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ELECTRONICS

The Maplin Magazine

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Super Scan – dramatically boosts your radio scanner's receiving capabilities!

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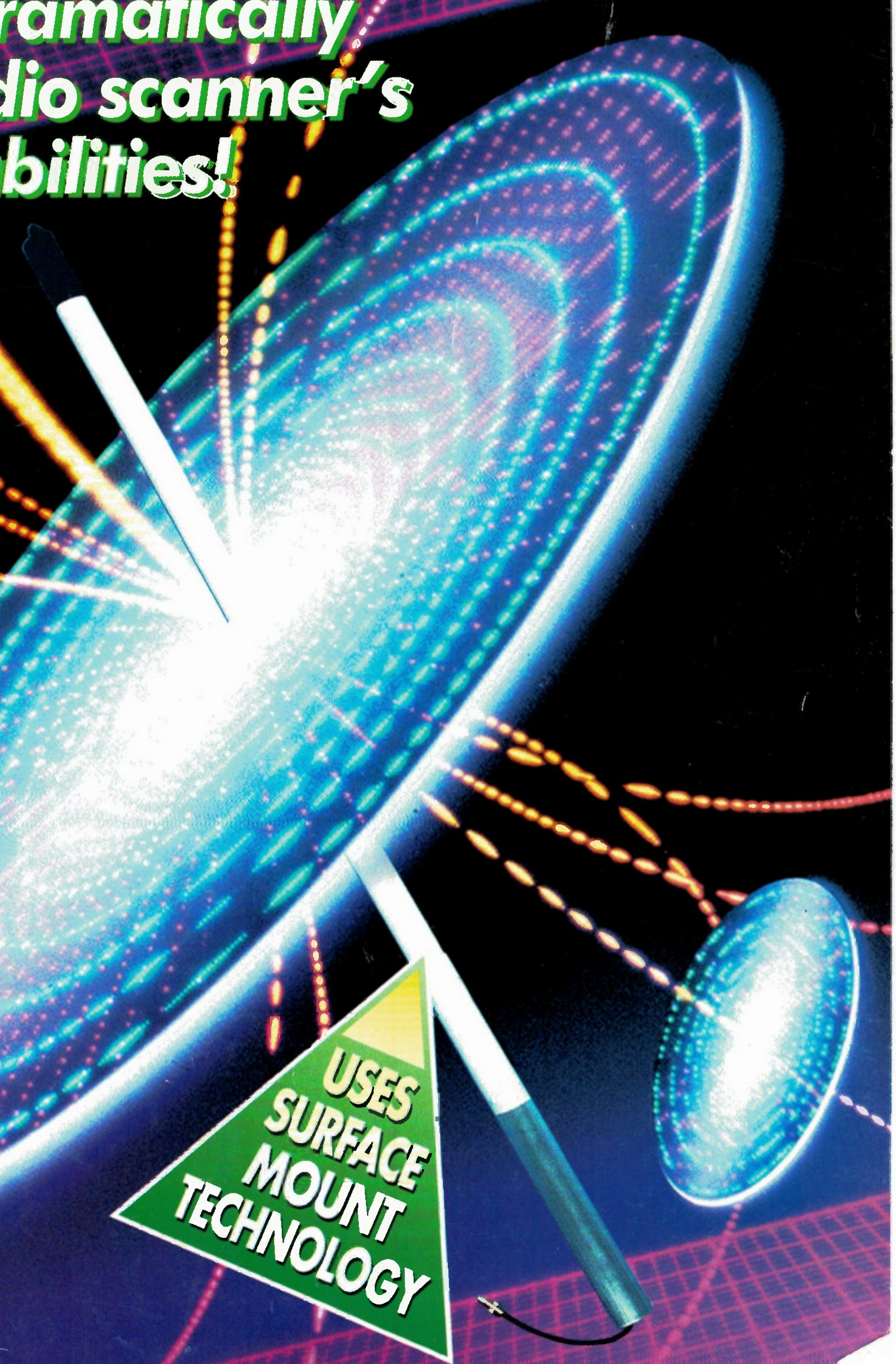

USES SURFACE MOUNT TECHNOLOGY

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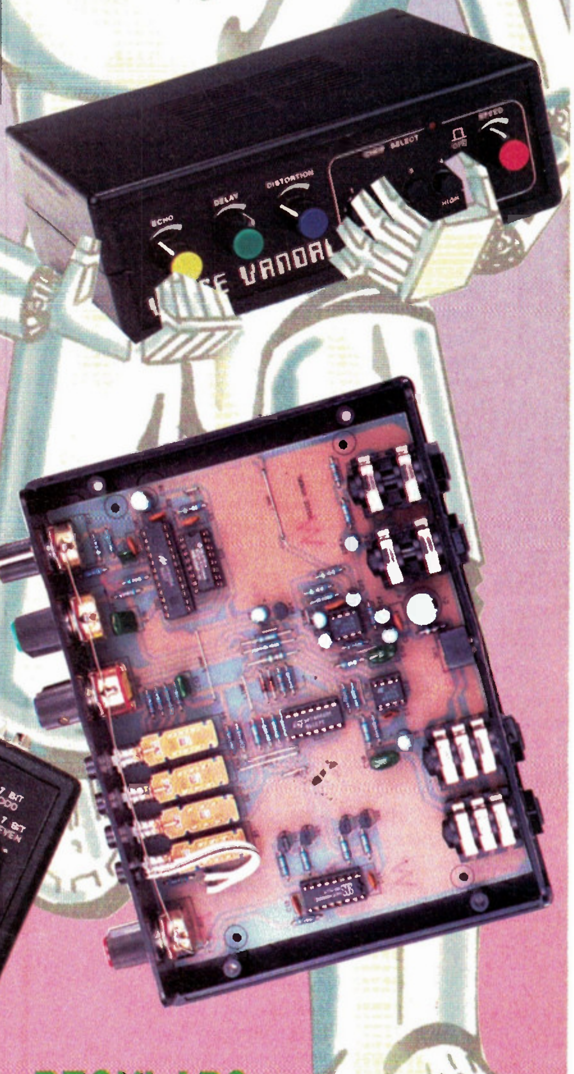
IN THIS ISSUE...

PROJECTS FOR YOU TO BUILD!

FEATURES ESSENTIAL READING!



REGULARS NOT TO BE MISSED!

ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue of *Electronics!* For those of you that do not already know, or who have forgotten, here follows a timely reminder. Commencing at 1.00 a.m. on April 16th (approximately one week after this issue reaches the newsagents), is *PhONEday*, when *all* UK national telephone dialling codes will be changing, to make phone numbers that bit harder than they already are to remember, courtesy of the nice people at BT. To be fair to them, these changes are necessary, to cater for the projected future expansion of the population, and hence greater numbers of telephones added to the network, an essential part of the burgeoning information superhighway. To summarise the changes, a **1** is added after the **0** at the beginning of the code, for example, 0702 becomes 0**1**702, and inner and outer London become 0**1**71 and 0**1**81, respectively. The cities of Bristol, Leeds, Leicester, Nottingham and Sheffield, have all been allocated new codes, whilst premium rate (0891, 0898, etc.), low-cost (0345), free (0800), and mobile phone codes, remain unchanged. The international dialling code changes from 010 to **00**, to bring us into line with the rest of Europe. Still confused? In that case, BT are operating a free service to answer any questions about *PhONEday*, Tel: 0800 01 01 01. One wonders as to the total cost to the nation of these changes, in terms of alterations required to office stationery and documentation headings, business cards, signwritten goods vehicles, wrongly-dialled numbers due to people still trying to use the old numbers, and so on, but I do not suppose that BT would be prepared to give an honest answer to that one!

In this issue, we present you with a veritable variety of four superb projects, namely; the RS232 Serial Line Tester for fast troubleshooting/testing of the hordes of equipment that use RS232 data cabling; the 'Superscan' active aerial, a surface-mount technology unit, designed to further boost the reception of scanners and other types of radio receivers. Then, there is the Voice Vandal, which utilises a form of digital signal processing, to add echo to audio inputs, or change the audio signal beyond all recognition, making for some very amusing sound effects! Also, there is the Wireless Alarm Siren Upgrade, produced as a result of readers' requests for further refinements and features to enhance this popular security system – we aim to please!

In addition, there is another enthralling part in the series, History of Electronics, by Ian Poole, covering the development and evolution of the bipolar transistor, and the second instalment of Mike Meechan's RIAA – Design Considerations series, detailing the types of record player cartridges, their characteristics and applications, equalisation techniques, and RIAA preamp feedback methods. A new, two-part series by John Woodgate, MS Stereo, examines the concept of Mid-Side, or Mono-Stereo (no, this is not an error!) sound recording and reproduction techniques. All this, plus our regular features. So, until next month, from everyone here at *Electronics*, try not to rattle your diodes when getting to grips with the changes to the old dog and bone, and enjoy this issue!

Exclusive Subscribers' Club Special

On offer this month, to subscribers only, is a selection of four specially selected items: A Freezer Alert, a Deluxe Ni-Cd Charger, a Car Air Ioniser, and a 76-piece Toolkit. There is a total saving of £13.00 on these items, based on their normal price. If you are a subscriber, full details of how to order these items are included on the special offer leaflet in this issue – if the leaflet is missing, contact Customer Services, Tel: (01702) 552911. If you are not a subscriber and would like to take advantage of future special offers and other benefits of subscribing, turn to page 43 of this issue to find out more or Tel: (01702) 554161. Note: if ordering by Mail Order, normal handling charges apply, but if you purchase from one of our retail outlets, you will not have to pay the carriage charges.

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

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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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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

A BRIEF HISTORY OF ELECTRONICS

PART 4: The Transistor is Discovered

by Ian Poole

Nobody could have realised the significance of the demonstration which took place on 23 December 1947 at Bell Laboratories. Three men, Shockley, Bardeen and Brattain were demonstrating the 'point contact' transistor to top executives of the company including Harvey Fletcher, Director of Physical Research and Ralph Brown, the Director of Research.

This all happened only seven days after an experiment which worked first time to give the initial working 'point contact' transistor. It was a tremendous Christmas present for the group who had spent many months investigating and researching semiconductor devices. It was also the dawn of a totally new age for electronics, although none of them had any idea of the way in which this new invention would revolutionise electronics and the way we live today.

Beginnings

The first foundations for the discovery of the transistor were laid many years before. Even in the nineteenth century it had been observed that a class of materials had some unusual electrical properties. These semiconductors had a negative coefficient of resistivity, they were able to rectify electrical currents and they exhibited a photoelectric effect. Like the Edison Effect for valves, these properties were not used and the mechanisms behind them were not understood for many years.

Similar to the thermionic valve, the first uses for semiconductors arose out of the need for better radio detectors. Fleming's diode valve and a little later, de Forest's triode or Audion were all expensive to buy and run. Simple crystal detectors made from a crystal of galena (lead sulphide) with a thin wire touching them found favour with radio enthusiasts. First used around 1906, these 'cat's whiskers' were cheap and easy to make, but they were notoriously unreliable. The position of the whisker on the crystal had to be changed quite frequently, but despite this they remained popular until the 1920s.

In spite of its problems the cat's whisker was the first semiconductor diode to be used. It was very crude but nevertheless it worked. Essentially the 'point contact' of the wire on the crystal gave a very basic p-n junction.

Although there was comparatively little interest in semiconductors at this time some other developments did occur. Copper oxide and selenium rectifiers started to be used, particularly in applications like battery chargers. The photoelectric effect was also exploited in photographic exposure meters. However, their use was relatively limited.

Theoretical Foundations

Although some development of semiconductor devices occurred in the 1920s and 1930s, most of the theoretical research into the sub-molecular physics was directed towards thermionic technology. This was because even small advances in this field would produce large rewards and a handsome return on investment.

Even so some academic research did progress in the area of solid-státe physics. The first major breakthrough occurred in 1926 when Schrödinger analysed the behaviour of electrons and devised an equation that described it.

A year later Heisenburg developed a theory known as his Uncertainty Principle. Another researcher, A. H. Wilson who was investigating the quantum mechanics behind semiconductors studied the process of conduction developing a theory which formed a crucial link for much of the later work on semiconductors.

All of this work meant that by the early 1930s much of the modern view of material quantum mechanics had been developed. The way was now open for more practical developments of semiconductors.

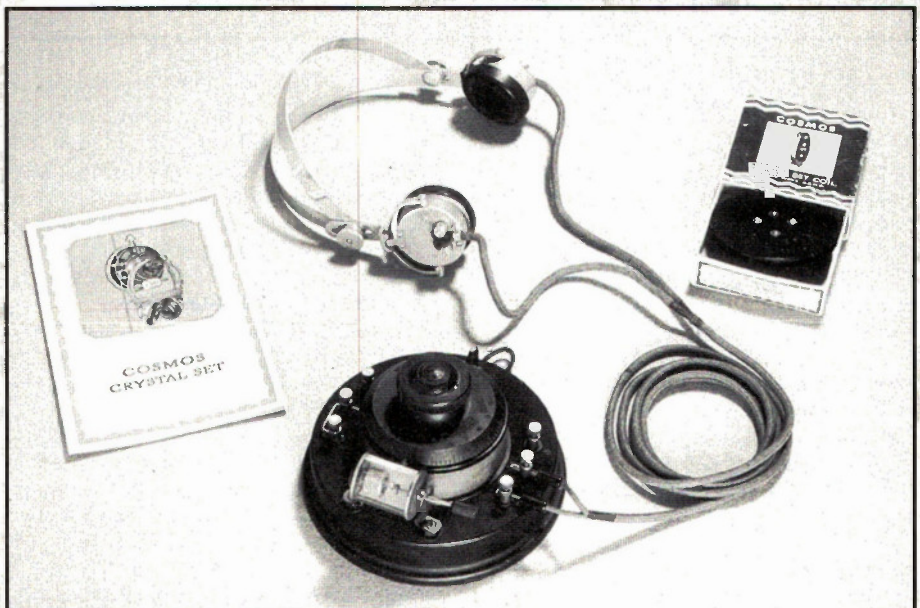
Diode Developments

By the 1930s, radio was firmly established and new possibilities were being investigated. Higher frequencies were being used, and it was found that valves with their relatively high inter-electrode capacitances gave only limited performance.

A further impetus to semiconductor research was given by the outbreak of war. One of the greatest advantages which Britain held over Germany was the use of Radar. Operating on relatively high frequencies the need for high performance high-frequency components became even more acute. With much smaller dimensions, semiconductor diodes were able to operate at much higher frequencies, although they were severely limited by the fact that they had not been developed to the same degree as valves.

Experts in all fields associated with the development of semiconductors from the UK and USA were quickly assembled. Work started on producing 'point contact' diodes.

Before the war, a chemist at Bell Laboratories named Russel Ohl had been working on the development of these diodes. He had succeeded in producing a consider-



Cat's Whisker. ©Copyright Science Museum.

able improvement in performance by improving the quality of the silicon crystals being used. This work also lead to him being able to introduce trace elements into the crystals to produce p and n type silicon.

Soon he managed to produce both types of silicon in the same substrate. With this work as a base, Ohl managed to develop a p-n junction and he found that this worked very well as a rectifier. As the work progressed semiconductor diode technology made many strides forwards. Teams on both sides of the conflict made developments which gave devices with a far superior performance to anything that was available before the war.

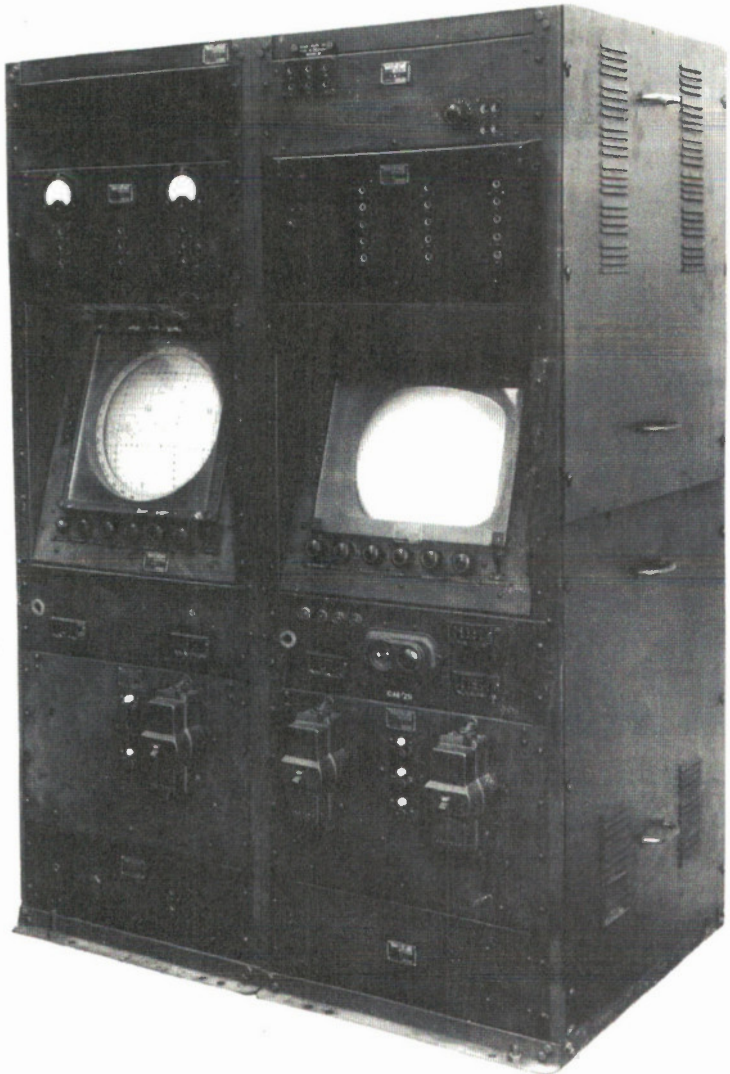
Further Research

As hostilities started to draw to a close, Bell Laboratories realised that there were major possibilities for semiconductor technology. In the spring of 1945 a major meeting was called to discuss the future research into them. Later that year authorisation was granted for research to proceed to seek 'new knowledge that could be used in the development of completely new and improved components'.

As a result a solid-state physics group was set up under William Shockley and Stanley Morgan. Shockley also headed up the semiconductor sub-group which was to include Brattain and Bardeen to make up the trio who invented the transistor.

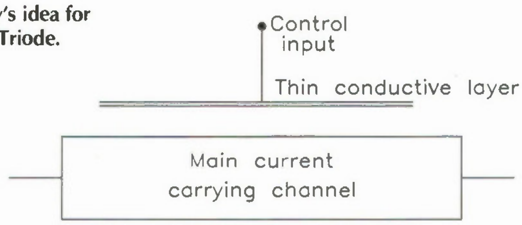
Transistor Trio

William Shockley was born in London in 1910 of American parents. He only remained in England for three years after which his parents returned with him to the USA, settling near San Francisco. Here he gained his first degree from the California Institute of Technology after which he moved to the Massachussetts Institute of Technology to gain his Ph.D. in 1936.



Wartime Radar – GCI Radar Receiver. ©Copyright Science Museum.

Figure 1. Shockley's idea for a Semiconductor Triode.



After leaving University Shockley joined Bell Laboratories, initially working on electron diffraction. In 1955 he moved on from Bell Laboratories to set up his own company called Shockley Semiconductors in his home town of Palo Alto. This company attracted many other semiconductor experts. With the influx of expertise several other companies started up in the area. One backed by the Fairchild Camera and Instrument Company was started in 1957 by a number of Shockley's old employees. This all had a snowball effect and before long this small area had the highest concentration of semiconductor experts in the USA. Silicon Valley was born.

Like Shockley, Walter Brattain was not born in the USA. He spent his first few years in China, moving to Washington State when his parents returned home. He took his first degree at Whitman College in Washington State, moving to the University of Minnesota to gain his Ph.D.

After leaving university Brattain applied to Bell Laboratories but they turned his application down. Instead he went to work for the National Bureau of Standards. Brattain soon applied again to Bell, and at the second attempt he was successful. After joining Bell, he initially worked on copper oxide and semiconductor rectifiers, giving him a good grounding in semiconductor technology. Brattain remained at Bell until his retirement in 1967. During his retirement he held the post of Visiting Professor at Whitman College until his death in 1987.

John Bardeen was the only one of the trio to be born in the USA. He was born in Wisconsin in May 1908. Taking his first degree at the University of Wisconsin, he moved on to Princeton for his Ph.D. After taking up a fellowship at Harvard and a teaching post at Minnesota University he joined the solid state physics group at Bell Laboratories in the Autumn of 1945.

In 1956 he received a Nobel Prize along with Shockley and Brattain for his work on the transistor, but by this time he was involved in research into superconductors. It was in this area that he felt he made his greatest achievements, and in 1972 he was awarded a second Nobel prize for this work.

In addition to his Nobel Prizes he received a number of other awards, including a gold medal from the Soviet Academy for Science. Bardeen died at the age of 82 at the beginning of February 1991.

Preparations

The semiconductor group started work on one of Shockley's ideas. He had deduced that it might be possible to develop a form of semiconductor triode. He envisaged a structure of layers of p and n type silicon. The main current would be carried in one of the layers and the conductance of this layer would be controlled by an external field. This would vary the number of charge carriers (holes or electrons) available to carry the current. Essentially this idea was the field effect transistor which is in widespread use today.

To create the structure to try out this idea, Shockley used some thin films of silicon which had been made by deposition. This in itself was a new process which had only just been developed by another Bell employee named Teal.

Using the new structure, Shockley expected that there would be a significant change in

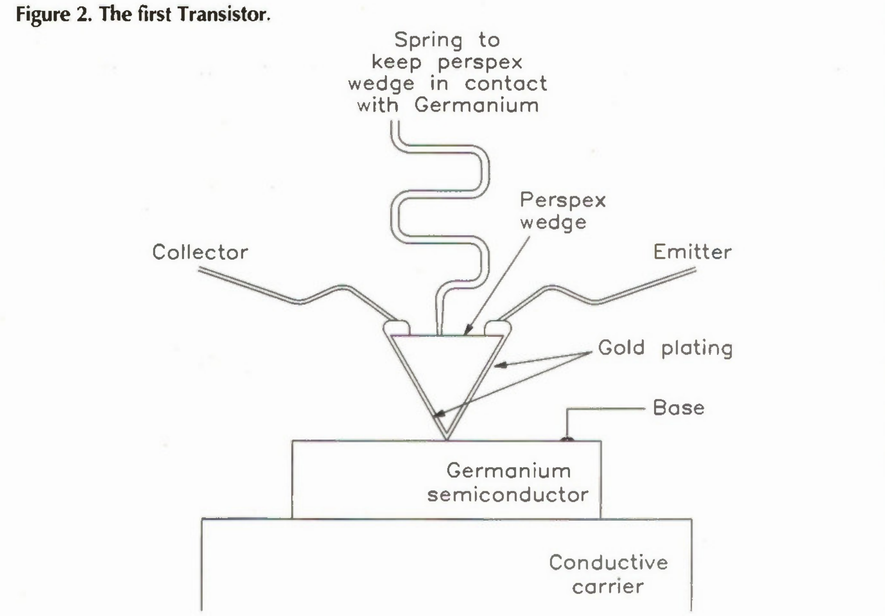


Figure 2. The first Transistor.

conduction as the controlling field was altered. To his great disappointment the effect was not observed. Calculations and theories were checked and rechecked by other members of the group and no reason was found for its failure.

It was not until March 1946 that the problem was solved. Bardeen reasoned that the semiconductor surface trapped electrons which screened the main channel from the effects of the external field. Later Shockley said that this discovery was one of the most significant developments in the whole of the semiconductor programme.

Change of Direction

Supposedly beaten by the trapped electrons the group changed direction. They turned their attention to investigations around reversed biased p-n junctions in an attempt to develop a new kind of lightning arrestor. Research revolved around three layer structures with one forward and one reverse biased junction; work progressed on this through most of 1947.

It was towards the end of that year that events started to look up for the group. In November a new recruit to the team came up with a crucial idea. Returning to their earlier work on field effect devices he suggested that if an electrolyte was placed between the control plate and the conduction channel then the screening effect of the trapped electrons might be overcome. A new experiment was set up and it was successful, if only to a limited degree. With a measure of success behind them the team found a new degree of motivation. In the days that followed a host of ideas for possible amplifying devices were discussed.

The Road to Success

In early December, Bardeen and Brattain started to experiment with two closely spaced 'point contact' junctions. They found that when they forward biased one and reverse biased the other, a small amount of gain was noticed.

Soon the team started some further experiments based around this idea, but initially they were not able to exploit the transistor effect properly. In one experiment an electrolyte was even placed around the sample, but with each new test they came a step closer to discovering the full transistor effect.

Finally they decided that it was necessary to place two diode junctions about 0·05mm apart. This was achieved remarkably easily. A layer of gold was deposited onto a small wedge of perspex. Then a razor blade was used to cut a very thin slit in the gold right at the point of the wedge. Then the wedge was placed onto a layer of germanium under the force produced by a small spring. The collector and emitter were formed by the two gold contacts and the germanium layer was the base contact.

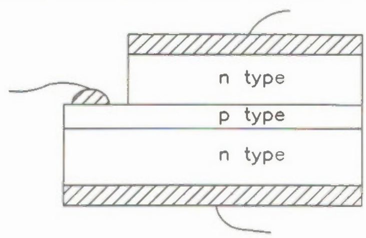


Figure 3. Shockley's idea for a Junction Transistor.

The idea was tried on 16 December 1947 and to their surprise it worked first time. The first 'point contact' transistor had been made.

Exactly a week later Shockley, Bardeen and Brattain found themselves demonstrating the new idea to senior management at Bell. This heralded the beginning of the transistor age. However, many more developments were needed before these devices could become an everyday reality.

The Transistor Develops

The first 'point contact' transistors were very unreliable and not suitable for manufacture. A more reliable and manufacturable idea was needed. Realising this problem Shockley himself came up with the idea for replacing the point contact with a p-n junction. This was not a just a passing thought because all the theory behind the operation of the new style device had been fully defined by calculations. Probably what is more surprising is that he came up with the idea only a matter of weeks after his team had invented the first 'point contact' device.

Even though Shockley was able to prove the feasibility of the junction transistor, it took somewhat longer for him to be able to make one in the laboratory. It was not until April 1949 that the first one was produced. He did this by dropping some molten p-type germanium onto some hot n-type. The resultant blob then had to be sawn down the middle to make the two p-n junctions. Using this very crude demonstration he was able to show that the device had both current and power gain.

Materials Development

During the 1950s very large changes occurred in the development of transistors. Much of this was brought about by the improvement in techniques for manufacturing and refining the raw materials.

In 1950 Teal managed to use the Czockralski process for manufacturing crystals of germanium. Later in 1952 Pfann demonstrated the process of zone refining. In this process an

The 1956 Nobel Prize winners, which include Walter Houser Brattain (far left), John Bardeen (fourth from right) and William Shockley (second from right). ©Copyright Hulton Deutsch.

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FEATURES

✲ Indoor or outdoor use ✲ Wideband HF/VHF/UHF preamplifier ✲ Low power consumption ✲ High gain ✲ Power supply through coaxial cable ✲ No tuning required ✲ Surface mount components

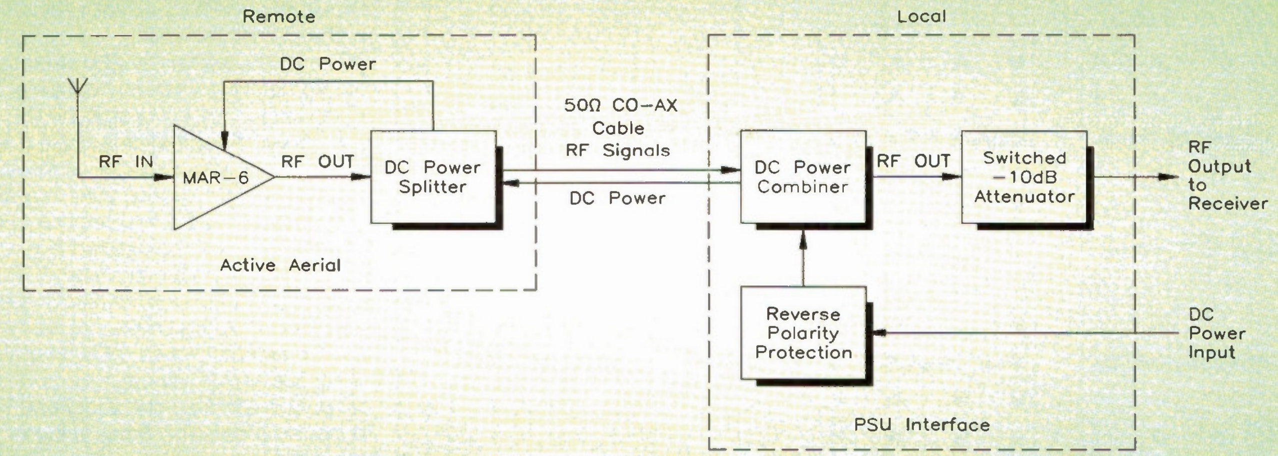
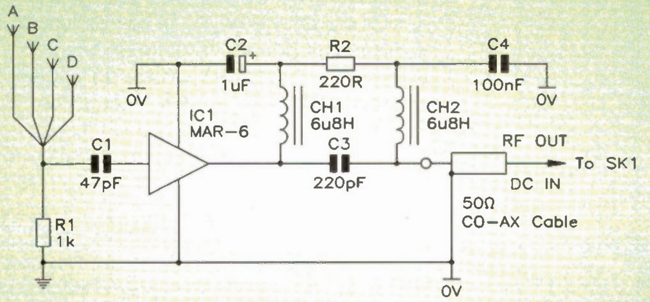
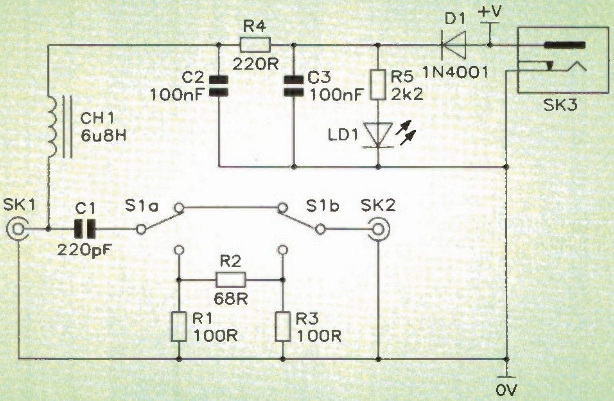


Figure 1. Block diagram of the active aerial system.





Above: Figure 2. Circuit diagram of the active aerial.
Right: Figure 3. Circuit diagram of the active aerial PSU.

A radio receiver or scanner, will only perform within operating restrictions of its aerial system. Nearly all scanners are supplied with a small telescopic aerial. Although this is adequate for local reception, for long distance (DX) or weaker signals, an outside aerial mounted as high as possible is required.

With the increasing frequency range of modern VHF/UHF scanners, a very broadband aerial is needed. The cable, or feeder connecting it to the scanner must have good low loss signal characteristics if the advantages of an outdoor aerial are to be fully realised. All cable will have some losses which increase with feeder length and frequency. To compensate for this the aerial must have signal gain. The passive method of achieving this would be, increase the number of elements, reduce bandwidth and make the aerial directional. All the things you do not want in a scanner aerial system.

The active method is to use a wideband masthead signal amplifier. The DC voltage used to power this amplifier is fed up through the centre core of the coaxial cable, which is introduced by using a PSU interface at the receiver end.

The aerial described in this article has a weatherproof housing for outdoor use, which is constructed from readily available materials.

Circuit Description

In addition to the block diagram detailed in Figure 1, the circuit diagram is shown in Figures 2 and 3.

Specification

DC Power supply:	+9V to +14V	Length:	1·24 metres
Supply current:	22mA (at +12V)	Weight:	0·55Kg
Frequency Range:	7MHz to 1500MHz	Connectors:	BNC/TNC
Gain:	19dB (Maximum)	Gain Controller:	−10dB Attenuator
Impedance:	50Ω	Coaxial Cable:	RG58U

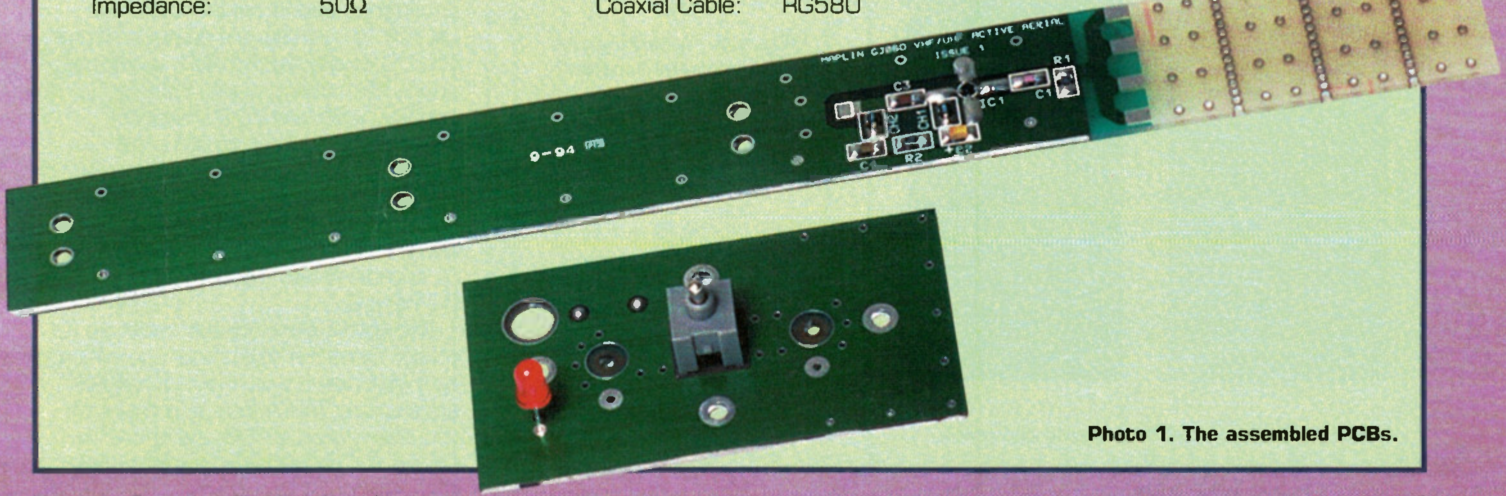


Photo 1. The assembled PCBs.

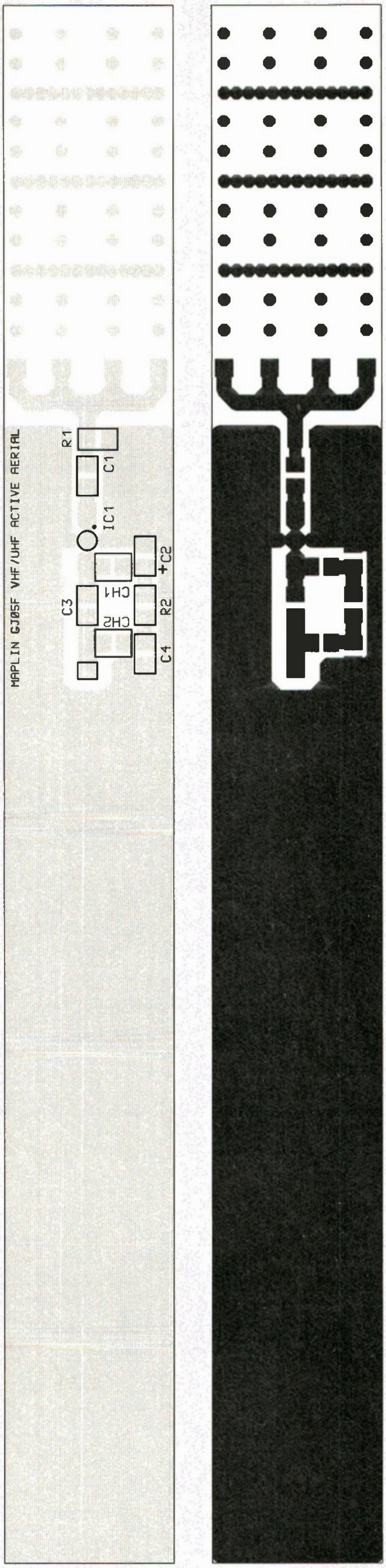
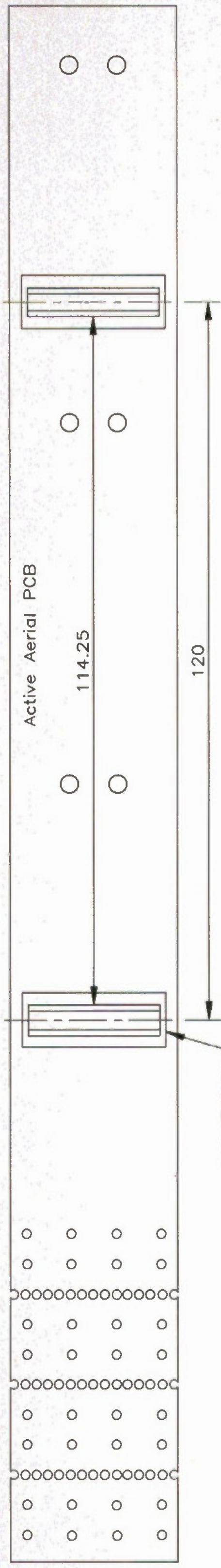


Figure 4. Active aerial PCB legend and track.



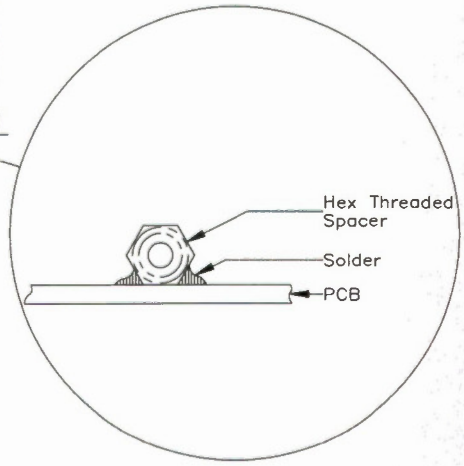


Figure 5. Mounting the two hexagonal threaded spacers.

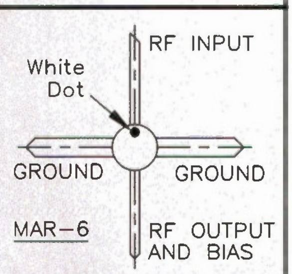


Figure 6. Pin out of the MAR-6.

This should assist in following the circuit description, or with fault-finding in the completed unit.

The four passive aerial elements are cut to differing lengths resulting in a wider frequency coverage. All the PCB components used in this project are of the surface mount device (SMD) type. This is to ensure that any stray capacitive, or inductive effects are minimised, thus maximising the performance of the circuits. A 1k resistor, R1, is used to discharge any static build up on the aerial elements. The RF signals picked up by the aerial elements are AC coupled via a 47pF capacitor C1, into the wideband RF signal amplifier. The small value of the component helps prevent overloading by strong MW/SW radio stations.

The amplifier, IC1, is based around the MAR-6 a Monolithic Microwave Integrated Circuit (MMIC). This device is used as a 50Ω input/output amplifier with low noise and high gain characteristics and an upper frequency response in excess of 2,000MHz (2GHz), see Photo 2. The input is on pin 1 and its output is on pin 3, with pins 2 and 4 used as ground returns. The output signal is AC coupled via a 220pF capacitor, C2, to the centre conductor of the coaxial cable. The positive voltage required to power the circuit is also on the centre conductor and must be split off from the received RF signals. This is achieved by using a small 6μ8H RF choke CH2. To frequencies above 10MHz this component offers a high impedance and in conjunction with C4 the RF signals are removed from the DC supply feed to IC1. Additional supply decoupling is provided by C2 and R2, with the 220Ω resistor limiting the current to IC1. The external output load and DC power feed for IC1 is provided by another 6μ8H choke, CH1, which sets the lower frequency limit of the amplifier to approximately 10MHz, again shown in Photo 2.

The active aerial circuit receives its power from the PSU interface which also includes a switched –10dB RF attenuator. The legend and track for the Active Aerial PCB are shown in Figure 4. The external power supply

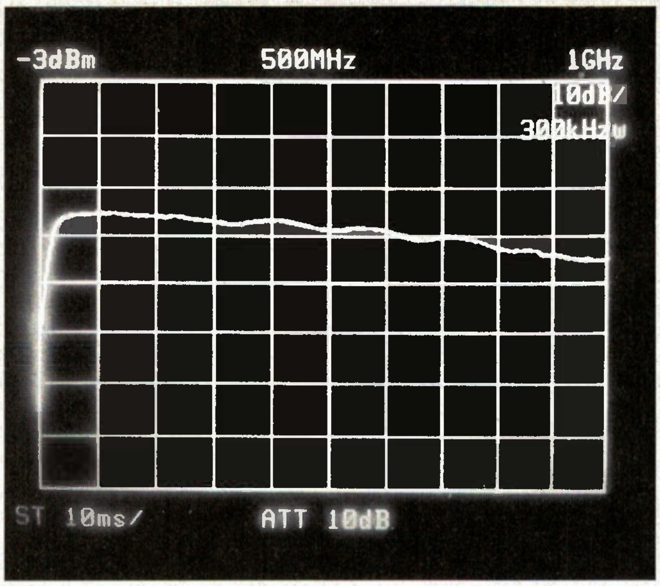


Photo 2. Preamplifier frequency response, as shown on a spectrum analyser.

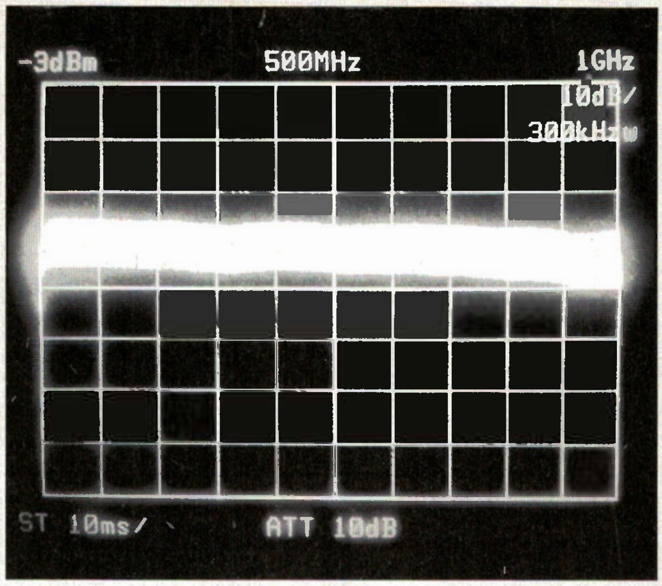


Photo 3. Insertion loss and −10dB attenuation of PSU, as shown on a spectrum analyser.

required by the system is applied to SK3, with the positive voltage on its centre pin. This supply must be within the range of 9V to 14V and have the correct polarity, otherwise damage will occur to the semiconductors and polarised components. To prevent this, a diode D1 has to have the positive supply voltage applied to its anode before the DC power can pass to the rest of the circuit. The red LED power 'ACTIVE' indicator LD1 has its anode connected to R5, which limits the current drain to only a few mA. Resistor R4, C2 and C3 provide the main RF decoupling for the +V supply rail. This is combined with the incoming received RF signals on the centre pin of SK1 via RF choke CH1. The RF signals are AC coupled via C1 into the switched −10dB attenuator circuit. With S1 in its bypass mode the RF signals appear at the output socket SK2 with very little attenuation, see Photo 3. The combined component values of R1, R2 and R3 are calculated to provide a −10dB attenuation whilst retaining a 50Ω impedance match. As can be seen from the lower trace in Photo 3, when switched in, the attenuation is constant over the entire frequency range.

Aerial PCB Construction

At first sight, the fact that this is a surface mount project may seem daunting, but do not be put off. There is an easy method of soldering these tiny components using only 'ordinary' equipment.

Before you start, it may be useful to check that you have the following items laid out on your work area:

1. A low wattage soldering iron (15W or less) with a fine bit (0.5mm is recommended).
2. A pair of tweezers or snipe-nose pliers.
3. A sheet of clean white paper (A4 is ideal) upon which to place each surface mount component, prior to positioning.
4. PCB cleaner and a small brush.

Observe the usual antistatic precautions before handling the MAR-6 IC; ensure that you touch an 'earthed' conductor (domestic water pipes, for example) to remove any static charge which you may have accumulated.

Construction of the Active Aerial PCB is suggested first. Identify the two hex threaded spacers; Figure 5 shows the mounting of these two hex threaded spacers onto the Active Aerial PCB. A high temperature is required to overcome the metal of the spacer and the ground plane of the circuit board, so the soldering iron has to be applied for some time, before everything becomes hot enough for the solder to flow evenly round the pads of the positions marked. There must be exactly 120mm between the centres of the two threaded spacers (and 114·25mm between the edges). It is important that these are mounted squarely, so the two screws for each spacer go through the tube and mounted correctly. These form the main mechanical mounting pillars for the project in the tube. It is advisable to use a high power soldering iron to solder onto the PCB the two threaded hex spacers, which support the PCB inside the finished tube. Make sure that the metal of each spacer is clean, or the solder will not flow onto it, also make sure that the solder does not flow into the ends where the threaded portion of the spacer, or it will block the threads. This must be carried out before mounting any of the SMDs, as the heat could damage or shift the components if they were already mounted onto the board.

