns in the database text most like the clue. Users do not need to worry about correctly spelled search clues or wild card search terms, since the technology takes even error-filled scanned and OCRed data, then retrieves documents based on text patterns rather than exact words. Adaptive pattern recognition technology recalls and prioritises data by how well it matches the search criteria in the form of a 'hit list'. The user can define the maximum number of likely matches to be included in the hit list, if desired.

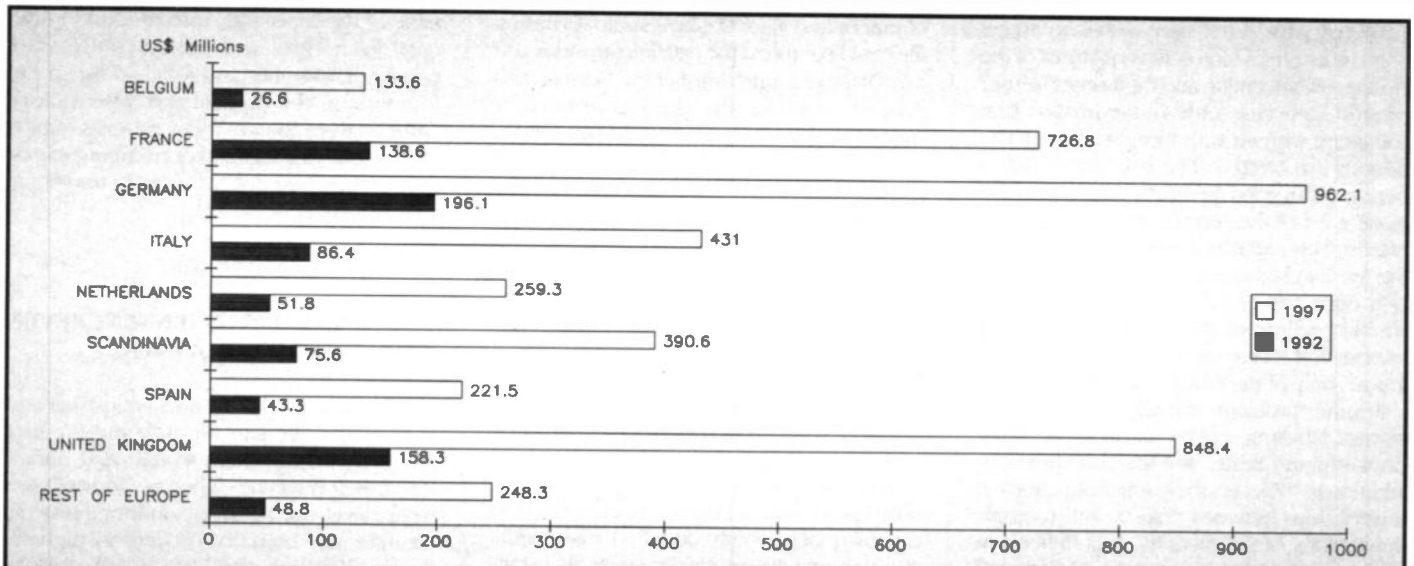


Figure 1. Annual revenues of all electronic image management systems in Europe. (Source: Frost & Sullivan Report 1821-73.)

Benefits

Adaptive pattern recognition technology offers four major benefits to its users: content-based retrieval, automatic indexing, accuracy and retrieval speed.

Content-based Retrieval/Fuzzy Searching

The system is intuitive and a clear analogy of demonstrating its power is as follows: if a person is meeting a friend at the airport and knows that he is of medium height, with dark hair and a moustache, his brain will recognise the friend as soon as he is in sight. If the friend arrives without a moustache, the brain will still identify him – there is a sufficient match between his actual appearance and the one that the person remembers to recognise him.

Adaptive pattern recognition technology eliminates manually paging through hundreds of files filled with key words, roots and stems to locate particular data. The technology assists the search process by returning the closest match to whatever is being searched. Since the technology scans data as binary patterns, the user does not have to be concerned with correct spellings, or the criteria used to file the information.

In addition, fuzzy searching overcomes the common typing and optical character recognition errors that can occur during data entry. While OCR is an extremely powerful tool, it is not accurate, and often misreads letters or words. Adaptive pattern recognition technology locates hits in scanned images, as it looks for patterns in images as opposed to complete images.

Automatic Indexing

Whenever a user enters new data, files a document or adds a new page to an existing document, adaptive pattern recognition technology automatically indexes the data, without requiring the user to select parameters for each document or update. Keywords and preprocessing of data are not required. Automatic indexing also helps system administrators manage the volume of data without having to create keyword tables, topics or directories for users. In addition, as users only need clues to retrieve information, the requirement for them to think alike for accurate information storage and access is obsolete.

Accuracy

Automatic indexing eliminates discrepancies between users on the criteria for indexing information. The technology's intuitive text retrieval process also provides a much higher search rate than the technology used in other text retrieval systems.

Retrieval Speed

Pattern recognition technology takes full advantage of computer technology's increased speed and memory capabilities. The index is only as large as the data demands and can be loaded into computer memory at high speed. Retrieval for even the largest files is fast – typically 10 seconds for 200,000 pages of text, for example.

Document Imaging Market Overview

The AIIM (Association for Information and Image Management) has indicated that the document image market-place is likely to grow at 47% annually. In an independent report on this market, Frost & Sullivan has estimated an electronic imaging marketplace worth US $4,221·7 million by 1997 (see Figure 1). Figures do seem to be being plucked out of the air and all seem to differ – but whatever else, it looks to be a big market.

Summary

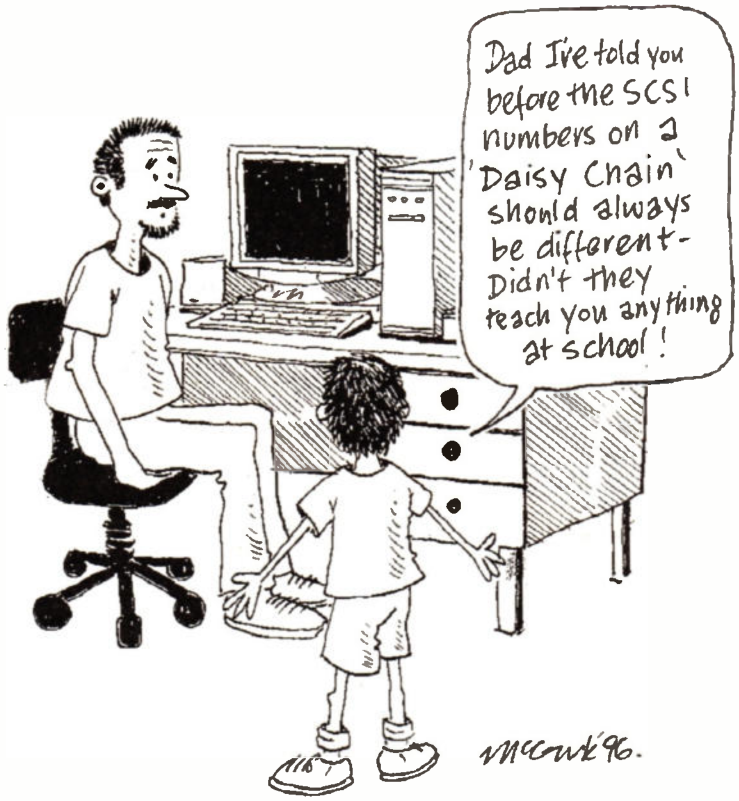
Content-based indexing technology (with its ability to manage large amounts of 'mixed-type' data, and to locate information in very flexible ways) shows that the task of dealing with multimedia data may be manageable after all. The software library (available from Excalibur) is also callable via network protocols to work in the client/server world. These callable libraries run in the VMS, UNIX, Microsoft Windows and Novell NetWare environments. The power of pattern recognition indexing and cognitive linking is a question of embedding the software library in a multimedia application.

Points of Contact

Excalibur has a world-wide technology and licensing agreement with Digital, and marketing affiliations with Hewlett-Packard, IBM and Oracle, as well as an international network of retailers supported by sales offices and five UK distributors: Digital, Digitus, Morse Computers, Morse Data Systems and Open Connections. Contact: Excalibur Technologies, Tel: (01753) 831978. E

Stray Signals

by Point Contact



Eating the Seedcorn

One cannot but have some sympathy with the desperate actions of the Government, as it attempts to hold down the public sector borrowing requirement. Eliminating it entirely would, in principle, be a good thing, but the spiralling cost of welfare makes that a pipe dream at present. (Remember the '80s, when the government actually had a surplus and did the decent thing, using it to substantially reduce the National Dept?) Naturally, in the present situation, all expenditure gets cut back, and this includes funds for the vital research needed to keep British industry up to date and competitive.

Mind you, there is a view that such funding as is available is largely misdirected, into basic research which will not bear any fruit until far into the future, if ever. In the IEE's view, more money should go to applied rather than basic research, for the UK's weakness in the process of innovation is in the later stages, in actually getting products onto the market. You may remember a firm called Scopex, which brought out the first oscilloscope with a Liquid Crystal Display, the basic research into LCDs having been done at the laboratories of RSRE. Although the first in the field, Scopex foundered, yet most oscilloscope manufacturers now offer 'scopes with LCD displays.

They do things differently in France, where the value of the seedcorn of R&D is appreciated. There, despite battling desperately to reduce its spiralling budget deficit, the government announced a few months back that it would actually *increase* next year's research budget by 2·4%. In particular, the Centre National de la Recherche Scientifique will benefit to the tune of a 4% increase in funding. There's real concern for you, and confidence in the future!

Halcyon Days

As a student on a 'thin sandwich' course (6 months at college and 6 months in industry, turn and turn about), the young PC was employed by the Central Research Laboratories of the firm that boasted it made 'Everything Electrical', which it jolly well (nearly) did do, in those far off days of the '50s. Though enlivened by the comradeship of sandwich students from other companies, and a good measure of youthful high spirits, the periods at Acton Technical College on a London External Honours Degree course were serious and for real. However, the days at the laboratories were much more relaxed, for the staff there consisted mainly of young graduates, many with higher degrees (Ph.D.s were two-a-penny), and a distinctly cheery, happy-go-lucky atmosphere pervaded the place. There was even a special job number for preparing for the annual Childrens' New Year Party. Hundreds of man hours and hundreds of pounds-worth of materials must have been allocated to it each year.

Each 6 months' period in industry was supposed to be spent in a different laboratory, but PC spent the first two in the Solid Physics laboratory, learning all sorts of tricks. These ranged from how to survive the japes of the many pranksters about the place (I must tell you about Big Black-ear someday), to blowing ornamental glass animals. I even hand-fabricated some silicon rectifiers for a mains powered battery eliminator for my home-built valve portable radio (with the usual 1S5, 1T4, etc. line-up). Making rectifiers is simple enough, if you just happen to have access to the right materials, and a high-vacuum silica furnace tube plus electric furnace. With his interest in wireless, PC soon discovered that vacuum wax – a tough, non-crystalline wax that does not outgas (release gas molecules), used for sealing pinholes in vacuum systems – was excellent for securing the ends of windings on RF coils.

On the third period in industry, PC found himself in a laboratory where the work involved developing transistor circuitry. Naturally, in those early days of transistors, just about everyone in the laboratory was busily making himself a transistor radio on the side (with home-wound coils for cheapness). Of course, PC soon joined in, and found folk wanting to know what this wonder stuff was, that kept his coils so neat and tidy. News of vacuum wax (till then unheard of outside Solid Physics) soon spread to the surrounding laboratories also. Thus it was, that PC was responsible for an unprecedented demand, and stores ran clean out of vacuum wax in the next couple of days.

Enlightening the Uninitiated

The ignorance of the non-technical about electronics in general, and computers in particular, is profound. Mrs PC (master of eight or nine languages though she be) is no exception. During PC's recent spell in hospital, she kindly brought in, one visiting time, his Toshiba laptop, so he could write this column for that month. On visiting the following day, she said that the computer had seemed heavier when she took it home than it had when she came. PC had to explain that in Stray Signals, there are on average, about 4·5 characters per word, each character represented by a full byte of no less than eight bits – not to mention spaces, punctuation, etc. With thousands upon thousands of extra bits in it, what else could she expect?

Yours sincerely,

Point Contact

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

2
PROJECT
RATING

KIT AVAILABLE
(90088)
PRICE £32.99 A2

Operates from internal batteries or external 12V supply

ELECTRONIC VOLUME PEDAL

Design by Alan Williamson
Text by Alan Williamson,
Mike Holmes and Maurice Hunt

Simple, low-cost 'passive' volume controls are readily available, but they have drawbacks. One obvious disadvantage is that, being mechanical, they soon wear out and become 'noisy'. To avoid the wear and tear of a mechanical potentiometer and its eventual but inevitable demise, this project uses an optical system for the control. This ensures longevity, as there is nothing to wear out, and a rugged pedal casing completes the design.

FEATURES

★ Noise-free, reliable operation
★ Optoelectric pedal position sensor
★ High impedance input for electric guitars, etc.
★ Doubles as a buffer for long cable runs

APPLICATIONS

★ Guitar practice sessions ★ Concerts and gigs

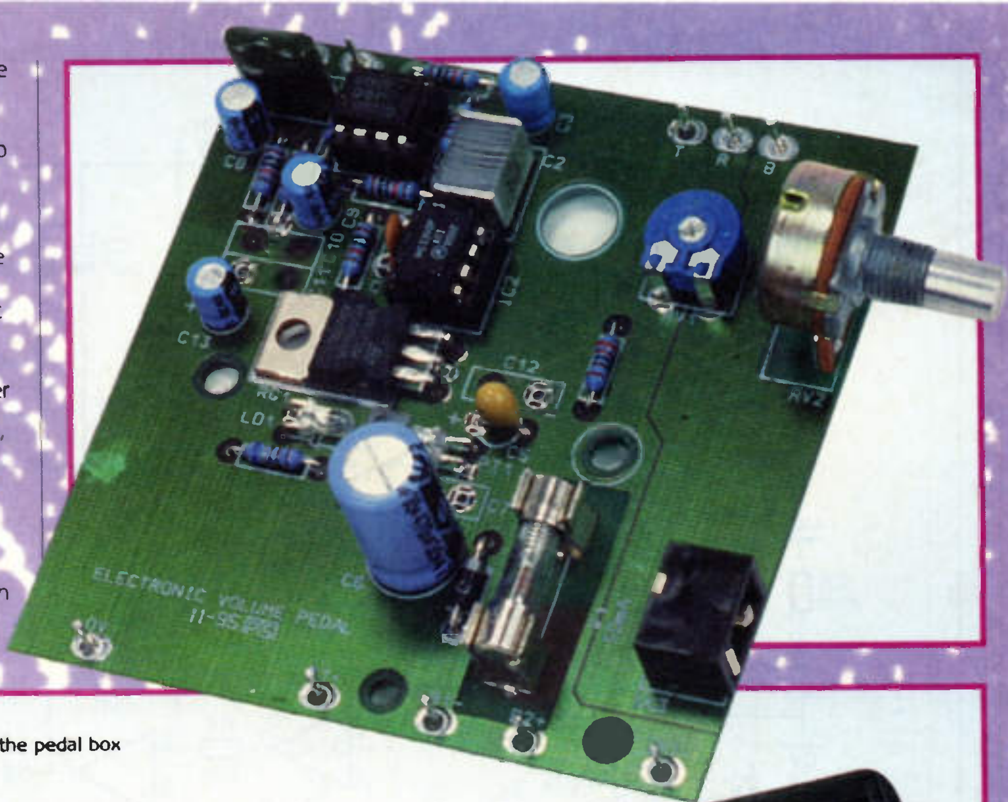
Specification

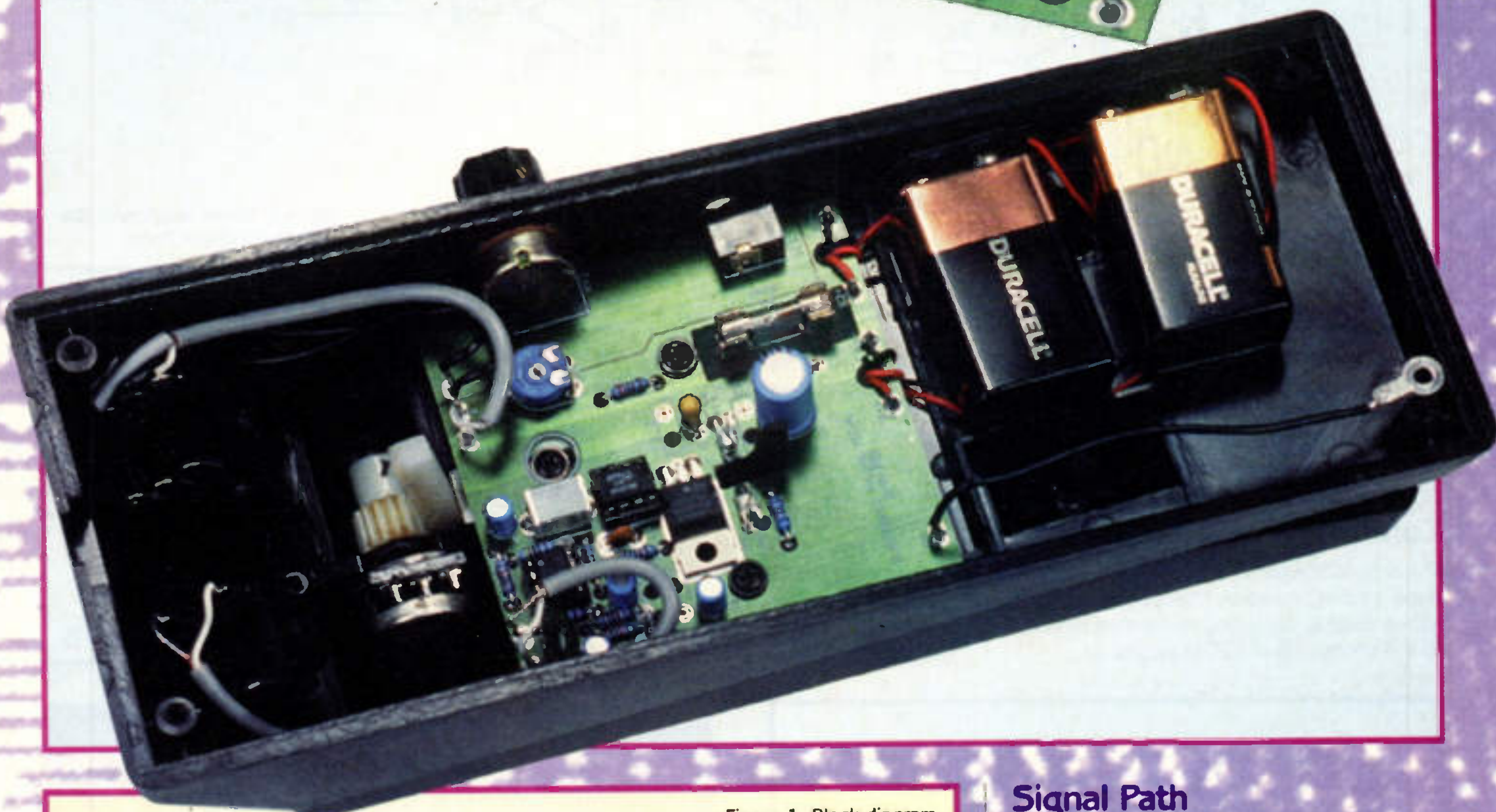
Power supply:	2 × 9V PP3 cells or external 9·5 to 18V DC regulated PSU
Operating current:	15mA @ 9·5V, 20mA @ 18V
Input level:	1·4V rms
Output level:	1·4V rms
Overall gain:	1 (approximately)
PCB dimensions:	77 × 74mm
Boxed unit dimensions:	238 × 101 × 104mm maximum

Another advantage of an 'active' volume control is that it acts a buffer with zero (unity) gain, high input and low output impedances. Most electric guitars do not contain any active electronic circuitry within them. The delicate pickup signal is unbuffered, and the guitar will have a relatively high output impedance. The cable to the amplifier will then have a marked influence on the sound quality, which is not ideal. By using a shorter cable to a buffer circuit such as this unit incorporates, this situation can be alleviated. Because a buffer has a low output impedance, a much longer cable to the amplifier can be 'driven' with less influence on the sound.

Circuit Description

Refer to Figures 1 and 2 for the block and circuit diagrams, respectively. The operation of the individual circuit stages is described in the following paragraphs.





Above right: The assembled PCB.
Below: Internal shot of the PCB installed in the pedal box

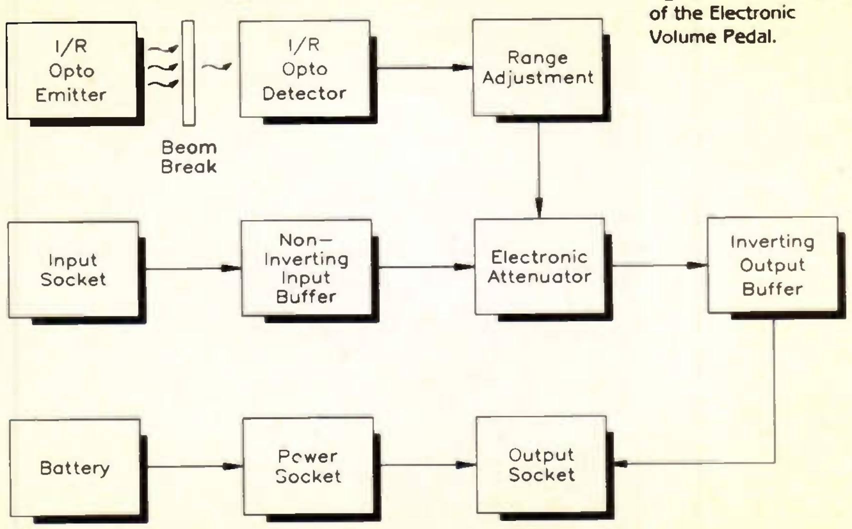


Figure 1. Block diagram of the Electronic Volume Pedal.

Signal Path

The signal from the instrument is applied to the unit via the input socket, SK1. IC1a is configured as a non-inverting buffer, having an input impedance of at least 1MΩ. Following this, resistors R2 and R3 are used to attenuate the signal. IC2 is an electronic attenuator IC. The specification of this device, an MC3340, states that the IC has a maximum gain of +13dB and a maximum attenuation of –90dB, with a maximum input signal of 500mV rms, hence the need for the attenuator at the input.

Gain and attenuation for IC2 is programmable either by applying an external voltage in the range of 3·5 to 6V (minimum to maximum attenuation) to pin 2, or an external resistance with a value of between 4kΩ and 33kΩ (minimum to maximum attenuation). This circuit uses the latter method.

Because IC2 has an inverted output signal, IC1b is therefore configured as an

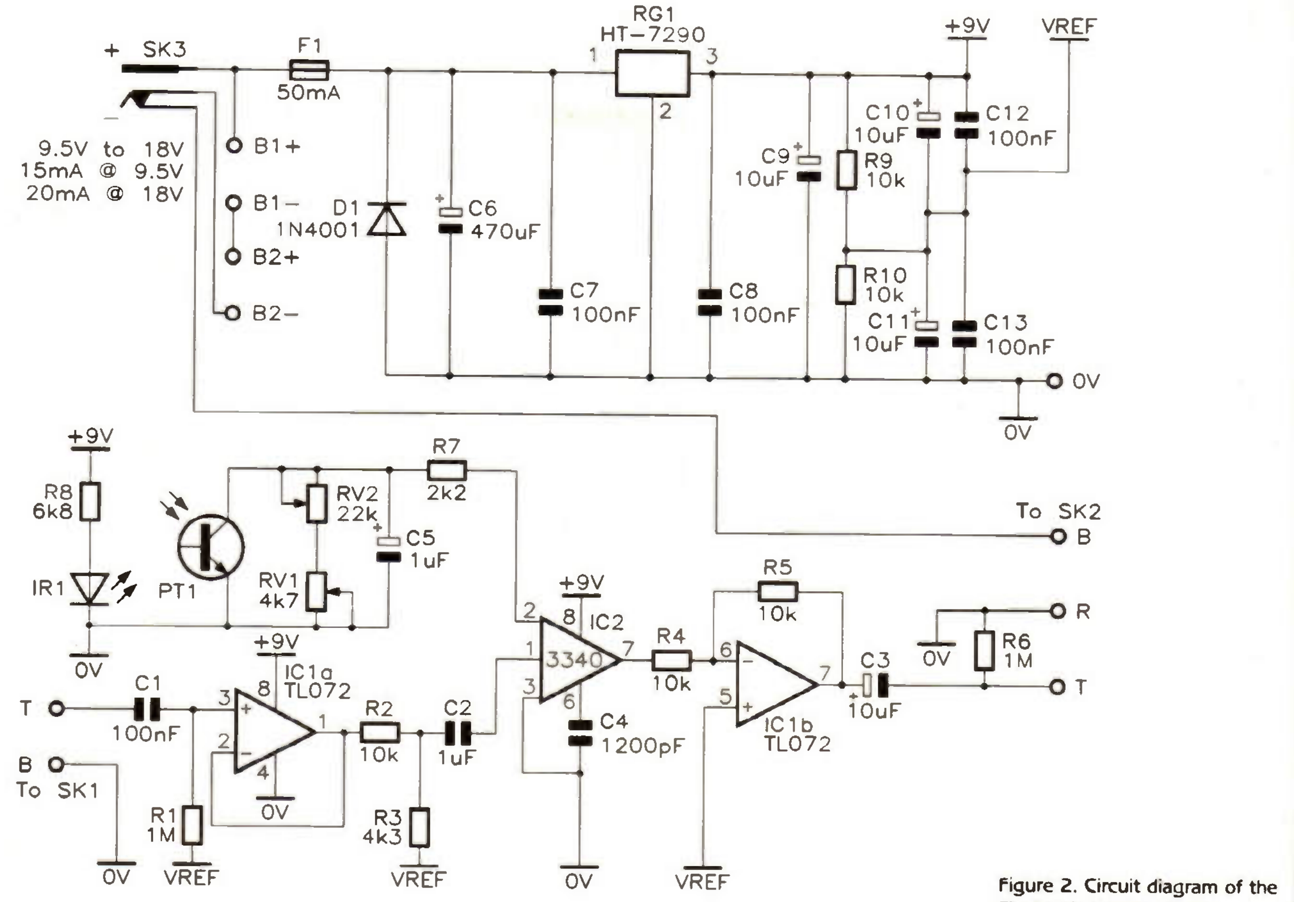


Figure 2. Circuit diagram of the Electronic Volume Pedal.

inverting output buffer, maintaining absolute phase from input to output. SK2 is the output socket, which also acts as the power switch. Inserting a 'MONO' jack plug into the 'STEREO' jack socket will short circuit the body and ring contacts of SK2 and power up the circuit by completing the 0V return path.

Control Circuit

The potentiometer as supplied within the pedal housing could be changed for one with a suitable value and connected directly to the control pin of IC2. However, to avoid the inevitable wear and tear of the mechanical potentiometer from affecting the operation of the unit, an optical system was chosen for the control – the potentiometer is retained, but is used *only as a form of friction damper.*

LED LD1 emits a wide beam of IR (Infra-Red) light. When the pedal is depressed a mechanical blade cuts through the beam, limiting the amount of light received by the IR phototransistor, which acts as a variable resistor. Potentiometer RV1 and preset RV2 are wired in series across phototransistor. The preset is adjusted to set the maximum

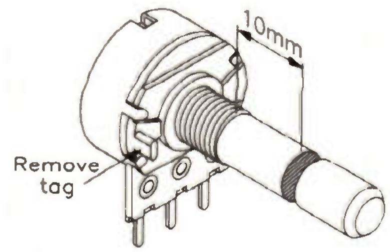


Figure 4. Potentiometer modification (RV1).

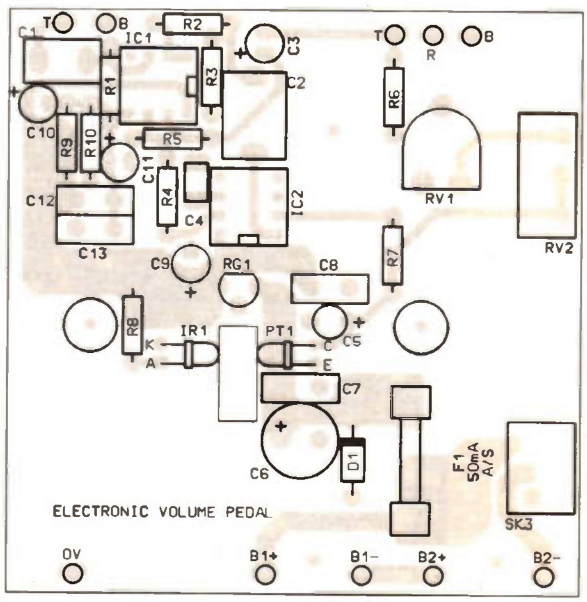
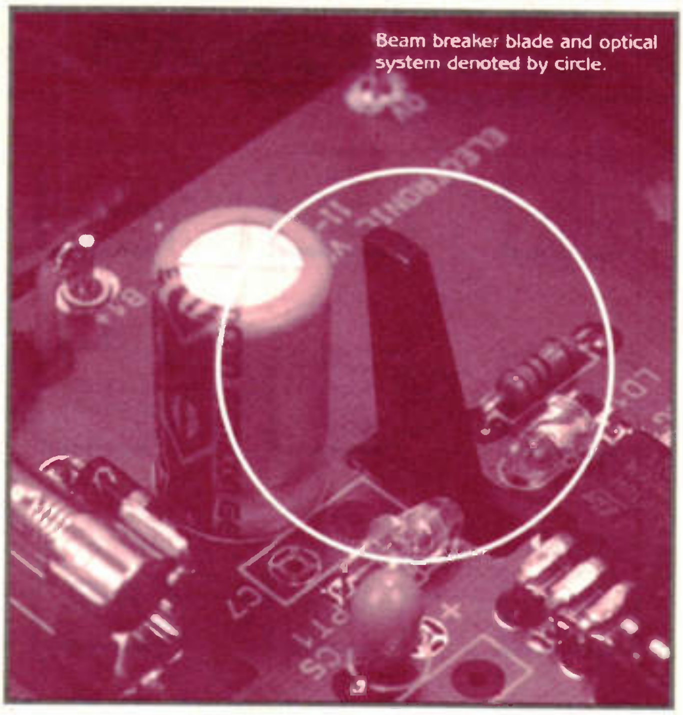


Figure 3. PCB legend and track.



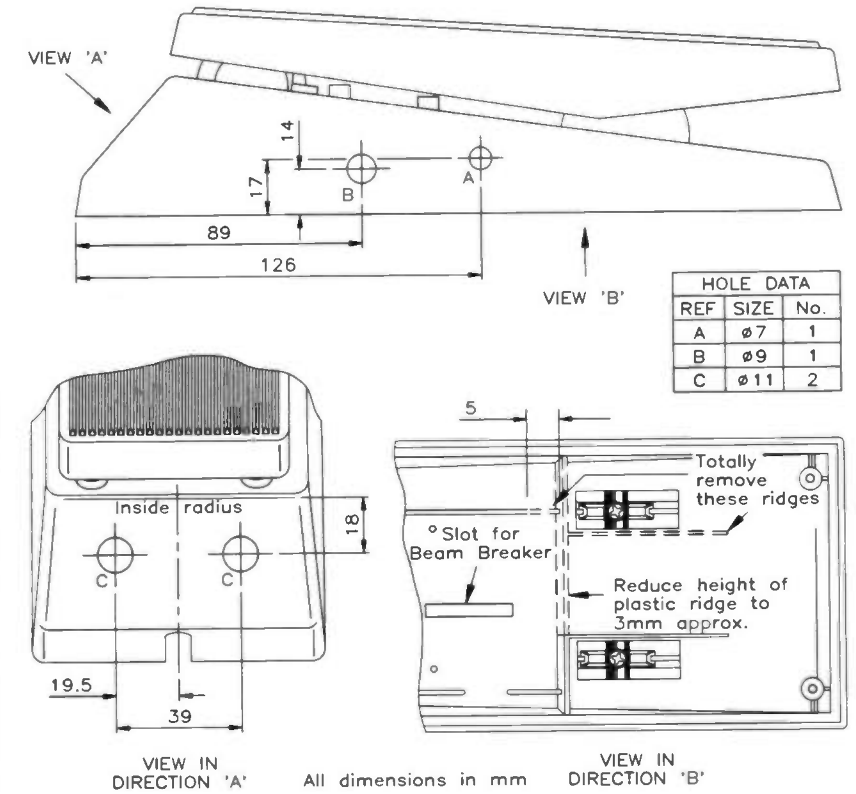
Beam breaker blade and optical system denoted by circle.

required attenuation, while the potentiometer is used as a 'range' control and appears on the side of the finished unit.

Power Supply

Power to the circuit can be supplied from either two internal PP3 batteries or an external 9·5 to 18V DC supply (which may be unregulated) via the power socket SK3. Diode D1 is reverse connected across the supply input. In the event of the external PSU being inadvertently connected with the wrong polarity, the diode will clamp the negative voltage across the circuit to –1V, the potential high current flow causing fuse F1 to blow, thus preventing expensive damage to the circuit. IC2 requires a minimum supply of 9V to function correctly, therefore, the circuit requires two PP3 batteries or a DC external power supply. Thereafter, a 9V supply rail is maintained by regulator RG1.

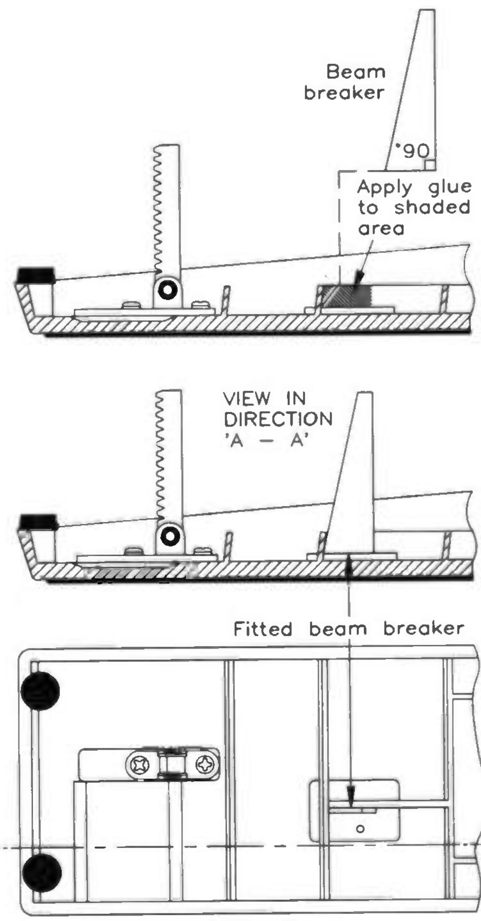
Just as a note of interest, a step-up Switch Mode Power Supply (SMPS for short) was originally tried, to enable the circuit to operate from a single PP3 battery, and the output ripple was only 5mV! It appeared to be a good idea initially, until the circuit was listened to. The noise figure at the output of IC1b was some 20dB up compared with the same circuit without the SMPS fitted – this made it unusable! The noise proved impossible to cure without vastly increasing the cost of the kit by adding special components, because the noise was



HOLE DATA		
REF	SIZE	No.
A	ø7	1
B	ø9	1
C	ø11	2

Figure 5. Box drilling and cutting details.

Figure 6. Mechanical assembly of the beam breaker.



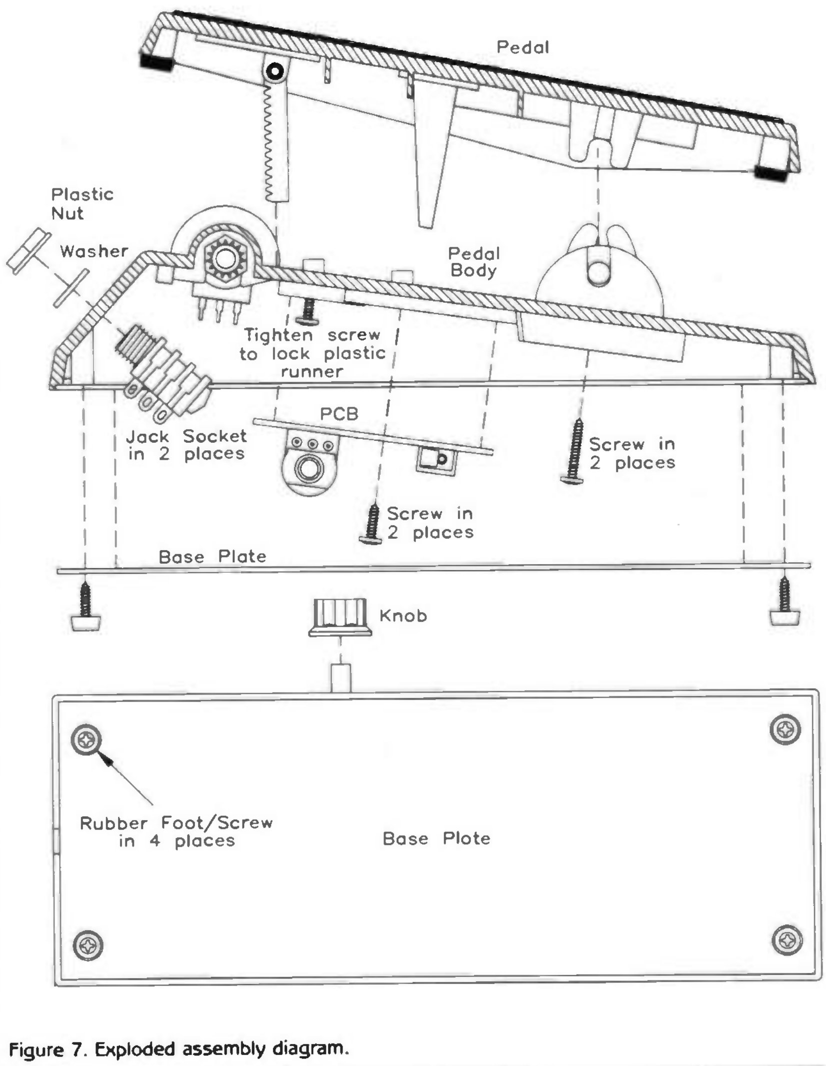


Figure 7. Exploded assembly diagram.

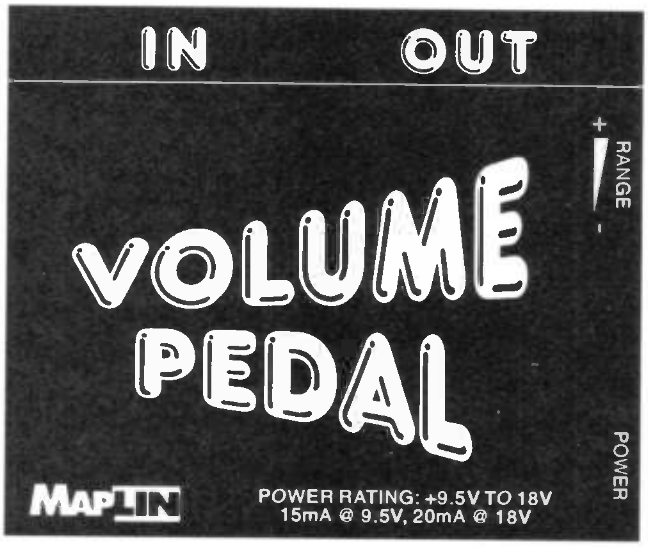
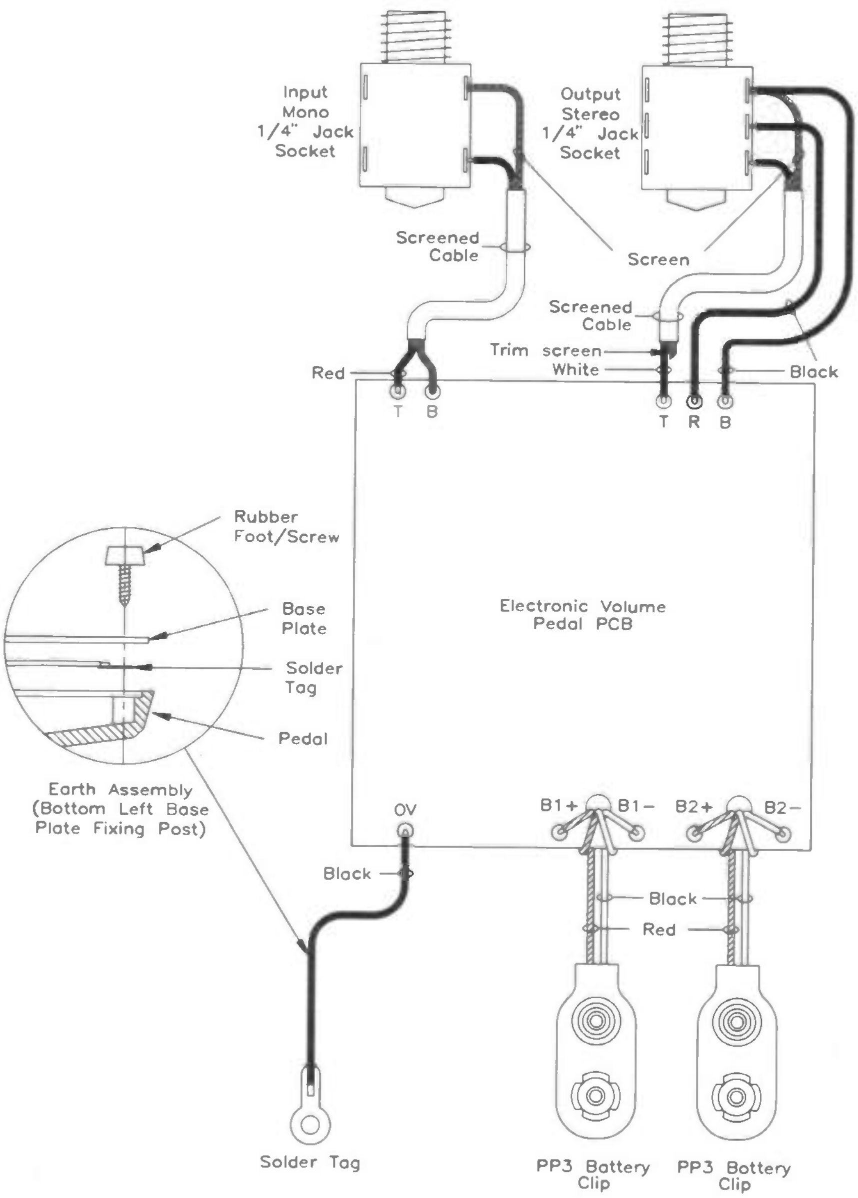


Figure 8. Electronic Volume Pedal Panel labels.

Figure 9. Wiring diagram.



electromagnetically injected into the 0V ground plane by the SMPS inductor.

Finally, components R14, R15, and C8 to 11 form a half supply reference for IC1a and IC1b. This is preferable to using a 'centre tap' between the two batteries, because they will discharge unevenly (in the event, the method of regulation makes this impossible anyway).

Construction

The PCB is a high quality glass fibre type, complete with solder resist and silk screen legend to aid construction. It also includes a ground plane on the component side to help reduce external interference, as the pedal box is plastic (with exception of the steel base panel) and is not screened.

PCB construction is fairly straightforward. Refer to Figure 3, showing the PCB legend and track, the Parts List, and the circuit diagram. Begin with the smallest components first, working up in size to the largest. The potentiometer RV1 will require modification before fitting, as per Figure 4. Insert the PCB pins from the track side. Be careful to correctly orientate the polarized devices, specifically electrolytic capacitors, diodes, LEDs and ICs. Do not directly solder the ICs at this stage – fit the IC sockets only, making sure to orientate the notch at one end with the marker on the PCB legend. See also the Constructors' Guide provided with the kit.

To identify which is the IR emitter and the IR phototransistor, look directly into the lens of each. The phototransistor has the large square black chip inside. The shortest lead on the LEDs and phototransistor is, in each case, the cathode (K), or collector (C) for the phototransistor.

Correctly orientate and insert the two ICs into their sockets, making sure to align the pin 1 marker to the end of the socket identified by a notch, and taking suitable antistatic precautions. Thoroughly check your work for misplaced components, solder whiskers, bridges and dry joints. Finally, clean all excess flux off the PCB using a suitable solvent.

Box Modification and Assembly

Unscrew the four rubber feet and remove the base plate. Disconnect and remove the jack lead from the potentiometer, along with the 'P' clip (you can attach a mono jack plug to the unterminated end of the wire for a spare lead). Loosen the screw on the friction block for the rack & pinion and slide it back, then remove the two screws through the pedal pivot bar and separate the two halves of the pedal.

Refer to Figure 5 for the pedal and box drilling details. Glue the 'beam breaker' blade in position as shown in Figure 6, and allow to dry. Assemble the unit as shown in Figure 7; DO NOT overtighten the PCB fixing screws. Visually check that the optical beam path covers the range from fully broken (closed) to fully exposed (open) over the full range of the pedal travel from one extreme to the other. Slight physical adjustment of the IR opto devices may be necessary.

The main portion of the self-adhesive label shown in Figure 8 is attached to the

Continued on page 23.

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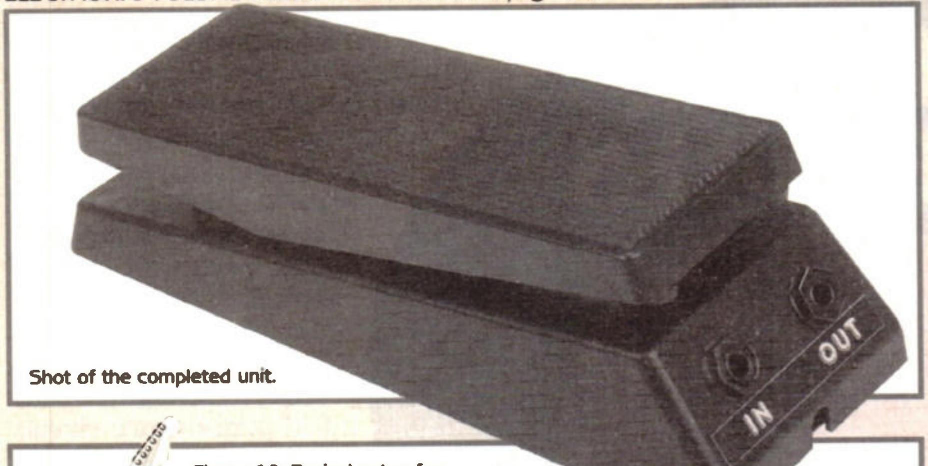
ELECTRONIC VOLUME PEDAL – *Continued from page 20.*



Shot of the completed unit.

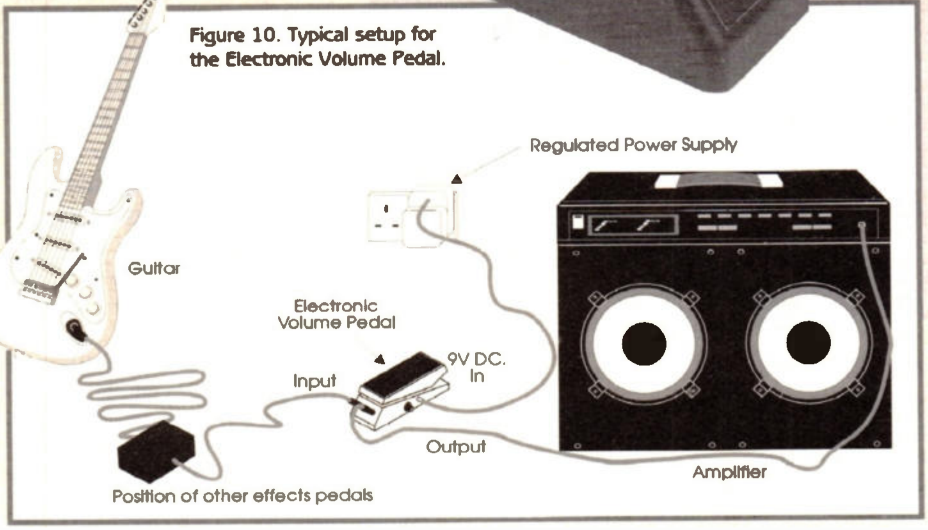


Figure 10. Typical setup for the Electronic Volume Pedal.

metal plate (base panel) of the box, whilst the detachable small label (showing 'IN OUT') is applied to the end of the casing, adjacent to the jack sockets. Wire up the circuit as shown in Figure 9. Note that the battery leads loop through the two larger holes in the PCB before soldering the ends to their respective PCB pins. Finally attach PP3 batteries to the clip connectors, though you do not *have* to install batteries if you intend to operate the unit from the optional external power supply. Do not refit the base plate at this stage, as the preset potentiometer RV2 requires adjusting.

Testing and Adjustment

Turn the preset potentiometer RV2 fully anticlockwise, and the potentiometer RV1 fully clockwise, also back off the pedal (place it in the heel down position). Connect the Electronic Volume Pedal in circuit as shown in Figure 10. Play a note on your chosen instrument, then adjust the preset clockwise until the *minimum* attenuation is found (the maximum is set by the potentiometer).

Disconnect the leads from the volume pedal and fit the base plate. When doing this, do not forget to fit the grounding wire solder tag under one of the base plate fixing holes. The Electronic Volume Pedal is now ready for use. E

Happy playing!

