# ELEKTOR ELECTRONICS

THE ELECTRONICS & COMPUTER MAGAZINE

DECEMBER 1997

£ 4·50

AUTOMOBILE NAVIGATION SYSTEMS

## EXTRA HI-FI LOUDSPEAKERS


## HANDYMAN: POCKET-SIZE CONTROLLER

## SMART-CARD READER/WRITER

## SIMPLE COPYBIT KILLER

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***We wish to thank all our readers for their continued support during the past year and wish you all a happy and peaceful 1998.***

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## IS MDF DANGEROUS?

A group of scientists has issued a warning that people working with medium-density fibreboard (MDF) are at risk since the material, or rather the glue sticking the various layers together, is a potential source of cancer. The Department of Health has started an investigation into the claim. Manufacturers of MDF say that there is no danger as long as operators observe proper safety procedures and working practices.

## DVD RIVAL?

In a joint venture, an American electrical retailer and a law firm are planning to launch a rival to the existing digital video disk (DVD), called Divx. The joint venture is being opposed by video rental companies which fear the new disk will confuse customers and that consequently retailers will lose money.

However, the new system has won support from the big film companies because of the alleged sophisticated encryption coding and the lower price. It is expected that more than 100 film titles will become available within a year of the launch.

Fortunately for consumers, the Divx equipped player (said to be already in production with Matshushita, Thomson and Zenith) will also play standard disks.

## DIGITAL BROADCASTING GLOBAL SUMMIT

The Digital Broadcasting – Global Summit 1997, which follows on the success of the Global Digital Television Strategies 1996, is to be held in the Regents Park Marriott Hotel, London, on 10–12 December. Details from Customer Service Manager, IIR Ltd, 6th Floor, 29 Bressenden Place, London SW1E 5DR; telephone +44 (0)171 915 5055; fax +44 (0)171 915 5056.

## SPREADING THE SCIENCE MESSAGE

Nearly half a million pounds sterling is to be spent over the next year in a bid to raise public interest and awareness of science. Launching a campaign to make scientific, engineering and technology (SET) topics more accessible and understandable, the UK's Minister for Science, John Battle, said: "I have a vision of a society where science and engineering are valued as part of our culture and given the recognition they deserve. In particular, it is vital that everyone realizes that we rely on SET to deliver improvements in the quality of life and sustain a healthy economy."

To achieve his aim, Mr Battle has granted nearly £150,000 to the British Association to stage next year's Science, Engineering and Technology Week. His department is allocation £325,000 to the Committee on Public Understanding of Science to promote interest in a variety of scientific and engineering ideas as well as funding a three-year survey to monitor a series of public understanding measures that are being developed.

The minister's public awareness campaign will also encourage greater cooperation between scientific research organizations, enabling them to share their experience and resources in creative alliances.

"The success of our campaign for public understanding will depend in part on the promotion of mutual understanding between the scientific and non-scientific communities, the experts and the wider public," he added.

"We also need to question whether we can make better use of the Internet, whether we can improve school networks or need to develop new ones and where we should be organizing debates or promoting new schemes." The Minister's Office of Science and Technology has just issued a new edition of *Science Connections* that lists over 40 organizations active in the public information field.

Further information from the Office of Science and Technology, Albany House, 94–98 Petty France, London SW1H 9ST. Telephone +44 (0)171 271 2120; fax +44 (0)171 271 2016.

## ONLINE INFORMATION 97

This year's Online Information conference will be held at the National Hall & Olympia Conference Centre, London, on 9–11 December.

Details from Learned Information Europe Ltd, Woodside, Hinksey Hill, Oxford OX1 5BE. Phone +44 (0)1865 388000; fax +44 (0)1865 736354.

## BOOTS' SMART CARD

UK high street chemists, Boots, has announced the nationwide roll-out of a loyalty card scheme using smart credit cards in cooperation with technology company AT&T.

Eight million customers are expected to join in the first year, creating one of Europe's largest loyalty programmes. Te Boots Advantage Card will make Boots the first high-street retailer to use smart-card technology in a loyalty programme.

Each card will have a microchip that will allow the holder to use the card instantly to collect and redeem points against purchases. The microchip embedded in the plastic is quicker to process than magnetic stripe cards when redeeming points.

AT&T contributes customer application processing, a customer service centre, a managed network to transport information into the loyalty scheme operation centre, as well as the supply of the Loyalty Scheme Operational System. The system will have the capacity in the first year for processing up to 150,000 card applications in a single day, and is likely to generate 0.7 Terabyte of data.

Boots the Chemist, 1 Thane Road, Nottingham NG3 3AA. Phone +44 (0)115 950 6111; Internet http://www.boots.co.uk

## WIDENING THE NET WITH TV ACCESS

Internet awareness is reaching saturation point but although 91 per cent of UK households are aware of the Internet, only 17 per cent have ever used it. These are some of the findings of the latest Durlacher and BT quarterly Internet market report.

It seems that it is people in the higher income bracket who have the higher level of awareness and people who use Teletext regularly were also found to be more Internet-friendly. But the more television people actually watch, the less likely they are to know about the Internet (or 'Net'). Over half of cable TV subscribers claim to have a poor knowledge of the Net (61 per cent) with a similar figure of 58 per cent for satellite.

The survey was carried out among 2000 households to determine the level of Internet awareness in the residential sector and to find out how involved it has become in everyday life. Integration with TV may be the next step towards widespread usage in the home. Access to the Net from home is generally via a modem connected to a computer. Consumers still attach a technology tag to the Internet and do not yet see it as an entertainment tool.

The main reason for not having an Internet connection was that it was too expensive (36 per cent), followed by 'no interest' (24 per cent). The most common types of Net activity are e-mail, web browsing and newsgroups, although there are a host of other Internet activities such as Internet Relay Chat or Internet shopping. The survey did indicate a demand in the UK residential market for goods and services bought across the Net.

Forty-eight per cent of those who have Internet access said they would buy goods and services across the Net, including five per cent who already have. The most popular product for purchase seems to be holidays, with 54 per cent willing to use to make a purchase. The next most popular is software (53 per cent) or entertainment, that is, CDs and videos (52 per cent).

The number of Internet users has now reached four million, excluding academic users, and the number of Net service providers has more than doubled, rising from 80 in September 1995 to just under 200 in June this year. Durlacher predicts the number of accounts in UK homes to reach 2.6 million by 1999.

Experts say that in order to increase the penetration of the Internet, the quality needs to improve, access speeds must increase, and more relevant content should be made available. The emphasis needs to shift from a technology focus towards a consumer market, which means that fast, immediate delivery is critical in determining its success in this market.

Durlacher website: http://www.durlacher.co.uk

## MILLENNIUM DOME GOES VIRTUAL ON THE WEB

The Greenwich Dome is being launched into cyberspace with an interactive site costing £150,000 a year on the World Wide Web. The site will contain a comprehensive guide to the 'New Millennium Experience' exhibition, from visitor information to updates on building work progress.

A Greenwich-based company, the Longitude0 Consortium, has been awarded the contract. The website is expected to be up and running soon and will include an interactive questions and answers section, games and competitions, a travel guide, and information on business and sponsors linked to the 'Experience'. It will also feature details of the Millennium Challenge, the initiative aimed at including all areas of the country in the 'Experience'. When the 'Experience' is open, the site will have time-tabled live link-ups to Greenwich allowing viewers from anywhere in the world to see what is happening there.

Rachel Mawhood of the consortium, specially put together to design the site, said: "The Experience, although physically based at Greenwich, will be available 'virtually' anywhere in the world and, as with the main Experience, the website will be the biggest, most thrilling, most entertaining and most thought-provoking site anywhere on the web."

New Millennium Experience Company Ltd, 110 Buckingham Palace Road, London SW1 9SB. Phone +44 (0)171 880 8200; fax +44 (0)171 880 2019.

Longitude0 Consortium, 10 Barley Mow Passage, London W4 4PH. Telephone +44 7000 583583; Fax +44 7000 583329

## BANK PIONEERS ELECTRONIC MONEY

A new electronic money service is being tested at BarclaySquare, one of the longest-standing British online shopping sites on the Net. Electronic money, called BarclayCoin, will soon be available at the site.

It has been developed, in conjunction with CyberCash in the USA, in response to the growing demand from Internet shoppers to make small-value purchases. BarclayCoin will allow online shoppers to purchase items between 25 pence and ten pounds sterling without using a credit card.

Shoppers will first have to download a software electronic wallet and complete a registration form which links the wallet to a Barclaycard account. Later, they can transfer money from the Barclaycard or any other card account into the electronic wallet, which in turn can be used for online shopping.

Tow of the first retailers on BarclaySquare to take advantage of this new way of retailing will be Emotion and Pooh Corner.