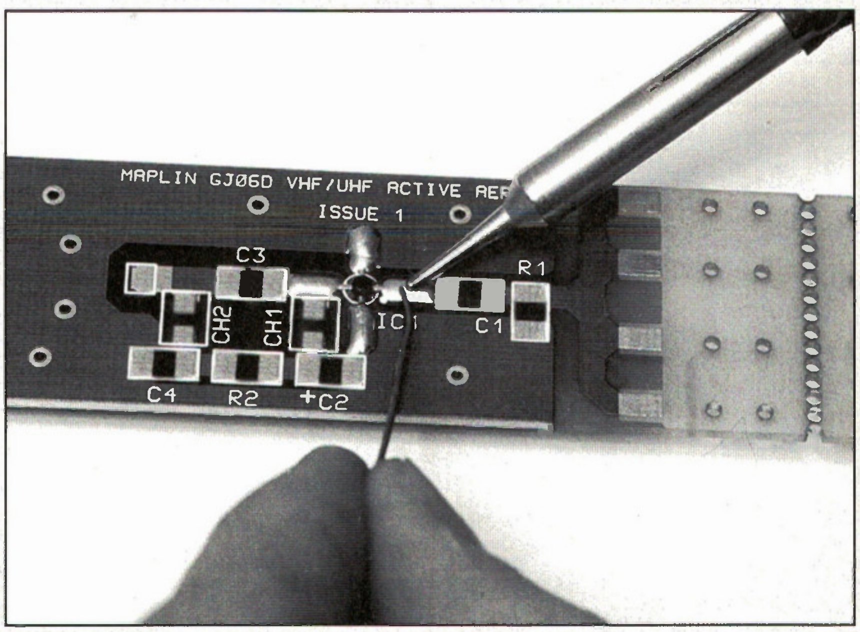


Photo 4. Mounting the MAR-6 IC.

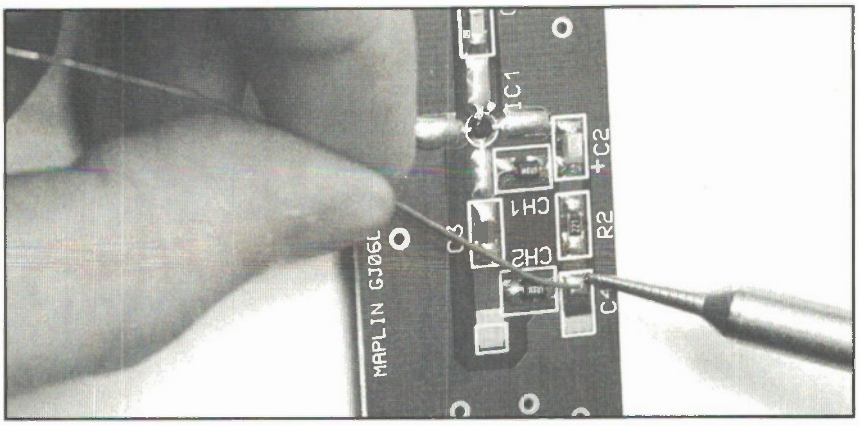


Photo 5a. Wetting one of the component pads with solder.

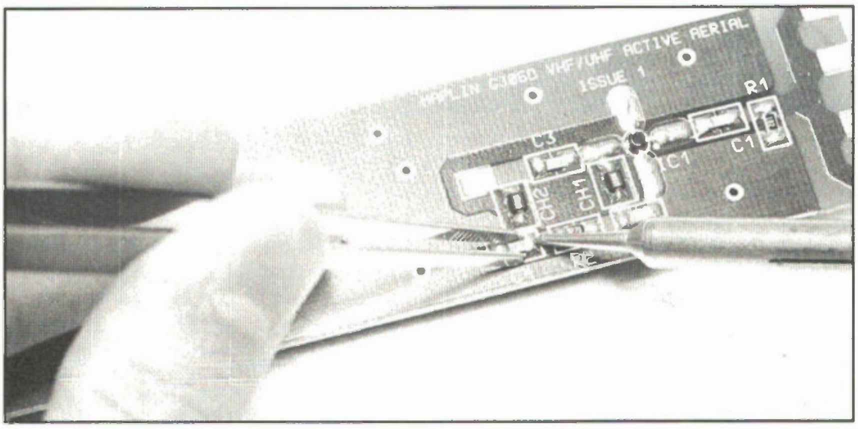


Photo 5b. Holding components in position with tweezers and reflowing the solder to wet the component.

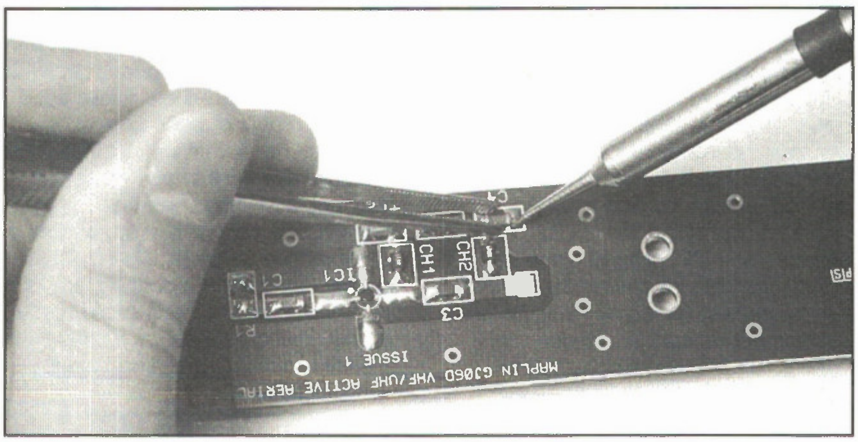


Photo 5c. Making the opposite joint of the component.

The pinout of the MAR-6 is shown in Figure 6. A white dot on the body of the device indicates the RF input lead, on some devices this is shown as a triangle. Another method identifying the RF input lead, is the end of the RF input lead is cut off at an acute angle. The soldering of the MAR-6 IC onto the PCB is shown in Photo 4.

A sequence of photographs show how to typically mount SMDs, by first wetting one of the components pads with solder as shown in Photo 5a, holding components in position with tweezers, and re-flowing the solder to wet the component as shown in Photo 5b, and then making the opposite joint of the component as shown in Photo 5c. The completed aerial PCB is shown in Photo 6a.

Fit the coax tail to the PCB as shown in Figure 7. With an offcut from diode D1, this can be bent into a loop to make the 0V or screen connection for the coax aerial, as shown in Figure 7. Pre-make the coaxial downlead cable with a 50Ω BNC line socket and a 500mm run of standard 50Ω coax. The idea of fitting a line socket at the base of the aerial is so that if the aerial needs to be changed of the position of the aerial needs to be altered, it can be done with the minimum of effort. It is possible to solder the whole downlead onto the PCB, but this would mean a long lead trailing the aerial, which would get in the way.

Cut and prepare the coax and solder the inner connection of the coax to the surface mount pad (the signal out from the preamp), this holds the cable in position, now fit the wire offcut from diode D1, this is bent round the cable to form a loop and put through the two associated holes, again shown on the diagram. The PCB is a double-sided maximum earthplane board. Unlike the surface mount which requires precision fine tipped soldering iron at low temperature, now use a bigger tip at higher temperatures to overcome the heatsink effect of the copper clad board. Once the soldered loop of wire is bent over the coax, the stripped braid underneath the loop is

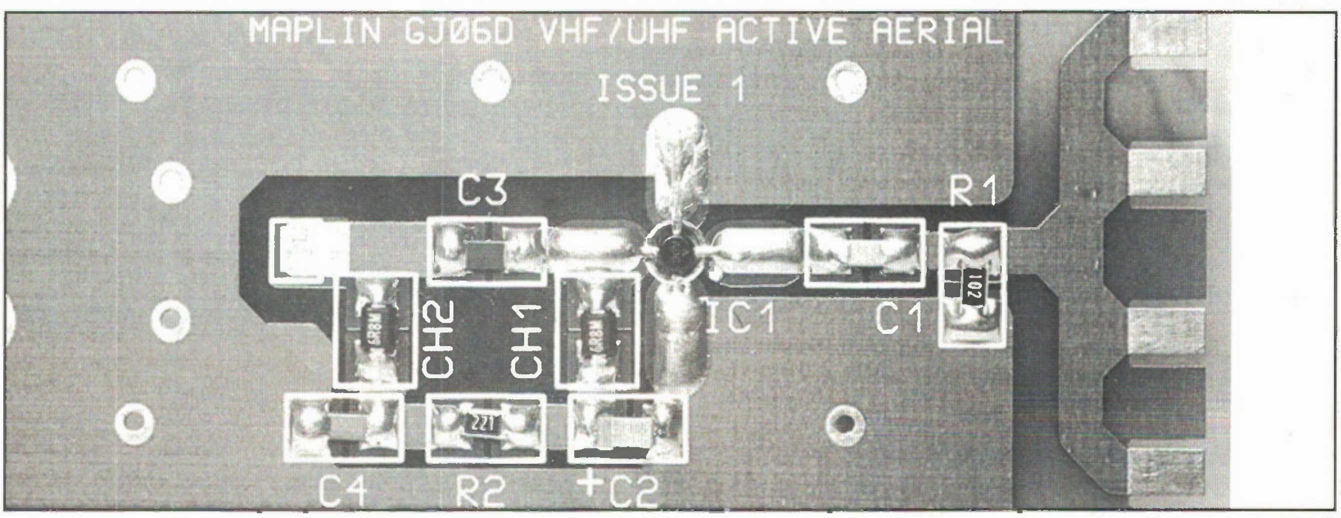


Photo 6a. Close-up of the assembled aerial PCB.

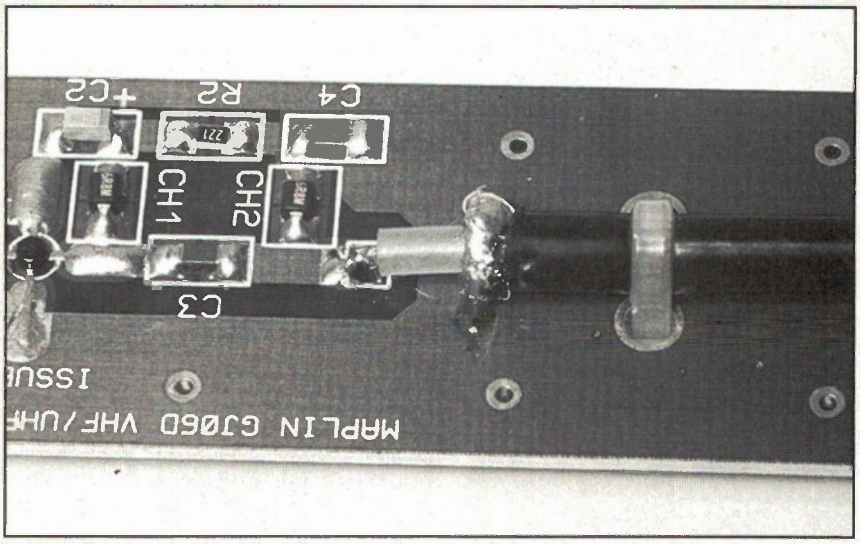


Photo 6b. **Close-up showing one of the cable ties holding the coax in position.**

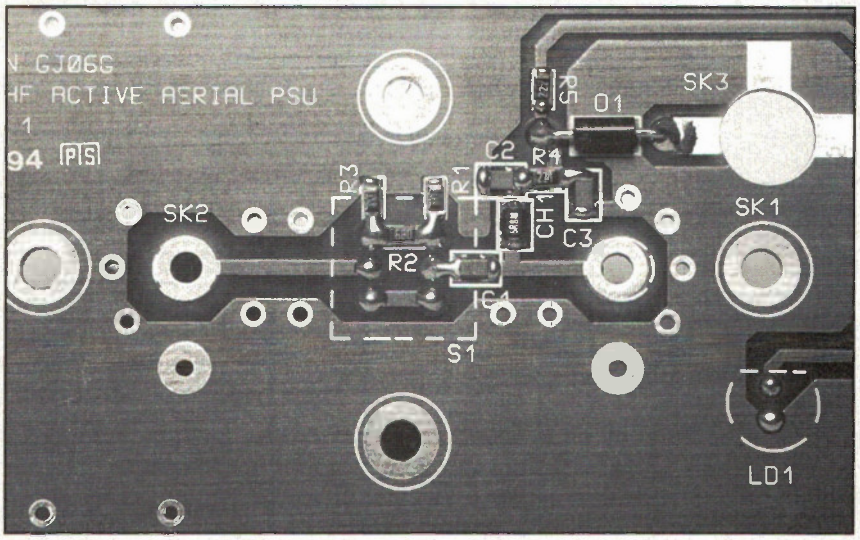


Photo 7. Close-up of the assembled aerial PSU PCB.

rolled back over the top of the tinned copper wire loop, and again solder the braid to the loop, being careful that the insulation does not melt through producing a short circuit on the connection. The coaxial cable is fixed in three places to the PCB by three cable ties to stop it moving around and fatiguing the solder joint, shown in Figure 7. These simply loop through the circuit board so the ratchet head is on the same side of the circuit board as the two hex spacers, the straps of the cable ties are tied over the top of the coax, see Photo 6b. Make sure that the cable ties have been tightened or mechanical stability of the coax on the circuit board will be lost. Trim off the excess on the cable ties, as shown in Figure 7.

The aerial elements are made up from black hook-up wires of varying lengths soldered onto the active aerial PCB, the remainder of each length is taken up with black lacing cord, this assembly is also shown in Figure 7.

Note that although the overlength is shown as 900mm, it is advisable to allow at least 10mm extra on the lacing cords for the knot. There is a cutting chart showing each aerial length (before it becomes lacing cord).

The actual spreaders holding the wires apart are part of the main circuit board, these snap off. It is advisable to start off with the longest length of wire element 'A'. This is soldered to the PCB and then threaded through the three spreaders. Then fit wire element 'D', as this will fix the position of the next off board spacer. The wire is 150mm long and is tied to the lacing cord which is then threaded through the remaining wire spreaders. Due to the wastage of the knot between the wire and the lacing cord, over-estimate the length of lacing cord by about 10mm. Once the lacing cord has been threaded through the spacer, the free end of the lacing cord is knotted onto the wire element 'D' (150mm), this is shown as an exploded diagram in Figure 7, which shows the knot and the transition where the aerial wire becomes lacing cord. Make sure that the knot is butted up against the PCB. You can reinforce the knot by sealing it with a suitable glue, such as a rapid drying epoxy resin, just to make sure that it does not slip and come apart. This is important as once the aerial has been completed, it will not be possible to reach the inside of the aerial tube (without destroying the heatshrink covering and the end cap).

Square up the wire spreaders. Next fit the wire element 'C', this time it is a 300mm run of wire, before it transitions into lacing cord. Just as before tie off with lacing cord 600mm to make up the total length of 900mm, this time it passes through the first aerial spreader, the knot occurs at the second aerial spreader.

Final aerial element 'B' 600mm, with 300mm lacing cord makes up the 900mm run, again remember to allow extra lacing cord for the knot.

Make sure that the wires, spreaders and lacing cords are neatly arranged.

It is advisable to spray the board with conformal coating just to keep any moisture that might build up in the tube from condensation, humid atmosphere, or dead insects.

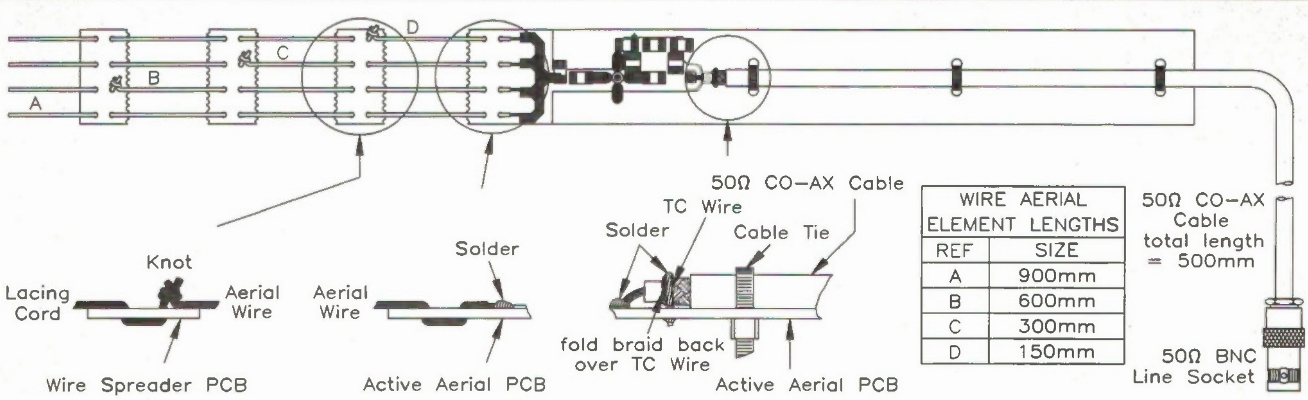


Figure 7. Fitting the aerial elements and coaxial cable.

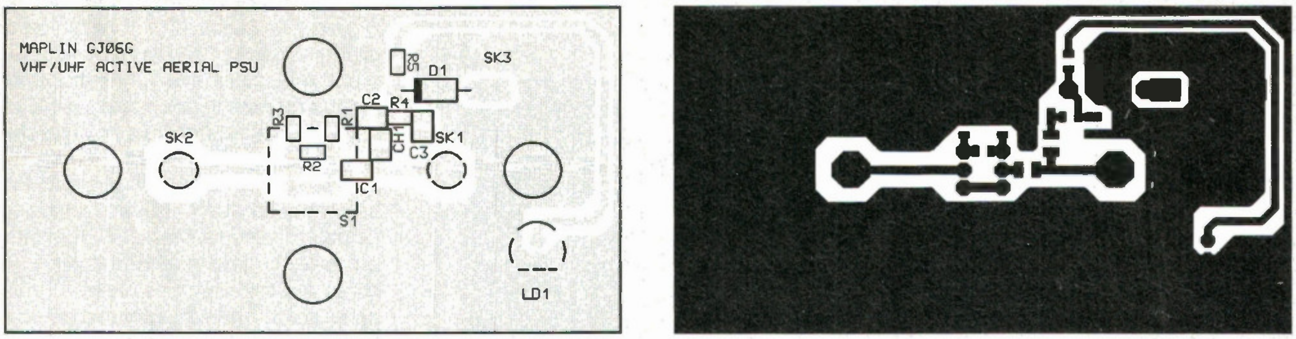


Figure 8. PSU PCB legend and track.

Aerial PSU PCB Construction

Again the majority of the components on the PSU PCB are SMD, apart from switch S1, LED LD1 and D1 a standard 1N4001 diode which is the protection diode on the power supply input. Figure 8 shows the VHF/UHF active aerial PSU PCB legend and track; the mounting details are shown in Figure 9. The assembled aerial PSU PCB is shown in Photo 7.

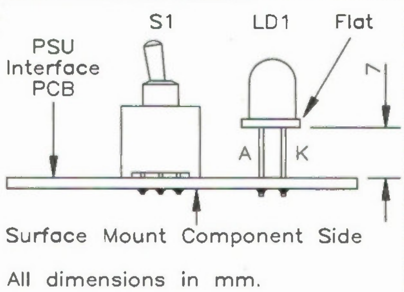


Figure 9. Mounting S1 and LD1 on to the PSU PCB.

Aerial Housing Preparation

The main body of the aerial is made out of white plastic pipe obtainable from DIY centres (e.g., Texas and B & Q) and any local bathroom suppliers that stock waste pipes, the aluminium tube (KP80B) is supplied with the kit. The inside dimension of the aluminium tube (35mm) and outside dimension (38mm) are shown in Figure 10. The outside dimension of the plastic pipe is 35mm or slightly less. The plastic pipe must be cut to a length of 1·24m, with four slots cut in the top of the tube. The aluminium tube is slid over the white plastic pipe, and when in position, the holes in the tube are used as a drilling rig, refer to Figure 11. Four of the holes are drilled at 2mm for the self-tapping screws, and the other four holes 3mm to allow for the 6BA bolts to pass through into the circuit board's hex spacers. At the other end of the plastic tube crosscut with a hacksaw four slots 7mm deep, these perform the function of locking off the ends of the wires of the aerial elements and lacing cord.

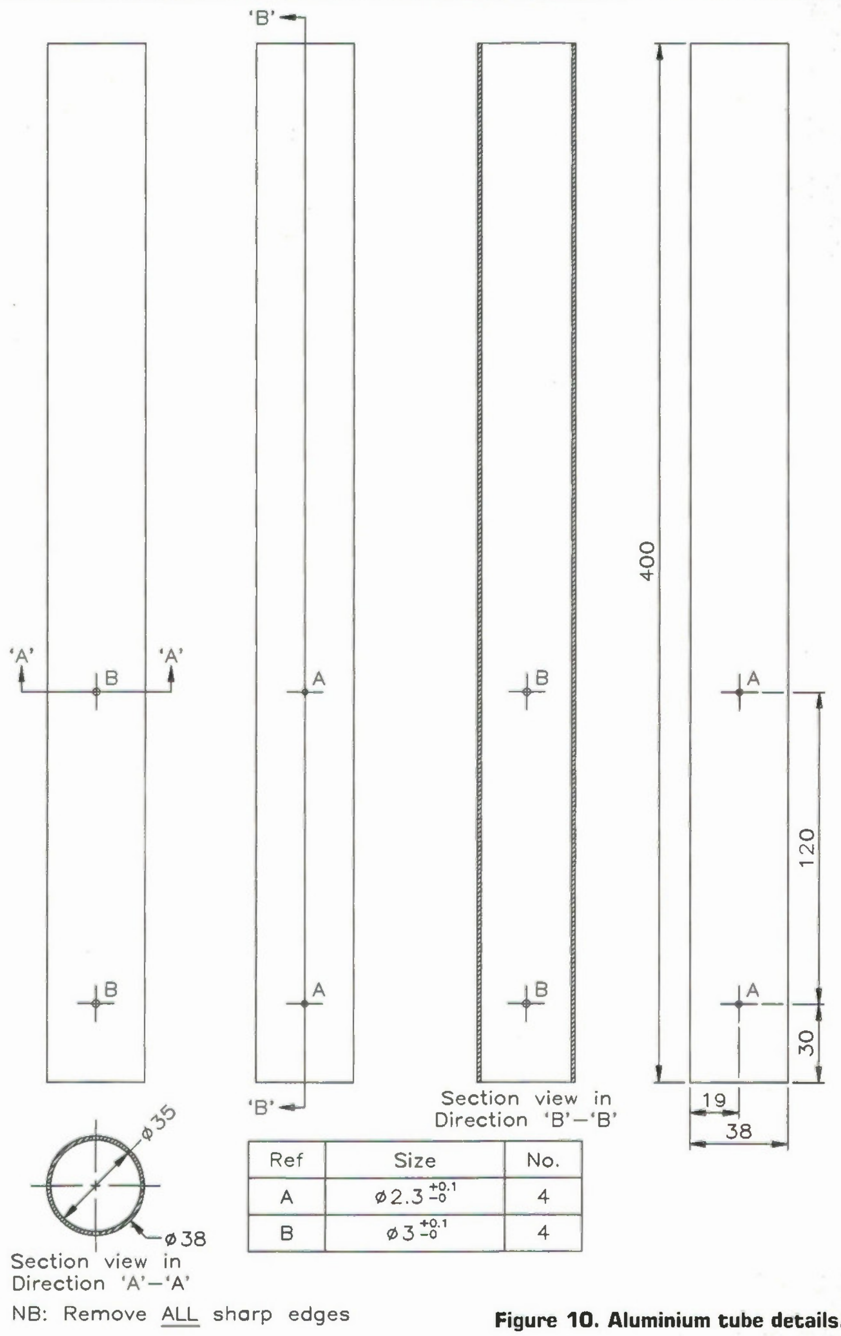
Aerial PSU Box Preparation

A suitable box for the PSU is the small diecast box type DCM5002 (LH70M). Refer to Figure 12 for the drilling details. The holes are drilled into the main body of the box, the holes for the countersunk screws should be finished off so that they lie flat once fitted, and do not lie proud of the surface.

Final PSU Assembly

The PSU final assembly drawing is shown in Figure 13.

Before mounting the PCB fit the label, this is shown in Figure 14, and



Ref	Size	No.
A	$\varnothing 2.3^{+0.1}_{-0}$	4
B	$\varnothing 3^{+0.1}_{-0}$	4

Figure 10. Aluminium tube details.

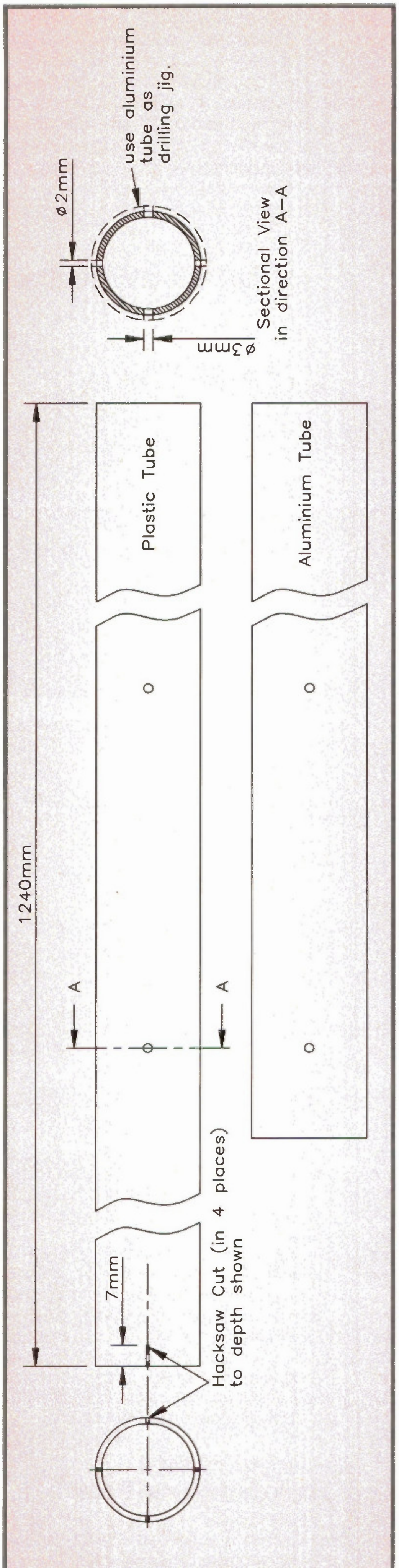
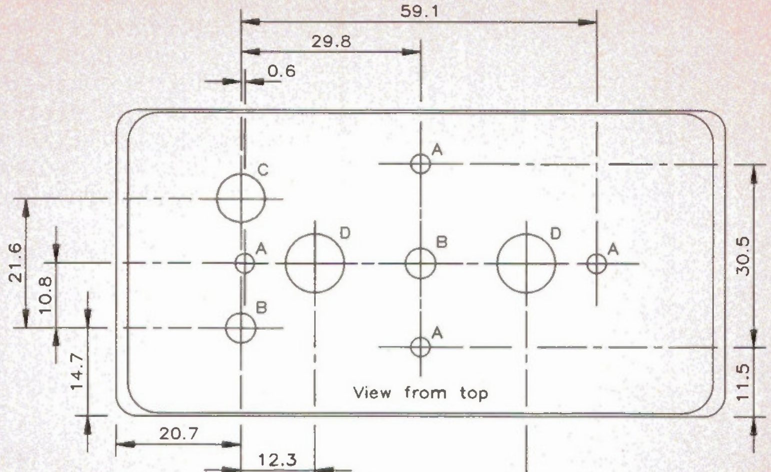


Figure 11. Plastic tube details.



HOLE DATA		
REF	SIZE	No.
A	ø3.2	4
B	ø5	2
C	ø8	1
D	ø9.7	2

ALL DIMENSIONS IN MILLIMETRES

Figure 12. PSU diecast box drilling details.

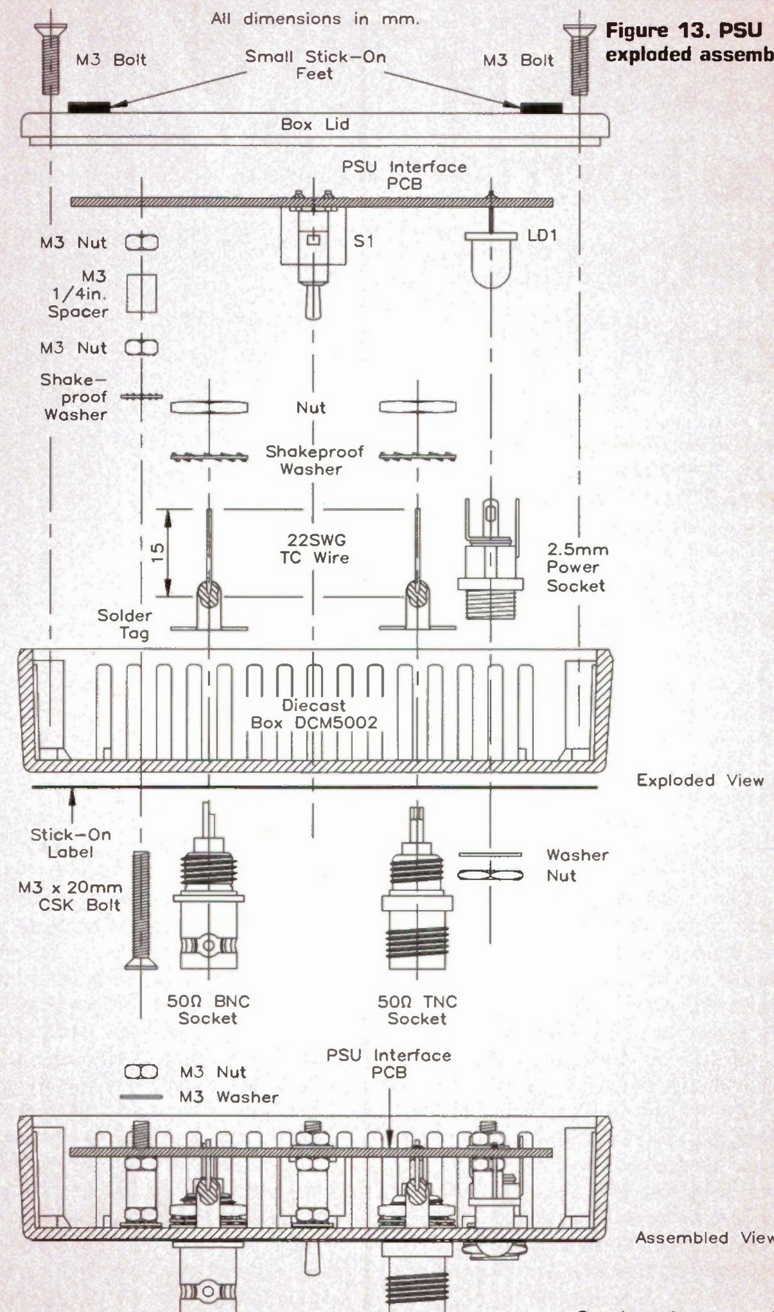


Figure 13. PSU exploded assembly.

Continued on page 27.

We mentioned in last month's opening gambit that there were some fundamental shortcomings in the technology of vinyl recording. Some of these preclude its use as a format intended for extended play applications. It might be considered justifiable, therefore, to look at the way in which information (music) is transferred first onto the blank vinyl disc. In this way, the absolute aspects of performance of (and the technical limitation inherent in), the process of disc reproduction will become more apparent to the reader. (These aspects are a function of the physics involved in the transfer and subsequent retrieval of information from a vinyl disc.) As such, semiconductor deficiencies, and other constraints centred on the essentially mechanical aspects of the system, mean that we are unable to exceed certain shortcomings of performance.

by Mike Meechan

CD versus VINYL

A Battle of the Formats – Irretrievably Lost?

PART 2

Design Considerations in RIAA Phono Preamplifiers

NEVERTHELESS, any worthwhile replay system should strive to equal these inherent technical limitations. Therein lies the fun, and challenge, for the audio design engineer.

Once this has been done, various design considerations can then be explored, and the virtues and vices inherent to each of the different topologies of RIAA preamp design laid bare. We can then culminate the series with a dissertation on the merits and shortcomings of the featured circuit, i.e. the Audiophile preamp.

There is something distinctly quaint and old-fashioned about some aspects of the record making process – perhaps this has gone some way towards hastening its demise, firstly in the hearts, and then in the collections of the music-buying public. If we contrast this with the high-tech CD player, with its laser, digital/optical storage and retrieval systems, error detection and correction systems, and the stacks of digital electronics, then the reliance for fidelity on the mechanically tortuous chiselling out of a record groove on a lacquer blank seems decidedly Heath-Robinsonish by comparison. Despite some unattractive aspects inherent in the disc manufacturing system, it has defied many of these unpromising roots, and proved to be both phenomenally successful, and to have stood the test of time quite effectively indeed (although some of the less appealing elements of the format seem also, against all odds, to have survived). However, the system HAS evolved and grown up considerably since Edison, back in 1877, first reproduced sound from an aluminium foil using a cylindrical phonograph. Ten years after this, Emil Berliner invented 'flat disc recording', setting a trend that has persisted to the present day. As a testimony to the many excellent aspects of its performance, it is agreed that until the advent of CD, the modern LP record had become universally accepted as a genuine world standard, with a widely distributed technology base. From a qualitative point of view, it would be a worthless exercise to pretend that the reproduction of sound from a vinyl pressing is anywhere near approaching perfect, but if the limitations are understood and appreciated, and an open-ended philosophy to the technology adopted, it will be seen that it is indeed capable of improvement. (Regrettably, the manufacturers of abacuses, slide rules and horse-drawn carriages might all have maintained the same thing, in spite of opposition and adverse competition, and their demise has remained fairly absolute . . .)

The Cartridge and How Music is Retrieved from Vinyl

The cartridge itself, the process used to place information on to the vinyl disc, and the mechanical retrieval of this information, all present many individual difficulties to the designer.

Of all electromagnetic transducers that convert one form of energy into another – loudspeakers, microphones, etc. – the phono cartridge presents what is possibly the greatest challenge for design, since it must perform more than one function simultaneously. Firstly, it must convert the groove modulations of the record into an electrical signal, but it must also support the tone-arm.

Principles of Vinyl Reproduction and Recording

The transducer used to convert groove modulation is known as a phono pick-up, phono cartridge, or needle whilst the cartridge supports the stylus. In the past, various materials have found their way into the stylus assembly – cactus needles, whale bones, all kinds of metals, gemstones, plastics and wood, to name but a few. The method by which the cartridge converts energy determines the classification under which it falls. Piezoelectric types encompass the inexpensive, 'Low-Fi' crystal and ceramic types, while moving magnet (MM), moving coil (MC), and induced magnet (moving iron) fall into the category of electrodynamic type cartridges. The latter three use the principle that a magnetic field, intersecting a wound coil, will generate an electric current. Moving magnet types have a magnet attached to the stylus tube or cantilever, and the coils are stationary. Moving coil types juxtapose this arrangement, not surprisingly, with the magnet fixed and the coils moving, while the moving iron type uses a magnet and coil, which are fixed, and a slug of soft magnetic iron that moves instead of the magnet, being magnetised by it.

Because of the interaction of magnet and coil in these types of cartridges, each presents a distinctly non-linear source impedance to any amplifier input. Faraday's law of induction shows that induced voltage is proportional to the relative velocity of both the magnet and coil parts of the assembly.

Since the signal voltage generated at any instant in time is proportional to rate of change of flux with respect to time, the design of the cartridge must ensure that a linear relationship exists between the position of the stylus cantilever assembly and the magnetic flux. Rate of change of stylus position with respect to time will thus be proportional to the signal voltage, although this means that the groove excursions (the waveform imprinted in the vinyl) are not directly proportional to the signal voltage. Rather, the groove shape is proportional to the integral of the signal waveform.

As the signal voltage is proportional to the velocity of the stylus, the signal SLOPE is proportional to the ACCELERATION of the stylus. For high signal slopes to be reproduced with any degree of fidelity, the cartridge cantilever assembly and associated suspension, and the magnet/coil system, form a resonant mass-spring system. In electrical terms, this is analogous to a complex series resonant circuit.

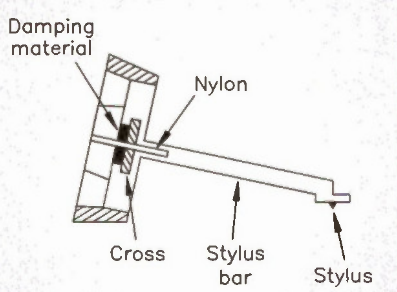


Figure 1. Stylus mounting with damping control.

Cartridge Basics

The amount of force required to move the stylus depends both on this 'springiness', and on mass. Using the damped mass-spring model of a magnetic cartridge, we are able to predict that the resonant frequency will depend upon the mass of the stylus cantilever assembly, and on the 'springiness' of the cantilever's suspension. 'Springiness' is given the symbol k, the spring constant, and is represented numerically. K is defined as the force needed to compress or extend the spring by a certain amount, so stiffer springs have a higher k value. Since the spring constants are almost unusably low numbers, the reciprocal of the spring constant (1/k) is quoted by cartridge manufacturers and is called compliance. It follows that a lower compliance figure equates to a stiffer suspension system. Compliance of the cantilever or stylus is the ability of the assembly to react to groove modulation, and it is measured (statically or dynamically) in cm/dyn or um/mN. The dynamic compliance allows us to calculate the resonant frequency of the tonearm/cartridge assembly, and to measure the effective mass of the tonearm. Compliance is calculated as follows;

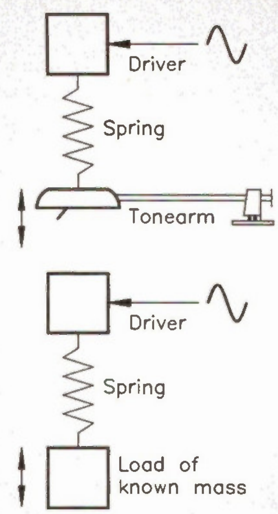


Figure 2. Method of measuring dynamic mass of a tonearm.

$$C = \frac{1}{4\mu^2 f^2 M}$$

Where c is the compliance in cm/dyne
f is the frequency in Hertz
M is the tonearm mass in grams

When the system resonates, the impedance of the cartridge is no longer related linearly to the driving force on the stylus, and the non-linearity results in distortion of the waveform. To overcome this, one measure is to shift the resonant frequency to a point in the spectrum that is below the lower audible limit. Since the cartridge resonant frequency is a function both of mass, and of the compliance of the cantilever and sus-

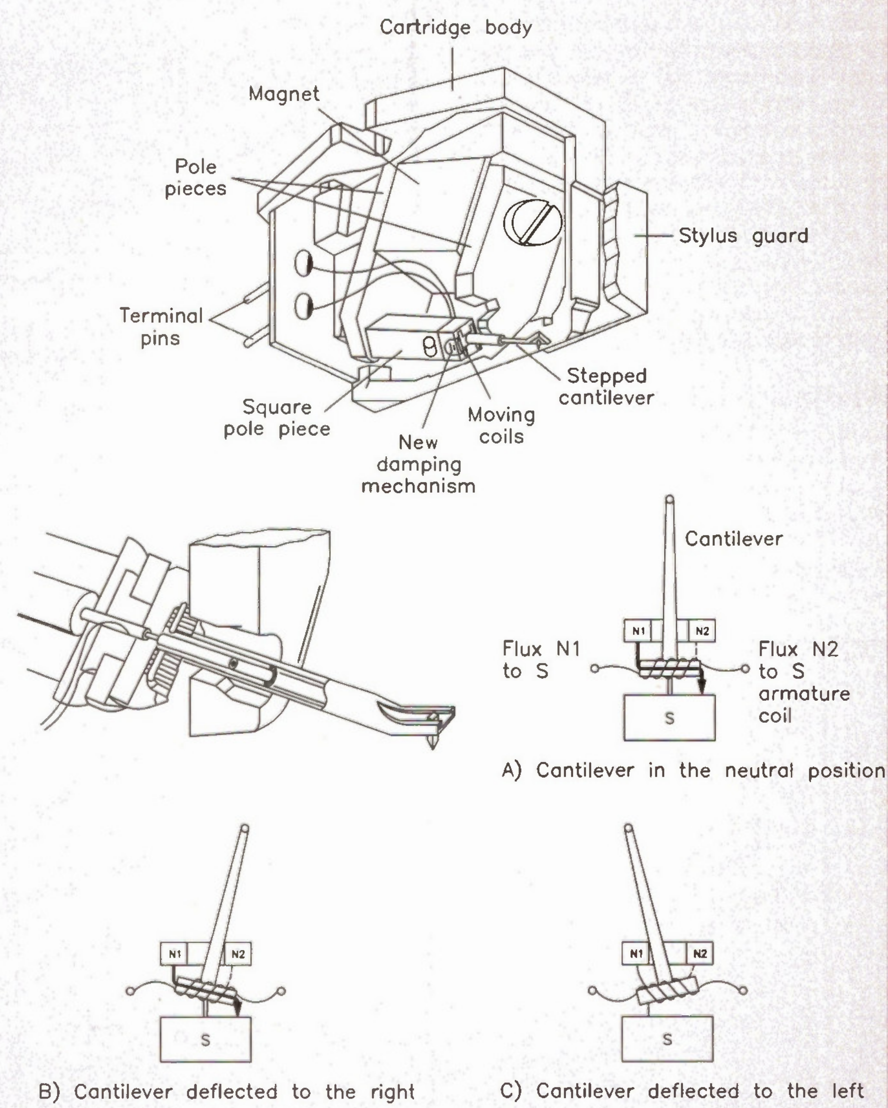


Figure 3. Cross sectional view of moving coil cartridge and stylus.

pension system, the cartridge resonant frequency can be decreased, by upping either the mass or the value of the compliance. Low mass is desirable so that the stylus is able to respond quickly to the changes in the record groove, so compliance is altered until a suitable resonant frequency, typically below 10Hz, is achieved. The most desirable range is between 8 and 12Hz, since resonance below 8Hz will produce instability of the tonearm, resulting in poor tracking of slightly warped records.

Resonant frequency can also be altered by lowering the Q of the system. Mechanical and electrical losses introduced into the system expedite this. Conventionally, friction introduced into the cantilever suspension assembly – using rubber mounting blocks – achieves the desired mechanical damping, while the absorption of energy (into the load resistance of the cartridge preamplifier) lowers the electrical Q of the system. See Figure 1. We can look at the various types of cartridges that prevail in the audiophile marketplace.

Tonearm (or cartridge vertical) resonant frequency is found by playing a special test record, with signals at specific frequencies, and recording the frequency at which the cartridge output is highest. Dynamic mass of the tonearm is calculated by suspending the complete arm/cartridge assembly from a spring (connected just above the stylus pivot), and connecting this spring to a loudspeaker-type driving force. The spring is then excited vertically at various frequencies, and the resonant frequency of the assembly noted. Next, the tonearm is freed from the spring, and precisely valued weights attached in its place. Dynamic mass of the tonearm equates to the mass of attached weights at which the resonant frequency is the same. Once both mass and frequency are known, compliance can be readily calculated. It would be correct to say that the reproduction of sound from a vinyl disc owes as much to complex mechanics as it does to electronics. See Figure 2.

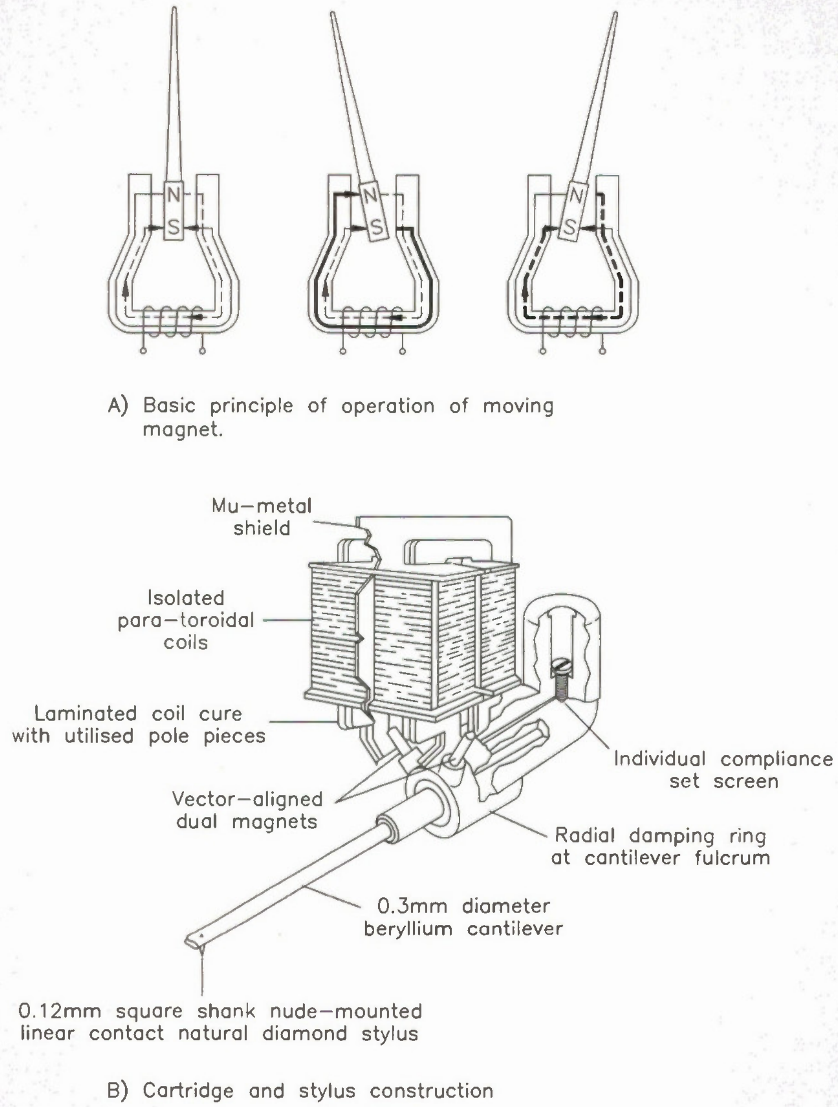


Figure 4. The moving magnet cartridge.