ELECTRONIC VOLUME PEDAL PARTS LIST

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

R1,6	1MΩ	2	(M1M)
R2,4,5,9,10	10kΩ	5	(M10K)
R3	4k3Ω	1	(M4K3)
R7	2k2Ω	1	(M2K2)
R8	6k8Ω	1	(M6K8)
RV1	22kΩ Miniature Linear Potentiometer	1	(JM72P)
RV2	4k7Ω Horizontal Enclosed Preset Potentiometer	1	(UH02C)

CAPACITORS

C1	100nF Mylar Film	1	(WW21X)
C2	1μF Polyester Layer	1	(WW53H)
C3,9,10,11	10μF 63V Radial Electrolytic	4	(AT77J)
C4	1n2F Ceramic Disc	1	(WX69A)
C5	1μF 35V Tantalum Bead	1	(WW60Q)
C6	470μF 25V Radial Electrolytic	1	(AT51F)
C7,8,12,13	100nF 50V Ceramic Disc	4	(BX03D)

SEMICONDUCTORS

IC1	TL072	1	(RA68Y)
IC2	MC3340	1	(AY17T)
D1	1N4001	1	(QL73Q)
RG1	HT7290	1	(CH49D)
IR1	Infra-Red Source	1	(YY65V)
PT1	Infra-Red Sensor	1	(YY66W)

MISCELLANEOUS

SK1	¼in. 3-way Jack Socket with Solder Tags	1	(HF92A)
SK2	¼in. 2-way Jack Socket with Solder Tags	1	(HF90X)
SK3	PCB 2·5mm DC Power Socket	1	(FK06G)
FS1	50mA 20mm Time Delay Fuse	1	(UJ90X)
	Beam Breaker Blade	1	(95073)
	Fluted Knob Type K7A	1	(YX01B)
	20mm Fuse Clip Type 2	2	(KU27E)
	8-pin DIL Socket	2	(BL17T)
	PP3 Clip	2	(HF28F)
	1mm PCB Pin Type 2145	1 Pkt	(FL24B)
	Remote Foot Control Casing	1	(XY28F)
	Twin Screened Cable	1m	(XR21X)
	16/0·2 Wire Black 10m	1 Pkt	(FA26D)
	M3 Solder Tag	1 Pkt	(LR64U)
	Panel Labels	1	(90090)
	PCB	1	(90089)
	Instruction Leaflet	1	(XV83E)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

	Alkaline PP3 Battery	1	(JY49D)
	AC Adaptor Unregulated 300mA	1	(XX09K)
	¼in. Plastic Mono Jack Plug	1	(HF85G)

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 90088 (Electronic Volume Pedal) Price £32.99 A2

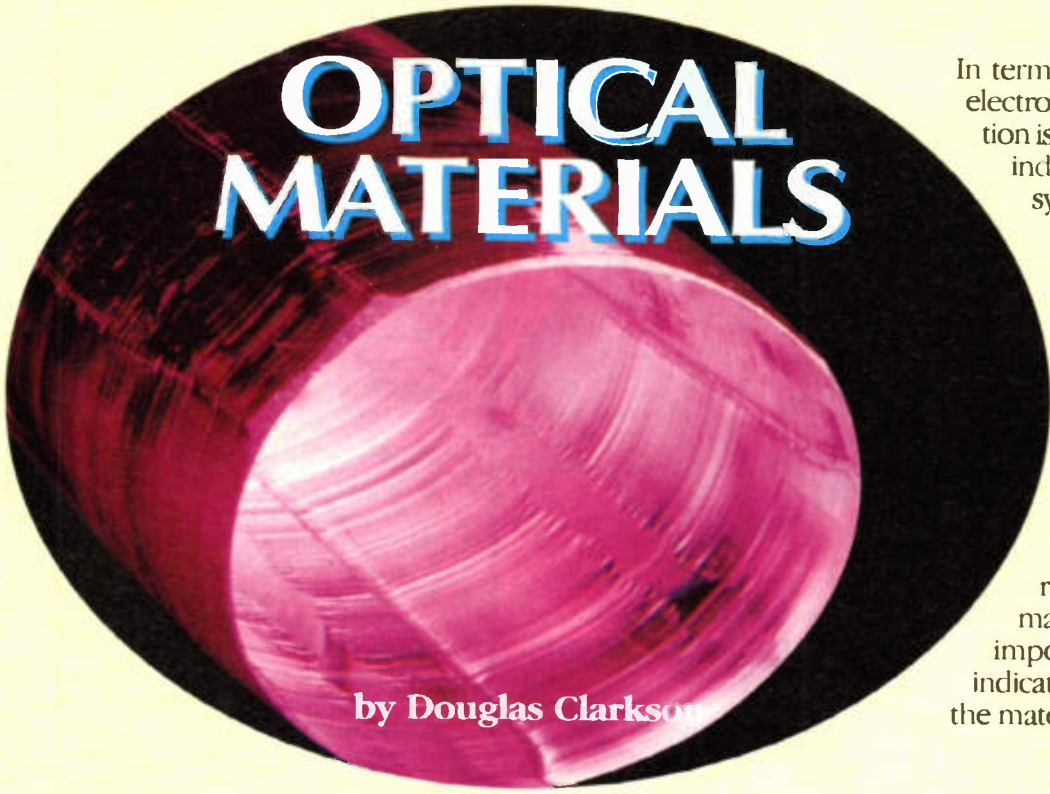
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1996 Maplin Catalogue.

Electronic Volume Pedal PCB **Order As 90089 Price £5.99**

Electronic Volume Pedal Panel Labels **Order As 90090 Price £2.49**

Beam Breaker Blade **Order As 95073 Price TBA**



OPTICAL MATERIALS

by Douglas Clarkson

In terms of the parallelism between electronic and optical design, function is based on the performance of individual components of such systems. An appreciation of the available 'building blocks' of both technologies therefore is an essential part of design, construction and service of such systems. Optical components often have highly specified performance characteristics which have a critical effect on the function of optical systems. This review provides a brief summary of a selection of the more important optical materials and indicates the typical uses made of the materials.

IN describing the specification of optical materials, key parameters include the Abbe νd value and refractive index at 587·56nm (the Helium d line). The Abbe νd value is given by:

$$\nu d = \frac{nd - 1}{nf - nc}$$

Where nd is the refractive index at 587·56nm, nf is the refractive index at 486·1nm, and nc is the refractive index at 656·3nm. Note that higher values of Abbe constant are associated with lower values of chromatic aberration.

The value of refractive index has important implications for optical components. Higher values provide generally for more compact optics although reflection losses increase and require to be corrected by use of appropriate surface film coatings. Optical materials such as specially grown crystals have a certain degree of fascination. Photo 1 shows a range of such optical materials fabricated by Zeiss, and Photo 2 shows a large boule of Sapphire with some rods of pink Nd:YAG crystal.

Sapphire

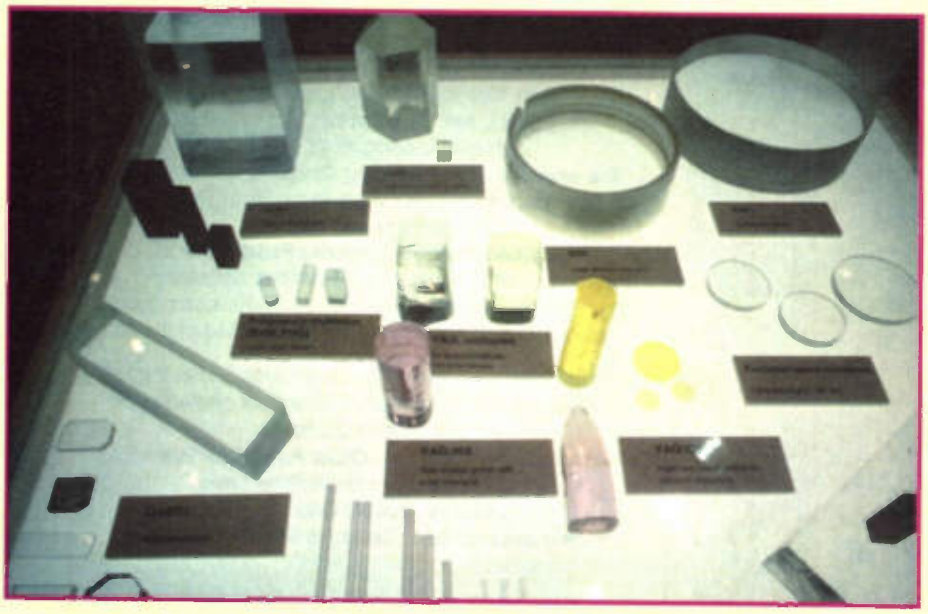
Sapphire, an oxide of Aluminium, is finding favour in a broad range of optical and electronic applications. The Czochralski crystal growing method is able to produce boules of the largest size for any crystal growing technique. Sapphire crystals can be grown up to 15cm in diameter and 60cm in length. In terms of its optical and physical properties, Sapphire is the hardest of the oxide crystals, maintains its strength at high temperature and is highly resistant to chemical attack. This characteristic, however, makes Sapphire especially difficult to grind.

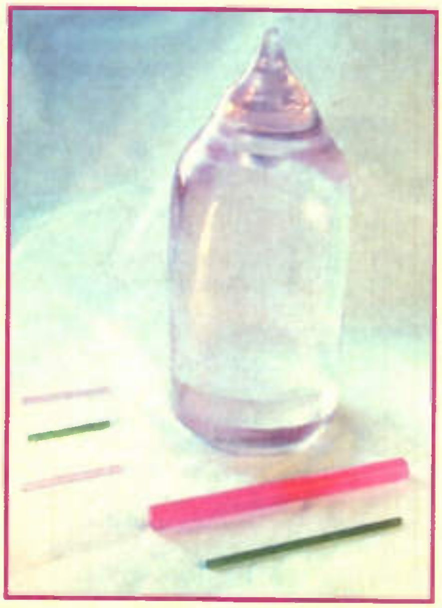
Figure 1 indicates the variation of refractive index of Sapphire as a function of wavelength. Sapphire therefore provides low values of chromatic aberration in the near infra-red between 1 and 2μm. Often in optical systems, the dispersion (the change of refractive index with wavelength) of lens material is a key factor in the degree of chromatic aberration present.

Figure 2 indicates the transmission characteristics of VUV grade material – a specialist material for ultra-violet transmission. Ultra-flat surfaces are recommended for transmission below 250nm. This grade of Sapphire thus provides a material for lenses in the short wavelength UV region. Sapphire is also used extensively as a shield for solar cells on spacecraft where its transmission to visible radiation is not impaired by exposure to high levels of energetic electrons such as occurs within the earth's radiation belts. Also, the transmission of the crystal is largely unaffected by temperatures as high as 500°C.

Coatings such as Magnesium Fluoride can reduce the single surface reflectivity to less than 0·15% – providing transmission in visible and near infra-red in excess of 98·5%. Sapphire crystal is used in a wide range of applications

Below left: Photo 1. Range of optical materials manufactured by Zeiss.
Below right: Photo 2. Large boule of Sapphire together with cut rode of Nd:YAG. (Courtesy Crystal Products.)





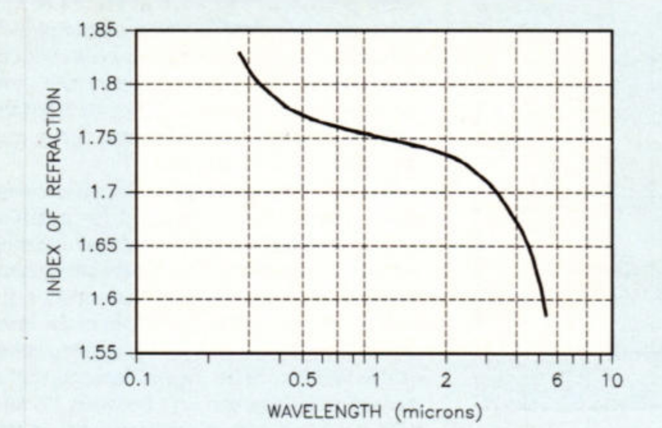


Figure 1. Variation of refractive index of Sapphire with wavelength. (Courtesy Crystal Products.)

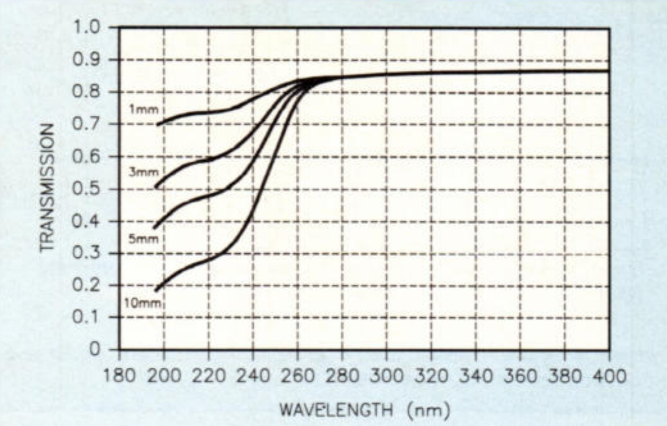


Figure 2. Transmission characteristics of Melles Griot VUV-grade Sapphire. (Courtesy Crystal Products.)

in both the optical and the electronics industry. Standard applications are found in UV and IR optics and lamp tubes and windows. Within the electronics industry, extensive use is made of the material for Silicon-on-sapphire wafers, thin-film substrates, heatsinks, thermocouples and superconductor substrates.

Completed boules are examined using laser illumination to identify scattering site defects which are eliminated in cut sections. As key components in laser systems, the elements of processed Sapphire are tested to determine the wavefront distortion. A typical value able to be reproduced is 0·03 of a wavelength per inch of crystal length.

Sapphire substrates used for deposition of Silicon are specifically grown with optimum crystal orientation. A specific type of Sapphire substrate is used in a range of fabrication/crystal growth techniques using Thallium and other superconductive components, high impedance resistors and the growth of GaAs devices. Such substrates are also used in the manufacture of pressure transducers.

The (0001) basal plane Sapphire substrates are typically used with compounds such as Mercury, Cadmium and Telluride for infra-red detector applications. Sapphire is an extremely hard material and is particularly resistant to scratching. Optical components fabricated from Sapphire are utilized where harsh operating conditions are anticipated. Table 1 summarizes a range of physical and optical properties of Sapphire.

Chemical formula Al_2O_3
Density 3·98g/cc
Melting point 2,040°C
Thermal conduct 46°6W/(m.K)
Specific heat 0·42J/(g.C)
Dielectric 11·58 (parallel to C axis)
Constant 11·58 (perpendicular to C axis)
Abbe number 72·2

Table 1. Summary of physical properties of Sapphire. (Courtesy Crystal Products.)

Titanium-doped Sapphire

The introduction of 0·1% doping of Sapphire by Ti^{3+} ions in place of Al^{3+} provides a widely used component for tunable vibronic laser crystals. Figure 3 indicates the region of absorption, peaking at 490nm and the wide region of fluorescence. Favoured pumping devices include Argon ion, Copper vapour, frequency doubled Nd:YAG and dye lasers.

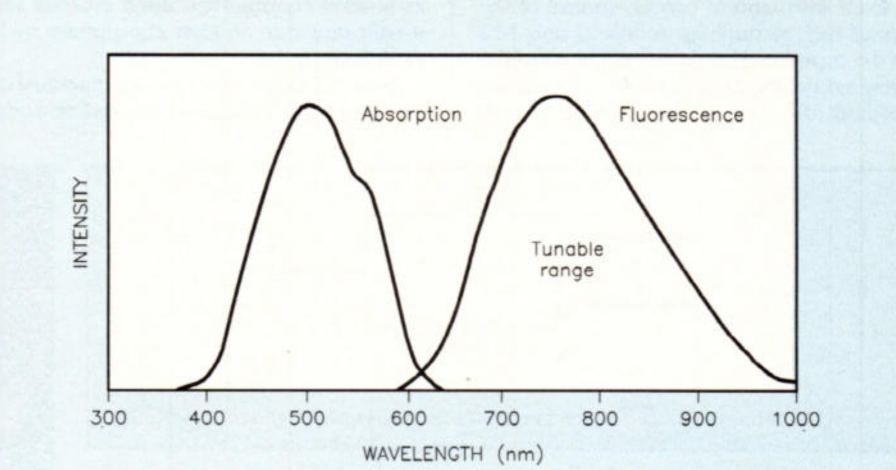


Figure 3. Optical characteristics of Ti-doped Sapphire, showing the regions of absorption and fluorescence. (Courtesy Crystal Products.)

Techniques of crystal growth seek to minimise the concentration of Ti^{4+} ions which cause defect structures in the crystal and also bubbles. Laser gain of such laser systems is typically 10dB/cm. Dopant levels vary typically between 0·03% and 0·15% weight of Ti_2O_3.

The fluorescence output wavelengths provide also opportunities for frequency doubling of the output of the laser. One of its key properties is its infinitely long stability as a laser material and associated useful life in laser systems.

Ruby:Chromium-doped Sapphire

Ruby was the first solid-state laser material to be developed. Continuous refinement of its manufacturing process has secured its role as a highly reliable crystal material, especially for high energy pulses. The physical properties of Sapphire and Ruby are quite similar. The doping level of Cr_2O_3 in Al_2O_3 varies typically between 0·05% and 0·03%. The major optical pumping bands for Ruby are 404nm (blue) and 554nm (green). The characteristic 'Ruby red' output wavelength is typically 694nm. In pulse generation applications, typically among 2 and 4 Joules can be developed per cubic centimetre of Ruby material. With appropriate Q-switch circuits, pulse times can be as short as 20ns.

Nd:YVO_4 Crystal

Vanadate crystals are rapidly increasing in use as a compact laser crystal, pumped by existing red laser diodes at around 809nm. High efficiency output resonances can be obtained at 1·06 and 1·34μm. The 1·064nm wavelength can, in turn, be frequency doubled by non-linear crystals such as KTP to produce 532nm green – close to that of the conventional He-Ne laser. By fabricating crystals of high Nd-doping, laser cavities can be designed which are extremely compact. Elements of Nd:$YV0_4$ as thin as 1 or 2mm are typically found to be adequate.

In a specific configuration, 730mW of laser diode input into a 1mm Nd:YVO_4 element in a laser cavity can produce 278mW of power at 1,064nm. In another configuration with a KTP crystal, for 890mW of laser diode input, 76mW of green 532nm was obtained. Pure YVO_4 is also used as a polarizing element between 2 and 5μm. Figure 4 indicates a typical configuration of laser diode, Vanadate crystal and KTP frequency doubling crystal.

Nd:YAG

Neodymium-doped Yttrium aluminium garnet material (Nd:YAG) is widely used as a versatile solid-state laser material. In the crystal structure, about 1% of the Yttrium is substituted by the Neodymium atoms. Since the substituted atom is larger than the Yttrium atom, care must be taken to ensure that the

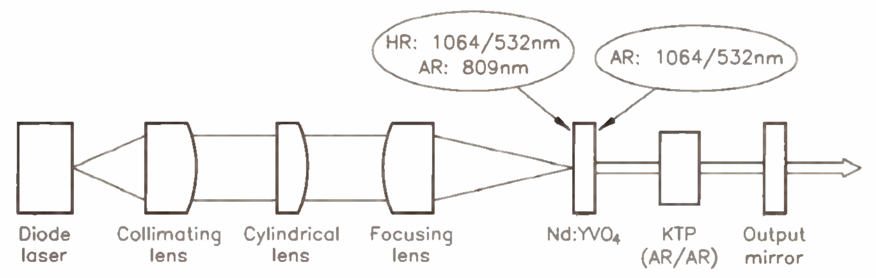


Figure 4. Typical configuration of laser diode, Vanadate crystal and KTP frequency doubling crystal. (Courtesy CASIX.)

doped atoms take up positions uniformly within the lattice and minimise distortion and strain. This requires very tight control of the melt temperature, to around 2,000°C.

Even with current precise control of the crystal melt technology, as little as only 10% of the completed boule can yield rods of the required quality. As part of the 'slow pulling method' of the crystal growing process, a very stable thermal environment is required to be maintained over a 2 to 3 week period. Even a brief minor change in power settings can introduce a defect zone extending as much as several centimetres. Such crystals are usually grown in an inert atmosphere such as Helium gas.

As part of the process of quality appraisal of the completed boule, inspection is first made using polarized light at right angles to the boule axis. This identifies areas of strain which are difficult to identify when the crystal is cut in rod form. Also, the region at the core associated with the conical growth interface introduces strain into the crystal lattice and this needs to be identified.

Once such zones of defects have been identified, the boule is assigned for cutting. Subsequent tests on the cut rods include evaluating the polarization extinction ratio where 'perfect' rods produce an extinction ratio matched by the polarizers. Strain in the crystal can introduce rotation of the polarization of the incident light. Typical leakage under crossed polarizers can vary between 1% and 0·1%, and is a critical measurement of the residual strain in a rod. Rods with zones of high strain are more likely to fail in use. The first Nd:YAG crystals were produced around 1965. Photo 3 indicates the characteristic hue of Nd:YAG crystal.

Below: Photo 3. Cut section of Nd:YAG crystal. (Courtesy Crystal Products).

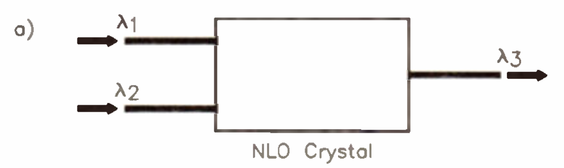
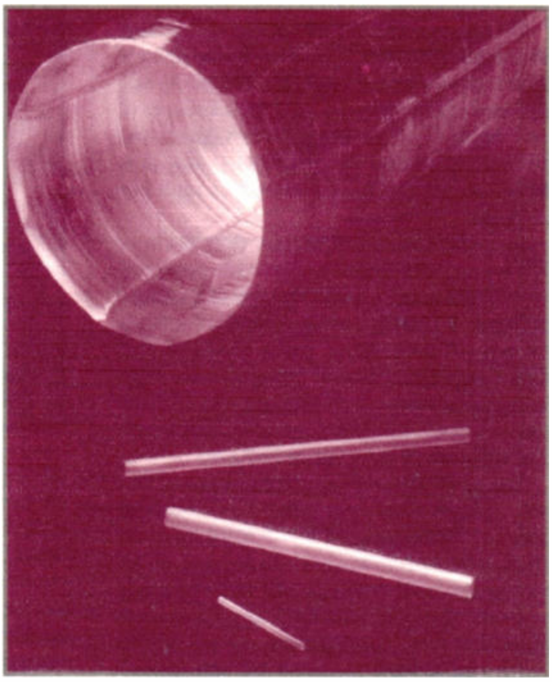


Figure 5a. Summary of the general process of sum frequency generation (SFG).



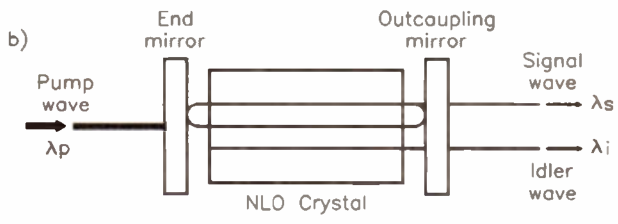


Figure 5b. Differential frequency generation (DFG). (Courtesy CASIX.)

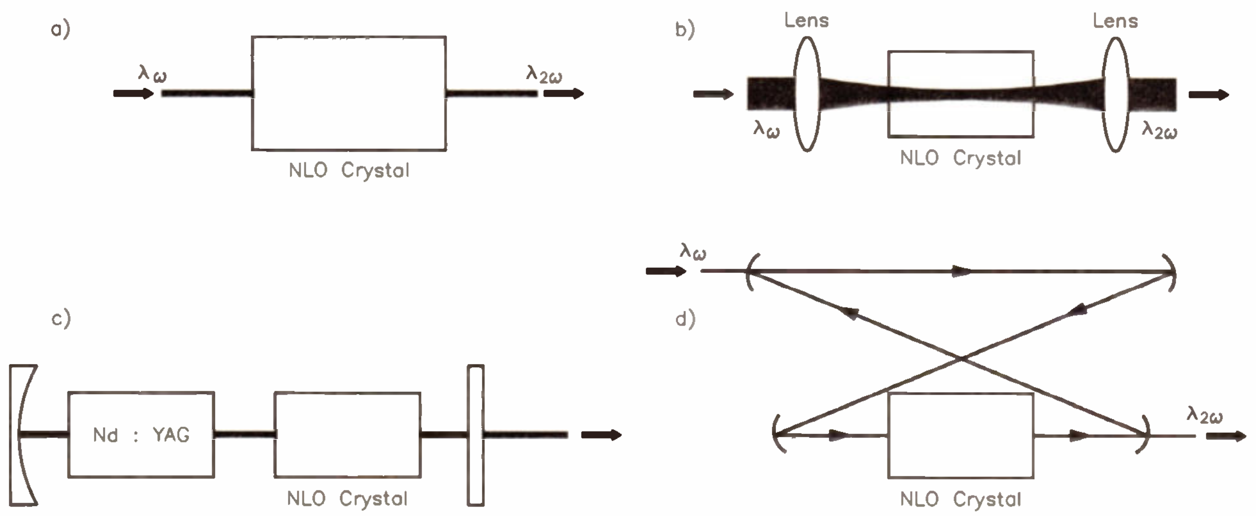


Figure 6. Configurations of frequency doubling with non-linear crystals. (a) direct beam (b) with beam focusing (c) intercavity action (d) external cavity action. (Courtesy CASIX.)

Alexandrite

This material comprises Chromium-doped $BeAl_2O_4$. Lasing action can be derived between 701 and 826nm, depending on the optical characteristics of the associated laser resonator circuit. The material has a dominant transition at 680·4nm. Alexandrite has been extensively investigated as an alternative to Ruby (dominant transition 694·3nm), though the poor efficiency of the Alexandrite transition has helped Ruby maintain its popularity. Typically, Alexandrite rods contain between 0·01% and 0·4% of doped Chromium. The emissive cross-section of Alexandrite at room temperature is relatively low, however, though surprisingly, it increases with temperature. Conversion efficiencies of electrical energy to laser output are of the order of 1%.

Nd:YAP

This material, Yttrium Orthoaluminate, has properties similar to Nd:YAG and has lasing wavelengths at 1·079 and 1·34μm. The longer wavelength of Nd:YAG provides for more efficient generation than the comparable line of Nd:YAG.

Non-linear Optical Crystals

Increasingly, use is being made of non-linear optical crystals to generate a broader range of output wavelengths from laser systems. Such materials function by allowing photons to interact and form secondary photons of different wavelengths. The commonest type of mode is a 'frequency doubling', where two photons of equal energy are combined to a single photon.

Figure 5a indicates the general process of sum frequency generation (SFG) and Figure 5b shows optical parametric generation (OPG). In SFG, the frequencies of the incident photons are added so that:

$$ø1 + ø2 = ø3$$

Where two photons of the one wavelength are combined, this is termed 'frequency doubling'. A typical example of this type of non-linear activity is doubling of the 1,064nm energy photon to 532nm. In frequency tripling or third harmonic generation (THG) in Nd:YAG lasers, the 1,064nm wavelength is added to the frequency doubled 532nm to create a 355nm line in the ultra-violet region.

In optical parametric generation (OPG), one high-energy photon is split into two low energy photons – one termed the 'signal' photon and the other, the 'idler' output.

In frequency doubling, the non-linear crystal can be used in a number of configurations, as indicated in Figure 6. In (a), the NLO crystal is simply placed in the output beam path while in (b), the effectiveness of the process is improved by focusing the beam into a narrower cross section in the NLO crystal. The NLO crystal can also be placed directly in the laser cavity as in (c) (intercavity action), or as in (d) external resonant cavity action.

Figure 7 indicates a selection of the possible transitions which such non-linear optics make possible. With such a framework, there is scope for many permutations of inputs/outputs. Thus, a first harmonic output from Nd:YAG can be converted by Optical Parametric Generation to form a tunable

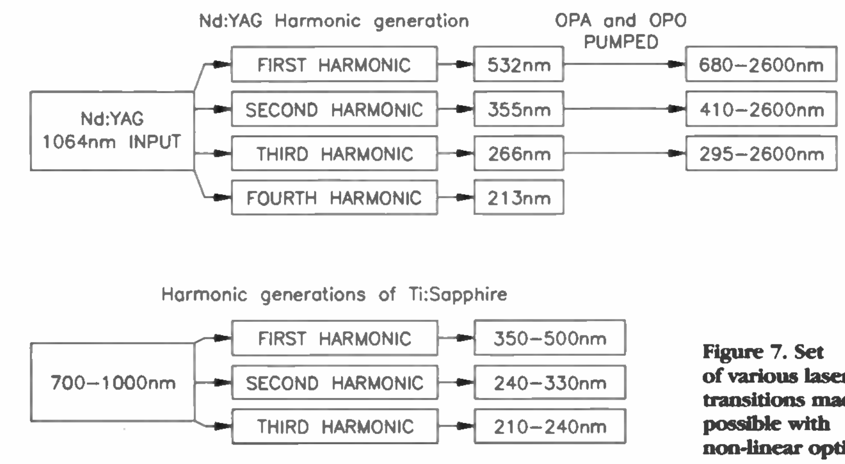


Figure 7. Set of various laser transitions made possible with non-linear optics.

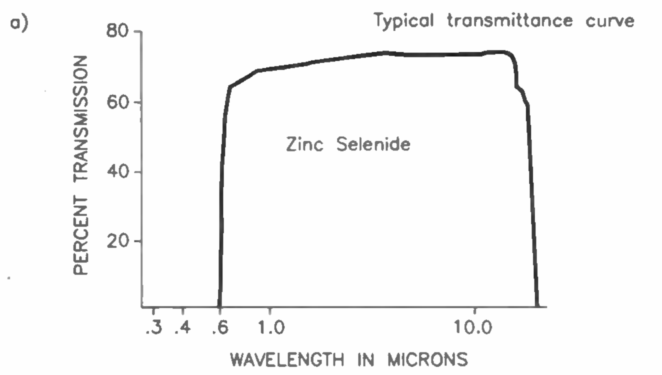


Figure 8a. Transmission spectra of Zinc Selenide: Uses include a transparent window for Carbon Dioxide radiation at 10·6nm. (Courtesy Melles Griot.)

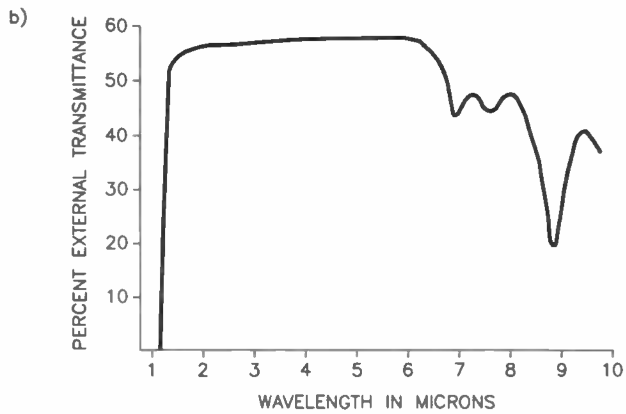


Figure 8b. Transmission characteristics of Silicon, which is used primarily for transmission in the infra-red region. (Courtesy Melles Griot.)

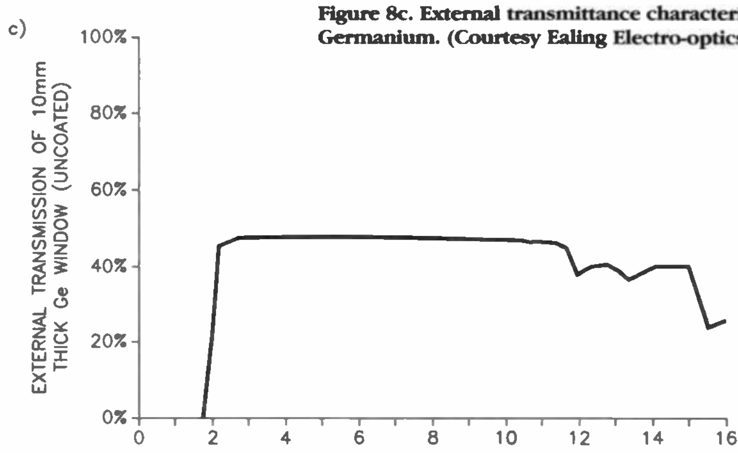


Figure 8c. External transmittance characteristics of Germanium. (Courtesy Ealing Electro-optics.)

range of output wavelengths between 680 and 2,600nm. An extensive range of non-linear optical materials are available. Summary details of a brief selection of such materials are now listed.

Barium Borate (BBO)

This material is widely used for 2nd, 3rd, 4th and 5th harmonic generation from Nd:YAG lasers and up to the 4th generation for Titanium-Sapphire and Alexandrite. Specific crystal cuts are required to maximise the output at a specific laser harmonic. As a material, however, BBO must be protected from moisture and handled carefully, since it is relatively soft.

Lithium Triborate (LBO)

This newly developed crystal tends to be used for frequency doubling of Nd:YAG and Nd:YLF lasers for high power applications. LBO is specifically used for ultra-short laser pulses, on account of its high damage threshold. Its properties are highly temperature dependent, and this effect can often be used for 'temperature-tuning' of systems. One particular transition using 532nm input can be tuned from 750 to 1,800nm by changing the crystal temperature from 106·5 to 148·5°C.

KTP: Potassium Titanyl Phosphate

KTP is the most commonly used material for frequency doubling of Nd:YAG lasers and other Nd-doped types. Conversion efficiencies as high as 80% have been obtained for frequency doubling of Q-switched Nd:YAG lasers. The damage threshold of KTP increases with temperature. It is recommended that for high power applications, the KTP crystal is maintained at around 80°C. Unlike many NLO materials, KTP has no hydroscopic susceptibility.

Infra-red Optic Materials

Zinc Selenide

This compound, with transmission spectra shown in Figure 8a, has applications in systems to transmit 10·6μm radiation of the CO_2

Material Formula (μm)	Chemical Range	Transmission Index ($\times 10^{-6}$/°C)	Refractive Expansion	Thermal Conductivity (W/m K)	Thermal
Lithium Fluoride	LiF	0·12 to 8·5	1·37 @ 3ω	37	11·3
Barium Fluoride	BaF_2	0·13 to 15	1·45 @ 3ω	18·4	12·1
Calcium Fluoride	CaF_2	0·13 to 12·0	1·4 @ 5ω	24·0	9·6
Magnesium Fluoride	MgF_2	0·11 to 10·0	1·38 @ 0·58ω	18·8	12·5
Fused Silica	SiO_2	0·16 to 2·5	1·474 @ 0·365ω	0·55	1·39

Table 2. Characteristics of UV transmitting materials.

	Abbe factor	Refractive Index	Density g/cc	Thermal Expansion (310^{-6})	Trans. 50% Limit (nm)
Low expansion borosilicate glass	66	1·474	2·23	3·25	345
Optical crown glass	58·8	1·523	2·55	9·3	330
BK7	64·2	2·27	2·51	7·1	320
SF11	25·8	3·05	4·74	6·1	–
LaSF9	32·23	3·31	4·53	7·6	–
Synthetic fused Silica (optical)	67·8	1·459	2·20	0·55	230

Table 3. Characteristics of a range of optical glasses.

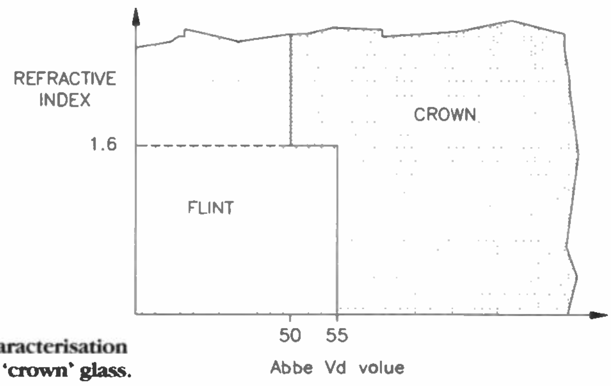


Figure 9. Characterisation of 'flint' and 'crown' glass.

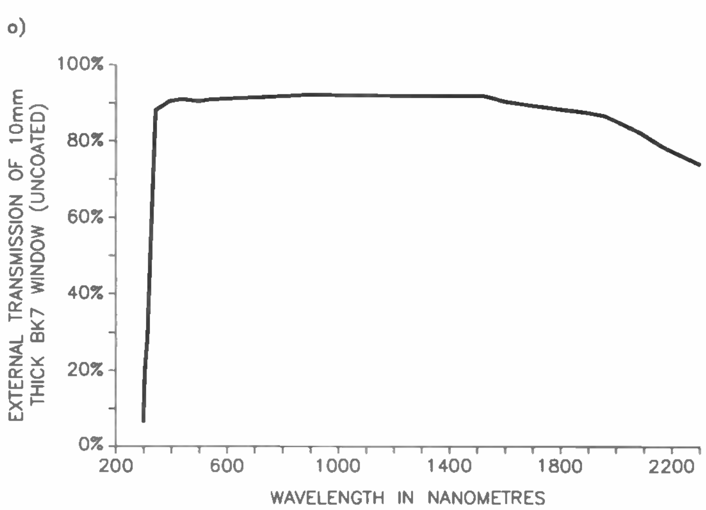


Figure 10a. Transmission characteristics of typical crown glass BK7.

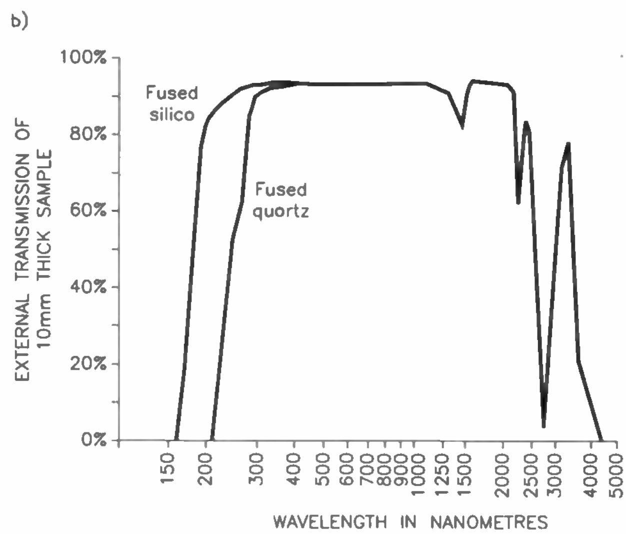


Figure 10b. Transmission characteristics of fused silica and fused quartz. (Courtesy Ealing Electro-optics.)

laser. The substance's high refractive index of 2·4 at this wavelength requires surfaces to be coated with antireflection layers. Without such coating, the surface reflectance would be around 30%.

Zinc Selenide, however, is a difficult material to manufacture. It is fabricated using chemical vapour deposition (CVD), with the material precipitating from a gas phase to form the characteristic transparent vitreous yellow solid. Where the compound is ground into optical components, however, the dust thus created is a significant health hazard. In addition, Zinc Selenide must never be cleaned with any acid preparation, otherwise highly toxic Hydrogen Selenide will be produced. Between 3 and 5μm, Zinc Selenide has an Abbe value of 178 and between 8 and 12μm, a value of 57·5.

Silicon

While Silicon is the mainstay of the electronics industry, it does also have applications in optical systems due to its transmission in the infra-red region. Silicon growth from a special melt system involves typically polycrystalline growth. Silicon is mainly used for transmission in the infra-red region, as indicated in Figure 8b. Silicon is used as silicon singlet lenses with diode lasers, where its high refractive index (3·51 at 1,250nm) allows excellent aberration correction.

Germanium

Germanium has some exceptional properties in the infra-red spectrum – its external transmittance characteristics are shown in Figure 8c. By having a very high value of refractive index of around 4·0, this allows fabrication of optical components of high refractive power without excessive curvature of thickness. The material demonstrates very high Abbe values of 101·5 between 3 and 5μm and 988 between 8 and 12μm. This tends to remove the requirement for achromatizing measures in optical design.

Germanium, however, is less suited to high power applications, since its poor thermal conductivity can lead to thermal runaway and component failure. Zinc Selenide would be the preferred component at higher power densities.

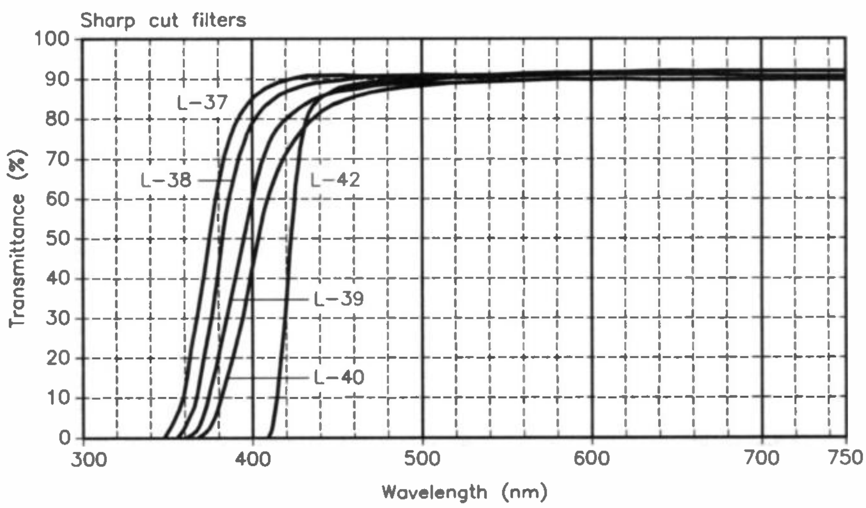


Figure 11. Transmission characteristics of such sharp cut filters around 400nm and for a thickness of 2·5mm. (Courtesy Hoya Corporation.)

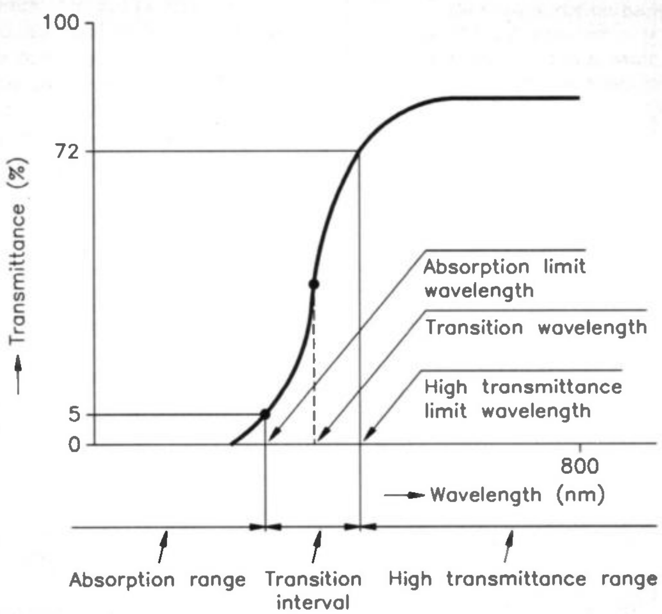


Figure 12. Convention used for defining absorption edge – 'sharp cut' filters. (Courtesy Hoya Corporation.)

UV Speciality Products

An increasing number of applications such as excimer lasers require optical elements with transmission in the UV region – down to wavelengths as short as 100nm. Table 2 summarizes the properties of some components in this area of transmission.

Magnesium Fluoride transmits to 110nm, Calcium Fluoride to 130nm and Lithium Fluoride to 120nm, although the first two materials are more durable and robust. All window materials, however, cease transmission at 100nm.

Silica and Optical Glasses

Synthetic Fused Silica

Synthetic fused silica is formed by the chemical combination of silicon and oxygen. There is a distinct difference between glass formed by crushing and fusing natural quartz crystals or silica sand. This use of 'natural' materials introduces impurities into such glasses which impairs their performance in the ultra-violet and infra-red wavelengths.

The purer form of synthetic fused silica demonstrates considerably less fluorescence than natural quartz and does not fluoresce in response to wavelengths longer than 290nm. This form of silica also demonstrates improved resistance to radiation darkening from UV, X-rays, gamma rays and neutrons.

Optical Glasses

The world of optical glasses is extremely diverse. Processes of manufacture have been intensely developed over the last 100 years. The development of optical fibres has also witnessed rapid developments in technology towards the manufacture of ultra-low loss fibres for global interconnection. Most optical applications which, however, utilise the spectrum between 350 and 2,500nm can utilise standard ranges of optical glasses. Table 3 summarises key characteristics of a range of different glasses.

Optical glasses can be characterised into two approximate types – flint and crown. Figure 9 indicates how the two sets of glasses are defined in relation to refractive index and Abbe value. Figure 10a indicates the transmission characteristics of the widely used crown glass BK7 and Figure 10b shows transmission characteristics of fused silica and fused quartz. Although several hundred types of glass have been characterised by optical glass manufacturers such as Schott, Table 3 indicates the ranges in values of specific parameters which can be encountered.

The bulk of applications relate to the formation of 'clear' optical components – principally lenses. The particular application, the intensity of light, the mix and range of wavelengths will determine the type of glass that will be appropriate.

Zerodur

Where ultra-stable performance is required for optical components such as mirror substrates, then Zerodur, a product developed

TECHNOLOGY WATCH!

with Keith Brindley

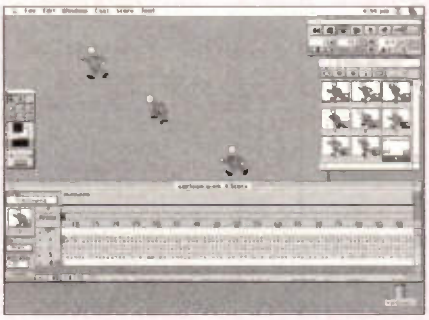
Going to the Movies

It has been my luck recently to be looking at methods of creating multimedia presentations on the computer. It seems to me that while there are several very complex methods of doing this (including writing the whole thing in base computer code) the most effective method and certainly the easiest, is to use the power of the computer to produce presentations. After all, people creating such presentations should be designers and graphics personnel, who probably should not (and would not) want to compile a single line of code, let alone a whole presentations-worth.

The whole thing is reminiscent of the dawning of desktop publishing software. The programs which were to become the standards for the craft (PageMaker and QuarkXPress) used the metaphor of the then standard publishing tool for the job (the pasteboard) to allow designers and graphics personnel to do their job on computer screen largely as they used to do by hand (some still do). The program I have been looking at which does the equivalent for multimedia presentations is Macromedia's Director, which uses the metaphor of directing a film to do its job. So, with a minimal amount of experience it is easy enough to create presentations. Of course, if you are in the film or presentation business anyway, it is an even easier job to transfer your craft to the computer screen.

As the Director, you assemble all items for the film (text, pictures, digitised video, sounds and so on) into a cast – just as in a real film. Many items can be created within Director, but they can be imported in from other applications too. Then you assemble the cast on stage, by drag-and-drop methods. The film's score is created in spreadsheet form, where each column represents a particular frame in the film. So, for a presentation of, say, 20 seconds at 24 frames a second (the standard film frame sequence rate) you need 480 columns in the spreadsheet. Finally, animation occurs as you play sequences of frames. All straightforward enough.

The beauty about sequencing within Director though, is that you do not actually need to create each frame in a sequence by hand, instead you just set out the cast in the first frame, set out the cast in the last frame, then tell Director what effects you want to fill in the intermediary frames. Time saved by this has to be seen to be believed, and some of the available effects are extremely clever.



It is this concept of the program which lifts Director above the norm. It is so simple to use, yet will create really stunning presentations for areas such as education, training, sales, museums and exhibitions. Despite the overriding popularity and use of computers for mundane tasks like word processing, databases and even spreadsheets, it is only the occasional program like Director which, for me, shows the *real* power of the computer as a tool.

At last, a use for a PDA

While we are on the subject of multimedia and its production, if you are lucky enough to visit the States over the next year, try and get to the Smithsonian Institution in Washington DC, or the University of California, Berkeley's Art Museum, where you will be able to see and use what are arguably the most sophisticated uses for a personal digital assistant (PDA) yet.

A company called Visible Interactive out there is installing Apple MessagePad PDAs in these sites, complete with touch screen and multimedia, for visitors to use as they look around the exhibitions. With literally thousands of pages of text, hundreds of graphics and hours of audio built-in to each MessagePad, they act as personal guides and mobile information kiosks to the museums and galleries.

While, by no means, the *only* good use for a PDA, it is certainly one of the best I have yet heard of, and points the way forward to the sorts of tasks they will be used for over the coming years at least.

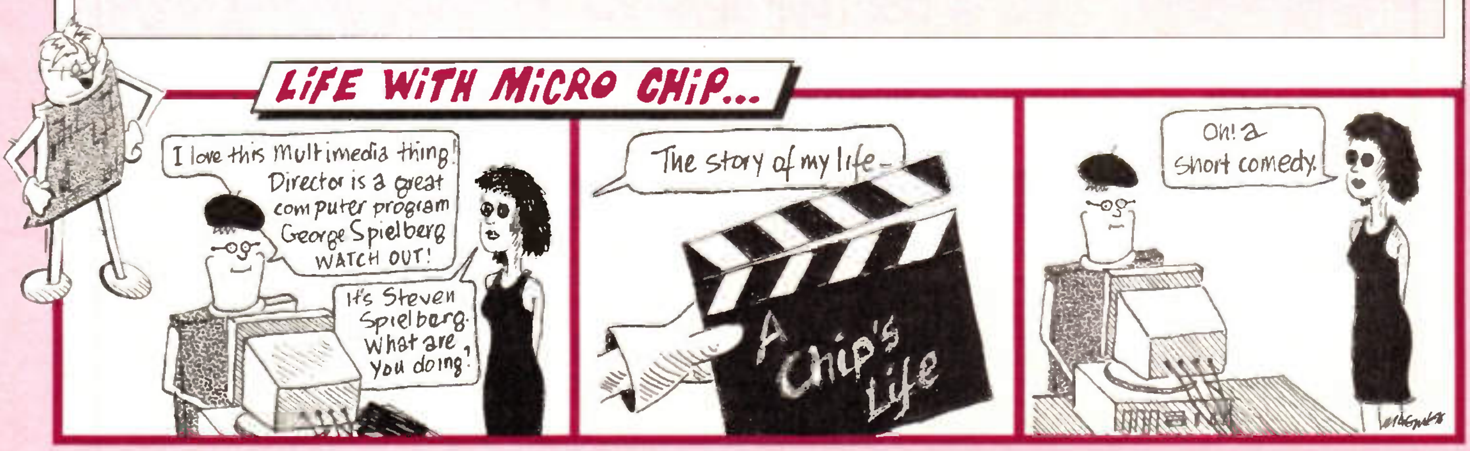
Son of PowerPC

Regular readers will already know I am an exponent of the PowerPC microprocessor and, anyway, it is no secret it has a good future. December 1995's issue of *Byte* magazine confirmed this, saying that a:

166MHz PowerPC 604e, armed with both the 604's speculative execution and branch prediction logic, and the improved load/store instruction performance, should endow a desktop system with processing power beyond that of any system based on Intel's new P6.

But there are even greater things to come. The PowerPC was always intended to be open, with third-party manufacturers being allowed to clone the design right from the start – a significant contrast to Intel's stance on its microprocessors. So it comes as no surprise that a new company, Exponential Technologies has announced a clone of the PowerPC, using a different fabrication process to the Motorola methods. What may be a surprise on the other hand is that the clone, expected to ship next year, will have a claimed performance some three times that of Intel's fastest Pentium.

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



by Schott Glass technologies can be used. In the temperature range of 30° to 300°C, this glass has a coefficient of linear expansion of $0{\cdot}05 + 0{\cdot}10\times10^{-6}$. This is typically five or six times better than fused silica and around two orders of magnitude better than standard optical glasses.

Glass with this property is processed by producing in the 'mix' of glass, a crystalline phase with a negative coefficient of expansion and a vitreous phase with a positive coefficient of expansion. On account of scattering of light at grain boundaries, however, this glass is not appropriate for use for transmissive optics. Such glass, however, is ideal for the fabrication of mirror substrates in order to minimise mirror distortion due to temperature changes.

Colour Glass Filters

Use is made of colour glass filters in a broad range of applications, ranging from general photography to scientific and laboratory equipment. Such glasses can be used to provide an 'aesthetic' improvement to a system, e.g., as a daylight filter in photography or to provide a specific measurement benefit in a laboratory system such as a filter to transmit a specific range of wavelengths.

One extensively used set of colour filter glasses is a 'sharp cut' type. Figure 11 indicates the transmission characteristics of such sharp cut filters around 400nm for a thickness of 2·5mm. These filters are tending to filter out ultra-violet wavelengths shorter than 400nm. Thus, the transition wavelength is the wavelength providing 5% transmission and the high transmittance wavelength limit is that wavelength providing 72% transmittance. The transition wave length is defined as the midpoint between the 5% and 72% limits. Hence, in the context of Figure 12, L-38 is a sharp-cut glass with a transition wavelength of 380nm. Typically, the actual transition wavelength of a glass will be within 5nm of that specified for a glass of equivalent thickness. The set of technical definitions of blue transmission filters (which filter out ultra-violet wavelengths) are depicted in Figure 13.