In addition, BarclaySquare shoppers can now get 'smart statements' which will keep for them a record of all the purchases they have made on BarclaySquare. 'Digital sales receipts' will also be provided.

Another added feature is 'digital coupons'. This allows retailers to send e-mail to their customers in which they embed a special offer, such as a 20 per cent discount on all purchases made within a specific time period.

"Internet usage in the UK is growing at a rate of between 10 and 15 per cent a month and much more is now known about what Net-using consumers and retailers expect from the virtual shopping environment," said a Barclays spokesman.

BarclaySquare website: http://www.barclaysquare.co.uk

## TRADE ON THE NET SHOULD BE VAT-FREE

The Internet in Britain should become a Value-Added-Tax-free zone to take full advantage of the expected boom in online business, according to a report from the European Media Forum.

Britain could pick up £310 million worth of business from a worldwide market expected to be worth £1.24 trillion by 2002.

The Government should take action to ensure that companies wanting to trade on the Internet are not lumbered with complex tax laws which become almost impossible to enforce in cyberspace.

The report says that the economic advantages of having online businesses based in the UK will outweigh any lost tax revenue. Taxing the Internet has become a major headache for governments worldwide in the past two year. Problems arise because it is almost impossible to apply existing tax laws to the new medium.

In the US, President Clinton has already signalled his intention not to impose taxes on the Internet – a model which Britain should copy, said the report's author, Roger Loosley, lawyer and chairman of the Computer Lawyers Consortium.

"A person establishing a business on the Internet will be tempted to base him/herself where taxes are low or non-existent. But money made on the Internet has to be spent somewhere – so, by encouraging businesses to come to Britain, the country will benefit in the long run."

European Media Forum, 20 Queen Anne's Gate, London SW1V 9AA. Telephone +44 (0)171 233 1456. E-mail: 100541.1060compuserve.com

## INFRARED CHIPS MAY LEAD TO OPTICAL COMPUTERS

Silicon chips have been induced t emit infra-red light by a team of scientists at Surrey University. The development could mean cheaper, fibre-optic communications and, eventually, optical computers.

Karen Reeson and her colleagues at the university's School of Electronic Engineering and Information Technology have achieved the light by bombarding a silicon chip with iron atoms. This crates small islands of iron disilicide in the boundary layer between the p-type conductor materials in the chip.

When subjected to an electric field across this junction, the iron disilicide behaves as a light-emitting diode, converting electrical energy to light at a wavelength of 1.5 μm, the frequency used in optical communications.

For some considerable time, scientists have been attempting to use light instead of electrons to ferry data within and between chips. By doing this, a speed increase of a factor of 10 compared with conventional electronic circuits is described by Ms Reeson as conservative. The use of light in chips would also make them less sensitive to heat and radiation.

The university researchers have already embarked on improving the implantation process and the amount of electrical energy converted to light. The prototype converts 0.1 per cent of the energy and the team hopes to reach a commercially viable two per cent by 1999.

If the Surrey team achieves its aim, the semiconductor industry will find it easy to adopt the new technique because the iron is implanted in the same way and at the same time that layers of silicon chips are built up.

Karen Reeson, Surrey University School of Electronic Engineering and Information Technology, Guildford GU2 5XH. Telephone +44 1483 300800; fax +44 1483 534139; e-mail: k.reesonsurrey.ac.uk; Internet: http://www.ee.surrey.ac.uk

## LINKING SCIENCE WITH BUSINESS

An awards scheme totalling 20 million pounds has been launched by the UK government to link science projects and industry in a bid to exploit innovative technology and find fresh export markets for British products.

The Foresight LINK awards encourage joint collaboration between scientific projects and business in identifying future needs and how developments in engineering and technology can provide further products. Some ten million pounds sterling from the Department of Trade and Industry (DTI) will be matched by a further £10.2 m investment from industry. The Foresight programme is designed t improve competitiveness of the UK economy and hopefully enhance the quality of life.

Department of Trade and Industry, 1 Victoria Street, London SW1H 0ET.Telephone +44 171 215 5000. Internet: http://www/coi.gov.uk.coi/dept/GTI/coi1005d.ok

## 'GHOSTBUSTERS' TACKLE THE SMALL SCREEN

An electronics expert at Reading University has developed a system that ends the problem of 'ghosting' on television screens. Like Shakespeare's unwanted guest at the feat, the double image on the television screen is a source of great irritation in many households. Dr Simon Sherrat of the university's Electronics Engineering Group has devised a low-cost linear filter system that, at the flick of a switch, puts to flight the alter ego of the television image.

In terrestrial television transmission, multiple paths occur from the transmitter to the receiver. Ideally, these paths are all received simultaneously by the television set, but when a path is delayed, a replica – or ghost – of the signal is received alongside the direct one. These delays are the result of th signal reflecting from static object such as tall buildings, trees and moving objects such as aircraft.

Even at the end of the 20th century, ghosting remains a great problem for television viewers in many countries. Despite numerous improvements to the television transmission system implemented to enhance picture quality, ghosting persists owing to the increase in high-rise urban areas.

The construction of the Canary Wharf Tower in East London in 1990 affected the reception of 100,000 viewers in the area. Cable television may also be affected by ghosting. The removal of double imaging is one of the few remaining practical problems to be overcome for current analogue television programmes.

The de-ghosting filter devised by Dr Sherrat works by cancelling distorted signal as they are received by the television. The device, designed to sit alongside the television set, is the first affordable one aimed at the domestic market.

Dr Simon Sherrat, Electronic Engineering Group, Reading University, Whiteknights, PO Box 227 Reading RG6 6AB. Telephone +44 118 931 8293; fax +44 118 031 0279. E-mail: s.sherratreading.ac.uk

## IMPROVED SECURITY FOR COMPACT DISCS

Pan Technology has launched a method of producing a compact disc (CD) that provides hacker-proof security against CDs being copied or software being pirated.

CopyLok prevents copying on CD recordable devices and on expensive Laser Beam Recorder machines which produce replicators, glass master and stampers for injection moulding. It allows any game or information to be loaded on to the hard disc of a computer, but will only allow that software to run if the original CD is in the CD drive. It stops friend-to-friend copying, illegal shop replication, mass replication and also prevents copying by Internet distribution.

Pan Technology could become the most popular company in the multimedia industry with the launch of this innovative technology, a proven solution to the scourge of the CD and software pirates who will cost the worldwide information technology industry over $US13bn this year.

Supporting the launch of CopyLok, some gamesware manufacturers are now claiming that up to four illegal copies are made of everything they produce, and the ultimate losers are legitimate consumers, who may be paying more than they need to support the resulting loss of revenue by manufacturers not yet using CopyLok technology.

CopyLok is the result of three years of intensive research and is the first and only anti-copying technology to have received Philips approval and a Philips patent application. Pan Technology says that during approval tests not even Microsoft have been able to hack the software on the test disc.

Pan Technology, White House, 65 Birmingham Road, Shenstone nr Litchfield WS14 0LQ. Telephone +44 1952 270 321. E-mail: metcalfpantechnology .com

## CHEAPER, FASTER NET ACCESS

Ionica, a Cambridge-based telecoms company which aims to set up a nationwide network in direct competition with BT, says its technology allows Internet users a faster and cheaper option.

The company claims that Internet users may be spending far more than necessary on connection charges and offers users advice on how to save money as they use the Net. For many, it's not personal computer or modem technology that makes the difference, but the telephone socket they use to connect.

Many PCs now come with the necessary software and modems to get users started and incentives entice connections to the Net with a particular service provider. Although modems operate fast, they can be slowed down by the maximum bandwidth of the telecoms network they send through.

Ionica says that its radio-based system offers extremely fast access because it does not rely on getting through old telephone cables installed in homes.

Ionica, St John's Innovation Centre, Cambridge CB4 4AS. Telephone +44 1223 223 223.

## INTERNET SIGNALS DOWN POWER LINES

Norweb Communications, in collaboration with the Canadian firm, Nortel, has invented a way to send Internet signals to home lines by using the mains (power) supply net and not telephone lines. Previous attempts at such a system have failed because the electricity in the cables interfered with Internet data. According to Ian Vance, chief scientist for Nortel's European division, {we have fixed the fuzz. We have patented technology that allows us to send data through the mains power cables without it being corrupted by interference from the power itself."

Users will need to install a card in their personal computers and fax a small box to their standard electricity meter to use the service. Trials are expected to start next spring in north-west England, the heartland of the company. They are expected to go on for at least six months before a wider roll-out is considered.

The company said it would concentrate on delivering the Internet through mains power cables rather than competing with telecoms companies to provide telephones. But when Internet technology allows telephone signals to be sent as Internet data, telephone applications could find their way into the new system.

Norweb Communications, Talbot Road, Manchester M16 0HQ. Telephone +44 161 873 8000.