Moving Coil Cartridges

Moving coil cartridges have existed since the very early days of electronic sound recording and reproduction. The design uses one heavy magnet, and the cantilever assembly, which cannot be replaced by the user. The inherent low impedance of the system means that it is insensitive both to input load impedance, (typically about 5 to 100Ω), and to capacitive loading, so that long cables can be driven without detriment to the frequency response. This is gained at the expense of low output – typically some 20 to 30dB below that of the moving magnet type, when referenced to an established sensitivity of 1mV/cm/sec. This means very careful amplification if noise performance isn't to be unduly impaired. (More of this when we move on to our noise discussion.) Furthermore, tracking forces are much heavier, but on the plus side, sound quality from the moving coil cartridge can be very good, with distortion figures typically lower than the moving magnet type. The very low impedance and inductance of the coils (very much less than the 0·3 to 1H of the MM type), combined with a very rigid and strong cantilever (it has to support a heavy magnet assembly) means that there is a very fast response to transients in any musical

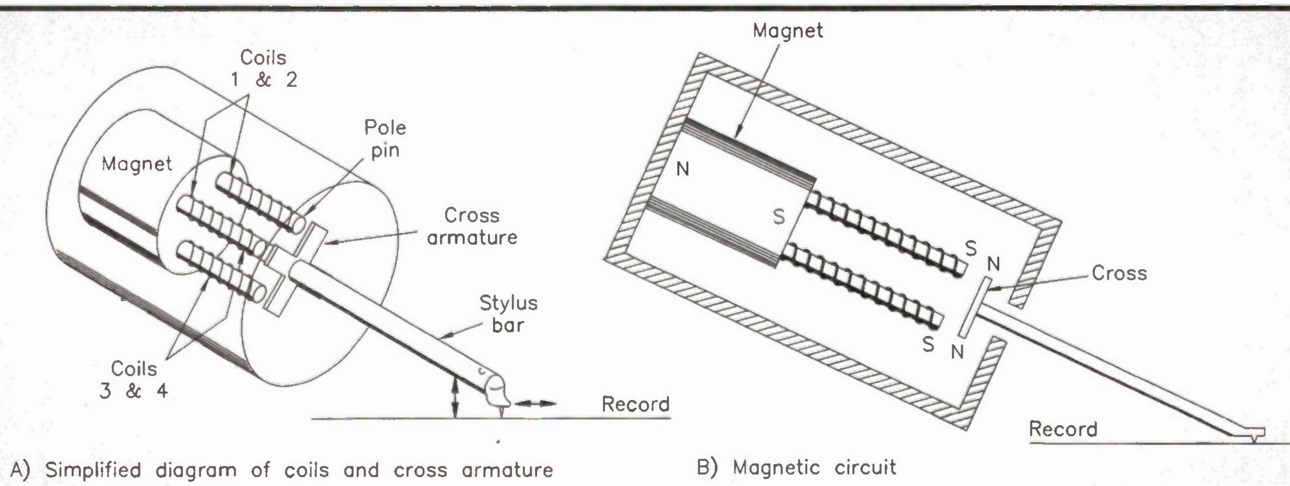


Figure 5. Variable reluctance cartridge.

passage, and a flatter and more extended frequency response. Better channel separation (some 30 to 40dB compared to the 20 to 30dB of the fixed coil type) is achieved because the stylus assembly and the coil system are in much closer proximity. Unfortunately, poor construction of the coil assembly, with numbers of unsupported turns, can cause vibrations in the assembly, and random output at HF. Also, lead-in and lead-out wires, if they are improperly secured, can vibrate in the magnetic field and cause colouration of the output signal. Despite problems as these, which are indigenous to some examples, the moving coil, because of the extended frequency response and excellent transient characteristics, has traditionally been favoured over other types by the true audiophile fraternity. See Figure 3.

Moving Magnet Cartridges

The moving magnet type of cartridge originated in Europe in the late fifties, and has since become the most popular example of the phono cartridge. It has low dynamic tip mass, high compliance and, because of the large number of turns in the coil assembly, reasonably high output. The basic principle of the moving magnet cartridge has been refined over the years, until now, modern-day cartridges in the vanguard of this type can produce outputs well above the audible frequency ceiling (typically 50kHz in some examples). Output level diminishes (or disappears) at higher frequencies because of the rising inductive component of the cartridge impedance, which has a typical resistive component of 200Ω to 1k. The short-lived quadraphonic era of the seventies (SQ, QS, CD4, UD4) prompted much of this development, since some of the systems (CD4 springs to mind) used a 30kHz carrier waveform onto which the narrower band audio signals of the other two channels of the system were modulated. The unique electromagnetic characteristics of the moving magnet cartridge mean that any input stage intended for use with it must have well-defined impedance at all frequencies (despite the worst excesses of the cartridge), if performance is not to be compromised. See Figure 4.

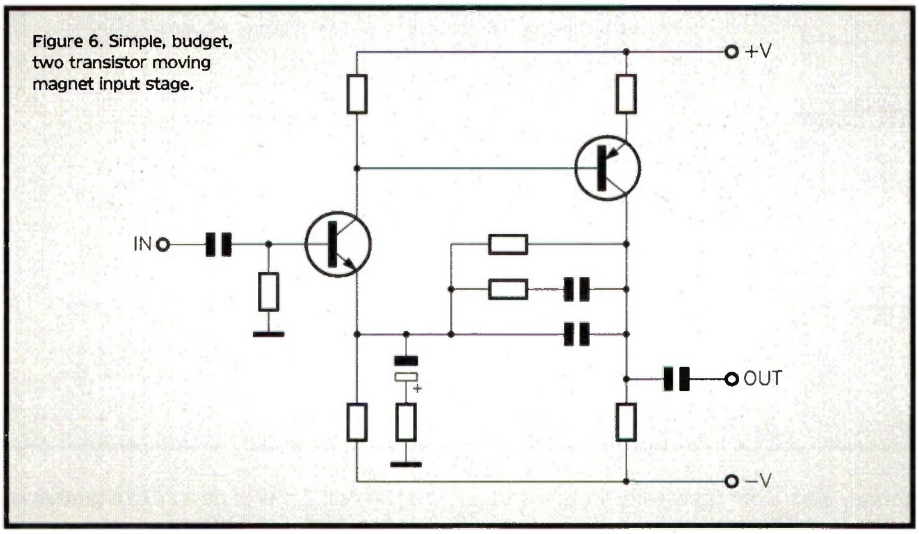
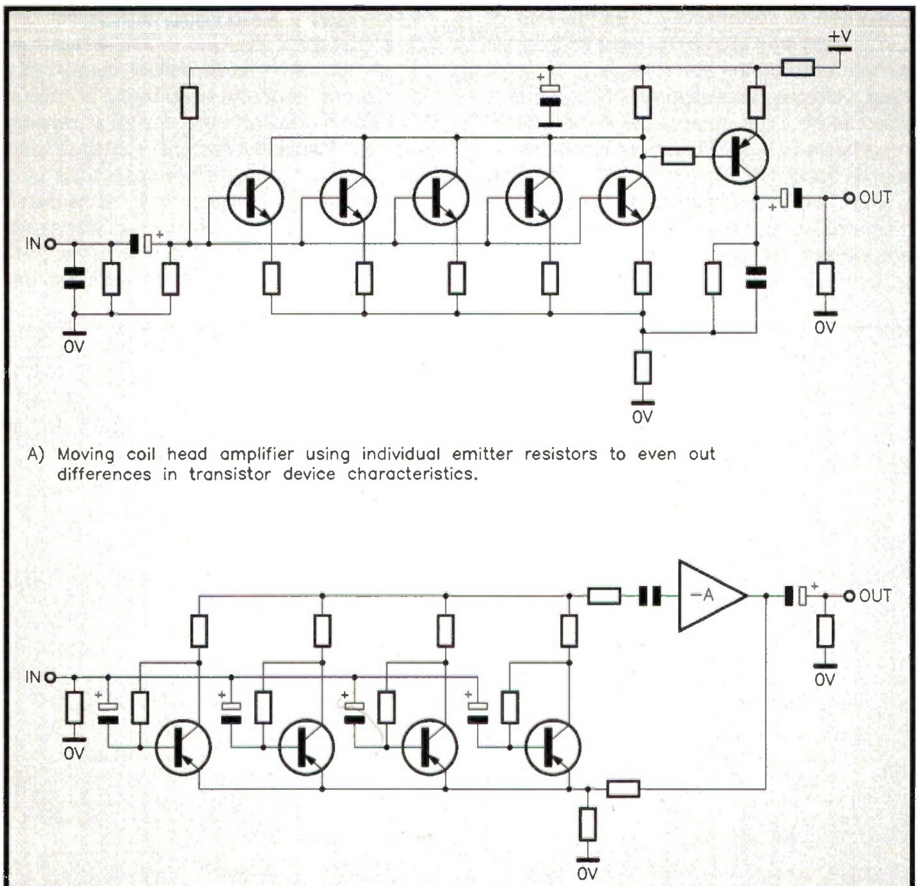


Figure 6. Simple, budget, two transistor moving magnet input stage.



A) Moving coil head amplifier using individual emitter resistors to even out differences in transistor device characteristics.

B) Moving coil head amplifier using individual base−collector bias current networks.

Figure 7. High quality moving coil preamplifiers.

Variable Reluctance (Induced Magnet)

These have performance characteristics almost identical to those of the moving magnet cartridge. A small armature, in the shape of a cross, swings between four pole pins and coils. A stylus bar, (which has the stylus at one end) is secured to the armature at the other. Forty-five degrees of motion to one side cause reverse voltage induction, which allows push-pull operation of the coils, and thus reduces harmonic distortion caused by non-linearities in the magnetic field. The coils also provide 'hum bucking' (rejection of mains frequency fields). Crosstalk components are also 'bucked' out, so channel separation is good, regardless of frequency. See Figure 5.

Other Types

The other types of cartridge in existence (but which we won't discuss in detail) are the semiconductor cartridge and the piezo-electric (crystal or ceramic) type. The latter type belongs to the group known as constant amplitude (or pressure sensitive) cartridges, since they give an output that is proportional to the force applied to the stylus, and so produce an output voltage that is independent of frequency (no equalisation is therefore required).

A high quality phono preamplifier presents many diverse and demanding challenges to the audio engineer. A phono preamplifier's primary task is to provide gain (typically around 30 to 40dB at 1kHz) together with accurate amplitude and phase equalisation to the signal from a moving magnet cartridge. Moving coil type cartridges typically have output voltages some 20dB lower than their Moving Magnet (MM) counterparts. Many of the higher quality (more expensive) preamplifiers have switchable inputs. A moving coil cartridge will be amplified up, using either transformer techniques, or low noise active devices such as super-matched transistor pairs, before being applied to the moving magnet input stage for equalisation and further amplification. Moving magnet cartridges are, of course, applied directly to the MM input stage. Any amplifier in the chain must, of necessity, be a very low noise, low distortion type. It must also possess good overload characteristics, and the equalisation network must be accurate so that the EQ curve can track exactly the rigidly defined, internationally recognised RIAA standard.

Choices and Options

Various approaches to the design have been tried in the past – discrete transistor, IC, a hybrid of both, series and shunt feedback, etc. Each type has its merits (and disad-

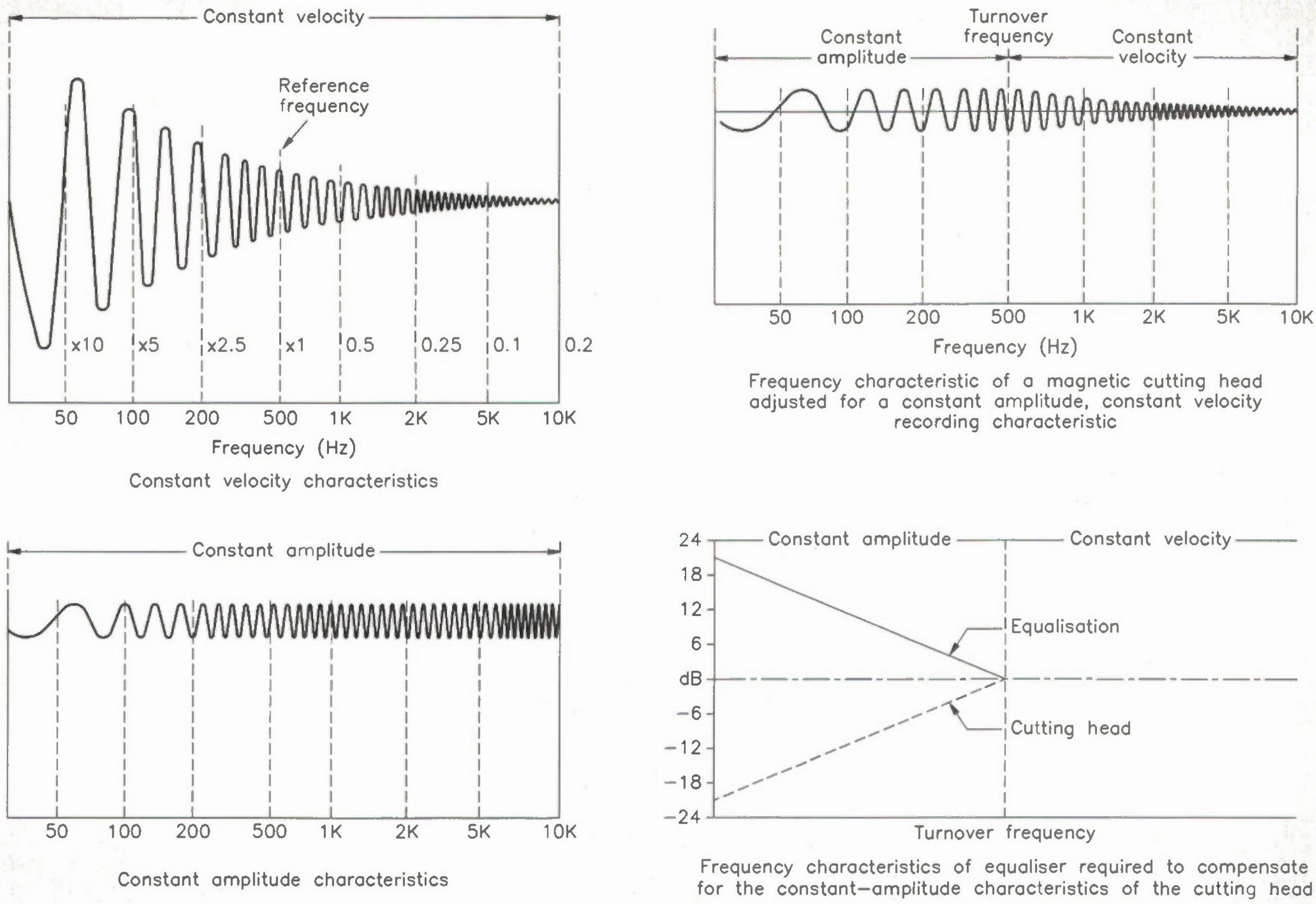


Figure 8a. Graphs of various record head characteristics.

vantages, too). Traditionally, transistor or discrete designs have been preferred by the 'golden-eared' fraternity of listeners. Many first class designs centred on this approach to the problem have been tested and proven, both within journals such as this, and in commercial products, too.

Good transistor designs can offer superlative noise and distortion characteristics, but can sometimes prove expensive, since the cost of several discrete, low noise, high performance audio-specific transistors quickly accumulates. Also, the transistors can also prove difficult to source, and component count and complexity is much higher than with similar integrated preamplifiers. There is also the problem of matching (to any great degree of accuracy) active components inherent in the design. Bipolar devices also exhibit a change in input resistance at high frequencies, Z_{IN} dropping off in value as audio HF is approached. What is required is a constant resistive load (up to the audible frequency ceiling and above) for the cartridge, and unfortunately, the inherent loss of gain at HF of the bipolar transistor, despite some emitter current flowing, means roll-off in a critical part of the audio spectrum.

A common band aid used in bipolar transistor stages is in the application of a large dosage of negative feedback. Decreased gain at HF also means decreased overall open loop gain, which, in turn, reduces the amount of NFB available. The feedback loop is susceptible both to the cartridge impedances, and to the reactances of the cables used for interconnection. Variations about a particular critical value, even when small in magnitude, can cause frequency response aberrations, 'muddiness' in the perceived sound, and even instability in extreme cases.

What happens with these simple types (common in commercial preamplifiers of some years ago) is that the input impedance is modulated by the absolute value of signal input voltage. Since the amplifier input is affected by input impedance if the source impedance is high, distortion increases as source impedance increases. Worst of all, it might only occur with particular cartridge/cable combinations. Such problem phenomena come under the heading of 'cartridge impedance interaction', and they plague ALL types of design, to a greater or lesser extent. See Figure 6.

Despite having said that many consumers of high quality audio equipment prefer discrete transistor designs to the integrated circuit approach, commercial constraints (tight profit margins) mean that it is difficult to realise a good discrete design at reasonable cost. We mentioned that individual testing and matching of transistors is a time-consuming process. This means that it is a costly process. Many manufacturers compromise by ironing out minor spreads in active device characteristics by using extra,

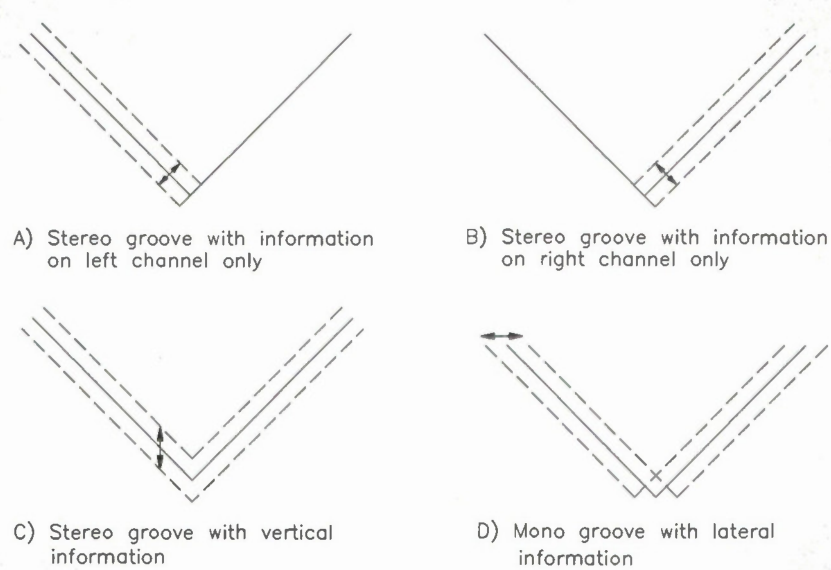
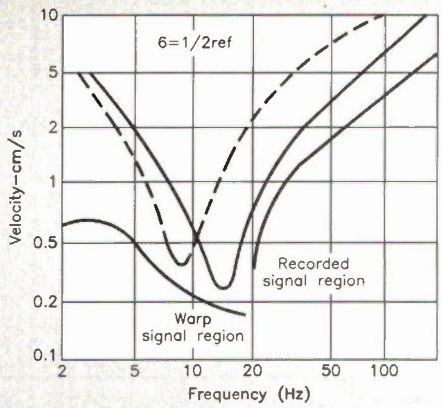


Figure 8b. Types of groove modulation.



Change in vertical tracking angle due to warped records

Figure 9. Graph of ward frequency versus velocity (as researched by Happ and Karlof).

passive components and circuit mechanisms to emulate the effects of truly matched components. One such ploy includes the use of emitter ballasting resistors. The resistors would be superfluous to the design were the devices in question properly matched – unfortunately, introducing them into the circuit brings problems of its own. See Figure 7.

Despite the feather-ruffling that it may cause in some quarters, op amps offer, in many ways, the ideal solution to the problem. Unlike a professional audio mixing desk, say, where commercial cost considerations preclude the use of state-of-the-art devices in every circuit across the console, the designer of a one-off phono preamp can specify the finest devices. Individual cost of these must, of course, be commensurate, with the overall projected cost of the unit.

Up-to-date analogue devices offer superb noise/distortion specifications, quite unlike the 741 genre of op amp upon which many modern-day judgements of sonic nastiness are still made. Slew rates, noise and distortion figures for the so-called 'audio-specific' op amps of the present day are better by an order of magnitude than the devices of ten or fifteen years ago. We mentioned the difficulty and expense of matching discrete devices –integrated circuit fabrication techniques ensure that transistors within the IC are all perfectly matched. The circuit designer can then concentrate all of his/her energies on the associated passive networks, upon which equalisation accuracy and other factors determining the overall noise performance and long-term stability of the design depend. See Table 1.

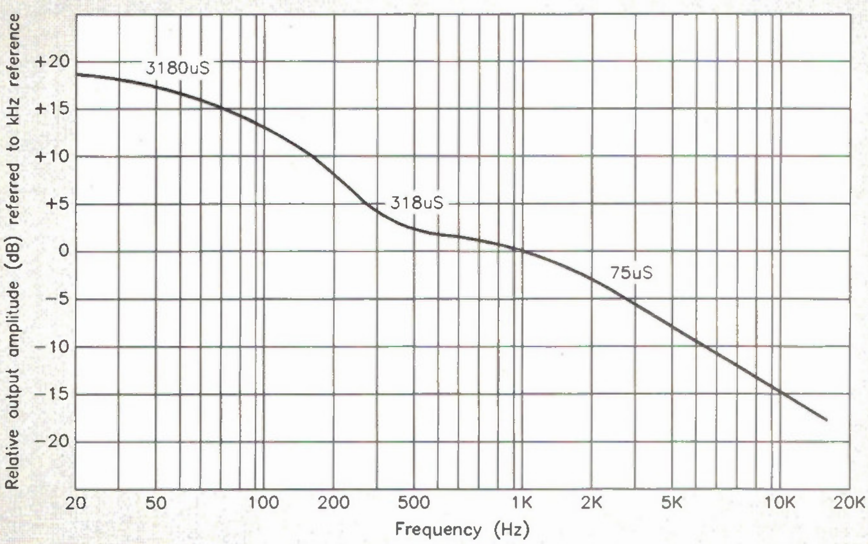


Figure 10. RIAA recording and reproducing characteristic.

	µ741	AD797
Gain bandwidth product	1MHz	100MHz
Slew rate	0·5µV/s	20V/s
Distortion	–	-120dB@20kHz
Noise	20nV/µHz	0·9nV/µHz

Table 1. Comparison of the specifications of two op amps – the classic 741 versus state-of-the-art AD797.

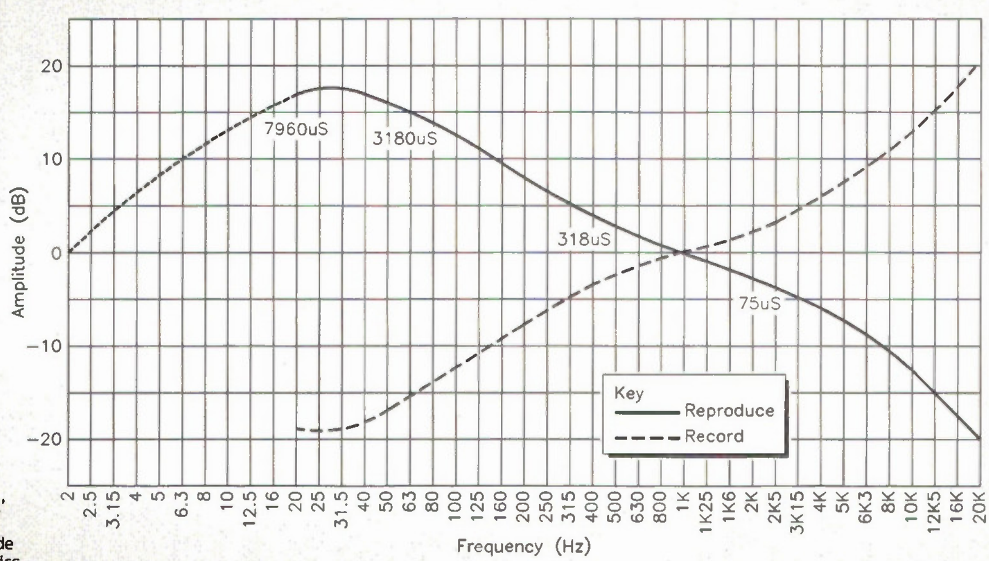


Figure 11. 'New RIAA' (DIN) recording and reproduction amplitude response characteristics.

Critical elements of the design, as previously noted, are good noise performance, and a frequency response which adheres strictly to the RIAA equalisation curve. As we shall see, there are some aspects of each that are inextricably linked, but initially, we'll look at both as two separate entities.

Equalisation

In an effort to overcome the limitations found in the disc-cutting/reproduction process, a special amplitude/frequency response characteristic was created. Signals are placed onto the disc using a constant velocity characteristic. This means that the frequency of the signal is inversely proportional to the amplitude, i.e. low frequencies have large amplitudes and high frequencies, small ones. This is a system that uses the storage space available on the disc surface very inefficiently, since information recorded at LF would quickly fill the grooves. That is, if we could place information at these frequencies onto the disc in the first place. Left and right stereo channel information is cut onto opposite walls of the groove. It follows, therefore, that in-phase, mono, LF signals would cause a huge stylus movement from an impractically thick disc. To overcome this, channels are recorded in anti-phase to one another. Also, there is a maximum allowable groove separation of 0·01cm. This, in turn, limits the size of the maximum permissible recording cutter excursion, which, in practical terms, means a consequent reduction in replay stylus with decreasing frequency. See Figures 8a and 8b.

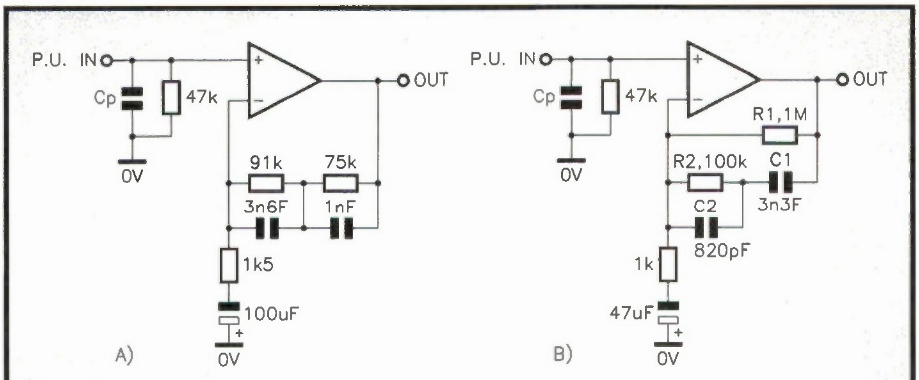


Figure 12. Typical series feedback-driven RIAA equalisation.

High frequencies present their own problems, since, with a flat recording characteristic, these will cause minute movements of the stylus. The output voltage would be hovering about, or just above the surface noise of the disc, so system signal-to-noise would be appallingly bad.

Equalisation – pre-emphasis and de-emphasis – simultaneously cure both the HF and the earlier LF problem. Early equalisation on the record side caused only substantial attenuation of the lower frequencies. This was initially adopted to lessen the irritating audible hiss due to the emery powder loading of the early shellacs. Present day curves encompass both the LF and the HF ends of the frequency spectrum, both cutting LF and boosting HF, so that higher amplitude midrange and high frequencies are cut into the disc. Playback juxtaposes this situation, with LF boost and HF cut. This offers another distinct advantage in that signal-to-noise ratio is improved further, since much of the system noise is present at HF, and so is attenuated on playback.

There are, in fact, two forms of equalisation in common usage. One is the ubiquitous RIAA, Recording Industry Association of America (or NAB) curve and the other is the German DIN (Deutsche Industrie Norm) standard, although both are confused so often as to be almost synonymous. The DIN standard (used in European countries), is sometimes known, somewhat erroneously, as the 'new RIAA' standard. It is identical in all respects to the RIAA curve but for the introduction of a fourth, low-frequency breakpoint. This has a time constant of 7960µs (20·2Hz) and was introduced on the playback side to improve signal-to-noise ratio

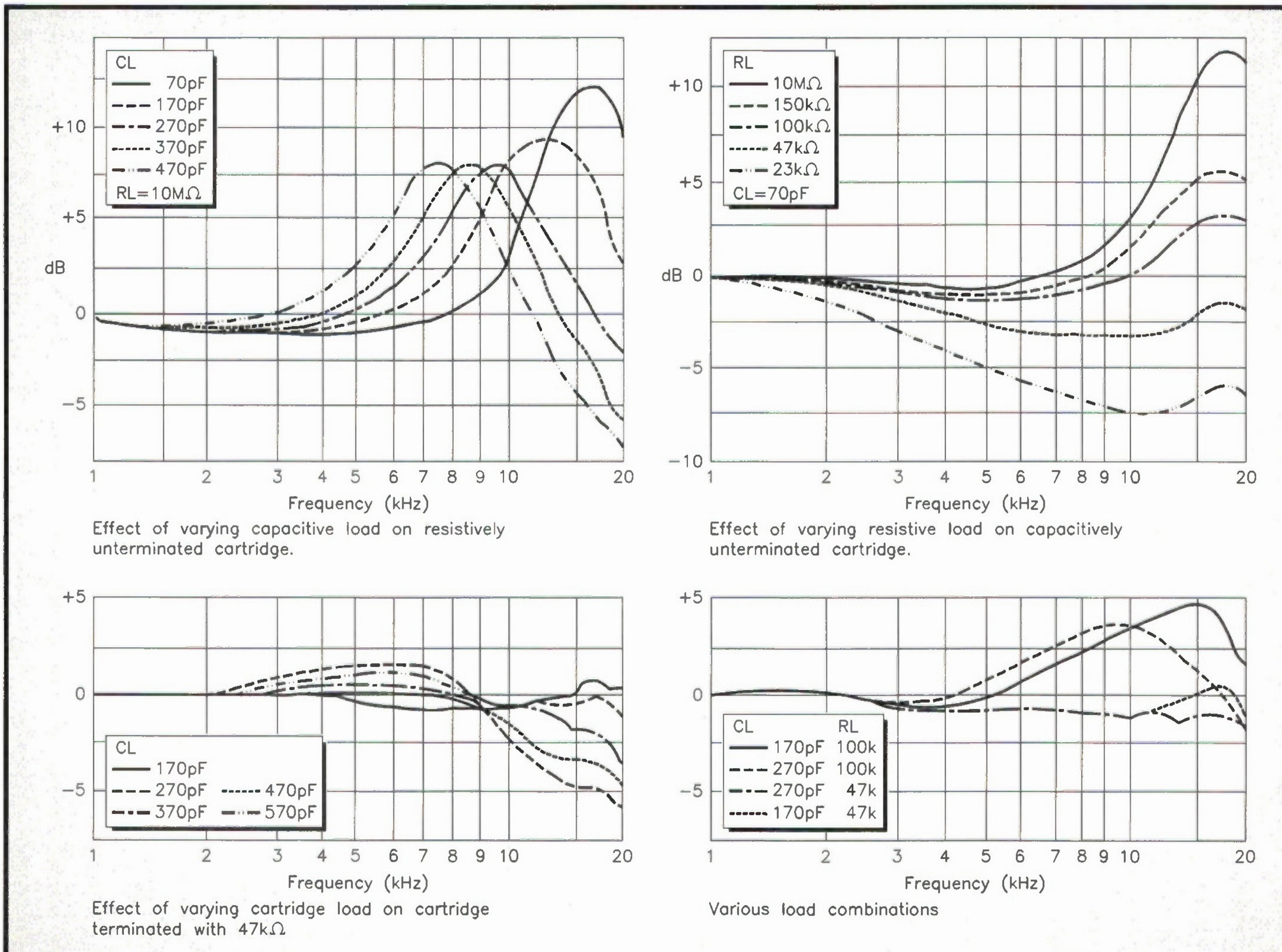


Figure 13. Effect of mismatched amplifier shunt capacitance on cartridge frequency response.

and stability of the system at extreme low frequencies. Such a single-pole filter, when coupled to the response created by the 3180μs time constant, gives a 6dB/octave roll-off to frequencies below 20Hz or so. This decision was made because of the problems encountered when using the existing RIAA curve, namely, that the large amplification given to frequencies down to and below the lowest audible frequency of the spectrum. This boost meant that mechanical disturbances (such as platter rumble or tonearm resonances) were amplified to the point where – because of the in-band harmonics which the subsonic resonances caused – 'muddying' of audible frequencies resulted, or bass cones of loudspeakers were endangered. The latter problem arises because loudspeakers can only dissipate power delivered at subsonic frequencies as heat. Other problems in this area of the audio spectrum can be caused by bad pressings, which in turn generate subsonic 'warp' frequencies. See Figure 9.

Figure 10 shows a gain versus frequency plot of the RIAA curve (record and playback), and Table 2 shows, in tabulated form, the gain at specific key frequencies. In Figure 10 the three main frequencies of interest (50Hz, 500Hz and 2122Hz) are shown. It is also traditional to show them as time constants, since it is more accurate – the frequencies are rounded whereas the time constants are absolute values.

50·5Hz and 2122Hz are the two main break frequencies (poles), with the frequency response rolling off at 6dB/octave above the 2122Hz frequency. The gain should, ideally, asymptote to zero. This may or may not be the case, depending upon which type of feedback is employed. We shall discuss this point further at a later stage. 500Hz is the zero and the third point of interest. Figure 11 shows the DIN curve, with the extra time constant at 20·2Hz highlighted on the playback curve.

Frequency (Hz)	Recording characteristic (relative amplitude) dB
20·0	–19·3
25·0	–19·0
31·5	–18·5
40·0	–17·8
50·0	–16·9
63·0	–15·8
80·0	–14·5
100·0	–13·1
125·0	–11·6
160·0	–9·8
200·0	–8·2
250·0	–6·7
315·0	–5·2
400·0	–3·8
500·0	–2·6
630·0	–1·6
800·0	–0·8
1,000·0	0·0
1,250·0	0·7
1,600·0	1·6
2,000·0	2·6
2,500·0	3·7
2,450·0	5·0
4,000·0	6·6
5,000·0	8·2
6,300·0	10·0
8,000·0	11·9
10,000·0	13·7
12,500·0	15·6
16,000·0	17·7
20,000·0	19·6

Table 2. Preferred frequencies and calculated recording characteristics, in accordance with RIAA standard.

Types of Feedback

There are two types of feedback used – series and shunt. It was mentioned that major prerequisite features of the overall design were low noise, low distortion, and accurate adherence to the RIAA curve. Unfortunately, both series and shunt feedback cause problems in one or other of these areas and neither can satisfy both requirements simultaneously – it is difficult to get really low noise performance with a series arrangement, and difficult also to get accurate amplitude response with shunt-applied feedback. We'll look at each type in turn to discover why this is so.

Series Feedback

Refer to Figure 12 that shows a typical series feedback arrangement. It is known sometimes as the 'non-inverting' type, for obvious reasons. The network based around R1, 2 and C1, 2 is representative of those found in commercial designs, but other topologies give equivalent results and can be used to replace it. R3 is typically kept below 1k in value, so that it is not contributing further noise along with that already caused by the finite impedance of the cartridge itself, which is typically approximately 500Ω to 2k.

R_S is a shunting resistor and provides damping for moving-magnet type cartridges, and C_S provides a shunting capacitance that should be equal to the combined total of cartridge capacitance (as specified by the cartridge manufacturer) and connecting cable capacitance. This shunt capacitance is more critical in value than many users/engineers give credit, since it resonates with the inductance of the cartridge (typically about 0·2 to 1H), at or near the audible frequency ceiling, and so determines the upper frequency response of the transducer, and the flatness of this response. Recommended load capacitances for various cartridges are specified by the manufacturer. Figure 13 shows the effect of wrong values of capacitance fitted to the circuit input.

The non-inverting configuration of the amplifier means that gain can never fall below unity. This means an error in the amplitude response, since the RIAA curve dictates that gain should roll-off smoothly to zero at a rate of 6dB/octave above the 2122Hz pole. A third pole (at the unity gain frequency) is now introduced.

Gain at frequencies where there should be none can cause distortion in any following stages, since frequencies that should have been attenuated can now freely be amplified. Preamplifiers intended for use solely with moving magnets suffer less in this respect, since the combination of the inductance of the cartridge/shunt resistance of the amplifier rolls off the response very quickly above 20kHz or so.

It can be a problem, however, with moving coil cartridges. These types possess very low inductance (in comparison with moving magnet types) and so are able to produce

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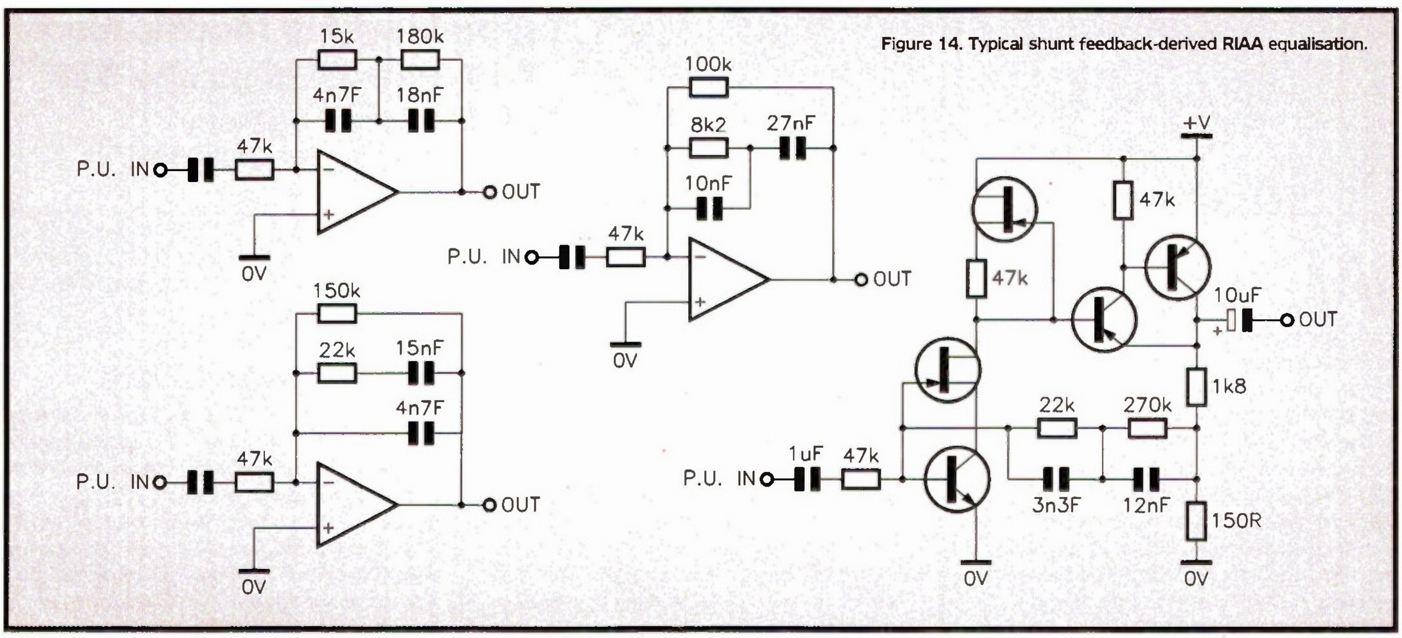

Figure 14. Typical shunt feedback-derived RIAA equalisation.

1
PROJECT RATING

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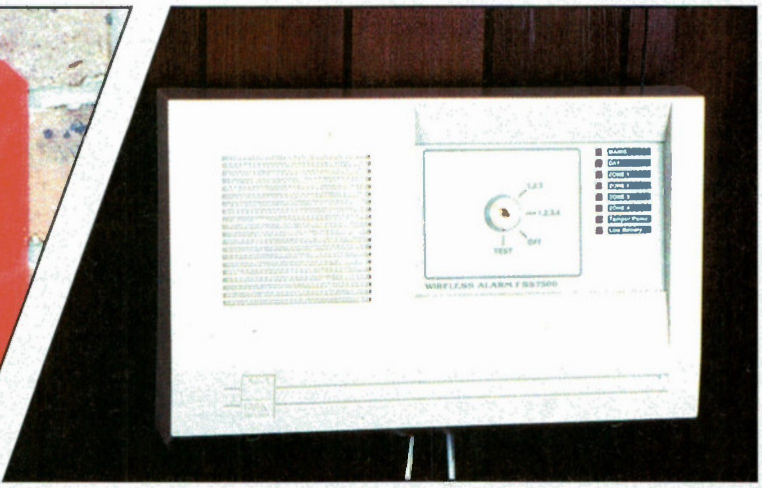
WIRELESS HOME BURGLAR ALARM SYSTEM

The 'Fox' Wireless Home Alarm system has proved very popular with many home owners, mainly because it is so easy to install. The Intruder detectors, for which there are four zones, communicate with the main control panel by radio, so your decor is not spoiled by yards of unsightly cable. It also means that the locations of the various components can be changed, at any time without a great deal of work. Each zone can have an unlimited number of detectors to extend the coverage.



FEATURES

- Upgrade for Fox Wireless Alarm FSS7500 (XS57M)
- Allows Fox Wireless Alarm to use Maplin Bell-Box (XP03D)
- Simple wiring modifications
- Highly-visible strobe light
- Back-up battery powered loud siren

While the Wireless Alarm has a companion alarm 'bell' box, there have been many requests from customers for a bigger bell box, with battery back-up and tamper protection.

The Assembled External Bell Box, Stock Code XP03D, has a long history going back to the very early Maplin Burglar Alarm Kit. Although compatible with the range of MSS2500/3000/3500 alarm systems (see Maplin Catalogue), the later style bell box is unfortunately not able to directly operate with the Fox FSS7500, because the Wireless Alarm does not provide the pair of 12V supply wires required.

The brightly coloured, polycarbonate bell box now has its own internal back-up battery, siren, strobe lamp and tamper switch, which makes it impossible to remove the cover, or the complete unit from the wall, without setting off the alarm. Similarly, cutting the connecting cable will also set it off, so it would make a really valuable addition to the Wireless Alarm. The latest version of the bell box also includes an integral 17 minute time-out timer.

The upgrade provides for just this modification by simply enabling the Wireless Alarm to present a DC supply potential to the Bell Box, which will use it to maintain its own battery charge and also monitors the line to detect any tampering with the wiring or the supply.

Wiring Configuration

The bell box requires a constant +12V supply to trickle charge its own back-up battery, a 0V or earth return wire and a control line which is switched to 0V by the alarm to sound the siren. While the Wireless Alarm provides the switched 0V line to sound the siren, there is, however, no provision for a *permanent* +12V supply (such a supply needs both +12V *and* 0V wires).

A constant +12V supply line can be taken from the Wireless Alarm's 'SIREN+' output, which is constantly held at +12V potential (this connection is normally used to provide the positive supply for the conventional bell box siren). That's half the problem solved. Now, where can you obtain a constant 0V supply?

The Wireless Alarm can have an optional sealed lead-acid back-up battery, which requires a current limited +12V supply and (of course) a 0V return. All that is necessary is to split the 0V return for the optional sealed lead-acid battery, and that's where the adaptor kit comes in. Please note that for best results the optional back-up battery should be used in the Wireless Alarm Control Panel main unit, otherwise, should you experience a mains power cut, the bell box will sound because the 12V supply has been interrupted. However, this battery is not essential.

Wiring Modifications for the Wireless Alarm

Install and test the Wireless Alarm as per its supplied instructions. The back-up battery connects to the alarm's main circuit board via 'Lucar' style 1/4in. connectors, a familiar type commonly used for motor vehicle electrical connections. These connectors are easily fitted to a wire, see Figure 1. Strip the wire to expose approximately 10mm of conductor, slide the insulating sleeve over the wire, and then crimp the connector onto the conductors with strong pliers. The narrow tongues at the rear of the connector are intended to be wrapped and crimped around the actual insulation prior to sliding the insulating boot over the completed connector. Crimped and soldered connections are best, but soldering is not essential, provided that the wire is tightly held.