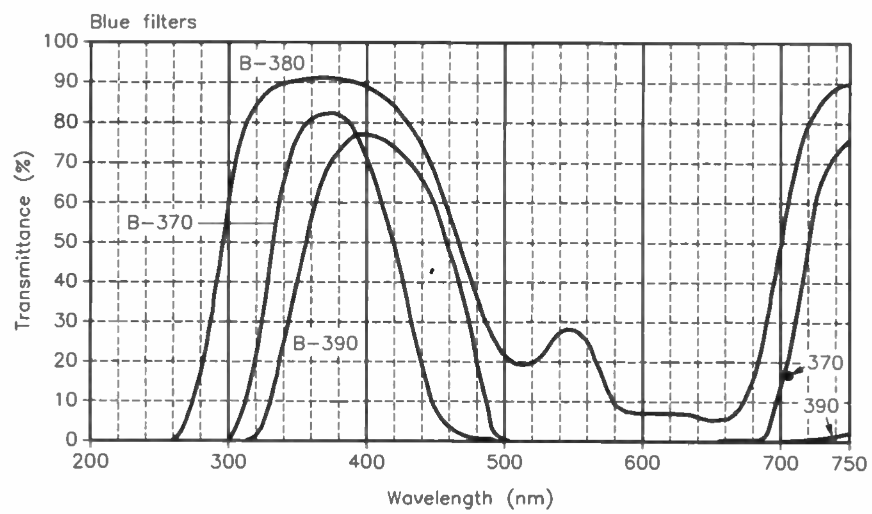


Figure 13. Spectral characteristics of blue transmission filters. These typically have wide bandwidths and are not suited to applications which require selectivity over a narrow spectral range. (Courtesy Hoya Corporation.)

Where glass is used of reduced thickness, however, the glass may not be able to demonstrate the sharp cut filter specifications. Typically, glasses of 2mm thickness or greater are used. Such sharp-cut filters can be of use in laser applications where specific lasing lines can be filtered from the laser output. In the Argon laser, for example, clinical applications can require that blue lines at around 492nm are removed from the main set of green ones at 514nm. A 'green only' filter with a transition wavelength of around 500nm can be used to undertake this. Where such sharp cut filters 'cut in' at around 800nm, these are used as infra-red transmitting filters. Specific Hoya types are referenced as IR-76, IR-80, IR-83 and IR-85.

The example of 'sharp-cut' filters indicates an example where the filters are acting in a highly selective way across a range of wavelengths – the transition interval. Where, however, colour glass filters are used to pass a band of wavelengths such as of blue light, as shown in Figure 14, the bandwidth of the filter is relatively great. For B-370, for example, the 50% transmission extends from 308 to 420nm. Thus, where relatively narrow filter transmission is required such as 10nm, this tends to be provided by more expensive interference filters.

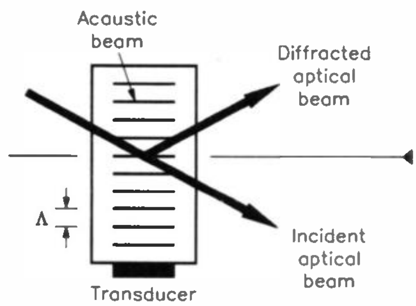


Figure 14. Function of Acousto-optic crystal. Standing vibrational waves established in the material diffract light and allow it to be 'steered' by the level of input acoustic power. (Courtesy CASIX.)

Figure 13 also shows how a filter glass such as B-370 can have a principal use as a blue filter in the visible spectrum, but it is also highly transmitting above 700nm. This requires care when dealing with applications where an optical spectra can have appreciable infra-red components, as will often be the case. While glass lenses tend to be mass-produced, colour glass filters are readily cut to size from standard glass blanks. This could involve, for example, cutting 1in. and 0·5in. circular discs of 2mm in thickness from $4cm^2$ glass blanks.

Antireflection Coatings

Surface coating of lenses to reduce reflection is increasingly important with the use of optical materials with high values of refractive index. Table 4 indicates how with increasing refractive index of, for example, lens material, the percentage reflected back at each interface increases and the percentage transmitted at subsequent surfaces (5 and 10 listed) decreases.

To prevent excessive losses where a significant number of interfaces are involved, antireflection layers are utilized. It can be shown that optimum antireflection performance is achieved (in air) for the value of the refractive index to be the square root of the refractive index of the substrate (i.e. glass) material. For optical glasses, this indicates that the ideal coating material should have a refractive index value of 1·23. Most glass lenses can be satisfactorily coated with a quarter wavelength thickness of Magnesium Fluoride which has a refractive index of 1·38 at 550nm. This typically provides acceptable reflection losses of around 1·5%.

Often a specific optical component supplier can provide multilayer coatings with optimum performance over a broad range of wavelengths. The HEBBAR range available from

Refractive Index	**% Reflection (1 surface)**	**% Transmission (5 surfaces)**	**% Transmission (10 surfaces)**
1·25	1·2	94·0	88·3
1·5	4·0	81·5	66·5
1·75	7·4	67·9	46·2
2·0	11·1	55·5	30·8
2·25	14·8	44·9	20·2
2·5	18·4	36·3	13·1
2·75	21·8	29·3	8·6
3·0	25·0	23·7	5·6
3·25	28·0	19·3	3·7
3·5	30·9	15·8	2·5
3·75	33·5	13·0	1·7
4·0	36·0	10·7	1·2

Table 4. Losses in transmission as a function of refractive index of optical material.

Melles Griot, for example, provides typical reflectance of around 0·5% over a broad range of wavelengths. Specialised coatings can also be provided for operation at specific wavelengths, e.g., the 632nm line of the He-Ne laser. Reflection losses of less than 0·1% can typically be achieved. This is an example of how individual optical components can have highly specialised optical properties.

Electro-optic Materials

The electro-optic effect changes the refractive index of a material when an electric field is applied across it – either in longitudinal (opposite ends) mode or transverse mode (top and bottom). For a linearly polarized input beam of light, the activated crystal can act to rotate the direction of polarization of light. If the light then passes through a polarizer at 90° to the initial one, then the output light signal will depend on the degree of phase shift induced in the crystal. This technique can act as a Q-switch to release energy as a pulse in a laser resonator or act as a general-purpose light modulator.

Lithium Niobate demonstrates a marked electro-optic effect. Typically for Lithium Niobate, the variation in signal transmission as a result of such switching is around 23dB – a factor in excess of 100. Switching voltages increase generally with wavelength, with values of 1·45kV being required at 633nm. KDP is a material widely used with Nd:YAG, Nd:YLF and Ti:Sapphire laser systems.

Acousto-optic Crystals

When a piezoelectric transducer is bonded to an acousto-optic (A-O) crystal, standing vibrational waves are established in the material, as shown in Figure 14. This will cause part of the incident optical beam to be diffracted by the variation in refractive index within the acousto-optic crystal. This degree of diffraction can be modulated by the acoustic power of the system. Acousto-optic crystals used include $LiNbO_3$, Lithium Niobate wafers and crystals of TeO_2 and $PbMoO_4$.

Summary

Modern optical materials are already used widely across many separate areas of technology, such as in industry, defence and medicine. It is clear that the key to many emerging areas of technology will lie in developing new optical materials and enhancing the performance of existing ones. In particular, so-called photorefractive crystals used in memory, information processing and holography applications are being extensively developed with a view to future exploitation.

Points of Contact

Melles Griot, Brookmount Court,
Kirkwood Road, Cambridge, CB4 2QH.
Tel: (01223) 420071.
(Copies of 'Optics Guide' can be requested.)

Ealing Electro-Optics plc, Greycaine Road,
Watford, Herts, WD2 3PW.
Tel: (01923) 242261.
(Copies of catalogue can be requested.)

IE Opto-Products Ltd., Crabtree Farm,
Newnham, Northants, NN11 3ET.
Tel: (01327) 704916.
(Copies of CASIX catalogues can be requested.)

Photonics Marketing Ltd.,
86 Gloucester Place, London, W1H 3HN.
Tel: (0171) 935 5918.
(Copy of HOYA colour glass filter catalogue can be requested.)

2
PROJECT RATING

Design by John Dakin
Technical support by Chris Barlow
Text by John Dakin, Mike Holmes and Maurice Hunt

This receiver module uses superheterodyne (superhet for short) techniques to provide a simple, stable design for the Rugby MSF transmissions. It is constructed on a single small printed circuit board, using partly surface mount devices, and no screening can is required to maintain stability.

Rugby Clock SUPERHET Rx

Above: The assembled Micron III.
Right: The assembled Rugby Clock Superhet Receiver in the suggested optional box.

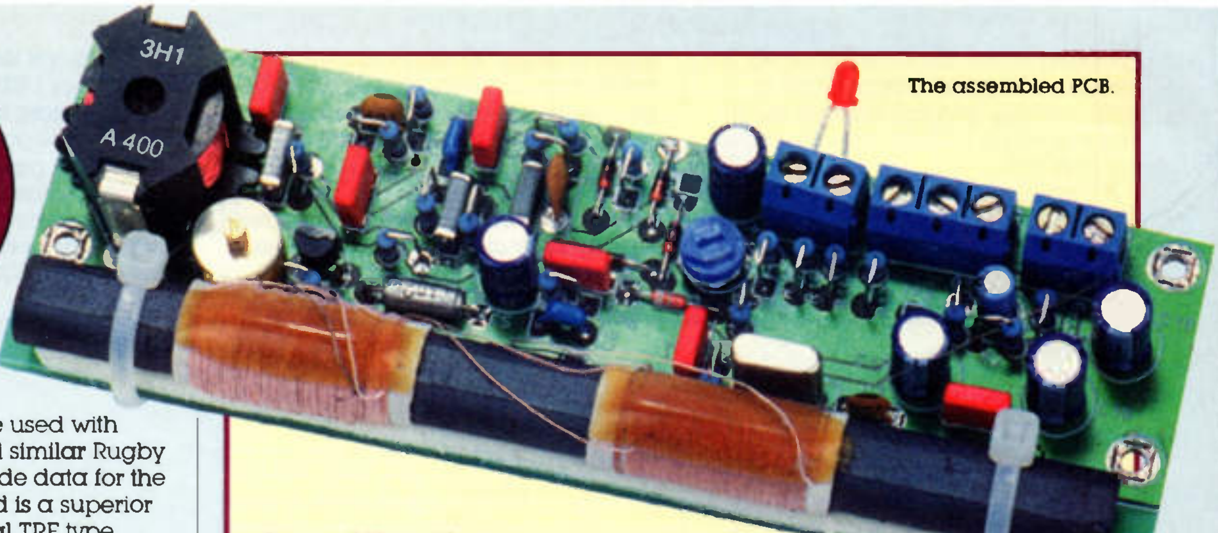
FEATURES

★ Superior superhet design ★ Single PCB construction
★ Positive- or negative-going standard serial data output

APPLICATIONS

★ Provides Rugby MSF time signal for synchronizing clocks
★ Can be added to the Micron III or practically any application requiring the MSF signal

KIT AVAILABLE (95021) PRICE £29.99



The assembled PCB.

THE module can be used with the Micron III and similar Rugby Clock kits to provide data for the display electronics, and is a superior alternative to traditional TRF type receivers.

The improvements in signal reception compared to the commonly used TRF type receiver mean that this receiver is capable of picking up the Rugby MSF time signal in noisy environments or areas of low signal strength, where the TRF type would not be able to due to interference, thus enabling the use of self-regulating and highly accurate Rugby MSF clocks in locations where they normally would not operate successfully.

Specification

Operating voltage:	12V DC regulated
Operating current:	13mA (average)
Output signal:	TTL level, 5V
Bandwidth:	40Hz (Slow Code)/120Hz (Fast Code)
Operating range from transmitter (Rugby):	>1,000 miles (Slow Code reception)
PCB dimensions:	126·5 × 41·5mm
Maximum height of completed board:	20mm

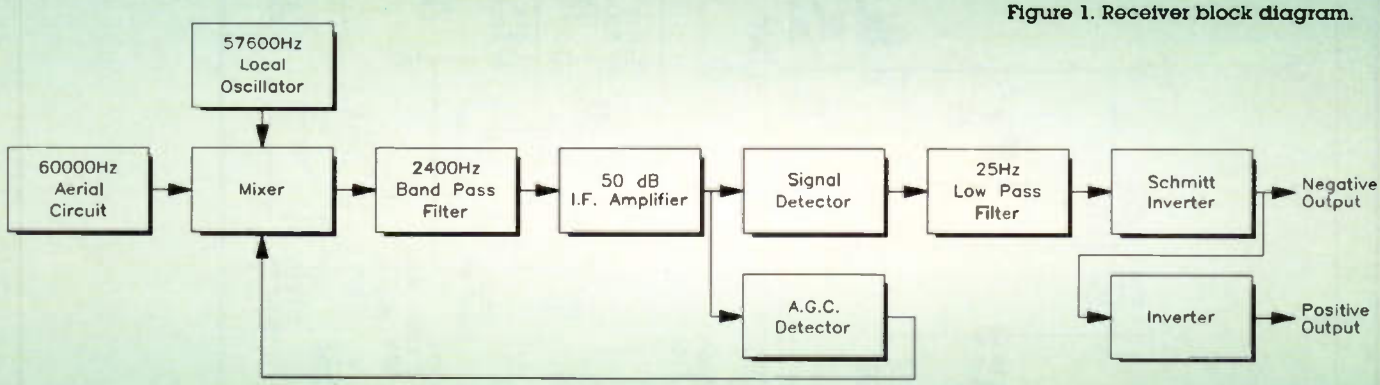
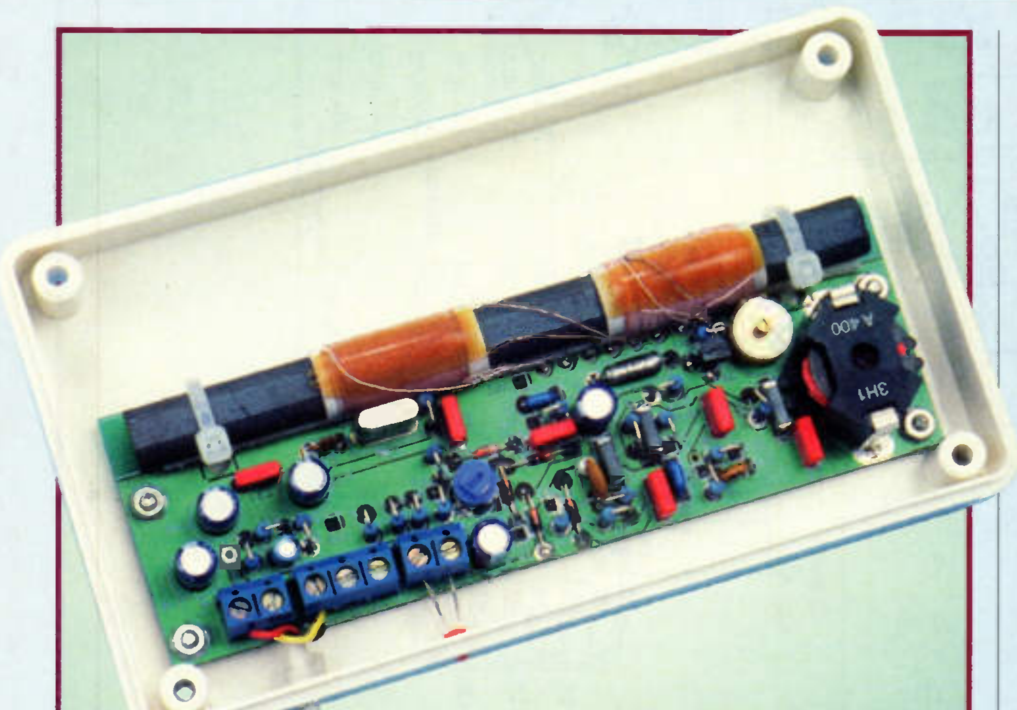


Figure 1. Receiver block diagram.



The assembled PCB installed in the suggested optional box.

Circuit Description

Refer to the overall system block diagram of the receiver shown in Figure 1, and the complete circuit diagram shown in Figure 2. The 60kHz signal is picked up by the ferrite rod aerial, comprising coils L1 and L2, which is tuned to the required frequency by C1 and VC1. The signal is fed to the gate of the FET TR1, which acts as a frequency converter or mixer. The source terminal of TR1 is fed with a local oscillator frequency of 57·6kHz from the frequency divider IC1, and ultimately from the crystal oscillator formed from XT1 and IC3a. At the drain of TR1 is a mixture of the two input frequencies and their sum and difference frequencies.

L3 and C8 form a tuned circuit at the difference frequency of 2·4kHz. This is the intermediate frequency or IF of the receiver, and this is the basic superheterodyne principle. A significant level of 57·6kHz is also present at this point. For the reception of 'Slow Code' signals only, the tuned circuit has only light damping provided by R4. The Q of the tuned circuit is 60, giving a bandwidth of 40Hz and rise and fall times for the IF of 30ms, when the MSF signal is keyed 'on' and 'off'.

If 'Fast Code' reception is required, then R4 is reduced from 1·8MΩ to 82kΩ and provides increased damping of the tuned circuit to limit the Q to about 20, and so increase the bandwidth to 120Hz. This reduces the rise and fall times of the IF to 10ms when the MSF signal is keyed 'on' or 'off'. The penalty for reducing the Q of the tuned circuit is 5dB lower sensitivity of the receiver, and greater susceptibility to noise signals. Unless reception of the 'Fast Code' is essential, it is recommended that R4 remains at 1·8MΩ.

The mixture of 2·4kHz and 57·6kHz is fed to a low-pass amplifier, IC2a, and associated components. This has a roll-off frequency of 4·5kHz, so that the output contains predominately the 2·4kHz component of the input signal. The gain of IC2a is about 270 at

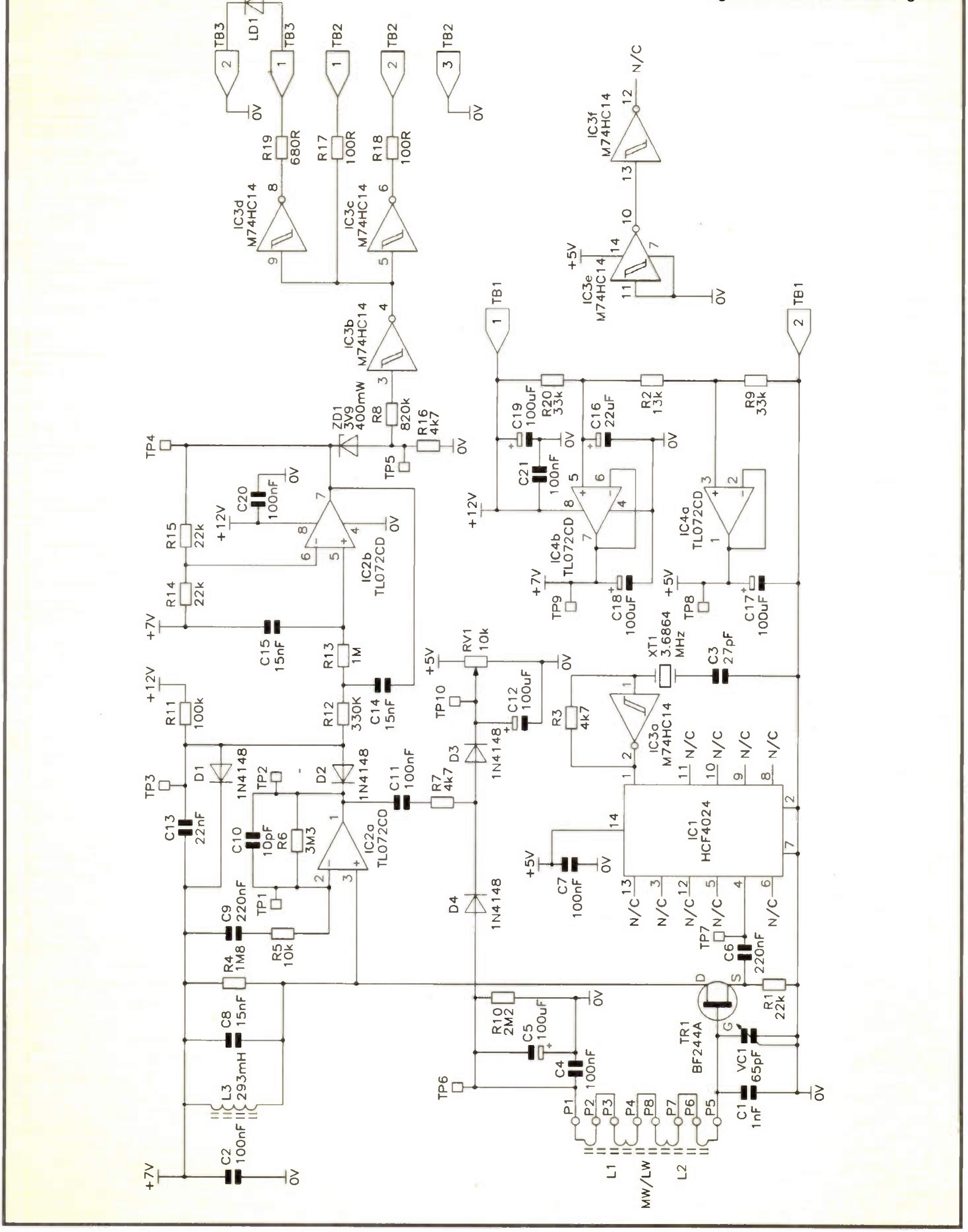


Figure 2. Receiver circuit diagram.

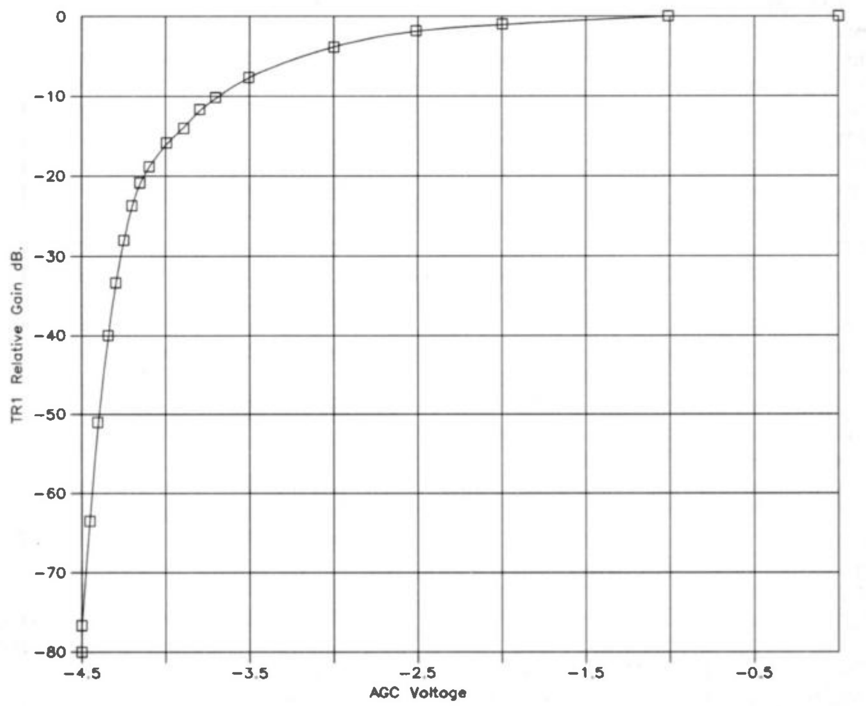


Figure 3. Graph showing AGC voltage versus relative gain of TR1.

2·4kHz, so that an output at TP2 of 6V Pk-to-Pk is obtained with an input of 22mV Pk-to-Pk.

The output from IC2a is fed to two circuits, an automatic gain control (AGC) circuit, and a diode detector, D2. The AGC circuit controls the gain of TR1, which depends upon the bias voltage on its gate terminal. TR1 is virtually cut off with about –4·5V of bias on the gate, and has maximum gain with 0V bias – see Figure 3.

D3 clamps the positive-going peaks of the signal from IC2a at the DC level set by RV1. D4 rectifies the negative-going peaks and delivers a negative AGC bias voltage to the gate of TR1 via L1 and L2. The output from RV1 can be set at between 0 and +5V, so that the AGC bias voltage can be adjusted from –5 to 0V; about 1V of the 6V Pk-to-Pk input is lost across D3 and D4. R7 prevents noise impulses causing undesirable reduction of the gain of the receiver, by limiting the current which can flow into C12 on any one peak of a cycle of the IF. Impulse noise is filtered out later in the receiver. With the prototype receiver operating at Chester, the AGC voltage is –4·2V; this represents a 23dB reduction in the maximum gain of TR1. As Chester is about 90 miles from Rugby, the receiver should operate satisfactorily at ranges of over 1,000 miles from the transmitter for 'Slow Code' reception. Figure 4 shows the bias voltage of TR1 for a given distance from the transmitter to maintain a 6V Pk-to-Pk signal at TP2. The propagation characteristics of the 5,000 metre wavelength of the MSF signals make very long distance reception practical.

The diode detector, D2, conducts during the negative peaks of the signal from IC2a. While the MSF transmitter is 'on', the output is a voltage with a DC component of about –2V, relative to the +7V rail, and a 1V Pk-to-Pk ripple voltage at 2·4kHz. The values of R11 and C13 are chosen so that when the MSF transmitter is keyed 'off', the output voltage rises to +7·5V at virtually the same rate as the envelope of the IF signal from IC2a, that is, in less than 30ms (or 10ms if R4 is 82kΩ). This 2·5V positive-going pulse is fed to a slight variation of a Sallen-Key low-pass filter, comprising IC2b and associated components. The filter eliminates the 2·4kHz ripple present at the input, and has a gain of 2, so that the output is a 5V positive-going pulse rising from about +3 to +8V. If 'Fast Code' reception is required, then the cut-off frequency of this filter must also be raised, by changing R12 to 43kΩ and R13 to 130kΩ.

Zener diode ZD1 shifts the DC levels of this pulse and attenuates it by about 20%, due to its slope resistance. At the junction of ZD1 and R16, the pulse has an amplitude of about 4V and moves between +0·5 and +4·5V. This signal is fed via R8 to a Schmitt inverter, IC3b, which produces a 0V output when the input rises above its 'high' threshold level of +3V. This output reverts to +5V when the input falls below its `low' threshold of +2V. IC3b thus eliminates up to 2·5V of noise present at its input at both the high and low levels of the input signal. R8 limits the current which can flow into the input of IC3b, should the input signal rise above +5V due to a fault in ZD1 or IC3d. The output of IC3b is also fed to IC3c and IC3d. IC3c produces a positive-going output pulse. IC3d drives LED1 via R19. LED1 is turned 'on' each time the MSF transmitter is keyed 'off'.

The local oscillator signal of 57·6kHz is obtained by dividing the output of a 3·6864MHz crystal oscillator by 64. A crystal-controlled oscillator is necessary, as the frequency stability required is better than 10Hz in 57·6kHz or 0·017%. IC3a, XT1, R3 and C3 comprise the crystal oscillator. IC1 is a seven-stage ripple counter. The output of IC1 is taken from the sixth stage of the counter, pin 4. This 5V Pk-to-Pk, 57·6kHz signal is fed to TR1 via C6, a 220nF capacitor. C6 also decouples the source terminal of TR1 to 'signal ground'. This occurs because the output impedance of IC1 is only 18Ω when in the high or low state, and so pin 4 is close to 'signal

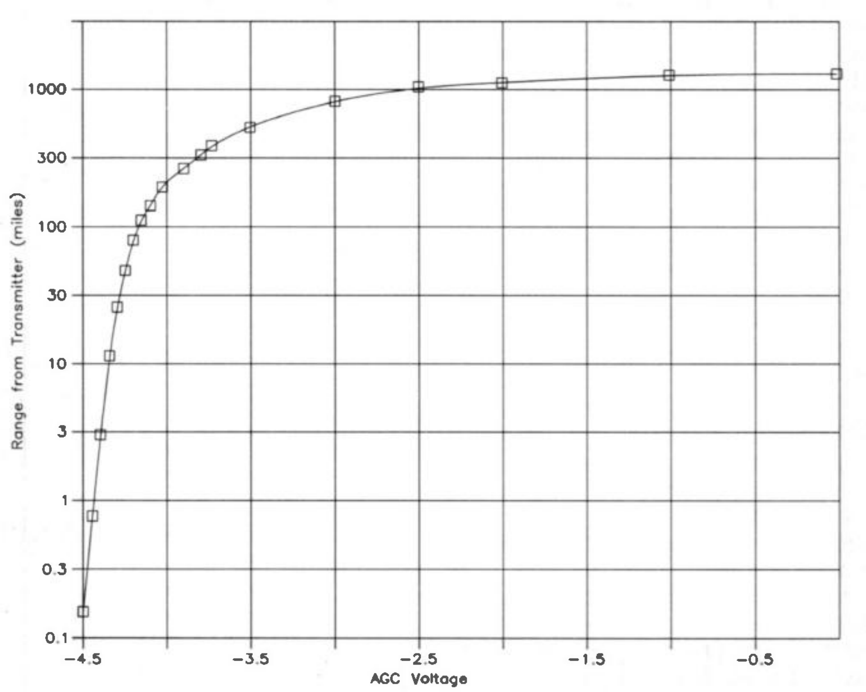


Figure 4. Graph showing AGC voltage relative to transmitter range in miles.

ground' except for the 10ns during each 8·7μs half cycle, when the counter stage is switching between the two states.

The +5V and +7V rails are derived from the +12V input by the resistor chain R20, R2 and R9. IC4a and IC4b are wired as voltage followers, to provide low impedance outputs from the resistor chain. The receiver draws about 13mA average current from the 12V supply.

Construction

The receiver is built on a single PCB. Figure 5 shows track and legend, which assists with achieving the correct component placement. The board includes a ground plane on the component side and surface mount devices (SMD) on the track side. Reference should also be made to the Parts List at the end of this article. Assemble the board in order of ascending component size (with exception of the ICs). Take care to ensure that polarized components – the semiconductors and electrolytic capacitors – are correctly orientated. Note that the prewound coil, L3, cannot be fitted the wrong way around, by dint of its pin layout. This part consists of 820 turns of 40swg enamelled copper wire, wound onto a Type 2 pot core former. Note however, that the dust iron cores are not currently available for these if you were planning on winding your own coil from separate parts – hence, a prewound coil is supplied in the kit (saving you the tedium of winding 820 turns!), which incorporates the core.

Apart from ICs 1 to 4 (the surface mount devices), assembly of the rest of the receiver is straightforward (refer also to the Constructors' Guide supplied with the kit). IC1, IC2, IC3 and IC4 should be fitted last, as they are surface mounted components and are installed on the track side of the PCB. A soldering iron with a small tip, say 0·5mm, is essential for this operation, as are all normal antistatic precautions.

The PCB legend shows the approximate positions for coils L1 and L2 of the ferrite rod aerial along the length of the ferrite rod, while Figure 6 depicts the way in which the aerial is mounted onto the board. Ensure that sufficient slack is allowed in the leads of L1 and L2 to enable adjustment of the coil locations, when it comes to tuning the receiver. A length of standard 11mm width foam draught-excluder, available from any half-decent DIY store, is used beneath the ferrite aerial, which holds the coils L1 and L2 in position when the tie-wraps at each end of the aerial are tightened down – having first set the coils into the correct position, of course. The tie-wraps should, therefore, be left slack enough to allow adjustment of the coil positions until you are fully satisfied that the receiver is tuned in correctly (see the Setting Up and Alignment section). Then they should be tightened gently, just enough to secure the aerial in place, and not so much as to cause bending of the PCB (or possible snapping of the ferrite rod!)

The leads of the coils L1 and L2 should be connected to the appropriate points (P1 to P8) on the PCB, as indicated in Figure 7. Note that the windings L1 and L2 have a cotton-type covering, which burns off with the heat from the soldering iron – alternatively, a naked flame could be used (taking care not to melt the wire itself). The leads are also colour-coded to assist in their identification.

Having completed the assembly of the board, check for any misplaced components, solder bridges (particularly on the SMD pins), whiskers or dry joints, then clean excess flux off the board using a suitable solvent.

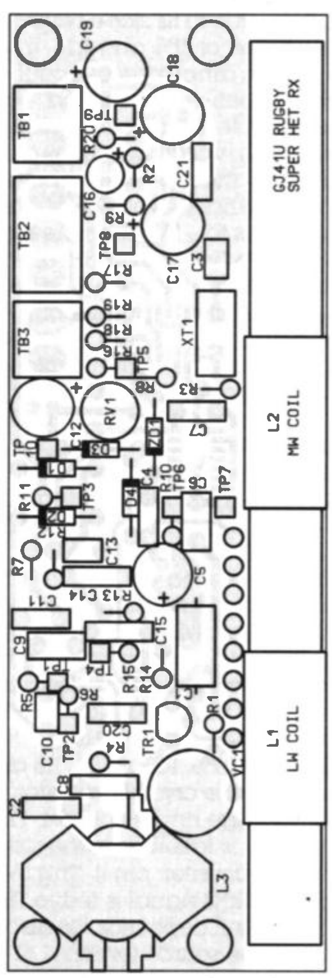


Figure 5. PCB track and legend.

Testing

A basic test to carry out on the completed receiver, prior to further tests and adjustments, is to use a multimeter to measure the resistance between the two power supply terminals on TB1, and whichever way round the test leads are applied, the resistance reading must be above 40kΩ – any less than this figure indicates a faulty or misplaced component, or a short circuit somewhere on the board, in which case, recheck your assembly work.

Assuming the receiver module passes this test, it should be connected up as shown in the general wiring diagram shown in Figure 8, to enable the setting up process to be carried out. Note that a 12V DC regulated supply is required to operate the receiver (which may be used to power the Micron III clock also). Having switched on the power, ensure that none of the components are getting warm – if this is found to be the case switch off immediately and recheck for faults.

Setting Up and Alignment

Setting up of the receiver module can be carried out by using a voltmeter/multimeter, an oscilloscope and a frequency/time interval counter or, almost as easily, using a high input impedance (e.g., 10MΩ) digital AC/DC voltmeter and an audio amplifier.

Measurements are taken at the test points TP1 to TP10, the locations of which are shown in Figure 9. The majority of these are test pads on the board itself, but some are the exposed lead ends of vertically mounted resistors – however, all are marked on the PCB legend. A high impedance

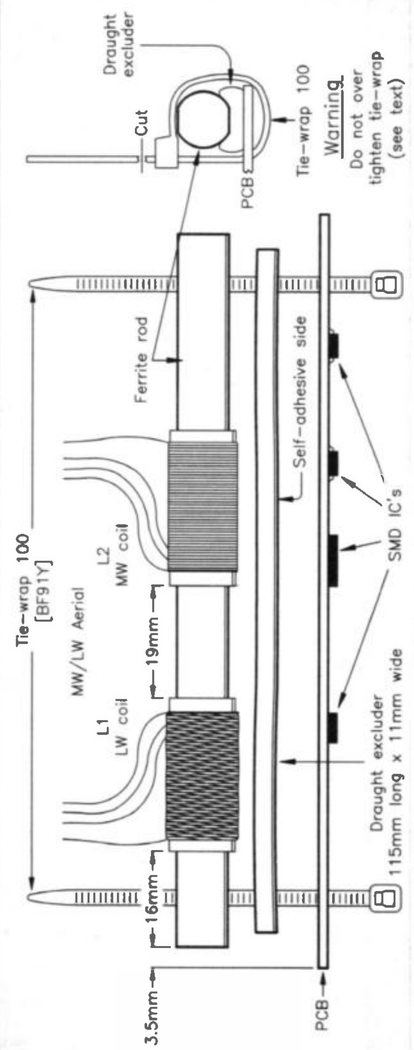


Figure 6. Mounting the coil L3.

voltmeter, an oscilloscope and a frequency/time interval counter will be required, together with a pot core adjuster tool for tuning L3 (e.g., BR51F), to carry out the following tests:

1. Checking the DC rails
Connect the voltmeter to TP8.
Check that the voltage is +5V ±0·2V.
Connect the voltmeter to TP9.
Check that the voltage is +7V ±0·2V.

2. Checking the local oscillator
Connect the frequency counter to TP7. A reading of 57·6kHz ±10Hz should be obtained.

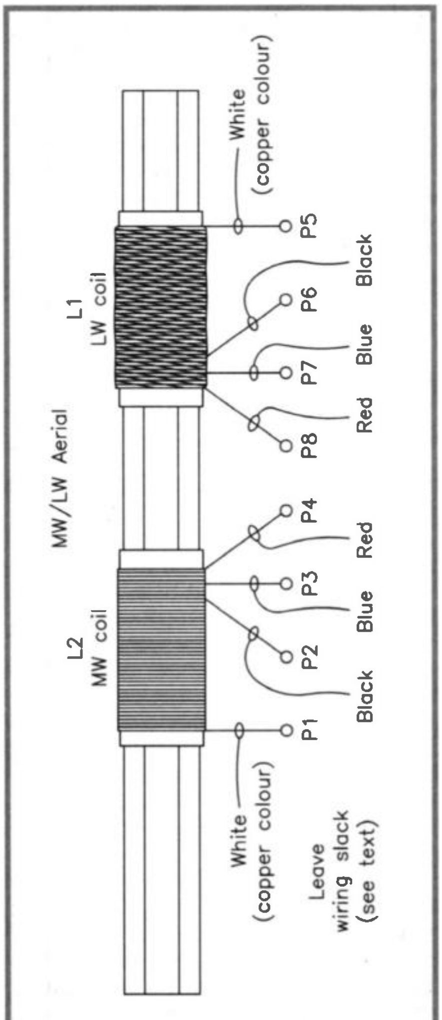


Figure 7. Mounting the aerial (L1 & L2).

3. Setting L1/L2 and L3 and VC1
Connect TB1b (0V) to TP6 with a temporary link. This maximises the gain of TR1 by putting a DC voltage of 0V on the gate.

Connect TP1 to TP2 with a temporary link. This reduces the gain of IC2a to 1. Connect the oscilloscope to TP1. Set the sensitivity to 50mV per division. Set VC1 to a half closed position.

Slide the LW/MW coils of L1/2 along the ferrite rod until a maximum signal is seen on the screen. This will typically have an amplitude of 400mV, comprising 300mV of 2·4kHz IF and 100mV of local oscillator frequency. Trim VC1 to give a maximum amplitude of the 2·4kHz signal.

Adjust the core of L3 to give a maximum 2·4kHz signal. This is a fairly sharp adjustment unless R4 is 82kΩ, due to the relatively high Q of the tuned circuit formed by L3 and C8.

Remove the temporary links from TB1b (0V) to TP6 and TP1 to TP2.

4. Setting the AGC delay voltage
Connect the oscilloscope to TP2. Adjust RV1 to give a 6·0V Pk-to-Pk amplitude 2·4kHz signal on the oscilloscope.

5. Final trimming of VC1 and L3
During stage 3 of this setting up procedure, VC1 and L3 were adjusted with 0V bias on TR1. While this gives very nearly the correct settings of VC1 and L3, the change to a bias voltage of –4·2V on TR1 alters the input capacitance of TR1 by a few pF, and changes the DC current flowing through L3. This slightly detunes the aerial circuit and the tuned circuit (L3/C8). It is important to carry out these adjustments carefully, as they critically affect the response curve of the IF tuned circuit.

Connect the voltmeter between test points TP1b (0V) and TP6. Adjust VC1 slightly to maximise the AGC voltage. VC1 should only require a small adjustment, corresponding to a few degrees of rotation of the shaft to find

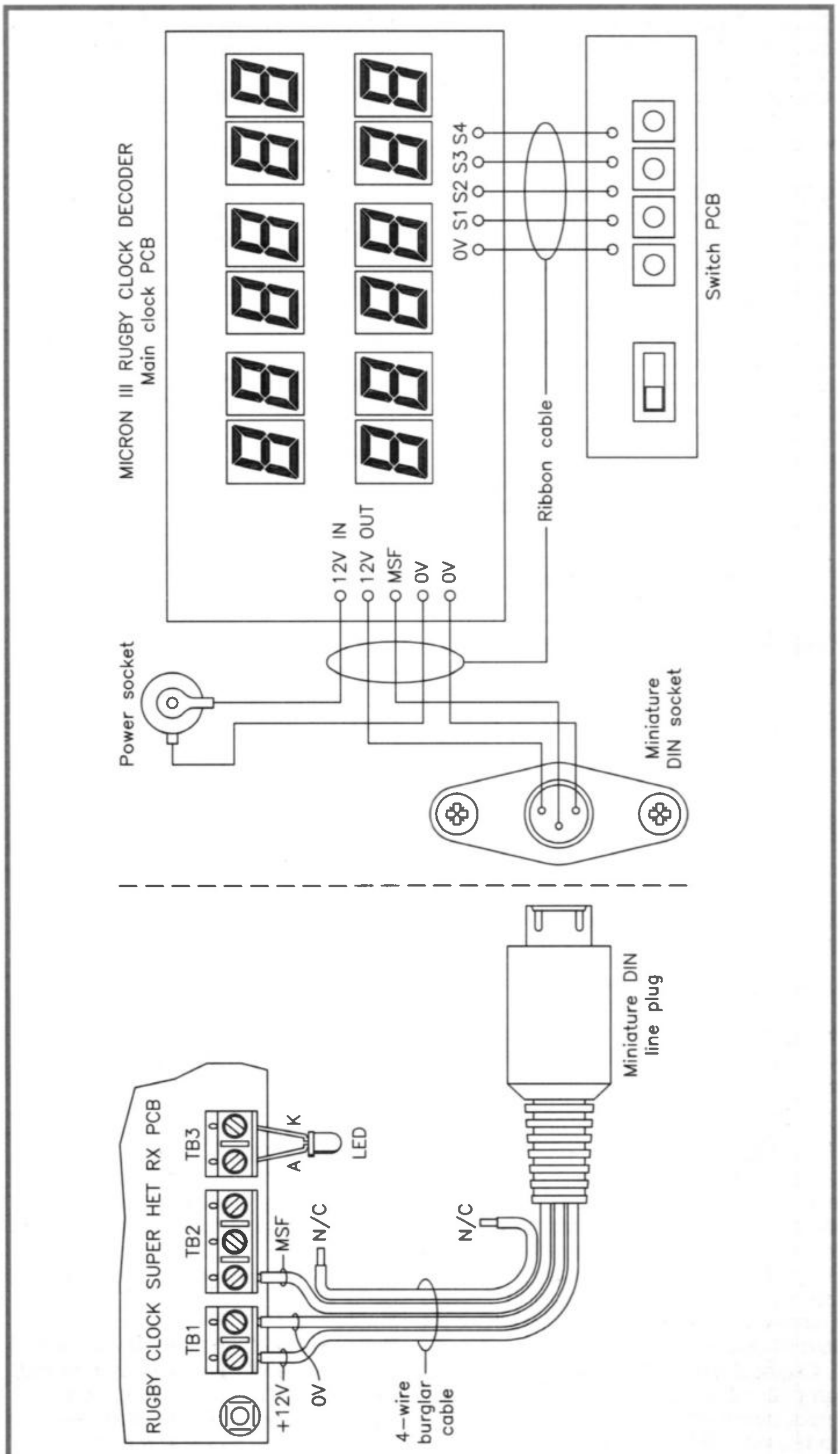


Figure 8. General module wiring.

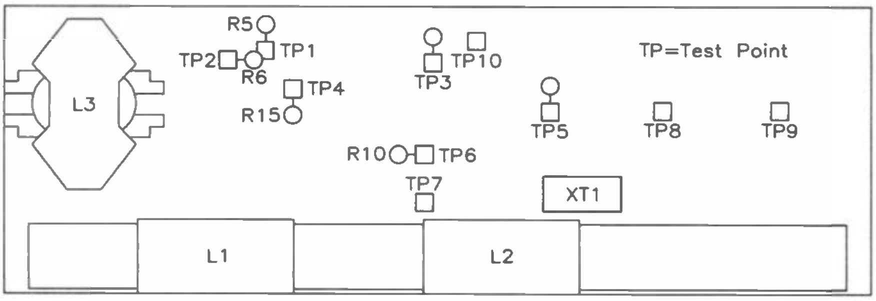


Figure 9. Map of PCB test points.

the maximum. Then adjust L3 slightly (it is supplied pre-tuned) to maximise the AGC voltage. The total increase in AGC voltage of the maximum will be less than 100mV, as the gain of TR1 is changing very rapidly with bias voltage in this region (see Figure 3).

6. Checking the output pulse widths
Connect the oscilloscope to TP5 and check that no noise is present on the signal. Connect the time interval counter to the (+) output terminal. Check that the pulse widths of the outputs are 100ms±5ms for a 'logic 0', or 200ms±5ms for a 'logic 1'. If they are outside these limits, adjust RV1 to correct the readings. Only a small adjustment to RV1 should be necessary. This completes the setting-up procedure using a voltmeter, an oscilloscope and a frequency/time interval counter.

Setting Up Using an AC/DC Voltmeter and an Audio Amplifier

1. Checking the DC rails
Connect the voltmeter to TP8. Check that the voltage is +5V±0·2V.
Connect the voltmeter to TP9. Check that the voltage is +7V±0·2V.

2. Checking the local oscillator
Connect the voltmeter to TP7 and set it to a suitable DC scale. The reading should be +2·5V±0·2V. If the reading is 0V or +5V, the oscillator or the divider is not working.

3. Setting L1/L2, L3 and VC1
Connect TB1b (0V) to TP6 with a temporary link. This maximises the gain of TR1 by putting a DC voltage of 0V on the gate.

Connect TP1 to TP2 with a temporary link. This reduces the gain of IC2a to 1.

Set VC1 to a half-closed position. Because the IF of the receiver is in the audio range, we can use an audio amplifier to listen to the signal, and by connecting the AC voltmeter to the amplifier output, measure the amplitude. Most modern AC voltmeters will respond satisfactorily to a frequency of 2·4kHz.

Connect the earthy side of the amplifier to TB1b (0V). Connect the input terminal of the audio amplifier to TP2 via a 0·1μF capacitor.

Set the amplifier volume to a reasonably sensitive level. Slide the LW/MW coils of L1/2 along the ferrite rod until the loudest 2·4kHz tone is heard and/or measured from the amplifier.

Trim VC1 to check that it is set to give a maximum amplitude of the 2·4kHz signal. Adjust the core of L3 to give a maximum signal. This is a fairly sharp adjustment unless R4 is 82kΩ, due to the relatively high Q of the L3/C8 tuned circuit.

Remove the temporary links from TB1b (0V) to TP6 and from TP1 to TP2. Remove the connection to the amplifier.

4. Setting the AGC delay voltage
Connect the voltmeter between TP9 and TP10. Adjust RV1 to give a reading of 5·0V, which corresponds to a 6V Pk-to-Pk signal at TP2.

5. Final trimming of VC1 and L3
During stage 3 of this setting up procedure, VC1 and L3 were adjusted with 0V bias on TR1. While this gives very nearly the correct settings of VC1 and L3, the change to a bias voltage of –4·2V on TR1 alters the input capacity of TR1 by a few pF and changes the DC current flowing through L3. This slightly detunes the aerial circuit and the L3/C8 tuned circuit. It is important to carry out these adjustments carefully, as they critically affect the response curve of the IF tuned circuit.

Connect the voltmeter between TB1b (0V) and TP6. Adjust VC1 slightly to maximise the AGC voltage. VC1 should only require a small adjustment, corresponding to a few degrees of rotation of the shaft to find the maximum. Next, adjust L3 slightly to maximise the AGC voltage. The total increase in AGC voltage of the maximum will be less than 100mV, as the gain of TR1 is changing very rapidly with bias voltage in this region (see Figure 3). This completes the setting-up procedure using a voltmeter and an audio amplifier.

Operation and Use of the Receiver

The use of AGC in the receiver means that considerable variations in signal strength can be accommodated without the need for readjustment. However, if the receiver is moved several hundred miles, then resetting of RV1 is recommended.

The receiver module can be installed into any suitably-sized housing, as long as it is not made of conductive material – i.e. metal, metallised plastic, plastic sprayed with metallic paint, etc. – since this will prevent the receiver from picking up the Rugby signal. An appropriately sized ABS box is suggested in the optional parts list. Note that a single tie-wrap is included in the optional parts list; this is used as a cable restraint around the 4-core cable within the (optional) box, to prevent it from being inadvertently tugged through the cable exit hole. The receiver board is secured into the box by means of four Pozidrive screws, spring washers and nuts, situated at each corner of the board through the pre-drilled holes.

Note that an extra hole needs to be drilled in the box to locate the LED (the only external component on the receiver), which is connected to terminal block TB3 (see Figure 8). In use, this LED provides visual confirmation that the time signal is being received, as it will flash on and off at a rate of 1Hz. If the receiver is used in conjunction with the Micron III clock, the LED flashes in synchrony with the DATA LED changing from green to red on the clock itself.

The receiver should not be used nearby electrical equipment that emits a strong RF field (such as TV sets, PCs, or the Micron III clock itself), since this will swamp the receiver and prevent reception of the MSF signal. The module can be remotely mounted well out of the way of such sources of RF interference, connected to the application hardware by means of 4-core burglar alarm cable. This may be of any length up to a maximum of approximately 10m, since only low-frequency TTL level signals and power supply lines are carried by this cable.

When using the receiver with the Micron III Rugby Clock (95072, detailed in *Electronics* April 1995, Issue 88), the existing built-in 60kHz Rugby Receiver (LP70M) is bypassed, so that the miniature DIN socket originally on the output of this receiver is instead connected directly to the Micron III's main clock PCB, at the 12V OUT, 0V and MSF terminals (see Figure 8). If you have a copy of Issue 88 handy, comparison between Figure 8 of this article to that of Figure 9 shown on page 31 will help clarify the changes required. The built-in receiver unit can be removed (or omitted) from the Micron III Clock if you are using this superhet receiver with it.

Use of the superhet receiver in conjunction with the Micron III clock is very straightforward. Simply plug the receiver's DIN plug into the socket on the Micron III clock, apply 12V DC power via the power socket on the clock, position the receiver so that the LED is flashing, and wait a few moments (up to a minute duration) for the clock to automatically update itself to the correct time and date.