## DOTMUSIC SIGNS ADVERTISERS

Music website dotmusic has signed advertising deals with Carlsberg, London's Capital Radio and Sony Music Europe. The site is also preparing content for an Internet Explorer 4 push channel.

Carlsberg said it wanted to promote its new C-mail (computer mail) digital postcard service solely on dotmusic. The campaign lasts a month and will deliver 150,000 page impressions.

Capital Radio is sponsoring an online Battle of the Bands contest in conjunction with the In the City music festivals. Users will be able to use LiquidAudio's high-quality sound software to listen to near-CD-quality soundclips downloaded from the site and vote online for their favourite unsigned bands.

Sony plans a month-long banner campaign to promote its new Netnoize audio show, part of the www.sonymusiceurope.com site. The ads will be delivered as 100,000 page impressions.

Meanwhile, dotmusic's IE4 channel, published by Miller Freeman, producers of *Music Week* magazine, will offer 'behind the scenes' music stories and a selection of features culled from the website.

Contact: Dotmusic website http://www.dotmusic.com

## LOYALTY CARD FOR ONLINE BOOK BUYERS

Bookpages, a UK bookshop selling over the Internet, is to start a loyalty card scheme for its customers.

In the face of mounting competition from high-street names such as Waterstones and Dillons, which are pressing ahead with their own Internet bookshops, Bookpages has decided that by rewarding customers they will retain a share of an increasingly competitive market.

One seller, the Internet Bookshop, announced earlier this year plans to float on the stock exchange. Selling books is one of the few Internet selling activities that has been shown to make money, because of the simplicity of the product and the ease of shipping it to the customer.

Students using a valid 'ac.uk' domain to send their e-mail will qualify for a special offer giving them double points.

Bookpages, Sterling House, 20 Station Road, Gerrard's Cross, Bucks SL9 8EL. Telephone: +44 1753 891 595. E-mail: infobookpages.co.uk

## INFORMATION SERVICE VIA MOBILE TELEPHONES

A service has been launched allowing people to get news, sports results, share prices and financial information sent to them via their mobile phones.

Telecoms company Cellnet will broadcast the information directly to users of digital mobile phones on its network. The information will also be available on the Cellnet website, and to anyone with an e-mail address.

Called Genie, the service will provide information provided by the Press Association, ICV, Reuters and Moneyfacts.

At first, Genie will provide financial information, such as share prices, and entertainments listings. In the coming months, additions will include football and rugby results, UK news, jobs and travel.

Cellnet, 260 Bath Road, Slough SL1 4DX. Telephone +44 1753 565 000. Internet: http://www.genie.co.uk

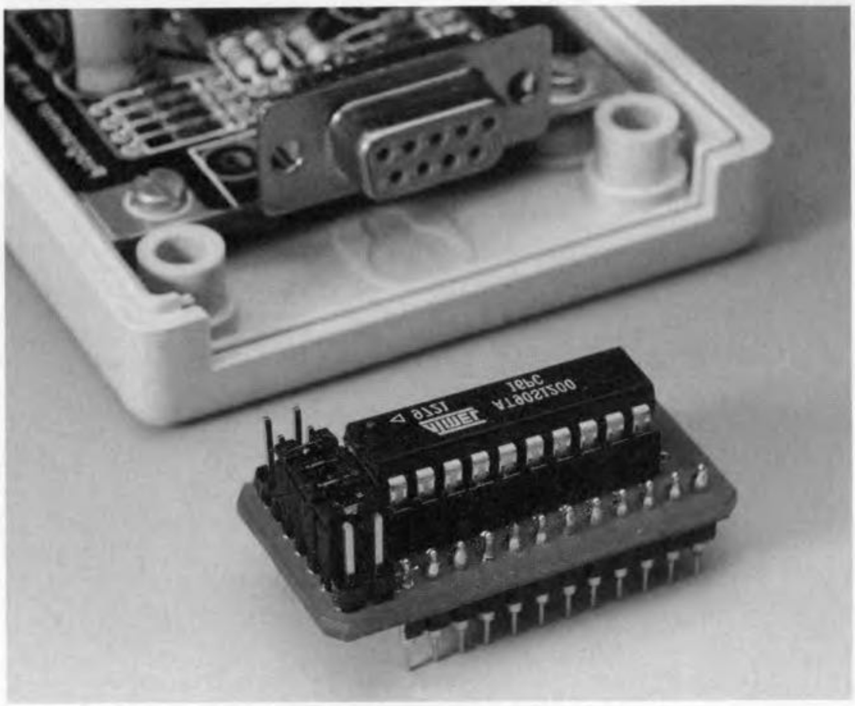
# Electronic Handyman

## *a multi-purpose RISC microcontroller system*

## *part 1*

Microcontrollers in your toaster, washing machine, the Mars Explorer or a Formula 1 race car; these beasts are literally all around us. Provided large production volumes are involved, developing a circuit board for every new application is not generally a problem, but what about one-offs and small production runs? In these cases, the Electronic Handyman comes to your rescue. Read all about a multi-purpose microcontroller module which only requires peripheral components like LEDs and pushbuttons to be hooked up to implement a powerful, versatile controller system.

By Dipl. Ing. Bernard C. Zschocke



These days, no one seriously involved in electronics, whether professionally or as a pastime, can avoid microcontroller applications. Functions which used to require complex and specially developed hardware are now performed by cheap microcontrollers running made-to-measure programs.

For simpler tasks, requiring few inputs and outputs and small application programs, a very special class of microcontrollers is available. These beasts are called RISCs (Reduced Instruction Set Controllers). They are usually capable of executing any instruction in one clock cycle, which results in highly efficient and very fast program execution. A very welcome side effect of RISC processing is a low energy requirement. In other words, RISCs are marked by pretty high MIPS/mW specifications. Further boons include 'narrow' internal 8-bit structures and few I/O connections, which allow many RISC controllers to be housed in space-saving enclosures with 'just' 20 or 40 pins. The market leader in this field is Microchip with its PIC processors which many of you will be familiar with from many projects and courses published in *Elektor Electronics* magazine and spin-off books.

Atmel's new AVR microcontrollers are aimed at increasing the product diversity in the market segment dominated by Microchip. AVR chips are fully equipped to do so: 1 MIPS for every MHz of clock frequency, no accumulator but register-to-register arithmetic, internal program memory in Flash technology with 1000 programming cycles guaranteed, an internal EEPROM with 100,000 write cycles, SRAM added depending on the exact AVR type, and an interrupt structure even in the simplest version (the AT90S1200 as used in the Electronic Handyman). By the way, AVR does not mean anything, *it's just a name*, according to Atmel.

### In-system programming with a question mark

Like many of its competitors in the semiconductor industry, Atmel claims that their microcontrollers can be pro-

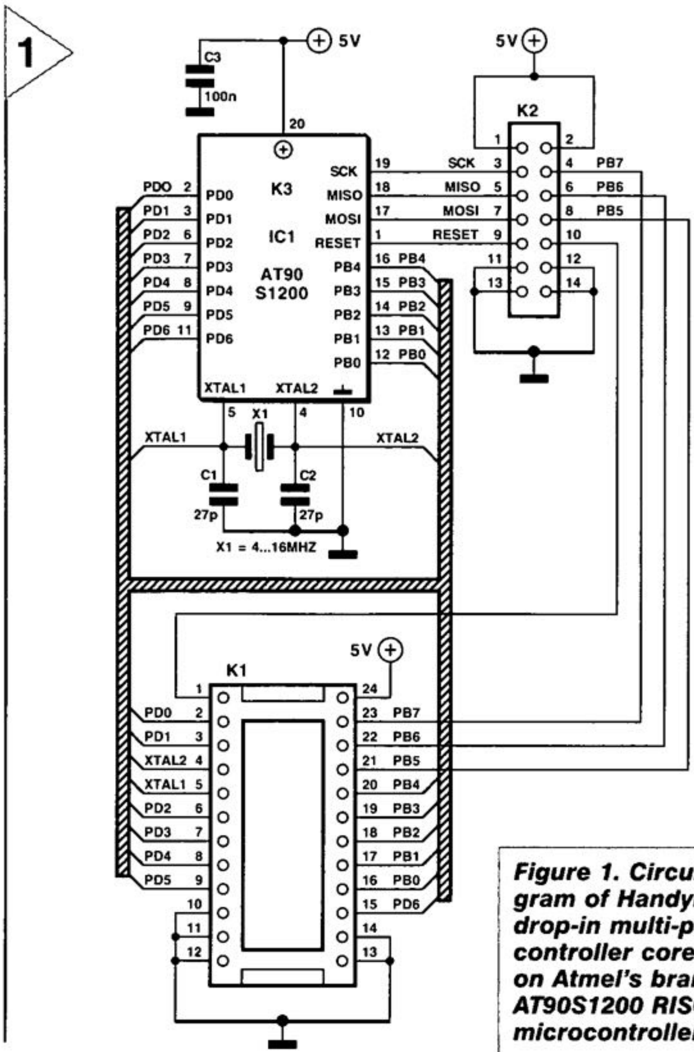



**Figure 1. Circuit diagram of Handyman, a drop-in multi-purpose controller core based on Atmel's brand new AT90S1200 RISC microcontroller.**

grammed *in-circuit* by way of a three-wire interface, plus a control at the reset input. Of course, any component is, in principle, programmable in-circuit, as long as the peripheral circuitry is effectively disconnected and/or properly protected. In many cases, however, the effort that goes into providing full protection may not be justified.