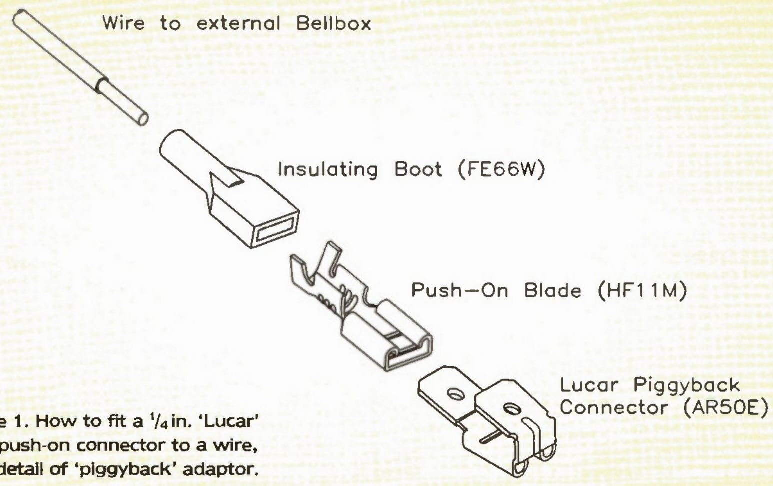
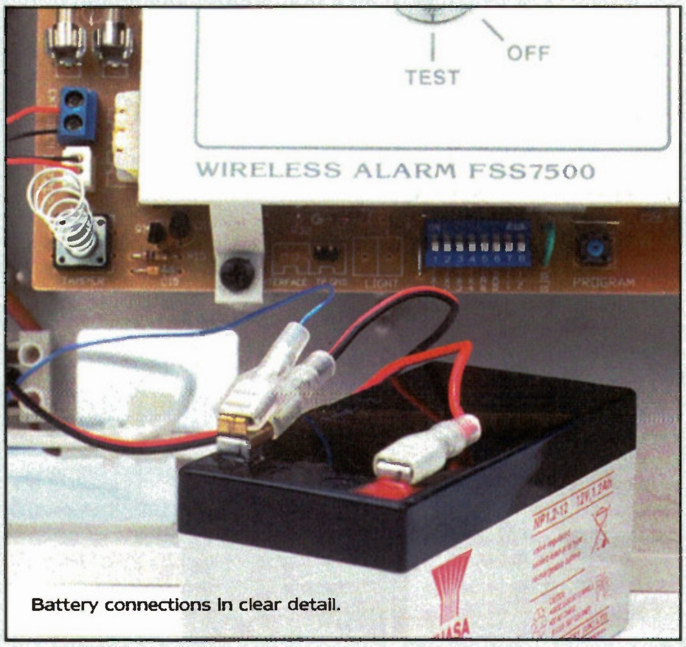


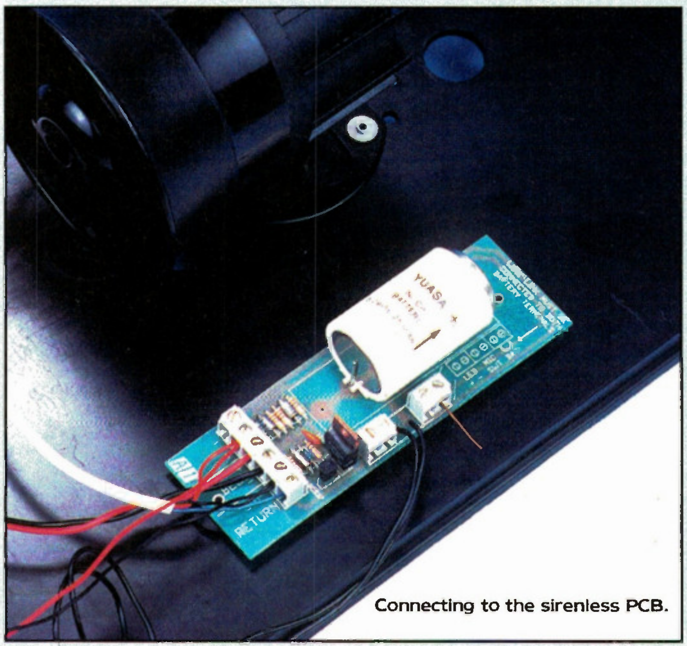
Figure 1. How to fit a 1/4in. 'Lucar' style push-on connector to a wire, with detail of 'piggyback' adaptor.

Using a length of 4-core Burglar Alarm Cable (XR89W), make the additional connections to the Wireless Alarm as shown in Figure 2. The Lucar 'piggyback' adaptor should be added, details are also shown in Figure 1. If the optional battery is fitted, it is pushed over the battery's (–) terminal, making two 1/4in. blades available. The black wire from the alarm main board connects to one of the blades of the 'piggyback' adaptor, restoring the original battery connection. The blue wire of the Burglar alarm cable, with its 'Lucar' push-on connector, is pushed over the other blade of the adaptor. If you do not have the optional sealed lead acid battery, lay the connector assembly in the base of the case. To ensure that the wires do not come into contact, wrap them in insulation tape.

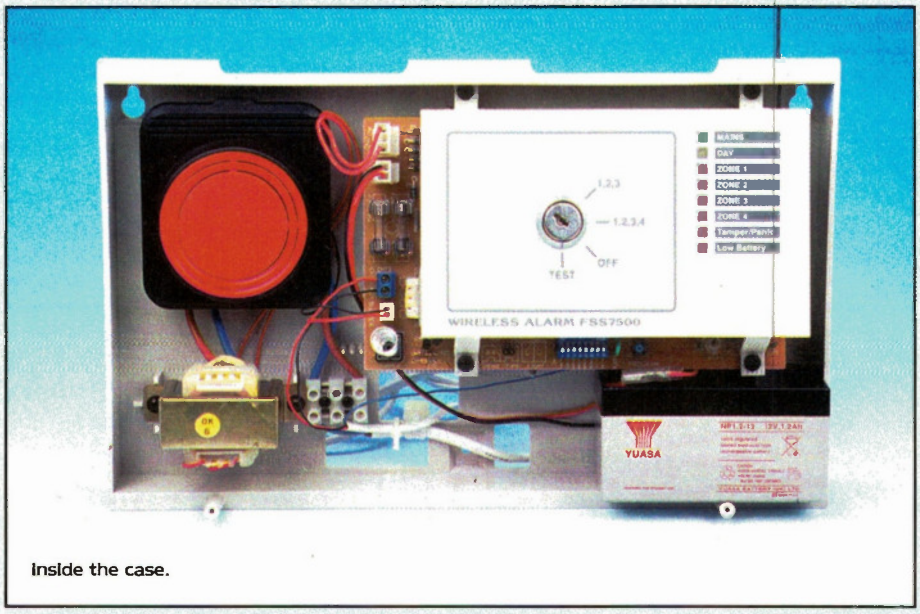
The red and black wires of the burglar alarm cable connect to the external siren screw terminals on the alarm main board as follows: red to 'SIREN+', black to 'SIREN–'. The yellow wire is not used and should be cut off completely, close to the end of the outer sleeve.



Battery connections in clear detail.



Connecting to the sirenless PCB.



Inside the case.

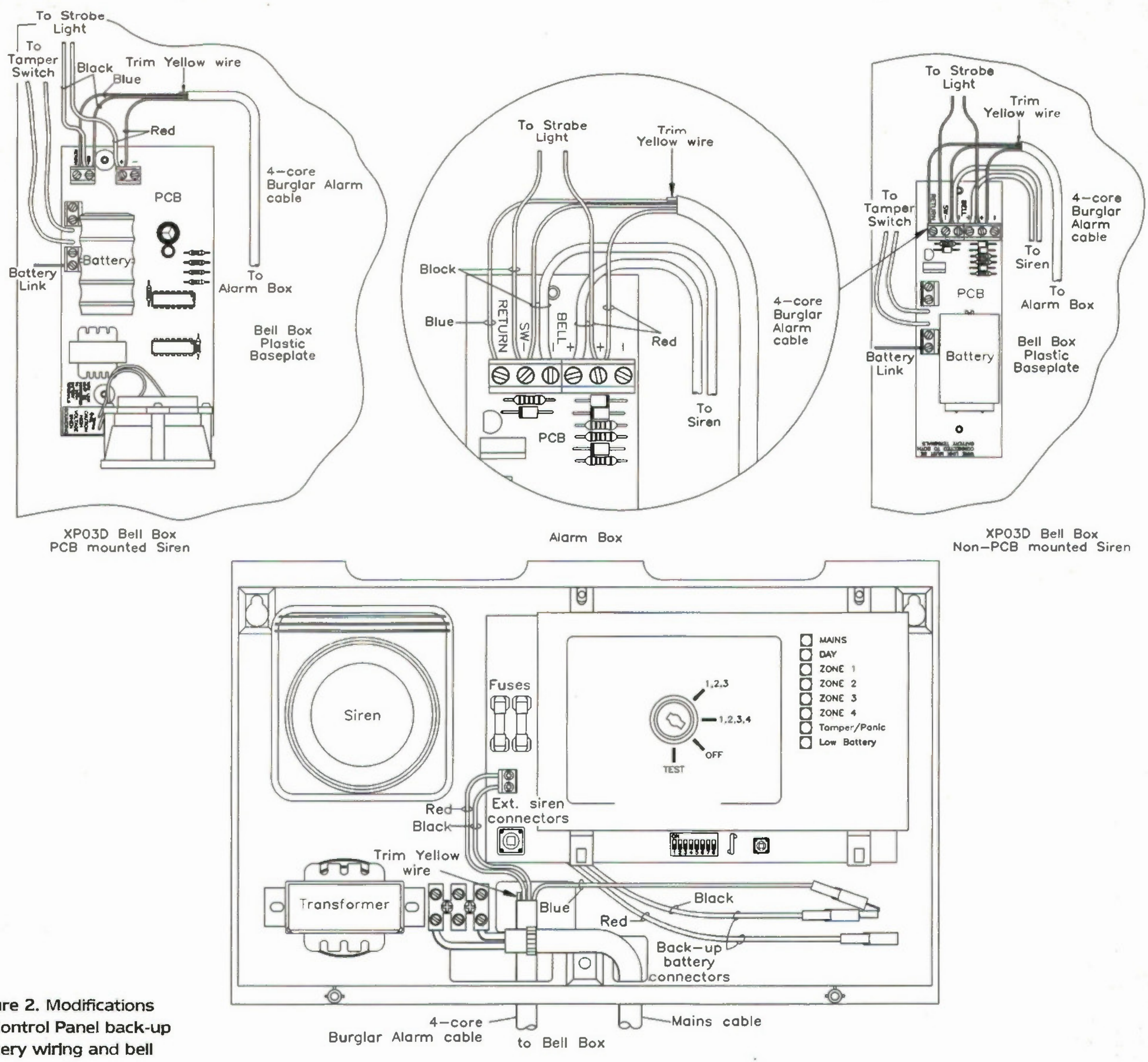


Figure 2. Modifications to Control Panel back-up battery wiring and bell box connections.

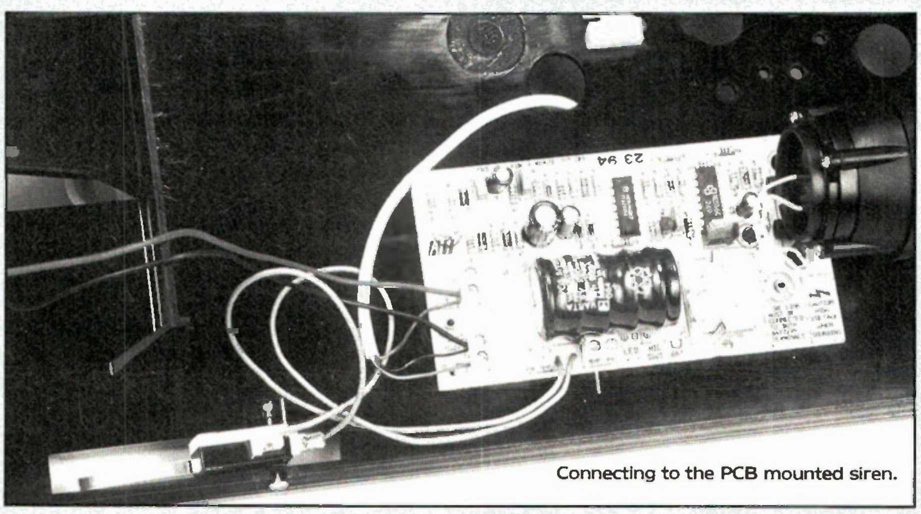
Now run the cable up to the intended position of the external bell box. The cable should be secured to the walls, with suitable cable clips (e.g., for 3·5mm cable, Maplin Stock Code BH19V (box of 20)).

Mounting the Bell Box

Select a suitable position on an outside wall, e.g., under the eaves, and drill four holes for the bell box fixings. Using a small diameter, long masonry drill bit, drill a hole through from the outside wall, angled such that the hole on the inside of the building is higher than the hole on the outside. This will help to stop ingress of rain. It is through this hole that the cable will pass.

Now for the tricky bit – feed the cable from the inside of the building, to the outside. If you have cavity walls you will soon discover how excruciatingly difficult this is! One solution is to use a straightened wire coat hanger (or thick solid core cable) and pass it through the hole, tape the burglar alarm cable to the end of the coat hanger, and then pull the wire and cable through.

Pass the cable through the back of the external bell box, and fix it to the wall.



Connecting to the PCB mounted siren.

Wiring Up the Bell Box

There are, currently, two types of Maplin bell box in existence. Connect the wires to the bell box, referring to Figure 2, depending on which version you are using.

The internal layout of the old type bell box is shown on the right in Figure 2. Connections to the old style (inset) comprise the black wire of the burglar alarm cable going to the 'SW–' screw terminal (which it shares with the Strobe Light black wire), and the blue wire to the 'RETURN' screw terminal. The red wire connects to the (+) terminal which it shares with the strobe light red wire. Again, the yellow wire is unused and should be cut back to the outer sleeve.

The internal layout of the new type bell box is shown on the left in Figure 2. Wiring to the new style bell box is exactly the same, even though there are only four screw terminals (the siren is integral to the PCB mod-

Continued on page 46.

SUPER SCAN – *Continued from page 15.*

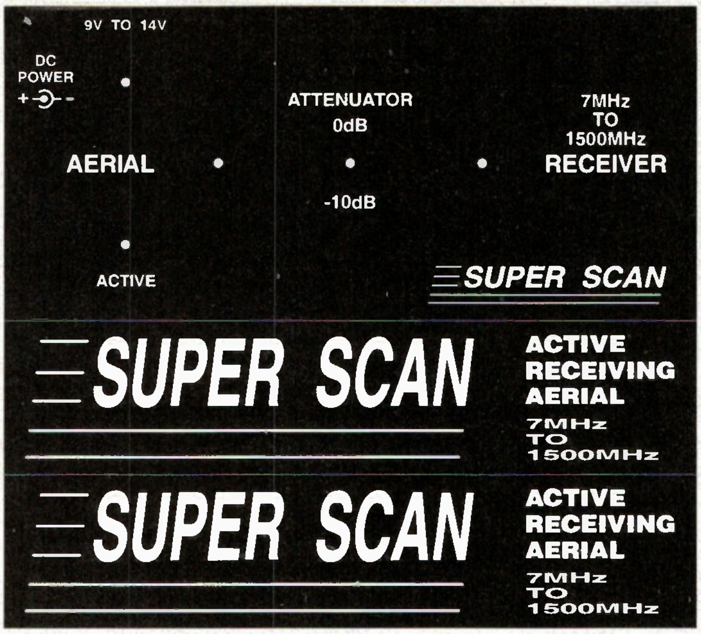


Figure 14. Active aerial label.

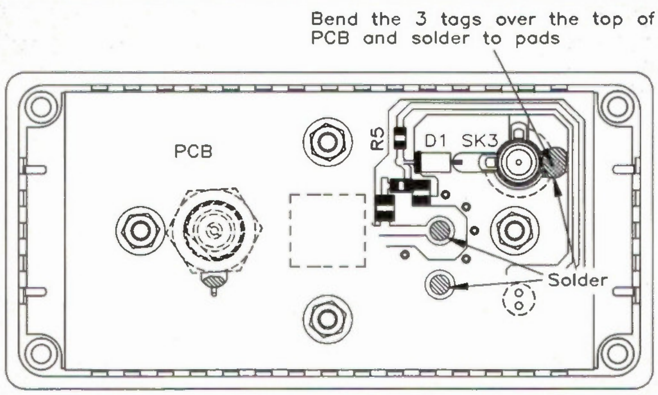
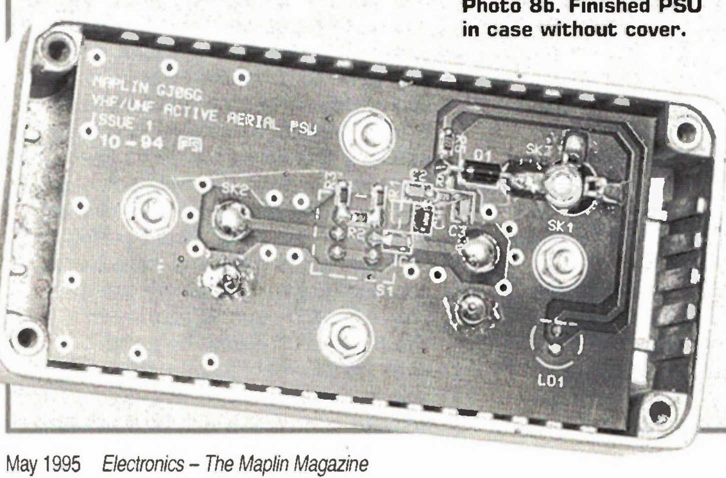


Figure 15. Final PSU assembly.

Photo 8a. Final PSU Unit.

Photo 8b. Finished PSU in case without cover.



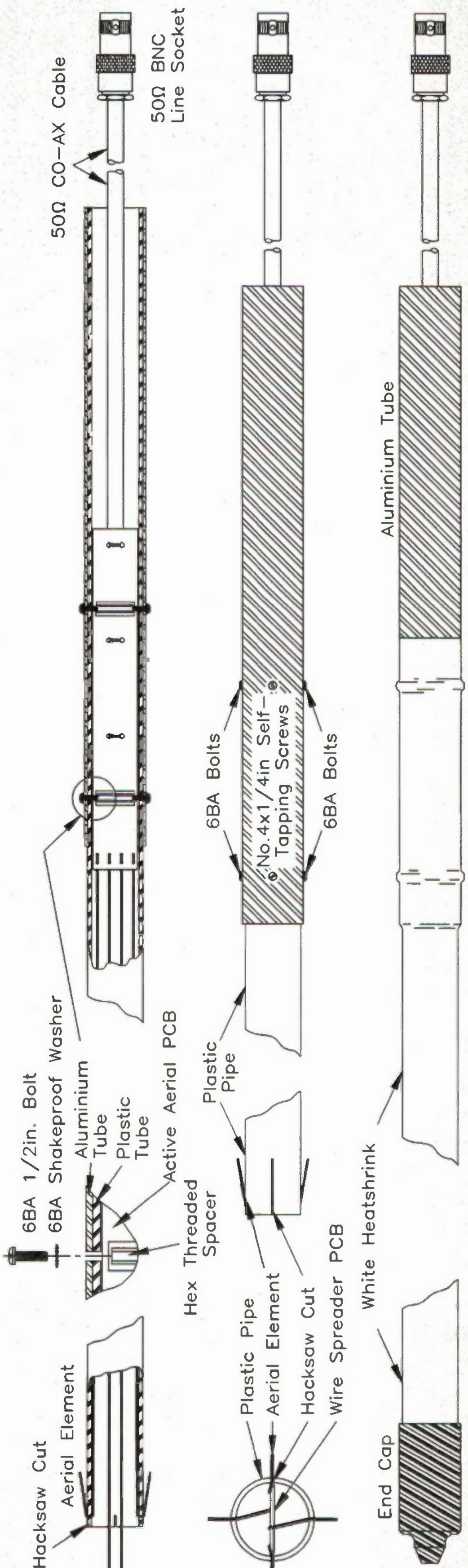


Figure 16. Final Aerial assembly.

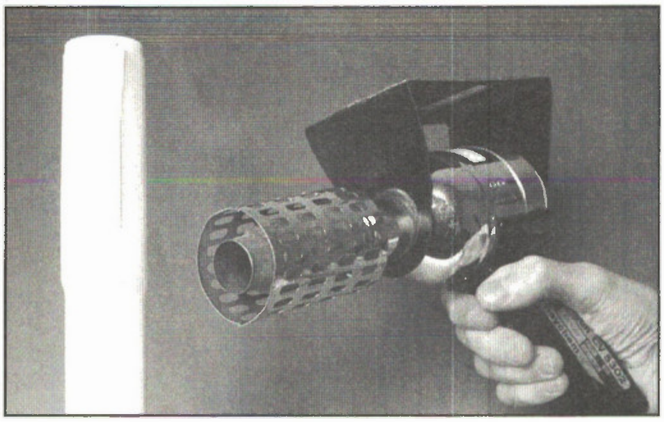


Photo 9. Fitting the heat-shrinkable tubing.

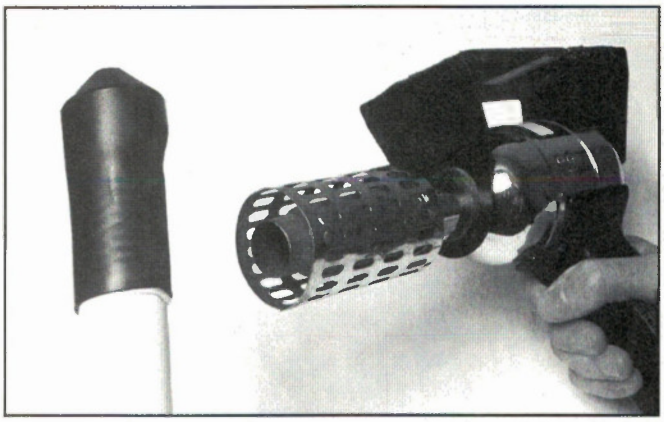


Photo 10. Fitting the heat-shrinkable end-cap.

is available with the kit or separately (KP81C). Note the label has to be separated into three parts, fit the upper portion to the PSU box, and one or both of the labels should be attached to the white portion of the aerial. Before applying the label to the box fit the four M3 × 20mm countersunk bolts, they are all mounted in the same way with the shakeproof washer, M3 nut, M3 spacer and M3 nut. Ensure that the PCB fits into the box correctly, before applying the label. Next fit the label to the box, use a sharp knife or scalpel to clear the holes ready for the components to be located through. The three sockets can now be mounted onto the body of the box in their correct locations, with their relevant washers and lock nuts. The PCB is offered up to the box, the three tags on socket SK3 are eased through the correct hole on the PCB, and the pins on socket SK2 through the relevant holes on the PCB refer to Figure 15. The LED and switch are eased through the body of the box at the same time.

When all is satisfactory, fit the remaining M3 washers and tighten up the M3 nuts. The three tags on SK3 are bent over the top of the PCB and soldered in position onto the pads; the connections on socket SK2 are likewise soldered. Once this operation has been carried out it will not be easy to demount the PCB. Photo 8 shows the PSU PCB located in the diecast box.

Testing Procedure for the Super Scan Aerial

The initial DC testing procedure can be undertaken using the minimum amount of test equipment. You will need a multimeter and a power supply capable of providing +12V DC at up to 300mA. All the following readings are taken from the prototype using a digital multimeter – some of the readings you obtain may vary slightly depending upon the type of meter used!

When testing the aerial, it has to be pre-tested outside the tube before the final assembly, but the first part to be tested is the PSU interface.

The PSU interface can only be fully tested when it is completed and in its box, to test for any short circuits on the PCB or sockets. Assuming that the unit is built up in its diecast box and bolted in position without the back on, you should be able to take the following resistance measurement before applying power.

Using a multimeter on the ohms range and applying the test probes on the power socket, either way round to the inner and outer should reveal a very high resistance of several megohms indicated. If using a digital multimeter, there will not be enough voltage to fire up the LED on the PCB. Some analogue meters will have more current available and will make the LED illuminate.

Next, connect the power (+12V DC) and observe the current, only the LED should be drawing current at this stage. When powered up with the current meter in series with the power input, LED LD1 should illuminate and a current reading of approximately 4·5mA should be indicated. That being the only current drawn, as the Active Aerial is not connected to the aerial input at this stage.

The next test is to make sure that the DC is getting through to only the aerial TNC socket, and that the BNC socket does not have any voltage on it. The voltage reading on the centre pin of the TNC aerial socket should be approximately 11·3V DC, which is 0·7V down on the 12V due to the drop across the protection diode. Check the centre pin of the BNC socket to confirm that there is not any DC voltage on it. The –10dB attenuator cannot be tested at this stage as it is in the signal path, but it is possible to check the DC resistance conditions by measuring the inner to outer of the BNC socket, with the attenuator in the 0dB setting it should read open circuit, and when switching in the –10dB, you should get a reading of approximately 63Ω. That will confirm whether the SMD resistors are in the right configuration.

That completes the tests on the PSU interface. Finally fit and fix the baseplate in position with the four countersunk screws provided, and stick on the four small rubber feet.

We now carry out similar tests on the actual active aerial on the BNC line socket, on the end of the fly lead coming out the base of the aerial. With the multimeter on resistance range, the probes either way round on the inner and outer of the BNC connector from the aerial, the reading should be approximately 1k2Ω. Now with the aerial connected to the PSU interface and with the meter reading current the aerial should draw 22mA, this indicates that the MAR6 is working DC wise. The only way of testing it further is to either connect it to a spectrum analyser or failing that, to a scanner receiver, hopefully with the sort of range the active aerial will work over, i.e. 7MHz to 1·5GHz. Tune to something that you would normally pick up on the whip aerial on the scanner, and when you change over to the Super Scan it should be of a relatively similar strength, or stronger.

That completes the testing procedure, now follow the final assembly details in the next section.

Aerial

Within Figure 16 are a number of relevant drawings for this section, these will assist in the construction of this next phase of the aerial.

Fit four No. 4 self-tapping screws through the 2mm holes in the aluminium tube into the plastic pipe, this holds the two parts together.

The position of the PCB inside the tube is critical and needs to be lined up with the 3mm holes. A cutaway drawing in Figure 16 shows the position of the PCB and the 6BA bolts and shakeproof washers. Positioning the PCB is relatively straightforward, it is best to drop the PCB from the top of the aerial (the end furthermost from the aluminium tube), this way the spacers and aerial elements lie inside the tube, and will not fall back down, the wires will then be accessible at the end of the tube. Start pulling the PCB down the tube and rotate into position by gently twisting the coax until the PCB roughly aligns with the holes. Put a 6BA bolt and its shakeproof washer through the 6BA hole in the pipe. Once one of the 6BA bolts is in position, do not overtighten,

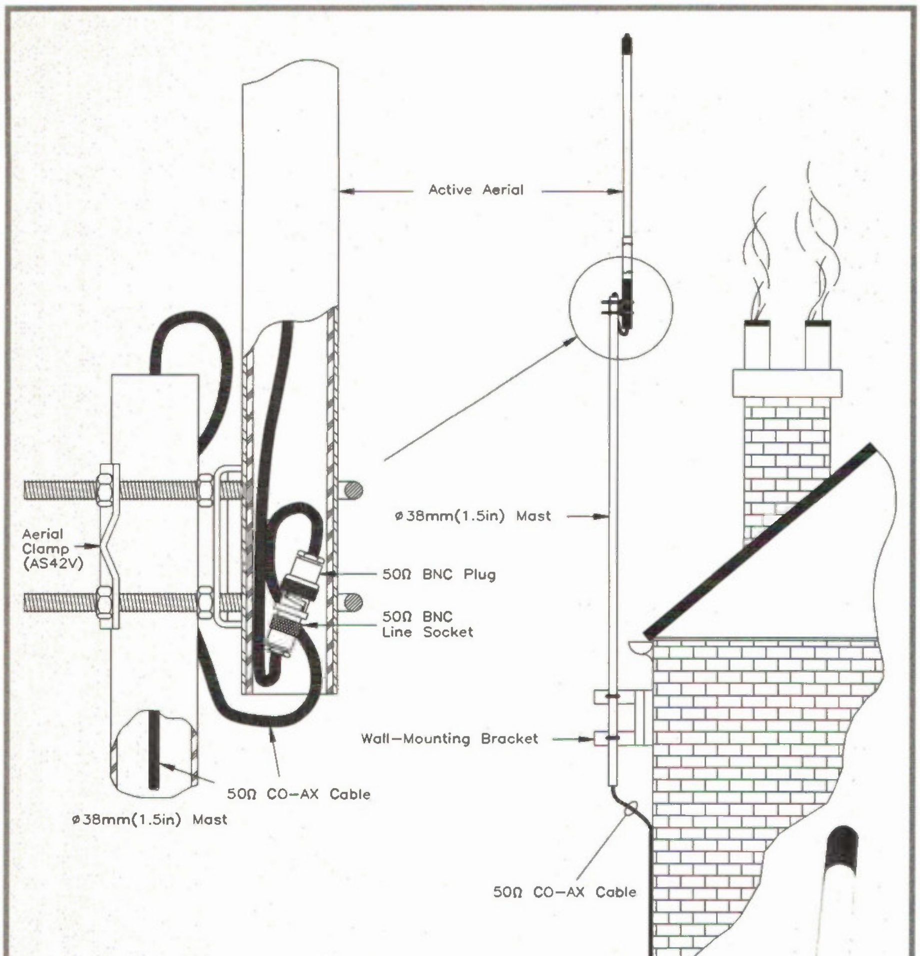


Figure 17. Typical aerial installation.

leave it loose, this will help in the registration of the other three 6BA bolts. When tightening up the 6BA bolts it is best to gently tighten up on one side and then the other, so the board has an equal amount of pressure on both sides of the board. Once the PCB has been fitted with the 6BA bolts, take the aerial elements, then looking down through the top end of the tube, make sure that the runs of wire down to the PCB are not twisted over each other, they should be running in parallel. Start pulling the aerial elements/wires and slowly bring up the tension and lock them off into the slots. It will be found that after tensioning the wires, the wires stretch and it is best to release each element in turn and retension them, but do not over tension them as it is possible to snap the lacing cord. Once these are locked off, trim them from the outside of the pipe as shown in Figure 16; tack the ends down with tape, all this does is to hold the wires flat, so that when the heat shrink material is fitted, which is the final method of locking them off, the wires lie in a perfect position underneath the heat shrink.

Before fitting the heat shrink material, make sure that the 6BA bolts and the No. 4 self-tappers are all fully tightened. When using a screwdriver it is possible to leave a sharp edge on the head of the bolt or screw, if heat shrink is then applied over these, as it shrinks on it will puncture and tear the heat shrink – so after tightening the bolts make absolutely sure that the heads are smooth; if not use a piece of emery paper or file to smooth off any rough edges on the ends of the aluminium or on the heads of the bolts.

Photo 11. Finished aerial.

Fit the very wide standard lay-flat white heat shrink sleeving which comes precut in 1m lengths, this is just right to cover the set of screws on the base, and the ends of the aerial elements at the other end of the tube. When the heat shrink is positioned on the pole, there should be a 5mm gap at the top. Do not overheat the heat shrink material, it only needs to mould itself over the aerial, as shown in Photo 9, excessive heat will weaken it and cause it to split. If a proper heat-gun is not available then either a heat-gun of the paint stripping variety (the heat from which is very strong) or an efficient hair-dryer at its maximum setting (this will be slower as the heat output is less).

After shrinking the white heat shrink onto the outside of the tube. It now remains to fit the black heat shrink end-cap, when heat is applied an adhesive will run out, this will be hot, so be careful not to touch it. The end-cap being of thicker heat shrink material, it takes a considerable amount of heat for it to shrink on, Photo 10 shows the process. The glue helps to provide a good waterproof seal at the end.

Finally to finish off the aerial, the sticky label supplied with the kit (which is printed in two parts) has to be cut up with a pair of scissors. The main part is the front panel of the control box, which contains all the various legends, the second part is merely the logo, which is stuck onto the aerial near the base, the spare can either be stuck onto the aerial or to the control box. Photo 11 shows the finished aerial.

Aerial Installation

The aerial installation is straightforward and follows normal practice for small aerials. First select a location on the side of the house or bungalow, preferably away from power and telephone lines etc. that might interfere with reception. With safety in mind when climbing ladders, make sure that the base of the ladder will not slide about. Next locate the wall mounting bracket on the side of the building. A suitable wall mounting bracket is the mast bracket No.3 type (XQ53H), or if it is to be located on a chimney, use the chimney lashing kit No.7 (XQ57M). A length of 38mm (1·5in.) aluminium tubing is required as a mast, and an aerial clamp (AS42V) for attaching the Active Aerial to the mast which is illustrated in Figure 17. Photo 12 shows such a typical aerial installation being conducted on a flat roof. Drill and fit with wall bolts, or if a lashing kit is used, fit round the brickwork. When fitting the mast, lower to its lowest position and fit the aerial clamp plus the active aerial.

Tightening up the clamps, holds the aerial to the mast, a good tip is to lightly grease the threads and the nuts on both clamps, this will make it easier to undo in the future. Next connect the prepared coax to the 50Ω BNC line socket and gently push the coax and connections into the body of the active aerial (see cut-away drawing), some form of packing may be used at this point. Now feed the coax down the centre of the mast, when this has been done, push the mast into position and tighten up the clamps. Then run the coax down the wall to the required location (fixed in position by clips) drill a hole into the window frame of the required room or use the existing hole used for TV or satellite coax.

The coax is connected to the TNC socket on the PSU box, and a coax connection with BNC plugs on each end runs to the scanner receiver. Finally connect the regulated PSU with centre positive on the 2·5mm plug to the active aerial PSU, see Figure 18.

Using the Super Scan

There are generally two main categories of scanning receivers, portables and desktop models. Both these types include scanners that are FM/AM only, and others which cover modes such as SSB and CW. The earlier type of scanning receiver did not have full coverage of the VHF/UHF spectrum, the gaps in the frequency coverage dependent on the type of scanner.

The modern scanning receiver now invariably covers virtually 0KHz to 2GHz (jokingly referred to as DC to light), and most of the modes, NFM, WFM, AM, USB, LSB and CW

Whatever type of scanner receiver, the VHF/UHF Active aerial will enhance the operation, especially if all that was previously used was the extended whip or rubber duck aerial as provided with the scanner.

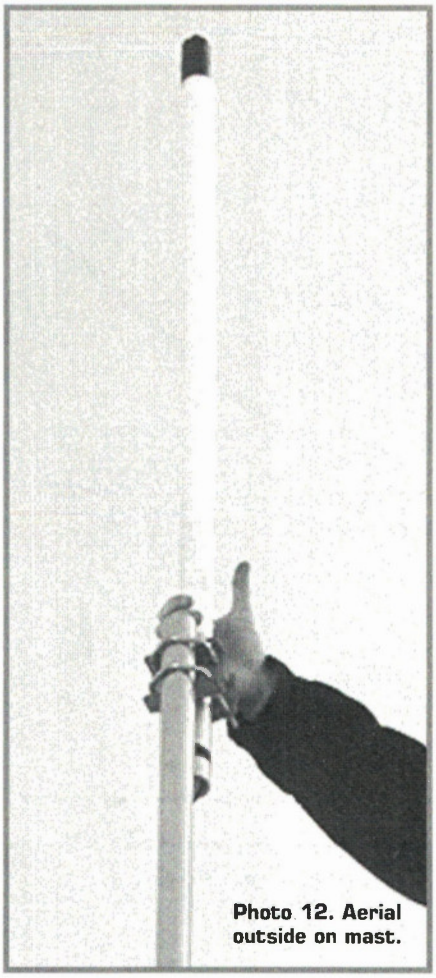


Photo 12. Aerial outside on mast.

These days, there are also a number of amateur radio transceivers that include extended receiver coverage, such as the aircraft and marine bands. It is important to remember to disable the transmit facility on these particular rigs, when using the active aerial, outside of these bands they should not be able to legally transmit.

The hobby of radio is very large and includes many areas, the average enthusiast might be a radio amateur who is also interested in aircraft, or an SWL who is interested in a particular area on VHF/UHF.

A selection of current typical scanners and scanner books are shown in Photo 13. There are a number of books dedicated to the scanner enthusiast, some of which are not always appreciated by the authorities. Responsible scanning must be the order of the day, as hefty fines and confiscation of equipment can be the result of insensitive listening and divulging classified information to third parties. Remember that it was not that long ago that the divulging of telegraphic information was punishable by imprisonment for a year, with or without hard labour.

Further Reading

The VHF/UHF Scanning Frequency Guide (WT70M), by Bill Laver.
Scanners – A VHF/UHF Listeners Guide (WP47B), by Peter Rouse.
Air Band Radio Handbook 5th Edition (WT83E), by David J. Smith.
Scanning Secrets, by Mark Francis and Bill Laver.
The UK Scanning Directory.

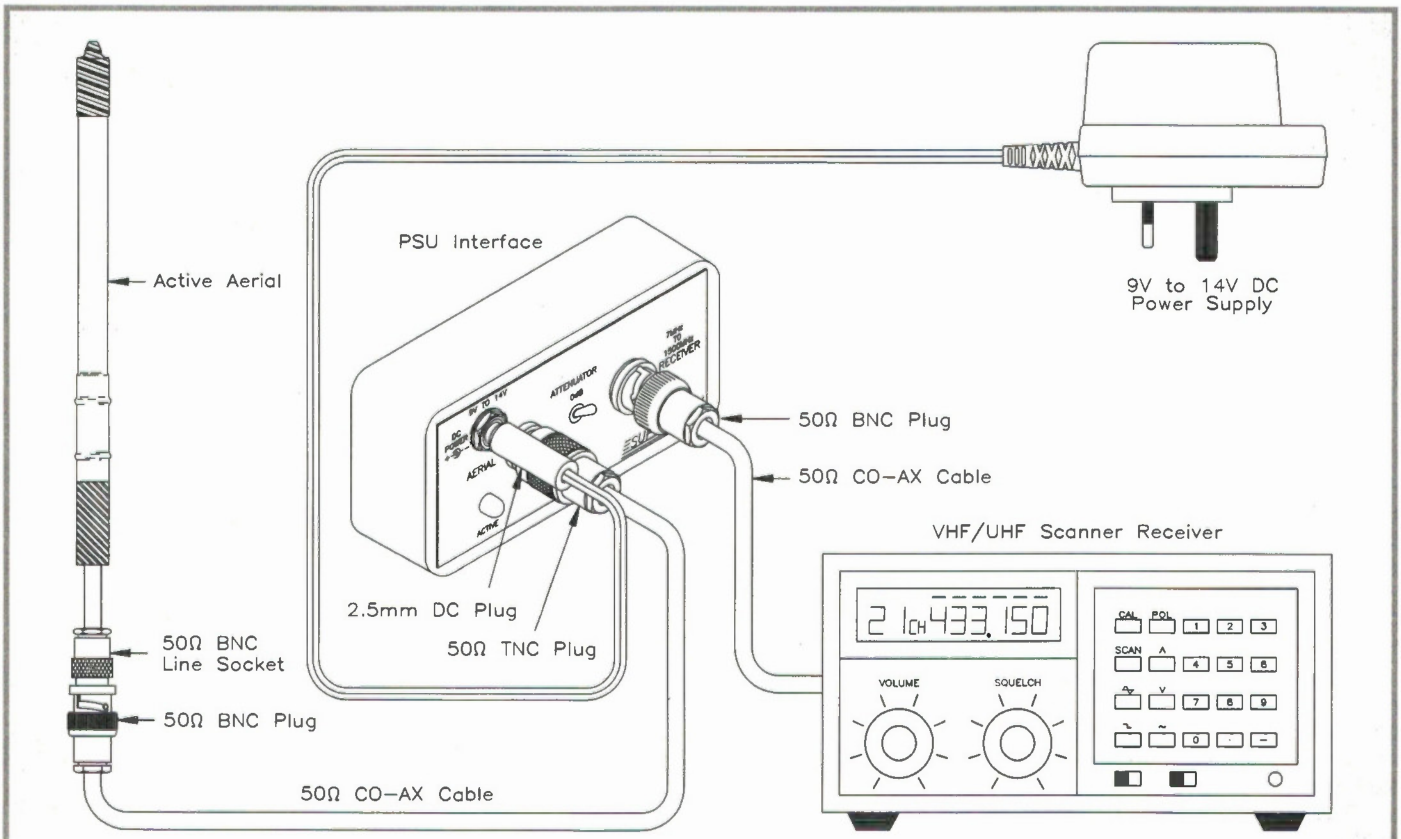


Figure 18. Active aerial system wiring.

Photo 13. Collection of scanners and scanner books.

SUPER SCAN PARTS LISTS

VHF/UHF ACTIVE AERIAL

RESISTORS (All Resistors Surface Mount)			
R1	1k	1	(DJ12N)
R2	220Ω	1	(DJ08J)
CAPACITORS			
C1	47pF SMD Ceramic	1	(DH89W)
C2	1µF/16V SMD Tantalum	1	(DK22Y)
C3	220pF SMD Ceramic	1	(DH91Y)
C4	100nF SMD Ceramic	1	(DJ00A)
SEMICONDUCTORS			
IC1	MAR-6	1	(DK24B)
WOUND COMPONENTS			
CH1,2	6·8H SMD	2	(DK23A)
MISCELLANEOUS			
	Tie-Wrap 100	3	(BF91Y)
	6BA Tapped Spacer 7/8	1 Pkt	(JG20W)
	7/0·2 Wire 10m Black	1 Pack	(BL00A)
	Lacing Cord	1 Reel	(BL65V)
	6BA × 1/2in. Bolt	1 Pkt	(BF06G)
	6BA Shake	1 Pkt	(BF26D)
	No.4 × 1/4in. Self-Tapping	1 Pkt	(FE68Y)
	Aluminium Tube	1	(KP80B)
	White Heat Shrink CHT67	1m	(BA06G)
	End-cap 40/14	1	(MK02C)
	PCB	1	(GJ05F)
	Instruction Leaflet	1	(XV32K)
	Constructors' Guide	1	(XH79L)

VHF/UHF ACTIVE AERIAL PSU

RESISTORS (All Resistors Surface Mount)			
R1,3	100Ω	2	(DJ07H)
R2	68Ω	1	(DJ06G)
R4	220Ω	1	(DJ08J)
R5	2k2	1	(DJ13P)
CAPACITORS			
C1	220pF SMD Ceramic	1	(DH91Y)
C2,3	100nF SMD Ceramic	2	(DJ00A)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
LD1	2mA 5mm Red LED	1	(UK48C)
WOUND COMPONENTS			
CH1	6·8H SMD	1	(DK23A)
MISCELLANEOUS			
S1	PCB Switch Vertical DPDT	1	(JX91X)
	Active Aerial Label	1	(KP81C)
	PSU PCB	1	(GJ06G)
OPTIONAL (Not in Kit)			
	50Ω Cable	As Req.	(XS51F)
SK1	TNC 50Ω Socket	1	(FE81C)
SK2	BNC 50Ω Round Socket	1	(HH18U)
SK3	2·5mm Panel Mounting Power Socket	1	(JK10L)
	Box DCM5002	1	(LH70M)
	Stick-on Feet Small	1 Pkt	(FE32K)
	TNC Plug	1	(FE80B)
	BNC 50Ω Plug	1	(HH17T)
	BNC Line Socket	1	(YW01B)
	M3 × 20mm Pozi-screw	1 Pkt	(JC71N)
	M3 Isoshake	1 Pkt	(BF44X)
	M3 Steel Nut	2 Pkt	(JD61R)
	M3 Steel Washer	1 Pkt	(JD76H)
	M3 × 1/4in. Spacer	1 Pkt	(FG33L)

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 LT27E (VHF/UHF Active Aerial) Price £29.99

The following new items (which are included in the kit) are also available separately, but are not shown in the 1995 Maplin Catalogue

Active Aerial PCB **Order As GJ05F Price £6.99**
Active Aerial PSU PCB **Order As GJ06G Price £4.99**
Aluminium Tube **Order As KP80B Price £5.99**
Active Aerial Label **Order As KP81C Price £2.29**

Designed by Robin Downs and Dennis Butcher
Text by Robin Downs and Maurice Hunt

KIT AVAILABLE (LT83E) PRICE £32.99 A1

RS232 Serial Line Tester in optional carry case.

RS232 Serial Line Tester

3 PROJECT RATING

FEATURES

* Easy to build/use * Multiple function * Versatile, pocket-sized unit * 8-bit PIC microcontroller-based * Four different Baud rates * Low current consumption

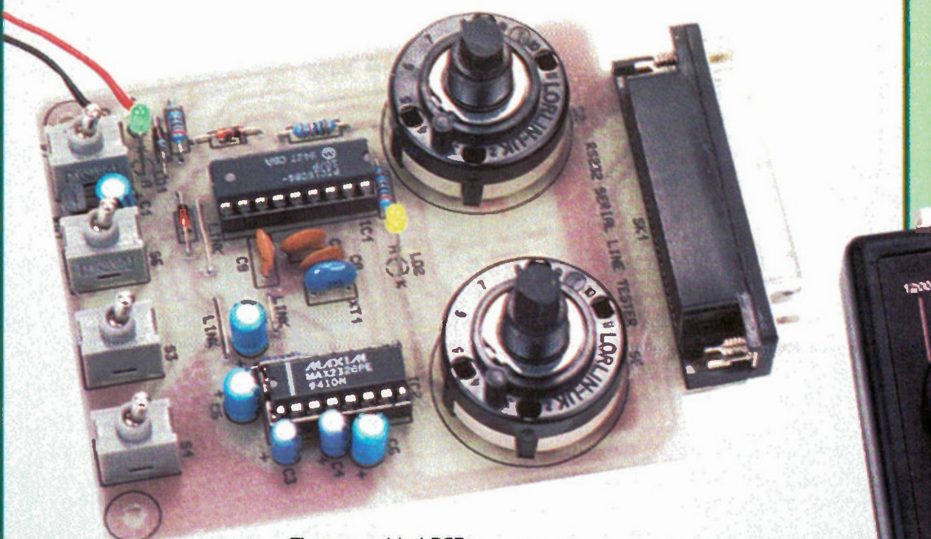
APPLICATIONS

* Terminals * Printers * Modems * Multiplexers * RS232 Cabling

The RS232 Serial Line Tester project presented here is an extremely handy, pocket-sized device for rapidly testing serial terminals, printers and other communications equipment using RS232 data cabling. It also provides a painless introduction to the world of PIC microcontroller-based projects, with no programming required!