RUGBY CLOCK SUPERHET RECEIVER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Specified)			
R1,14,15	22k	3	(M22K)
R2	13k	1	(M13K)
R3,7,16	4k7	3	(M4K7)
R4	1M8	1	(M1M8)
R5	10k	1	(M10K)
R6	3M3	1	(M3M3)
R8	820k	1	(M820K)
R9,20	33k	2	(M33K)
R10	2M2	1	(M2M2)
R11	100k	1	(M100K)
R12	330k	1	(M330K)
R13	1M	1	(M1M)
R17,18	100Ω	2	(M100R)
R19	680Ω	1	(M680R)
RV1	10kΩ Cermet Preset Potentiometer	1	(WR42V)
CAPACITORS			
C1	1nF 1% Tolerance Polystyrene	1	(BX56L)
C2,4,7, 11,20,21	100nF Metallised Polyester	6	(CX21X)
C3	27pF Ceramic Disc	1	(WX49D)
C5,12,17, 18,19	100µF 16V Radial Electrolytic	5	(AT40T)
C6,9	220nF Monolithic Ceramic	2	(RA50E)
C8,14,15	15nF Polyester Layer	3	(WW31J)
C10	10pF Ceramic Disc	1	(WX44X)
C13	22nF Ceramic Disc	1	(WX78K)
C16	22µF 16V Radial Electrolytic	1	(AT37S)
VC1	65pF Trimmer	1	(WL72P)
INDUCTORS			
L1,2	MW/LW Aerial	1	(LB12N)
L3	293mH RF Coil	1	(95071)
SEMICONDUCTORS			
IC1	HCF4024BM1 SMD	1	(AB31J)
IC2,4	TL072CD SMD	2	(DB92A)
IC3	M74HC14M1R SMD	1	(AE46A)
TR1	BF244A	1	(QF16S)
D1,2,3,4	1N4148	4	(QL80B)
ZD1	BZY 3V9 Zener	1	(QH04E)
LD1	High-brightness Miniature Red LED	1	(CZ22Y)
MISCELLANEOUS			
XT1	Crystal 3·6864MHz	1	(UJ04E)
TB1,3	2-way 5mm PCB-mounting Terminal Block Type 301	2	(FT38R)
TB2	3-way 5mm PCB-mounting Terminal Block Type 301	1	(RK72P)
	100mm Tie-wrap	2	(BF91Y)
PCB		1	(95022)
Instruction Leaflet		1	(XV91Y)
Constructors' Guide		1	(XH79L)
OPTIONAL (Not in Kit)			
	ABS Box Type BM11	1	(CC81C)
	Tie-wrap 100	1	(BF91Y)
	M2·5 12mm Pozidrive Screw	1 Pkt	(BF40T)
	M2·5 Steel Nut	1 Pkt	(JD62S)
	M2·5 Spring Washer	1 Pkt	(JD97F)
	Miniature 3-pin DIN Line Plug	1	(JX01B)
	4-Wire Burglar Alarm Cable	As Req.	(XR89W)
	Micron III Clock Kit	1	(95072)
	12V Regulated Mains Adaptor	1	(BZ83E)

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.

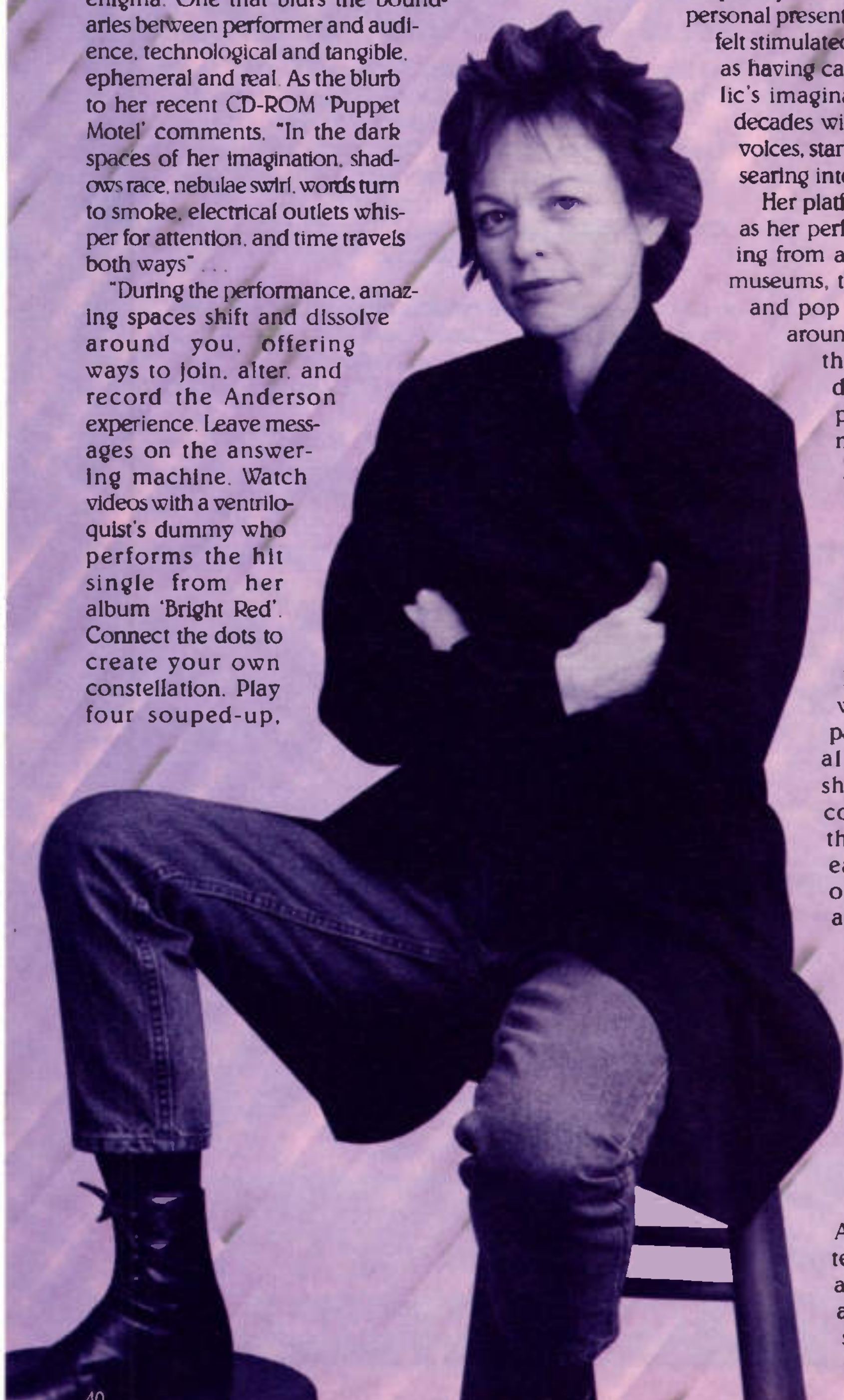
Order As 95021 (Rugby Clock Superhet Receiver) Price £29.99

The following new items (which are included in the kit) are also available separately, but are not shown in the 1996 Maplin Catalogue.

Rugby Clock Superhet Receiver PCB **Order As 95022 Price £6.99**

293mH RF Coil **Order As 95071 Price £14.99**

Laurie Anderson Takes Centre Multimedia Stage



Over the past twenty years, Laurie Anderson has established herself as one of the most respected and successful performance artists in the world. Along the way, she has embraced such roles as artist, composer, author, poet, political commentator, photographer, film maker, ventriloquist and musician. Her shows feature multiple screens, myriad projections and vocal filters – combining as the Royal Festival Hall programme notes suggest, a unique technological and musical experience.

More noted, perhaps by many, for her international pop hit 'O Superman', and others, by her performance trademark of spiky hair and dressed-down sneakers (not to mention computer-driven keyboards and holographic projections) she has remained an artistic enigma. One that blurs the boundaries between performer and audience, technological and tangible, ephemeral and real. As the blurb to her recent CD-ROM 'Puppet Motel' comments, "In the dark spaces of her imagination, shadows race, nebulae swirl, words turn to smoke, electrical outlets whisper for attention, and time travels both ways" . . .

"During the performance, amazing spaces shift and dissolve around you, offering ways to join, alter, and record the Anderson experience. Leave messages on the answering machine. Watch videos with a ventriloquist's dummy who performs the hit single from her album 'Bright Red'. Connect the dots to create your own constellation. Play four souped-up, electronic violins. Watch the set of the 1995 tour assemble itself as Laurie sits on a virtual stage explaining the elements of the show. Familiar Anderson images and tools – telephones, fax machines, TVs, typewriters, and a glowing, howling electrical outlet at the centre assist you in navigating a world saturated with her presence while interacting with her intelligence and art."

Cult Laurie Anderson

No wonder, therefore, that Laurie Anderson has become one of the world's premier performance artists. Her explorations of the boundaries between technology and art continue to astonish, inspire, and provoke audiences. Even London's Institute of Contemporary Art, which hosted a personal presentation by Laurie, felt stimulated to describe her as having captured the public's imagination over two decades with her haunting voices, startling images and searing intelligence.

Her platform is as varied as her performance, ranging from art galleries and museums, to opera houses and pop concert stages around the world. At the talk, Laurie dismissed the plaudits by commenting, "I'm just a storyteller". Not quite though – as the lead to her latest book 'Stories From The Nerve Bible' put it, the heart of her work is a deadpan, comic surrealism. Whether she goes to the corner store or the ends of the earth, she finds oddities. These are her treasures, stories she tells with sound effects and rhythm sections . . . intimate, goofy and smart.

Telling Stories

As one reviewer tells: "Anderson actually managed to turn a simple reading session into yet another piece of performance art. Surrounded by banks of synthesizers, processors and voice modulation equipment, she at once managed to reinvent book reading for all time. All the while, she enveloped her tales into all manner of haunting, synthesized sheets of sound, and if sometimes her words were drowned out in a bleep, wheeze or whoosh of synthesized sound, it seemed to be a small price to pay for sitting in on the birth of an entirely new art form – ambient storytelling."

It was back in 1974, when wearing ice skates (frozen in a block of ice), that Laurie Anderson made her first public performance, playing a duet with a tape hidden in her violin. The violin appeared to talk, thanks to a small speaker hidden in her mouth.

The art gallery performance was over when the ice melted, but this enterprise set the way ahead. Now, playing her hyped-up violin and facing a huge bank of video screens displaying such oversized logos as 'zero one, zero one, zero one', she comments "no-one wants to be a zero."

Her views on the famed Internet are clear. "The information superhighway is being used mainly for tracking people down in terms of debt and credit – not for tapping into the Library of Congress. In an ideal world, I would like to personally meet all my fans to discuss my work, but it's just not practical". What is practical, however, is her Web site, called The Green Room **(http:/www.voyarerco.com)**, where people can log on for a chat. "The Internet is quite possibly our long term salvation."

Reality is Pretty Boring

Her beliefs are pretty legendary. "Reality is pretty boring. Technology today is the camp-fire around which we tell our stories" are but two well-publicised statements. As *Electronics* recently commented, most popular music is electronically generated now, and from humble and relatively crude beginnings, the synthesizer has become a powerful and expressive instrument.

Laurie Anderson would certainly go along with that. As her recent biographer John Howell reveals, her studio-converted loft in downtown New York features stacks of electronic equipment with hardly a musical instrument in sight. A rack of electric keyboards stands opposite a computer-driven console; much of her actual composing is done with a Macintosh program. Wires lead out of the computer in all directions, and are attached to odd-looking boxes and gadgets that produce the variations of voices and sounds for which Laurie Anderson is famous. Large foam balls stand in front of a screen. They hold slide and video images, and are capable of both front- and rear-projection of those images. The visual effect is pure Anderson: a dizzying multi-dimensional, multi-layered view of simple images. E

Exclusive Competition

Listen Out!

Internet apart, if you would like to hear more of the person who calls herself 'the techno-ice-queen observer', read on . . .

Electronics – The Maplin Magazine has no less that five copies of Laurie Anderson's latest CD "The Ugly One With the Jewels and Other Stories" to give away to fortunate readers.

How to enter

To win, all you have to do is complete the coupon below, correctly answering the four questions, or send your answers on a postcard or back of a sealed-down envelope.

Send your entry to: **Laurie Anderson Competition, The Editor, *Electronics – The Maplin Magazine* P.O. Box 3, Rayleigh, Essex SS6 8LR.**

Your entry must be received by 30th April 1996. Good luck and happy listening!

Laurie Anderson Competition

ELECTRONICS

Answer all the questions below, ticking one box for each question:

1. Laurie Anderson is:
- [ ] An electronics freak.
- [ ] A member of the LA Baseball team.
- [ ] A war-time transport shelter.

2. Laurie Anderson has performed at:
- [ ] The Scout's Hut, Golders Green.
- [ ] Royal Festival Hall, London.
- [ ] Maplin Sands Pier.

3. Laurie Anderson's big pop hit was:
- [ ] 'I've Got Those Electronic Blues'.
- [ ] 'Bits & Bite from the Future'.
- [ ] 'O Superman'.

4. Laurie Anderson makes great play with her:
- [ ] Electronic violin.
- [ ] Hi-tech bagpipes.
- [ ] Low-tech filofax.

Name ______________________________

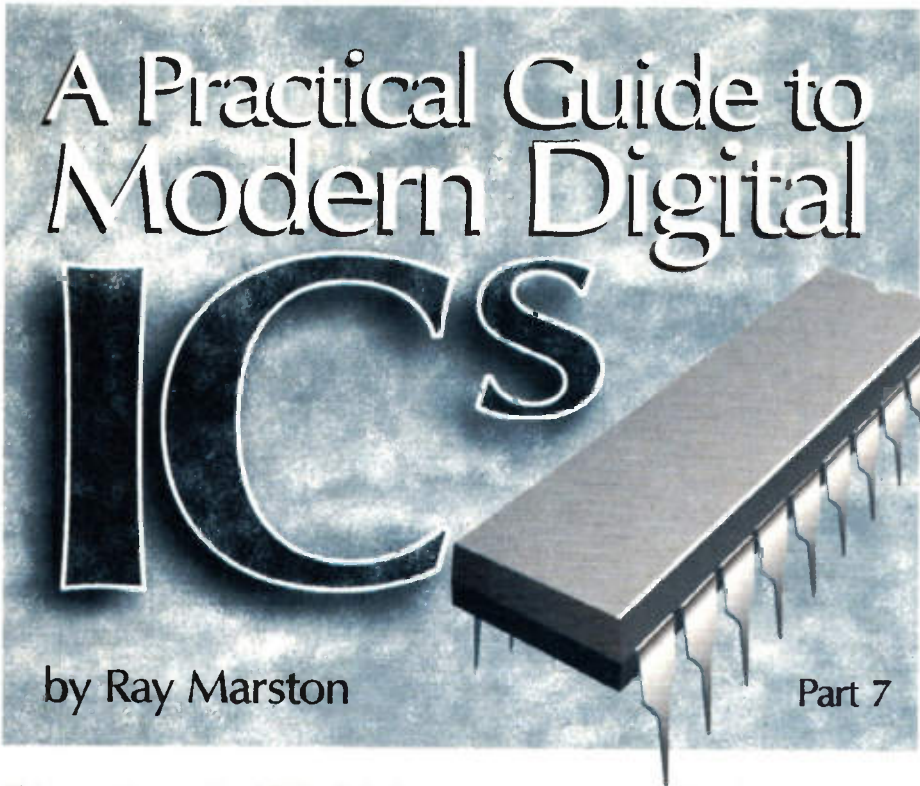
Address ______________________________

____

______________________________ Postcode ______________

Daytime telephone number ______________________________

Please note that employees of Maplin Electronics, associated companies and family members are not eligible to enter. In addition, multiple entries will be disqualified. The prizes will be awarded to the first all-correct entries drawn. The Editor's decision will be final.



This month practical TTL digital waveform generator circuits are discussed. TTL Digital ICs must, in general, be driven or clocked by clean input waveforms that switch abruptly between normal logic levels and have very sharp leading and trailing edges; suitable waveforms can be easily generated using standard TTL logic elements or special waveform generator ICs.

Waveform Generator Basics

Most digital waveform generator circuits fit into one or other of the four basic categories shown in Figures 1(a) to (d). Schmitt trigger circuits Figure 1(a) produce an output that switches abruptly between logic-0 and logic-1 values whenever an input signal goes above or below preset instantaneous voltage levels. Circuits of this type can thus be used in waveform shaper applications, such as for converting a sine or ramp input waveform into a square or pulse-shaped output, etc.

Simple bistable circuits Figure 1(b) have two input terminals, known as SET and RESET. The circuit's output can be latched into the logic-1 state by applying a suitable command signal (usually a brief logic-1 pulse) to the SET input terminal; the output can then be latched into the alternative logic-0 state only by applying a suitable command signal to the RESET terminal, and so on. 'Latch' circuits of this type are useful in a variety of digital signal-conditioning applications.

Monostable circuits Figure 1(c) have an output that switches high on the arrival of an input trigger signal, but then automatically switches back to the low state again after some preset time delay. Circuits of this basic type thus act as triggered pulse generators.

Astable circuits Figure 1(d) have an output that switches into the logic-1 state for a preset period, then switches into the logic-0 state for a second preset period, and then switches back into the first state again, and so on. Circuits of this basic type thus generate a free-running squarewave output.

In practice, all of these basic circuits can be elaborated into more complex forms. The simple monostable, for example, can be elaborated into a 'resettable' form, in which the output pulse can be terminated prematurely via a 'reset' signal, or into a 'retriggerable' form, in which a new monostable timing period is initiated each time a new trigger pulse arrives. Astable circuits may be completely free-running, or may be 'gated' types which operate only in the presence of a suitable gate signal, etc. Practical circuits of all these types are described in this article.

Schmitt Waveform Shapers

A number of Schmitt sine/square converter and switch 'debouncer' circuits, etc., have already been described in earlier parts of this series. Another useful application of the Schmitt element is as an 'edge' detector that produces a useful output pulse on the arrival of either the leading or the trailing edge of a

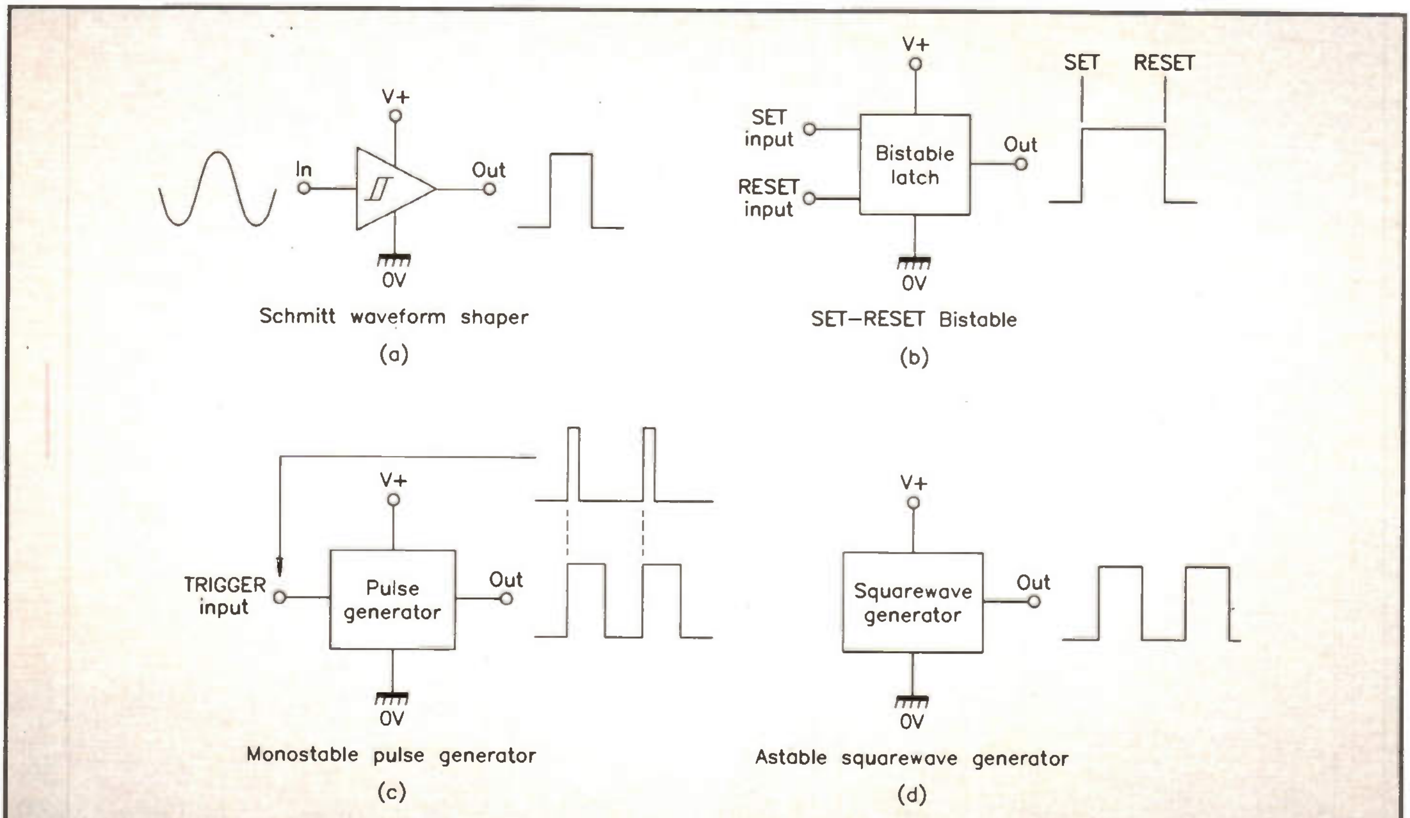


Figure 1. Four basic types of digital waveform generator circuit.

digital input waveform. The basic principle of 'edge' detection can be understood with the help of Figure 2. Here, a 3V squarewave input signal is applied to the input of a simple C-R coupler that has a time constant that is very short relative to the period of the input waveform; the coupler's action is such that its output switches abruptly to +3V on the arrival of the squarewave's 'rising' edge, decays rapidly to 0V as C1 charges up via R1, switches abruptly to −3V on the arrival of the square wave's 'falling' edge, then decays rapidly to 0V as C1 discharges via R1, and so on.

Thus, the C-R coupler generates a positive spike on the arrival of a rising input edge, and a negative spike on the arrival of a falling edge. Figure 3(a) shows how this coupler can be used in conjunction with a TTL Schmitt inverter to make a pulse-generating rising-edge detector. Here, R1 normally ties the Schmitt input low, so that its output is at logic-1, but on the arrival of the input rising edge, the R1 positive spike drives the Schmitt output briefly to logic-0, so that it generates a negative-going output pulse. Note that, since the Schmitt's input is normally tied low, the negative 'falling edge' input spikes have no effect on the circuit. Figure 3(b) shows how the circuit can be made to give a positive-going output pulse by simply taking the output via another Schmitt inverter.

Figure 4(a) shows the basic circuit modified so that it generates a positive-going output pulse on the arrival of a falling (rather than rising) input edge. Here, the Schmitt's input is normally biased above its 1·6V upper threshold value via the R1-R2 divider, so it ignores the effects of positive 'rising edge' spikes, and its output is normally at logic-0. However, on the arrival of each negative 'falling edge' spike, its input is driven below

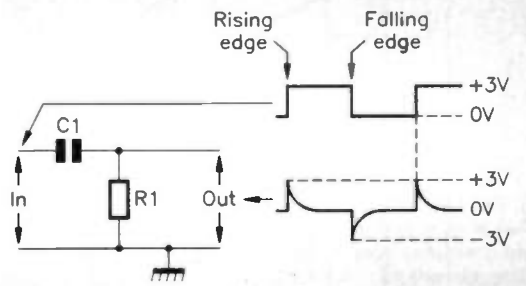


Figure 2. A simple C-R coupler can be used to distinguish between the 'rising' and 'falling' edges of a digital waveform.

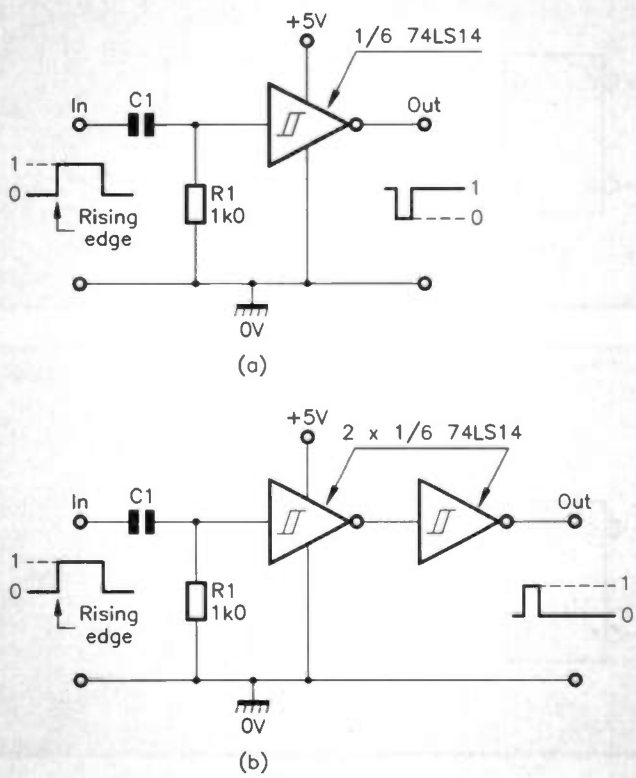


Figure 3. TTL rising-edge detector giving (a) negative-going or (b) positive-going output pulse.

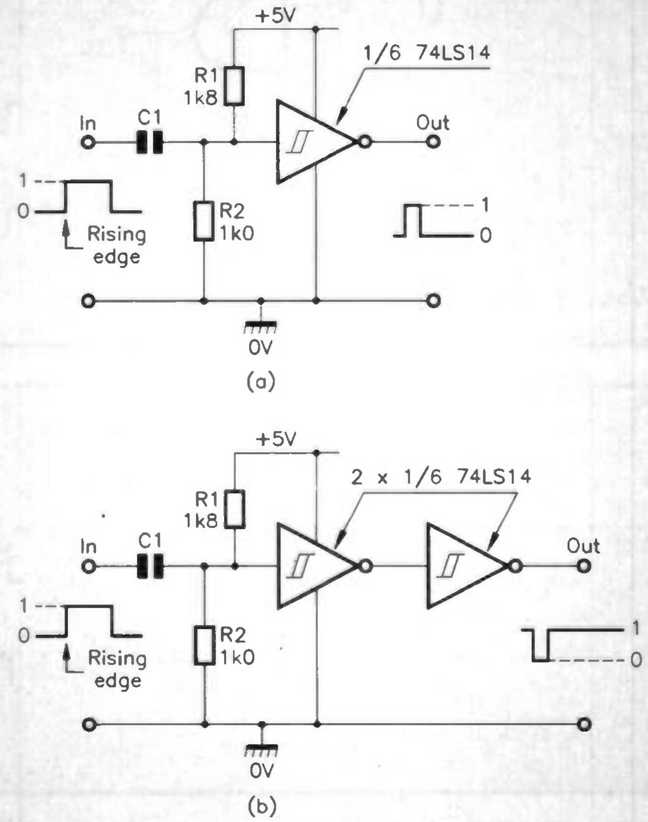


Figure 4. TTL falling-edge detector giving (a) positive-going or (b) negative-going output pulse.

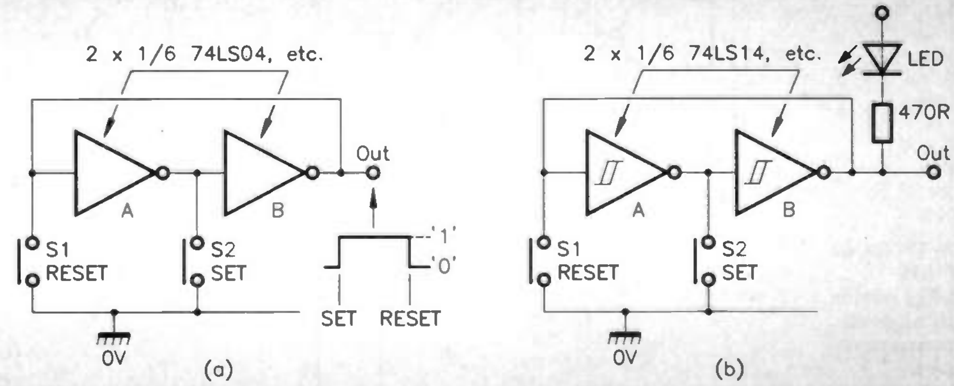


Figure 5. These manually triggered TTL bistable circuits can be built from either (a) normal or (b) Schmitt inverter elements.

the Schmitt's 0·8V lower threshold value, and it generates a positive-going output pulse. Figure 4(b) shows the circuit modified to give a negative-going output pulse via an additional Schmitt inverter.

Note from Figure 2 that a positive-going input pulse has a rising leading edge and a falling trailing edge, so in this case, a rising-edge detector acts as a 'leading-edge' detector. However, a negative-going input pulse has a falling leading edge and a rising trailing edge, so in this case, a rising-edge detector acts as a 'trailing-edge' detector. Also note that the output pulse widths of the circuits shown in Figures 3 and 4 vary greatly with individual ICs, but roughly equal 1μs per nF of C1 value.

Bistable Waveform Generators

A bistable waveform generator is a circuit that can have its output set to either the logic-1 or logic-0 state by applying a suitable control signal to either its SET or RESET input terminal. The simplest way to make an S-R (or R-S) circuit of this type is to wire a pair of normal or Schmitt inverter elements into a feedback loop, as shown in Figure 5. If RESET switch S1 is briefly closed, it shorts the A input low, driving the A output and B input high, thus making the B output go low and lock the A input into the low state, irrespective of the subsequent state of S1. The circuit thus latches into

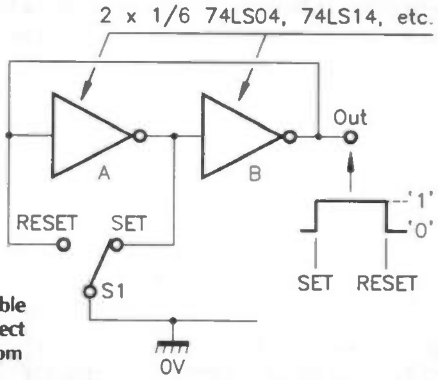
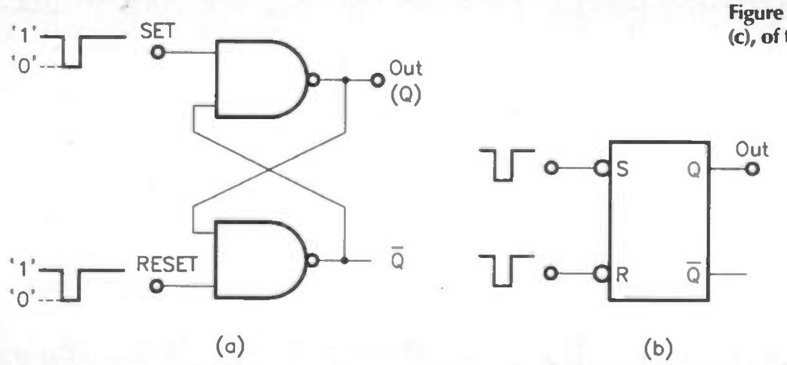


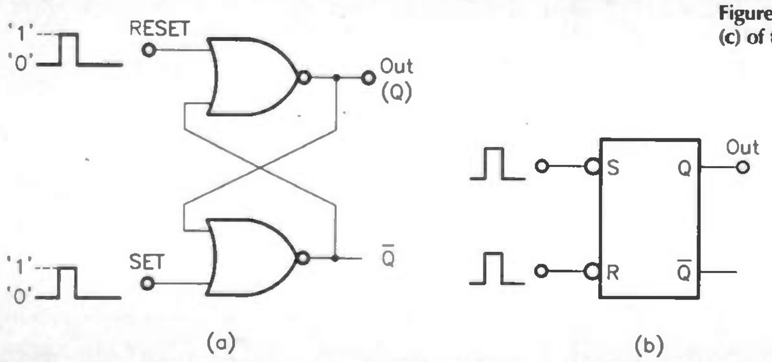
Figure 6. This TTL 'bistable toggle switch' gives perfect waveform generation from a normal toggle switch.



S	R	Q
1	1	no change
0	1	1
1	0	0
0	0	invalid−1

(c)

Figure 7. Basic circuit (a), symbol (b), and Truth Table (c), of the NAND-type S-R (or R-S) bistable.



S	R	Q
0	0	no change
0	1	0
1	0	1
1	1	invalid−0

(c)

Figure 8. Basic circuit (a), symbol (b), and Truth Table (c) of the NOR-type S-R (or R-S) bistable.

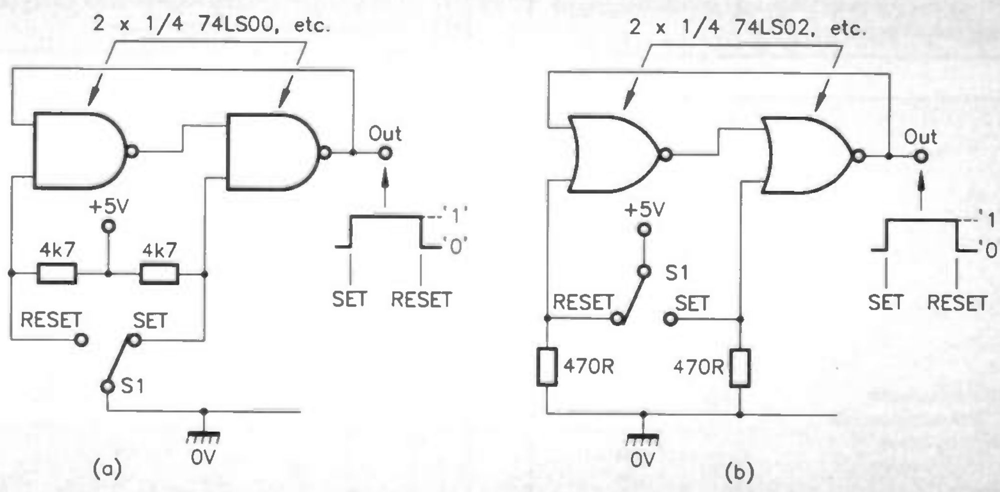


Figure 9. TTL NAND (a) and NOR (b) bistables used as manually triggered 'toggle' waveform generators.

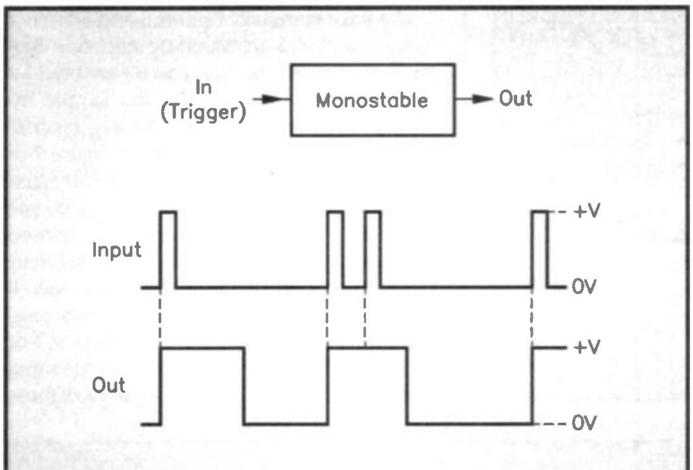


Figure 10. A standard monostable generates an accurate output pulse on the arrival of a suitable trigger signal.

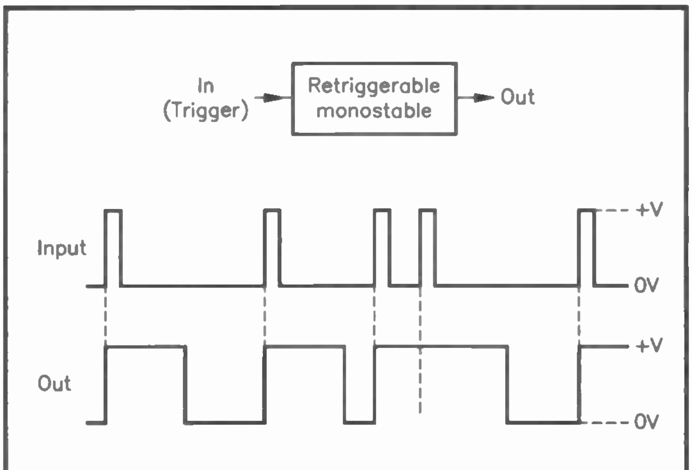


Figure 12. A retriggerable monostable starts a new timing cycle on the arrival of each new trigger signal.

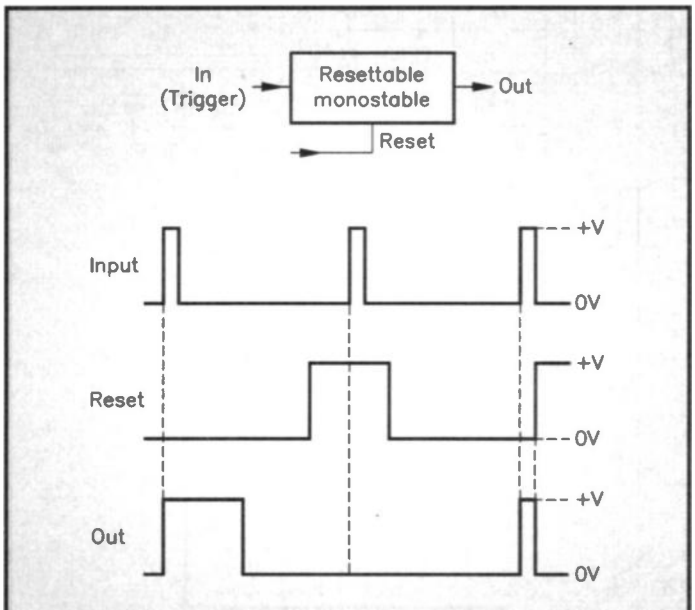


Figure 11. The output pulse of a resettable monostable can be aborted by a suitable reset pulse.

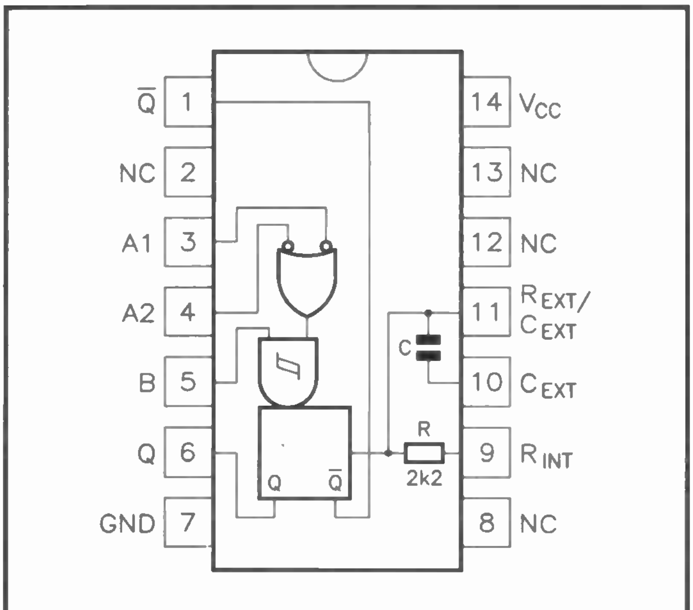


Figure 13. Functional diagram of the 74121 'standard' triggered monostable IC.

this RESET state, with its output at logic-0, until SET switch S2 is briefly closed, at which point, the B output and A input are driven high, thus making the A output go low and lock the B input into the low state, irrespective of the subsequent state of S2. The circuit thus latches into this SET state, with its output at logic-1, until the S1 RESET switch is next closed, at which point, the whole sequence starts to repeat again.

Note that each time S1 (or S2) is operated, it places a short between the B (or A) output and ground, but the resultant output current is internally limited to safe values by the inverter's totem-pole output stage and only effectively flows for the few nanoseconds that are taken (by the circuit) to switch the inverter into its latched 'output low' state. These apparently brutal circuits are thus, in reality, soundly engineered and are delightfully cheap and effective designs that generate perfectly 'bounce-free' output switching waveforms. If desired, the circuit's output state can be monitored by an LED connected as shown in Figure 5(b), so that the LED glows when the output is in the 'RESET' (low) state. The basic design can be modified for operation via a single toggle switch by connecting it as shown in the circuit of Figure 6, which generates a perfectly reliable and bounce-free 'toggle' output waveform.

Figure 14. Basic 74121 connections for (a) rising-edge or (b) falling-edge triggering.

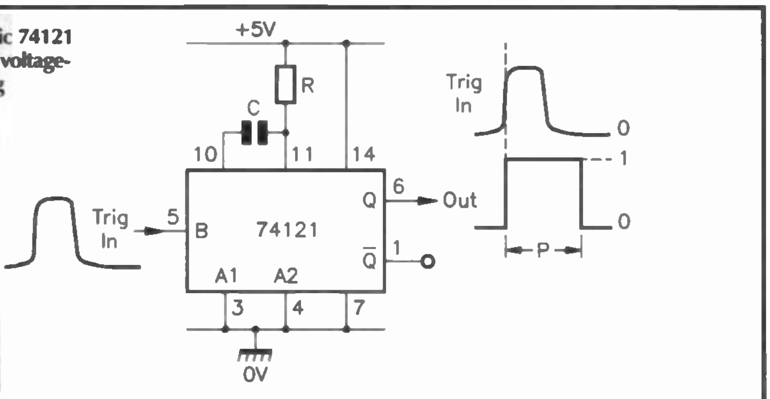
(a) Rising–edge or voltage–level triggering

A1	A2	B
0	0	TRIG

(b) Falling–edge triggering

A1	A2	B
TRIG	1	1
OR		
1	TRIG	1
OR		
TRIG	TRIG	1

Figure 15. Basic 74121 rising-edge or voltage-level triggering connections.



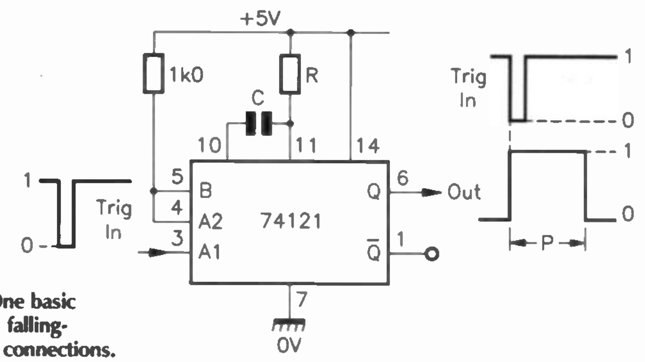


Figure 16. One basic set of 74121 falling-edge trigger connections.

The basic circuits of Figures 5 and 6 are not really suitable for activation by electronic trigger-pulse signals, etc., but can be adapted for this operation be replacing the simple inverters with 2-input NAND or NOR gates connected in the basic ways shown in Figure 7 or 8, so that the control inputs are not subjected to odd loading effects. If NAND gates are used, both inputs must normally be biased high, and the output is SET or RESET by briefly pulling the appropriate control input low. If NOR gates are used, both inputs must normally be biased low, and the output is SET or RESET by briefly driving the appropriate input high. Figure 9 shows practical versions of these

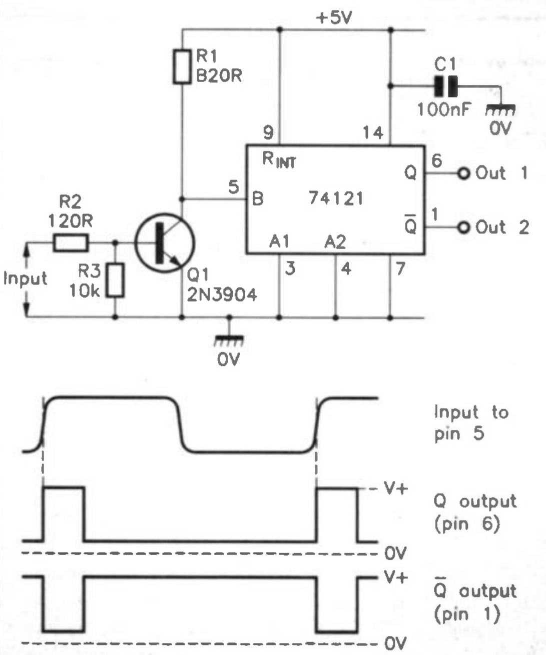
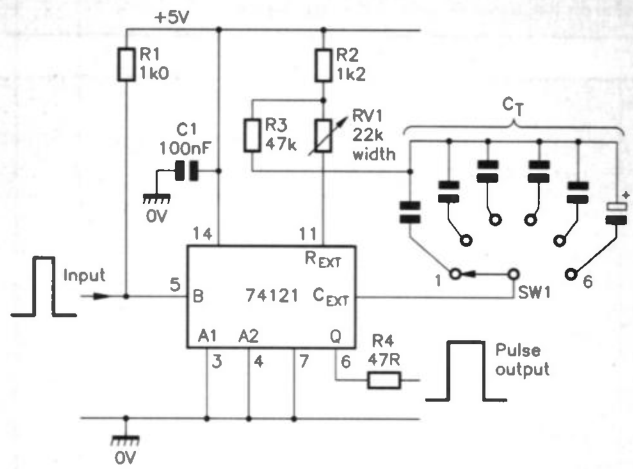


Figure 17. 30ns pulse generator using 'B' input (Schmitt) rising-edge or voltage-level triggering.



SW1 RANGE	CT VALUE	PULSE–WIDTH RANGE
1	100pF	100ns–1us
2	1nOF	1us–10us
3	10nF	10us–100us
4	100nF	100us–1ms
5	1uOF	1ms–10ms
6	10uF	10ms–100ms

Figure 18. This high-performance add-on pulse generator spans 100ns to 100ms.

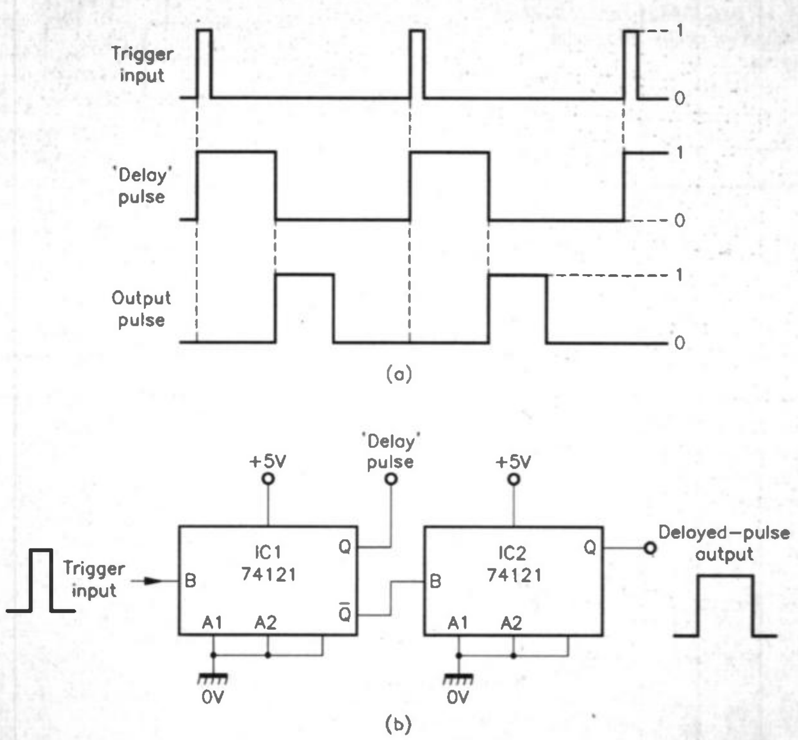


Figure 19. Basic delayed-pulse generator waveforms and circuit.

circuits, modified for use as manually triggered 'toggle' waveform generators.

Monostable Pulse Generators

A monostable ('mono') or 'one-shot' pulse generator is a circuit that generates a single high-quality output pulse of some specific width or period p on the arrival of a suitable trigger signal. In a standard monostable circuit, the arrival of the trigger signal initiates an internal timing cycle which causes the monostable output to change state at the start of the timing cycle, but to revert to its original state on completion of the cycle, as shown in Figure 10. Note that once a timing cycle has been initiated, the standard monostable circuit is immune to the effects of subsequent trigger signals until its timing period ends naturally, but it then needs a certain 'recovery' time (usually equal to *p* or greater) to fully reset before it can again generate an *accurate* triggered output pulse; it can thus not normally generate accurate pulse output waveforms with duty cycles greater than about 50%. This type of circuit is sometimes modified by adding a RESET control terminal, as shown in Figure 11, to enable the output pulse to be terminated or aborted at any time via a suitable command signal.

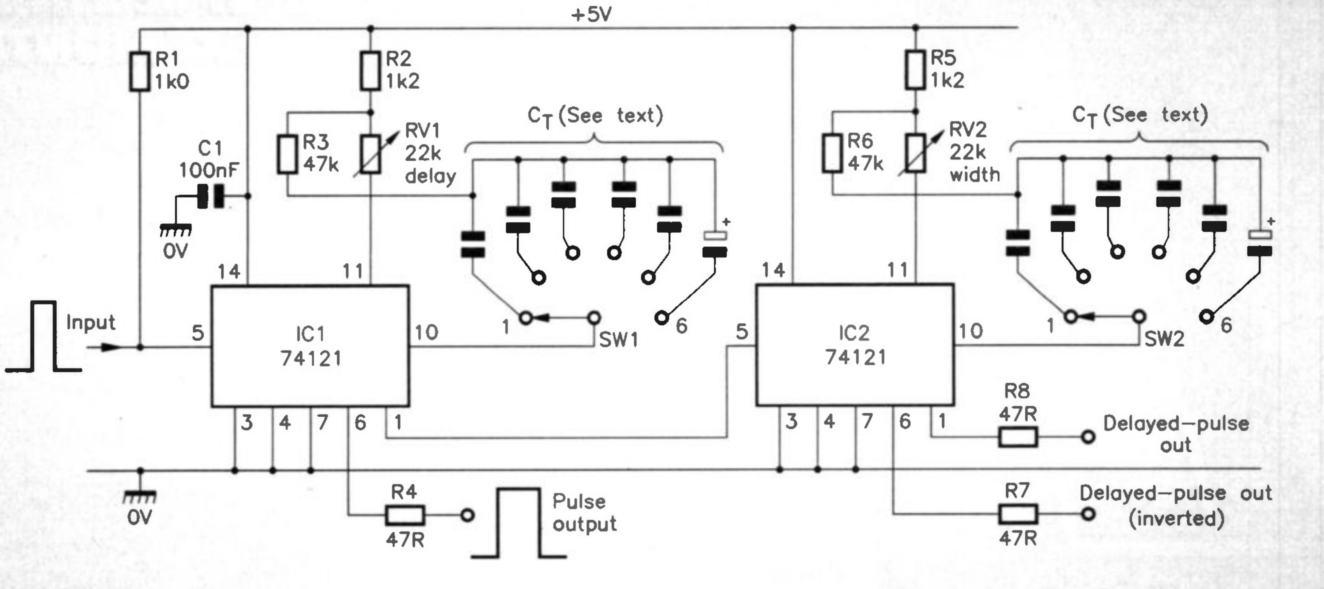


Figure 20. High-performance add-on delayed-pulse generator spans 100ns to 100ms.

Another variation of the monostable is the 'retriggerable' circuit. Here, the trigger signal actually resets the monostable and almost simultaneously initiates a new pulse-generating timing cycle, as shown in Figure 12, so that each new trigger signal initiates a new timing cycle, even if the trigger signal arrives in the midst of an existing cycle. This type of circuit has a very short recovery time, and can generate accurate pulse output waveforms with duty cycles up to almost 100%.

Most monostables are 'edge' triggered, i.e., their pulse generation cycle is initiated (fired) by the arrival of the trigger signal's rising or falling edge; this type of monostable needs a well-shaped trigger signal, with fast edges. Some monostables, however, are 'voltage level' triggered via a Schmitt input stage, and fire when the voltage reaches a predetermined value; this type of mono can be fired by any shape of input signal.