Here, this problem is solved by means of a trick. As you will probably know, pinheaders (and their plastic-encapsulated counterparts called box-headers) have the same pin distance as jumpers. In this way, it is possible to configure the pinheader in such a way that jumpers either establish the links between the circuit and the connections needed for programming, or break the links when the device is to be programmed by way of a flatcable.

Apart from the RISC processor itself, you only need a quartz crystal, two 27-pF parallel-load capacitors and a 0.1-$\mu$F decoupling capacitor on the supply line to build your first Electronic Handyman. The parts may be found back in the circuit diagram shown in **Figure 1**. The C1-C2 series combination acts as the parallel load capacitance required to make quartz crystal X1 oscillate. C3 is the supply decoupling capacitor, and K2 the pinheader via which the programming takes place. In normal use, jumpers take the relevant four lines identified as SCK, MISO, MOSI and RESET to DIP connector K1. In this way, all connections of the AVR controller are available to the application connected via the 24-way DIP header. In addition, no fewer than five ground connections are available (which you will come to value when building experimental circuits using the Electronic Handyman). Only one of these has to be connected, though.

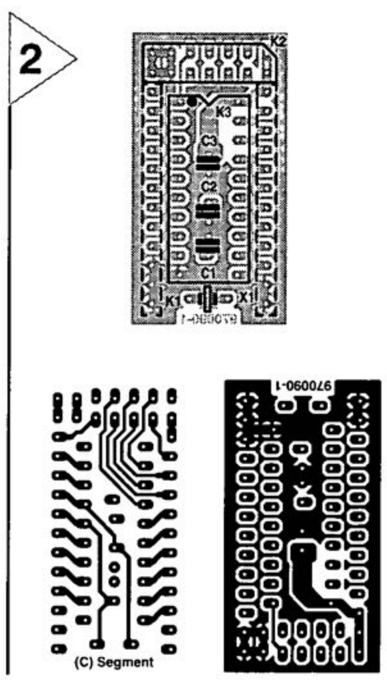
## A SMALL BOARD

Although a single-sided board would have offered ample space for the Electronic Handyman, a double-sided board is used for EMC compliance, and to ensure a low-impedance ground path. The artwork of the PCB is shown in **Figure 2**. Construction is simple provided all components have the appropriate dimensions. Start by mounting and soldering the capacitors with a 0.1-inch (2.5 mm) lead distance. The maximum height of these caps is 5 mm. Next, mount the IC socket, which consists of two 10-way socket strips. If the capacitors do not fit, they have to be mounted at the underside of the board. Proceed by mounting the 14-way pinheader, K2, onto the board. Then follow the two 12-way pin strips which form K1. The short sides of the pins are inserted from the underside of the board, and then fixed by soldering (carefully). The quartz crystal is the last component to be fitted on the shuttle board.

## HANDYMAN PLAYS DICE!

Before discussing the programming aspects of the AT90S1200 controller in next month's magazine, a small example is given showing how the Handyman can be programmed to function as an electronic dice. A port pin may

**Figure 2. Artwork of the Handyman PCB (board available ready-made).**




**COMPONENTS LIST**

**Capacitors:**
C1,C2 = 27pF
C3 = 100pF

**Semiconductor:**
IC1 = AT90S1200-P

**Miscellaneous:**
X1 = quartz crystal, 4 to 12 MHz, low profile
K1 = 2 off 12-way IC socket strip, turned pins, pin diameter <0.5 mm
K2 = 14-way pinheader
K3 = 2 off 10-way socket strip
PCB 970090-1
Note: PCBs 970090-1 (Handyman shuttle), 970090-2 (Handyman docking programmer) and disk 976017-1 are also available as a package under order code **970090-C**.

# 1997 Microprocessor Design Contest

# Results Overview

*The Contest we launched in this year's July/August 1997 issue resulted in far more entries and prizes than we had expected. After quite a bit of paperwork, five evaluation rounds and more heated debates, the members of the Jury are now able to clear their desks, sit back in admiration of some of the designs, smile and arrange for the prizes to be sent to the respective winners. Is your name on this page, too? Congratulations!*

## International First Prize winner

The Jury has unanimously awarded the **International First Prize**, a complete PIC Development system worth £2310 and donated by Arizona Microchip (France/USA), to **Laurent Lamesch** of Luxembourg for his superb design of an **IC Tester**. This design will be described (in outline) in next month's 16-page Supplement.

## National Prize winners

Winners of prizes sponsored by advertisers in *Elektor Electronics*, and the Publishers themselves, are shown below in tabular form. All winners have been advised personally of their prize.

## Let's see those designs!

A selection of prize-winning Contest entries will be published (in condensed form) in the 16-page Supplement inside the January 1998 issue of *Elektor Electronics*. This will include entries from France, Germany, The Netherlands and the UK. As promised in the article outlining the Contest rules (July/August 1997), **all prize-winning entries** will be packed (integrally and 'as received') on a **compilation CD-ROM** which we hope to have available for you by the end of January 1998. Moreover, some of the Contest entries, we feel, are so good that they will undergo the usual prototype construction and test procedures in our design lab. In this way, they are turned into full-blown projects for publication in future issues of Elektor Electronics, complete with PCBs and software items you can buy. The IC Tester is certainly among these projects, so stay tuned! (975109-1)

**National Prize Winners**

| Prize | Description | Name | Project |
|---|---|---|---|
| 1 | Number One Systems Software suite | Ben de Waal | PIC on the rocks |
| 2 | Proteus IV (Labcenter Electronics) | Ricardo Rocca | Penelope robot |
| 3 | 680X0 ANSI C Compiler (Crossware Electronics) | Alberto Ricci Bitti | Video DVM |
| 4 | ADC-200 (Pico Technology) | Tony Kemp | Simple programmable controller |
| 5 | Electronic Workbench 5 (Robinson Marshall) | A.V. Som O'Neil | 8031 BASIC compiler with macro assembler |
| 6 | 80C537 Microcontroller kit (C-I Electronics) | John Kokkoris | Digital PLL synthesizer 1-200 MHz |
| 7 | Edwin NC software (Swift Designs) | Chistopher Morris | The AVRC parallel programmer |
| 8 | Micro-ISP programming system (Equinox Technologies) | Panagiotis Tsironis | Stepper motor controller using the PIC16c54 |
| 9 | AVR Starter System (Equinox Technologies) | Jan Szymanski | PIC based indicator board |
| 10 | ADC43 PC based oscilloscope (Pico Technology) | M. Alexandre Wistainer | Using the Net for remote experiments with 8052AH-BASIC |
| 11 | CH-19 autoranging DMM (Cirkit Distribution) | Anthony Williams | ACE7102D mains monitor/genset controller |
| 12(1) | Book/subscription/CD-ROM (Elektor) | Robert Kiss | Intelligent stepper motor controller |
| 12(2) | Book/subscription/CD-ROM (Elektor) | Agelos Dimitriadis | Central heating consumption timekeeper |
| 12(3) | Book/subscription/CD-ROM (Elektor) | Peter Friend & Gareth Evans | Five function bike light |
| 12(4) | Book/subscription/CD-ROM (Elektor) | Nicos Chalikias | CNC machine interface |
| 12(5) | Book/subscription/CD-ROM (Elektor) | Hayssam Serhan | Billboard project |
| 12(6) | Book/subscription/CD-ROM (Elektor) | Gordon Serff | Motorised security gate controller |
| 12(7) | Book/subscription/CD-ROM (Elektor) | L. Kok Keong | 6809 based security system |
| 12(8) | Book/subscription/CD-ROM (Elektor) | Andrew Early | Safety interlocked rocket launching system |
| 12(9) | Book/subscription/CD-ROM (Elektor) | Anthony Williams | Electric gate controller |
| 12(10) | Book/subscription/CD-ROM (Elektor) | Watchara Chantang | SB-31 single-board microcontroller |
| 12(11) | Book/subscription/CD-ROM (Elektor) | M. Hewitt | Ignition system |
| 12(12) | Book/subscription/CD-ROM (Elektor) | Cheang Tak Meng | Microcontroller based MOSFET variable PSU |
| 12(13) | Book/subscription/CD-ROM (Elektor) | Frank Martin | BCD indicator |
| 12(14) | Book/subscription/CD-ROM (Elektor) | Dusko Lolic | DD51 |
| 12(15) | Book/subscription/CD-ROM (Elektor) | Jeremy Crook | Z80 interactive disassembler V1.0 |