Specification

DC power supply voltage:	Single 9V PP3 cell
Supply current (typical):	14mA
Battery life (estimated):	>30 hours (using recommended GP alkaline cell, Order Code ZB52G)
Visual indicators:	Two miniature LEDs provide power on/battery state and data flow indication
Test facilities:	80- and 132-column test modes Choice of test patterns Choice of Baud rates (1200, 2400, 4800, 9600) Choice of data formats (7-bit Odd/Even/Mark/Space, 8-bit None) Visible confirmation of software flow control (X-On/X-Off)



The assembled PCB.

This tester is an invaluable aid to diagnosing problems with serial RS232 equipment. For example, where a multi-user computer system has a large number of terminals and printers distributed around one or more sites, they are often connected via simple asynchronous RS232 data cabling for a cost-effective and flexible installation. However, when a device fails to operate correctly, usually at the furthermost point of the system (!), a way of testing the equipment quickly and independently of the host system can save a great deal of time in isolating the fault. Described here is a low-cost, portable, and easy to use instrument, capable of providing several useful test functions to enable rapid trouble-shooting.

For terminals, the following test features are available, as shown in Table 1.

When used in 'Terminal' mode, the unit displays a short message and prompts for the user to select a test. This start up message can be used to try various speed and parity options if the configuration is unknown, for both printers and terminals. The small amount of data sent will not generally cause a printer set at the wrong speed to print reams of rubbish.

On a VDU, the test number (1 to 4) is entered, followed by <CR> to start the test.

PCs used to emulate serial terminals via Kermit, MS Windows™ Terminal, Procomm™ or any similar package may also be tested in the same way.

In 'Printer' mode, tests are selected by front panel switches allowing two types of test print (sliding/straight) and two widths (80/132 Column) to be selected.

RS232 Communication – Overview

A brief description of asynchronous RS232 communications principles may be useful at this point as background to the use of the unit; Figure 1 shows a representation of the levels and timing for a 'typical' data byte.

Data Format

RS232 is a serial data protocol, i.e., each data WORD is sent one bit at a time, unlike a parallel printer port where there are eight data lines, one for each bit and a number of control lines to regulate the data flow.

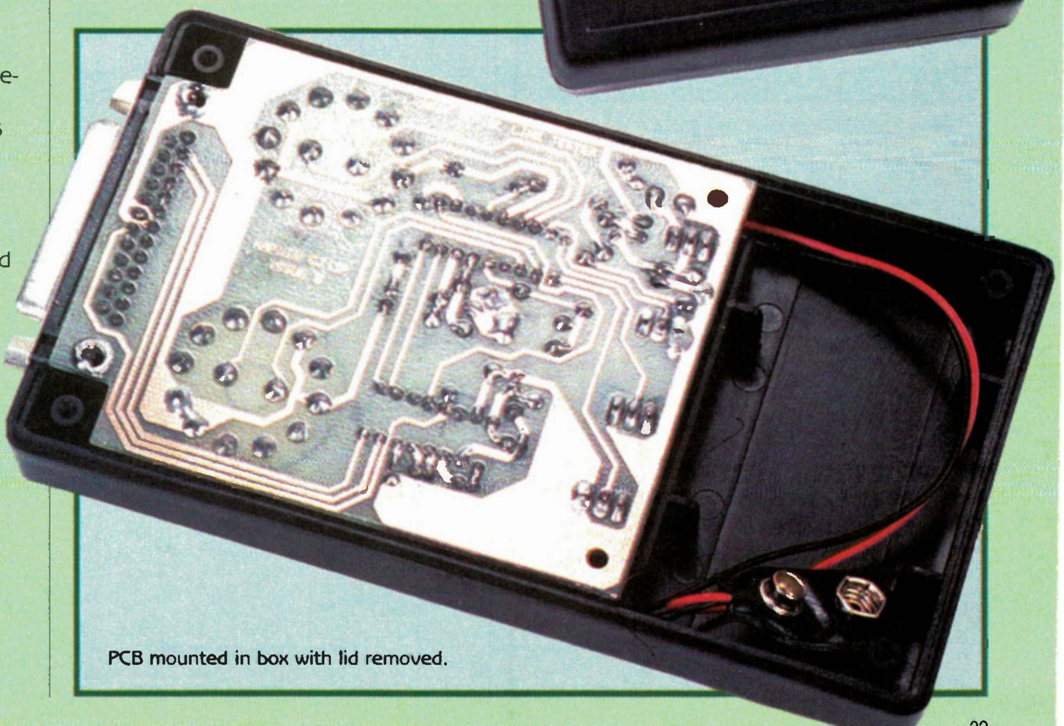
Signal Levels

All signals are either driven high (+3V to +12V) or low (–3V to –12V) to signify a logic 0 or a 1, respectively. It should be noted that the idle state of the data lines is a logic 1, and the RS232 buffers invert on transmit and receive such that the data lines, when idle, are negative.

Each bit has the same period, defined as 1/(Baud rate), i.e., at 9,600 baud, the bit period is about 104μs.

Serial Data Transmission

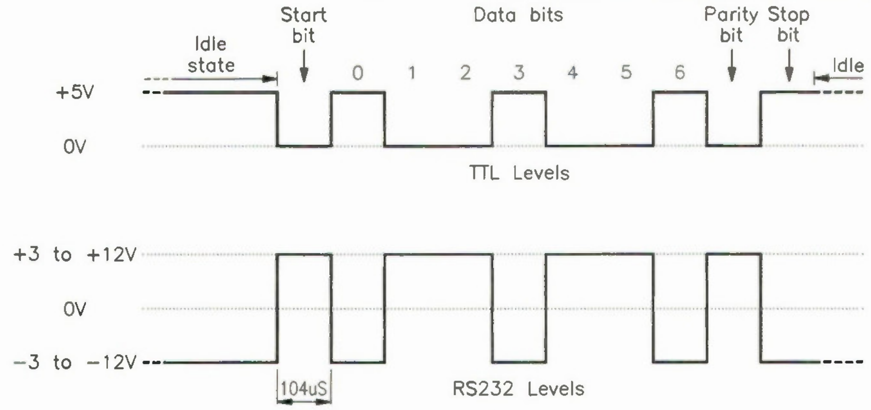
In order to send a data word, the sender initially sends a 'Start Bit' (Logic 0) to indicate that the receiver should expect a number of data bits to be sent, followed by the 7 or 8 data bits and terminated (optionally) by a 'Parity Bit' and a 'Stop Bit'



PCB mounted in box with lid removed.

Test	Function
1 & 2	Display character set (straight/diagonal pattern)
3	Fill screen with selected character (to set screen focus, etc.)
4	Hex dump of received data (to test control/function keys)

Table 1. Terminal display options.



Example of sending ASCII chr 73 'I' ($2^6+2^3+2^0$) with spare parity and 7 data bits at 9600 baud.

Figure 1. Examples of serial data timing and signal levels.

(Logic 1). The parity bit was originally designed as a check bit to indicate that the data word contained an odd or even number of logic ones, hence odd or even parity, however, it is often unused (Space parity) or set permanently to logic one (Mark parity). In these cases only the parity bit is checked for correctness, the data cannot be verified. In any case, with parity enabled, only single or odd numbers of bits in error can be detected – there is no error correction information.

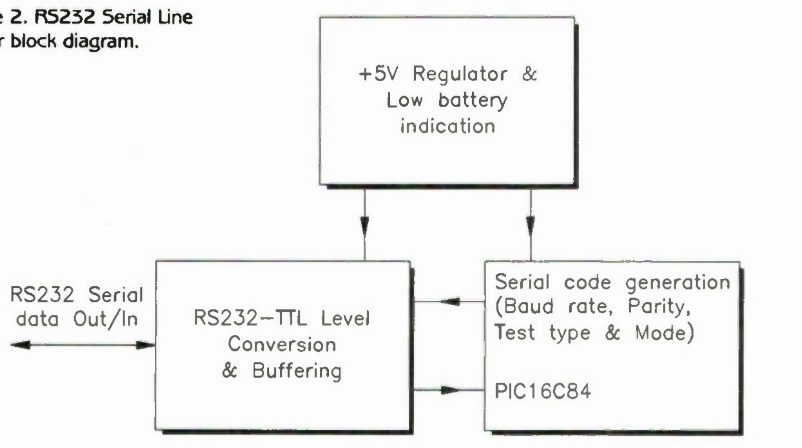
The stop bit is a gap of one bit period to allow a gap between characters for the receiver to resynchronise with the transmitter. In this way, slight speed differences can be accommodated between the sending and receiving units. At very low speeds, i.e., under 300 baud, mechanical teletypes required longer stop periods of 1·5 or 2 bits between characters.

When the receiver detects the start bit, it counts halfway into the first data bit (to minimise errors) and then latches each data bit in turn into a shift register until all 7 or 8 data bits and parity are received. The parity bit is optionally checked and the data presented in parallel form to the receiving device.

Pin	Label	DTE	DCE	Description
1	Frame GND	–	–	Protective Earth
2	TXD	OUT	IN	Transmit Data
3	RXD	IN	OUT	Receive Data
4	RTS	OUT	IN	Ready to send
5	CTS	IN	OUT	Clear to send
6	DSR	IN	OUT	Data Set Ready
7	Signal GND	–	–	Signal Earth
8	CD	IN	OUT	Carrier Detect
20	DTR	OUT	IN	Data Terminal Ready

Table 2. RS232 pinout description.

Figure 2. RS232 Serial Line Tester block diagram.



Flow Control

Since devices are not always ready to receive data (printers, for example, cannot print as fast as computers can send data), a method of 'Flow Control' is required to stop the transmitting unit before the receiver runs out of buffer space.

HARDWARE flow control uses extra signal lines to signify if the receiver is ready or not. A High level generally indicates 'Ready', while a low indicates 'Not Ready'.

SOFTWARE flow control uses 'Stop' and 'Start' characters embedded in the transmit data to indicate if the device is ready to receive. Software flow control is generally harder to verify the correct operation of, due to the data being on the 'normal' data lines.

Classes of Devices

RS232 devices are split into two categories, Data Terminal Equipment (DTE) and Data Communication Equipment (DCE). All printers, terminals and systems are deemed to be DTE, while modems and similar devices are DCE. DTE and DCE have different pin connections to allow DTE and DCE to be connected with a simple 'straight-through' cable, as this is how most equipment used to be connected to mainframe systems.

Where a DTE to DTE (or DCE to DCE) connection exists, crossovers are inserted between Transmit and receive data and other like pairs. This is often called a 'Null Modem' cable, i.e., the cable required to replace the pair of modems that would normally have been used with a mainframe to remote site or PC-to-PC set up. Pin connections and data direction are shown in Table 2. Note that for a modem, Transmit data is an INPUT, the naming of signals for DCE equipment is relative to the link between the DCE, i.e., the telephone line for modems.

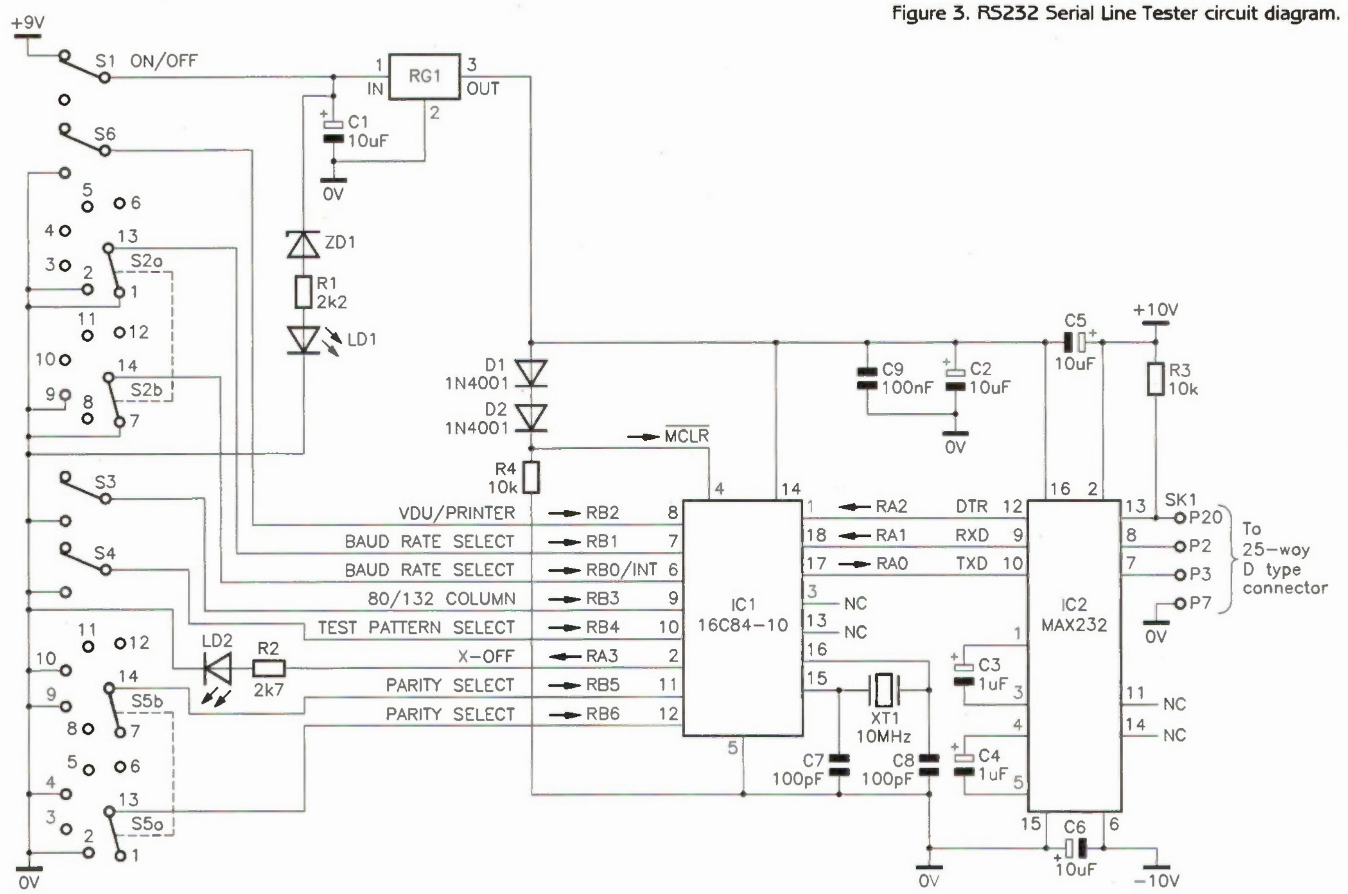
Note that the terms 'Straight-through' and 'Cross-over' only have a sensible meaning where the pin connections are similar at both ends! When connecting to a 9-way serial port on a PC (for example), pins 2 and 3 are reversed compared to a 25-way connector, so a crossover cable to another DTE has pin 2 wired to pin 2, and pin 3 to pin 3. Thanks are due to IBM for that little piece of inspired standardisation! (Figures 8a to 8d show the connections for different configurations).

Circuit Description

As can be seen from the block diagram of Figure 2 and the circuit diagram shown in Figure 3, this project is based around a single Microchip PIC 16C84 chip microcontroller, effectively a complete (although small) computer system in itself with EEPROM, RAM, CPU and I/O all in a single 18-pin DIL chip. A MAX232-C RS232 buffer provides the required voltages for the serial interface and incorporates transmit and receive data buffers as well.

RG1 provides a regulated 5V supply from the 9V battery and the Zener diode, ZD1, and an LED, LD1, provide an indication of

Figure 3. RS232 Serial Line Tester circuit diagram.



healthy battery condition, the LED dimming, and ultimately extinguishing, when the battery runs low.

The microcontroller has its own on-chip oscillator and uses an external 10MHz ceramic resonator to provide a stable clock source.

The rotary switches allow selection of a wide range of test modes and types, making the unit both versatile and simple to operate dependent on the position of the switches, various I/O lines on the PIC will either be held at V_{DD} by an internal (on-chip) pull-up resistor, or taken low (to V_{SS}). These I/O lines are shown in Figure 4 as RB0 to RB6, and their different states are shown in Table 3.

Construction

Construction of this project is very easy! There is no hard wiring to switches, etc., so provided that a reasonable amount of care is taken, a very professional piece of test equipment should be produced, first time around.

PCB Assembly

There is no 'preferred' order for assembling the PCB components, but the following order is suggested, and referring to the PCB legend and track, shown in Figure 5, will assist assembly.

Firstly, solder the resistors and diodes in position, followed by the IC sockets, and using offcuts from component leads, install the wire links.

Fit and solder the ceramic capacitors, ceramic resonator XT1, and the electrolytic capacitors, ensuring their correct polarity. Solder voltage regulator RG1 in position with correct orientation, else none of the circuit will work, and keep its leads reasonably short (about 5mm or less), but without unduly stressing the component.

Solder LD1 and LD2 in position; note that the flat on the package and the shorter lead denotes the cathode and is marked 'K' on the PCB legend; the LEDs should be mounted with 13·5mm ±0·5mm between the base of the component and the top side of the PCB. An easy way to measure

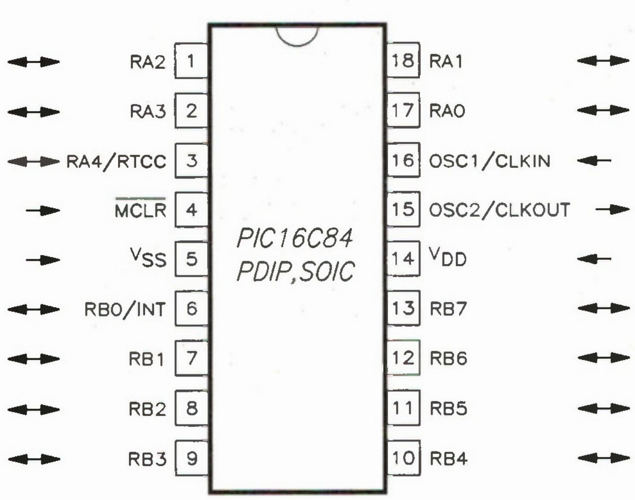


Figure 4. PIC microcontroller pinout diagram.

Various connection devices.

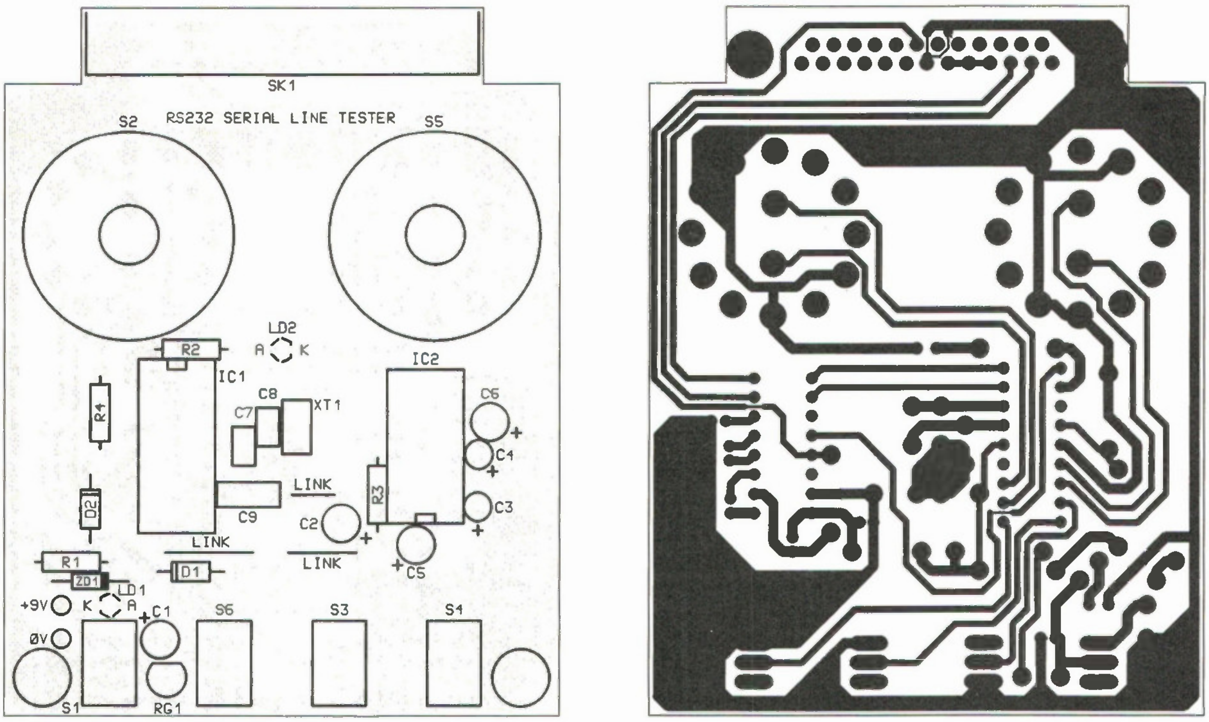


Figure 5. PCB legend and track.

this is to cut a piece of thin card 13·5 × 13·5mm and use this as a gauge, held between the LED leads whilst they are soldered into position. Insert and solder the toggle switches in position, ensuring that they are seated firmly on the PCB.

With each of the rotary switches, carefully cut the spindles of the two wafer switches to leave 6mm protruding from the body of the switch. An easy way to cut these is to hold the end of the spindle (never the body of the switch) in a vice, cut through the spindle with a junior hacksaw, and using a small file, chamfer the edges.

Next, cut off the ends ('eyes') of each terminal with a stout pair of wire cutters, as close to the 'eye' as possible, and if necessary, straighten the remaining 'pins' carefully with a pair of pliers. Insert the switch with the moulded locating spigot aligned as indicated on the PCB legend, and solder it in place, ensuring that all the pins are soldered, including the unused ones.

Fit and solder the two PCB pins in the B+ and B− positions, and then solder the PP3 battery clip to the pins, with the red lead to the B+ pin. Finally, insert the two ICs into their sockets; note that the notch in each DIL socket marks the pin 1 end of the IC, and that the ICs are inserted 'top-to-tail' in the board.

Box Drilling and Cutting

A front panel label for the box is supplied in the kit, and is also available separately (Stock Code KP86T), prior to applying the label, the box must be drilled to accept the switches and LEDs, as described:

Carefully drill the box in accordance with the drilling template of Figure 6, measuring the hole centres accurately, and double-check prior to drilling. Alternately, a photocopy of the template can be used, ensuring that the copy remains the same size as the original (some photocopiers slightly alter the dimensions!), then temporarily stick the copied template in the correct position on the box lid using Pritt Stick™ or similar adhesive, prior to drilling directly through the marked hole positions. The front panel label may well hide any holes drilled in the wrong place, but obviously it is preferable to get it right first time!

Having drilled the hole centres, use a small rat's-tail file to carefully elongate the four holes for the toggle switches, keeping to the guidelines shown by the drilling diagram.

Next, mark and cut out the top end of the box (i.e., the end opposite the battery compartment) for the 25-way D-type connector. This opening is not critical, so if you cut it out slightly larger than shown, don't worry, it should still be OK.

Clean up any rough edges, wipe the box clean, and ensure it is dry. If using the label template comprising of Figure 7, or a photocopy of it (beware, however, of slight distortion or a change in the size of the image that may occur with photocopies), cover the label with clear plastic film (Fablon) to protect it, this being available at any popular stationery or DIY store. The label should be cut out leaving a small overlap, then carefully stuck onto the box, the excess that extends beyond the raised edges on the box face can be removed, using a scalpel, and the label smoothed down with a soft cloth. Alternatively, the label could be cut out around its perimeter leaving no overlap, prior to sticking it to the box, but this leaves no margin for error, and a neater result will probably be achieved using the first method. With the label firmly in place, punch through the label in the positions where the box is drilled using a pointed instrument, and enlarge them to accept the switches, etc.

Final Assembly

After a final check for any dry joints, solder 'whiskers' or 'bridges', etc., the completed PCB is secured in the box by the mounting collars of the two wafer switches and by two self-tapping screws in the 'bottom' corners, as described below.

Remove the nuts and star washers from both wafer switches, along with each tagged locking ring, re-inserting these with the 'tag' in the hole marked with a figure 4; this gives each switch a 4-way operation.

Without losing the locking rings, push the spindles of the switches through the relevant holes in the casing and gently manipulate the board until the locating spigots lock into place. Holding the box and PCB together, refit each star washer and securing nut. When both nuts are finger tight, apply a final quarter-turn with a spanner, being careful not to damage the front panel label.

Fit the two self-tapping screws through the fixing holes in the PCB, and drive them home until their heads are seated against the PCB. Do not over-tighten them; they are not needed to hold the PCB in place, but are provided to prevent the PCB from being pushed back if undue pressure is applied to the top of the toggle switches.

Thread the PP3 battery connector into the battery compartment and fit the bottom of the box, securing it with the screws provided. Fit the knobs to the wafer switch spindles, with the grub screws tightened against the flats of the spindles, and finally, install a PP3 battery – an alkaline type is recommended.

If the optional carrying case is purchased, two foam padding inserts will be needed to line the top and bottom of the case, and hold the contents in place. These can be made from foam padding obtained from craft outlets or upholsterers, etc., cut to

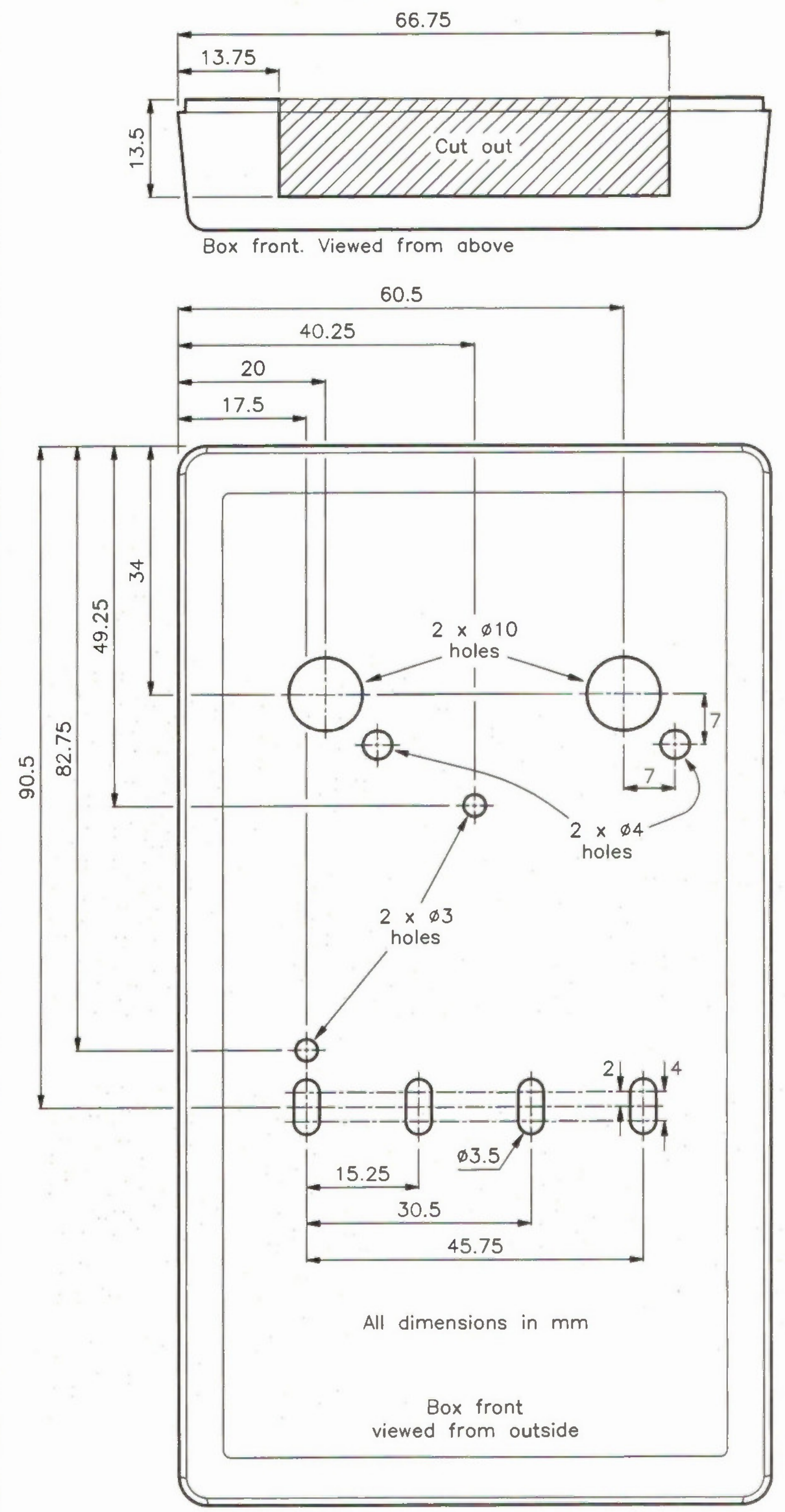


Figure 6. Box drilling diagram.

Baud Rate Select	RB0	RB1	Baud Rate
	LOW	–	1,200
	HIGH	–	2,400
	LOW	–	4,800
	HIGH	LOW	9,600
VDU/Printer Test	**RB2**		**Test Mode**
	LOW	–	VDU
	HIGH	–	Printer
80/132 Column	**RB3**		**Columns**
	LOW	–	80
	HIGH	–	132
Printer Test Mode	**RB4**		**Mode**
	LOW	–	Straight Pattern
	HIGH	–	Sliding Pattern
Parity Options	**RB5**	**RB6**	**Parity**
	HIGH	HIGH	8-bit/None and 7-bit Space
	HIGH	LOW	7-bit Mark
	LOW	HIGH	7-bit Odd
	LOW	LOW	7-bit Even

Table 3. Test modes.

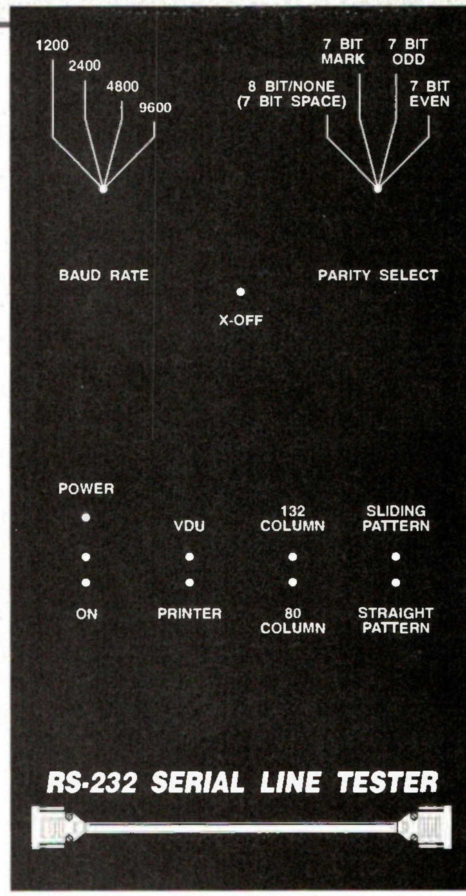
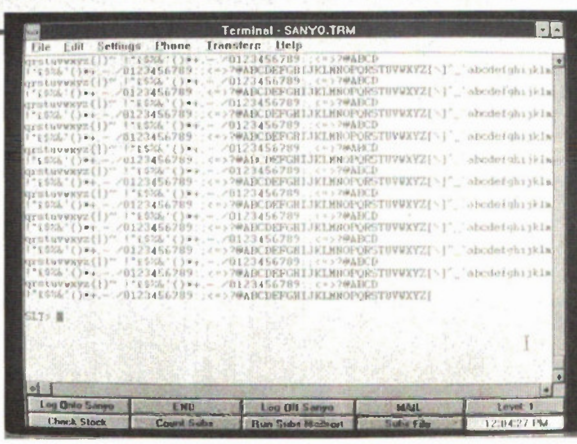
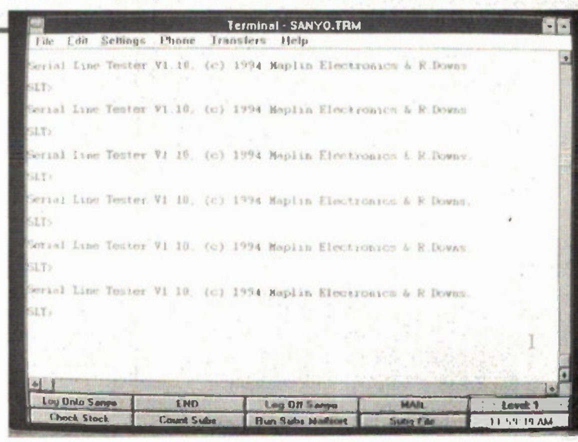


Figure 7. Box label detail.

Two examples of screen displays.





size (320 × 210 × 40mm approximately), and then glued into each half of the case. Further cut outs can be made in the lower insert, to locate each of the accessories, along with the tester unit.

Testing

No test equipment is required to set up the completed unit – it is all done in the software! With the unit disconnected, turn it on and the POWER LED should be illuminated; if it is not, or is glowing very dimly, then the battery is either very low or completely dead, or a fault exists with the circuitry – if this is the case, the unit may still work, but the operation cannot be guaranteed. If a Mini-Tester is connected to the tester and it is switched on in VDU mode, then the Read Data (RD) LED should be illuminated.

A quick way of testing the finished unit is to connect it to a PC's serial port, e.g., COM1 or COM2, using a suitable direct connection lead and 9/25-way adaptor if required, and using a terminal program such as the one found with MS Windows™, conduct a series of trials by matching the terminal programs parameters with those of the Serial Line Tester, stepping through each test as laid out in Table 3.

If some of the tests appear to be OK but others do not, then a multimeter can be used to check the voltage levels on RB0 to RB6, referring to Figure 4 and Table 2 for the relevant pinout and expected levels for each switch position.

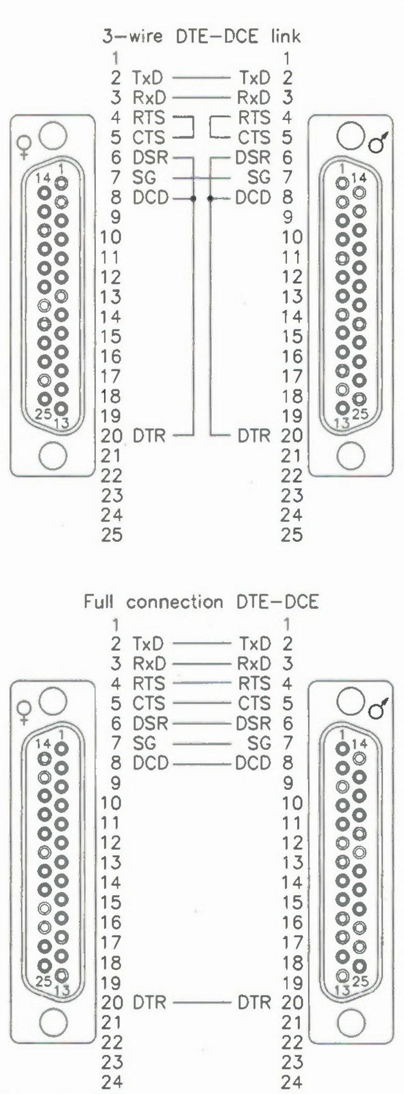


Figure 8a.

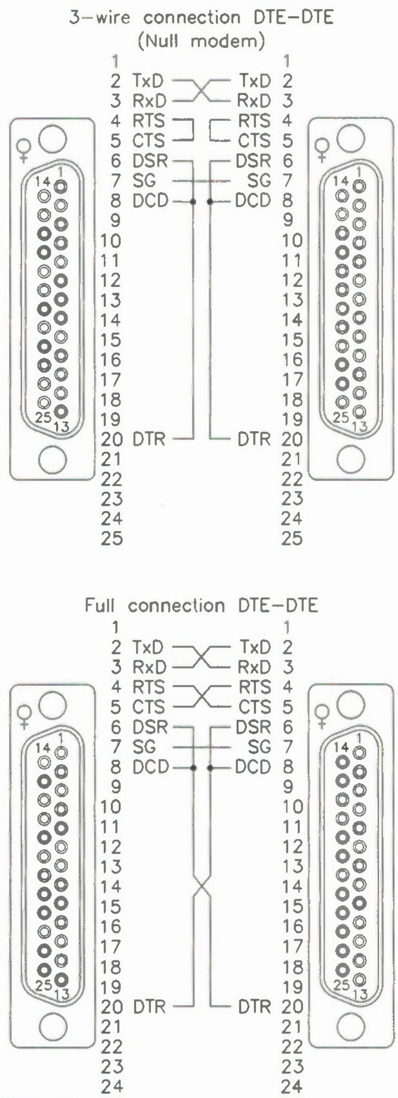


Figure 8c.

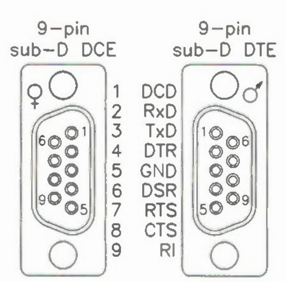


Figure 8b.

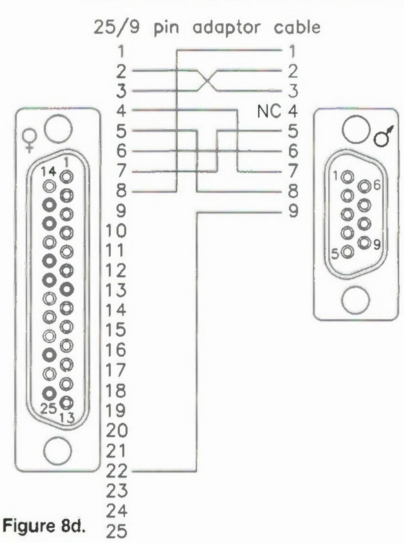


Figure 8d.

Figure 8a. 25-way DTE/DCE connector pinout.
Figure 8b. 9-way DCE/DTE connector pinout.
Figure 8c. 25-way DTE/DTE null modem connections.
Figure 8d. 25-way to 9-pin adaptor cable.

Operation and Use

The unit will be of greatest benefit when used in conjunction with a Mini-tester to indicate the status of the RS232 signal lines, and optionally with a gender changer where required. However, Figures 8a to 8d show a selection of typical RS232 cabling formats and their interconnections. The tester is wired as a 'DCE' to allow direct connection (with no additional crossovers) to either a terminal or printer. This is the most basic use of the device to test for correct operation of the peripheral.

If no fault is found with direct connection to the peripheral, then the data cabling can be tested as well by moving the tester further from the peripheral device in stages, as allowed by the data cabling at the site. If the data cabling includes crossovers (i.e., pins 2 and 3 are reversed at some point) then it may be necessary to connect via a simple crossover adaptor in order to connect the tester correctly.

A Mini-Tester will show the correct crossover orientation, by illuminating both Tx data and Rx data lights when the peripheral device and tester are correctly connected and powered up, equally, misplaced or non-existent crossovers will be shown by the same technique without dismantling the connectors at both ends of the cable.

By connecting the 'Mini-tester' to the data source (be it a system or this project) and the peripheral in turn, the signals from each end can be monitored. Two signals on the same line indicate a crossover problem, while no signal on 'Tx Data', for example clearly indicates a break in the cable at some point.

Plugging the cable together via the tester will show if shorts exist in the cable as the appropriate LED will extinguish. Two LEDs going dim or out, indicates a short between those lines.

A common failure with printers is lack of flow-control with the host system. While hardware (DTR/DSR or RTS/CTS) flow control is easily seen with a Mini-tester, software (X-On/X-Off) flow control is difficult to check for due to the very short duration of the single flow control characters (1ms at 9,600 Baud) providing insufficient time for an LED to illuminate noticeably. Figure 9 illustrates typical test outputs from a printer, showing all available characters, arranged in a straight or diagonal pattern.

The Serial Line Tester provides a front panel LED (X-Off) which lights when an X-Off is received and extinguishes when an X-On is received, hence when a device is handshaking correctly the LED will flash on and off, with no loss of data evident at the peripheral.