Thus, the circuit designer may use an edge triggered or level triggered standard monostable, resettable monostable, or retriggerable monostable to generate triggered output pulses. In TTL circuitry, the most cost-effective way of generating high quality output pulses is via a dedicated TTL pulse-generator IC, such as the 74121. Figure 13 shows the functional diagram of this old but very popular 'standard' monostable pulse generator IC, which can give useful output pulse widths from 30ns to hundreds of ms via (usually) two external timing components, and can be configured to give either level-sensitive rising-edge or simple falling-edge triggering action. Note that the IC has three available trigger-input terminals; of these, A1 and A2 are used as falling-edge triggering inputs, and B functions as a level-sensitive Schmitt rising-edge triggering input; Figure 14 shows how to connect these inputs for specific types of trigger action.Thus, for rising-edge or voltage level triggering, A1 and A2 must be grounded and the trigger input is applied to B, as shown in Figure 15 (which also shows the two external timing components wired in place). For falling-edge triggering, B must be tied to logic-1, and the trigger input must be applied to A1 and/or A2, but the unused 'A' input (if any) must be tied to logic-1; Figure 16 shows an example of one of these options, with B and A2 tied to logic-1, and the trigger input applied to A1.

Dealing next with this IC's timing circuitry, note that the 74121 has three timing component terminals. A low-value timing capacitor is built into the IC and can be augmented by external capacitors wired between pins 10 and 11 (on polarized capacitors, the '+' terminal must go to pin 11). The IC also incorporates a 2kΩ timing resistor that is used by connecting pin 9 to pin 14, either directly or via a resistance of up to 40kΩ; alternatively, the internal resistor can be ignored and an external resistance (1k4Ω to 40kΩ) can be wired between pin 11 and pin 14. Whichever

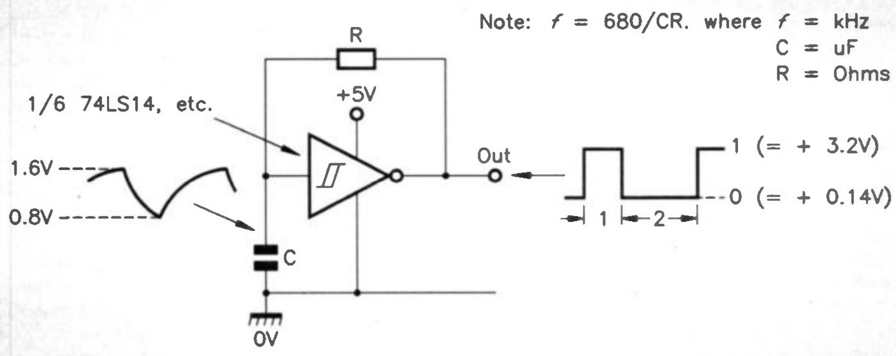


Figure 21. Basic circuit and waveforms of a TTL Schmitt astable.

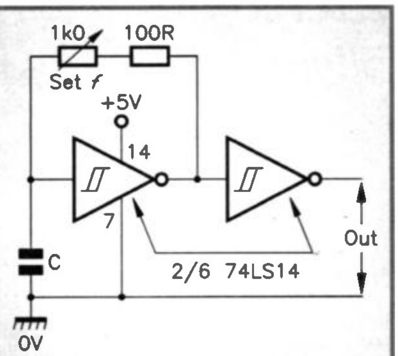


Figure 22. Variable-frequency buffered-output TTL Schmitt astable.

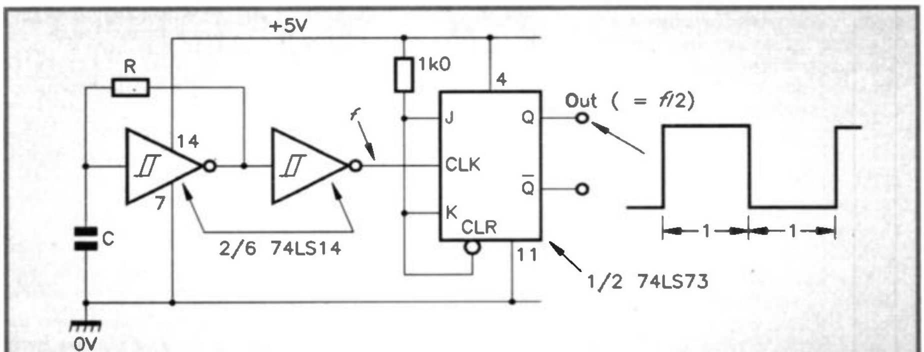


Figure 23. TTL Schmitt astable with precise 1:1 mark-space ratio output.

Continued on page 54.

DON'T MISS BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE NEXT MONTH!

ELECTRONICS
The Maplin Magazine

100th EDITION

NEXT issue

To celebrate the achievement of producing our 100th issue of *Electronics – The Maplin Magazine*, we are planning a bumper, jam-packed edition, with a superb variety of terrific projects and features heading your way – don't miss it!

PROJECTS

COURTESY LIGHT CONTROLLER

This redesign of the Car Interior Light Controller kit incorporates a number of improvements over the original version, to ensure highly effective and useful control of your vehicle's interior courtesy light, significantly adding to the driver's and passengers' safety and convenience during night-time motoring, as well as adding a touch of luxury to your pride and joy!

CRYSTAL SET

Return to a bygone age to experience the satisfying sounds of crystal radio, by constructing this superb authentic crystal set – built on a wooden base, with Galena crystal 'cat's whisker' detector. Fun and educative, this is one electronic item that certainly won't require costly batteries or a power supply to run it, since the energy to power the earphone is sourced from the radio waves themselves, via the aerial.

MULTI-STROBE SEQUENCER

The long-awaited second part of the Multi-Strobe project, the sequencer, or Serial Command Unit, can be utilised in conjunction with a computer via an RS-232 interface to control the flashing pattern of the Multi-Strobe lights. The unit has 8 channels and stores 100 patterns in read-only memory (ROM) for some really dazzling lighting effects at discos and parties!

NI-CD BATTERY CHARGER

An update of the popular Intelligent Ni-Cd Battery Charger project, this improved, and yes, *more intelligent* version caters for an even wider range of battery types and capacities, so that the more recently introduced varieties of batteries may be given the same optimum charging levels as existing types.

PC WEATHER STATION SOFTWARE UPDATE

This update to the original PC Weather Station software enables extremely effective monitoring of climatic changes, allowing accurate storage and forecasting of weather data by means of your PC, so that you can confidently pit your weather forecasting abilities against those of the Meteorological Office, and have fun in the process!

SERIAL LINE TESTER UPDATE

A redesign of the versatile PIC-based RS-232 Serial Line Tester project, incorporating new features, courtesy of a reprogrammed PIC microcontroller and additions to the circuitry, to enable even more comprehensive testing of equipment using the widely used RS-232 interconnection format.

FEATURES

The centenary edition (hotly tipped to become a priceless collectors' item!), April 1996 issue of *Electronics* will contain a fascinating assortment of features and articles. These will include Earth Resources Satellites by Douglas Clarkson, concerning satellites capable of measuring Earth's atmosphere and surface properties (such as pollution levels on land, sea and air, and earthquake detection) with new levels of accuracy, High Bandwidth Memory by Frank Booty, describes new memory technology capable of operating at speeds sufficient to match the requirements of today's super-fast microprocessors, and Internet Cafe by Alan Simpson, detailing how you too can surf the information superhighway whilst supping a steaming cappuccino at such a venue. There are also the final parts of the informative series EMC by John Woodgate, and The Internet by Stephen Waddington, together with Ray Marston's Practical Guide to Modern Digital ICs.

Look out for another great competition in *Electronics* next month. There are two first prizes of 2-hour Introductory Training Courses (worth £25 each) to the Internet, at the Cafe Internet in Victoria, London, plus six runners-up prizes of free Internet sessions (worth £3 each) at this superb high-tech cafe!

TECHNOLOGY

by Ian Poole

Demand for battery power has never been greater. Look through any consumer shop and there will be a wide range of battery powered goods from shavers to motorised toys. Electrical shops are also filled with battery powered equipment. Items like portable radios and calculators have used batteries for many years, but the major area of growth has been in laptop computers and mobile telephones.

THE dramatic growth in the number of battery powered goods has led to many developments in battery technology over the past few years. The sheer volume of demand has meant that manufacturers are trying to improve their products to increase their share of the market. If they can achieve this, enormous returns can be made on their investment.

The requirements being placed on batteries are becoming ever more demanding. Higher levels of charge need to be contained within smaller packages. If this was not enough, the green lobby is having a significant effect. Some of the old battery technologies contain chemicals that can be considered as toxic. Now new designs are seeking to use more environmentally friendly chemicals. This is becoming a major issue in some countries. Sweden for example, is discussing the possibility of banning nickel-cadmium rechargeable batteries because of the amounts of cadmium they contain. Other batteries also contain harmful chemicals and this is likely to have a significant impact on the direction of future developments.

Semiconductor manufacturers are pulling their weight, by developing new chips that consume less power. The switch away from the 5V logic standard to 3V is proof of this. In addition to this, however, there are new advanced technologies being developed which will use even less power than those currently on the market.

Primary vs Secondary

The majority of battery sales are for the non-rechargeable or primary batteries. There is a very wide variety available. A quick look along the shelves of a supermarket or any other shop which sells batteries will show just how wide the range is (from the standard cells to the long life alkaline cells, as well as the variety of smaller, more specialised cells for use in calculators, cameras and watches) see Table 1.

Primary batteries can only be used once, and they should not be attempted to be recharged. This can be very dangerous, with the possibility of the battery exploding. Even so, some people do claim to have workable systems to recharge them. The fact that these recharging systems are not in everyday use must indicate something!

Until the last ten years or so, the only rechargeable battery in common use was the lead-acid type used in cars. As electronics equipment became more portable and as nickel-cadmium (Ni-Cd) batteries started to become more common, the sales of secondary batteries started to rise. Surprisingly, the sales of primary batteries

Cell Type	Diameter (mm)	Height (mm)
AAA	10·5	44·5
AA	14·5	50·5
C	26·2	50·0
D	34·2	61·5

Table 1. Standard cell sizes.

Cell Type	Nominal Voltage	Characteristics
Primary cells		
Alkaline manganese dioxide	1·5	Widely available, providing a high capacity. Shelf life of up to five years. Capable of providing a moderate current.
Lithium thionyl chloride	3·6	Good for low to medium currents. High energy density and long shelf life.
Lithium manganese dioxide	3·0	Long shelf life combined with high energy density and moderate current capability.
Mercury oxide	1·35	Used for button cells – but they are being phased out because of the mercury they contain.
Silver Oxide	1·5	Good energy density. Used mainly for button cells.
Zinc carbon	1·5	Widely used for consumer applications. Low cost, moderate capacity. Operate best for intermittent use.
Zinc Air	1·4	Mostly used for button cells. Have a limited life once opened and low current capability, but a high energy density.
Secondary or rechargeable cells		
Nickel-cadmium	1·2	Very common. Have low internal resistance and can supply large currents. Long life if used with care.
Nickel-metal hydride	1·2	Higher capacity but more expensive than nickel-cadmium. Charging must be carefully controlled. Being introduced onto many laptop computers, etc., as battery packs.
Lead-acid	2·0	Widely used, particularly for automotive applications. Relatively cheap, but lifetime can be relatively short.

Table 2. Comparison of cell types.

remain very high, rechargeables only making inroads into a number of areas. Part of the reason for this is the cost of rechargeables. These cells can be several times as expensive, making the prospective buyer think twice before buying them, even though in the long-term they may work out much cheaper.

Technically primary batteries have the edge in a number of areas. Obviously, cost is a major consideration, but they also have a much higher energy density. A typical primary battery may have several times the capacity of a secondary one. For a number of applications, this can have significant impact.

Another area where primary cells beat secondary ones is in terms of self-discharge. Any battery will tend to discharge over a period of time, even when no external current is being drawn. Often primary batteries have lifetimes of several years. Secondary ones are unlikely to hold their charge for as long, even when they are new. Table 2 summarises the differences between the various battery types available.

Figure 1. A basic zinc carbon cell.

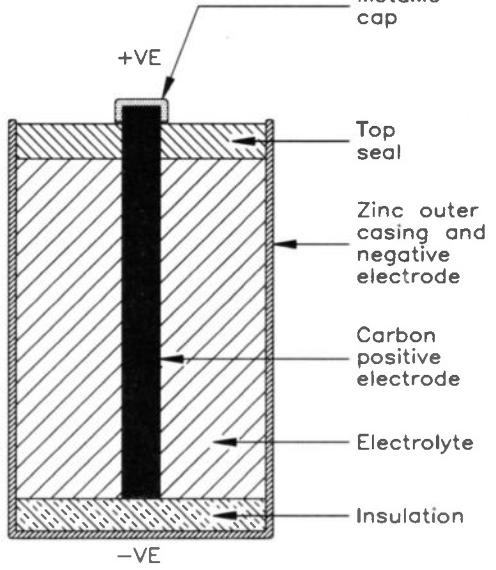
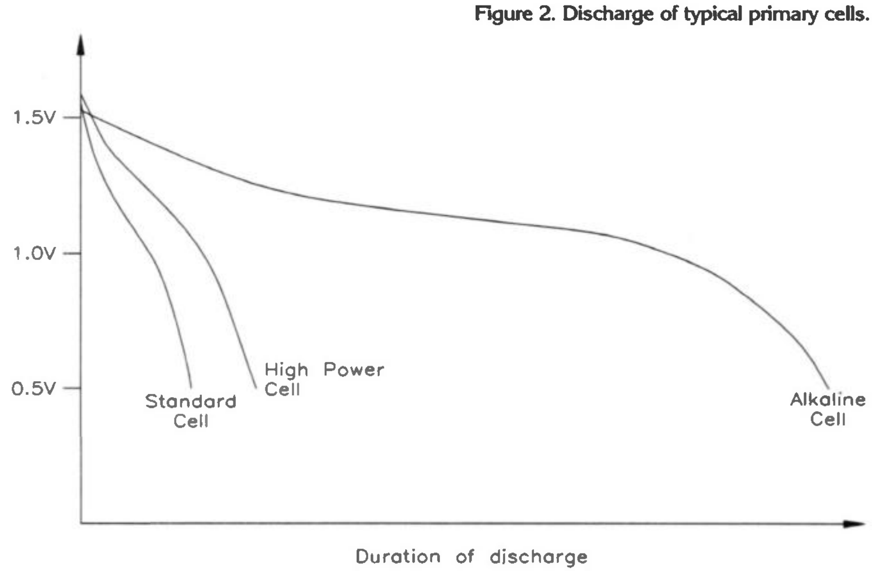


Figure 2. Discharge of typical primary cells.



Current Battery Technology

The zinc carbon variety is possibly the most widely cell used today. It is cheap and readily available from all stores which sell batteries. In its original form, its construction is simple, as shown in Figure 1. The zinc electrode, which is the negative connection to the cell, forms the case, and in the centre, there is a carbon rod which acts as the positive electrode. The electrolyte can be any one of a number of substances. In standard cells, ammonium chloride is used. Then in the high power cells, zinc chloride is used. For the alkaline cells which are now very popular for long life, heavy-duty applications, sodium hydroxide is used. Manganese dioxide is also present, and this acts as a depolarizer, combining with the hydrogen produced to give manganese oxide and water.

The standard zinc carbon technology has been improved over the years. The cells are contained in plastic and metal cans, which are sealed at both ends to prevent leaks. These cells perform best when there is an intermittent load. In general, it is found that their capacity is greater if the load is less. The voltage of these cells is nominally 1·5V, but this falls over the life of the cell, (see Figure 2).

Zinc Air Cells

These are more of a specialist battery. They consist of a zinc anode and a very thin catalytic cathode which allows air to flow inside the cell. When the cell is new, it is sealed so that no air can enter, allowing it to have a very long shelf life. The cell is activated by removing the seal and allowing air to enter. It can be resealed to extend its life if it is not in use, but it should then be used within about ten weeks.

Lithium Thionyl Chloride

These batteries have an output voltage of 3·6V, and are widely used as back-up batteries in electronic circuits, usually CMOS ones which have very low quiescent currents. They are often found in personal computers, where the clock needs to remain running and configuration details need to be stored even when the power is removed from the equipment. In many of these applications, the current consumption is very low and the long shelf life of the battery means that its life will often exceed that of the equipment itself. The cells have a carbon cathode and an anode made from lithium. The electrolyte consists of thionyl chloride and the whole assembly is contained in a nickel-plated steel can.

Lithium Manganese Dioxide

Like lithium thionyl chloride cells, these ones also have a long life. They find many similar applications, being used as battery back-ups as well as finding uses in organisers, calculators and the like. Inside the cells, the anode is made of lithium and the cathode is a mixture of a treated form of manganese dioxide and carbon, selected to give a sufficiently high conductivity. A variety of electrolytes are used, but they generally consist of an alkali metal salt dissolved in an organic solvent.

The cells incorporate a safety vent, as do the lithium thionyl chloride ones. This provides a method of relieving the pressure in cases of over-stress. This may occur if the cell is mechanically stressed, overheated, or if too much current is drawn. Without the vent, excess pressure in the cell could cause a hazard.

Mercury Oxide and Silver Oxide

These cells perform well where low currents are required over a long period of time. If the current drain is low, they give an almost constant voltage. In view of this, they find widespread use in items like hearing aids and other small electrical items where size is at a premium. However, these days, mercury oxide batteries are not liked because of their toxic mercury content.

Rechargeable Batteries

One of the major growth areas over the past few years has been in rechargeable batteries. The lead-acid cell has been with us for many years, and is widely used in the automotive industry. However, it is large, heavy and does not have a very high capacity. With the development of much more portable electronics equipment, more convenient forms of battery were needed. Today, the nickel-cadmium or Ni-Cd battery is the most widely used. It was the first viable form of rechargeable battery which came in the familiar standard sizes like the AA, C, or D type cells used in small portable items.

One of the most important parameters for batteries used in portable equipment is the amount of energy which can be held. Often, this will be specified in terms of volumetric energy, i.e. the amount of energy that can be held in a certain volume. At other times, a figure called the specific energy is used where the energy is assessed in terms of the weight of the cell.

With current Ni-Cd technology, specific energy ratings of 30Wh/kg are being quoted. With large amounts of development being invested into Ni-Cd cells, it is anticipated that figures of almost twice this value might be expected within a couple of years. The volumetric capacity is also increasing, with figures of about 150Wh/litre expected in the same timescale.

However, it is some of the new technologies that seem to be the answer for the future. In the short term, a modification of the Ni-Cd called the nickel-metal hydride or Ni-MH cell offers an improvement in capacity over Ni-Cds, although charging has to be managed very carefully. As a result, Ni-MH cells are more often sold in battery packs which have special battery management facilities to ensure they do not become overcharged. Despite this, some separate Ni-MH cells are available separately. To give an idea of their capacity in more understandable terms, a typical AA sized Ni-Cd will have a capacity of 600 to 800mAh, whilst its Ni-MH equivalent is likely to have a capacity of around 1,200mAh.

Whilst Ni-MH cells seem to be taking over in the short term, on the horizon, lithium ion or Li-ion cells promise to offer far greater improvements. These cells are still only in their development stages, but existing cells have been shown to have specific energies of around 100Wh/kg with rises of around 40% expected in a few years. Their density also means that the volumetric figures are extraordinarily good. Figures nearing 300Wh/litre are anticipated within about five years. In view of their low weight, high power and long life, this technology will undoubtedly become the favourite for applications such as portable computers, mobile phones and the like. However, their manufacture is relatively complicated and this means that they will initially be expensive, although as production methods improve and demand rises, their cost will undoubtedly start to fall.

Lead-Acid

The first type of rechargeable cell that became widely available was the lead-acid variety. Found in virtually every car today, it has become an essential part of the automotive industry. Although it is not as widely used elsewhere, other versions are available and can be used for a variety of applications.

These cells are very different to many of the other types like Ni-Cds, which are widely used to power portable pieces of electronic equipment. Lead-acid cells give a nominal voltage of 2V, and they are often put together in a pack of six, as in a car battery, to give an output of 12V.

The cells are charged with a constant voltage. Initially, the current drawn will be higher than later in the charging cycle. If the charging voltage is limited to about 2·4V per cell, then the current falls to almost nothing once fully charged.

These cells perform best if they are not fully discharged. If they undergo full charge/discharge cycles, their life can be as little as about 50 cycles. They perform best if their level of charge is regularly maintained, as in the case of automotive use.

Even though lead-acid batteries have been around for many years, they are still being improved. Most batteries sold for cars these days are the low maintenance or maintenance-free types. In the older versions, it was found that hydrogen and oxygen were given off at the electrodes when the cell was overcharged. This used up the electrolyte in the cell, and it would need topping up with distilled water every so often. Now, the maintenance-free ones should never need any attention. The hydrogen and oxygen recombine within the cell so that none of the electrolyte should be lost.

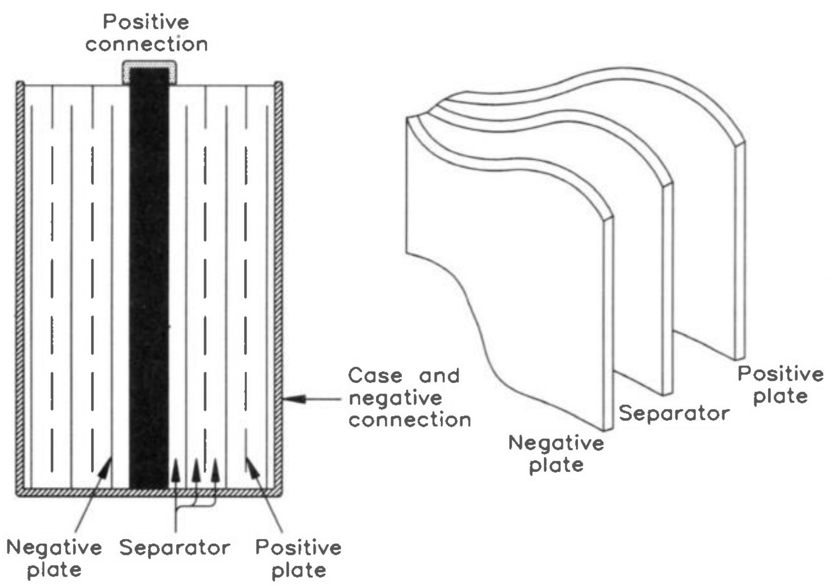
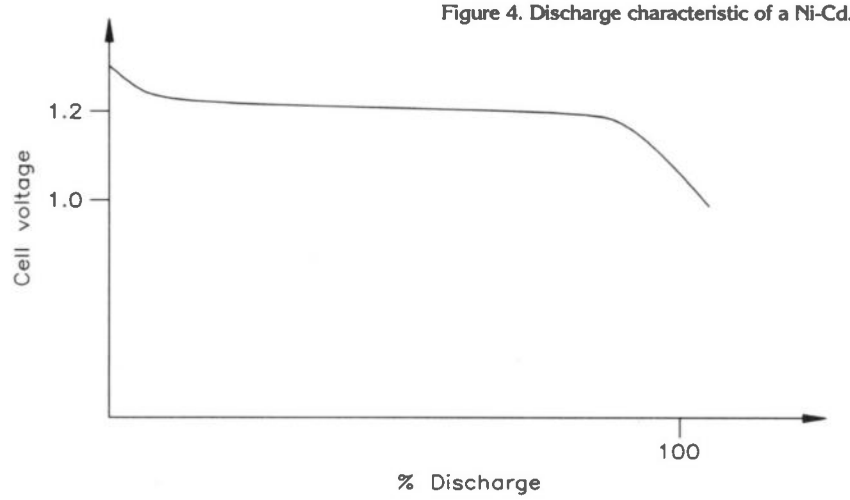


Figure 3. A nickel-cadmium (Ni-Cd) cell.

Figure 4. Discharge characteristic of a Ni-Cd.


Nickel-Cadmium (Ni-Cd)

The nickel-cadmium (Ni-Cd) cell is the most widely used type of rechargeable battery found in electronic equipment at the moment. It combines convenience of use with a relatively high power density and acceptable cost.

The cells consist basically of positive and negative plates with a separator and electrolyte, as shown in Figure 3. In the discharged state, the positive active material consists of nickel hydroxide ($Ni(OH)_2$) and the negative material is cadmium hydroxide. During charging, these convert to NiO OH and cadmium, together with some water. Although the separator does not take place in the reaction, it serves to insulate between the plates. An electrolyte is also needed, and potassium hydroxide is used for this. It does not participate in the reaction, but enables electron transfer to take place between the two plates.

The cell voltage is nominally 1·2V, which it holds well for most of the time, only falling when most of the charge has been used. From the output characteristic shown in Figure 4, it can be seen that its output voltage is held much better than the equivalent zinc carbon primary types. Whilst the flat curve shows the advantage that the output voltage from the cell is very stable, it does mean that when the cell becomes flat, it looses its voltage very quickly, giving little warning to the user.

Ni-Cd cells have a very low level of internal resistance. A good quality alkaline cell might have an internal resistance of about 300mΩ when new. This figure might rise to about 900mΩ when 20% discharged, and several ohms when completely discharged. A Ni-Cd has very much lower figures, and any internal resistance can be ignored for most purposes, as it is of the order of only a few milliohms, dependent upon the exact type of cell and the manufacturer. This does mean that the cell is capable of producing very high currents, especially if the cell is accidentally short circuited. In view of this, care must be taken to ensure this does not happen, as large amounts of heat can be generated.

Unlike the lead-acid cells, Ni-Cds are charged using a constant current source. Their internal resistance is such that if a constant voltage was used, they would draw excessively large currents which would damage the cells. Normally cells are charged at a rate of around capacity (C)/10. In other words, if their capacity is 1A/h, then they would be charged at a rate of 100mA. The charge time is usually longer than ten hours, because not all the energy entering the cell is converted into stored electrical energy.

Today, many applications require that the cells should be charged faster than this. Accordingly, it is possible to obtain some cells that can be charged in an hour or two. It is found that the life expectancy of these cells when they are repeatedly fast charged is less than one which is charged at a slower rate. However, for many commercial users, the cost of replacing the cells is worth the convenience of being able to fast-charge them.

There is a lot of talk with nickel-cadmium batteries about the memory effect, and whether it is of any importance to the average user. The effect was discovered when satellites started to use Ni-Cd batteries. In this application, they were repeatedly partially discharged. Soon it was discovered that their overall capacity was reduced, as they 'remembered' the amount by which they were normally discharged. For most normal applications, it appears that the memory effect is not a major issue, although if the cell is run through its full cycle occasionally, this may help reduce the effect if it is suspected. The list below gives hints on extending the life of Ni-Cd cells.

Precautions to ensure long life of Ni-Cd cells.

1. Do not short-circuit the cells, as very large currents can be drawn. This can be dangerous, as large amounts of heat can be generated. It is also advisable not to discharge the cells at very high rates.

2. Never overcharge the cells at a rate greater than or equal to their normal charging current. Trickle charging is permissable.

3. Never reverse-charge the cells. This can occur when a battery consisting of several cells in series is completely discharged. As some cells will hold less charge than the rest, as the total battery becomes discharged, some cells will be put into the reverse-charge situation.

4. Never discard cells in a fire.

5. Cells operate best under normal room temperature conditions. High and low temperatures reduce their effectiveness. High temperatures can cause permanent damage to the cell.

Nickel-Metal Hydride (Ni-MH)

The nickel-metal hydride (Ni-MH) cell bears many similarities to the faithful Ni-Cd. Its construction is very similar, having many of the same components. The positive plate is nickel, and the electrolyte is potassium hydroxide. The difference lies in the negative plate. This is made from a metal hydrogen storage metal. The actual way in which the cell operates is very complicated, involving some equally complicated chemistry. However, in essence, the cell operates by storing and releasing hydrogen. During charging, the negative plate absorbs hydrogen from within the cell, releasing it as the cell is discharged. The hydrogen storage metal is a complex compound, capable of storing hydrogen gas many times its own volume and at less than atmospheric pressure.

In operation, the Ni-MH cell has many similar characteristics to the more familiar Ni-Cd. It follows a very similar discharge curve to that of the Ni-Cd, allowing for the extra charge it can take, as shown in Figure 4. However, it is very intolerant of overcharging, suffering a reduced capacity if this occurs. This presents a significant challenge to battery charger designers. Many intelligent chargers for Ni-Cds sense a small but distinct 'bump' in the output voltage when a Ni-Cd is fully charged, as shown in Figure 5. However, for Ni-MH cells, this increase is very much smaller, making it more difficult to detect. As a result, the temperature of the cells is also detected as well, because once fully charged, the cell dissipates much of the additional charge as heat. A further complication is that the characteristics of Ni-MH cells vary significantly from one manufacturer to the next, making charge performance more difficult to detect.

One of the problems being addressed by companies manufacturing these cells is the fact that they self-discharge over a relatively short period. Typically, it might be expected that a fully charged cell might self-discharge over a period of about two weeks. Ni-Cds are not as good as normal primary cells but will retain a charge over several months.

Lithium Ion

This is the newest of the battery technologies and is not ready for the open market at the moment. A number of manufacturers are investing heavily into it, but few have products on the market. Despite this, there is plenty of hype about the possibilities they are expected to fulfil.

The lithium ion cell is comparatively complicated to manufacture, requiring over 30 components. Basically, it consists of a lithium cobaltite cathode and a graphite anode. These are wound tightly together, so that they can be placed into a cylinder along with a plastic insulator. The cylinder is then filled with an electrolyte and the end is capped.

Unlike the Ni-Cd and Ni-MH cells which exhibit very similar characteristics, the Li-ion cell is quite different. The cell potential starts at around 4V, decaying to around 3V before it is said to be discharged, as shown in Figure 6. This has a number of advantages. Items like cellphones require a minimum operating voltage of around 3V, which can be provided by a single Li-ion cell. Having a single cell also simplifies charging.

Other characteristics of the Li-ion cell show improvements over its competitors. It has been shown to be able to withstand over 1,000 charge/discharge cycles and still be able to hold 80% of its initial capacity. Ni-Cds offer up to around 500 cycles, although this is very dependent upon the way they are used. A badly treated cell may only give 50 or 100. Ni-MH cells are even worse, and this is one of the main areas receiving development. They are only able to give 500 cycles at the very best, before their capacity drops to 80% of the initial charge rating.

Battery Management

Increased reliance is being placed on battery packs. Laptop computers need to be able to operate reliably when they are in use and not run out of power in the middle of a long calculation. Nickel-cadmium cells in particular maintain their voltage until most of the charge is used, and then their voltage falls rapidly.

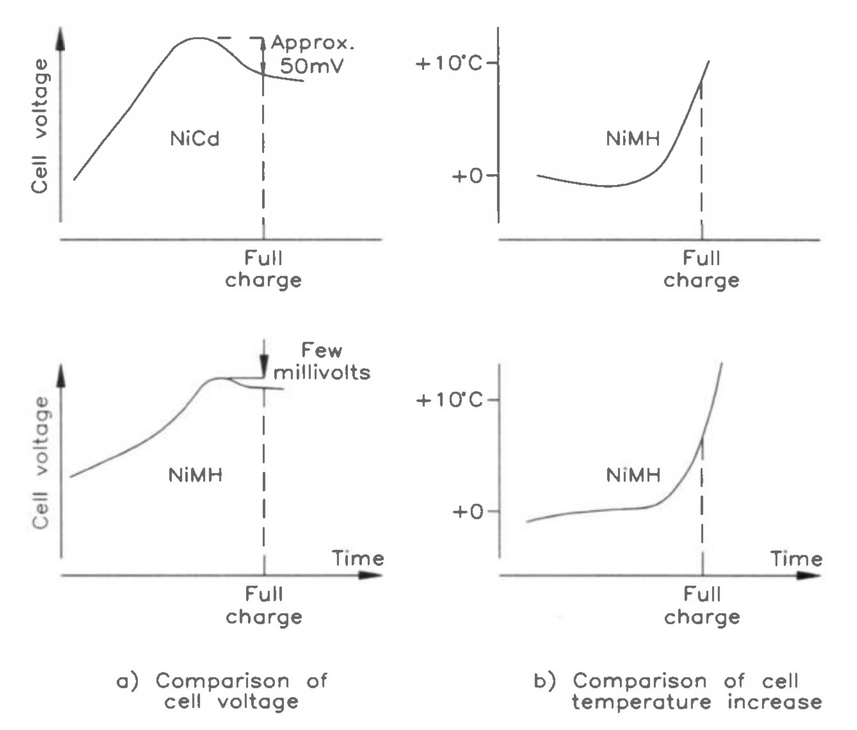


Figure 5. Comparison of end-of-charge characteristics of Ni-Cd and Ni-MH cells.

This could give many problems when a cell pack is being used in a vital application.

To overcome these problems, many battery packs use battery management circuits. These monitor the state of the battery, looking at the amount of charge entering and leaving. In this way, many laptop computers are able to give an indication of the amount of time available before the battery fails, giving sufficient time for the computer to be closed down and programmes saved before it goes dead.

The only problem with these chips is that they and their associated circuitry need to be included as part of the battery itself. This is because the monitor needs to be continually updated about any activity on the battery, and of course this can only be done if it is always connected. In addition to this, much additional data which is learnt about the battery is stored in the circuitry so that a full picture of the battery can be deduced. Data like the amount of charge the battery can hold is one item. This will be a facet of each individual battery and it will change over its life, reducing as it becomes older and requires replacing.

Battery management ICs are also very valuable when charging cells or batteries. They are designed to detect the signs of full charge, so that charging can be stopped at the right time. This is particularly important for Ni-MH cells, where overcharging reduces their capacity very quickly. These ICs detect full charge by monitoring the voltage on the cells. As full charge is reached, the voltage rises, falling again when charging needs to be terminated. This can be detected by the charge monitor IC. Normally, they take several samples to ensure that the voltage is falling and then they terminate the charging cycle. As full charge is not always easy to detect on Ni-MH cells, many monitor chips have the facility for measuring the cell temperature as well. It was found that when the cell was being overcharged, its temperature rose quite quickly, and if this is detected, charging can be stopped in time to prevent any damage.

Battery management ICs fall into one of two categories. The first type control the charging, whilst the second are used for monitoring the state of the battery. As they perform two different functions and they require different monitor points, it is normally found that two separate ICs are used for them.

A number of manufacturers supply battery management chips. This field is seen as a large growth area for the future. As prices for ICs fall and as the number of pieces of equipment using batteries increases, anyone who can capture a large slice of the market will be able to make large profits. Even now, sales of these chips are high. Many laptop computers use them and worldwide, the sales of these chips represent a significant turnover. Many of the manufacturers like Philips, Maxim, and Telefunken are familiar names, but others like Benchmarq are not quite as familiar. However, if sales of these chips grow as predicted, they may well become far more well-known.

Future Developments

Battery technology is receiving vast amounts of development money. The technologies for batteries seem to have stood relatively still for many years. Now with users like portable computers and cellular phones, large returns on small improvements can be seen by manufacturers. As a result, this has given a totally new impetus to the amount of development being undertaken. Not only are more sophisticated battery management and charging systems likely to be available before too long, but also the batteries themselves will see major improvements. The Ni-Cd has reached maturity now, and there are likely to be few developments in this field. However, both Ni-MH and Li-ion cells are likely to see major improvements and become more widely available. It is also likely that more batteries will be sold as battery packs for specific pieces of equipment. These will not only include the battery but also all the associated electronic circuitry for their monitoring and control. No longer will the battery pack be just a piece of plastic containing a set of standard-sized cells available from the local shop. In the future, they are likely to be custom-made for their particular equipment, and capable of giving far superior performance.

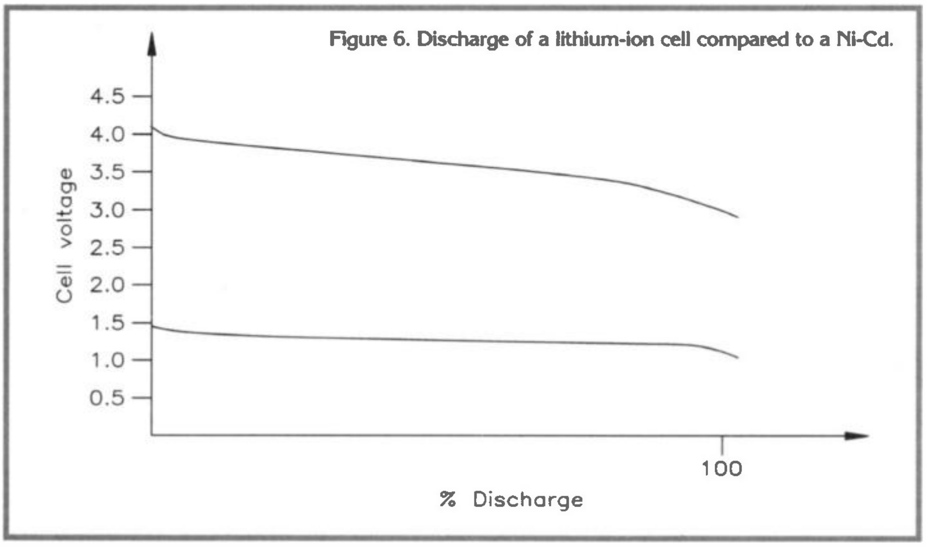


Figure 6. Discharge of a lithium-ion cell compared to a Ni-Cd.

Continued from page 47.

connection is used, the output pulse width equals $0{\cdot}7R_TC_T$, where width is in milliseconds, R_T is the *total* timing resistance, and C_T is the timing capacitance in microfarads. Note that the circuits of Figures 15 and 16 show the normal methods of using the 74121, with external timing resistors and capacitors.

Figure 17 shows the 74121 used as a 30ns pulse generator, using only the IC's internal timing components, with its trigger signal connected to the B (Schmitt) input via a simple transistor buffer stage, and Figure 18 shows it used to make an add-on pulse generator that can be used with an existing square-wave 'trigger' generator, spanning the range 100ns to 100ms in six decade ranges, using both internal and external timing resistors and decade-switched external capacitors.

One type of pulse generator widely used in laboratory work is the delayed-pulse generator, which starts to generate its output pulse at some specified delay time *after* the application of the initial trigger signal. Figure 19(a) shows the waveforms of this type of generator, and Figure 19(b) shows the basic way of making such a generator from two 74121 ICs. Here, the trigger input signal fires IC1, which generates a 'delay' pulse, and as this pulse ends, its inverted (not-Q) output fires IC2, which generates the final (delayed) output pulse.

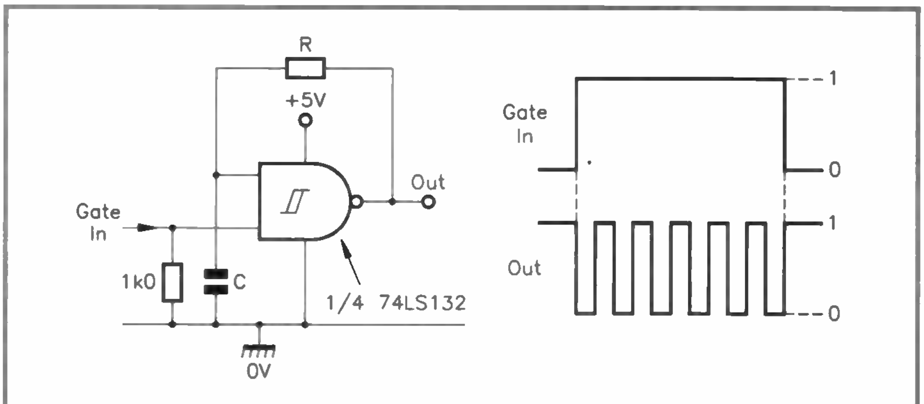


Figure 24. Gated TTL Schmitt astable with logic-1 gate-on and normally high output.

Figure 20 shows how two of the basic Figure 18 circuits can be coupled together to make a practical 'add-on' wide-range delayed-pulse generator in which both the 'delay' and 'output pulse' periods are fully variable from 100ns to 100ms. Note in this circuit, that both fixed amplitude inverted and non-inverted outputs are short-circuit protected by 47Ω series resistors. This circuit's timing periods and CT values are identical to those listed in the table of Figure 18.

Astable Squarewave Generators

In TTL applications, astable squarewave generators must produce clean and stable output waveforms that switch abruptly between normal TTL logic-levels and have very sharp leading and trailing edges; suitable waveforms can be easily generated using standard TTL logic elements or special waveform generator ICs. The easiest and most cost-effective way to make a TTL astable is to use a 74LS14 or similar Schmitt inverter element in the basic circuit of Figure 21, which operates as follows:

Suppose that the voltage across C has just fallen to the Schmitt's lower threshold value of 0·8V, making the Schmitt's output switch to logic-1; under this condition, the Schmitt output is at about +3·2V, so C starts to charge exponentially upwards from 0·8V until it reaches the 1·6V upper threshold value of the Schmitt, at which point the Schmitt's output switches abruptly to a logic-0 value of about 0·14V, and C starts to discharge exponentially downwards from 1·6V until it reaches the 0·8V lower threshold value, at which point, the Schmitt's output switches to logic-1 again, the whole process repeats again, and so on.

This simple Schmitt astable circuit generates a useful but asymmetrical squarewave output; its mark-space ratio is about 1:2 (i.e. it has a 33% duty cycle), and its operating frequency (*f*) approximately equals 680/(CR), where C is in μF, R (which can have any value in the 100Ω to 1k2Ω range) is in ohms, and *f* is in kHz; thus, C and R values of 100nF and 1kΩ give an operating frequency of about 6·8kHz, etc. Note that the operating frequency has a slight positive temperature coefficient, and has a supply voltage coefficient of about +0·5%/100mV. The circuit can, in theory, operate at frequencies ranging from below 1Hz (C = 1,000μF) to above 10MHz (C = 50pF), but in practice, is best limited to the approximate frequency range 400Hz to 2MHz, because the need for large C values makes it uneconomic at low frequencies, and it has poor stability at high frequencies.

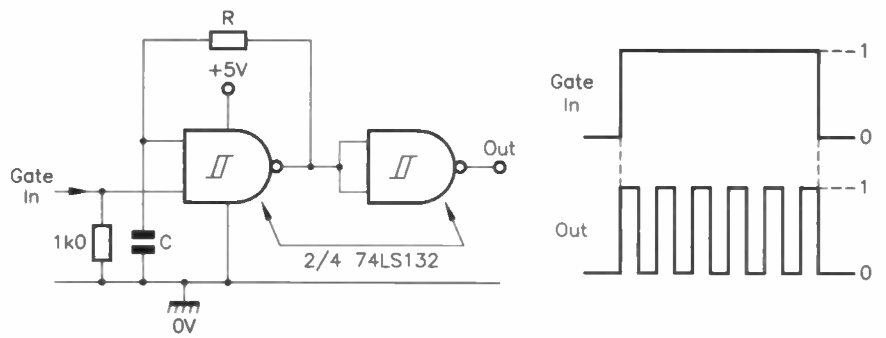


Figure 25. Gated TTL Schmitt astable with logic-1 gate-on and normally low output.

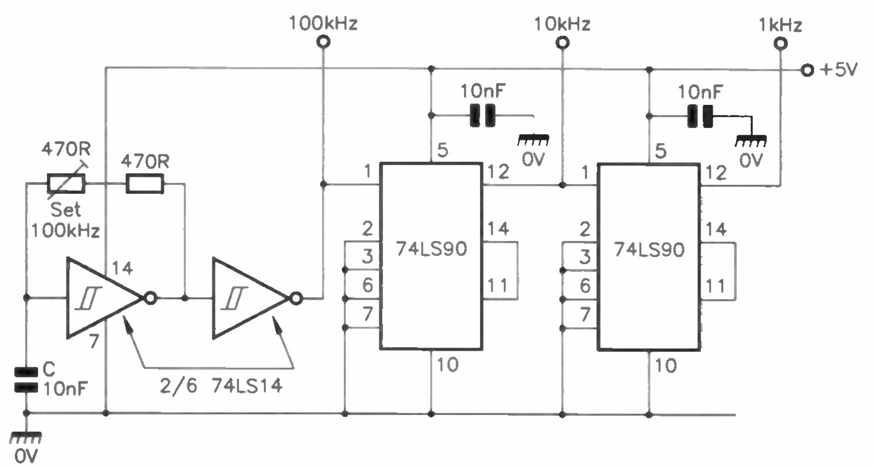


Figure 26. This expanded 100kHz TTL Schmitt astable circuit gives 10kHz and 1kHz outputs.

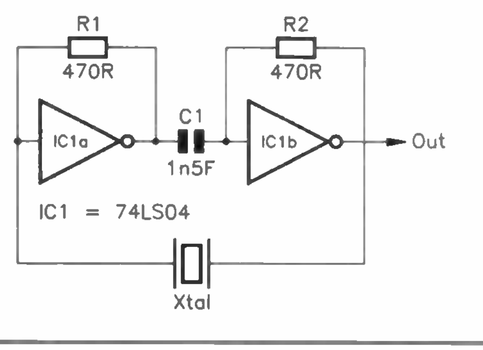


Figure 27. TTL crystal oscillator, for use with series-resonant crystals.

The basic Schmitt astable circuit can be usefully modified in a variety of ways. The operating frequency can, for example, be made variable by using a fixed 100Ω and variable 1kΩ resistor in the R position, and the output waveform can be improved by feeding it through a Schmitt buffer stage, as shown in Figure 22. If perfect waveform symmetry is needed, it can be obtained by feeding the output of a buffered Schmitt astable through a J-K flip-flop, as shown in Figure 23, but note that the final output frequency is half of that of the astable. The basic circuit can be converted into a gated Schmitt astable by using a 74LS132 2-input Schmitt NAND gate as its basic element, as shown in Figure 24; this particular circuit is gated on by a logic-1 input and has a normally high (logic-1) output; it can be made to give a normally low (logic-0) output by feeding the output through a spare 74LS132 element connected as a simple Schmitt inverter, as shown in Figure 25.

The main drawback of the TTL Schmitt astable is that its low maximum value of timing resistor (1k2Ω) makes it necessary to use large and often very costly C values at low operating frequencies. Suppose, for example, that a design calls for the use of a 1% polystyrene capacitor, to give an adequate degree of precision and thermal stability. The largest readily available 'decade' size of these is 10nF, and they cost about 40% more than a single 74LS14 IC and in a Schmitt astable using a 1kΩ timing resistor, gives an operating frequency of about 68kHz. Thus, if you need a 1kHz output, you could wire 68 of these capacitors in parallel, to make a Schmitt astable that has a total 'components' cost 96 times greater than that of a single 74LS14 IC. One sensible alternative is to use a single 10nF capacitor to make a precision 100kHz astable, and then divide its output frequency by 100 by using two decade counter ICs, as shown in the circuit of Figure 26, which provides outputs of 100kHz, 10kHz, and 1kHz, and has a total component cost only 9 times greater than a single 74LS14 IC.

Finally, Figure 27 shows how two simple 74LS04 or similar TTL inverter elements can be used as the basis of a crystal oscillator by biasing them into their linear modes via 470Ω feedback resistors and then AC coupling them in series via C1, to give zero overall phase shift; the circuit is then made to oscillate by wiring the crystal (which must be a series-resonant type) between the output and input as shown. This circuit can operate from a few hundred kHz to above 10 MHz. Next month, Part 8 will look at modern clocked flip-flop and counter circuits. E

2 PROJECT RATING

KIT AVAILABLE (95035) PRICE £14.99

DIGITAL ALARM CLOCK

FEATURES

- ★ LED display ★ Battery back-up
- ★ Sleep facility ★ Musical alarm
- ★ 50Hz or 60Hz operation
- ★ AM/PM, alarm/relay indicators
- ★ Selectable 12/24-hour clock
- ★ Loudspeaker/relay outputs
- ★ Hour/minute or minute/seconds display modes

The completed Digital Alarm Clock in the recommended optional case.

APPLICATIONS

- ★ Alarm clock
- ★ Switching control timer

Text by Maurice Hunt

Specification

Operating voltage:	230V AC 50Hz/60Hz, into 6-0-6V 250mA transformer
Operating current:	20mA rms
Display type:	LED, 4 × 15mm (0·6in.) high digits
Loudspeaker:	8Ω impedance
Relay output:	6V DC 50 to 100mA relay
Overload protection:	50mA Quick-blow fuse and 3A fuse in mains plug
Main PCB dimensions:	92 × 83mm
Display PCB dimensions:	92 × 26mm

IMPORTANT! MAINS SAFETY WARNING

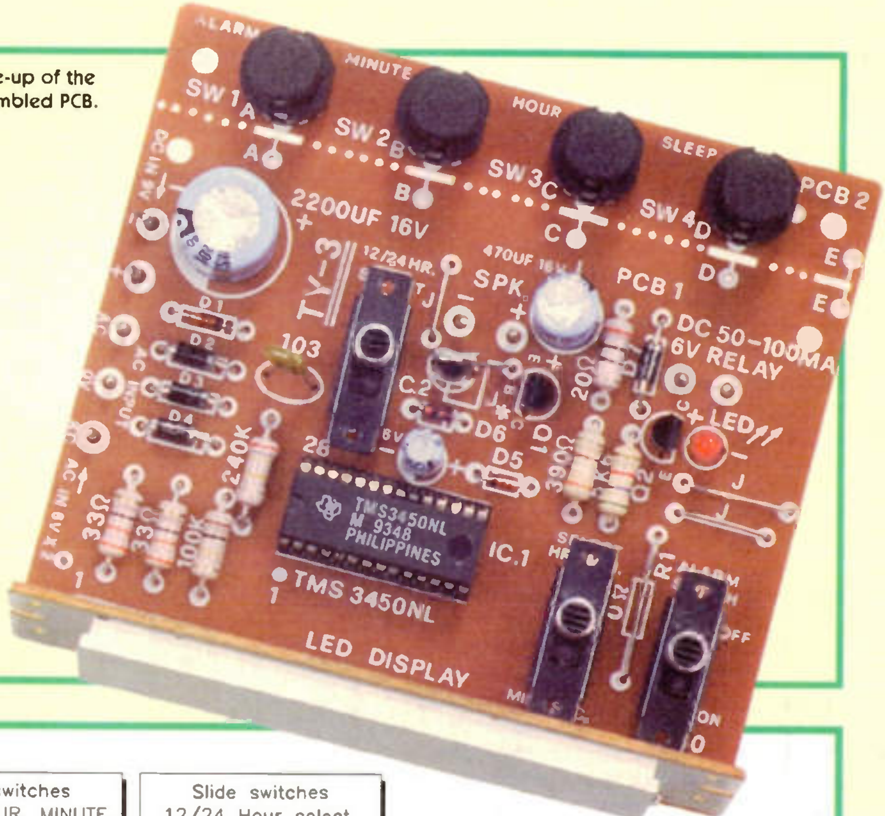
It is important to note that mains voltage is potentially lethal. Full details of mains wiring connections are shown in this article, and every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit, which should never be operated with the box lid removed. Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article. If you are in any doubt as to the correct way to proceed, consult a suitably qualified engineer. Note that the specified casing is not waterproof, so do not use the unit in a bathroom or kitchen.