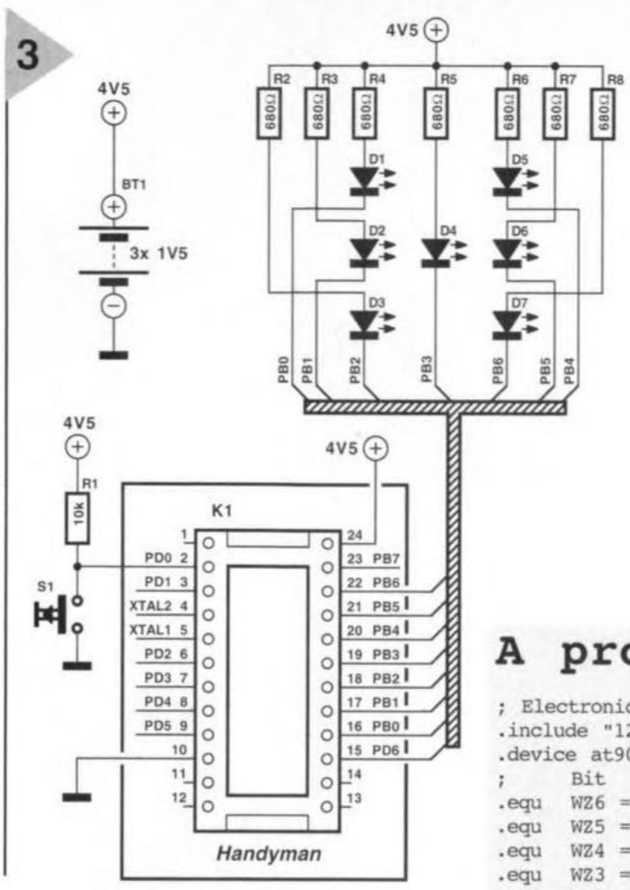



**Figure 3. Example application: Handyman rolls the dice.**

be an input or an output. To establish the function, each port has a Direction register called DDRx, where x stands for the port number. A port pin is read using the instruction **PINx**, while **PORTx** writes to the port. After a reset, all port pins are inputs by default. A 1 at the bit position in the DDRx register switches the corresponding port bit (pin) to output mode. If a pin functions as an input, and a 1 is written into PORTx, an internal pull-up resistor is switched. In our example, an external pull-up resistor is provided. The LEDs that mimic the dots on the sides (faces) of the dice, and the switches, are connected to the Electronic Handyman as illustrated in **Figure 3**. It should be noted that the total current consumption of the LEDs may not exceed 80 mA.

To start with, the instruction **.EQU** is used to define the constants that represent the six faces of the dice (WZ1 through WZ6). To make a LED light, the controller has to output a logic 0. WZa serves to determine the state of the output pins. The argument **key** is used to identify the port pin to which the push-button is connected. The dice faces are constantly sent to variable Dice_Reg (**ldi Dice_Reg, WZ1**, where ldi means *load immediate, load constant*). The instruction to copy the dice face to the port (out **PORTB, Dice_Reg**) is skipped (**sbis PIND, key**, where sbis means *skip if bit is set*) until the switch is pressed (= 0). To ensure that the degree of randomness is the same for all faces (sides) of the dice, relative jumps are made (rjmp) between face images. At the start of the program, in the RESET section, port B is switched to output, and all LEDs are switched off. The inset shows the generic output format required by the AT90S1200 programmer to be described in next month's follow-up article. The Electronic Handyman rolls the virtual dice until you press the switch. When the switch is released, the last face (dice side) is displayed by the LEDs. (970090-1)

***On-line support***

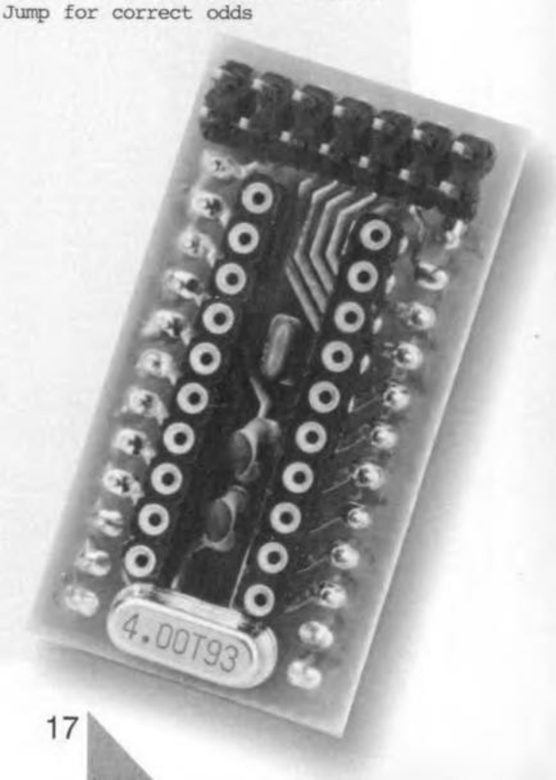
*The author has set up an Internet address to enable users of the Handyman and the docking programmer to communicate practical experience as well as solve problems. The URL is*

***http://www.zschocke.com/handyman***

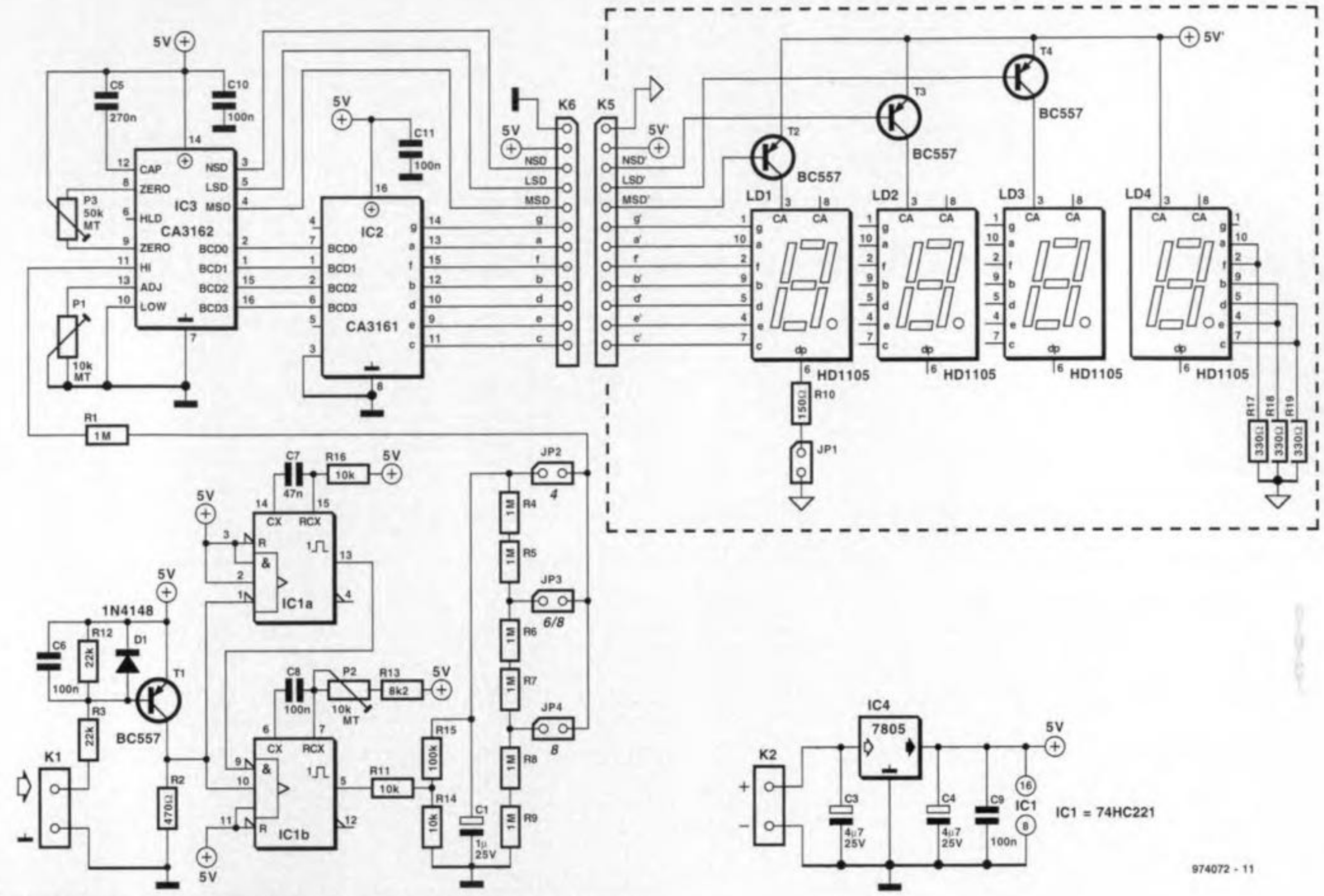
*Electronic Handyman is a registered trademark.*