Note: Most modern VDU's will operate at 9,600 baud without flow control if set to 'Jump Scroll'. Using Smooth Scroll or pressing 'Hold-Screen' will demonstrate the presence (or lack) of flow control.

```
Serial Line Tester V1.10, (c) 1994 Maplin Electronics & R.Downs.
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Figure 9. Examples of RS232 Serial Line Tester outputs from printer.

RS232 SERIAL LINE TESTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,2	2k7	2	(M2K7)
R3,4	10k	2	(M10K)
CAPACITORS			
C1,2,5,6	10µF 16V Radial Electrolytic	4	(YY34M)
C3,4	1µF 63V Radial Electrolytic	2	(YY31J)
C7,8	100pF Disc Ceramic	2	(WX56L)
C9	100nF 16V Disc Ceramic	1	(YR75S)
SEMICONDUCTORS			
D1,2	1N4148	2	(QL80B)
IC1	PIC16C84 MS07	1	(AS55K)
IC2	MAX232CPE	1	(FD92A)
LD1	Low Current Green LED (3mm)	1	(CJ56L)
LD2	Low Current Yellow LED (3mm)	1	(CJ57M)
RG1	LM78L05ACZ	1	(QL26D)
ZD1	BZY88C 4V7 Zener	1	(QH06G)
MISCELLANEOUS			
S1,3,4,6	SPDT Vertical PCB Toggle Switch	4	(JX90X)
S2,5	6-way, 2-pole, Rotary Switch	2	(FF74R)
XT1	10MHz Ceramic Resonator	1	(DJ38R)
	Collet Knob (15mm)	2	(JZ47B)
	Cap Black (15mm)	2	(JZ76H)
	Lined Nut Cover (15mm)	2	(JZ57M)
	16-pin DIL IC Socket	1	(BL19V)
	8-pin DIL IC Socket	1	(HQ76H)
	Plain HH2 Box	1	(ZB16S)
SK1	25-way D-type Right-Angled Socket	1	(FG27E)
	Single-ended PCB Pin 1mm (0·04in.)	1 Pkt	(FL24B)
	PP3 Battery Clip	1	(HF28F)
	Front Panel Label	1	(KP86T)
	PCB	1	(GJ13P)
	Instruction Leaflet	1	(XV31J)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Alkaline PP3 Battery	1	(ZB52G)
	4 pairs of black 1in. Velcro squares	1 Pkt	(FE45Y)
	RS232 Mini Tester	1	(YP80B)
	Null Modem RS232	1	(YP85G)
	25-way Male-Male Gender Changer	1	(JM48C)
	25-way Female-Female Gender Changer	1	(JM49D)
	25-way Male-Female Serial Cable	1	(JC13P)
	9-way Female-25-way Male Adaptor	1	(JM08J)
	Carrying Case B	1	(ZF04E)

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 LT83E (RS232 Serial Line Tester) Price £32.99 A1

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

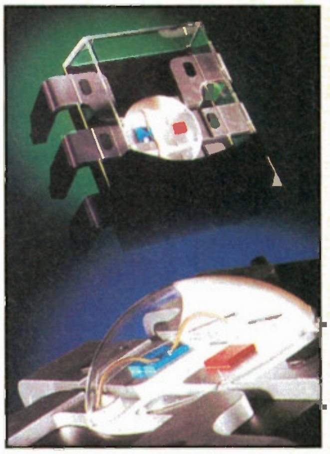
The following new items (which are included in the kit) are also available separately, but are not shown in the 1995 Maplin Catalogue

RS232 Serial Line Tester PCB **Order As GJ13P Price £3.49**

Front Panel Label **Order As KP86T Price £2.39**

NEWS Report

Revolutionary Packaging Technology



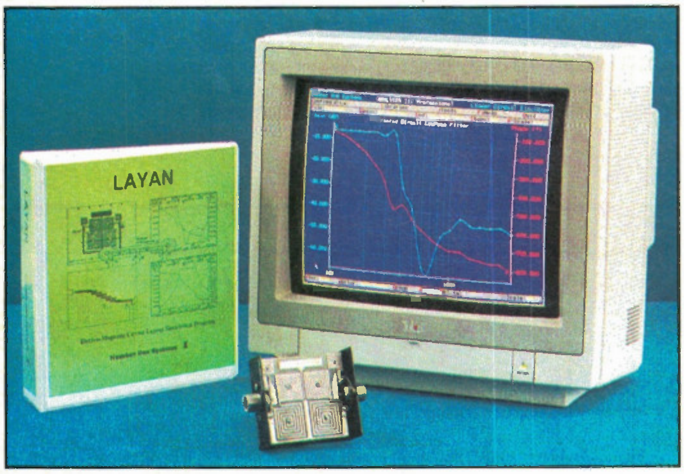
Quality Technologies Corporation (QTC) has developed a new high-voltage optocoupler packaging technology, which QTC has called Optoplaner. The name derives from the coplanarity which is the key feature of the new technology, such as placing all of the dice-emitter detectors, and in some cases, drivers – on the same plane. This does away with leadframe folding or flipping – operations which are both difficult to control and potential source of problems. The second feature of Optoplanar technology is its reflective structure – a dome of transparent silicone resin, which encapsulates the emitter die and the detector sensitive area. The dome is completely coated with a layer of silicone gel filled with Titanium dioxide $TiO2$, forming a dense white reflective coating. From an optical point of view, this structure resembles a sphere. Its coupling efficiency is very much higher than traditional configurations where up to 70% of the total light output can be absorbed by the black compound, and thus lost. The integrating sphere effect is also independent of the relative positions of the emitter and detector, so highly accurate placement of the die is not required. Finally, the integrating sphere effect is not dependent upon the size of the sensitive area. Consequently the detector die can be reduced in size without loss of transfer ratio. The third principal feature is the absence of interface between the surface of white gel and the epoxy moulding compound which encapsulates the whole device. A special formula bonds the white gel to the black epoxy, achieving an intimate contact with no gap between the two materials. With virtually no internal creepage path, high isolation is maintained. Moisture penetration and possible degradation of the isolation is also prevented.

Contact: Quality Technologies, Tel: (+02) 466 6769.

Four Kilometre Distance Backup at SCSI Speed

Memory Technology has launched SOFT (SCSI Over Fibre Transceiver), the first system to allow vital data to be mirrored or backed up remotely, from up to four kilometres away. SOFT enables SCSI storage peripherals to be connected via fibre optic cable to the host computer at a remote site of another part of the building. Information can be backed up at a 10M-bit/s transfer rate, with as little as 3% degradation of performance when compared with a standard 6 metre SCSI connection. The system comprises one SOFT unit installed at each end of the fibre optic link. Each unit has a 25MIPS processor and offers unique Nexus Pipeline Architecture (NPA), a strategy which uses multiple concurrent data paths to maximise data throughput. SOFT supports the entire SCSI command set including full support for Logical Unit Numbers (LUNs), target routines and asynchronous event notification. The SOFT units are transparent to devices and applications, and run on single-ended or differential FAST 8-bit SCSI with an upgrade path to FAST & WIDE SCSI. It operates with 50 or 62·5μm multimode optic fibre allowing a 125Mbaud data rate. The SOFT units are the standard, full-height 5¼in. form, with high dynamic range, low noise and 1300nm transceivers.

Contact: Memory Technology, Tel: (01734) 771588.



Major Breakthrough in Electromagnetic Circuit Simulation

After twenty man-years of research and development, Number One Systems has launched the Electromagnetic Simulation program, which breaks through the barriers that have until now prevented most design engineers from fully understanding the behaviour of their PCB-based designs. In the past, many engineers found that their prototypes failed due to electromagnetic coupling effects between the PCB tracks and pads – even when the theoretical circuit has been successfully simulated. Simulators capable of analysing the electromagnetic effects within the layout have been available, but at a prohibitively high cost in the software itself, and in the hardware required. Number One Systems' new LAYAN programme brings electromagnetic simulation within the reach of every engineer. LAYAN fits neatly between the EASY-PC Professional XM Schematic and PCB Layout tool, and ANALYSER III Professional, a Linear Analogue Circuit Simulator. LAYAN examines the PCB layout, noting all the track positions, pad dimension and copper areas. The programme then extracts an equivalent electrical circuit from the physical layout data and combines this with the theoretical circuit so that the behaviour of the entire system can be simulated. LAYAN uses the dielectric constant and loss tangent of the circuit substrate to allow for Radio Frequency effects such as the transmission line behaviour of PCB tracks and the increase in conductor impedance due to the skin effect. LAYAN can even take non-uniform metallisation, such as gold or tin over copper, into account. Including physical layout effects in this way gives a whole new insight into circuit behaviour, trapping out potential problems before committing to a prototype. By designing LAYAN to run on a standard 486 PC, Number One Systems are assured of a large and expanding market. This has enabled them to keep the price of LAYAN unbelievably low. For example, existing users of EASY-PC Professional XM and ANALYSERS III Professional can benefit from all the advantages of LAYAN for less than £500. The complete set of three programmes, working as a fully integrated Electronic Design System, is available for less than £1,000.

Contact: Number One Systems, Tel: (01480) 461 778.

Digital and ARM Announce Agreement to Develop

Digital Equipment and Advanced RISC Machines (ARM) have announced the licensing of the ARM RISC architecture to Digital Semiconductor for the development of high-performance, low power microprocessors. The StrongARM family of 32-bit RISC products to be developed under the agreement is intended to complement and broaden the existing ARM product line for performance critical applications such as:

- next-generation personal digital assistants (PDAs) with improved user interfaces and communications,
- interactive TV and set-top products,
- video games and multimedia 'edutainment' systems with realistic imaging, motion and sound,
- digital imaging, including low-cost digital image capture and photo-quality scanning and printing.

Combining Digital's proven leadership in high-performance microprocessor design and manufacture with ARM's expertise in low power design, will result in processors that set a new standard for high performance, while meeting the low power, space and cost requirements of products such as hand-held devices. The StrongARM family will offer full software compatibility with the ARM6, 7 and 8 chip families, which will help accelerate market acceptance of the new products. The first product in the StrongARM family is currently under development at Digital Semiconductor's Palo Alto, California, and Austin, Texas, research centres and ARM's Cambridge, UK headquarters. Digital expects the device to be among the first products manufactured at its new FAB 6 state-of-the-art chip fabrication facility in Hudson, MA. The products developed under the agreement will be sold through Digital Semiconductor's sales channels. In addition, processors and processor cores developed under this agreement will be available for licensing to other semiconductor partners.

Contact: Advanced RISC Machines, Tel: (01223) 400 400.

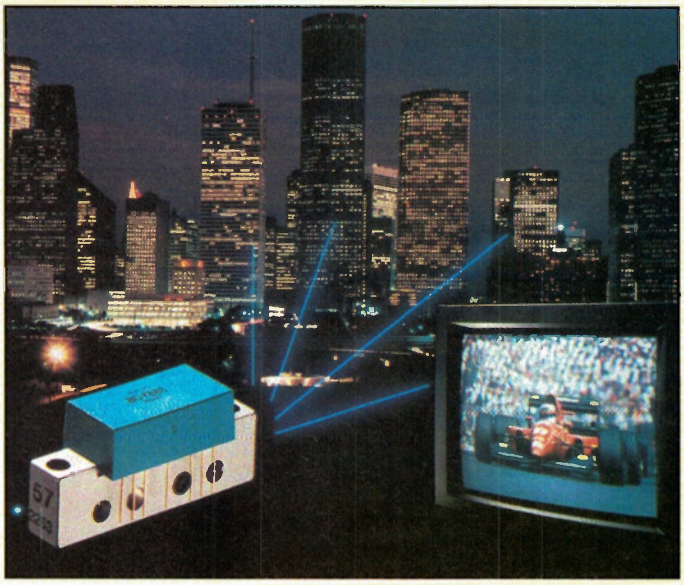
Memory Versatile 16-bit Microcontrollers

Mitsubishi Electric has announced the introduction of the M37710 Group 16-bit single chip microcontrollers, ideal for office, business and industrial controller applications requiring high-speed processing for large data volumes. The new product group devices are available in a range of memory options and include Mask ROM, one time PROM and EPROM versions, as well as with low voltage and packaging options, enabling system integrators to select the optimum microcontroller for their specific design requirements.

Contact: Mitsubishi, Tel: (01707) 276 100.

Boost to CATV Network Performance

Providing 34dB of power gain in a SOT115 packaged module, the new BGY888 CATV Amplifier Module from Philips Semiconductors makes it possible to build 860MHz CATV line extenders containing only one active device. The thin-film hybrid amplifier, which utilises two cascaded amplifier stages to achieve its exceptionally high gain, also features excellent linearity. Low current consumption, an industry standard mechanical footprint and accurate 75dB input and output matching which results in return loss specifications typically better than 14dB make the BGY888 suitable not only for new networks, but also for upgrading the performance of existing ones. Other applications include RF amplifiers for telecommunications systems and wide area computer networks. The BGY888 utilises push-pull cascade amplifier stages which achieve an overall frequency response flatness of ±0·5dB worst case over the device's entire 40 to 860MHz bandwidth. Operating from a 24V DC supply, it draws a maximum supply current of only 340mA – considerably less than that drawn by the two or more amplifier modules usually found in CATV line extenders. The result is a significant reduction in overall network power consumption.



The BGY888 is housed in a rugged SOT115 package, which is pin-compatible with industry-standard 600MHz CATV amplifier modules. The package, together with the silicon nitride passivation and gold metallisation used in the hybrid circuit, provides the BGY888 with very high reliability, and a mounting-base operating temperature range of –20°C to +100°C.

Contact: Philips Semiconductors, Tel: (+31) 40 72 20 91.

MPEG Debut

IC Works has announced the capability of its ZOOMDAC high-speed graphics chip to provide full MPEG-1 decoding, without additional hardware support. The MPEG video/audio decoding is performed in software which can playback MPEG movies at the standard 352 × 240 resolution. Full motion playback of 15 or 30 frames per second is achieved with a standard 60 or 90MHz Pentium PC. The ability to perform the decode function with this combination of hardware and software is a significant benefit for MPEG-1 systems designers, since it offers a lower systems cost and eliminates the hardware and software development cycle associated with current MPEG-1 solutions. The ZOOMDAC supports resolutions up to 1280 × 1024, and provides hardware 2-dimensional zooming capability from 1:1 up to 32:1, with independent X and Y expansion. This is supported by a tracking filter which enhances the quality by removing the pixel artifacts, but without sacrificing frame rate. The design provides 8, 15, 16 and 24 bits per pixel modes in support of all major image formats. The 24-bit colour look-up table allows the 8-bit to select 256 colours from the 16 million colour palette. The product includes a 16-bit interface for higher data rate throughput. In 8-bit pixel modes, an on-chip 2:1 multiplexer and on-chip clock doubler reduces external clock frequencies for easier certification. The easy replacement capability enables existing RAMDAC designs such as the 20C498 from AT&T to be directly upgraded, by replacing the existing 44-pin PLCC package with the ZOOMDAC, without any other hardware addition or modification. Software changes can be made to the internal registers at any convenient time, and only become functional after the first vertical blank cycle has returned to the '0' state. Thus, intelligent BIOS and plug-and-play implementations can be readily supported. Power down modes are included for battery or green-PC designs.

Contact: Microelectronics Technology, Tel: (01844) 278 781.

Audetel at G7 Conference

Audetel, the audio system which brings in a new aural dimension to television, has been demonstrated at the G7 Ministerial Conference on the Information Society in Brussels which was held between 24th and 26th February 1995. This innovative technological development uses a special data signal carried in the television picture to provide an audio commentary describing what happens in programmes during gaps in the dialogue. A special set-top receiver enables the commentary to be heard, either through headphones or a loudspeaker. Originally developed by a consortium of broadcasting, consumer electronics companies and organisations working with the visually impaired and older people, the additional audio commentary will also appeal to viewers who can follow a wide range of programmes without looking continuously at the screen. There are an estimated 10 million visually impaired people in Europe. The G7 Showcase was an opportunity to demonstrate the technology to Ministers, industrialists, the European Commission and Parliamentary Officials, and the media to enable other European Governments to evaluate its potential. The Audetel project has already been awarded the 1994 Royal Television Society Communications Innovation Technology Award. A four-month period of experimental transmissions on both ITV and the BBC was broadcast between July and November last year in association with the Royal National Institute for the Blind (RNIB). The Audetel consortium is led by The Independent Television Commission. The Members are: Age Research Centre; University of Manchester; British Broadcasting Corporation; The Independent Television Association; Motorola Limited; Portset Systems Limited; Royal National Institute for the Blind; Seleco SpA; Softel Limited and SPEKA Limited.

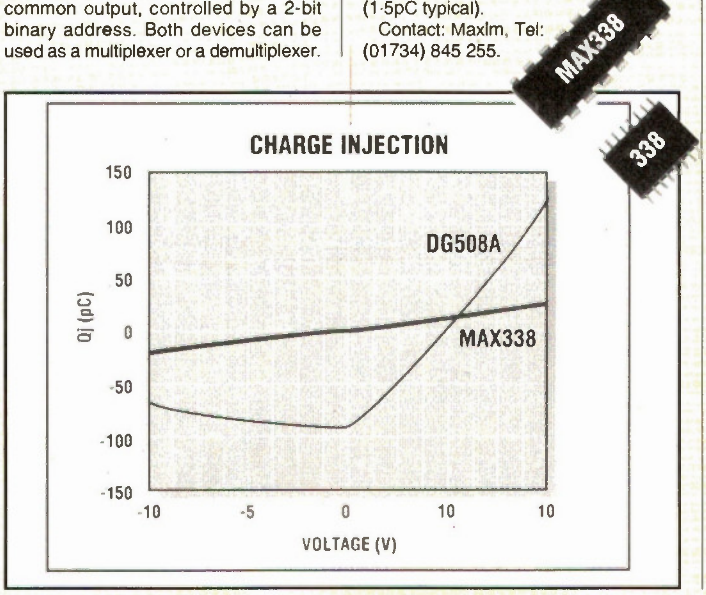
Contact: Independent Television Commission, Tel: (0171) 255 3000.

Multiplexers Feature Low On/Off-Channel Leakages and Low On-Resistance

Maxlm Integrated Products has introduced the MAX338 and MAX339 monolithic, CMOS analogue multiplexers. The MAX338 eight-channel multiplexer Is designed to connect one of eight inputs to a common output by control of a 3-bit binary address. The MAX339 is a dual 4-channel multiplexer which connects one of four outputs to a common output, controlled by a 2-bit binary address. Both devices can be used as a multiplexer or a demultiplexer.

The MAX338/MAX339 feature low off-channel leakages of less than 20pA at 25°C, and extremely low on-channel leakages (<20pA at 25°C). These devices offer low (400Ω maximum) on-resistance and conduct current equally well in both directions. The new design guarantees a low charge injection of 5pC (1·5pC typical).

Contact: Maxlm, Tel: (01734) 845 255.



Malicious Callers Get the Message

BT's new caller display and call return services have brought a 20% drop in malicious calls reported to the company – and hoax calls to the emergency services show a similar fall. Malicious calls reported to the network of BT bureaux around the country began to fall as soon as the new services were announced. By January, the previous monthly average of 57,000 had dropped to 45,000 actual complaints. Early figures show that the fall of 21% is being maintained for February. Michael Biden, BT's Director of Sales and Marketing said, "By any standards this represents a very real reduction in human anxiety and fear. Our technology not only helps create a more efficient and convenient world but is helping our customers feel safer". The total number of 999 calls also show a near 200% fall between October 1994 – the month before the new services were introduced – and January of this year. Michael Biden said, "All the signs are that the drop is down to hoaxers getting the message that their calls can be traced. BT is delighted to be helping the emergency services in this way. In reducing the amount of time wasted by the emergency services in dealing with hoax calls, it can even help save lives". Call return – where a customer can dial 1471 to check the number of their last caller – is also proving hugely popular with customers. Nearly three million calls a day are being made to the free service.

Contact: BT, Tel: (0171) 356 5369.

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CD versus VINYL – *Continued from 23.*

significant output at frequencies up to, perhaps, 150kHz. Although such ultrasonic signals cannot be heard (except by bats!), they must be considered in any design since they can cause slew rate limiting of an amplifier. This, in turn, can cause all manner of distortion – transient, intermodulation, slew-induced – to in-band audio signals. Although not shown in the diagrams, some series feedback configurations use a passive lag network or an active integrator to provide the roll-off prescribed by the RIAA specification. Naturally, the first stage is used to shape the 20Hz to 1kHz part of the curve.

Another possible failing of the series feedback arrangement is in the way in which input stage non-linearities can cause distortion. We're now back to that earlier topic, cartridge impedance interaction. The input circuit impedance rises with increasing input frequency, and causes an increase in the output noise voltage. Further, the impedance of the cartridge interacts with the amplifier, modulating the input impedance of it. The feedback loop, of course, cannot correct for this. The high common-mode rejection qualities of modem op amps means that this is a problem more readily associated with discrete two or three transistor types, since these, typically, have poor performance in this respect.

Shunt Feedback

All the aforementioned problems might suggest that the shunt arrangement of feedback is definitely the path to pursue in any design. Typical shunt configurations are shown in Figure 14. Apart from the obvious disadvantages of the overall inverting response (it is widely accepted that it is better to maintain the absolute phase of the signal) the shunt-type seems to present itself as an ideal solution to the problem. The circuit can follow accurately the standard RIAA curve, since absolute gain can be made to be less than unity, that is asymptoting to zero at some high frequency. This can mean lower distortion (no unwanted out-of-band products present to cause slew rate limiting and subsequent transient intermodulation distortions) although this is not necessarily the case, and is as much to do with the designer's skill and choice of components and devices as anything else. The configuration is also very straightforward.

That the input is virtually earthed (and therefore has no voltage swing) means that distortion is lower in those cases where the amplifier has poor common-mode performance. It is for this reason that THD figures are typically better for inverting configurations that for non-inverting ones (though intuitively, one might think this a little strange). In addition, shunt feedback types seem to offer a much higher degree of immunity to input overload (caused by scratches and clicks on the record).

As with everything in life, there has to be some compromise. The shunt feedback arrangement is no different, and the compromise assumes the guise of inferior noise performance. The 47k load impedance necessary for the cartridge now appears in series with the amplifier input. White noise from the resistor, assuming a 20kHz bandwidth, and a 290K temperature, can be calculated as follows:

$$\bar{e}_n = \sqrt{(4kTBR)}$$

$$= \sqrt{4\times(3\times10^{-23})\times290\times(20\times10^3)\times(20\times10^3)}$$

$$= 4\mu V$$

Such a high impedance in series with the input also results in an increase in noise from a further source. This time, it is caused by an increase in noise current. This situation is worsened when the impedance increases (as the moving coil resonates). The series arrangement, on the other hand, has the load resistor shunted by the real part of the impedance of the cartridge, (the winding resistance), which is around 500Ω to 2k.

Simple calculations would show that the series arrangement achieves a noise performance some 13 to 18dB better than the shunt arrangement, with the absolute value dependent upon source impedance and the inherent noise current of the op amp in use.

However, this does not take into account that the RIAA gain stage does not have an effective gain bandwidth of 20kHz, and that the cartridge has an inductance of around 0·5H. Input circuit impedance, whilst rising with increasing f_{IN} in the MM stage, actually falls in the MC stages, thus reducing noise with this type.

Combo EQ

A further development that exploits the best aspects of both types is the arrangement shown in Figure 15. The first amplifier (non-inverting, of course, and so possessing superlative noise performance) provides the 3180μs and 318μs de-emphasis time constants. The passive network formed from the 2k4 resistor and the 33n capacitor form the 75μs one and the 2k4, 56k and 2μ2 capacitor provide the fourth (at 1·5Hz, in this example). According to the DIN specification (or IEC recommendation shown in Publication 98, Amendment No. 4) it should be at 20·2Hz, or 7960μs.

A further advantage inherent to the two amplifier approach is in the realisation of lower distortion figures. This is the case because each amplifier is operating at much lower gain than with the single amplifier approach, and, since neither of the amplifiers is required to drive capacitive feedback networks with the full preamplifier output voltage, distortion can be reduced further still.

Electrical Loading

Whilst on the subject of equalisation, and the need for accuracy, it is as well to point out one of the many design criteria to which good, commercially minded engineers must adhere. It is NOISE BUDGET. Whilst we have yet to tackle noise, that particular term applies to a specific problem – a more general term might be OVER engineering. Consider a typical design where the designer has, say, a very precise instrumentation engineer. He/she uses 0·1% tolerance resistors, but ruins the accuracy that these would afford by fitting an op amp that has high inherent drift and offset problems, and which creates errors by an order of magnitude greater than the fitting of 5% resistors ever would.

Electrical loading of the cartridge, at the amplifier input, is analogous to the op amp section gaffe in the above scenario. It is a pointless exercise – and very wasteful of design time and resources – to have an amplifier fitted with an RIAA equalisation network that is accurate to 0·1dB across the audio spectrum, but which is connected to a cartridge where an incorrect value of shunt capacitance has been connected across it. Input capacitance, as specified by the cartridge manufacturer, is the TOTAL capacitance of all the conductors between the cartridge and the amplifier input. This includes cartridge connectors, tonearm wiring (both to ground and between conductors), connecting leads, preamplifier board layout, and shunt capacitance on the board. Incorrect values typically cause a peak or resonance in the circuit, somewhere between 7 and 8kHz, before the response rolls off prematurely in the upper HF part of the audible spectrum. Aside from the effect of electrical loading at high frequencies, the cartridge may also suffer because of the effective mass of the tip, since this effectively determines how close the coupling between stylus and groove wall is. Forces in effect during movement of this mass at high frequencies can actually deform the groove, which delays the acceleration of the stylus, and slurs high-frequency sounds.

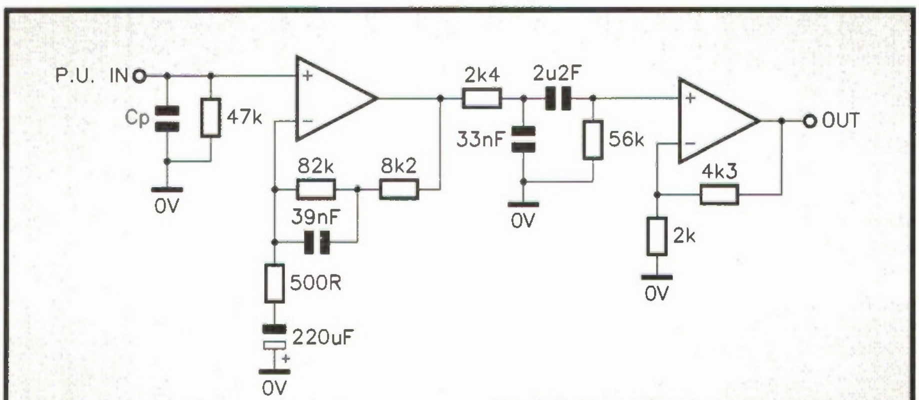

Figure 15. High performance two-stage network.

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Pickup Amplifier Design, David Tilbrook, High Quality Phono Amplifiers, Jan-Feb 1982, Electronics Today International (published by Argus).

WIRELESS HOME BURGLAR ALARM SYSTEM – *Continued from page 26.*

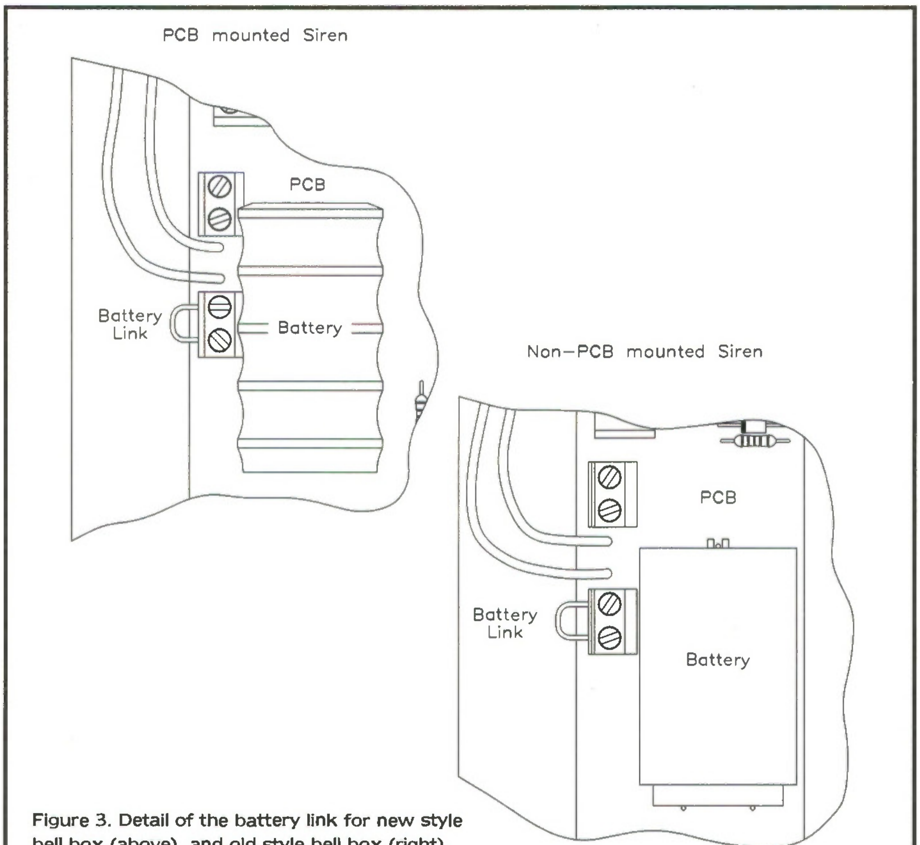


Figure 3. Detail of the battery link for new style bell box (above), and old style bell box (right).

ule in this design and so there are no BELL (+) or (–) terminals). The other legends on the PCB, (+), (–), 'SW–' and 'RETURN' are identical to the old style module.

As well as charging the back-up battery, the new +12V feed to the bell box is constantly monitored. If, for any reason, this +12V supply should be cut (for example, if the wires to the bell box are severed), then the bell box will sound its siren using its internal back-up battery.

The bell box is equipped with a Tamper Switch, with its own output for a control panel. However, the Wireless Alarm does not have an external Tamper input and therefore cannot, under normal circumstances, utilise this feature.

This is, obviously, a great disadvantage since, if the bell box were to be wrenched from the wall (without severing the connecting cable), then the siren would not sound!

To overcome this, a quite ingenious method of wiring the Wireless Alarm Control Panel to the Bell Box is used. If the blue wire is connected as described above (to the 'RETURN' terminal), the 0V supply return (blue wire from the burglar alarm cable) will be made *through* the tamper switch. Then, if the bell box were pulled from the wall or the cover removed, the tamper switch contacts will open, the 0V return to the bell box would be disconnected and the siren will sound.

Final Installation

Before the bell box is ready for use the battery link must be completed (see Figure 3). First, switch on the Wireless Alarm Control Panel and carry out the setting procedures described in the Wireless Alarm instructions. Ensure that you have a 12V supply available between the red and blue wires of the burglar alarm cable entering the bell box.

Warn your neighbours that the siren is going to sound! As soon as you complete the battery link, the siren will sound (assuming that there is enough power in the bell box back-up battery), because it will detect that the tamper switch is 'open' (12V supply is interrupted). The siren will stop as soon as the outer cover is fixed in place, closing the tamper switch.

WIRELESS ALARM UPGRADE PARTS LIST

Lucar Piggyback Connector	1 Pkt	(AR50E)
Push-On Receptacle	1 Pkt	(HF10L)
Push-On Receptacle Covers	1 Pkt	(FE65V)
Instruction Leaflet	1	(XV43W)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are available as a kit.

Order As LU09K (Wireless Alarm Upgrade Kit) Price £1.49

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 item is also available separately.
Lucar Piggyback Connector **Order As AR50E 79p**

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.

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

7, 14, 21, 28 April. 'Caught in the Net', Arts Theatre, 6-7 Great Newport Street, London WC2. Tel: (0171) 836 2132.

9 to 11 April. European Computer Trade Show, Business Design Centre, London. Tel: (0181) 742 2828.

10 April. AGM, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

22 April. Special International Marconi Day, exhibition station at Puckpool Park, Wireless Museum, IOW. Tel: (01983) 567665.

24 April. Visit to Sutton Coldfield, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

2 May. Starting in Contesting, Sunbury & District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: (01787) 313212.

5 May. 'Caught in the Net', Arts Theatre, 6-7 Great Newport Street, London WC2. Tel: (0171) 836 2132.

8 May. Working Wartime CW Short-wave Station, to celebrate VE-Day, Puckpool Park Wireless Museum, IOW. Tel: (01983) 567665.

8 May. Two Metre Foxhunt, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

16 to 18 May. Internet World, Wembley Centre, London. Tel: (0171) 976 0405.

6 June. Using Thermionic Valves, Sunbury & District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: (01787) 313212.

12 June. Open House/Night-on-the-Air, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

14 to 15 June. Government Computing and Information Management, Royal Horticultural Halls, London. Tel: (0171) 587 1551.

26 June. Top Band Foxhunt, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

27 to 29 June. Networks Exhibition, NEC, Birmingham. Tel: (0181) 742 2828.

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

10 July. Summer Social, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

24 July. Construction Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740 994.

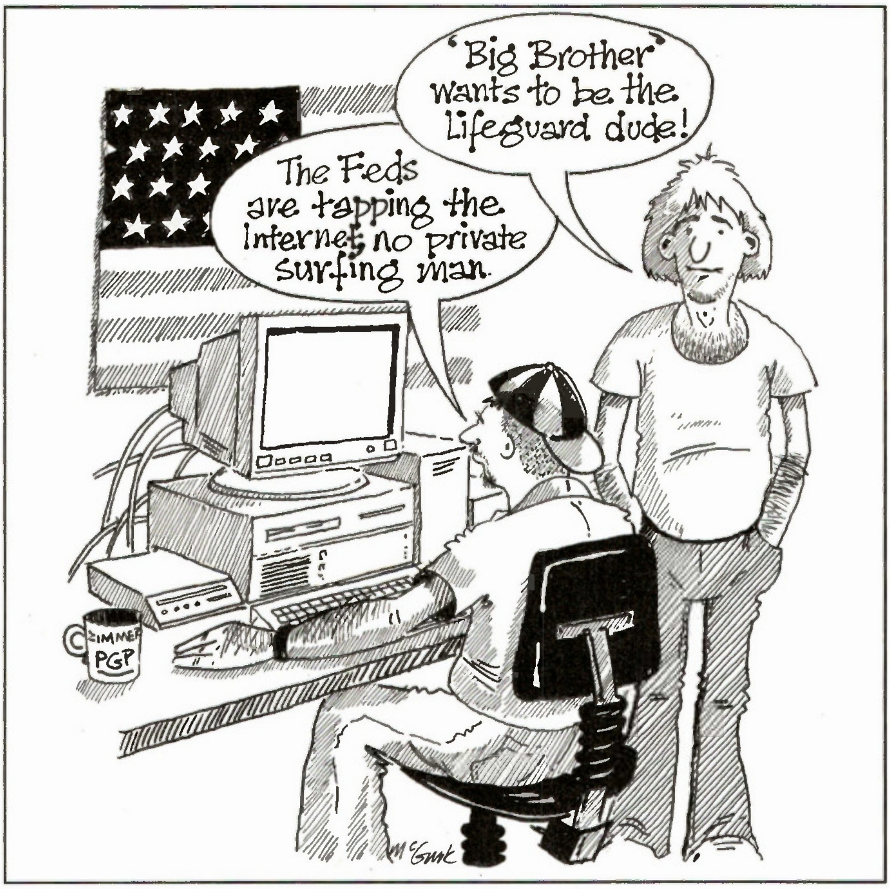
2 September. Wight Wireless Rally, Arreton Manor Wireless Museum, Newport, IOW. Tel: (01983) 567665.

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

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

Stray Signals

by Point Contact



Don't be Frightened to Ask!

While at college, PC must have seemed (to the lecturers) to be the thick one in the class. Being a slow learner, when I didn't understand something, I tried seeking an explanation, after the lecture, from one of the (supposedly) brighter students. As often as not, they were soon floundering (often complaining that they had understood it until I had asked them to explain it) and finishing up with a hopeful "I expect it will all come clear when I come to revise it for the exams!" So, I took to asking questions of the lecturer at the time – and found that lots of others were grateful for a fuller explanation also, but were too shy to ask. Since then, PC has never been afraid to show his ignorance in public, even in these columns – as regular readers will know. And it pays dividends, since I am always learning. For example, readers wrote in from across the country in response to my comments on Residual Current Circuit Breakers (RCCBs). Several kindly explained again how an RCCB (RCD) works, and the various ways in which the test button can be arranged to unbalance the live and neutral ('go' and 'return') currents, causing the unit to trip. Several pointed out that the unbalanced test current is arranged to return through the neutral rather than the earth connection, the integrity of which is thus not tested by the test button. I. B. of Manchester added some useful information, which explained why my RCCB tripped as soon as it was plugged into my standby generator (which was already running at the time). It appears that many RCCBs include circuitry which causes the trip to operate if a substantial voltage is detected between the neutral and ground leads, a useful safety measure as crossed-over live and neutral wires in a socket is such a common fault. He went on to add that in a TV outside broadcast set-up running from its own motor-generator set, all the other vehicles are powered, via RCCBs, from the one with the generator. The neutral of the generator output is strapped to the generator frame and to the earth pins of all the outlets (preventing tripping of the RCCBs due to their detecting excessive neutral-earth volts), and then to ground, via an earth spike for extra safety. Another reader from Manchester confirmed that most RCDs monitor for, and trip on, excessive neutral-earth volts, recommending that readers requiring more information on the difference between ELCBs (earth leakage circuit breakers) and RCDs, consult the IEE Wiring Regulations, or one of the books on wiring practice to be found in the Maplin Catalogue, page 424 onwards. Meanwhile, another reader wrote in to allay any fears that PC might have about the addition of sodium hexaferrocyanate (II) in table salt. Apparently, it is just the new name for your old friend sodium ferrocyanide, and has been used as an anti-caking agent in table salt for 60 years. There, now that is reassuring to know! After all, smoking was introduced in England over 300 years ago, and for most of that time, was considered harmless, nay, beneficial even; and we have all been eating saturated fats since the dawn of history, and only recently found out how bad they are for us.