At last, here's a versatile and easy to build mains-powered digital alarm clock kit, which offers some useful additional features beyond the normal timekeeping and alarm functions of an 'off-the-shelf' digital clock, lending it numerous applications in timer switch-controlled projects as well as providing the basis for a well-specified bedside alarm clock. This version is capable of providing either a musical alarm, or driving a relay output, which in turn, can switch on all manner of appliances at the set time – such as a radio/cassette player, lamp, motor, etc.

THIS clock can show the time in 12- or 24-hour format, with a display of hours and minutes, or minutes and seconds, from its 4-digit LED display, which also indicates AM/PM (on 12-hour mode), and alarm on settings, plus there is a separate LED to indicate when the output relay is energised. A 'sleep' facility is also provided, and built-in battery back-up maintains the correct time in the event of a mains failure, should there be a power cut or if someone accidentally pulls the plug out while doing the hoovering!

Circuit Description

Refer to Figures 1 and 2, showing the block and circuit diagrams, respectively. The circuit is based around the Texas Instruments TMS3450NL (IC1), a large-scale integration (LSI) device which contains all that is needed to implement the clock and alarm functions, and to drive the 4-digit LED display, which requires very few external components to produce a basic clock.



Close-up of the assembled PCB.

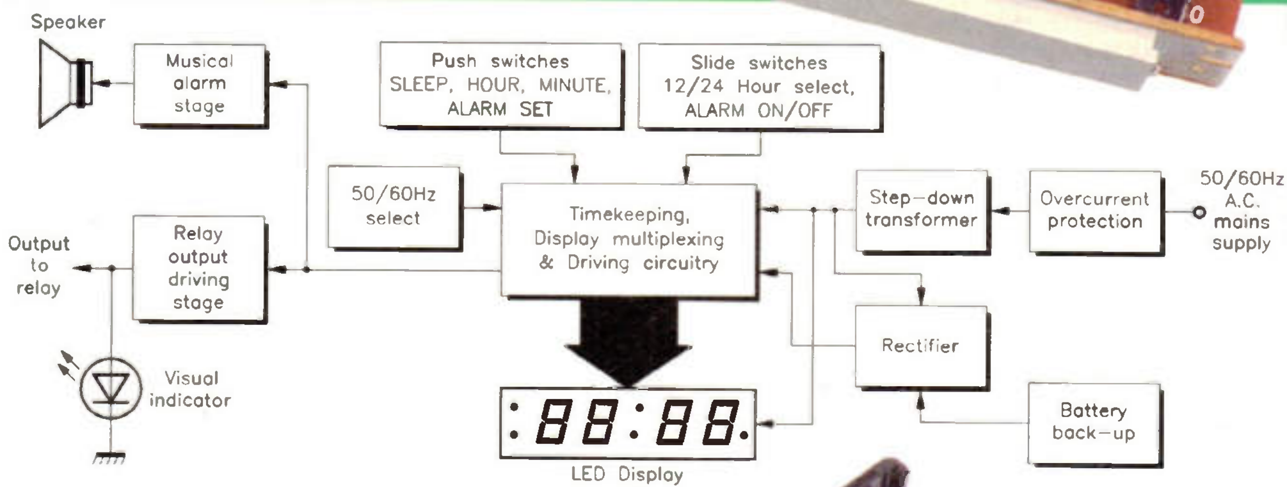
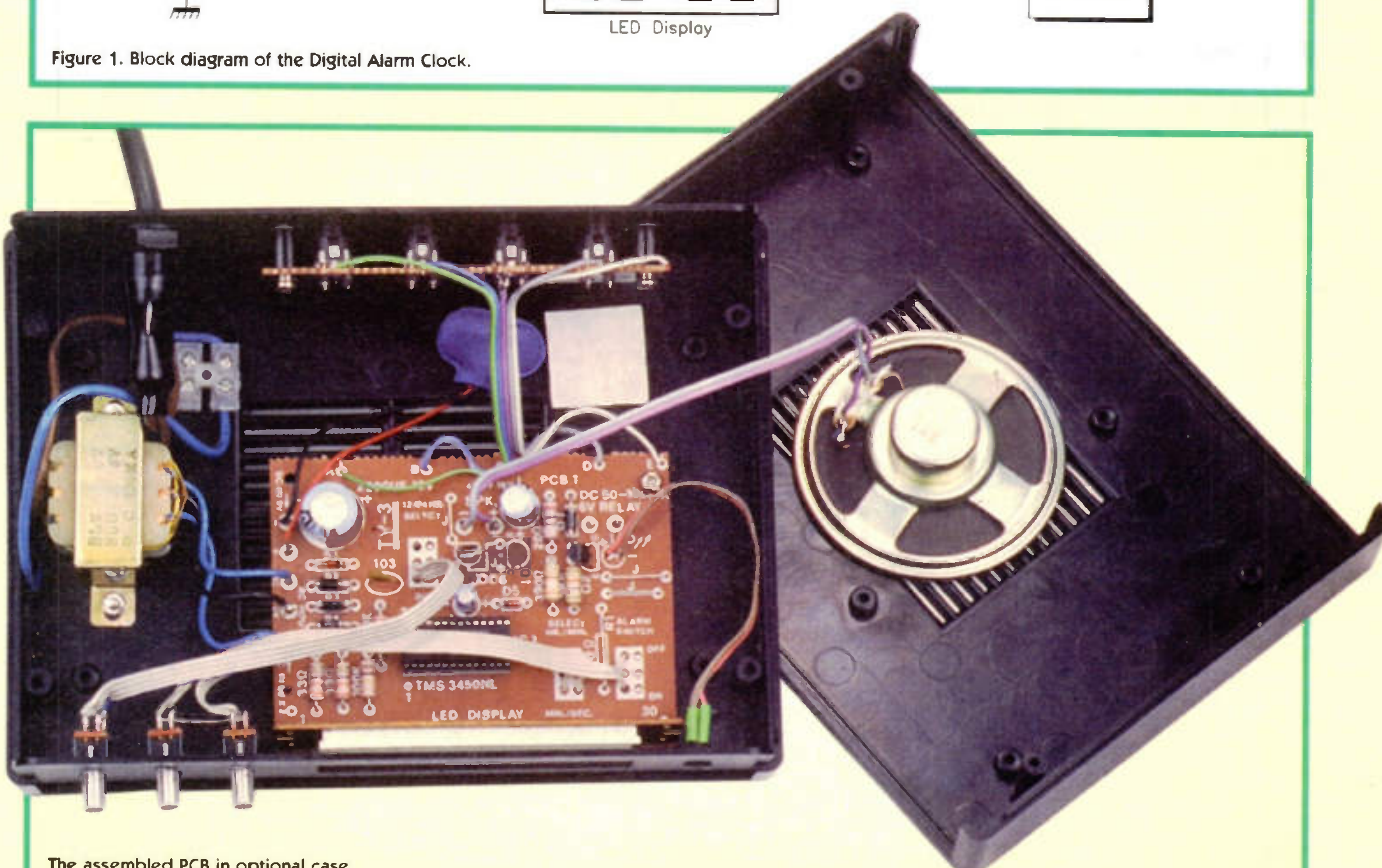


Figure 1. Block diagram of the Digital Alarm Clock.


The assembled PCB in optional case.

For time regulation, the accurate 50Hz (UK) or 60Hz (Continental) frequency of the AC mains supply is utilised, as appropriate; this is fed into pin 25 of IC1, after having been reduced to 6V rms by the step-down transformer, and then rectified and filtered to supply the rest of the circuit. One half of the transformer's 6V rms output is connected to the LED display common terminal, to provide a display multiplexing action; the display numeric segments are driven by IC1, which controls the multiplexing. During a mains power failure, a 9V back-up battery (not included) is used to maintain the timekeeping circuitry, although the display is extinguished to save on battery power. Advanced low-power operation ensures that the back-up battery lasts for much longer than is the case with other designs of LED-display digital clocks.

The chime alarm output of the clock appears at pin 16 of IC1. This is a rising-edge output, which turns on transistor Q1. The turn-on voltage is clamped to 3·9V maximum by the inclusion of the Zener diode, D6. The transistor is connected as an emitter-follower, and drives IC2, a musical sound generator chip. The alarm output from pin 16 of IC1 is also used to activate the external relay, driven via Q2, which also lights the relay activated indicator, LED1. Alternatively, if the timeout function is programmed into IC1, a rising-edge output signal from pin 17 activates Q2, which causes the relay to be de-energized. Diode D7 across the relay coil prevents damage to Q2 that would otherwise be caused by back emf induced in the coil. If a SPDT type relay is used, the contacts can be used to control any appliance whose power rating does not exceed that of the relay contacts – this would include most low-power mains operated devices found in the home.

PCB Construction

A soldering iron of no higher than 40W rating and fitted with a small bit will be required, since some relatively close-clearance soldering is needed. It is advisable to read through the instructions before starting the assembly process, so that you are familiar with each step.

First, select whether the clock is to be for 50Hz or 60Hz AC mains operation; there is a circular-shaped split copper pad on the underside of the PCB marked by an asterisk, (*), which should be bridged with a blob of solder if the clock is for 50Hz (UK mains) operation, and left unbridged if the clock is to run on a 60Hz supply (continental mains). Assemble the board in order of ascending component size, from smallest to largest, commencing with the wire links. Do not insert the link in the position marked (J*), located between IC2 and Q1, at this stage. Note that it is recommended that a wire link is fitted into the position marked 'LED' on the board, since the LED should preferably be connected instead in parallel to the relay coil, to avoid the LED being overloaded by the switching of the relay. A 1kΩ current-limiting resistor should be connected in series with the LED, as indicated in the circuit diagram of Figure 2.

Fit the diodes, ensuring their correct orientation and taking care to correctly differentiate between the 1N4148 signal diodes (D1 and D5) and the Zener diode D6, since these components all have glass

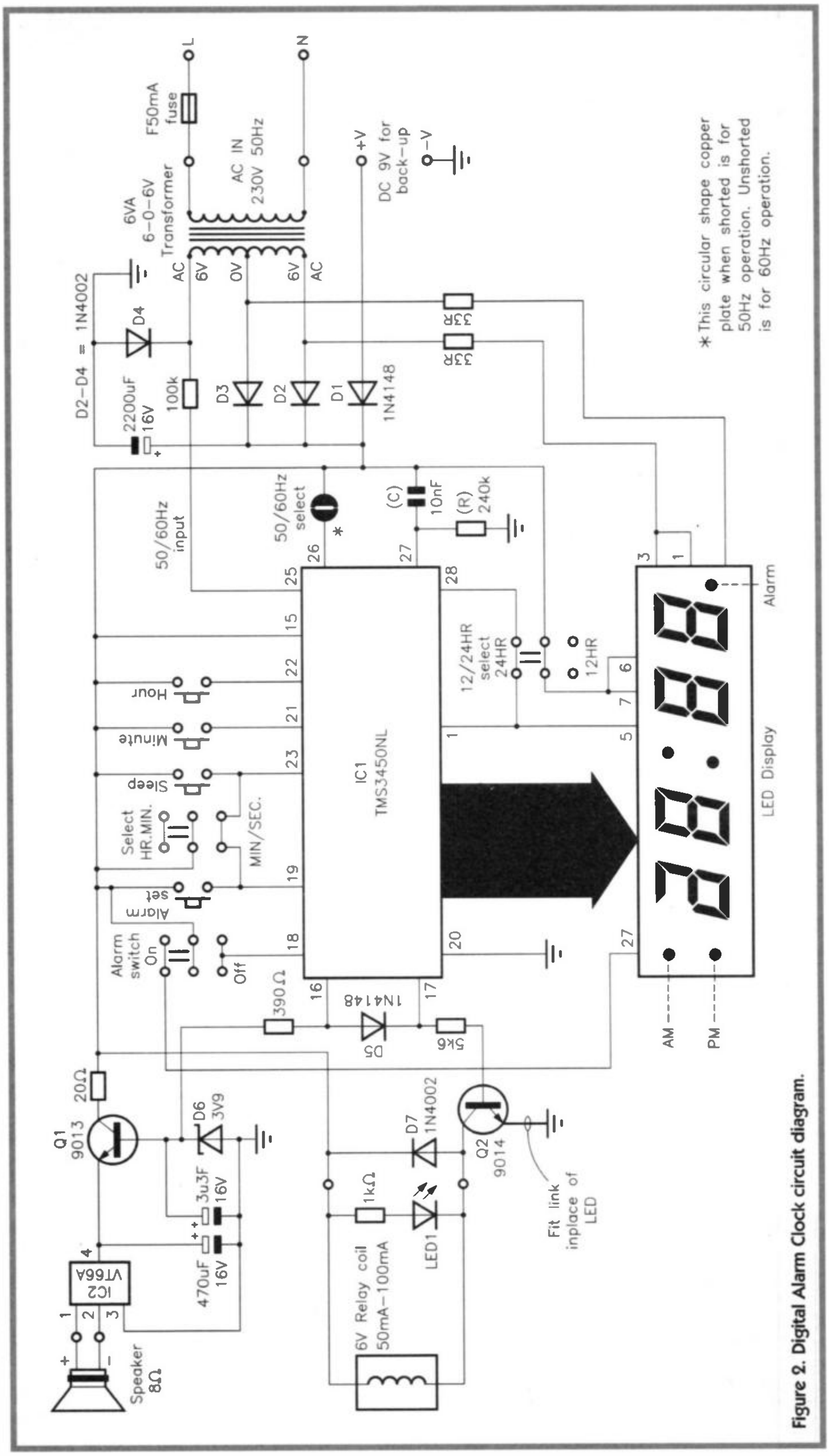
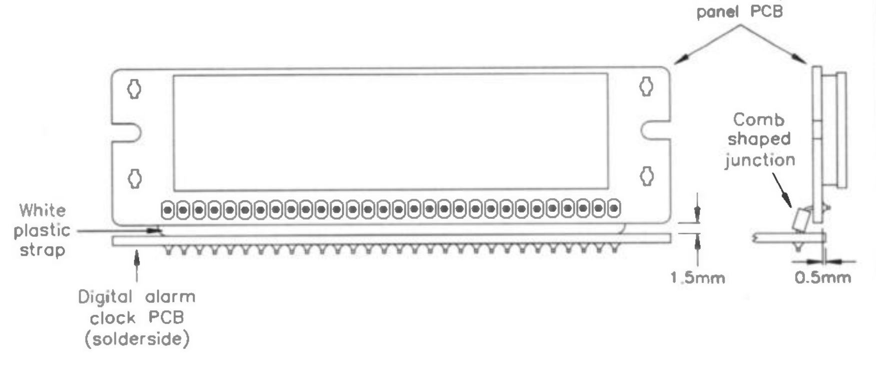


Figure 2. Digital Alarm Clock circuit diagram.

Figure 3. PCB assembly.



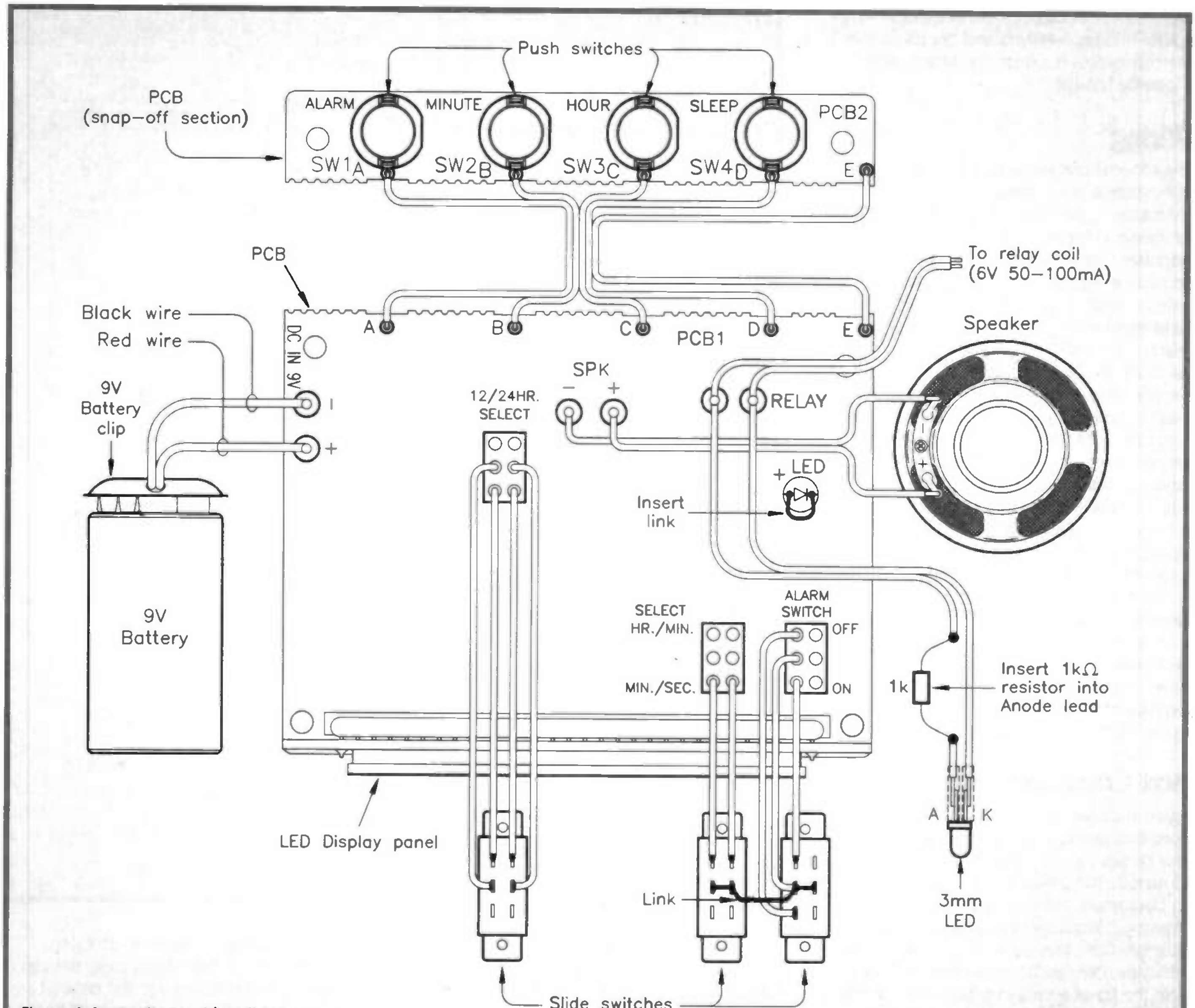
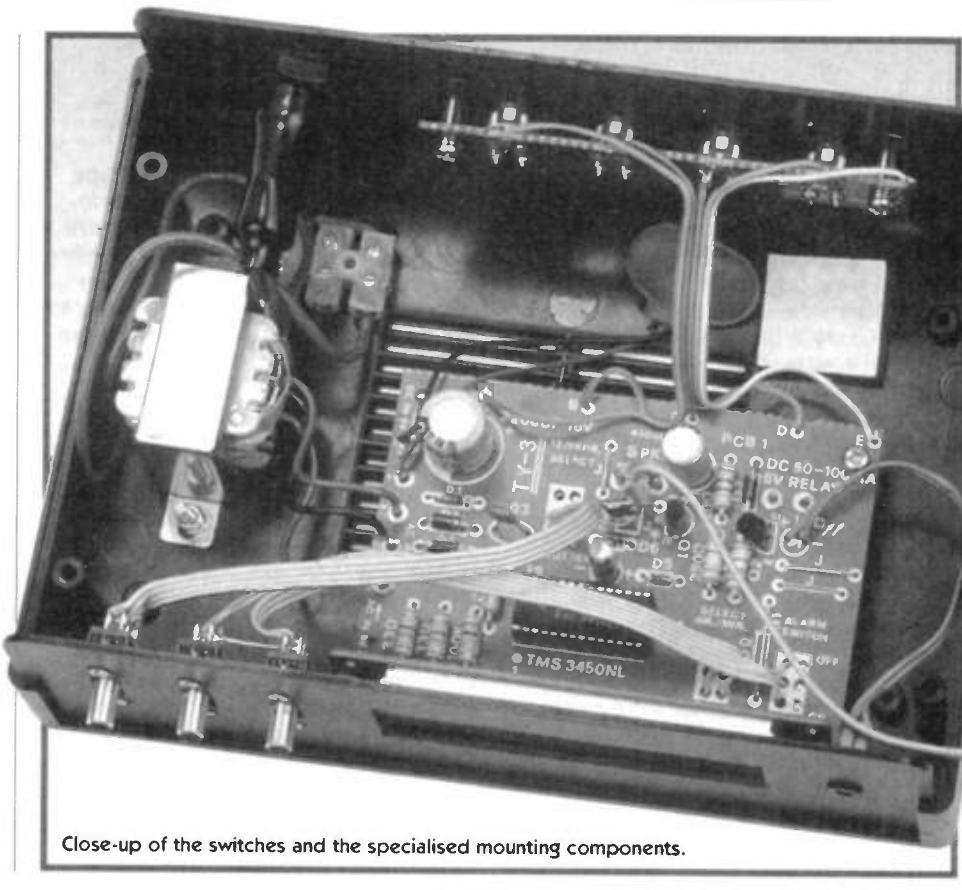


Figure 4. Low voltage wiring diagram.

cases and look very similar – the Zener diode will have different markings. The large body diodes, D2 to 4 and D7 have black plastic bodies, and are marked 1N400X. In all cases, the end marked with a black or silver band is the cathode (negative) terminal.

Next install the resistors, capacitors (ensuring electrolytics are fitted the correct way round), transistors (marked C9013 or C9014) and IC2 (which looks like a transistor, but has a metal tag on top – the jumper (J*) is attached to this, the other end of which goes into the hole marked on the board), and the switches. Note that the push-buttons are located on a snap-off section of the PCB, to allow remote mounting of the switches at a convenient location in the box. If this option is required (such as for installation in the recommended housing), wire links or 5-way ribbon cable (depending on how remote you want the switches to be) will be needed to join the PCB sections, at the points marked A to E on the legend.

The display panel is fitted to the board next, which involves soldering in the 30-way 'comb' connector as shown in Figure 3. A 28-pin IC holder (supplied) should be used for IC1 (ensure correct orientation of the notch), and the chip itself should be plugged into the socket last of all, taking suitable antistatic precautions. Having completed the board assembly, check your



Close-up of the switches and the specialised mounting components.

work for erroneous component placement, solder bridges, whiskers and dry joints, then remove excess flux from the board using a suitable solvent.

Wiring

The external components – transformer (low voltage side), relay, loudspeaker and 9V battery – are connected to the board as shown in Figure 4. Figure 5 shows the necessary mains wiring for the clock, which should be adhered to in order to ensure safety – refer to the safety warning at the beginning of this article. Use the appropriate mains-rated cable for all mains wiring, but the switches, loudspeaker, relay coil and LED can be connected using either ribbon cable (the neatest option) or general hook-up cable. Keep the cable lengths to a minimum, and restrain any loose cabling, particularly in the region of the mains terminals, using cable ties. Strain relief grommets should be used where the cables exit the housing, to prevent damage caused by chafing, and to avoid wires from being pulled loose.

The choice of relay will depend on the device(s) that you wish the clock to control – i.e. select a relay with a switch contact current rating appropriate to the load. Whichever type of relay is used, however, the relay coil must be rated at 6V and 50 to 100mA for successful operation.

Box Construction

Figure 6 shows the drilling details for the specified (optional) box. The front and rear panels can be detached from the box to simplify the drilling. Use suitable drill bits to countersink the holes indicated in the drawings, and to get the (metal) screws to sit totally flush, place the respective screws into their holes and carefully heat their heads with the tip of a soldering iron whilst evenly applying gentle force for a few seconds, until the screws sink to the required depth into the casing. Do this in a well-ventilated environment, and take care not to overdo it!

Having drilled and filed the holes (and checked to ensure that they allow the switches to operate smoothly), chamfer off any burrs. Refer to Figure 7, showing the exploded assembly of the clock. Cut the terminal block down to a 3-way item, and fit it inside the base of the box in the area indicated in the diagram – it is held in place by 2 × 10mm M3 countersunk nylon bolts and nuts (do NOT use metal versions here). Attach the three slide switches to the front panel (6 × M2·5 6mm countersunk screws), and the PCB containing the four push-switches to the rear panel (2 × M3 6mm countersunk screws) BEFORE applying the labels. Wipe the panels clean and apply the front and rear panel labels, shown in Figure 8. Use a pointed instrument and scalpel to cut away excess label material from the region of the holes. Also, apply the small mains connections label (showing live (L) and neutral (N) terminations) adjacent to the terminal block within the casing. Next, fit the LED clip to the front panel, and the strain relief grommet (containing the mains cable) and fuseholder to the rear panel. If a relay is being installed, an additional grommet will be needed for the output cables.

Once the wiring in of the switches, fuseholder (remember to use the rubber insulating boot to cover the terminals) and mains cabling has been done in accordance with the wiring diagram, slide the front and rear panels into their slots in the box, taking care not to crease the labels. Note that the mains wires should be kept as short as possible, so that in the event of a wire coming loose from the terminal block, it will not come into contact with the PCB, switches or transformer. The loudspeaker should be glued to the centre of the underside of the box lid, using instant type (cyanoacrylate) adhesive. Take care not to get glue onto the speaker cone, but ensure that enough glue is used to hold the speaker securely in place. The speaker connecting wires should be long enough to allow the lid to be separated a reasonable distance from the box, to allow access for future battery replacement, etc.

The relay, if small enough (e.g., microminiature relay FM89W), may be attached directly onto the PCB pins on the Digital Clock PCB, but if a larger relay is required (and as an absolute necessity if it is to switch mains voltages) it should be mounted off the board, preferably on a separate PCB or Veroboard, and situated well away from the clock's mains supply wiring. The specified casing allows room to the rear right-hand side of the enclosure for a typical 6V relay with mains-rated contacts. Wiring to the relay contacts should be of a rating appropriate to the output load being controlled, and a grommet should be used where the wiring enters the box. An extra terminal block could be mounted adjacent to the relay, to provide a convenient and easily alterable method of attaching wiring to the relay contacts.

Fit a 9V Alkaline PP3 battery onto the clip connector, and secure it into the base of the box using a Velcro mounting pad or similar, in the position indicated in the diagram. Finally, fit the lid onto the box (again being careful not to damage the labels), and secure it with the four self-tapping screws supplied. This completes the assembly of the digital clock.

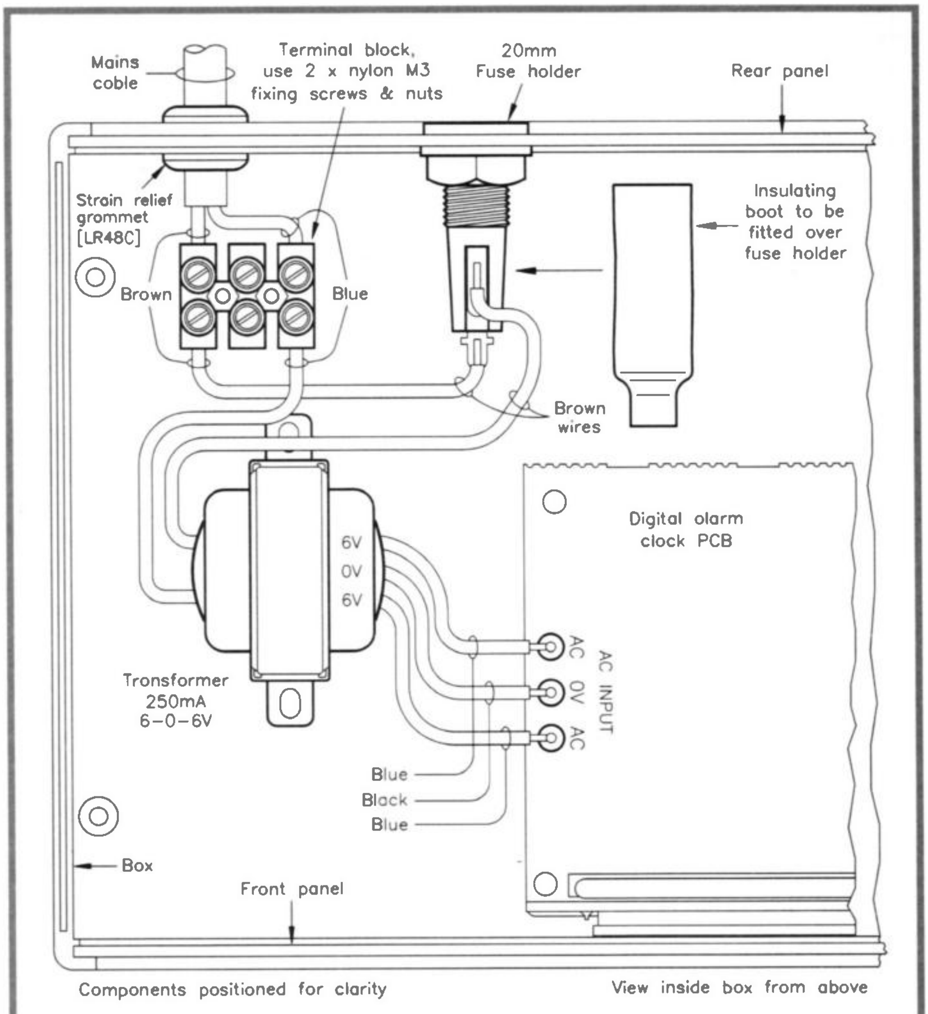


Figure 5. Mains wiring.

Testing and Use

Having installed the completed unit into a suitable housing, install a 20mm 50mA Quick-blow fuse into the fuseholder, fit a plug containing a fuse of the appropriate rating (3A) onto the mains lead, plug it in and switch on. All being well, you should be greeted with the display flashing '12:00' or '0:00', depending on whether 12- or 24-hour mode is selected. Set the correct time as described below, and leave the clock switched on for a sufficient duration for the accuracy to be monitored.

Refer to Table 1 for a summary of clock function and setting details. A more detailed description of how to operate the clock is given below.

For a normal hour and minutes display, the SELECT switch should be placed in the HR./MIN. position. To set the time, simply press the HOUR and MINUTE buttons (or hold them down) as appropriate until the display shows the correct time (pressing both at once increments both hour and minute). Set the display to show 12- or 24-hour clock as required, by means of the

Figure 6. Box drilling details.

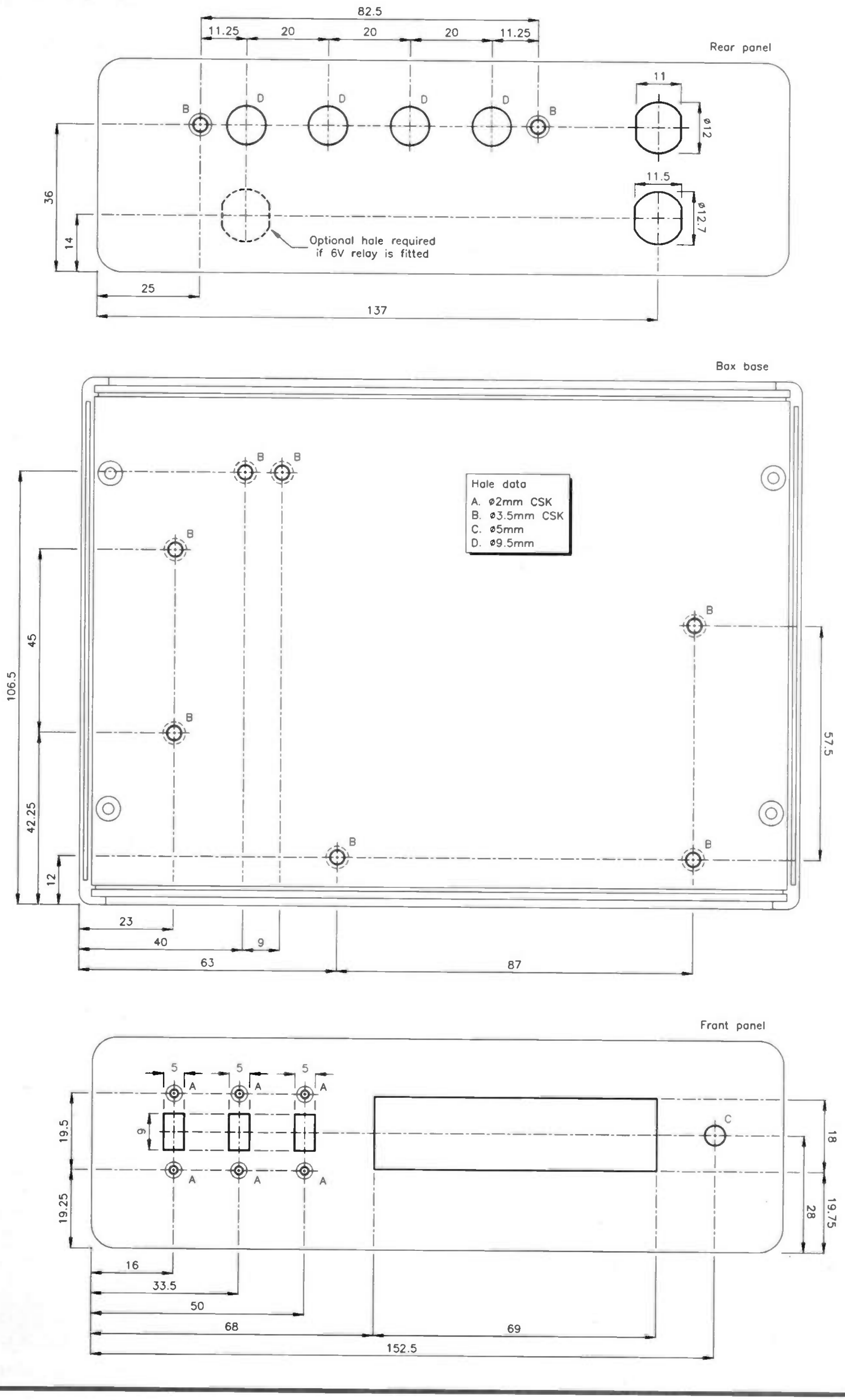
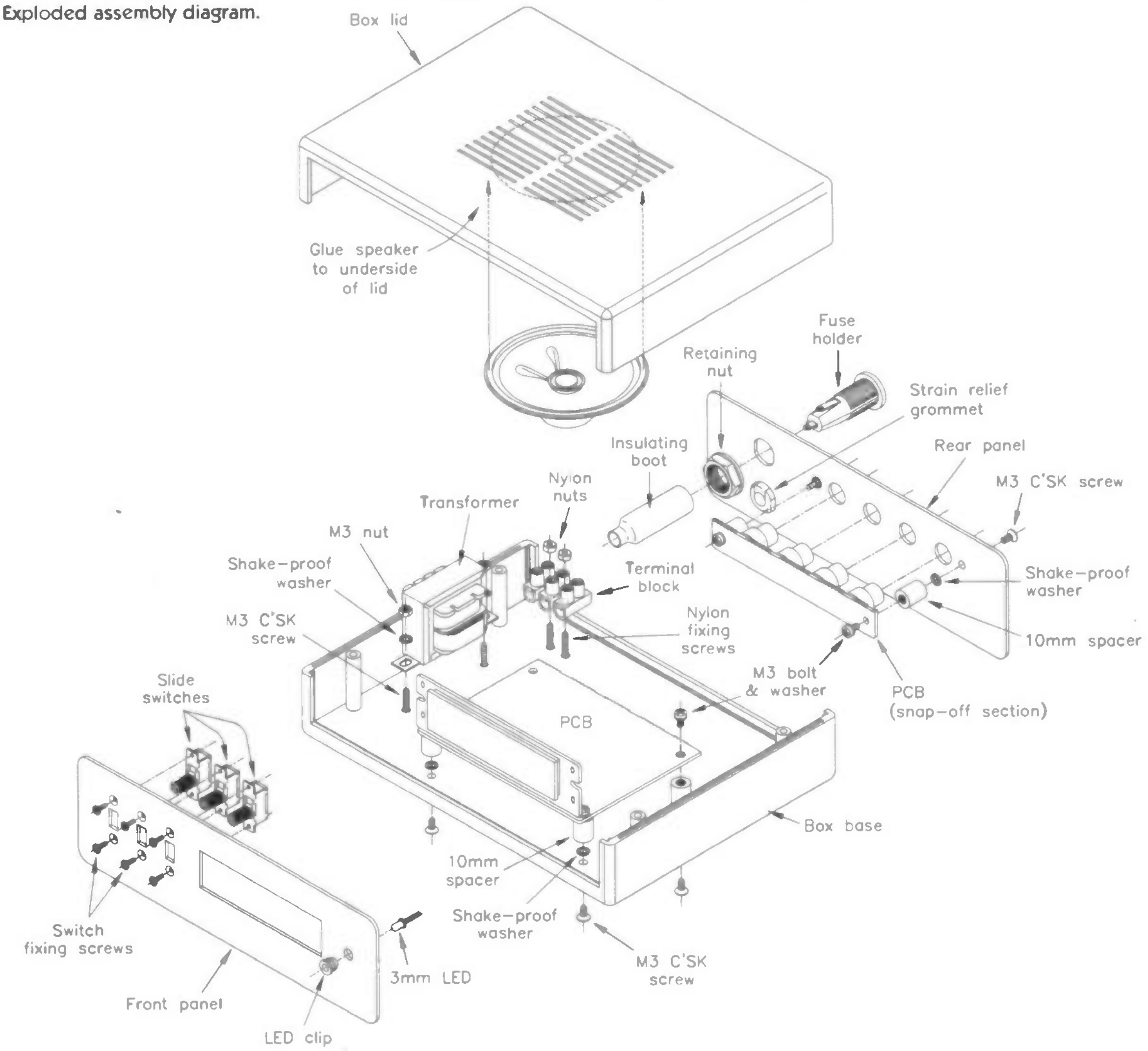


Figure 7. Exploded assembly diagram.



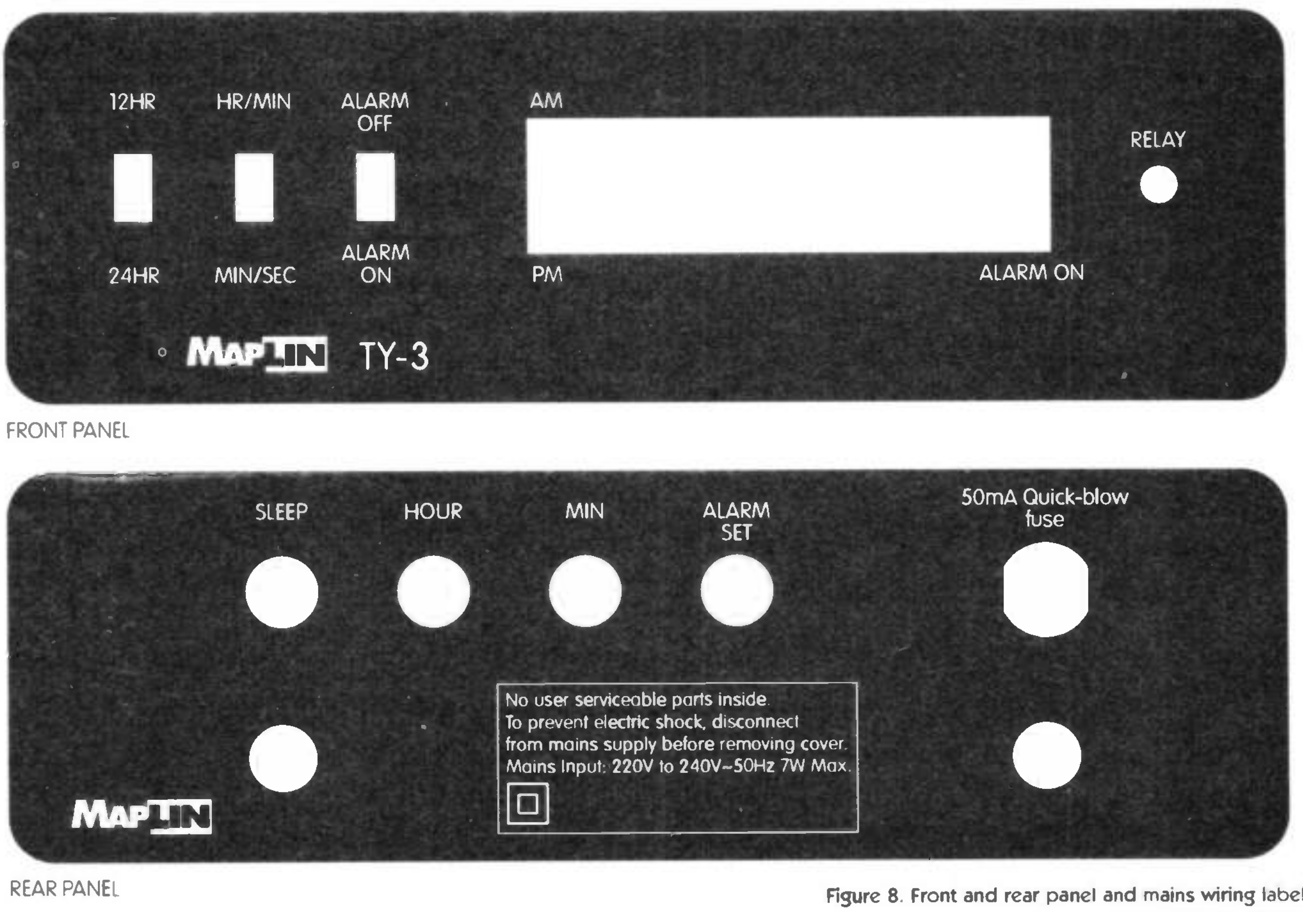


Figure 8. Front and rear panel and mains wiring labels.

Slide switches:

SELECT – selects either hour and minute (HR/MIN) or minute and seconds (MIN/SEC) displays.
12/24HR SELECT – selects 12- or 24-hour clock mode. Also applies to alarm time display.
ALARM – switches the alarm on and off, with display indicator to confirm alarm is on.

Push switches:

ALARM – displays the alarm time when pushed.
HOUR – increments the hour, manual or automatic (with button held in) setting.
MINUTE – increments the minute, manual or automatic (with button held in) setting.
SLEEP – turns the relay output on for the displayed period, adjustable from 0 (off) to 1 hour, 59 minutes.

Time setting:

Press HOUR and MINUTE buttons as appropriate until correct time is displayed, with AM/PM indication on 12-hour mode.

Alarm time setting:

Press and hold in the ALARM button whilst using HOUR and MINUTE buttons to adjust to the required alarm time. Ensure that the alarm is switched on by means of the ALARM slide switch.

Table 1. Clock function and setting details.

slide switch marked 12/24HR. SELECT. Note that with the 12-hour clock, AM (uppermost) or PM (lower) is indicated in the left of the display – adjust the hour setting so that the correct AM/PM indicator is lit.

Note that the colon will flash every second to indicate that the clock is running. Should you wish to see a display of the seconds, slide the SELECT switch to the MIN./SEC. position – the display will then show the unit of the minute (i.e., if it is 11:58, then '8' will be displayed), the flashing colon, and the seconds.

To set the alarm, hold the ALARM button down, and press the HOUR and MINUTE buttons (or hold them down) as appropriate until the required alarm time is set (ensuring the appropriate AM or PM indicator is lit if in 12-hour mode). Note that pressing both HOUR and MINUTE buttons simultaneously resets the alarm time to 0:00 hours (12:00am). The ALARM SWITCH should be put in the ON position, whereupon the alarm indicator will appear in the bottom right-hand corner of the display. At the set alarm time, the musical alarm will be activated, together with the relay, if fitted (which will emit an audible click), and the relay activated indicator LED (LED1) will light up. To switch the alarm (sounder, relay and LED) off once activated, slide the ALARM SWITCH to its OFF position.

The SLEEP button also controls the relay output; it can be used to activate the relay for a preset duration, which commences the moment that the SLEEP button is pressed. This is achieved by holding the SLEEP button down (which defaults the duration to 59 minutes), then pressing the HOUR and MINUTE buttons (or holding them down) until the required duration is set – the range is from 0 (deactivating the relay) to 1 hour and 59 minutes. Note that in this mode, pressing the HOUR button increments the hour, whilst pressing the MINUTE button decrements the minutes. The relay will then be activated for the time displayed, and will automatically de-energize once the time is up – the LED will also be extinguished.

To test the battery back-up facility, install a fresh 9V Alkaline PP3 battery, set the correct time and then switch off the mains supply to the clock for a while, during which, the display will be extinguished. Switch the mains supply back on, and the correct time should once again be indicated – the alarm time setting should also be retained. Note that the battery will require periodic replacement (which depends on how often and for how long the mains supply is interrupted), and that an alkaline type is recommended for long life and leak resistance. On average, the battery life should be at least a year.

The clock must not be used in situations where there is the possibility of moisture ingress into the casing, such as in bathroom or kitchen areas, next to washbasins, etc.

DIGITAL ALARM CLOCK PARTS LIST

RESISTORS: All 5% 0·5W	
20Ω	1
33Ω	2
390Ω	1
5k6	1
100k	1
240k	1
CAPACITORS	
10nF	1
3μ3F 16V	1
470μF 16V	1
2,200μF 16V	1
SEMICONDUCTORS	
9013C or 9014C	2
1N4002	4
1N4148	2
3V9 500mW Zener	1
TMS3450NL	1
VT66A Melody IC	1
3mm Red LED	1
MISCELLANEOUS	
28-pin IC Socket	1
1·6mm PCB Pin	9
DPDT Slide Switch	3
Push Switch	4
30-way Comb Connector	1
4-digit LED Display	1
Battery Clip	1
PCB	1

OPTIONAL (Not in Kit)		
Plastic Instrument Case	1	(KC61R)
9V PP3 Alkaline Battery	1	(JY49D)
Black Moulded Mains Plug and Lead	1	(CY32K)
6-0-6V 6VA Transformer	1	(WB00A)
Loudspeaker	1	(WB13P)
Terminal Block 2A	1	(FE78K)
Strain Relief Grommet Type 5R2	1	(LR48C)
Grommet	1	(JX65V)
20mm Flush-fitting Fuseholder	1	(KU33L)
20mm 50mA Quick-blow Fuse	1	(WR93R)
Fuseholder Insulating Boot	1	(FT35Q)
Large Stick-on Feet	1 Pkt	(FW38R)
10-way Ribbon Cable	1m	(XR06G)
PP3 Battery Clip	1	(HF28F)
3mm LED Clip	1	(YY39N)
M3 × 10mm Insulated Spacer	2 Pkt	(FS36P)
M3 × 6mm Countersunk-head Screw	1 Pkt	(BF36P)
M3 × 10mm Countersunk-head Screw	1 Pkt	(LR57M)
M3 × 12mm Nylon Countersunk-head Bolt	1 Pkt	(JX79L)
M3 Nylon Nut	1 Pkt	(JX80B)
M3 Steel Nut	1 Pkt	(BF58N)
M3 Shakeproof Washer	1 Pkt	(BF44X)
M2·5 × 6mm Countersunk-head Screw	1 Pkt	(BF39N)
25mm Velcro Mount	1 Pkt	(FE45Y)
Cable Tie	5	(BF91Y)

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 95035 (Digital Alarm Clock) Price £14.99

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

NEWS Report

Op Amp with 2·7V Micropower Rail-to-rail I/O Performance

A single-channel operational amplifier from National Semiconductor sets a new industry high for its rail-to-rail I/O performance. The new device, known as the LMC7111, offers 2·7, 3, 5 and 10V performance in a TinyPak SOT-23 housing, making it ideal for battery-powered systems such as mobile communications, laptop PCs, and portable and handheld instrumentation.

Rail-to-rail output voltage is specified with 10kΩ to 100kΩ loads. With a 100kΩ load, the output swings to within 10mV of either rail. Voltage gain for the device is rated at a typical 104dB over temperature. A low input current of 20pA and low offset voltage optimise 3V performance – a key advantage in high-source impedance applications. The LMC7111 is specified to operate over the industrial temperature range and is offered in 8-pin DIP as well as the TinyPak package.

For a data sheet and user information on the LMC7111, contact the National Semiconductor European Customer Response Group.

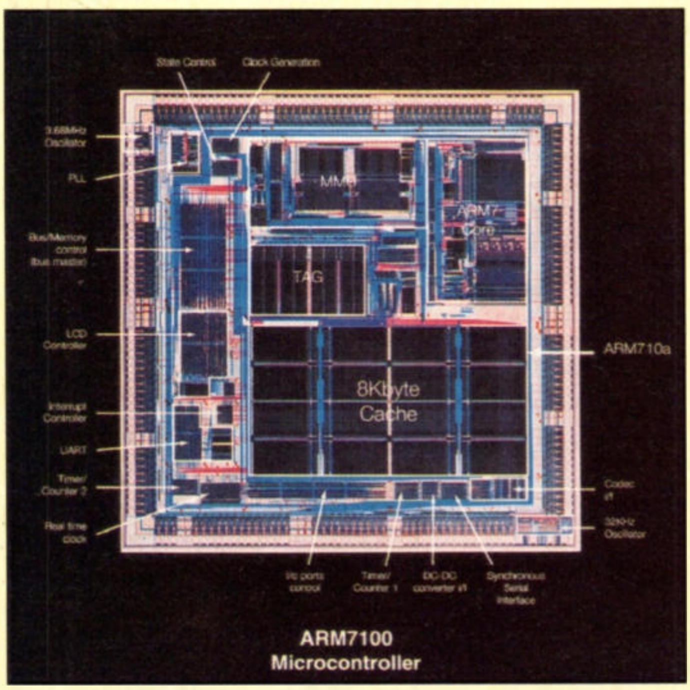
Contact: National Semiconductor, Tel: (+49) 1805 32 7832.

ARM Aims ARM7100 Microcontroller at Personal Electronics

This month sees the announcement of another device from Advanced RISC Machines' (ARM) Cambridge design stable. The ARM7100 contains all the functionality system designers need for PDAs and mobile communications products in a low-cost, low-power consumption, yet powerful, single chip solution.

Built around the ARM710 microprocessor, the device integrates all the complex peripherals that make other solutions expensive. Peripherals include: a LCD driver, direct DRAM interface, PLL clock multiplier, serial ports, Infra-Red IrDA SIR protocol support, timers, codec interface and Real Time Clock. The ARM7100 will form the hardware base of an open architecture serving personal electronics. Device drivers, operating systems, communication support, desktop interface and application software to accompany the ARM7100 are all under development. Cirrus Logic is the first ARM semiconductor partner to make the ARM7100. Samples are being delivered to key customers now, and fully supported volume product will be available in the summer of 1996.

Contact: Advanced RISC Machines, Tel: (01223) 400400.



Patients Virtually Overcome Dental Surgery Nerves

Virtual Reality headsets are being installed in dental surgeries in an attempt to relax patients. According to the headset manufacturers, Virtual Products, patients experience the effect of the 2m 3-D screen with stereo sound, while retaining the sense of the real world through the use of see-through lenses. Virtual Products expects to sell 1,500 units to UK surgeries during the next 12 months.

Contact: Virtual Products, Tel: (+49) 6251 80 22 00.

Racal to Enter UK Telephony Market With BR Acquisition?