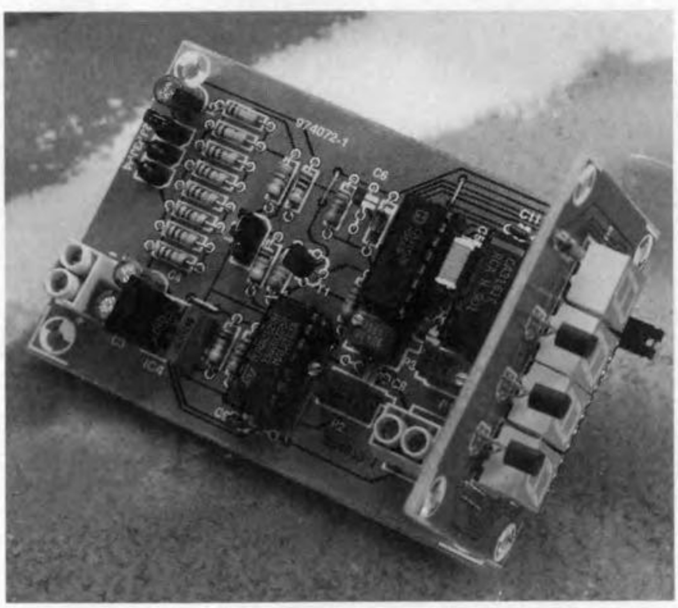
# A programming example

```
; Electronic dice
.include "1200def.inc"
.device at90s1200
;       Bit      76543210
.equ    WZ6 = 0b10001000
.equ    WZ5 = 0b10100010
.equ    WZ4 = 0b10101010
.equ    WZ3 = 0b11100011
.equ    WZ2 = 0b10111110
.equ    WZ1 = 0b11110111
.equ    WZa = 0b01111111              ; All LEDs
.equ    key = 0x00                    ; Key on Port-Bit 0 from Port D
.def    Dice_Reg = r17                ; Register for dice faces
.def    Temp = r16                    ; Register to switch Port as Output

; ***** Init after RESET *****
RESET:
        ldi Temp, Wza                 ; Switch Port B as Output
        out DDRB, Temp
        ldi Temp, 0xFF                ; All LEDs off
        out PortB,Temp

; ***** repeat loop endlessly, show if key is pressed.
Loop:

LD6:    ldi Dice_Reg, WZ6             ; show '6'
        sbis PIND,key                 ; Skip if key is not pressed
              out PORTB,Dice_Reg      ; if key is pressed, show act.dice
        rjmp LD5                      ; Jump for correct odds

LD3:    ldi Dice_Reg, WZ3
        sbis PIND,key
              out PORTB, Dice_Reg
        rjmp LD2

LD5:    ldi Dice_Reg, WZ5
        sbis PIND,key
              out PORTB, Dice_Reg
        rjmp LD4

LD2:    ldi Dice_Reg, WZ2
        sbis PIND,key
              out PORTB, Dice_Reg
        rjmp LD1

LD4:    ldi Dice_Reg, WZ4
        sbis PIND,key
              out PORTB, Dice_Reg
        rjmp LD3

LD1:    ldi Dice_Reg, WZ1
        sbis PIND,key
              out PORTB, Dice_Reg
        rjmp LD6
```



# rev(olution) counter



The proposed circuit is a general-purpose rev(olution) counter for cars. It is suitable for 4-, 6- or 8--cylinder engines.

In a traditional manner, a direct voltage is derived from the ignition pulses. The voltage level is directly proportional to the number of pulses per unit time. The direct voltage is converted by an ADC (analogue-to-digital converter) into a BCD (binary-coded decimal) signal, which is read with the aid of a decoder and a set of 7-segment displays.

The requisite pulses are taken directly from the circuit breaker (CB) in the engine compartment and applied to $K_1$. Any unwanted peaks are removed by low-pass filter $R_3$-$C_6$, while the level is held to a safe value by $D_1$.

The signal is subsequently amplified by $T_1$ and then applied to monostable multivibrator (MMV) $IC_1$. This stage converts the signal into a series of regular pulses, which are integrated by $C_1$. In other words, the potential across this capacitor is a measure of the number of pulses, that is, engine revolutions. This voltage is measured by ADC $IC_3$. This circuit has four BCD outputs and three digit-drives and, in conjunction with $IC_2$, a BCD-to-7-segment decoder, drives displays $LD_1$–$LD_3$.

The number of engine cylinders is determined by correcting the potential across $C_1$ with the aid of divider $R_4$–$R_9$. Four-cylinder engines

**Parts list**

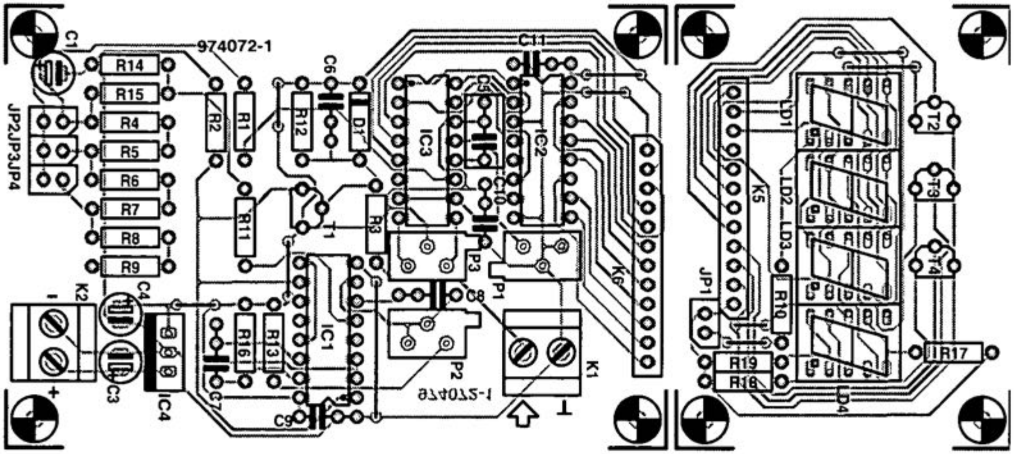
**Resistors:**
$R_1$, $R_4$–$R_9$ = 1 MΩ
$R_2$ = 470 Ω
$R_3$, $R_{12}$ = 22 kΩ
$R_{10}$ = 150 Ω
$R_{11}$, $R_{14}$, $R_{16}$ = 10 kΩ
$R_{13}$ = 8.2 kΩ
$R_{15}$ = 100 kΩ
$R_{17}$–$R_{19}$ = 330 Ω
$P_1$, $P_2$ = 10 kΩ, multiturn preset for vertical mounting
$P_3$ = 50 kΩ, multiturn preset for vertical mounting

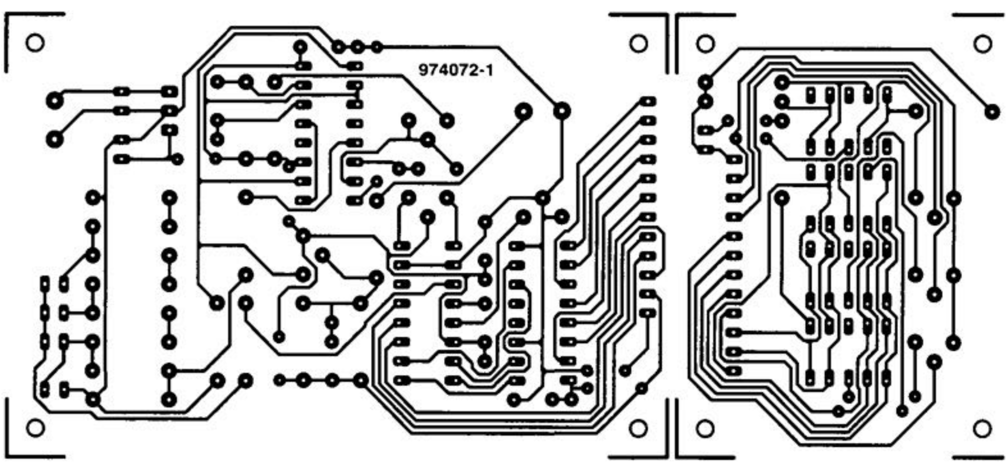
**Capacitors:**
$C_1$ = 1 μF, 25 V, radial
$C_3$, $C_4$ = 4.7 μF, 25 v, radial
$C_5$ = 0.27 μF
$C_6$, $C_8$–$C_{11}$ = 0.1 μF
$C_7$ = 0.047 μF

**Semiconductors:**
$D_1$ = 1N4148
$T_1$–$T_4$ = BC557

**Integrated circuits:**
$IC_1$ = 74HC221
$IC_2$ = CA3161E
$IC_3$ = CA3162E
$IC_4$ = 7805

**Miscellaneous:**
$LD_1$–$LD_4$ = HD11050
$JP_1$–$JP_4$ = jumper
$K_1$, $K_2$ = 2-way terminal block for board mounting
$K_5$, $K_6$ = 12-pin SIL header, right-angled
PCB Order no. 974072




produce four pulses, six- cylinder engines, six pulses, and eight-cylinder engines, eight pulses, for every two revolutions. In the case of a four-cylinder engine, $JP_2$ is short-circuited and the potential across $C_1$ is applied to $IC_3$. With six-cylinder engines, $JP_3$ is short-circuited so that the voltage across $C_1$ is divided by 4/6, and with eight-cylinder engines, $JP_3$ and $JP_4$ are short-circuited which results in the potential across $C_1$ being divided by two.