Dirty Washing

In the USA, the President's Advisory Committee on Human Radiation Experiments, reported towards the end of October last year (halfway through its projected one year programme) that the number of radiation experiments conducted by the U.S. government and military from 1944 to 1974, was likely to be in the thousands. Its interim report listed experiments which included injecting people with radioactive plutonium, marching troops onto ground zero after a nuclear explosion, and releasing radioactive substances into the air, to track their progress or effects. It is difficult to see how such activities could have been sanctioned in the first place, but it is good that in a free society, they should be brought to light, whereas in a totalitarian regime, the dirty washing remains firmly in the closet. It is said that the price of freedom is eternal vigilance, and that must include the ability to keep tabs on those who might want to curtail a nation's freedom, by whatever means. So, just a fortnight before the President's above-mentioned committee reported, the US Congress approved legislation requiring telephone companies to install new equipment or software, to make digital networks accessible to law-enforcement taps. Under the bill, the government is authorised over the next four years to reimburse up to US$500M to the phone companies, to pay for the retrofitting required. Following that period, the FCC will decide whether further costs should fall upon the government, the 'phone companies, or both.

Fairy Wonderland

A couple of months ago, PC passed on an article to a retired colleague (who nevertheless retains an avid interest in electronics/physics/science-in-general), the article from the journal of one of the Institutions, gave a very complete but concise exposition of the state of play in the intriguing field of particle physics, which has latterly fused with the previously quite distinct field of cosmology. Apparently, the proved non-existence of the presently undiscovered, and entirely hypothetical Higgs boson, would be a major spanner in the works for the theorists, necessitating some profound and extensive retheorising. From his limited reading on the subject, PC long since arrived at the conclusion that those ancient Greeks who thought that matter was indefinitely divisible were probably right. It is just that the picture is more complicated; with Avogadro's molecules, like billiard balls, turning out to be made up of atoms, which were then found to be made of protons, neutrons and electrons. These in turn are now apparently made of quarks, which will doubtless someday be found to be made of smaller particles still. . . . It really seems that Charles Dodgson did not get the words quite right; how does it go now, ". . . for the quark was a boson, you see?"

Yours sincerely,

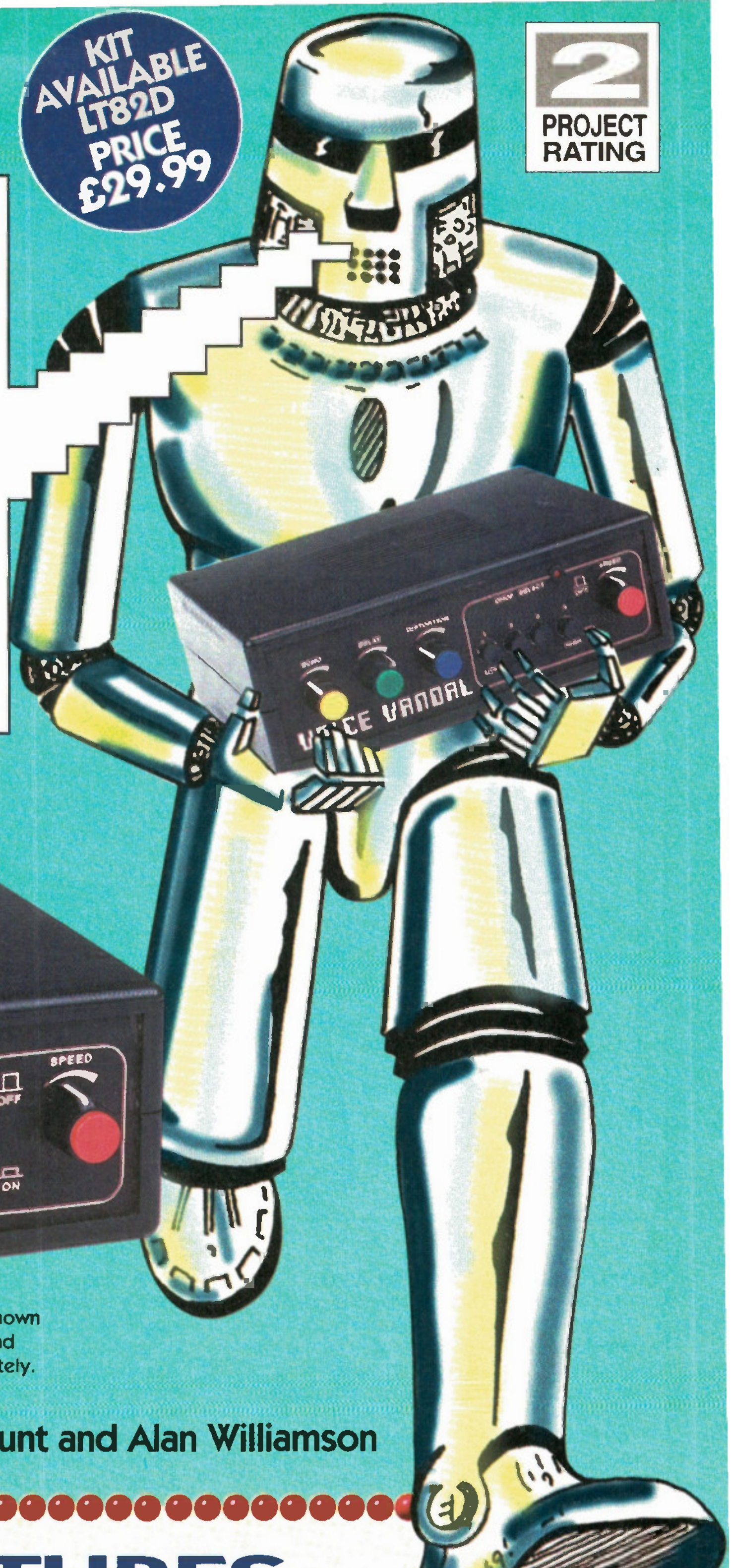
Point Contact

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

KIT AVAILABLE LT82D PRICE £29.99

2 PROJECT RATING

"Here is a project to enthral fans of film and TV 'characters' that appeared in series of Dr Who, Metal Mickey, Red Dwarf and others featuring distorted voices. You too can now imitate the Daleks, Chewbakka, et al, without straining your voice, by building the VOICE VANDAL"



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

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

DESCRIBED here is an audio signal distortion unit, that will take the audio signal from a microphone and/or line input, and by means of digital sound processing, selective clipping and storage and feedback of 'sound bites', will alter the original sound, by a widely adjustable level, ranging from a subtle change in pitch to a barely recognisable, completely altered form, and with the option of echo repetition of the resultant noise.

This will be a boon for anyone requiring a wide spectrum of special sound effects from one inexpensive, versatile unit, either for 'serious' use in productions, etc., or just for laughs.

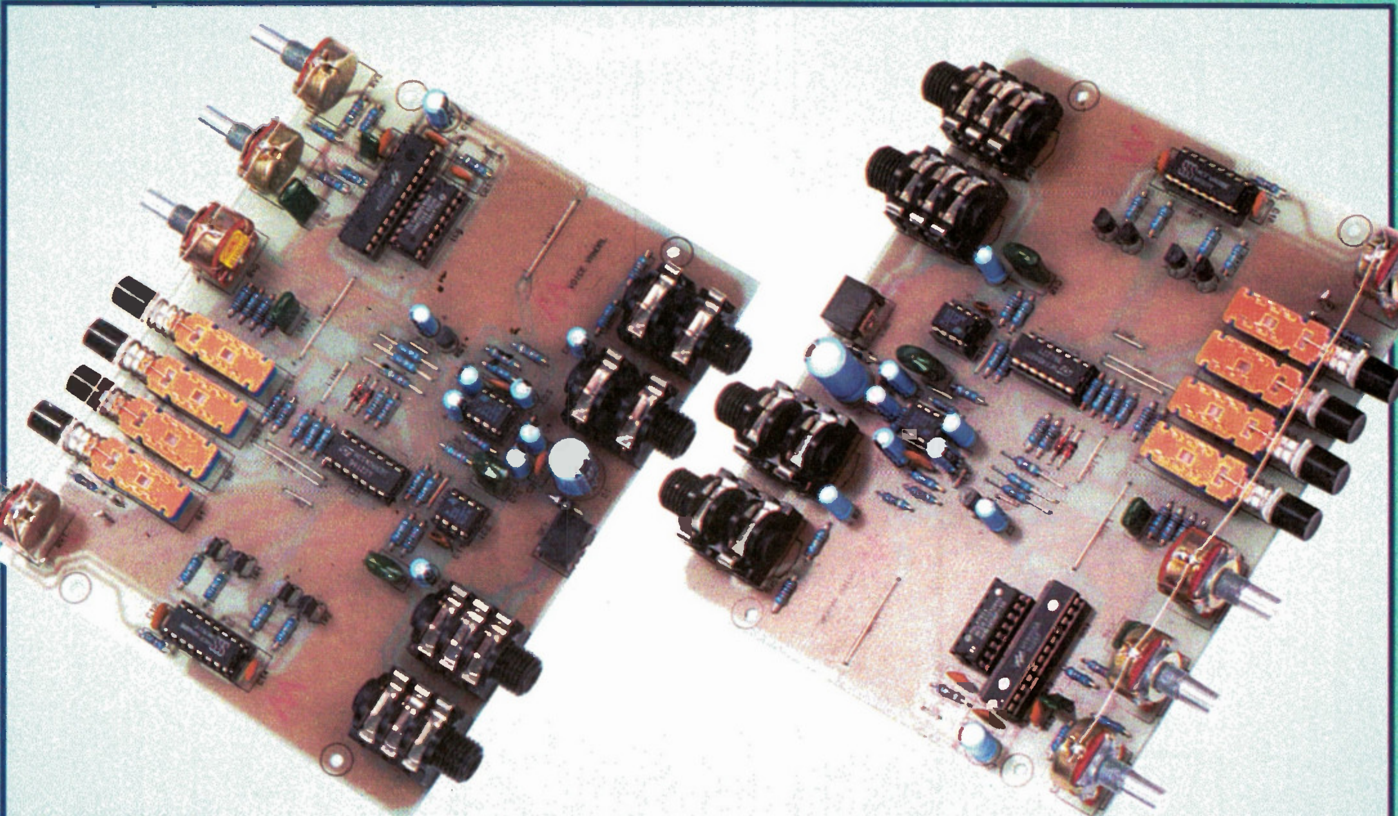
With both microphone and line inputs/outputs, the unit also enables simple mixing of signals from more than one source, so that, for example, soundtracks from films, music albums, etc., could be altered to suit your requirements. This provides scope for much amusement – just imagine what you could do to 'improve' that awful album or

FEATURES

* Low Current Consumption
* Microphone & Line Input/Output
* Digital Audio Signal Delay Processor
* 256K DRAM memory
* Easy to Build/Use

APPLICATIONS

* Echo generator
* Party entertainment/general amusement
* Sound effects for models/toys
* DJ/Public Address systems
* Sound effects for dramatics or film use
* Simple mixer



The assembled PCB.

video that you would not readily admit to paying good money for, or why not liven up the next party political broadcast with some wacky distortion of the speaker's ramblings!

The output signal of the unit, via microphone and line outputs, can be fed into a suitable audio amplifier for immediate listening, or into the input of a tape recorder, etc., to allow replaying of your audio creativity.

Circuit Description

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

The heart of the circuit is IC5, a Holtek HT-8955A, which is a dedicated Voice Echo chip, or CMOS digital audio signal delay processor. This is an LSI device containing preamplifier, system and time-delay oscillators, DRAM interface, 10-bit A/D and D/A converters and control logic, A/D converter correction comparator, shift register, timebase generator, row/column multiplexer, address counter, and, last but not least, a DRAM size selector section.

Working in conjunction with an external 256K DRAM (IC6), this provides a continuously adjustable delay time of up to several seconds, and operates in the following manner; resistors R27 and R28 set the gain of the built-in input op amp at −2·13, the output of which is fed to the A/D converter correction comparator and also the output amplifier, IC1b.

The comparator supplies the A/D converter, whereupon the digital output is fed serially, after a short delay (determined by RV4) into the shift register, which then presents a parallel 'word' to the D/A converter; the resulting analogue signal output from pin 4 is then fed back into the input op amp via C20, R29 and RV3, which produces the 'echo' effect, the level of echo being controlled by RV3.

The final mixed signal is taken from pin 3, and is buffered and amplified by IC1b, whose gain is equal to R37/R38 +1, in this case, a gain of 3·13.

IC1a and associated components form a 'half supply generator', whereby resistors R1 and R2 produce the voltage reference for IC1a, whilst capacitors C3 to C6 symmetrically decouple the input and output of IC1a to the supply rails. Capacitors C9 and C10 provide AC coupling of the input signals to the inverting amplifier, IC2a, the gain of which is set by resistors R3 to R5, according to the formula, G=−R5/R3 (or R4); gains of −1 or −10, respectively.

Diodes D2 and D3 clip the output waveform of IC2a, to produce a signal rich in harmonics (akin to a fuzz box). This signal is then applied to the inputs of IC3, a quad CMOS analogue switch. The signal is then 'chopped' by turning the four solid-state switches on and off with the aid of TR1 to TR4, controlled by IC4, a 14-stage divider and oscillator, the rate of switching being determined by the timing components, RV1, R15 and C12.

The 'chopped' waveforms are then selected via the latch switches, S1 to S4, the signals being recombined via R20 to R23. The reconstituted signal is then passed on to the 'distortion' control, dual-ganged mixing potentiometer RV2, and the 'clipped and chopped' signal combines with the direct signal from IC2a via R25 and R26; the ratio of mixing is dependent on the wiper position of RV2.

PCB mounted in the casing.

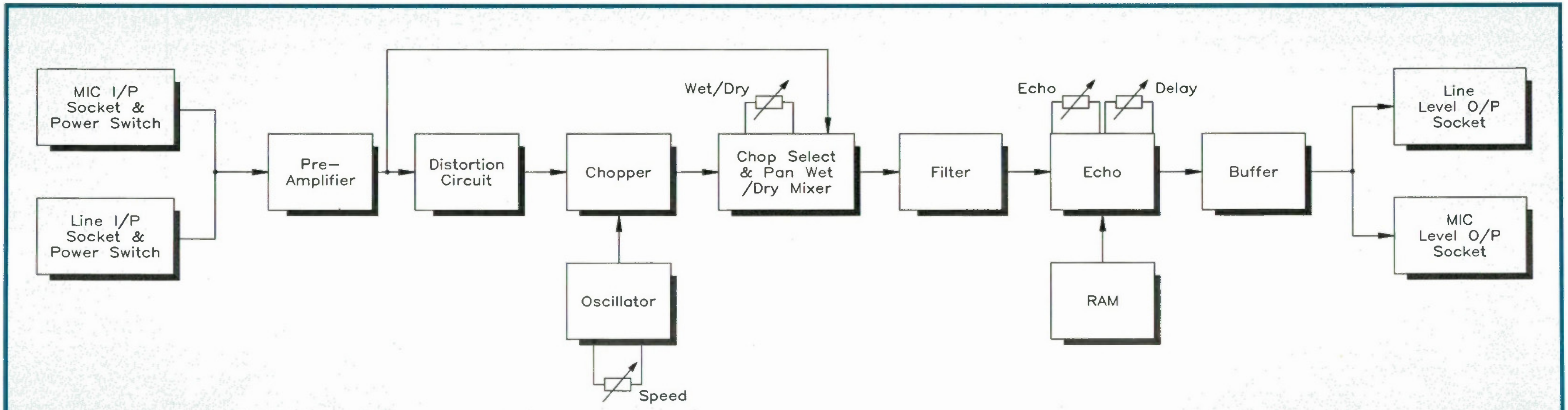


Figure 1. Block diagram of the Voice Vandal.

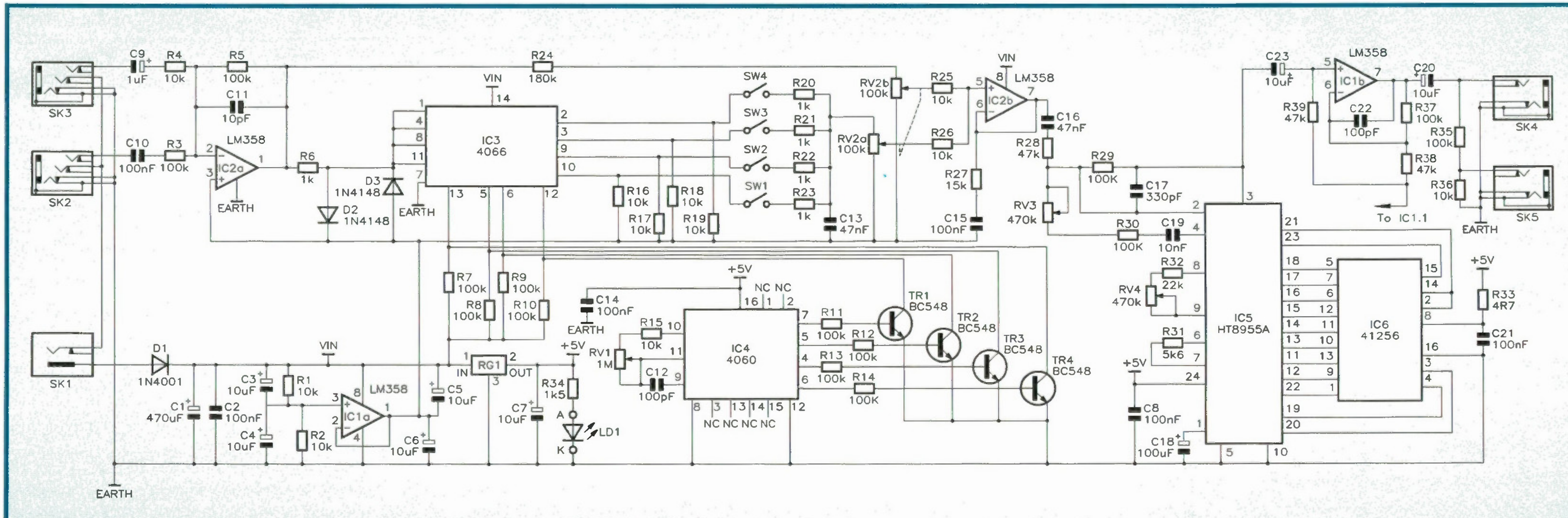


Figure 2. Circuit diagram of the Voice Vandal.

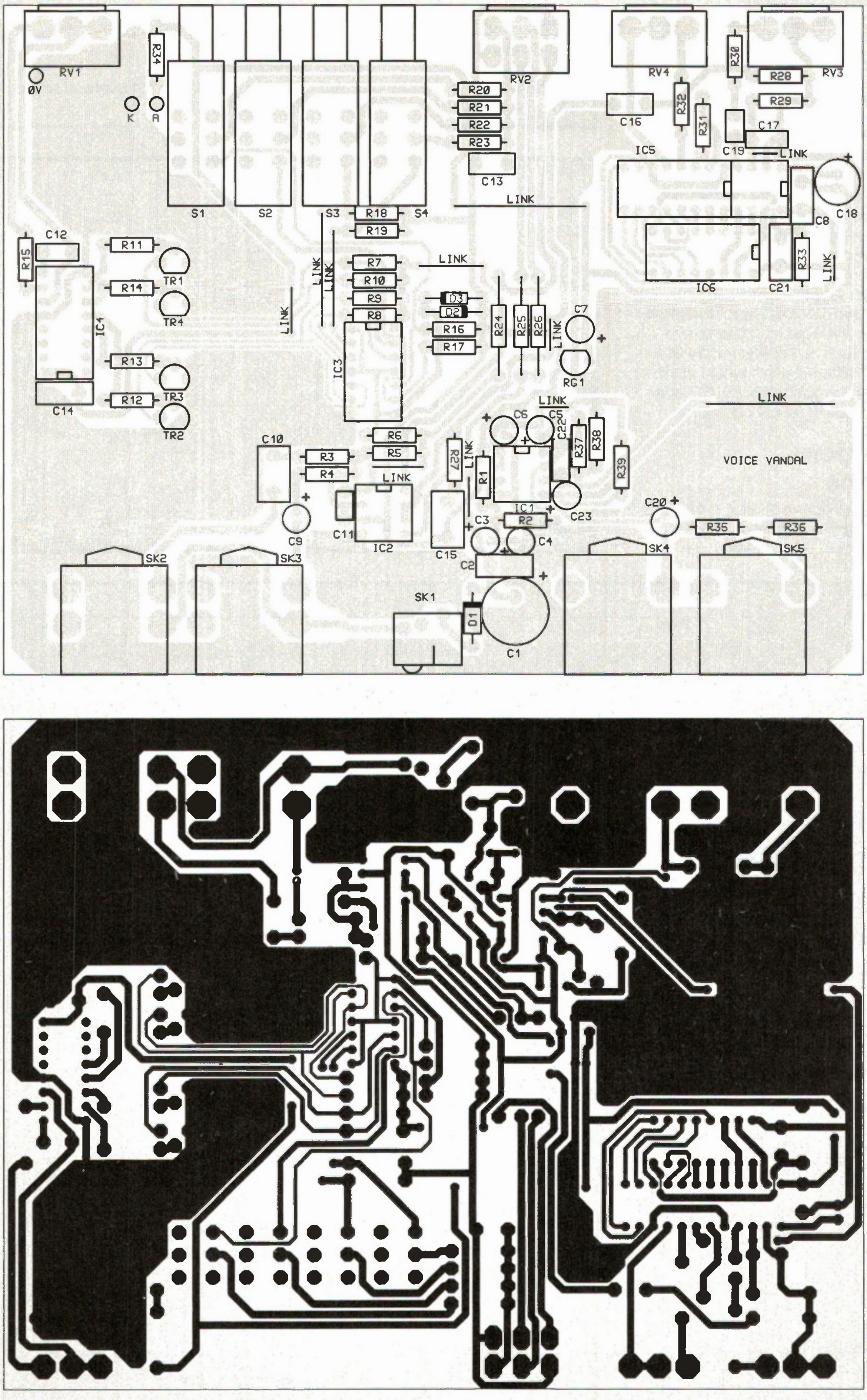


Figure 3. PCB legend and track.

There are several filters within the circuit, a combination of high- and low-pass types, to produce an overall band-pass response of approximately 100Hz to 3kHz between –3dB points. The low-pass filters consist of C13 in conjunction with the combined impedance of the resistive mixer network, C15 and R27, and C17 and R29, whilst the high-pass filter is effected by C16 and R28, on the output of IC2b. The input filters formed by C9 and R4, or C10 and R3, and C11 and R5, reduce the out-of-band gain of IC2a.

RG1 is a 5V regulator that supplies power to IC5 and IC6, which are 5V devices, and it also provides a constant supply voltage to IC4, preventing oscillator drift that would otherwise result from supply variations. The remaining circuitry is happy to operate at the applied power supply voltage, which may be between 8V and 18V DC. The relatively high lower voltage limit is the reason why a 9V battery is not used as a power supply, as a slight drop in battery strength would prevent the unit working properly. An LED, LD1, gives visual confirmation of supply connection.

Construction

PCB Assembly

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

Specification

DC power supply voltage:	Single-rail supply via power socket, 8 to 18V DC, LED indication of supply
Supply current (typical):	19mA
PCB dimensions:	155 × 120mm
Case dimensions:	175 × 130 × 58mm
Functions:	Echo, Delay, Distortion, Chopping level and speed adjustment
DRAM memory:	256K (262,144 × 1 bits)

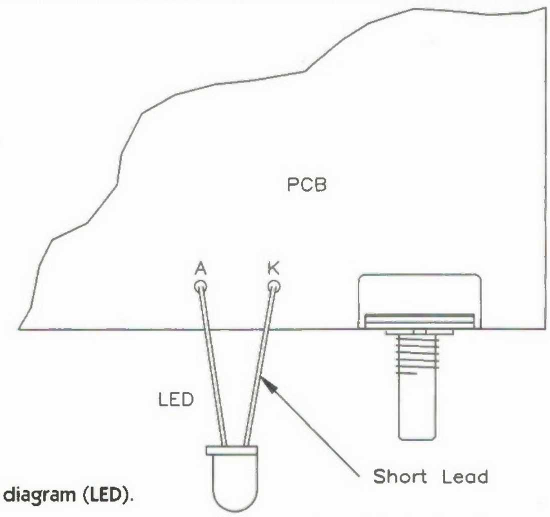


Figure 4. Wiring diagram (LED).

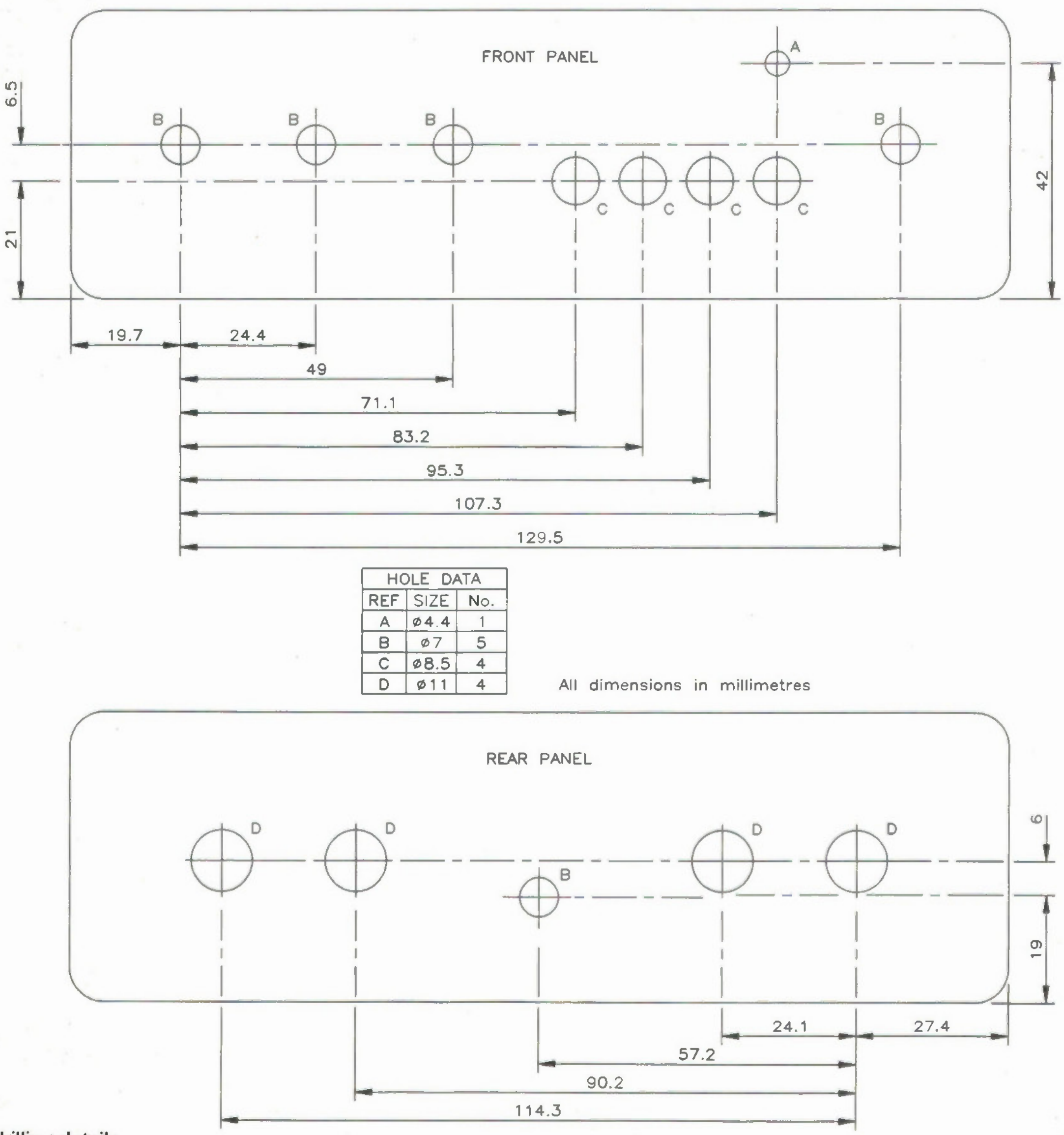


Figure 5. Box drilling details.

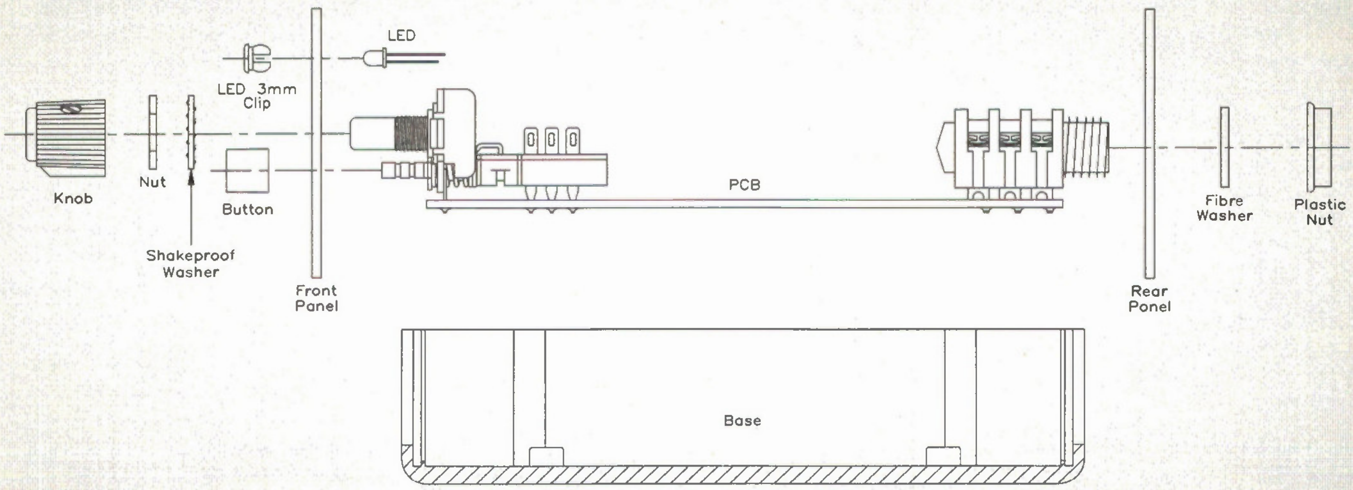


Figure 6. Exploded assembly.

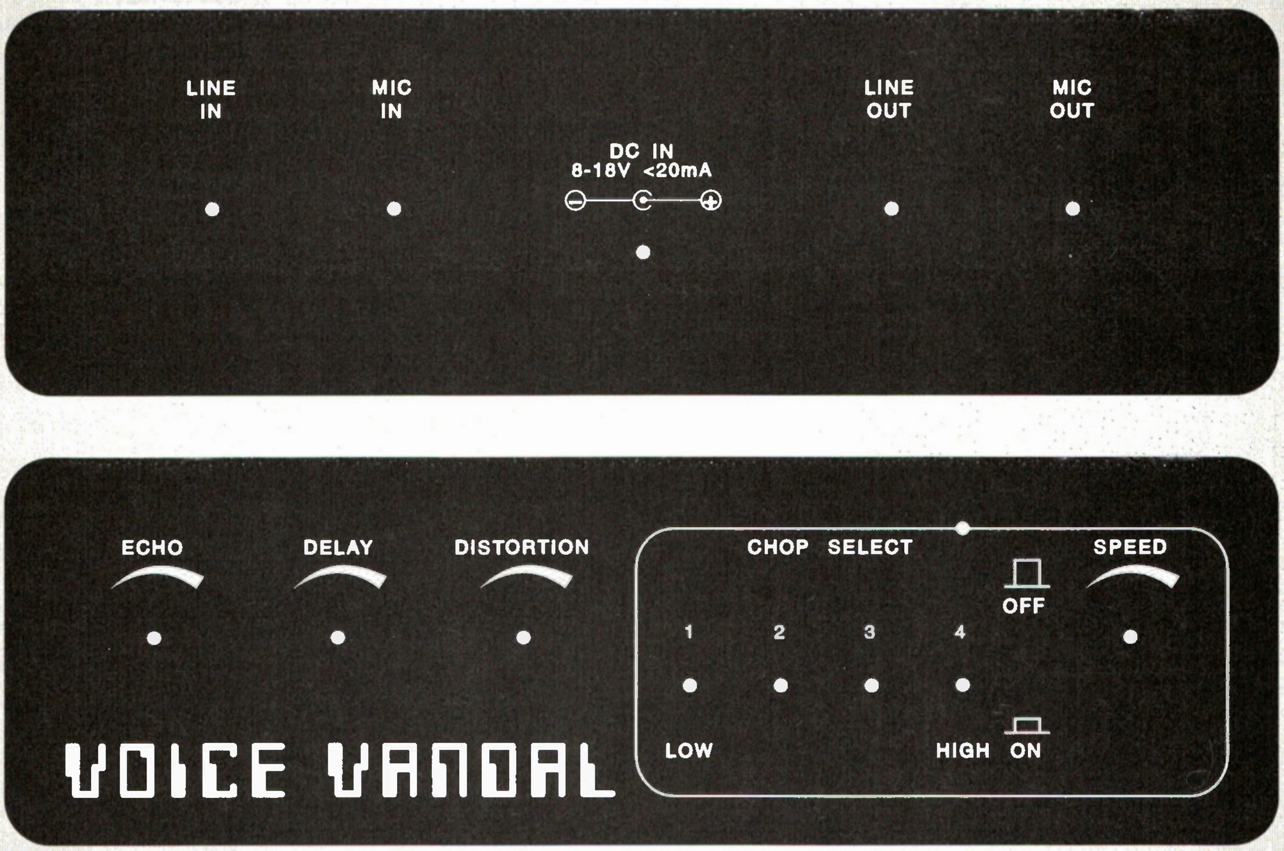


Figure 7. Voice Vandal front and rear panel labels.

smallest components, working up in size to the largest.

If you are new to project construction, please refer also to the Constructor's Guide (XH79L) for hints and tips on soldering and assembly techniques.

22swg tinned copper wire should be used for the long links, whilst component lead offcuts can be used for the shorter wire links.

Insert the PCB pins from the track side, there being three required; one for the potentiometer casing earth link – use a length of 22swg tinned copper wire (approximately 16cm) soldered to, and spanning the uppermost part of the potentiometer's metal bodies (once the potentiometers have first had their spindles cut to the right length –9mm, for the knobs supplied in the kit – and then soldered in place on the PCB), prior to joining the PCB pin – and two pins to which are attached the short interconnecting cables to the LED, see Figure 4 – twin core bell ('Zip') wire, approximately 5cm long is suitable here. Take care to correctly orientate polarised devices, such as electrolytic capacitors, diodes, transistors and ICs. The ICs should be inserted into their sockets last of all.

Thoroughly check your work for misplaced components, solder whiskers, bridges and dry joints. When the PCB has been fully built up, clean all the flux off using a suitable solvent.

Case Assembly

Refer to Figure 5 for the box drilling details, noting that the recommended box has slide-out front and rear panels to enable easier drilling. With the holes drilled and chamfered to remove burrs, the front and rear panel labels can be applied, and the marked hole positions punched through with a pointed instrument, being careful not to damage the labels. The LED bezel can then be fixed into its aperture in the front panel, a simple push-fit. Before fitting the front panel, ensure that the holes drilled for the push switches allow them to operate without sticking.

Next, secure the front panel with the potentiometer nuts, then secure the rear panel with the jack socket nuts, ensuring the panels are the correct way up!

This sub-assembly should then slide into the lower box section along the panel tracks. Ensure that the LED is connected and mounted in the front panel correctly, and then slide the upper section (lid) of the box onto the exposed half of the panels. Four screws, supplied with the box, are used to secure the sections of the box. A look at Figure 6, showing the exploded view of the unit, will assist in this process.

The only remaining assembly job is to affix the knobs onto the potentiometer spindles, by means of the grub screws, in the colour order of your own preference.

Testing

Except for connecting the unit up with a microphone input and output to an audio amplifier and seeing if wild voice distortions can be produced, the only testing that can be readily carried out, having connected a suitable power supply via the power socket, is to plug in a connecting lead terminated in a ¼in. stereo plug, to either the line or microphone input sockets, and ensure that the LED lights when the plug is pushed home, indicating that the unit is on (the LED should extinguish with input leads removed).

A multimeter can be used to check that the voltage regulator, RG1, is providing a stable 5V supply to IC4 to IC6, and that the other ICs are receiving the supply voltage (i.e. between 8V and 18V DC) at their supply pins.

An oscilloscope, or earpiece, could be used to confirm that IC4 is providing oscillatory signals, with differing frequencies at its divider outputs.

The rear of the completed unit.

Other than these tests, check for any components getting warm or smoking hot, a fair indication that all is not well!

Operation

The operation of the device is straightforward, connect a microphone and/or line source via the appropriate input sockets, via leads terminated in ¼in. stereo jack plugs, and connect the appropriate output to an audio amplifier, tape recorder, etc., via leads having ¼in. mono jack plugs. With the power supply connected, speaking into the microphone or providing other audio input (!) and trying out different settings of the potentiometers and combinations of the control switches, should result in some very alternative output sounds being produced!

The variety of sound effects obtainable from the unit is too wide to describe here, so it is up to you to experiment and make your own notes, if you wish, on how to produce certain sound effects.

Alternatively, just twiddle the knobs and make noises as you see fit!

VOICE VANDAL PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,2,4,15-19,36	10k	9	(M10K)
R3,5,7-14,25,26, 29,30,35,37	100k	16	(M100K)
R6,20-23	1k	5	(M1K)
R24,28,38,39	47k	4	(M47K)
R27	15k	1	(M15K)
R31	5k6	1	(M5K6)
R32	22k	1	(M22K)
R33	4·7	1	(M4R7)
R34	1k5	1	(M1K5)
RV1	1M Miniature Linear Potentiometer	1	(JM76H)
RV2	100k Miniature Dual Linear Pot	1	(JM82D)
RV3,4	470k Miniature Linear Pot	2	(JM75S)
CAPACITORS			
C1	470µF 35V Electrolytic Radial	1	(FF16S)
C2,8,14,21	100nF 50V Ceramic Disc	4	(BX03D)
C3-7,20	10µF 50V Electrolytic Radial	6	(FF04E)
C9,23	1µF 100V Electrolytic Radial	2	(FF01B)
C10,15	100nF Mylar Film	2	(WW21X)
C11	10pF Ceramic Disc	1	(WX44X)
C12,22	100pF Ceramic Disc	2	(WX56L)
C13,16	47nF Mylar Film	2	(WW20W)
C17	330pF Ceramic Disc	1	(WX62S)
C18	100µF 25V Electrolytic Radial	1	(FF11M)
C19	10nF Mylar Film	1	(WW18U)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
D2,3	1N4148	2	(QL80B)
TR1-4	BC548	4	(QB73Q)
RG1	LM78L05ACZ 5V Voltage Regulator	1	(QL26D)
LD1	Low Current Miniature 3mm Red LED	1	(CZ28F)
IC1,2	LM358N	2	(UJ34M)
IC3	HCF4066BEY	1	(QX23A)
IC4	HCF4060BEY	1	(QW40T)
IC5	HT8955A Voice Echo IC	1	(AE14Q)
IC6	41256 100ns 256K DRAM	1	(QY74R)
MISCELLANEOUS			
SK1	PCB 2·5mm DC Power Socket	1	(FK06G)
SK2,3	Stereo PCB ¼in. Jack Socket	2	(FJ05F)
SK4,5	Mono PCB ¼in. Jack Socket	2	(FJ00A)
S1-4	Latchswitch 2-Pole	4	(FH67X)
	Single-ended PCB Pin 1mm (0·04in.)	1 Pkt	(FL24B)
	DIL Socket 8-pin	3	(BL17T)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 16-pin	3	(BL19V)
	Zip Wire	1m	(XR39N)
	Tinned Copper Wire 0·71mm 22swg	1 reel	(BL14Q)
	Front and Rear Panel Label	1	(KP83E)
	PCB	1	(GJ09K)
	Instruction Leaflet	1	(XV29G)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	ABS Plastic Instrument Case	1	(KC61R)
	Small Black Latchswitch Button	4	(KU75S)
	LED Clip 3mm	1	(YY39N)
	Knob RN18 Blue	1	(FD65V)
	Knob RN18 Green	1	(FD66W)
	Knob RN18 Red	1	(FD67X)
	Knob RN18 Yellow	1	(FD68Y)
	Square Stick-on Feet	1 Pkt	(FD75S)
	AC Adaptor Regulated	1	(YB23A)
	Low-Cost Dynamic Microphone	1	(ZA31J)

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 LT82D (Voice Vandal) Price £29.99

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

The following new items (which are included in the kit) are also available separately, but are not shown in the 1995 Maplin Catalogue.

PCB **Order As GJ09K Price £5.99**

Front and Rear Panel Label **Order As KP83E Price £2.29**

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

Dear Editor

Keep it Down!

Congratulations on the well-presented and unbiased article by Douglas Clarkson about light pollution in the January issue of *Electronics*. Hopefully, a much needed awareness will have been generated. Light pollution has only become a problem because too few are aware of the consequences of excessive use of artificial light. It may interest readers to know that the Institution of Lighting Engineers (I.L.E.) has issued a revision of their excellent document *Guidance Notes for the Reduction of Light Pollution*. This is very useful in showing not only the better designs of lighting fixtures, but even more importantly, giving information on setting them up properly. It is a credit to Maplin, who after all, make some of their money by selling security products, that they realise that 'brighter is not always better', and that an appropriate (usually quite low) level of lighting is often more useful than high-intensity lighting.
May I suggest that Maplin follow up this responsible approach by including a copy of the I.L.E. guidance notes with every exterior lighting product sold.
For many years, the Maplin Catalogue cover has had a space theme, it is only appropriate to preserve the right to view the real thing! The night sky is a beautiful and inspiring sight. Directionally-controlled lighting, with the intensity toned down, would allow everyone to appreciate the night sky without the use of specialist filters and still maintain useful illumination. The best of both worlds can be achieved, and quite easily with a bit of common sense and regard for others. Finally, Mr. Clarkson would probably be very disappointed if he visited Helmsdale, Sutherland, now. It is lit by 'decorative' Victorian-style lanterns, which have a high upward emission coupled with horizontal glare – the opposite of what is prescribed in the article.

This subject has recently been given additional, national exposure, in BBC's Watchdog *programme, specifically referring to the nuisance caused by halogen security floodlights of excessive intensity, the automatic sensors of some being set so sensitively that they are triggered by changes in wind direction, causing a disturbance to people in the vicinity. Also pointed out was that the very high power versions (of 1kW upwards) that are sometimes fitted, have the running costs of an electric fire, when in most cases, as you say, a lower intensity lamp of 150 to 500W maximum is adequate, with the benefit of far cheaper running costs, a factor many people have a keen interest in. Maplin's security floodlights do not exceed 500W, and come with instructions as to correct fitting and placement, to avoid causing such problems.*

S·T·A·R L·E·T·T·E·R

In this issue, Bill Eaves of Caithness, Scotland, wins the Star Letter Award of a Maplin £5 Gift Token for his enlightening comments concerning light pollution.

£5 Gift Token

Overhead Valve

Dear Editor,
Is there any chance of *Electronics* publishing a design for a car power supply for the Millenium 4-20 valve amplifier? Years ago, all car radios were valve.
James Knight, Reading, Berkshire.

You never know, it might appear in the April edition! Reminds me of the joke about the latest 16-Valve car from [insert your favourite (favorit?) eastern-bloc manufacturer]; 8 in the engine, 1 on each wheel, 4 in the radio!

Surface Mount

Dear Sir,
You asked in the March issue (Editorial) for views on the increasing use of surface mount technology in projects, so here is mine. As amateurs, we can and must use any and all modern technology to our advantage. As history has proved, the 'amateur' has had a significant part in the advancement of science, in all fields!
E. R. Billiald, Arnold, Nottingham.

Thank you for this encouraging and positive opinion on the use of surface mount devices (SMDs) in projects, which, in fact, is the only letter relating to this we have received to date. Admittedly though, we only started offering SMD-based projects from the September 1994 issue, so perhaps people are still coming to terms with this technology before casting judgement!

Power Trip 1

Dear Editor,
I have been following with some interest, Point Contact's comments on problems with his standby power generator. Presumably, he now has a less lethal method of connecting the machine in place of the incoming mains supply, however, the use of an RCCB on its output, while an excellent idea, will give rise to yet more problems. An RCCB will not normally operate correctly with a floating generator supply; either it will not function as an RCCB at all, acting merely as an overcurrent circuit breaker, or will not stay connected. In the television business, it is common to run large outside broadcast operations on local generators rather than mains power, as up to 200A at 240V is not always easy to arrange at a moments notice. It is also usual that all power outlets are centrally located, normally the main control truck, and anything external to this vehicle is connected via an RCCB. To overcome the afore-mentioned problem, it is usual to ground one side of the generator to its earth frame. This then becomes the Neutral side of the generator mains supply.
A good earth is provided by means of a spike into the ground. Although it sounds lethal, connecting the power supply to earth, this is just what happens to the mains supply from the power company, at the substation, whereby the Neutral side of the mains (transformer star point, this being 3-phase) is connected directly to a good earth buried under the substation. RCCBs are designed to operate with this type of connection, hence they will work with the generator setup described.
Ian W. Berry, Manchester.

Power Trip 2

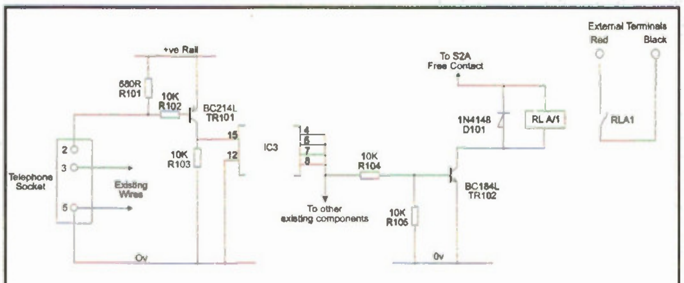
In Issue 86, I noticed the ongoing saga of Point Contact's mains back-up generator. He and J. H. of Kent, both correctly state that an RCD will not operate properly when used with a generator, in which its supply is floating with respect to its earth/chassis connection. What is not mentioned, even in the Maplin Catalogue, is that most RCDs also detect live and neutral conductors reversed, this being a very common fault in domestic (especially DIY) wiring. In a floating system, the RCD cannot detect which way round the L and N wires are. PC quotes his generator having a potential between earth (chassis) and neutral of 200V Pk–to–Pk. I suspect that this is what is tripping the RCD, although the circuit of the RCD itself changes the reactive coupling between L–E and N–E.
Note that RCDs will also fail to operate as expected when connected to the isolated side of an isolation transformer, for much the same reason. Also, I feel it prudent to remind other readers that ELCBs and RCDs (or RCCBs) are NOT the same thing, and operate in subtly different ways. For more information on protective devices, see the IEE regulations, or one of the many books on wiring practice (catalogue pages 423 to 425). A gadget that may be useful, uses three neon lamps connected L–E, L–N and N–E, in a plug-style housing. If a wall socket is wired correctly, the L–E and L–N neons only should light. If L–N and N–E light, then live and neutral are reversed, and if L–E and N–E light, live and earth have been reversed.
However, this device will not detect neutral and earth reversed. Usually included, is a simple graphic representation of the possible light combinations and the state of wiring each indicates. Such a unit is easy to build, but be extra careful to label the neons correctly, as you will be using their indication as a basis for deciding that an electrical outlet is wired correctly.
Jason, Manchester.

Thank you for your letters on this subject. The correct use of RCCBs certainly seems to cause some confusion. Due to the variety of different types available, we cannot give detailed guidelines on their use here, but advise closely following the instructions that should be supplied with the device. Also, look out for a future article in Electronics, *concerning circuit breakers.*

The Bells, The Bells . . .

Dear Sir,
Congratulations on a great magazine, which I have read for many years. Since retiring from work as an analogue circuit designer, I have come to appreciate just how much it keeps me in touch with the electronics scene. I recently built an AutoRing telephone ringer kit (January 1993, Issue 61), and added two modifications, which might interest other readers. The first is to sense when the telephone is 'off hook', and inhibit IC3, stopping the internal buzzer (if in use) and LED flashing, whilst allowing the user to hear their voice in the earpiece. This is achieved by the left-hand side of the circuit shown. Pin 15 of IC3 needs to be isolated from 0V, which I did by bending the pin so it does not enter the IC socket, and soldering a wire directly to it. The second 'mod' is the addition of a relay to operate an external bell, this forming the right-hand side of the circuit shown below.
J. J. H. Bamford, Wells, Somerset.

Thank you for your comments about the magazine, and for sharing your AutoRing circuit modifications with our readers. They will help to add to the realism and versatility of this project.



This change adds side tone to the telephone, and allows the hook switch to stop the AutoRing internal buzzer, and the external trembler bell.

This change allows the AutoRing to operate an external battery and trembler bell.

Parts List

Resistors All 0.6w 1% Metal Film

M680R 1 (680 ohms)
M10K 4 (10 k)

Semiconductors

QB57M 1 (BC184L)
QB62S 1 (BC214L)
QL80B 1 (1N4148)

Relay

YX96E 1 (3 Amp Min. Relay)

Miscellaneous

HB22Y 1 (Quickstick Pads)
FD69A 1 (Terminal Black)
FD72P 1 (Terminal Red)

AutoRing Modifications.

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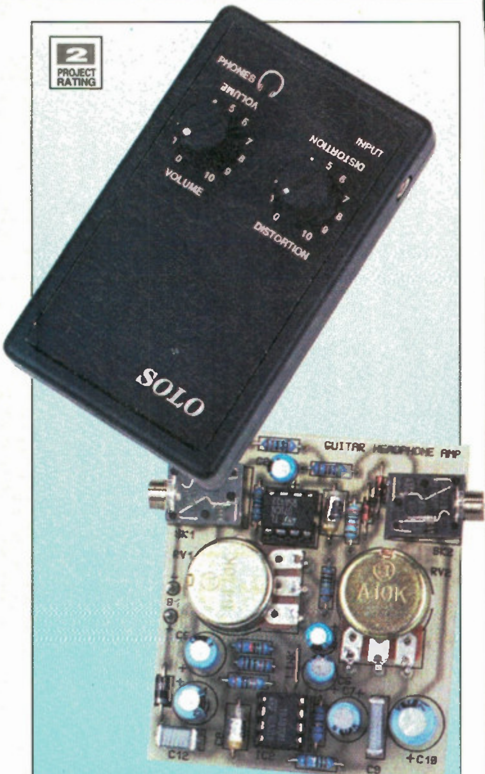
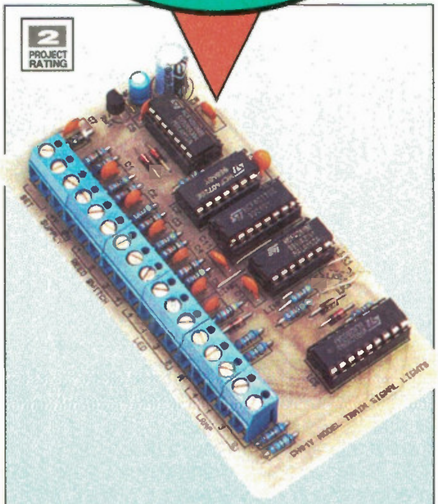


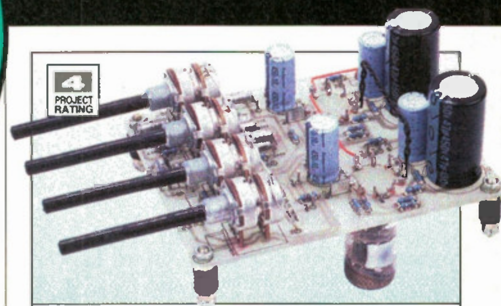
GUITAR HEADPHONE AMPLIFIER

Now you can practise in private and without annoying the family or neighbours (where's the fun in that?). Clip this inexpensive project to your belt and throw yourself into your most torturous, ear-wrenching solo and you won't even disturb the cat.
Order as: LT80B, **£12.99**. Details in *Electronics* No. 86, February 1995 (XA86T).



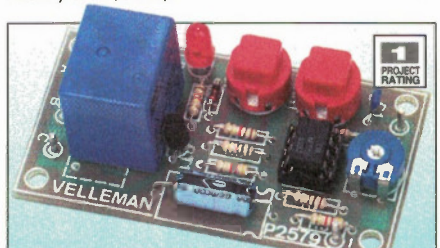
MODEL TRAIN SIGNAL LIGHTS CONTROLLER

Build authentic 2, 3 or 4 aspect signalling systems with this superb Signal Lights Controller project. The passage of the train can be detected by magnetic sensors on the track, automatically advancing the signal lights in the correct sequence.
Order as: LT66W, **£9.99**. Details in *Electronics* No. 86, February 1995 (XA86T).



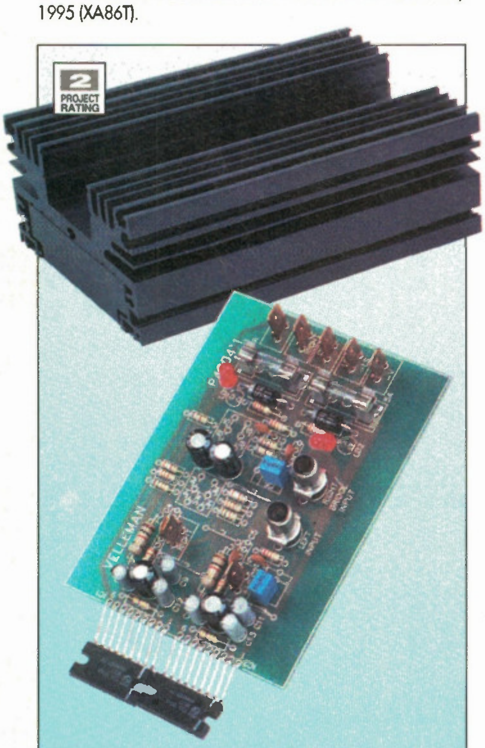
'NEWTON' VALVE PREAMPLIFIER TONE CONTROL

Completing the set of modules for the 'Newton' Valve Preamplifier, is this passive stereo valve Tone Control Unit which provides bass boost and cut of +16dB and –12dB @ 20Hz max., and treble boost and cut of +18dB and –19dB @ 20kHz max.
Order as: LT77J, **£39.99** A1. Details in *Electronics* No. 86, February 1995 (XA86T).



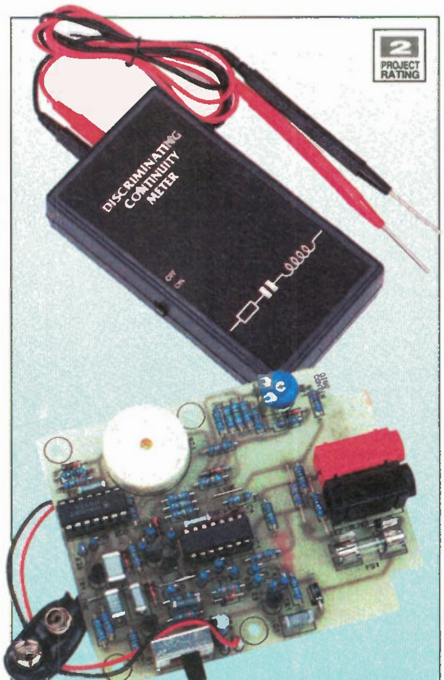
UNIVERSAL TIMER MODULE

Employing the classic 555 timer IC, you are sure to find many uses for this Universal Timer project. With a switch-on or switch-off delay variable between 2 seconds and 15 minutes, this timer is ideal for applications like egg-timers, snooze controls and automatic control of equipment like tape recorders etc.
Order as: VF06G, **£8.99**. Details in *Electronics* No. 86, February 1995 (XA86T).



100W MONO/STEREO AMPLIFIER

This versatile amplifier module can be configured as either a stereo amplifier producing 50W per channel into 4Ω, 40W per channel into 8Ω, or a bridged mono 100W amplifier. The design features overload and short circuit protection, and speaker 'pop' protection at switch on and switch off. Power supply requirement is ±28V.
Order as: VF39N, **£48.49** G8. Details in *Electronics* No. 87, March 1995 (XA87U).

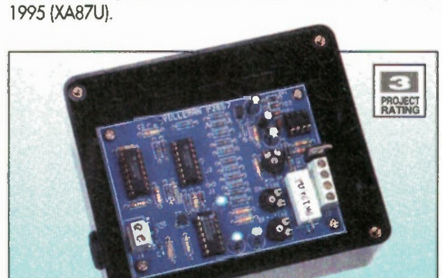


DISCRIMINATING CONTINUITY & LEAKAGE TESTER

Test for more than just 'Go' or 'No go' conditions with this ingenious tester. A variety of sound outputs of varying pitch and duration allow you to differentiate amazingly accurately between a good connection and a high resistance one, test for leakage, and check both passive components and semiconductors.
Order as: LT78K, **£19.99**. Details in *Electronics* No. 87, March 1995 (XA87U).

ELECTRONIC MEMOPAD

Record messages up to 16 seconds long for playback – up to 10 years later! Ideal for memos and messages in the office or home, and a boon to the blind, partially-sighted, and anyone with reading or writing difficulties.
Order as: LT79L, **£29.99**. Details in *Electronics* No. 87, March 1995 (XA87U).



SLOW ON/SLOW OFF LAMP DIMMER

Look – no hands! Instead of the normal manual control, this dimmer uses two variable timers to slowly increase or decrease the level of light. Both the 'on' and 'off' timers are variable from 1 second to 30 minutes. Ideal lighting control for slide/film shows, and as a gently reducing 'slumber' switch.
Order as: VE51F, **£15.99**. Details in *Electronics* No. 87, March 1995 (XA87U).

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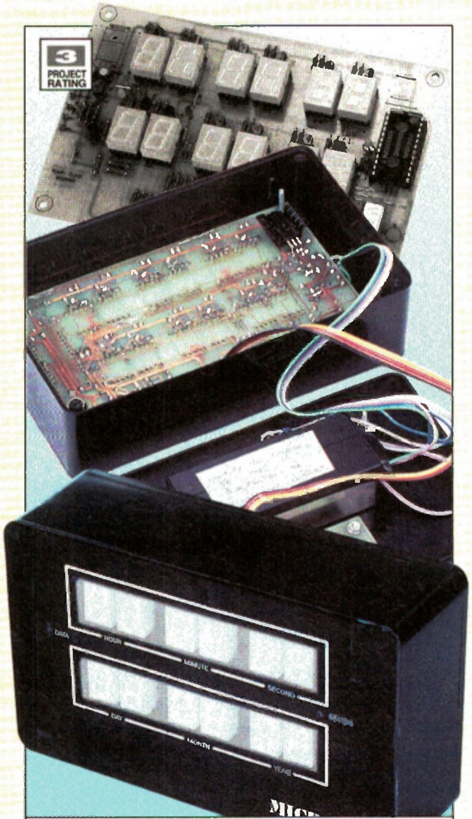
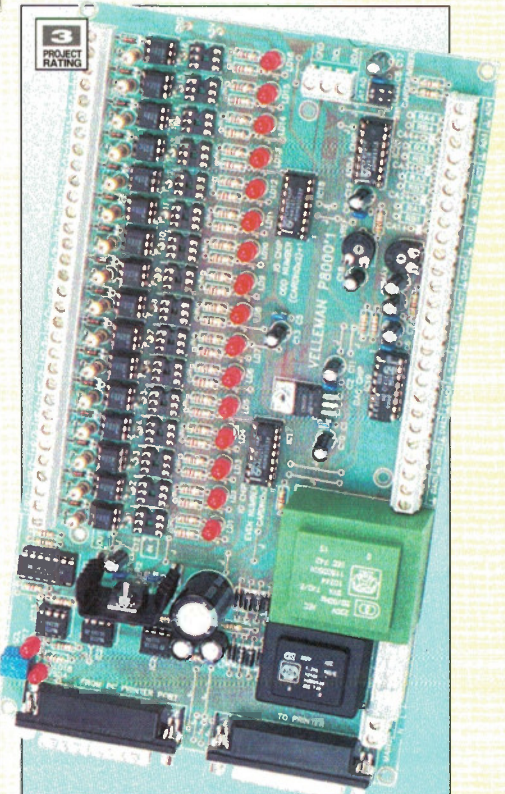


MICRON III RADIO CONTROLLED CLOCK

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

SOUND ACTIVATED FLASH TRIGGER

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



COMPUTER INTERFACE BOARD

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

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MS Stereo

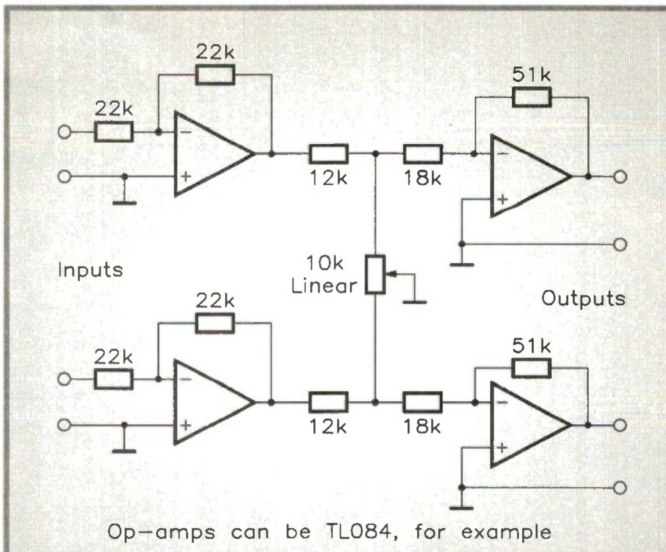


Figure 2. Approximate sine-cosine potentiometer circuit, with buffering and gain make-up.

New Harvests from an Old Field?

Part 1: The Basic Principles

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