Racal has completed the purchase of BR Telecommunications for a cost of £132·75million. BRT's current business consists of the provision of telecommunications services, principally to the railway community. The company will operate as a separate subsidiary within the Racal Network Services group and will be renamed Racal-BR Telecommunications Limited.

David Elsbury, chief executive of Racal Electronics, commented, "We are delighted to have today completed the purchase of BRT. A profitable company with a highly skilled workforce, it already enjoys considerable synergies with our existing managed telecommunications activities. The combination of the two businesses will provide a major platform for future growth in the UK and Continental Europe."

Contact: Racal, Tel: (01734) 669969.

IBM Characterise New Particle

Using one of the world's fastest supercomputers non-stop for two years, IBM scientists have calculated the properties of an elusive elementary particle, called a 'glueball', and shown they match those of a previously unidentified particle detected in several experiments carried out over the last 12 years. The new IBM result resolves a long-standing puzzle in particle physics. Although glueballs are predicted to exist by Quantum Chromodynamics (QCD), the fundamental theory of nuclear interactions, none had ever before been positively identified in an experiment. It is now clear that glueballs are frequently created in particle accelerators. They have gone unrecognised, however, because the properties predicted for glueballs by QCD had not been found with sufficient accuracy.

The new QCD calculation provides the first accurate numerical values for the mass of the lightest glueball and for the rate at which it decays into several different combinations of more stable particles. The close agreement between these numbers and the observed properties of a particle named f(1710) make its identification as a glueball practically certain. The identification of a glueball also provides a direct confirmation of the existence of the chromoelectric field, the key idea on which QCD is based.

The calculation was carried out on GF11, a massive parallel computer designed and built specifically for QCD calculations at the Watson Research Centre by Weingarten, in collaboration, principally, with Monty Denneau and David George. The calculation, which required more than four hundred million billion arithmetic operations, ran continuously for two years on 448 of GF11's 566 processors, each of which has about the same power as today's fastest PCs.

According to QCD, protons, neutrons and many other hadrons (the particles which respond to nuclear forces) are composed of quarks and antiquarks. For example, the proton and neutron each consist of three quarks, and the pion is made up of a quark and an antiquark. Each quark or antiquark gives rise to a chromoelectric field, much as an electron or its antiparticle, the positron, generates an ordinary electric field. And just as electrons in an atom are bound to the nucleus by the action of the electric field, so the quarks and antiquarks of hadrons attract each other through the force produced by the chromoelectric field.

The analogy between the electric field and the chromoelectric field is less exact when it comes to the particles that 'carry' the force. In the case of the electric field, there is a single uncharged particle, the photon, whereas in the case of the chromoelectric field, there are eight different kinds of gluons, each of which has a 'colour' charge, analogous to the electric charge. QCD predicts that, by means of their charge, gluons can interact with each other to form a new family of particles called glueballs. The identification of a glueball in experiments provides an important additional confirmation of the correctness of QCD.

Contact: IBM, Tel: (0171) 202 3744.

Book Attacks Gates

A new book attacking Microsoft Corporation and its chairman, Bill Gates, is published in the US this month by Orange State Press. The book's author, Anthony Martin, is the Executive Director of the Committee to Fight Microsoft, a division of Computer Consumers of America. The book, entitled *Bill Gates: The Robber Baron of Cyberspace*, fights Gate's world, which Martin perceives as one in which ordinary individuals are monitored relentlessly, and in which a handful of plutocrats such as Gates live like reigning monarchs over the cyberserfs.

According to Martin, "Gates and Microsoft are doing their level best to enrich themselves while government seeks to impose Orwellian restrictions on the American people and citizens of the world. The new book answers Gates and his dire forecasts, and exposes the truth behind Microsoft and its drug-crazed culture at corporate headquarters. The book is based on original research, 'inside' Microsoft sources, and a searching review of available public records and documents", said Martin.

The Committee to Fight Microsoft has successfully led international boycotts to fight Windows '95, and is participating in lawsuits against Microsoft. *Bill Gates: The Robber Baron of Cyberspace* is available from Orange State Press, P.O. Box 1132, Palm Beach, Florida, priced US$19.95 including shipping and handling.

Contact: Committee to Fight Microsoft, + 1 212 879 0086.

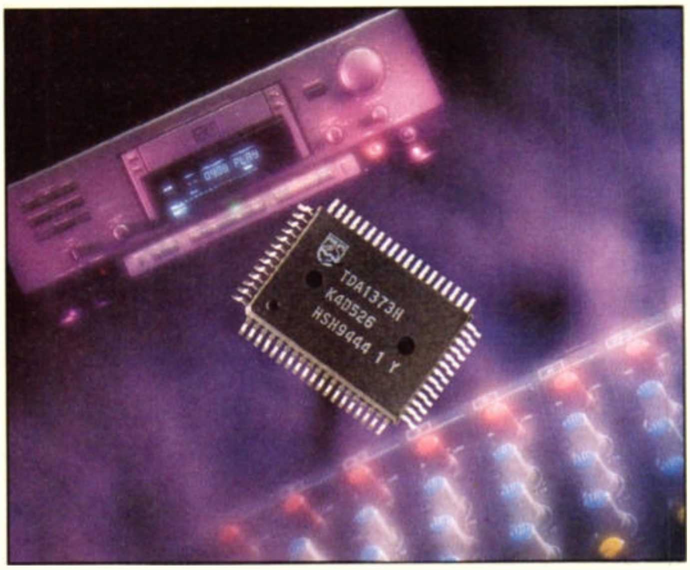
Dundee Hospital Wins State-of-the-art Videoconferencing Kit

Christmas came early for Dundee teaching hospital, when medical staff of the department of Child Health received a PC-based videoconferencing system from PictureTel. This follows a competition run in the Internet-based magazine *d.Comm* for the most original application for videoconferencing. Doctors and research staff expect to use their new equipment for a variety of purposes, ranging from face-to-face video meetings with colleagues in other hospitals, to distance learning, and telemedicine.

The PictureTel LIVE PCS 50 system will be put to immediate use by the Cystic Fibrosis Group, which is currently undertaking Europe-wide research into possible treatments for the disease. Research staff are already planning to have regular face-to-face video meetings with colleagues from other hospitals across Europe. They will be able to discuss methodology and results of the research, as well as exchange data using the PCS50's data-sharing facility.

Another application for the system will be distance learning: senior medical staff are planning to hold lectures and seminars for medical students via video in the new year. This will allow medical experts from Dundee to share knowledge and information with students in other teaching hospitals across the country and Europe.

Contact: PictureTel, Tel: (01753) 673000.



Audio Simplification

A newly launched interface IC from Philips Semiconductors simplifies the interconnection between audio systems that use different data formats and sample rates. The TDA1373H converts I^2S, Japanese or IEC958 input data into I^2S or Japanese format output data. On chip up-sampling and down-sampling filters allow the sample rate of the audio data to be increased or decreased. The TDA1373H can also be used with Bitstream ADCs and DACs to build high-performance Bitstream codecs. Typical applications include professional grade sound mixing and recording equipment, universal digital speaker systems, DCC and DAT recorders and digital amplifiers.

Contact: Philips Semiconductors, Tel: (+31) 40 724 825.

Silicon Graphics to Expand European Centre

A new factory will double total European manufacturing capacity and bring production of Silicon Graphics' most advanced servers and graphics supercomputers to Europe for the first time. The Advanced Manufacturing and Technology Centre will represent a new investment of US$26 million, in land, buildings, equipment and training. The centre will share the site of Silicon Graphics' existing factory in Cortaillod, Switzerland, 60 miles northeast of Geneva.

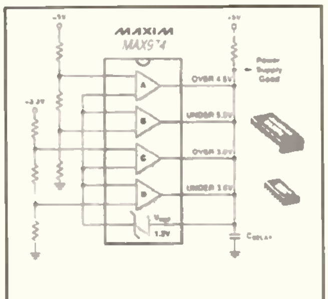
The new centre will also allow expansion of major technical activities, including the European Network Operations Centre, new training facilities, an advanced virtual reality centre, and the Supercomputing Technology Centre. The home of one of the most powerful supercomputers in Europe, a 64-processor Silicon Graphics POWER CHALLENGEarray. The co-location of manufacturing and technical resources is expected to accelerate volume production and improve European support of high-performance systems.

Contact: Silicon Graphics, Tel: (01734) 257500.

Micropower Comparators

A series of low-voltage comparators from Maxim intended for battery powered applications, operate from a 2·5 to 11V supply, draw less than 4μA current, and include a 1·2V voltage reference. The MAX971 to MAX974 single/dual/quad range have open-drain outputs, allowing wire-OR connected configurations. The 11V output and separate GND pin for the output transistor make these devices ideal for level translators and bipolar to single-ended converters.

Contact: Maxim, Tel: (01734) 303388.



Power Supply Voltage Monitor

HP and Netscape Enhance Internet Printing

Hewlett Packard (HP) and Netscape have announced a partnership to develop open, non-proprietary printing standards for HyperText Markup Language (HTML), the language used by content providers to develop their World Wide Web sites. These HTML printing extensions will allow users to print information in the same context-rich format in which it was originally designed. While it is already easy to display formatted documents on a computer screen, it is not possible to print items retrieved from the Internet as they were originally designed.

Contact: Hewlett Packard, Tel: (01344) 369222.

Tektronix Bridges Gap for Teleworkers

Tektronix has chosen Xylogics' CLAM bridges and ISDN links to give home-based teleworkers throughout Europe full access to local and worldwide services. Roll-out has already begun in Germany, with the UK, Sweden, Italy and Spain among the first countries to follow. The homeworkers enjoy the same facilities from Tektronix's global Wide Area Network as they did at their office desk, and keep in touch with colleagues by e-mail.

Based in Wilsonville, Oregon, Tektronix operates computer graphics, measurement and video systems businesses in 24 countries. Offices across Europe are connected to the Tektronix global WAN via International Private Leased Circuits. These are backed up by ISDN links between the offices and Marlow in the UK – the hub for the European WAN.

Contact: Xylogics International, Tel: (01908) 222112.

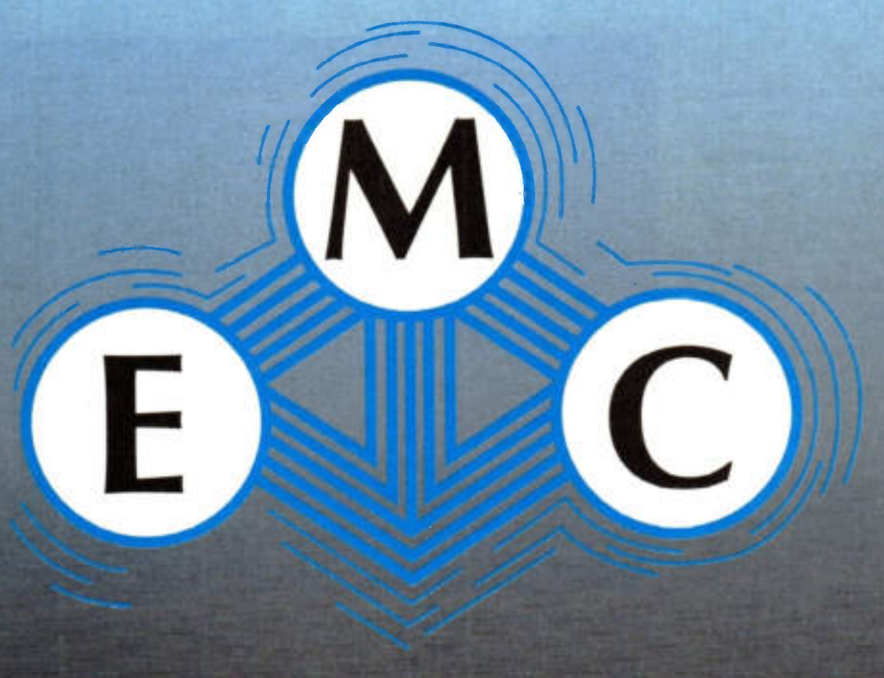
Vital Connection for Aviation Challenge

Townsend Coats has risen to the Virgin Global Challenge. The electronics component distributor is supplying Amphenol 602 connectors for use on the Virgin Global Challenger (piloted by Richard Branson and Per Lindstrand) which is attempting the first non-stop circumnavigation of the world.

The record attempt, which Branson describes as "the last great aviation challenge" will involve a flight of between 18 and 21 days duration. The flight will take place some time between now and the end of February, depending on weather patterns. At the time of going to press, the Virgin team were still awaiting take-off.

The Amphensol 602 connector is being used as a bulk head connector for all circuitry wiring that travels inside the command capsule, to essential systems on the exterior of the capsule. This includes circuitry for the control of the engines, helium valve and exterior lighting.

Contact: Townsend Coats, Tel: (01162) 769191.



– an Extra Major Calamity?

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

Part 3– Immunity

EMC (Electromagnetic Compatibility) is about electrical and electronic equipment either producing electrical disturbances which can upset other equipment, or being over-sensitive to legitimate signals, such as broadcast transmissions, natural phenomena, i.e. atmospheric disturbances (not normally including direct lightning strikes, except for such items as overhead power and telephone lines) or reasonable levels of unintentional disturbance, since it is not practicable to reduce disturbances to zero. How could you watch TV if the set was in a six-sided, welded mu-metal box?

Immunity

The welcome trend towards lower power consumption in electronic products does not, of course, come without disadvantages – almost nothing does! Most signal-processing, especially amplification, depends on transferring power from the power supply to the signal, so that if power consumption is reduced, the signal is more or less forced to be processed at a lower power level itself. This applies even, for example, in a high-power audio amplifier. For the highest power efficiency, the power gain has to be concentrated in the output stage and the one that immediately precedes it. The output stage usually provides a large current gain but very little voltage gain, while the reverse is true for the driver stage. The product of the driver voltage gain and the output stage current gain gives most of the power gain of the amplifier.

If the signal spends most of its passage through the equipment at a low power level, less disturbance power is required to upset things, i.e. the immunity is, in principle, less than it would be in more power-hungry equipment. In the days of yore (read 1950), there were things called 'magnetic amplifiers', used for such applications as industrial control, which depended for their operation on the non-linearity of the permeability of iron-cored inductors. Minimum signal levels were of the order of 1V and 5mA, and the resulting immunity from interference (from, for example, large commutator motors) was one of the advantages of these large, heavy and quite costly products.

By contrast, consider an op amp, in particular, an FET input type with an input resistance of 1TΩ (1 teraohm, a million million ohms) and an open-loop voltage gain of 100dB, or 100,000 times. Normally, of course, this would be used in a feedback circuit as shown in Figure 8, which has the much lower overall gain of 20 times, but that does not alter the fact that for say, 1V output, the actual net input signal to the device itself must be 10μV and the input current is therefore 10^{-17}A, or 10aA (attoamps!) In fact, 1V is quite a big signal at the output, and it might well be only 10mV! While the *circuit* input impedance at the inverting input is only 1Ω, if the feedback resistor is 100kΩ, it is clear that this input is a very sensitive point, and running track connected to it around even a small PC board is unlikely to be wise. Any conductor acts as an antenna to pick up whatever electric fields are around it, and if it forms a conducting loop, it picks up from magnetic fields as well, often rather more efficiently. If it is unavoidable to connect a long track to an inverting input, a resistor of around 1kΩ should be introduced close to the inverting input pin of the op amp, and the long track connected to the other end. If the circuit won't tolerate such a resistor, change the circuit!

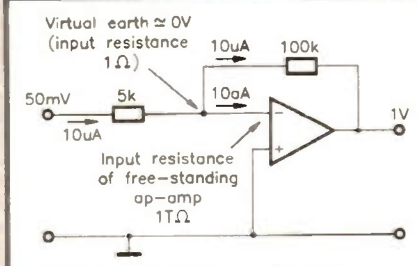


Figure 8. Signal levels and input resistances in a typical op amp circuit.

Disturbances to be Considered

There are many sorts of disturbance that *could* cause problems, but there are quite enough that are *likely* to do so, hence, we should not indulge in any barrel-scraping, unlike the people that I call 'EMC crusaders'. They see all the potential problems and want every conceivable possibility investigated by long, costly measurements, often of very doubtful accuracy or realism, and are not prominent in proposing sensible solutions.

Radiated and Conducted Radio-frequency

We can deal with these together, because radiated RF normally gets into the equipment by being picked up on the associated cables. These act as efficient receiving antennas only if they are longer than about a quarter of a

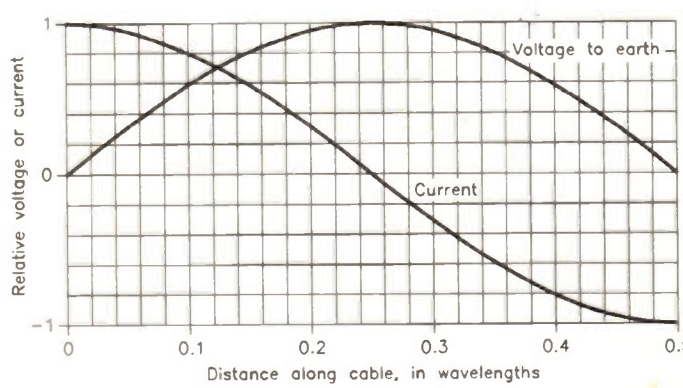


Figure 9. RF voltage and current distribution on a conductor half a wavelength long, earthed at both ends.

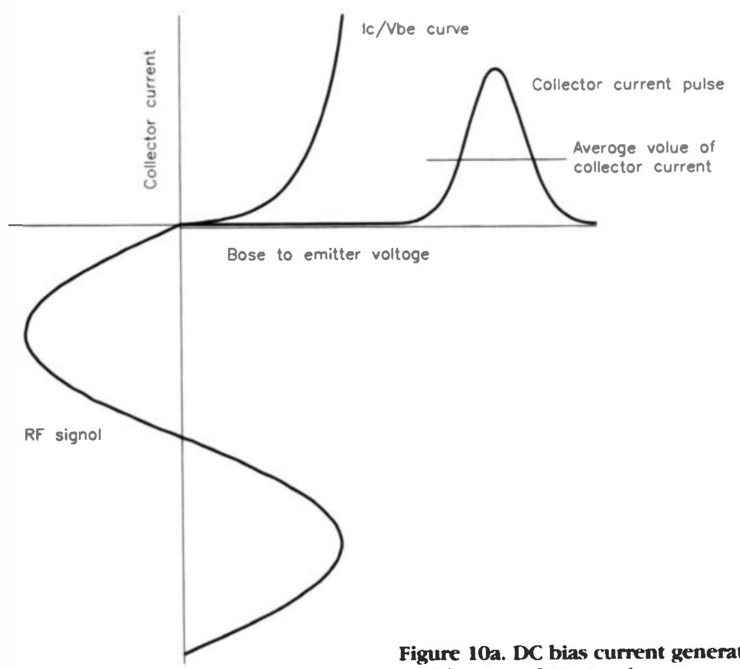


Figure 10a. DC bias current generated by rectification of RF signal.

wavelength of the radio frequency, so for example, a 10m cable works well from 7MHz upwards. Screened cables introduce a fascinating new complication. Let us begin with a simple coaxial cable, initially ignoring the inner conductor. Although the screen may be solidly earthed at one or both ends, the non-earthed end can be at a significant RF voltage to earth if the cable is more than a quarter-wavelength long, or an RF current can flow around the earth loop. Either way, the RF energy on the screen can make its way into the equipment connected to the cable (see Figure 9). Thus, it does not appear that the screen is being very helpful. However, we now have to add the inner conductor back in. The action of the screen is usually explained as 'shielding' the inner conductor from the RF field, and indeed, if I were writing this in American English, I would use the word 'shield' instead of 'screen'.

In fact, the screen works by *picking up a very nearly identical amount of RF energy as the inner conductor does*, so that the RF voltage between the screen and inner conductor is very nearly zero at all points. If the equipment connected to the cable is earthed, then an RF current flows through it from the cable to earth, and if it is not earthed, then the whole equipment develops an RF voltage to earth. Lack of immunity occurs when some of this voltage or current gets into the circuitry of the equipment. Usually, this is caused by allowing signal paths to share conductors with paths carrying RF currents or at a significant RF voltage with respect to the circuit common rail. This voltage may simply be due to RF current flowing through the inductance formed by a few centimetres of wire: 1cm provides 1·2 to 1·8nH, depending on layout, and 1mA at 100MHz flowing through 1·2nH develops 7·5mV across the 1cm length of wire!

Unmodulated or frequency-modulated RF causes little trouble unless it is very strong – of the order of 200mV at least, when rectification of the RF by a bipolar transistor base-emitter junction, or an actual diode, may cause a DC bias shift, as shown in Figure 10a. However, amplitude-modulated (including pulse-modulated) RF is a different matter. Rectification of this liberates the modulating signal into the equipment, and normally this is at a much lower frequency than the RF carrier, as in Figure 10b. For example, it may be the audio signal of the local taxi office operator's voice, and it may come through the sound system in the local council chamber – in the middle of the mayor's most important speech, of course.

At very low signal levels, bipolar junctions show a square-law rectification characteristic, which means that the recovered modulation signal decreases by 6dB if the RF signal level decreases by 3dB. A relatively small reduction of the RF pickup, by using screened cables or improving the earthing, for example, can make a dramatic improvement in the level of interference (refer to Figure 10c). The classical methods applied to discrete bipolar transistors are to connect a 1nF ceramic capacitor directly between base and emitter, with the shortest possible leads, and supplement this if necessary with a 100Ω resistor directly in series with the base. However, the latter can often worsen noise performance (internal noise as opposed to interference), so a ferrite bead or a low-value inductor may be used instead, and neither of these affects the noise.

For analogue op amp circuits, the best solution is to use FET input op amps, which are typically 26dB less sensitive to modulated RF than bipolar op amps in the same circuit. It is advisable to be careful about connecting capacitors between the inputs of op amps, because it can cause unexpected oscillation.

A very fundamental solution to all sorts of immunity problems is to use balanced input technology, even if the actual signal input to the equipment as a whole remains unbalanced. The idea is based on the fact that, while nearly identical interfering signals are picked up on any conductors that run close together (such as the screen and inner of a coaxial cable), the two inner conductors of a balanced connection carry very closely, equal interfering signals together with equal ***but mutually inverted*** wanted signals (see Figure 11). If the two conductors are connected to the two inputs of an op amp, the identical 'common-mode' interfering signals are not amplified (provided they are not big enough to cause overloading), but the ***'differential-mode'*** wanted signals are amplified. It is possible to adapt this technique to improve the immunity of unbalanced interconnections, such as coaxial cables, by connecting one of the op amp inputs to the inner and the other to the screen at the point where it enters the equipment – right at the connector itself. Actually, the two inputs of an ordinary op amp are well balanced in terms of gain (if closely matched

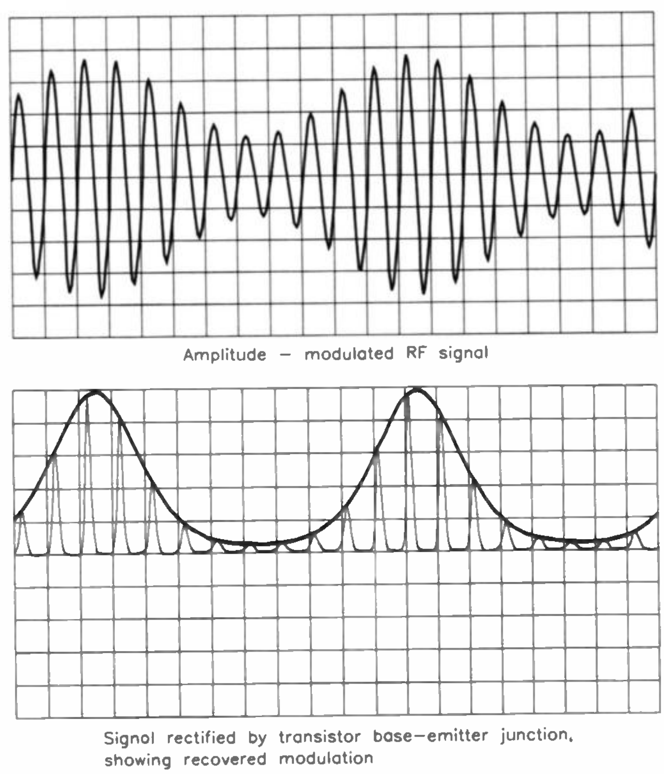


Figure 10b. Interfering property of amplitude-modulated RF signals.

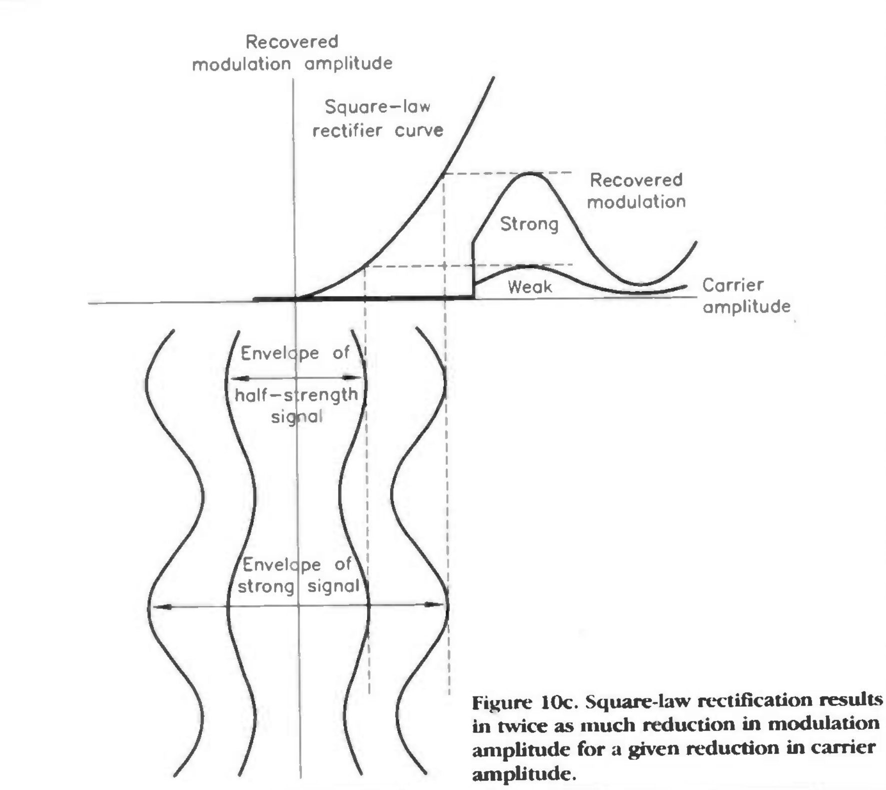


Figure 10c. Square-law rectification results in twice as much reduction in modulation amplitude for a given reduction in carrier amplitude.

resistors are used in critical places in the circuit), but are not balanced in terms of equal impedances to the common rail. This does not matter if the source impedance is low, but if not, more complicated input circuits have to be used to ensure impedance balance as well as gain balance.

Direct pickup on circuitry is unusual, but it occurs with strong UHF fields (such as from cellular phones) and plastic enclosed equipment. Although it is a dramatic change, a double-sided PC board may be needed, with one side acting as a ground plane. However, spraying the inside of the case with special conducting metallic paint (ordinary metallic paint is *no good at all*) may well be sufficient, provided the metallising is connected to the common line of the circuitry.

Magnetic Fields

Problems with these normally occur at the 50Hz mains frequency and its 3rd and 5th harmonics at 150Hz and 250Hz respectively, which come from the non-linearity of the iron cores of mains transformers. In fact, much of the stray field of such a transformer is at the harmonic frequencies.

Magnetic fields cause interference by inducing voltages into conducting loops. It is not possible to eliminate all loops, because, at least, the input and output currents must have one (each!) to flow in. The strategy is to eliminate all unwanted loops and to minimise the areas of the remaining ones. Screening with the necessary high-permeability magnetic alloy against low-frequency magnetic fields is usually impracticable, and often too costly, except for such things as tape heads and microphone transformers, for which there is no real alternative.

However, there are methods, other than magnetic screening, of reducing the stray fields produced by transformers, as shown in Figures 12a and 12b. An existing transformer may be improved by surrounding the whole unit with a very low resistance conducting path, such as a thick sheet of copper (anything less than 1mm thick is not usually very effective), well soldered at the joint, or a slice off a square or circular aluminium extrusion. This works because the stray field induces currents in the conducting path which produce their own magnetic fields that very nearly cancel the stray field externally. Copper sheet can be 'moulded' closely around the body of the transformer, but it is usual for an extrusion to be spaced away from the body, simply because one of the exact shape and size required cannot be obtained. The greater the spacing, the thicker the wall of the extrusion needs to be.

New transformer designs can be improved by reducing the maximum magnetic induction in the core, which is proportional to the applied voltage and inversely proportional to the cross-sectional area of the core and the number of turns on the primary winding. It is also necessary to assemble the core (if it is of the EI or TU laminated type) very carefully, so as to minimise the inevitable air-gaps at the joints. This can be checked by squeezing the core together to minimise the no-load primary current, or *magnetising current*. The ultimate solution is to use a toroidal core or a C-core, which has much lower flux leakage and may be smaller and lighter, but usually carries some cost penalty.

Another technique, which may cost very little, is to take advantage of the fact that both the source of the field and the 'receiving' loop have directional properties. The loop is completely insensitive to fields in its plane, so by orienting the loop and the source so that the direction of the strongest field is in the plane of the loop, a considerable reduction in interference may be secured. Since the pattern of the source field is usually unknown (except for a toroid or C-core, where it comes directly out of the 'bore' and wraps round like those pictures of fields made with iron filings that feature in every textbook), this is best carried out by experiment. However, BE CAREFUL to avoid contact with the mains transformer with the power on! I put it into a stout cardboard or rigid plastic box, carefully stuck closed with adhesive tape, to ensure that the mains terminals are well protected from any damage they might suffer through touching my hand!

Electrostatic Discharge

This is normally much less of a problem for the home-constructor with completed equipment than it is when the equipment is under construction, or still in component form. At that stage, of course, the remedy is not to ignore the warnings on the packaging of sen

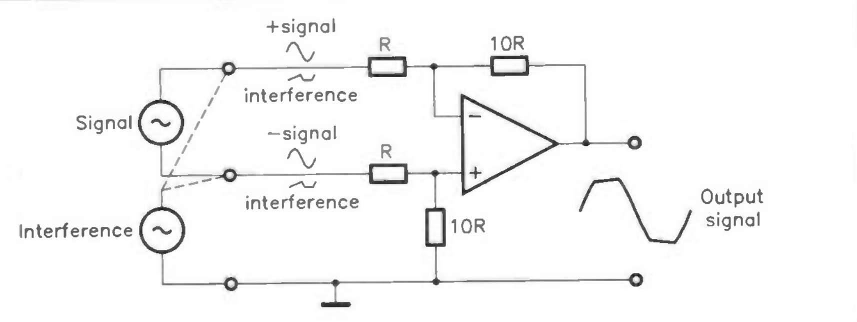


Figure 11. Balanced circuit with common-mode interference and differential-mode signal.

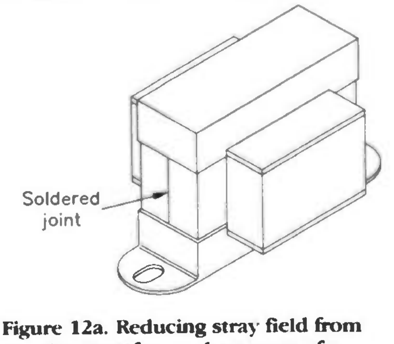


Figure 12a. Reducing stray field from a mains transformer by means of a copper band.

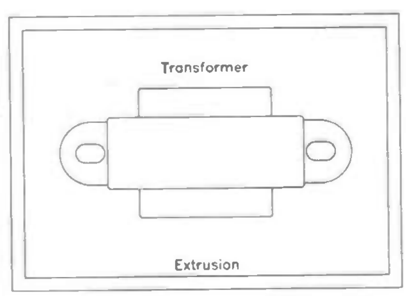


Figure 12b. Reducing stray field by means of a hollow extrusion.

sitive devices. Touch an *earthed* metal object before you handle any components and avoid clothes and shoes which cause you to become charged up. In this respect, the female of the species is definitely more deadly than the male, and grandmothers are particularly dangerous, because they tend to have double the normal 500pF capacitance to earth (think about it!)

On complete equipment used other than in particularly adverse environments, such as factories where compressed gases or fine, dry dusts are around, problems are unlikely if there is an earthed metal case. Plastic cases should preferably be reserved for home use, unless externally or internally metallised with the metallising earthed, or kept at least 8mm away from any connectors not having metal shrouds, because otherwise a spark can jump from the metallising to the connector and thence into the circuitry.

Mains Voltage Dips and Interruptions

Obviously, the ultimate solution for both dips and interruptions is built-in battery back-up or an UPS (Uninterruptable Power Supply). Built-in back-up is practicable if the current and/or voltage requirements are fairly low, but float-charging of nickel-cadmium batteries can be troublesome. The necessary charging conditions and duty-cycle (ratio of time on to time off) are interdependent, and if incorrect, are very likely to result in premature failure of the cells (or, usually, just one of them!) Nickel metal-hydride cells are less delicate in this respect, although more costly at present. Sealed lead-acid batteries, too, are much more tolerant of non-optimum charge and discharge conditions, than are nickel-cadmium batteries.

If a back-up power supply of any form is not practicable, attention is needed to the stored energy in the power supply. The energy is stored in the reservoir capacitor of the rectifier circuit, and is equal to $\frac{1}{2}CV^2$ microjoules, where C is the capacitance in microfarads and V is the voltage across it. It is interesting to compare typical values for 'linear' and switch-mode power supplies. A linear supply might have 47mF (millifarads) charged to 5V, so storing nearly 0·6J, while a typical small switch-mode supply might have 100μF charged to 320V (nearly the peak voltage of the mains supply), thus storing 5·12J. This is nearly nine times as much, in spite of having 470 times less capacitance, and which also costs considerably less. It is clearly an advantage to store energy at as high a voltage as convenient, because the energy is proportional to voltage squared. Doubling the switch-mode voltage, which is not, in theory, difficult or costly if alternative operation from 120V (American) mains supplies is not required (as it is for many commercial switch-mode products), is nevertheless fairly impracticable, because it is very difficult to make electrolytic capacitors with a working voltage greater than 600V or so – a fact which has become little-known since valves went out of fashion. It is possible to connect capacitors in series, with voltage-sharing resistors in parallel, but this is not very economical or convenient in volume production, although it is a definite possibility for custom-made designs.

For commercial switch-mode power supply modules, a 'hold-up time' is often specified, which is the time for which the regulated output voltages are maintained, under rated current demand, after the mains supply ceases. In order for equipment to be reasonably immune to mains voltage dips and interruptions, it should be completely unaffected after an interruption of 20ms (1 cycle) and should not crash (fail to resume working properly) after a 60% voltage reduction for 100ms and after a 95% reduction for 5s.

Next Time

It seems like a good idea to devote Part 4 to FAQs (Frequently Asked Questions), because EMC is a new subject for so many people. However, because of the magazine production schedules, Part 4 has to be written even before Part 1 is published, so the FAQs have obviously not come from readers' letters. Of course, that does not by any means stop you from writing in with your own questions, and if that justifies an update article later on, well, that's one less new topic for me to dream up! E

CLASSIFIED

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AMIGA A1200 6M-byte RAM, maths co-processor, 80M-byte hard drive, external disk drive, Philips 8833 MkII stereo monitor, excellent condition, original manuals, most boxes, space needed, £500 o.n.o. Tel: (01782) 533016.

BBC MICRO BITS, Paul Fray 'spider' £10, various ROMs, Archimedes ROMs and software £4, also digital IC tester, interfaces to BBC micro, with software £20. Tel: (01924) 406377 for details.

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ELECTRONIC INSTRUMENTS suitable for college student or hobbyist, plus 40 electronics books. Tel: (0181) 427 3034 for list.

FLUKE 79 METER, price new £222, for sale £150 (1 year old). Fluke 12+ holster, price new £108, for sale £70 (2 years old). Exchange for 72-pin SIMMs considered. Tel: (0116) 2359539.

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TRANSFORMERS AND CABLE, assorted: 500VA toroidals, 3 of, £12 ea.; 6VA 20V, 25p each.; and several in-between sizes, e.g., 35-0-35V/300VA; lots of multicore, ten different sizes 4-38 cores screened and various mains types, small pieces and almost complete reels, all at ¼ list prices, e.g., 95m 12 core 7/0·2 screened for £25 (or split). Tel: (0161) 681 3146.

BBS CORNER

APPLE CRACKERS. FirstClass Client BBS, mainly for AppleMac and PC users. Baud rate 2·4K-bit/s to 28·8K-bit/s, 8 data bits, no parity, 1 stop bit. Tel: (01268) 781318/780724.

MACTEL METRO/ICONEX. FirstClass Client BBS, AppleMac and PC users. E-mail address on Internet for registered users. Baud rate 2·4K-bit/s to 28·8K-bit/s, 8 data bits, no parity, 1 stop bit. Tel: (0181) 543 8017 (Metro) or (0115) 9455417 (Iconex).

SPIDER! AMIGA BBS. The lighter alternative. Mainly Amiga and some PC files. Fidonet, Mercurynet and Mufonet. Online games. Speeds up to 19200. Tel: (01568) 613520.

CLUB CORNER

AARS (Aberdeen Amateur Radio Society) meets on Friday evenings in the RC Hall, 70 Cairngorm Crescent, Kincorth. For details contact: Martin, (CM0JCN), Tel (01569) 731177.

THE BRITISH AMATEUR ELECTRONICS CLUB (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members £13.50). For further details send S.A.E. to: The Secretary, Mr. J. F. Davies, 70 Ash Road, Cuddington, Northwich, Cheshire CW8 2PB.

BURY ST. EDMUNDS AMATEUR RADIO SOCIETY. Meetings held at Culford School, 7.30pm for 8.00pm on the third Tuesday of each month, unless otherwise stated. Further details from Kevin Waterson, (G1GVI), 20 Cadogan Road, Bury St. Edmunds, Suffolk IP33 3QJ. Tel: (01284) 764804.

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) 699 5732.

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

DERBY AND DISTRICT AMATEUR RADIO SOCIETY meets every Wednesday at 7.30pm, at 119 Green Lane, Derby. Further details from: Richard Buckby, (G3VGW), 20 Eden Bank, Ambergate DE56 2GG. Tel: (01773) 852475.

E.U.G. User group for all 8-bit Acorn Micros, since 1991. Still going strong. Programming, news, information, sales. Contact: E.U.G., 25 Bertie Road, Southsea, Hants. PO4 8JX. Tel: (01705) 781168.

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.

SCIENCE AT YOUR FINGERTIPS, for 'hands-on' science experiences and experiments, *Science at Your Fingertips Science Review*, Membership £2.50. For further details, please contact Daniel and Caroline Gee, The S.A.Y.F., 37 South Road, Watchet, Somerset TA23 0HG.

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.

SUDBURY AND DISTRICT RADIO AMATEURS (SanDRA) meet in Gt. Cornard, Sudbury, Suffolk at 8.00pm. Visitors and new members are very welcome. Refreshments are available. For details please contact Tony, (G8LTY), Tel: (01787) 313212 before 10.00pm.

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 N. Wiltsher, TESUG, P.O. Box 576 Orpington, Kent BR6 9WY.

THANET ELECTRONICS CLUB. For school age Ham Radio and Electronics enthusiasts, enters its 16th Year. Meetings held every Monday evening from 7.30pm at The Quarterdeck, Zion Place, Margate, Kent. For further details contact: Dr. Ken L. Smith, (G3JIX), Tel: (01304) 812723

WAKEFIELD AND DISTRICT RADIO SOCIETY meet at 8.00pm on Tuesdays at the Community Centre, Prospect Road, Ossett, West Yorkshire. Contact Bob Firth, (G3WWF), (QTHR), Tel: (0113) 282 5519.

THE (WIGAN) DOUGLAS VALLEY AMATEUR RADIO SOCIETY meets on the first and third Thursdays of the month from 8.00pm at the Wigan Sea Cadet HQ, Training Ship Sceptre, Brookhouse Terrace, off Warrington Lane, Wigan. Contact: D. Snape, (G4GWG), Tel: (01942) 211397 (Wigan).

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

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.

What's On?

IEE Conference Powers Up

The sixth International Conference on AC and DC Transmission will be held at the Institute of Electrical Engineers (IEE), London from 29th April to 3rd May.

Advances in power electronics have resulted in the prospect of extraordinary gains in AC transmission transfer capability, as a result of real time control using FACTs devices to widen stability margins. The same advances have also had their impact on DC transmission and therefore the economic break-even distances between AC and DC are much more reduced.

Planners are under considerable pressure to exact greater use and capability from the capital employed in transmission, while maintaining security standards, providing for open access and limiting environmental impacts. The scope of the 1996 Conference has therefore been to take account of these issues with a section entitled 'The Role of Transmission'.

The Conference will be opened by Professor Stephen Littlechild, Director General of OFFER, the UK utility regulator. Topics for discussion include, the Ontario Hydro Wheeling studies, transmission access, electromagnetic fields, and the public enquiry process.

Contact: IEE, Tel: (0171) 240 1871.

Measurement at NEC

An instrumentation conference and exhibition with a heavy bias towards sensors is being launched this month at the National Exhibition Centre, Birmingham. The Measurement Technology Exhibition & Conference will be held from 24th to 25th January.

With the emphasis on the practical side, the event is intended to range from the pethrochemical industry through process and design to communications.

The conference programme has attracted 21 papers, and Trident the event organisers expect the exhibition to attract around 100 exhibitors and over 3,000 visitors.

Contact: Trident, Tel (01822) 614671.

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.

20 January to 25 March. Science Museum Superhighway UK Tour, National Museum of Wales, Cardiff. Tel: (0171) 938 8192

22 January. Projects, Grouses, Problems and Solutions, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

26 January. VHF Packet evening on the air. Mid Sussex Amateur Radio Society. Tel: (01444) 241 407.

2 February. Novice Night with 2E1AOU & 2E1DCP. Mid Sussex Amateur Radio Society. Tel: (01444) 241 407.

9 February. Project Evening. Bring your Project along. Mid Sussex Amateur Radio Society. Tel: (01444) 241 407.

11 February. Fifth Northern Cross Rally, new large hall venue at Thornes Park Athletics Stadium, Wakefield. Details from Dave Gray, (G0FLX),

Tel: (0113) 238 3622.

12 February. DX Cluster, John Clayton G4PDQ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

12 February. Doing Business on the Internet, Wave Technologies UK. Tel: (0800) 393 205.

16 February. Kit building with 8th Burgess Hill Scouts. Mid Sussex Amateur Radio Society. Tel: (01444) 241 407.

18 February. RSGB VHF Conference, Sandown, Surrey. Tel: (01707) 659015.

24 February. Radio Rally, Rainham, Kent. Tel: (01634) 365980.

24 February. Radio Rally, South Shields, Tyneside. Tel: (0191) 265 1718.

26 February. Test Equipment Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

9 to 10 March. RSGB London Amateur Radio and Computer Show, Picketts Lock, Edmonton. Tel: (01707) 659015.

11 March. Visit to The Cable & Wireless Company College, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

17 March. Radio Rally, Norbreck, Blackpool. Tel: (01707) 659015.

25 March. Surplus Equipment Sale, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

31 March. Radio Rally, Magnum, Scotland. Tel: (01294) 215457.

8 April. Annual General Meeting, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

14 April. Radio Rally, Launceston, Cornwall. Tel: (0161) 762 9308.

21 April. White Rose Rally, Leeds. Tel: (01707) 659015.

22 April. The First Century of Sound Recording, Brian Hayward G8VXQ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

23 to 25 April. Eighth International Conference on Road Traffic Monitoring and Control, IEE, London. Tel: (0171) 344 8425.

23 to 25 April. The Institute of Physics Annual Conference, Telford International Centre, Telford. Tel: (0171) 235 6111.

27 April. Marconi Day, commemoration of 100 years of wireless. Special exhibition of early Marconi equipment and exhibition short wave transmitting station GB3WM at the Puckpool Park Wireless Museum, Seaview, Isle of Wight. Tel: (01983) 567665.

29 April to 3 May. Sixth International Conference on AC and DC Transmission, IEE, London. Tel: (0171) 344 5472.

4 May. RSGB Open Day, Potters Bar. Tel: (01707) 659015.

13 May. Astronomy, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

20 May. Visit to Nickelodeon, Ashorne, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

21 to 22 May. International Conference on Public Transport Electronics Systems, IEE, London, Tel: (0171) 344 8432.

27 May. Open Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

10 June. 2m Direction Finding Contest, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

15 June. RNARS, HMS Collingwood, Hants. Tel: (01707) 659015.

24 June. Repeater Management Group Chairman, Geof Dover G4AFJ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

30 June. Radio Rally, Longleat, Wiltshire. Tel: (01707) 659015.

8 September. The Fifteenth Lincoln Hamfest, Lincolnshire Showground. Entry is £1.50. Morse tests available, plus all usual attractions. Caravans welcome (Saturday night only). Details from Sue Middleton, (XYL) (G8VGF) (QTHR), Tel: (01522) 525760

Please send details of events for inclusion in 'Diary Dates' to: News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR or e-mail to swaddington@cix.compulink.co.uk.

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

AIR YOUR VIEWS

STAR LETTER

In this issue, Stephen Maltby of Rothwell, Northamptonshire wins the Star Letter Award of a Maplin £5 Gift Token, for his letter on vanishing legends.

Dear Editor,
I wonder if fellow electronics hobbyists have observed that the identification numbers on integrated circuits tend to disappear very rapidly these days? Are circuit makers perturbed about rivals stealing their designs? Over the last six months, numbers and text printed on new chips have been fading to nothing in a short space of time. I have arrived at the conclusion that exposure to light is the main cause of the trouble, as chips kept in the dark are still (just) readable. Unfortunately, I discovered this a little too late, and now have a dozen or so unidentified bits of plastic with metal legs on them. I don't suppose that there is any way of discovering what they are? Is there any chance of the stock code being printed permanently on the chips, or failing that, on the packaging? I realise that the responsibility for cataloguing components rests with the end user, but when you have a lot of items with very faint markings, it could lead to errors in identification. Any comments on this?
Onto a different theme, is there any chance of more multichannel remote control/telemetry projects appearing in *Electronics*, on the lines of fibre optics, mains signalling, radio or infra-red? The Velleman 8-channel kits are very good, but operate in only one direction and still need two cables. The 15-channel infra-red controller is only line-of-sight operation, and the radio projects only have one channel, so none of these can transmit varying quantities of data, such as temperature. Any person with out-houses, greenhouses, garages, etc., located a long way from the house will appreciate the need of multi-channel bidirectional signalling/control. The temperature/status of the greenhouse could be relayed to the house for visual inspection, and the heater, lights, fans, alarms, etc., could be turned on and off from the house without the need for wires. Maybe you can suggest something along these lines? Keep up the good work.

The issue of the printed legends disappearing from ICs is a tricky one to address, since it does not seem to be a widespread problem in our experience – the Maplin development lab keeps a wide stock of ICs, the less utilised of which have been sitting about on the shelves for months (in trays, admittedly, though not light-proof ones), yet their legends remain clearly legible. The most recently ordered ICs, some of which reside in our latest projects, do not show signs of the printing fading either. Perhaps the problem is confined to one particular IC manufacturer's printing process being at fault (Maplin's ICs are produced by a multitude of different suppliers). If you were able to specify which make(s) of ICs were being affected by this malady (assuming you could still make out the manufacturer's name!), this matter could be investigated further, and a more definitive answer given. Have any other readers experienced this problem? If so, please write in! Computer software exists that is capable of identifying 'unknown' integrated circuits, particularly TTL and CMOS-series logic chips plugged into an accompanying ZIF test socket. The programs operate on the basis that most such ICs have a common power terminal arrangement (top left is usually V_{CC}, whilst bottom right is usually GND), and by applying low-current pulsed inputs to the remaining terminals in combination, the outputs of those without a signal being applied at any moment are monitored. From the results, the type of logic gates in the chip may be ascertained. Various circuits have been published to carry out a similar test, using LEDs, or even a multiplexed oscilloscope waveform, to indicate the output on all the pins simultaneously, from which you can manually work out the type of logic within – providing hours of fun! If you are particularly well organised, you could label a set of storage boxes/trays/racks for each type of IC you wish to keep 'in stock', though this takes up a fair bit of space if you have many varieties, and requires a certain amount of dedication to prevent them from being inadvertently mixed up. Regarding the radio control/telemetry projects, we certainly plan to feature more of these in future issues of Electronics, and your suggestions have been noted and passed to the project development team. The Humidity Module stocked by Maplin (ZA38R) provides a 4-bit parallel packed BCD (Binary Coded Decimal) output, and the Temperature Module (FE33L) a 13-bit serial output code, which would be relatively straightforward to link to a suitable encoded/modulated radio control system, for the monitoring of greenhouse humidity and temperature. An alternative method of remote control transmission is via encoded signals sent along the existing mains supply wiring linking rooms or even buildings, but of course, convenient as this technique is, it would not be wireless.

Could I Chip In?

Dear Sir,
Congratulations on your first-class series, Practical Guide to Modern Digital ICs. I have found this very informative, especially in decoding the mysterious information contained within TTL and CMOS data books that any circuit designer must be fully conversant with. Further to A. Bianchi's letter in the December issue, regarding the inclusion of source code for the use of programmable devices such as FPGAs and PIC microcontrollers (it is the PICs I am particularly interested in) I must support his view that to fully understand the use of these chips in a circuit requires the user to know how they have been programmed. However, I fully understand that it is not practical to show these listings in the magazine, not forgetting the copyright restrictions that apply in doing so. But how about including some development notes and state diagrams that can be used by the circuit builders or designers to develop their source code?
Neil Rankin, Test Systems, neil_rankin@uk.xyratex.

We are pleased to hear that you have found Ray Marston's series to be of use. Where possible, and space permitting, we do include a chart, in combination with the circuit description, describing the operation of the programmed device, such examples being the Micron III and MIDI Test Box projects.

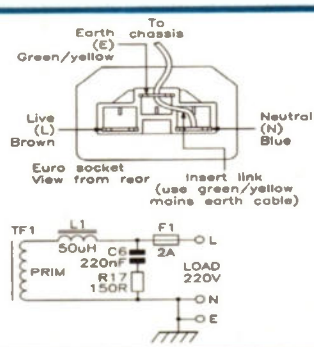
Electronic Avenue

Dear Sir,
Your correspondence page is always interesting and I send you an unusual request on the assumption that you are open to new ideas. I ask you to print this as an offer to some enterprising electronics engineer somewhere out there, who wants to get his teeth into a much neglected area of technology.
I designed and built my house in 1980 (when I retired for the second time), as a low-energy, self-regulating building using all the then-available technology; since that time, I have refined the individual installations to the point where it is now self-sustaining as well. I have been much assisted by Maplin's mail-order and technical advice services in achieving this. Unfortunately, I began it all too late in life, and I must now change down so far as my house is concerned, and find somewhere that takes less of my personal energy – what with the extensive garden, Dartmoor walks, river Dart sailing, and all. So, I am selling this remarkably comfortable domestic test-bed, and it would please me greatly to pass it onto someone who can develop it from the present stable plateau.
The next stage would be to introduce a PC or processor as overall monitor and controller (replacing me) as this would bring even greater comfort and economy.
I have enjoyed my situation very much over the past fifteen years, and I assume that there are others out there who would get as much fun out of it as I have; for much of the time, I ran an engineering consultancy business from home as well.
If anyone is interested, I will send the technical data direct to them, so that they can decide whether they should get in touch with my agent or not. The fax is a bureau number and should carry my name as identification – I poll it daily.
Fax: (01803) 867881 GILBERT.
Martin Gilbert C.Eng FIEE, Totnes, Devon.