To calibrate the circuit, remove any jumpers and short-circuit the input of $IC_3$ ($R_1$) to earth. Adjust the offset with $P_3$ until the display reads '000'. Next, apply a voltage varying from 0 V to 1 V to the input of $IC_3$, measure every step with a DVM (digital voltmeter) and adjust $P_1$ for a display of exactly the same voltage. Finally, use a good-quality rev counter as reference, or apply a suitable voltage from a function generator with digital display to $K_1$, and adjust $P_2$ until both readings are the same.

The printed-circuit board, which is not available ready made, may be cut into two to separate the display section from the remainder. The two parts should then be interconnected by a length of flatcable between $K_5$ and $K_6$.

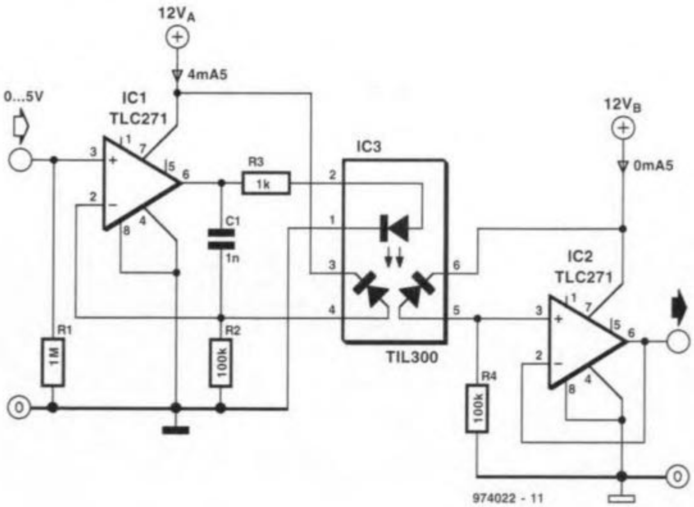
In case it is desired to get a display of '3400' instead of '340' when the number of revolutions is 3400, add $LD_4$. When only three displays are used, place $JP_1$ as indicated. This causes the decimal point of $LD_1$ to light to show that the display reading must be multiplied by 1000.

[Lemmens – 974072]

# linear opto-isolator

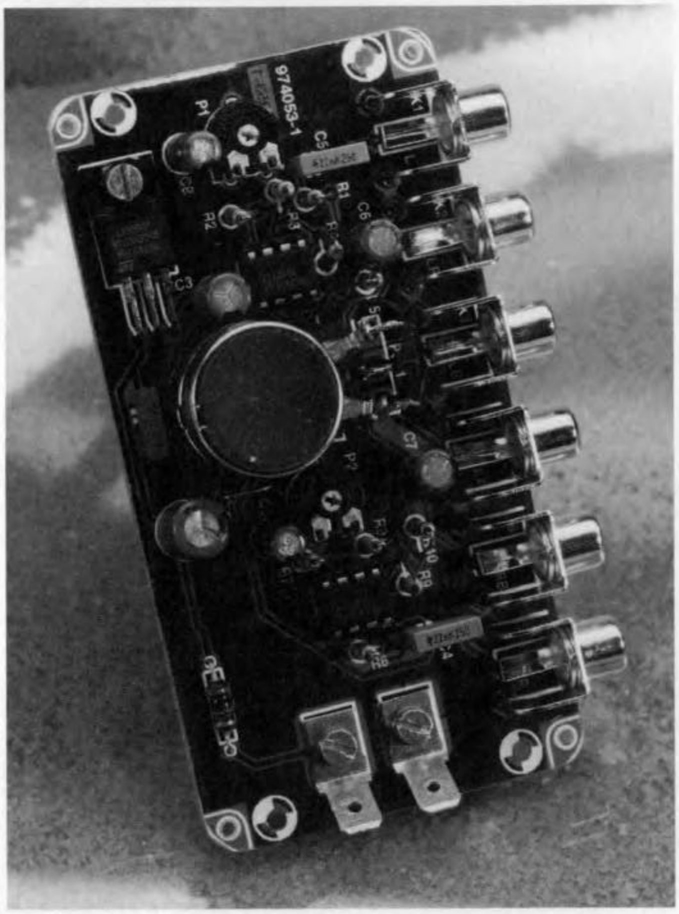
The fact that the Texas Instruments TIL300 opto-isolator contains two photodiodes is exploited here to endow the device with a virtually linear transfer characteristic. The trick is to include one of the photodiodes in the feedback circuit of the LED driver, while the other is used to drive an output buffer as usual. Assuming that the two photodiodes are virtually identical, the feedback circuit irons out any non-linearity of the transmit diode and the photodiode.

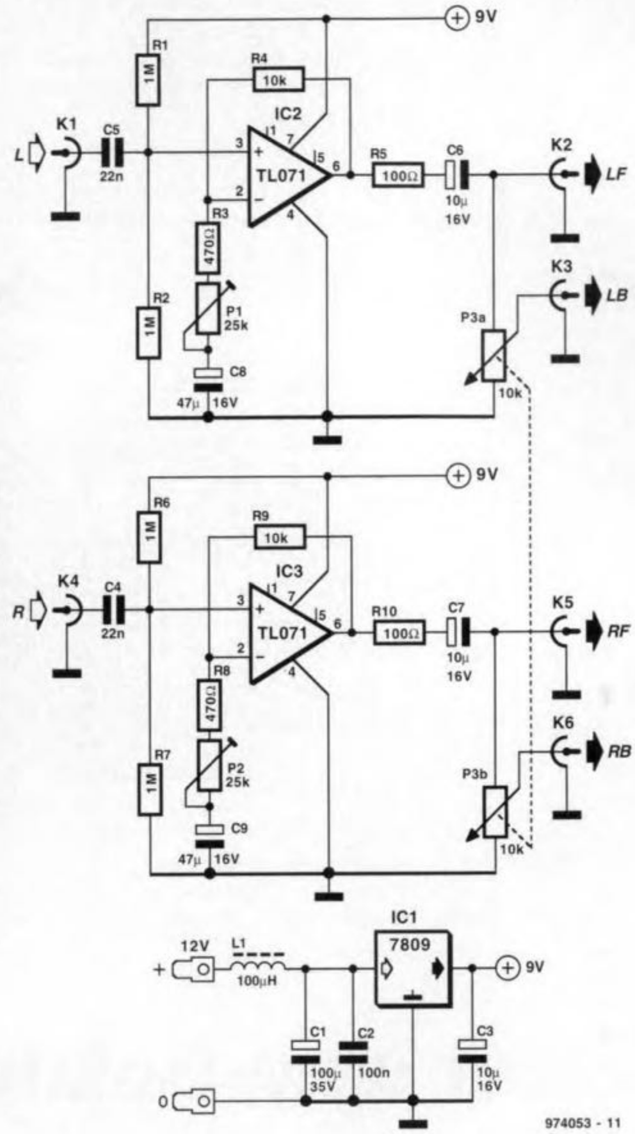
Although the circuit shown here was not tweaked for optimum performance, non-linearity should be less than 2% or so, which is not bad for such a simple setup. The thing about using a TLC271 here is that its common-mode range goes down to 0 V, allowing small input and output voltage levels to be used also, while the supply voltage may remain asymmetrical. A prototype of the circuit produced an output signal of 10 $V_{pp}$ at 50 kHz, albeit at considerable distortion. For accurate operation, the frequency should be much reduced. In this respect, it is recommended to experiment with the value of C1, which may need to be fine-tuned to achieve the best possible frequency compensation (strive to minimize overshoot in the output signal). Also, the TLC271 is used in high-bias mode here (pin 8 tied to ground). No doubt the use of faster and more accurate opamps will produce even better results.