As with practically everything else, MS stereo was first studied by Alan Dower Blumlein more than sixty years ago. The expression 'MS' has been variously interpreted as 'mid-side' and 'mono-stereo', both of which are meaningful. Because, in both broadcasting and recording, stereophonic techniques are explained in terms of 'left' and 'right' signals, the possibility of other ways of looking at the signals has been sadly neglected, and has led to excessive preoccupation with 'separation' between the left- and right-channels, or its *alter* ego, 'crosstalk'. Demand for higher and higher levels of separation (anything less than 80dB is regarded as impossibly defective in some quarters!) has led to the actual effect of finite crosstalk on image position being completely disregarded. In fact, crosstalk at –40dB, which is easily achieved except on playback of analogue discs, represents an image shift of only 10mm on a 3m loudspeaker baseline.

Generating MS Signals

In deriving MS stereo signals from conventional LR (or AB for purists) signals, we deliberately stir them together and use the results. This might seem to cause a disastrous loss of 'stereo information', but if done correctly, there is no loss at all. Regular readers have met the Σ-Δ (Sigma-Delta) matrix before. This should not be confused with the Σ-Δ analogue-to-digital converter, which is an entirely different animal altogether. Sigma means 'sum' and Delta means 'difference', and this is what the matrix does, in producing M- and S-signals from L and R. The equations are:

$$M = \frac{1}{\sqrt{2}}(L+R)$$

$$S = \frac{1}{\sqrt{2}}(L-R)$$

The factor $1/\sqrt{2}$ represents a 3dB loss of signal amplitude in the matrix, and is purely there to make the same matrix also suitable for the reverse process:

$$L = \frac{1}{\sqrt{2}}(M+S)$$

$$R = \frac{1}{\sqrt{2}}(M-S)$$

If we ignore the 3dB loss, we get effectively 3dB of unexpected gain out of each matrix circuit, which often does not matter, or is even advantageous. Figure 1 shows a practical circuit with buffered inputs, and optional 3dB gain correction.

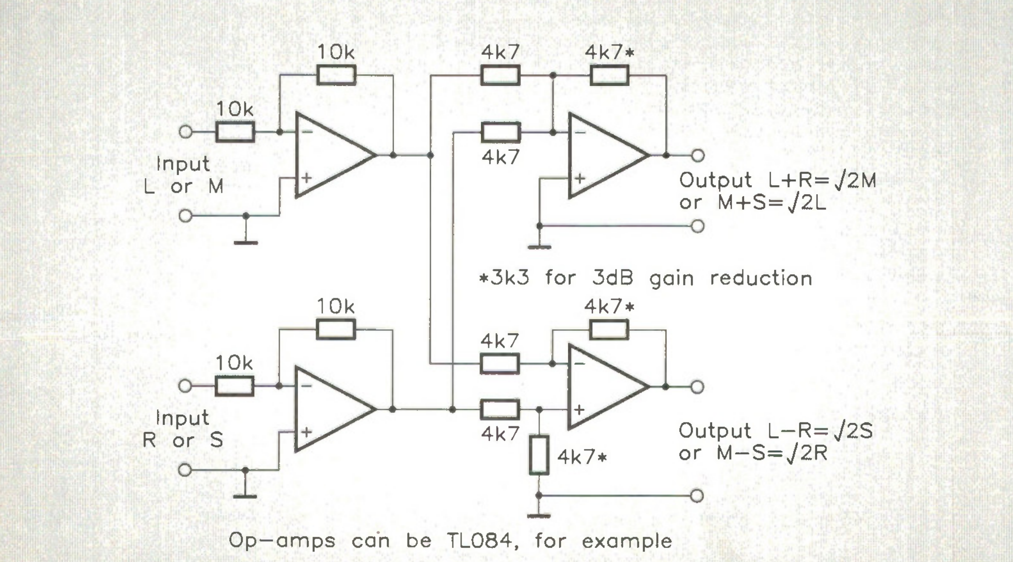


Figure 1. MS or Σ-Δ matrix circuit.

MS and the Pilot-tone System

Once we have the signals in MS form, we can see the reason for the 'mono-stereo' tag. The broadcasters take particular care that the sum signal, $L + R$, reproduces properly on mono equipment, with no strange effects. However, this has not always been the case with analogue discs; a spectacular example is the occasional recording of a centrally-positioned soloist with one channel inverted (so-called '180 degrees out of phase'). When reproduced in stereo, this gives a sort of disembodied effect, but in mono, the soloist becomes more or less inaudible, depending on the amount of residual crosstalk. The difference signal, $L - R$, can be considered to carry the stereo information only, and in fact, we can usefully describe the broadcast stereo signal (in the pilot-tone system used in almost all countries) in MS terms. The M-signal directly frequency-modulates the main carrier, and can thus be received correctly by mono receivers, while the S-signal modulates the 38kHz sub-carrier in double-sideband suppressed carrier (DSB-SC) mode.

Wider Still and Wider . . .

With MS signals available, there are a number of simple processes which we can use to obtain effects that are rather difficult to achieve in LR format. One of the simplest is *stereo dimension control*, whereby changing the level of the S-signal relative to the M-signal, we can effectively widen or narrow the stereo baseline, independently of the actual separation of the two loudspeakers. If we overdo this, though, the stereo image 'falls apart', and the disembodied effect supervenes. This technique can be realised with the circuit shown in Figure 2, in which a continuous variation from mono (no S-signal), through unmodified stereo to rather wider than is wise, is available on the single control. This is an example of a sine-cosine potentiometer circuit, which preserves the signal energy practically constant at all control settings. This circuit appeared in the September 1994 issue (No. 81), but due to a last-minute improvement in the circuit values, the text there does not quite match the Figure.

Curiously, the matching of the shapes of the attenuation curves (graphs of attenuation against rotation angle of the potentiometer) to the sine and cosine shapes depends only on the value of the parallel combination of source and load resistors of the potentiometer, relative to the value of the potentiometer resistance. The optimum value is 0·71 (or $1/\sqrt{2}$) times the potentiometer resistance, so any combination such as 8·2kΩ/82kΩ or 12kΩ/18kΩ is suitable for a 10kΩ potentiometer, but 12kΩ/18kΩ results in a preferred value for the gain make-up resistor in the output buffer, and a lower noise level. To use this module with conventional LR equipment, you need one Σ-Δ matrix before it, and one after it, and it is quite possible to obtain stable stereo images considerably beyond the loudspeakers, with appropriate programme material.

The Work of Holger Lauridsen

When stereo broadcasting was being seriously considered for the first time in Europe in the early 1950s, Holger Lauridsen began experimental work at Danish State Radio. His initial work on the psychoacoustic effects of electronically-generated echoes produced interesting results, which can be reproduced fairly easily. A tape recorder with two playback heads, separated by 100ms of playing time, provides a source of delayed signals, but nowadays, a solid-state delay could also be used. In the first experiment, you place one loudspeaker 1m in front of you and an identical one 1m behind you, and when they are fed with identical signals, the effect of the back loudspeaker on the sound is not very noticeable. However, if the rear sound is delayed by 100ms, the effect is to make the room seem much larger, while the apparent sound source stays at the front. With side loudspeakers delayed by up to 100ms and a rear loudspeaker delayed by up to 200ms, the effect is even more marked. (This is getting close to some aspects of Dolby surround technology, but pre-1954!)

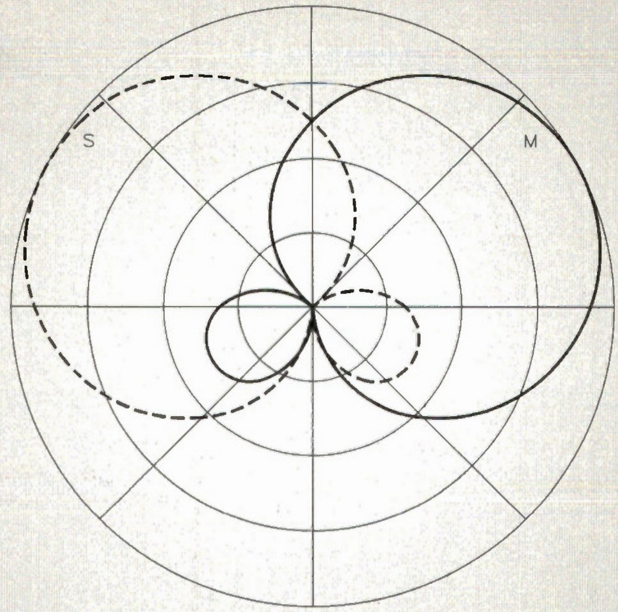


Figure 4. Result of applying the Σ-Δ matrix to the microphone responses shown in Figure 3. Applying it to these responses returns the Figure 3 responses again.

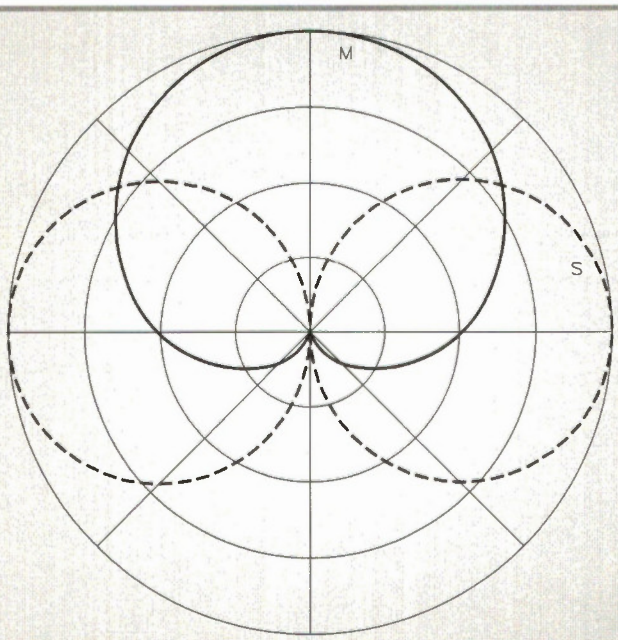


Figure 3. Directional responses of M and S microphones.

Headphone Experiments

Lauridsen also experimented with headphone listening, with results that could be very useful for some of the less acceptable applications of virtual reality. Mixing direct and *inverted* delayed signals gives the sense of being in a large room that was obtained with front and back loudspeakers, but one of the most spectacular and disturbing demonstrations consists of an anechoic recording of a pistol shot, which is replayed with two delayed copies. The sound appears to fly towards you from a distance, and you could really believe that you have been shot in the head! However, the bullet can be painlessly extracted and returned to the gun by replaying the signals with changed polarity. This effect can also be created with loudspeakers in an anechoic room.

Single-box Stereo

Another experiment, which led directly to the MS technique, used a conventional closed-box loudspeaker in front of the listener, behind which was a drive unit mounted on a flat baffle about 600mm square, such a 'dipole' loudspeaker having a figure-of-eight (lemniscate) directional response, at low frequencies anyway, and if this loudspeaker is fed with delayed signals, all the psychoacoustic effects can be demonstrated. In addition, in a well-damped room, the sound source seems to recede as one approaches the loudspeakers from the front, because the relative strength of the dipole increases at short distances.

Clearly, since the two loudspeakers are adjacent in this arrangement, they can both be included in one enclosure – 'one-box stereo'. I hope to describe such a device in Part 2 of this article, although the final design may not be quite as simple as suggested here. Another MS loudspeaker has four drive units in an horizontal line, and I hope to deal with that concept in Part 2 also.

The MS Microphone

Many experimenters with MS techniques will doubtless wish to make their own recordings. Blumlein had only omnidirectional microphones available for his early work, so was forced to use a pair of these, spaced a few inches apart and with a baffle in between. He was, of course, well aware that this was not optimum, and spent much effort in processing the microphone output signals to eliminate the unwanted effects. Lauridsen, however, had capacitor microphones available, with a choice of omni, lemniscate and cardioid directional responses. For the M-signal, we want the maximum response to be in the forward direction, so a cardioid response is indicated, whilst for the S-signal, we want maximum response at the sides, and the left and right side signals should be in opposite polarity, and this is exactly what a lemniscate response gives us, Figure 3 showing the two-directional response superimposed. Unfortunately, lemniscate microphones are not so easy to obtain, especially with characteris-

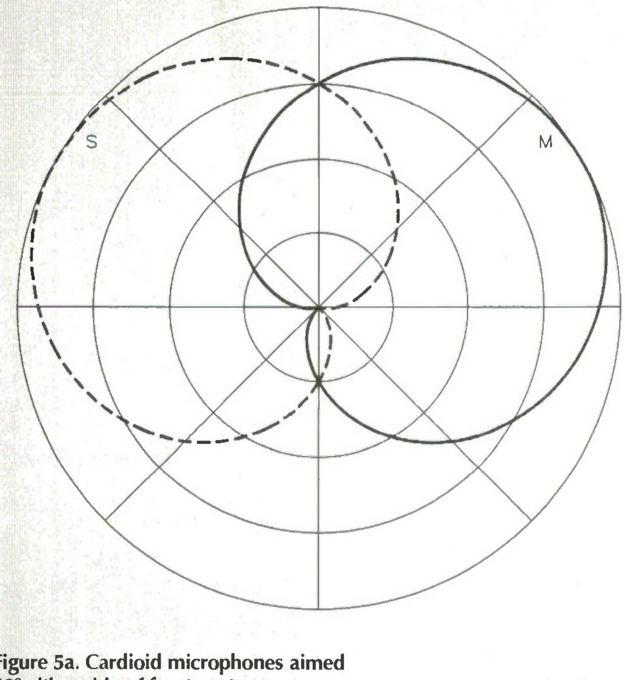


Figure 5a. Cardioid microphones aimed 60° either side of front centre.

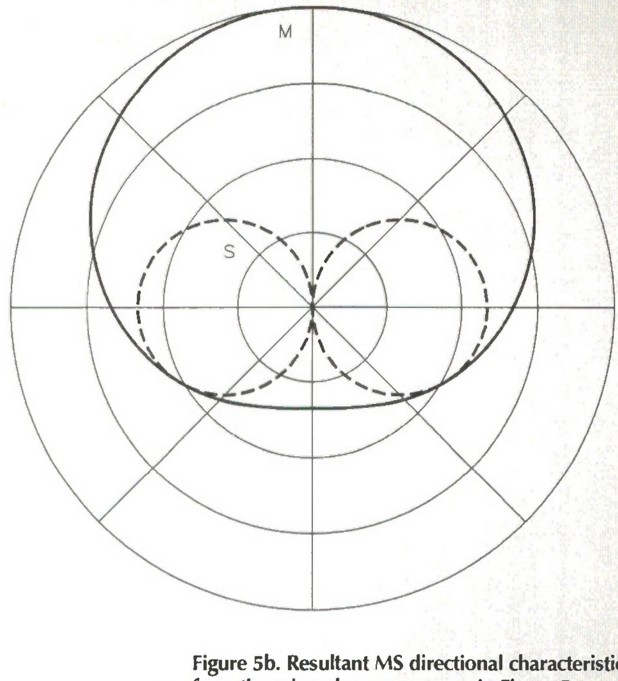


Figure 5b. Resultant MS directional characteristics from the microphone responses in Figure 5a.

tics matching one of the relatively freely-available cardioid units, but luckily, the Σ-Δ matrix comes to our aid again – the polar co-ordinate equation for the lemniscate is:

$$r = \sin\Theta$$

Actually, to plot this, and some other polar curves, using a computer graph-drawing program, you usually have to use the 'absolute value' function:

$$r = \text{ABS}\,(\sin\Theta)$$

otherwise the stupid beast (sorry, *literal-minded faithful servant of Man*) plots the two circles superimposed. In the following, I am going to leave out the 'ABS'. The equation for the cardioid is:

$$r = \frac{1}{2}(1+\cos\Theta)$$

Note that these forms of the equations allow us to put '0°' at the top of the diagram, representing the frontal direction of the listener, instead of at '3 o'clock', as is usual in pure mathematics. The factor of 1/2 in the cardioid equation is to keep the diagram at the same scale as for the lemniscate.

Now, if we do the Σ-Δ operations on these equations, we get:

$$\text{sigma: } r = \frac{1/2(1+\cos\Theta)+\sin\Theta}{\sqrt{2}}$$

These equations are plotted in Figure 4, and the curves are called 'hypercardioids' or 'supercardioids'.

$$\text{delta: } r = \frac{1/2(1+\cos\Theta)-\sin\Theta}{\sqrt{2}}$$

Strictly, the latter name ought to be reserved for one particular variety of this sort of shape. The axes of these microphones are directed at 63·4° either side of the forward axis, as we can find as follows. The axis is the direction of maximum response, i.e. we need to find the angle Θ which makes the value of r greatest. By symmetry, we can use either equation if we interpret the result correctly, and we can simplify the process by multiplying by $2\sqrt{2}$. We then need to find the maximum by differentiation:

$$\frac{dr}{d\Theta} = \frac{1}{2\sqrt{2}}\frac{d}{d\Theta}(1+\cos\Theta+2\sin\Theta)$$

$$\frac{d}{d\Theta}(1+\cos\Theta+2\sin\Theta) = -\sin\Theta+2\cos\Theta$$

and maximum and minimum values occur when this is equal to zero. Dividing by $\cos\Theta$, we get:

$$-\tan\Theta + 2 = 0$$

so that $\tan\Theta = 2$, and one solution of this is $\Theta = 63{\cdot}4°$. From Figure 4, we can see that this is the angle between the axis of the left-hand microphone and 'twelve o'clock', so the angle between the axes of the microphones is 126·8°.

Classifying Hypercardioids

Hypercardioids form a family of curves whose extreme members are the cardioid, which has only one lobe, and the lemniscate, which has two equal (circular) lobes. They are usually classified in electroacoustic studies according to the angle from the main axis at which the response is zero. For the cardioid, this is 180°, of course, and for the lemniscate it is 90°. Our hypercardioids are clearly of the same shape, so we can consider just one:

$$L = M+S = \frac{1}{2}+\frac{1}{2}\cos\Theta + \sin\Theta$$

and we want to find the value(s) of Θ for which $L = 0$. This equation can best be solved by rearranging:

$$\sin\Theta = -\frac{1}{2}(1+\cos\Theta)$$

and, for convenience only, putting $\cos\Theta = x$. Then:

$$\sqrt{(1-x^2)} = -\frac{1}{2}(1+x)$$

becomes:

$$1-x^2 = \frac{1}{4}+\frac{1}{2}x+\frac{1}{4}x^2$$

Simplifying and multiplying by 4:

$$5x^2+2x-3=0$$

whose roots are –1 and –3/5.

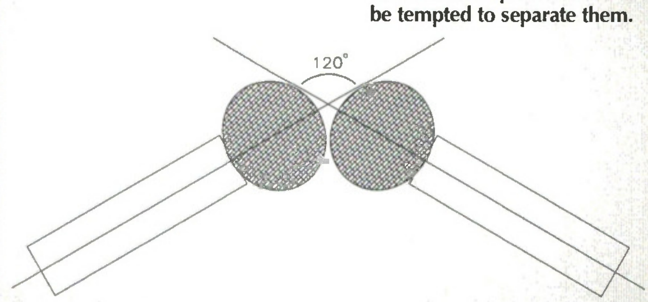


Figure 6. Arrangement of two cardioid microphones. Do not be tempted to separate them.

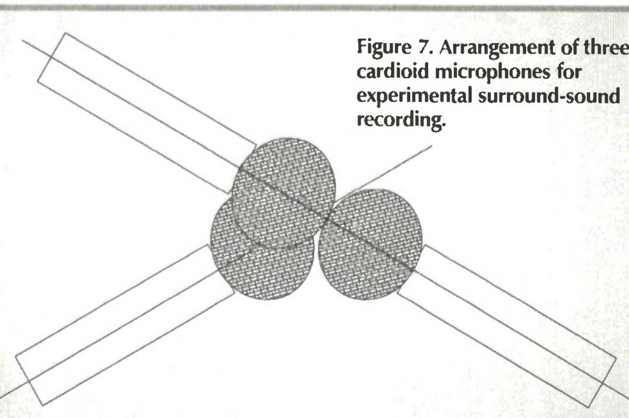
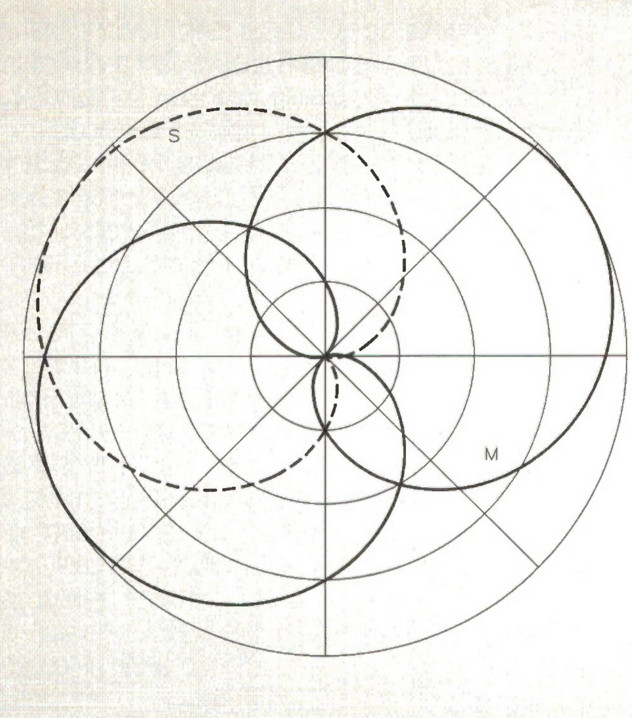


Figure 7. Arrangement of three cardioid microphones for experimental surround-sound recording.



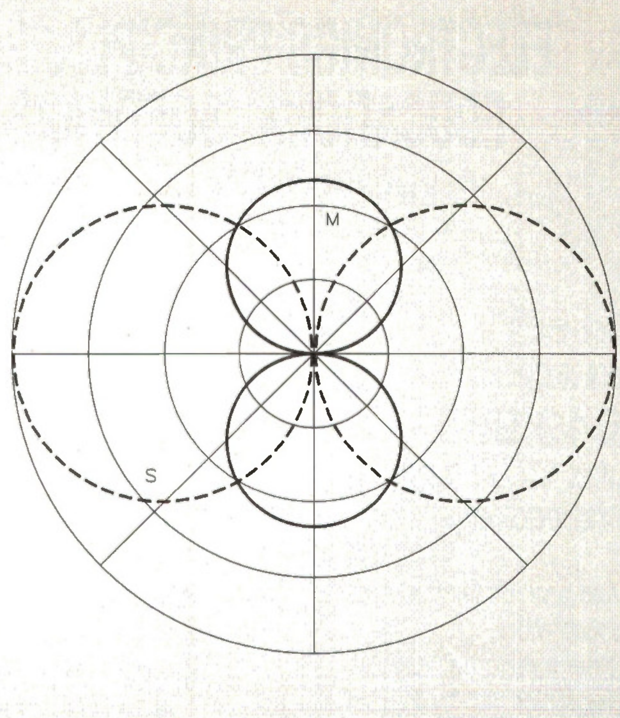


Figure 8a. Directional response patterns of three cardioid microphones arranged for surround-sound recording using MS techniques.

Figure 8b. Difference responses obtained from the array of Figure 8a.

$\cos\Theta = -1$ gives $\Theta = 180°$, while $\cos\Theta = -3/5$ gives $\Theta = 126{\cdot}9°$ according to the calculator. However, almost all of these trigonometric equations have multiple roots, and we can see from Figure 4 that $\Theta = 180° + 126{\cdot}9° = 306{\cdot}9°$ (or $360° - 306{\cdot}9° = -53{\cdot}1°$). These values of Θ are the angles from the 0° direction (twelve o'clock), whereas we want the angles from the direction of maximum response, which we found above to be at 63·4°, so the angles of the nulls relative to this are 180° −63·4° = 116·6° and 306·9° −63·4° = 243·5°. There is a slight 'rounding error' here, due to using only one decimal place: the two angles should, by symmetry, add to 360°. We take the smaller null angle to classify the hypercardioid, so 116·6° is the answer we want. Our hypercardioid is the one which has nulls at ±116·6°. Other interesting varieties have nulls at 110°, 126° (the genuine 'supercardioid') and 135°.

Using Cardioid Microphones

If we use two true cardioid microphones inclined at 60° (120° included angle), whose directional response equations are:

$$C = \frac{1}{2} + \frac{1}{2}\cos\left(\Theta \pm \frac{\pi}{6}\right)$$

instead of hypercardioids, we get an S-signal with the correct directional response but a 1·25dB reduced level (ratio $\sqrt{3/2}$):

$$S = \frac{1}{2}\cos\left(\Theta + \frac{\pi}{2}\right) - \frac{1}{2}\cos\left(\Theta - \frac{\pi}{6}\right)$$

which we can compensate in the amplifier, while the M-signal response:

$$M = 1 + \frac{1}{2}\cos\left(\Theta + \frac{\pi}{2}\right) + \frac{1}{2}\cos\left(\Theta - \frac{\pi}{6}\right)$$

is increased in level by 3·5dB (ratio 3/2) and the directional response shape is acceptable in the forward direction but it has only a 10dB (ratio 3) front-to-back ratio. Any sounds to the rear of the microphones would thus be recorded too prominently, but often there would be no such sounds (or perhaps no *wanted* sounds!). Setting the axes at 90° improves the front-to-back ratio a little, at the expense of an even smaller S signal. If the microphones are positioned back-to-back (180° included angle), the combination is equivalent to an omnidirectional M-microphone equal in output to the lemniscate S-microphone. This means that sounds all round are recorded, but there is complete confusion between front and rear sounds, these points being illustrated in Figures 5a and 5b. In any case, the directional characteristics of real microphones only approximate to the theoretical curves, so there is no point in being very pedantic. Make some recordings, and do not be put off from experimenting with the relative gains of the M- and S-channels. The maximum useful difference is about 10dB: if it is greater, the low-gain channel contributes only a very subtle effect. Note that the microphones should be as close together as possible, which can be achieved as shown in Figure 6.

Surround Sound Recording

In order to record sounds all around without creating front-to-back confusion, the M-microphone has to produce signals from rear sounds which are in opposite polarity (inverted) to those from front signals. This means that the M-microphone, as well as the S-microphone, has to have a lemniscate directional response. Unfortunately, we cannot simulate a crossed pair of lemniscate microphones (so-called Blumlein coincident pair, from his later work when he had such microphones available) by any combination of two other types of microphone. This can be seen from the directional response equations:

$$M = \cos\Theta$$

$$S = \sin\Theta$$

No (linear) combination of these can produce the constant term (independent of Θ) which appears in both the omnidirectional and cardioid responses:

$$\text{omni} = 1$$

$$\text{card} = \frac{1}{2}(1 + \cos\Theta)$$

However, if we use *three* identical cardioid microphones, spaced around a circle so that the angles referred to the forward direction are −60°, 60° and 120° as in Figure 7, the difference signals between the one at 60° and the other two represent the responses of two crossed lemniscates with axes at 0° (the M-channel) and 90° (the S-channel), which is exactly what we want (see Figures 8a and 8b). There is a gain difference: the S-channel is 1·25dB down (relative to the sensitivity of the individual microphones), while the M-channel is 6dB down. This can easily be corrected in the microphone amplifiers. We do not use the sum signals at all in this case. I have not found this idea mentioned elsewhere, but I expect it has been used already.

Microphone Matching

Using identical microphones and Σ-Δ circuits, we eliminate all the problems of trying to match the characteristics of a cardioid and a lemniscate microphone. This is also the case for double-diaphragm capacitor microphones, but these are very costly.

The Σ-Δ circuit in Figure 1 is perhaps too noisy to use directly at microphone signal level, and is best included after the microphone amplifiers or mixer. One or more of these could even be built into a DIY mixer or an external FX box to be fed from cue or echo outputs.

Next Time

Next month, in Part 2 we examine the implications of MS techniques for loudspeaker design and also signal processing circuits for direct MS reproduction, mainly at the practical level.

@Internet

One of the main worries stated by those not in the know when asked about the Internet, is that they do not understand how to get started. This, as it happens, is a truly valid fear brought about in the main by loads of unnecessary jargon and considerable numbers of existing cliquish users. It is rather like life in general, really – loads of computer nerds huddled together at parties, talking about bits, bytes, bauds and bugs while the rest of us like to circulate and chat about barbecues, boats, bills, and books.

While nobody doubts how the Internet is going to affect us over the next few years though, this 'technophobia' is going to hamper its good effects until the net becomes easier to get into. Sure, well-written software like World Wide Web browsers make 'net-life' a little bit easier, but you still have to have a certain knowledge of computers and computing terms, and you still have to take for granted the myriads of unexplained acronyms (url, http, html) along with the archaic Unix-based addressing system. After all, computers are meant to make things easier for us, not more complex. We can not even easily come to terms with a simple telephone number change (phONEday for example), let alone battle our way through a sentence-long World Wide Web url address with all its slashes and points.

Food for thought all you Internet software developers.

TCP/IP

One of those unexplained acronyms mentioned above is TCP/IP. We looked at it back in January, but it is time for a closer peep. TCP/IP stands for *transmission control protocol/Internet protocol*. Not a lot of people know that. Trouble is, knowing what the acronym stands for does not really help us to understand it.

A history lesson should help, though. TCP/IP was developed by the US Defense Advanced Research Projects Agency (DARPA), for the Advanced Research Projects Agency Network (ARPANET) – I didn't say we didn't have to wade through even *more* acronyms, did I? Initially, when the network commenced, a single protocol was envisaged. In simple terms, a protocol is a definition of the signals and controls passing between computers as they communicate. If no protocol exists, there may be a time when both computers are waiting for the other to send a signal, and there may be another time when both computers are sending signals.

A protocol merely lays down the rules by which each computer knows it has to listen for signals *from* the other computer, or can send signals to the other computer. It is rather like (although a lot more complicated than) communicating via ham radio with all its 'Over' and 'Over and out' etiquettes – which if you think about it are protocols by another name.

In 1969, when the ARPANET project commenced, it was assumed that everything could be handled by a single protocol (in those days known as the *network control protocol* – NCP). By splitting up all data between the two computers in a communication link into packets, labelling each packet, and shipping it off to the other computer in a controlled manner, everything should be 'hunky dory'.

However, as ARPANET grew, it rapidly became obvious that the protocol to govern communications had to do *two* things, not just one. Hence the slashed split in the TCP/IP name. TCP governs the physical connections of the communications, ensuring each packet of communications actually gets to the computer at the far end of the link and telling each computer what to do with the received packets, while IP simply governs the end-to-end communications. It is the same as getting in touch with someone on the 'phone. Dialling the other person's number is rather like the TCP bit of TCP/IP; tones going down the line tell the exchange and the network where to route the call to. The IP analogy is apparent once you are connected and chatting – you do not need to think about the connection again, you just talk.

Every main access point to the Internet is called a node. Each node has an address which is usually given as four decimal numbers separated by dots (say, 123.45.67.890). These numbers represent a 32-bit binary number, used by the TCP/IP protocol to locate the node on the Internet. It works much like a telephone number does to identify any telephone throughout the world. Interestingly, much like the reason for phONEday (mentioned above), Internet addresses are about to change shortly, simply because there are no longer sufficient addresses to cope with the demand for required nodes. As a result, the 64-bit SIP (simple IP) protocol will be used. This is totally backwards-compatible though, and will not affect existing addresses at all (unlike the phONEday telephone number changes).

Sony Online

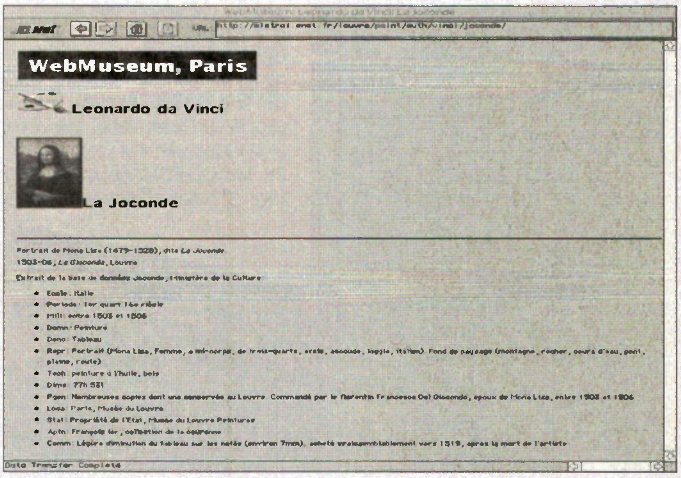
Sony has launched Sony Online, bringing together a number of new and existing online activities of Sony subsidiaries in one site on the Internet's World Wide Web. Accessible at **http://www.sony.com** on the Web, Sony Online combines online services from Sony Music Entertainment, Sony Electronics, Sony Pictures Entertainment, Sony Electronic Publishing, Sony Signatures, and Sony Retail Entertainment. The service is available worldwide to anyone with access to the Web. In its area on Sony Online, Sony Music Entertainment provides blurbs on artists who record with the label, news of albums and tours, and sound and video clips. In another area, Sony Electronics has an online catalogue of more than 300 of its products, with technical specifications and prices. The Sony Theatres area includes an introduction to the company's Sony Theatres Lincoln Square complex in New York, information about other facilities such as the Sony Imax theatre, and a state-by-state listing of theatre locations. Sony Electronic Publishing offers samples of current and upcoming software and video game releases, while Sony Pictures Entertainment has highlights of films from Columbia Pictures, TriStar Pictures, Sony Pictures Classics, and Triumph Films. Besides the Internet offering, Sony said it hopes eventually to offer Sony Online through commercial computer networks. The company hopes to begin this in the Autumn, adding some premium services for an extra charge, which is not easy to do on the Web today.

Surf into Top Gear

The BBC's motor sport magazine, *Top Gear*, is giving Internet users the chance to run their own Formula One team, by holding the Fantasy Formula One game for a second year. World Wide Web users are each given a budget of £30 million to buy two drivers and cars. Each week, throughout the season, the results of the real races are fed into computers which calculate the leaders of the parallel virtual season. Last year, more than 20,000 users played the game through coupons printed in the magazine. That number is set to soar this year as the game goes global on the Internet. Competitors in the UK and Ireland can register their teams to compete for prizes that range from a model of a Formula One car to a weekend at the Monaco Grand Prix. Users in other countries are unable to compete for prizes but the magazine is encouraging them all to take part. Weekly updates of the competition will be available on the Web. To take part in Fantasy Formula One on the Web, go to: **http://www.bbcnc.org.uk/bbctv/topgear_mag/fantasy.html.**

Site Survey
– the month's destination

Once again, we have been surfing the net to see what is of interest out there. Art lovers among our readers should appreciate this little gem – a museum archive, with details of quite a few museums (mostly French) including complete tours and specific information of individual artists and indeed paintings in 'down-loadable' form. The one we have chosen should bring a smile to your face (there is a joke in there somewhere!). **http://mistral.enst.fr/louvre/paint/auth/vinci/joconde/**



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CLUB CORNER

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CRYSTAL PALACE & DISTRICT RADIO CLUB. Meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. For further details, contact: Wilf Taylor, (G3DSC). Tel: (0181) 699 5732.

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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.

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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.

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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.

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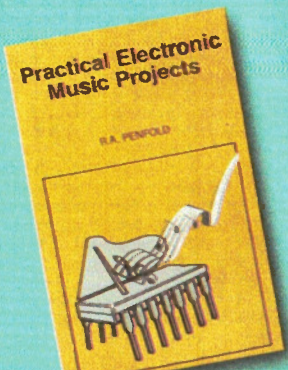


Practical Electronic Music Projects

by R. A. Penfold

Music related projects have consistently proved popular with the electronics constructor. This is not surprising, since many electronic music projects can be built for much less than the commercial equivalent. In many instances, there is often no ready-made equivalent. At one time music projects usually meant simple effects units and amplifiers, it is now possible to build a wide variety of music related projects.

This handy book provides a number of circuits for electronic music projects of various types, including guitar effects units, and other guitar related projects, as well as general projects such as metronomes, audio mixers and preamplifiers. The final chapters describe several MIDI related projects including MIDI testers, a MIDI pedal, noise gates and a THRU box. The circuits cover a wide range of complexities but are not beyond the average electronics constructor. As with other projects books from this author, the circuits are based on relatively inexpensive, and readily available components.

130

1994. 178 × 113mm. ***Order As AN33L (Pract Elec Music Pjt) £4.95 NV***

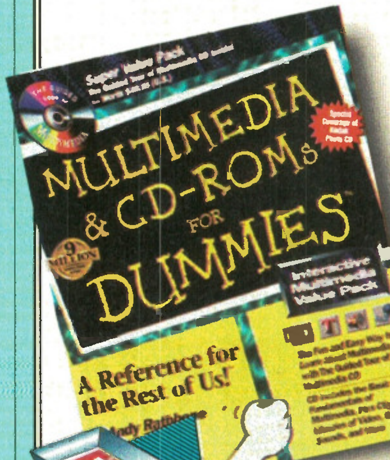
MULITIMEDIA & CD-ROMs FOR DUMMIES

by Andy Rathbone

For many years, computers and sound did not mix – in fact, sound often signalled an impending catastrophe! However, with todays new multimedia computers, sound has taken on a whole new meaning, adding a refreshing novelty to computing. All aspects of multimedia are discussed in an enjoyable and amusing way that has become a hallmark of the 'Dummy' series of books, so making them international bestsellers. From the basics to selecting a sound card; installing cards and CD players; adding sound and video to Windows; putting photographs and films on your computer are all discussed with the usual style. Additionally, budding musicians can discover how to set up an inexpensive recording studio in their garage. Children and adults can find out how to make the ultimate games machine, and business people can learn about computerised presentations.

Included with this volume is a CD-ROM, *The Guided Tour of Multimedia*, the first CD-ROM that uses multimedia to teach multimedia. It contains over 20 hours of interactive multimedia information for both beginners and professionals. You will learn to capture/playback video, add music and voice overs, add animations and lots more.

Multimedia is more than just a sound card and two speakers, and this exciting multimedia pack will help you work out what equipment is needed, how to install it, and most importantly, how to make it all work together.



1994. 232 × 188mm, ***Order As AN26D (M/M & CD-ROM/ Dummies) £28.99 Includes CD-ROM***

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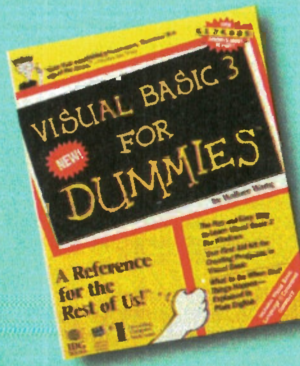
Visual Basic 3 For Dummies

by Wallace Wang

Microsoft's Visual Basic has been around for over four years, and is now the leading choice for programmers working in the Windows environment than any other development language. Microsoft have made Visual Basic the cornerstone of Windows programming. Within the near future the Visual Basic language will be embedded in all of Microsoft's major Windows applications.

For those who have tried programming and found it to complicated, Visual Basic may well be the answer. Written in plain English, this book provides interesting programming trivia, example programs and step-by-step instructions for writing programs in Visual Basic. Programming does not have to be difficult, and can actually be fun, which is the style in which this book is written. Visual Basic is not hard to learn, but it can be difficult to remember all the petty details needed to write useful programs. This book will show you all the steps needed to write a Visual Basic program, and give you all the confidence to do it without the need for technical details and elaborate explanations. You will learn the fundamentals of writing Basic code; the crucial differences between Visual Basic and other languages; to design a user interface; to write subprograms; how your program can retrieve data from a user interface, and much more.



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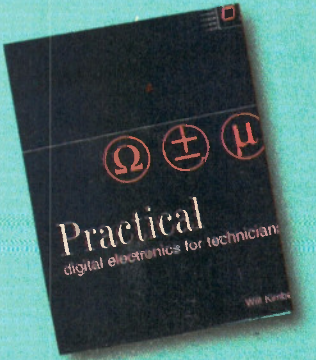

Practical Digital Electronics for Technicians

by Will Kimber

For engineers, for whom 'practice' is a way of life, the current emphasis on coursework seems an obvious and natural feature of effective training. With this in mind, this book gives an explanation of the basic theory of digital techniques reinforced by 40 practical exercises. These exercises can be carried out with equipment that is normally readily available in education departments running electronics courses. The book is primarily aimed at students studying for BTEC Electronics at levels NII/NIII, but it will also be applicable to those students studying the optional Electronics unit of the GNVQ in engineering at intermediate and advanced levels. The exercises are layed out in a 'cookbook' style, and are intended to provide the opportunity to become familiar with a wide range of digital integrated circuits, and to gain a thorough understanding of the way digital systems work.

The text is liberally scattered with questions and (where appropriate) answers, some of which require further research and reading.

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Photograph shows fully assembled Newton preamplifier with tone controls and optional switches. The Newton preamplifier is not available ready built. The kits listed are rated 4 (Advanced) on the 1 to 5 Maplin Construction Rating Scale.

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