An unusual request indeed for Air Your Views, but then folk do like to see a nice spontaneous letters page, and who are we to stand in the way of this? Your high-tech house design sounds fascinating, Mr Gilbert, and we wish you every success in finding a buyer. Perhaps an Electronics feature on aspects of designing a high-tech house might be of interest to readers wishing to make their homes more energy-efficient, and to update them for life in the 21st Century? Now, onto the small matter of our home-advertising commission fee (don't fret, we're only joking!)

CORRIGENDA

IMPORTANT! It is essential that a connection link is made between the neutral (N) and earth (E) pins on the Euro outlet socket, which should be implemented using green/yellow mains earth cable (see diagrams showing the Euro socket and annotated section of the circuit diagram). This is required in addition to the earth wire that is connected between the earth pin on the Euro socket and the chassis (metal box), described within the Inverter article on page 40 of Issue 98. These are needed to ensure adequate earthing of the unit, and to allow correct operation of an RCD, should one be used in conjunction with the unit. Additionally, references to transformer 'T2' made in Figures 5, 7 and 8 should instead state 'TF2'.



The INTERNET PART:4

Business on the Internet

In the previous three parts in this series, we have seen how to get on the Internet, and what you can expect once you are there. In this part, Stephen Waddington examines how to create your own presence, and takes a look at some business users already established on the World Wide Web (WWW).

Companies have rushed to establish a World Wide Web (WWW) presence. Industry pundits claim that if you are not on the Internet this year, you will be out of business next. However, the textbook rules of sales and marketing do not transfer easily to this new medium.

Lessons in Marketing

Articles and advertisements in magazines are targeted at the magazine's audience. If you wish to advertise a PCB design service, you would advertise in the electronics press and not the national or lifestyle press. Magazine publishers and advertisers know their audiences well.

By advertising in the electronics press, not only can we be sure of reaching individuals who need a PCB design service, but by selecting the appropriate title, we can be confident of hitting an appropriate sector of the electronic engineering community such as systems designers, as opposed to software engineers.

This model can be adopted to fit any marketing element. Television advertising, display advertising and public relations all rely on identifying a target audience and knowing the most appropriate tools to hit them with.

WWW as a Marketing Tool

Compare this with the WWW. The WWW is unlike any other media format. At best, it is a complex mix of television, print media and radio, and at worst, a poor form of classified advertising. The number of individuals with access to the WWW is unclear. Since the first article in this series, the figure has jumped by another 10 million. Current estimates put the number of on-line users at approximately 35 million across the world.

Here, the demographics are curious. According to surveys by the USA Internet provider AccessCom, at **http://www.survey.net** (shown in Figure 1), at present, the average Internet user is a professional male between the ages of 26 and 30, typically with a degree, or some form of college qualification, as shown in Figures 2, 3 and 4. Not entirely coincidentally, this cross-section of the community has the greatest spending power of any sector.

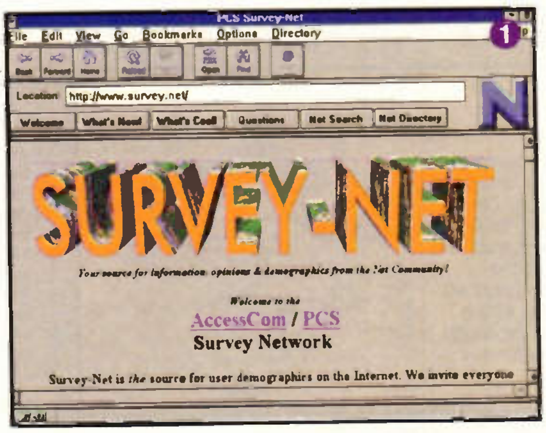


Figure 1. Survey-Net, an on-line source of Internet statistics from US Internet provider, AccessCom.

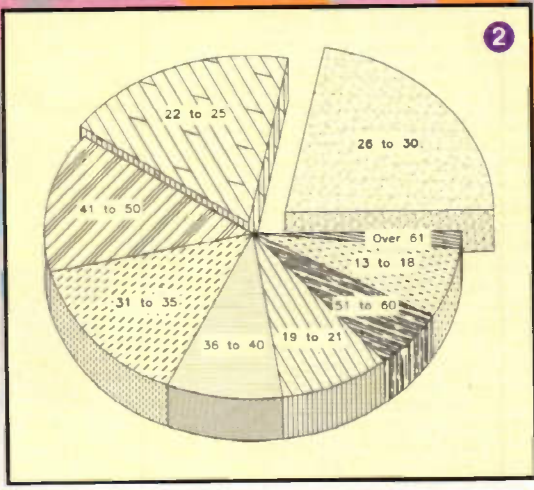


Figure 2. Analysis of Internet users by age group.

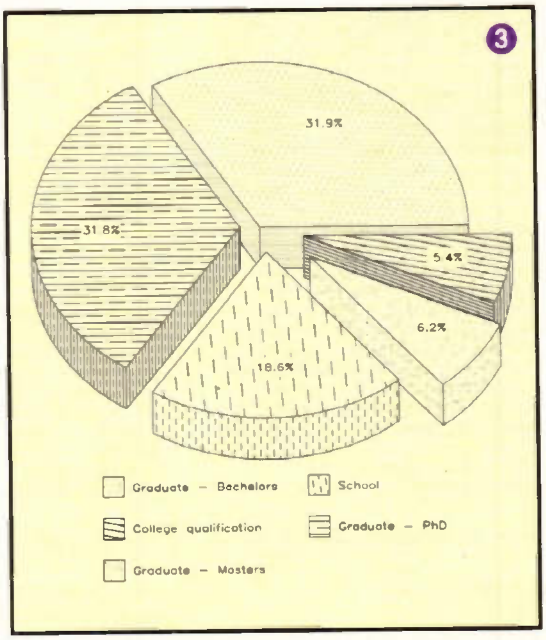


Figure 3. Analysis of Internet users by educational background.

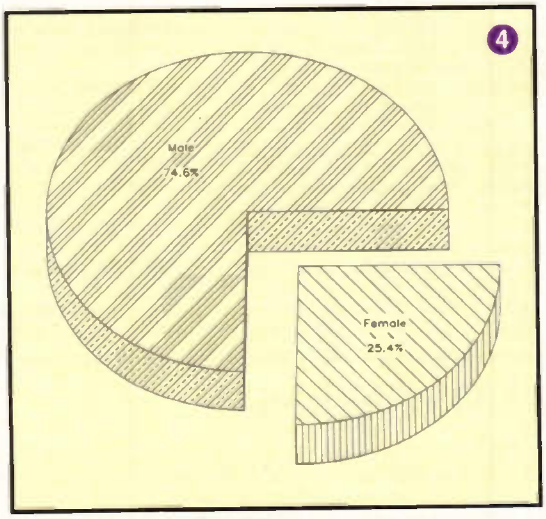


Figure 4. Analysis of Internet users by sex.

Challenges

The challenge to business is clear. As the breakdown of educational backgrounds in Figure 3 shows, there is a potential audience of millions of well-educated individuals out there, who can be reached relatively inexpensively. According to Ivan Pope, director of the

Internet consultancy Webmedia, "The WWW is the sexist subject of the decade."

Getting the presence correct is the key, while the potential audience is huge, the breakdown is incredibly diverse. The only way to meet this diversity is to target an approach to reach a single segment of this audience or reach the whole via a variety of focused messages, each targeted at an appropriate segment.

The concept of a WWW industry or even WWW experts is a nascent one – even in the US, there are very few people who have a holistic understanding of the Internet, WWW, media, marketing, technology and publishing. However, that has not stopped advertising and public relations agencies jumping on the bandwagon, offering clients WWW creation services.

Immature Markets

The barriers to entry are relatively inexpensive to hurdle. According to Paul Youlton, director of multimedia publishing house PYA, "Anybody with a PC, text editor and Internet connection can set themselves up as an instant authority on the WWW."

Any company wishing to establish a WWW presence is at the mercy of an ill-defined and uninformed market-place, where a field of back bedroom-based consultants abound. Overnight, advertising and public relations executives have become self-proclaimed technology experts, while IT professionals are advising companies about their marketing strategy. Even freelance journalists are having a go!

There are numerous routes to establishing a WWW presence, from in-house project building to specialist independent contracting. It is important to select a strong team, led from the top of the organisation.

"In the same way that you would not want your network administrator to start sending out self-designed brochures, you shouldn't let anyone seize control of your Internet efforts just because they are technically competent", claims Ivan Pope.

Under Construction

At the moment, the problem is that there are few individuals with a track record of competency in the handling of WWW site design. While it is not difficult to design WWW sites, linking pages together, providing and maintaining useful data, and adding interactive elements are more complex.

WWW Site	strategy
	direction
	site design
	interface design
	editorial content
	production
	technical management

Table 1. Elements of a WWW site design.

As Table 1 shows, there are at least seven elements which contribute to the construction of a WWW site: strategy, direction, site design, interface design, editorial content, technical management, and production. The interaction between these roles is crucial to the design of a site. With over a hundred WWW sites coming on-line every day, it is proving increasingly hard to maintain visibility.

WebShop

One company that seems to have a grasp of utilising the WWW is WebShop. Based in the South of England, the company consists of a team of respected journalists, programmers and marketeers. The company differentiates itself from others in its space by using the WWW to reinforce a company's image online, rather than simply concentrating on the creation of WWW pages.

With prices starting from £200, the company will build a WWW site from the ground up, taking care of issues such as domain registration, WWW page creation, gateway programming and ongoing maintenance. To check out their WebShop's expertise, e-mail: **info@webshop.demon.co.uk**

Helping Hand

A number of tools have been produced to create WWW pages. Both Microsoft and Novell have produced WWW authoring macros for Word and WordPerfect, respectively. Using these tools, you format your document normally using predefined styles, then the word processor adds the HTML tags to match the document to the format required for a WWW browser. There are other stand-alone packages to help create WWW pages, such as HotMetaL. The really brave can, of course, always write raw HTML documents using a text editor, as outlined earlier.

WordPerfect WWW Authoring

Internet Publisher for Windows is a free add-on for WordPerfect 6.1, which allows users to create and view documents on the Internet without having to learn hypertext mark-up language (HTML), the original document format of the WWW. The software, which also includes Netscape Navigator, can be downloaded at **http://www.novell.com**, as shown in Figure 5.

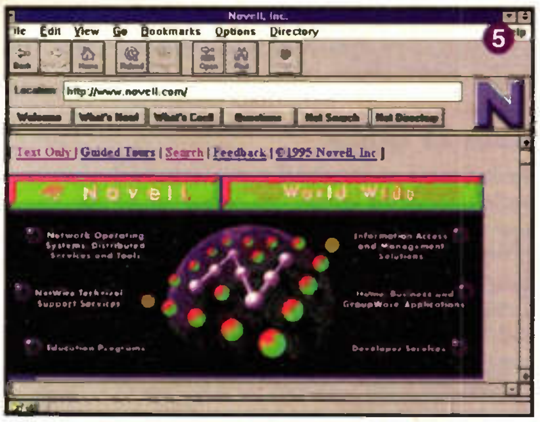


Figure 5. Novell's Internet publisher for use with WordPerfect 6.1 can be downloaded from the Novell WWW site.

Internet Publisher includes fonts in the document template which more closely resemble how the text will appear in Netscape, so users can get an accurate view of how their documents will appear when posted on the Internet. If users are not connected to the Internet, they can use Netscape Navigator 1.1 on their local drive to see what their documents will look like on the WWW.

Indeed, the software gives WordPerfect 6.1 users everything they need to create hypertext mark-up language (HTML) documents, the original document format of the WWW. A template guides users through the process of creating an HTML document, and a conversion program automatically converts the WordPerfect document into a native HTML file.

Users can access HTML features such as hypertext links, graphics and bullet lists from the WordPerfect toolbar, as well as the features most commonly used in creating a home page, such as links to other documents, graphic images and lists for easy navigation to other areas on their page.

Technology

In addition to considering the creative elements that make up a WWW site, it is important also to consider the underlying technology. Before anything else, a WWW presence requires a WWW server connected to the Internet. There are two options. Either rent space on a server from a third party, or utilise an internal system.

There are advantages and disadvantages to both approaches. Having a WWW server sited locally means that you remain in total control. Pages can be modified and updated instantaneously, and you can see who is accessing the server in real time. The downside is that you must be familiar with the technology, and install firewalls to prevent intruders from hacking into your network.

Bandwidth

Internet providers offer a high-bandwidth connection to the Internet. This means that individuals accessing your WWW site will be able to secure a connection at first attempt. To secure a dedicated high bandwidth connection to the Internet is costly, and has to be done via a leased line direct to an Internet provider.

Under this model, the local telecommunications company will provide a leased line from your site to the Internet provider. Typical bandwidth ranges from 64K-bit/s to 2M-bit/s, allowing for between 2 and 70 high-speed modem connections at any one time. The Internet provider will connect you to the Internet via a router. This device will manage connections to your site and deal with all physical addressing issues associated with the connection. A typical cost for a commercial 64K-bit/s line including rental, the router and technical support is £9,600 per month.

With an Internet connection in place, the next consideration is to select a computer to act as the WWW server. A Pentium PC or Apple PowerPC can be configured for this task, costing in the region of £3,000. However, most WWW servers which run on the Internet are UNIX-based, allowing numerous accesses at any one time. A widely used machine is the Sun Netra, costing in the region of £9,000.

Budget Entry

Renting space on somebody else's server is the low budget entry-level option, and means you do not have to get too involved in the technology. Indeed, individuals are opting to create their own WWW sites using this approach. Most Internet providers such as CompuServe, Cityscape and Pipex offer this facility. In each instance, their server is connected to the Internet using a high bandwidth connection.

Here, the major disadvantage is the loss of control. You are reliant on a third party to maintain the site, based on updates which you provide. Another concern can be getting access to the server. If a number of popular WWW sites are held on the same server, it can very quickly become locked, with demand outstripping available bandwidth.

Naming Conventions

Whatever route you choose to follow, you will have to give it a domain name. To avoid duplication, domain names are registered centrally by paying a one-off fee of £200. This process is usually handled by the Internet provider. A domain name should reflect the content of the site. Typically, these are based on company or individual names. The key to a successful domain name is to make it memorable. Users have to remember it to type into their WWW browsers, so simplicity is the key to getting your site noticed.

Case Studies

And so we come back the question with which we began, can marketing on the Internet really create business? Surrey-based Interactive Media Communications (IMC) think it can. The company's Route-One pages at **http://www.route-one.co.uk/route-one** (shown in Figure 6) provide some of the first proof that the Internet offers completely new opportunities for business. IMC creates electronic brochures for clients on its WWW space and then uses its Net listing and market knowledge to attract WWW browsers to its clients' pages.

"Clients come to us to create a presence on the WWW. But what invariably happens is that we can show ways to take advantage of the technology to create marketing opportunities not otherwise possible", claims Jeremy Gassman, technical director at IMC.

Figure 6. Interactive Media Communications WWW site.

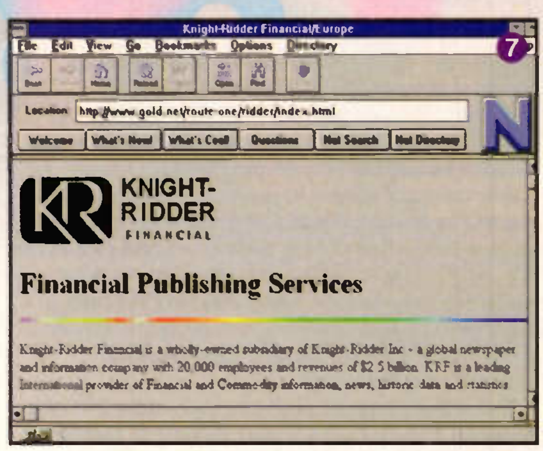


Figure 7. Knight-Ridder claims it saves on sales and administration costs by using its WWW site.

Knight-Ridder Financial Services

This was the case with Knight-Ridder Financial/Europe, a subsidiary of the US global billion dollar organisation providing Financial and Commodity Information, news, historic data and statistics. Knight-Ridder Financial (Europe) supplies unique historical investment charts plus prices to update trends daily. The information covers cash, futures, agricultural, and stock indices for 50 exchanges, covering 500 markets.

For the UK arm of Knight-Ridder, IMC created a WWW brochure at **http://www.gold.net/route-one/ridder/index.html**, as shown in Figure 7, on which clients can see a full description of the company's services. IMC also organise the downloading of examples of the financial information provided, so within minutes of finding the information, potential clients can test out for themselves exactly how useful it would be for them. As a direct consequence, Knight-Ridder staff are saved substantial time and expense answering and mailing requests for disks carrying this sample information, and the company is automatically informed of the addresses of callers downloading their information.

Once pages are up on the WWW, the cost of advertising 24 hours a day around the world is virtually zero. Knight-Ridder's pages have been drawing hundreds of enquiries each month. "The volume and quality of business has been much higher than we expected", claims Knight-Ridder sales and marketing executive, Binaifer Vakil. New accounts have included some from the USA.

By contrast, Scotlens is a relatively small company. It is an independent Scottish manufacturer of contact-lenses made with advanced materials, which are sold only to professional practitioners. "The Scotlens pages show how innovative thinking to make best use of the Internet can open up completely new business possibilities", claims Gassmann. Jack Brown of Scotlens was sceptical at first about the value of using the Internet. "I didn't think there would be too many practitioners on the Internet". However, as an innovative company within the industry, Scotlens gave it a try.

The development which brought the profession flocking to Scotlens' WWW pages was a world-first service made possible only by the new technology. Optometrists found they could order the most complicated lenses by simply typing in measurements on-line on the WWW. A 'send' button has the prescription in Scotlens laboratories within seconds, and manufactured and returned by post within a day or two. Free consultancy for any problems was also introduced by e-mail.

The Internet can also bring marketing success for unexpected reasons. With the help of research photos which can be seen on-line, Scotlens' WWW pages at **http://www.gold.net/route-one/scotlens/index.html** (as shown in Figure 8) describe the value to contact-lens wearers of new materials.

Scotlens sells only to practitioners, but to their surprise, the company has received countless calls from contact-lens wearers asking for the lenses. Jack Brown said, "We tell them we supply only practitioners. So what callers have done is print out our information, take it to their practitioners, asking them to order the lenses for them. We've gained numbers of new professional clients this way for our Aquasil and Aquasulfone lenses."

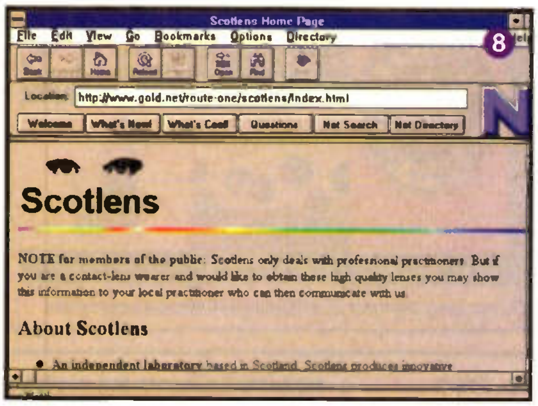


Figure 8. Scotlens has automated the process of ordering contact lenses with the use of its WWW site.

A Worthwhile Opportunity?

As the case studies demonstrate, the Internet has massive potential to create business opportunity, but as yet, there are very few examples of companies using the Internet seriously. At the moment, we are playing with the medium, and this is the way it will stay until consumers get online en-masse, and Internet providers make services more reliable and secure.

At the moment, I am the only Internet user in my immediate family. Not surprisingly, my characteristics map completely onto the statistics outlined in Figures 1, 2 and 3. Business on the Internet will become a true reality when my fiancee, and my parents get on-line, and until then, it is a fun game.

Further Browsing

- For further statistics on the profile of Internet users, **contact http://www.survey.net** (see Figure 1)
- A Microsoft WWW publisher companion for Word can be downloaded from **http://www.microsoft.com**
- Stephen Waddington can be reached by e-mail at **swaddington@cix.compulink.co.uk**

@Internet

We have looked at FirstClass systems before on these pages, but it's nice to see a British one take to the Internet with a great deal of panache and flair. You can reach *the frame* on the Internet as a World Wide Web (WWW) site with a conventional Web browser, at: **http://www.theframe.com/**

Alternatively (and preferably), you can access it fully using FirstClass. Use the latest version (2.7) of FirstClass if you've got it, and for the terrific graphics you'll need to have *the frame* settings (which can be downloaded from the site). If you use FirstClass via an Internet connection, point your FirstClass setup to the server: **fc.theframe.com**

or, if you want to do it by IP number: **194.129.172.99**

– either way, make sure you're set to port 3000 under advanced settings.

Alternatively, you can dial-in through a modem by telephoning (0171) 734 1200. Whatever method you use to access *the frame*, you need a user ID and password: use the word demo for both. Designed essentially for people in the creative, production or design businesses, *the frame* is a nice combination of a FirstClass bulletin board look-and-feel, with the versatility of being a full-blown Internet provider. Using *the frame* you can chat in real time with others, have your own e-mail address, with the ability to transfer megabytes of files from or to suppliers or customers, rapidly and cleanly. Pipex points of presence around the country are used to provide full UK coverage, mostly with local call access.

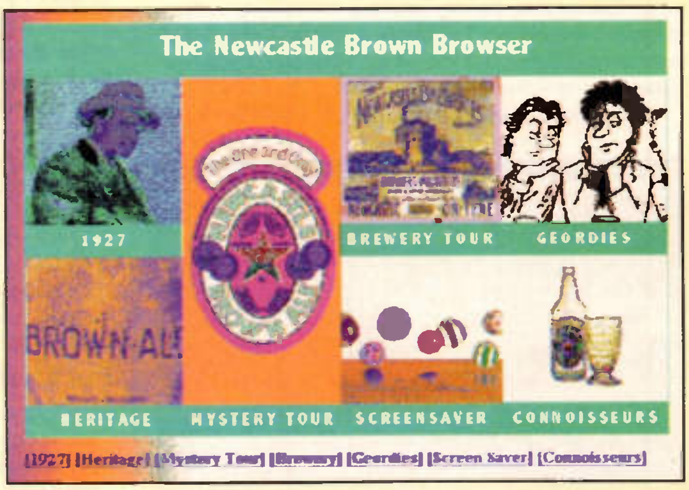
FirstClass has had Internet-ability since version 2.6, and many FirstClass servers worldwide have been on-line with the Internet since – we've looked at some in earlier issues. However, *the frame* is, we believe, the first such commercial UK service and well worthy of note for that. It is worthy of note too, for its superb graphical Interface, which is both attractive and speedy.

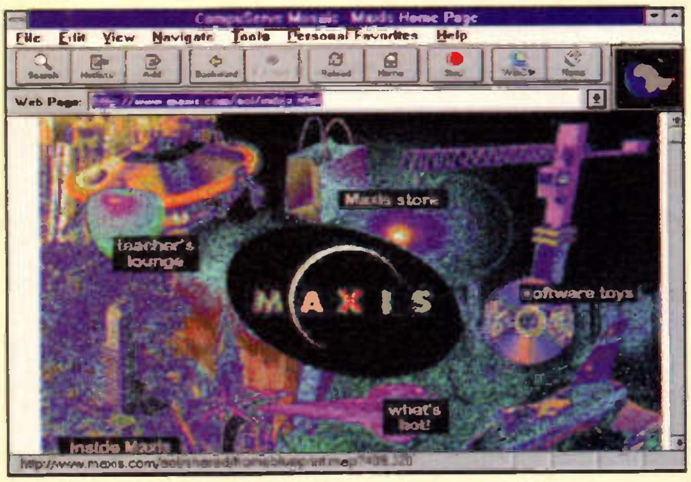
Swap Guinness for Newcastle Brown

If you've got bored with the Guinness screen saver, here's another to download. Newcastle Brown Ale has opened for business on the WWW, with a brewery tour at: **http://alpha.communicata.co.uk/broonale/contents.html**. Visitors can also download a neat screensaver and learn about the history of Newcastle Brown and the North East.

SAAB Site

SAABs have a reputation of being among the safest cars on the road. They have now taken to the information highway. SAAB recently launched a WWW site at: **http://www.saabusa.com**, where among other things, visitors can take part in the SAAB quiz and register to win a six-month lease on a new 1996 SAAB 900S Convertible. The site also includes model information, news and a store.





SimCity Extends to WWW

Maxis, developer of SimCity and other simulation games, has launched a WWW site at: **http://www.maxis.com**. The site includes news about Maxis products, technical support, product-related links, and hints and cheats.

Users can also download the latest cities for the SimCity game, order software and other Maxis paraphernalia. There is also a teacher's lounge, where the teaching professional can learn about the sociological models on which SimCity is based, for subsequent use as teaching aids.

CompuServe Gets Personal

CompuServe will soon support Personal Addresses, thus allowing members to be addressed by name, not number. The feature is optional, and can be used in addition to the user identification number. To handle the onslaught of requests, users can preregister, with long-time members having top priority. The addresses will be supported in early 1996.

Contact: CompuServe, Tel: (01272) 670 700.

Creating Your Own Pages

The language that WWW pages are written in is the hypertext markup language (HTML). This consists basically of codes which instruct whichever Web browser you're using to display the text and pictures the way the page designer wants it to appear (more-or-less, anyway). So, a textual phrase such as:

"Hello there. How do you feel?" could be written In HTML as: Hello there. How do <EM>you</EM> feel?

Of course, there's a little more to it than just that – quite a lot more to it in fact, but to date, anyone with a bit of common-sense, a computer and a book of HTML codes could construct a Web page ready for displaying on the WWW. However, many modern computer applications such as word processors and the like are getting in on the act, Incorporating HTML filters which enable users to export existing documents as HTML files. There are several dedicated WWW page creation programs around too, some of which are pretty versatile. We will be looking at the approaches over the next few months.

One of the best tools for the job is BeyondPress. Now, just to confuse the issue, BeyondPress isn't a dedicated HTML-creation program, neither is it an HTML filter. It is a complete add-on utility which is designed for use solely with the desktop publishing program, QuarkXPress. In terms of popularity, QuarkXPress is probably the favourite DTP program for producing magazines and brochures and, indeed, this very magazine you're reading *and* the Maplin Catalogue are both produced with QuarkXPress.

BeyondPress is a plug-in tool for QuarkXPress which extends the capability of the program (such plug-in tools are given the name *XTensions* in QuarkXPress parlance), so that users can create HTML files ready for the Web directly from existing QuarkXPress documents. So, it's feasible that a magazine publisher like Maplin could directly export a magazine from an existing document.

The main feature of BeyondPress is a new palette (the Document Contents palette) where the parts of a QuarkXPress document to be formed into a Web page are added. You can edit, move, adjust and control these contents to suit, as well as adding extra features and parts such as horizontal rules and spaces, within the palette. What is even nicer, is the ability to work with a Web browser in parallel, so that any particular part of the document can be viewed at any time. Similarly, once a document is finished and exported, you can opt to see it complete in your browser.

In essence, a tool as powerful as BeyondPress takes the slog out of creating Web pages. You don't even need to know a single HTML code, and you can view the results of additions and changes, while not quite in real time, at the touch of a button.

BT Inmarsat Helps Antarctica Become a Virtual Reality

Students are being invited to join an interactive expedition to the blue icescapes of the Antarctic, thanks to the Internet and satellite links from BT Inmarsat. Pictures, expedition updates and scientific information are being beamed from the ship direct into classrooms around the world. The international expedition, TerraQuest, set off from the world's southernmost city, Ushuaia in Argentina, on December 13, and is now ready for interaction. Through the Internet, students will be able to take part in daily discussions, landing parties and study groups.

'Virtual passengers' will be able to experience for themselves, the diverse landscapes, see icebergs carving into the sea and learn about its ecological relevance. Topics for study Include global warming, ozone depletion, krill harvesting and the Antarctic eco-system's dependence on it at the bottom of its simple food chain. The Interaction between the ship and UK schools by direct-dialled telephone, fax, e-mail and data transfer will be accomplished via SatMail and C-Sat technology, two of BT Inmarsat's services for ocean-going vessels.

Having left Ushuaia, the crew are currently on their way to Antarctica through Drake Passage, a rich feeding ground for whales, seabirds and other sea life, sailing toward Half Moon Island, Deception Island and Charlotte Bay for an 'ice cruise'. To catch up on daily activities and progress, future plans and background information, Internet browsers can access the TerraQuest expedition on **http://www.terraquest.com**. For further information on BT Inmarsat, call the BT Inmarsat Customer Service Centre (UK) on Freefone (0800) 318684.

Surf the Silicon with Digital

Internet explorers can now check the latest information about the world's fastest microprocessors and Alpha's push into the Windows market, through Digital Equipment Corporation's new Digital Semiconductor InfoCenter on the World Wide Web (WWW).

The new WWW site also enables system and board manufacturers, end users, industry and other interested parties to learn about Digital Semiconductor's industry-leading PCI-based networking and bridge chips, PCI multimedia chips, and the forthcoming StrongARM low-power, high-performance chip family now being developed.

A broad range of information is offered, including a complete product catalogue, new product news, history, literature ordering information, sales contacts, and more. Supported by an AlphaServer multiprocessor system in Palo Alto, the Digital Semiconductor InfoCenter is accessible directly at: **http://www.digital.com/info/semiconductor**

All For One and One For All

The Rand Institute in the US has conducted a study into the Internet and its uses, and has concluded that every US citizen should be provided with an e-mail address: by right, not by measure of being able to pay for it. The purpose of its findings is to ensure that a situation is not allowed to arise where those without money have no access to information, while those with money have all the information they need. The report suggests that a situation could otherwise occur of an 'information apartheid' between social classes.

Ironically (and remember, Americans aren't famed for their irony), this comes from a country whose wealthiest 1% of the population owns 40% of the nation's own capital. Part of the solution would be, says the report, to provide Internet access and an e-mail address for everyone in the country, and computers in public places and streets, much as 'phones exist now. That solves only a fraction of the problem, of course. Surfing the Internet and e-mailing is significantly more difficult than 'phoning.

Low-Cost Internet Service

We are not sure how much how much Martin Turner, CompuServe's product marketing director pays for his fish and chips, but they are expensive. Announcing CompuServe's Internet-service, Turner claimed that now anybody could have Internet access for the price of a bag of fish and chips.

The new CompuServe SPRYnet tariff is cheap, but not that cheap. SPRYnet's Bronze club will cost £3.95 per month for the first three hours of connect time. As users grow from novices to power Internet experts, they can move up to the 'Silver Club' at £6.95 per month for the first seven hours or the 'Gold Club' at £14.95 for the first 20 hours. Additional hours for all pricing plans will be charged at £1.50 per hour. SPRYnet will be available at the end of the year. In March 1996, customers will be able to request a free disk giving them access to SPRYnet, by contacting CompuServe on (0800) 000444.

Roughing It on the Internet

The Rough Guide brand is renowned across the world for its down-to-earth travel guides. I suppose it was only a matter of time before the series moved into cyberspace, with the Rough Guide to the Internet. The Rough Guide to the Internet is written by Angus Kennedy, ex-editor of EMAP's Internet magazine. Kennedy goes back to basics, showing readers how to get connected to the Internet, before discussing WWW browsers and embarking on a site-by-site journey through some the best WWW sites around.

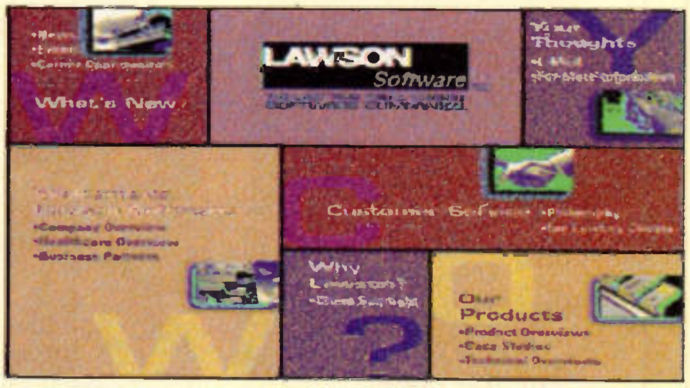
Published by Penguin, the Rough Guide to the Internet is in the book shops now priced at £5, and is a must for individuals who have yet to take a step out into Cyberspace. For more details check out the Rough Guide WWW site at **http://www.roughguides.com**, or contact Penguin.

Contact: Penguin, Tel: (0171) 416 3000.

WebTree Maps-out WWW Sites

Webtree is a utility designed by Lawson Software to guide Internet users through the hundreds of pages of corporate, product, customer, partner and media information typically available on WWW servers. The software tool provides a hierarchical view of the WWW site structure, allowing users to see where they are at any given time and enabling them to skip directly to the information they are seeking.

Webtree will also assist WWW site developers to create sophisticated, hyper linked sites by automatically generating the HTML code that creates the WWW tree structure, and populating each page with standard navigational, copyright, and company signature codes. Although the company has yet to decide how it will distribute the software, Version 1.0 is available now, and can currently be downloaded from Lawson Softwares' WWW site at: **http://www.lawson.com**



Site Survey

The month's destinations

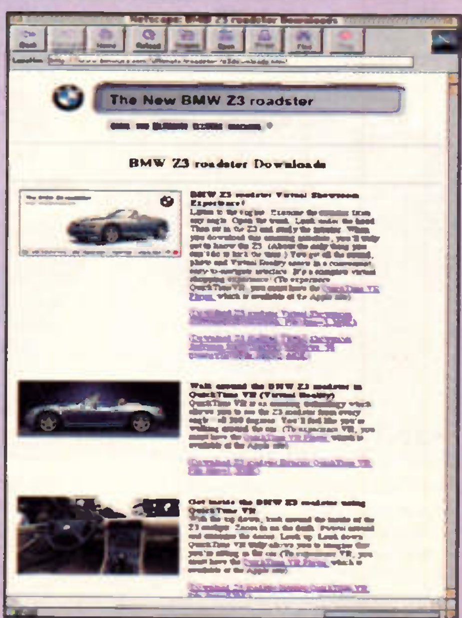
If you've been to see the latest Bond film *Goldeneye*, you'll be aware of the BMW Z3 Roadster used in the movie. Want to try the car for yourself? Well, you can now take a close look at it – complete in virtual reality. The BMW Z3 Roadster page is at: **http://www.bmwusa.com/ultimate/roadster/z3downloads.html** – where you'll find all sorts of interesting virtual reality movie clips to download. Do not hold your breath while downloading, though, because they're all mega-big. You will also need Apple's QuickTime VR player, which you can get from: **http://qtvr.quicktime.apple.com/**

QuickTime VR player is available in both Mac and Windows formats and, as such, looks set to become the Internet standard for virtual reality surfing. A site which calls itself the very first functioning clock on the WWW (and it probably is – we've never found another so far) can be browsed at: **http://www.higgs.com/cgi-bin/time.html**

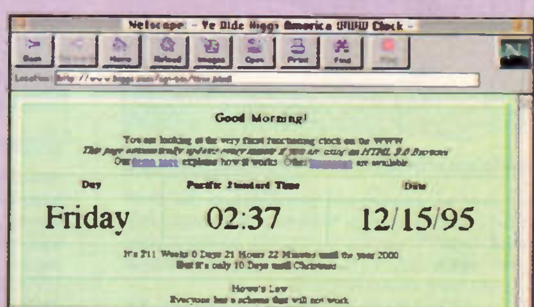
Now, at long last, while you're browsing your heart out and your 'phone bill's soaring skywards, you can at least keep track of net-time.

Apple's QuickTime VR player ▶

▼ BMW Z3 Roadster Site



▼ WWW Clock



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.

The referenced back-numbers of *Electronics* can be obtained, subject to availability, at £2.10 per copy.

Carriage Codes – Add; A: £1.60, B: £2.30, C: £2.90, D: £3.40, E: £4.00, F: £4.70, G: £5.50, H: £6.00.

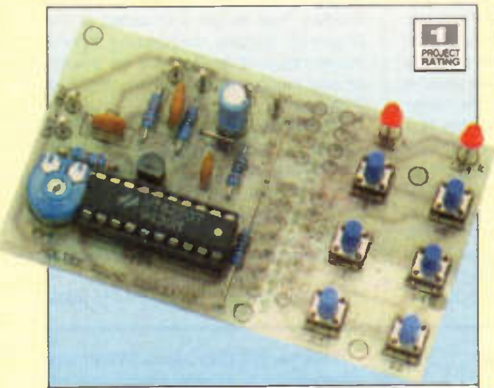
DID YOU MISS THESE PROJECTS?

The Maplin 'Get-You-Working' Service is available on all of these projects unless otherwise indicated.

To order Project Kits or back-numbers of *Electronics*, 'phone Credit Card Sales on (01702) 554161. Alternatively, send off the Order Coupon in this issue or visit your local Maplin store.

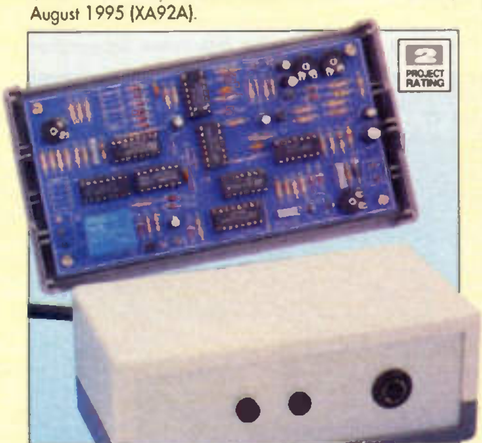
Maplin: The Positive Force In Electronics

All items subject to availability. Prices include VAT. E&OE



WESTERN SOUND GENERATOR

Mosey on down to the workshop and build this super 'audio six-shooter'. The easy-to-build unit produces 6 'Wild West' sounds like horses, guns, etc., for plays, toys, novelty doorbells, or simply just for fun.
Order as: 90030, **£7.99**. Details in *Electronics* No. 92, August 1995 (XA92A).

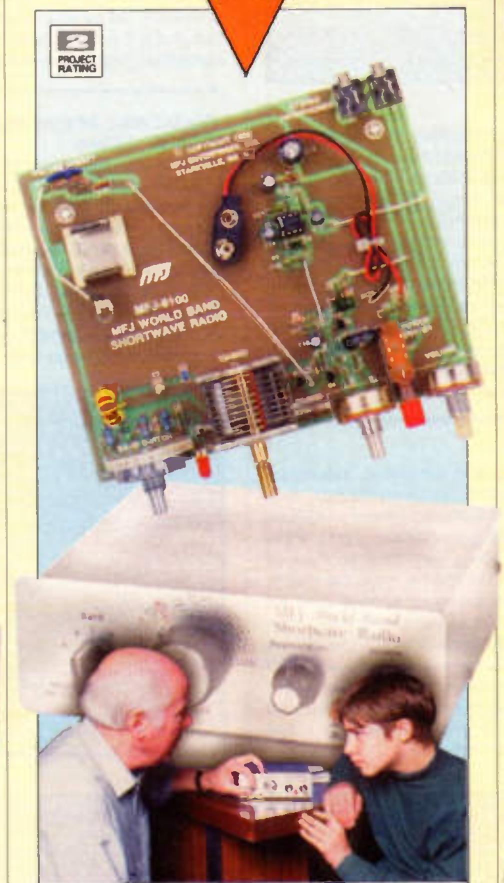


CALL CODE SWITCH

Don't just 'phone home, 'phone the microwave and start your dinner cooking! This telephone activated switch and timer can be used for a host of remote control functions like turning lights on and off while you're on holiday. What is more, there are no huge 'phone bills or direct connections, as the unit is controlled by the sound of the 'phone ringing.
Order as: 90029, **£22.99**. Details in *Electronics* No. 92, August 1995 (XA92A).

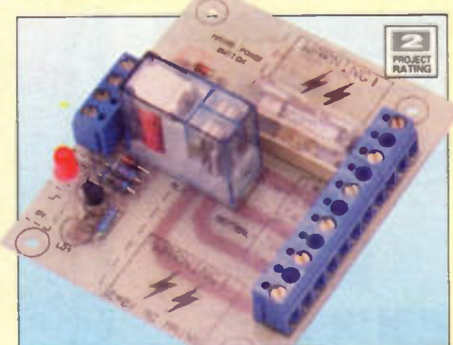
CW FILTER

A very useful add-on continuous wave (CW) peak filter circuit for basic shortwave receivers, which helps to separate closely bunched Morse CW signals and cut out the 'unwanted' ones. The unit operates from 11 to 15V DC and is small enough to fit inside many existing receivers.
Order as: 90045, **£4.99.** Details in *Electronics* No. 93, September 1995 (XA95D).



SHORTWAVE REGENERATIVE RECEIVER

Listen to the world and recapture some of the look and feel of the early days of short wave radio reception. The receiver covers frequencies from 3·5 to 22MHz in 5 bands, using a regenerative technique, and is therefore easy to build and set up.
Order as: 90032, **£69.95** C. Details in *Electronics* No. 92, August 1995 (XA92A).

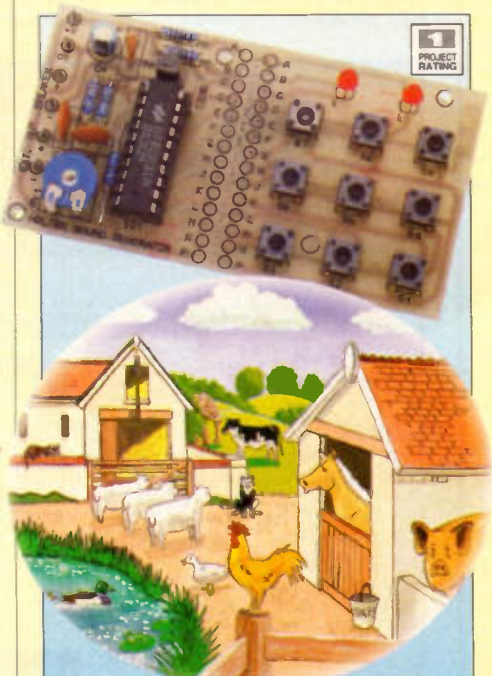


MAINS POWER SWITCH

Give power to the elbow of your low-voltage projects, etc., by enabling them to control mains-operated equipment. This versatile, low-cost project can safely switch 230V AC mains equipment up to a maximum current of 5A (resistive). The versatile inputs give the option of either low-voltage (9 to 15V DC) or an open or closed contact. Order as: 90043, **£6.99**. Details in *Electronics* No. 93, September 1995 (XA95D).

MULTI-STROBE

The flashiest strobe in town! This stand-alone strobe unit can also be 'daisy-chained' with more units to produce stunning multiple strobe effects, controlled via the built-in RS232 input. Features include built-in variable speed controller and optional remote-control oscillator.
Order as: 90015, **£34.99** A1. Details in *Electronics* No. 92, August 1995 (XA92A).



ANIMAL SOUND GENERATOR

An electronic farmyard of 12 animal sounds at the push of a button, without the usual accompanying smells, or mess to clear up! Ideal for toys, games, doorbells, plays, etc. Nine push-buttons select pig, cow, cockerel, hen, frog, sheep, cat, horse and a 'medley' of elephant, dog, bird, duck, plus all the other sounds in sequence.
Order as: 90033, **£6.99**. Details in *Electronics* No. 93, September 1995 (XA95D).

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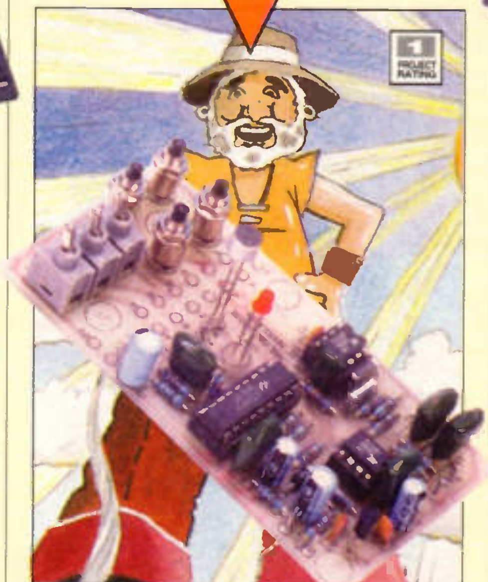
VIDEO DIGITISER

A real-time digitiser card for PCs running Windows™ 3.1 and higher. The project converts video signals into digital data that can be viewed, processed and stored by the PC. Ideal for producing hard copy from security cameras, computer graphics design, capturing pages of teletext or other information, or even scenes from *Baywatch*.
Order as: 95010, **£139.99** G1. Details in *Electronics* No. 96, December 1995 (XA96E).

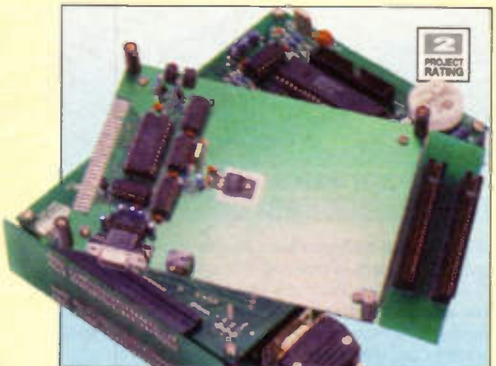
REAR WINDOW DEMISTER AERIAL

No need to drill holes in your pride-and-joy! This clever project allows the rear window demister element to double as an aerial. Ideal for classic cars, or those with fibreglass bodies, or where the local kids practise origami on conventional aerials. Much neater and effective than a wire coat-hanger.
Order as: 90065, **£24.99** A1. Details in *Electronics* No. 96, December 1995 (XA96E).



VOICE MODULATOR

No, it won't make you sound like Arnie Schwartzenegger or Tina Turner – Metal Mickey or a Dalek maybe. This project produces robotised and vibrato effects which are ideal for toys and games, sound effects for plays etc., discos, or simply just for fun. Accepts microphone and line level inputs.
Order as: 90077, **£17.99**. Details in *Electronics* No. 96, December 1995 (XA96E).



Z80 DEVELOPMENT SYSTEM

For low-cost applications, the evergreen Z80 microprocessor with its 64K-byte addressing space, I/O space, and a wide-ranging instruction set, is still first choice. This project allows the existing Maplin Z80 CPU Module (LK67X), to be used with Windows™-based software running on a PC. The project comprises a serial interface, RS232 data link and Windows™-based software (note the Z80 CPU Module is not included in the kit).
Order as: 90053, **£34.99** A1. Details in *Electronics* No. 97, January 1996 (XA97F).

RS232 TO 8-BIT CONVERTER MODULE

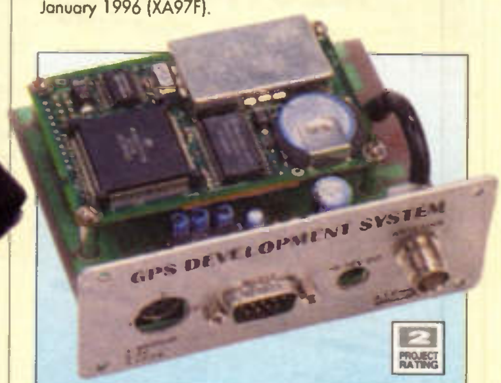
This PIC microcontroller based project provides an ideal communications building-block for computer equipment. Each I/O line is TTL and CMOS compatible, individually configurable as input or output, and can even be switched on-line, via the RS232 interface.
Order as: 95018, **£14.99**. Also available ready-assembled, Order as: 95049, **£19.99**. Details in *Electronics* No. 97, January 1996 (XA97F).

K7100 DIGITAL MULTIMETER KIT

Build yourself a high accuracy, manual/autoranging LCD Digital Multimeter with AC and DC voltage and current ranges, resistance, continuity and diode test facilities. Ideal for newcomers setting up their first test bench, and accurate enough for professionals.
Order as: 95011, **£60.99** A1. Details in *Electronics* No. 97, January 1996 (XA97F).

VIDEO KALEIDOSCOPE

Produce music-controlled psychedelic patterns on your TV with this PIC microcontroller-based project. The patterns change in accordance with the beat of the music in the room or from a direct audio input. Ideal for the latest House, Rave and Hip-Hop music, and those of us who remember platforms and flairs.
Order as: 90073, **£39.99** A1. Details in *Electronics* No. 96, December 1995 (XA96E).



GPS DEVELOPMENT SYSTEM

Global Positioning Systems (GPS) use 'Star Wars' satellite technology to pin-point your exact position on the Earth's surface. This project, when coupled to a lap-top computer, can be used as a stand-alone navigational aid, and provides an ideal platform for experimenters to develop their own satellite navigation applications (note the Oncore Receiver Module, Antenna and sundry items are not included in the kit and must be purchased separately).
Order as: 90079, **£32.99** A1. Details in *Electronics* No. 97, January 1996 (XA97F).

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12/24V TO 220V INVERTER

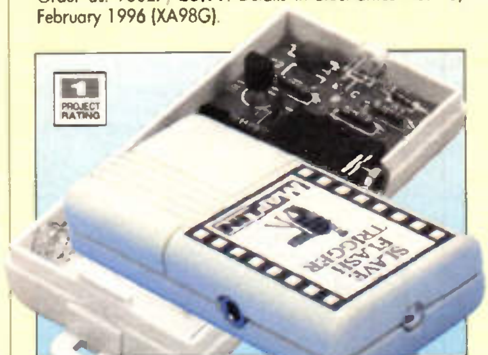
Use mains powered equipment where there's no mains! Providing you've got a 12 or 24 volt battery, e.g., as used in cars, caravans, boats, etc., this project converts the low voltage of the battery into 220V 'mains'. Ideal for power tools, TVs, computers, and field-service applications where sophisticated test equipment may be required where there is no mains supply. Order as: 95013, **£49.99** B1. Details in *Electronics* No. 98, February 1996 (XA98G).

CCD CAMERA TV MODULATOR

Enables the output of monochrome and colour CCD cameras or other 'video only' equipment to be displayed on your UHF TV set. Ideal for home CCTV security systems. Order as: 95020, **£13.99**. Also available: Ready-assembled CCD Camera and Modulator: Order as: 95055, **£149.99** H1. Details in *Electronics* No. 98, February 1996 (XA98G).

REAR WINDOW DEMISTER TIMER

Save fuel and wear and tear on your car's electrical system by using this project to turn off your heated rear window when you forget to!
Order as: 95027, **£8.99**. Details in *Electronics* No. 98, February 1996 (XA98G).



SLAVE FLASH TRIGGER

Trigger several flash-guns from a single camera and flash-gun, without yards of awkward interconnecting cables. The Slave Flash Trigger detects the flash from the main flash-gun and almost instantaneously fires the slave flash-gun providing lighting from more than one direction, avoiding unwanted shadows and dark areas.
Order as: 95015, **£9.99**. Details in *Electronics* No. 98, February 1996 (XA98G).

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