(974022)

# car booster adaptor

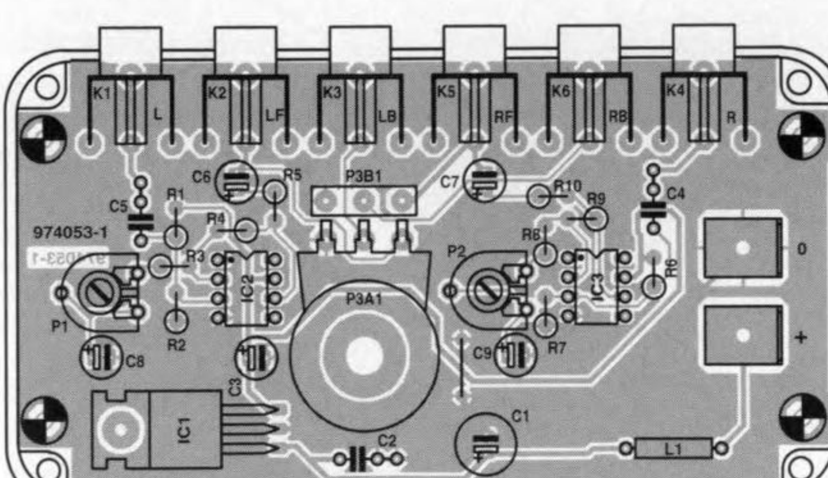



Judging by the cacaphony emanating from an increasing number of cars on the road, car radio boosters unfortunately remain popular with young people. Unfortunately, because deafness among these young people is becoming quite common.

From a technical point of view, the setup with a booster is often very in efficient, because these power monsters are normally connected simply to the loudspeaker terminals of the existing car radio installation via an attenuator. This puts the two output amplifiers in series, which is, as said, quite inefficient.

It is much better to take the signal from the wiper of the volume control in the car radio and




**Components list**

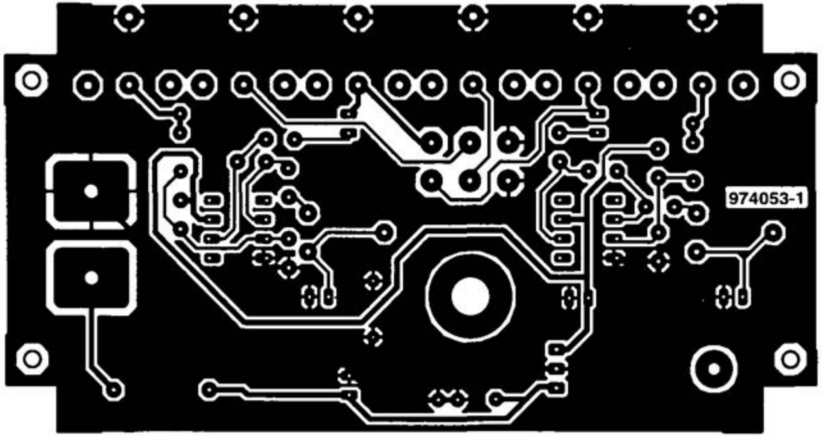
**Resistors:**
$R_1$, $R_2$, $R_6$, $R_7$ = 1 MΩ
$R_3$, $R_8$ = 470 Ω
$R_4$, $R_9$ = 10 kΩ
$R_5$, $R_{10}$ = 100 Ω
$P_1$, $P_2$ = 25 kΩ preset
$P_3$ = 10 kΩ log stereo potmeter

**Capacitors:**
$C_1$ = 100 μF, 35 V, radial
$C_2$ = 0.001 μF, high stability
$C_3$, $C_6$, $C_7$ = 10 μF, 16 V, radial
$C_4$, $C_5$ = 0.022 μF
$C_8$, $C_9$ = 47 μF, 16 V, radial

**Inductors:**
$L_1$ = 100 μH

**Integrated circuits:**
$IC_1$ = 7809
$IC_2$, $IC_3$ = TL071CP

**Miscellaneous:**
$K_1$–$K_6$ = audio socket for board mounting
2 off car-type connector for board mounting




use this as the input to the booster. This is normally not much of a job. The signal so obtained must, however, be buffered and sometimes also amplified.

The adaptor provides both these functions in a simple manner. The stereo signals are applied via $K_1$ and $K_2$ and buffered an amplified by an op amp in each channel. The amplification may be set between ×1.5 and ×22 with $P_1$ and $P_2$ respectively. These levels should be more than adequate for most situations. The peak output voltage is 2 $V_{RMS}$.

The output in each chan-nel is split into a front and a rear branch (left-hand front, LF, and left-hand back, LB, and RF and RB respectively). The volume of the rear speakers is set with $P_3$.

Regulator $IC_1$ provides a stable 9 V supply line for the op amps. The circuit draws a current of not more than 7 mA.

The adaptor is best built on the printed-circuit shown, which is, however, not available ready-made.

The input and output terminals are audio sockets for board mounting.

The battery voltage is applied to the circuit via two car-type connectors mounted on the board. When the adaptor is fitted in a small case, care must be taken that $P_3$ remains accessible.

[Bonekamp – 974053]

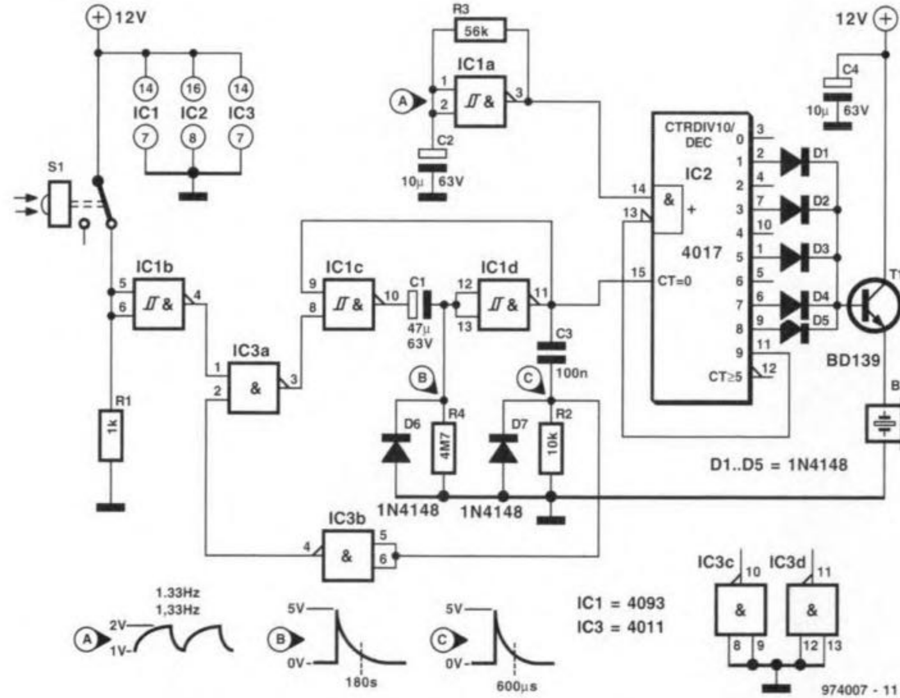
# intruder alarm

The alarm uses a pyrosensor to detect the presence of animals or human beings by changes in heat radiation.

The contact of the relay in the pyrosensor is linked to the input of the circuit and is closed in the quiescent state. If an animal or person approaches the sensor, the relay contact opens. The input of $IC_{1b}$ then goes low and its output becomes high. Pin 8 of $IC_{1c}$ goes low, which enables the MMV (monostable multivibrator) formed by $IC_{1c}$ and $IC_{1d}$. Owing to the feedback to pin 9 of $IC_{1c}$, the MMV output remains low for about three minutes, even if the sensor is disabled. If on completion of the three-minute period the sensor is still actuated, a new period also three minutes long is started. Alarm pulses generated when the MMV is enabled are ignored.

When the MMV is quiescent, its output is high and counter $IC_2$ remains reset. The counter position is then zero and, since output $Q_0$ (pin 3) is not linked to $T_1$ and the buzzer via a diode, the buzzer remains inactive.

When the MMV is enabled by the pyrosensor, its output goes low. The counter is then no longer reset and begins to count the clock pulses from $IC_{1a}$. The buzzer is then actuated intermittently via diodes $D_1$–$D_5$ and $T_1$.




When the counter reaches its highest position, $Q_9$ (pin 11), the high level at this output impedes the clock at the enable input (pin 13). The counter stops counting and retains this position. After a short while, the mono time elapses and pin 11 of $IC_{1d}$ goes high, whereupon the counter is reset. A 600 $\mu$s pulse is then passed to $IC_{3b}$ via $R_3$ and $C_2$. This pulse briefly disables $IC_{3a}$ which reenables the MMV, provided the sensor is still actuated.

The mono time may be changed by altering time constant $R_4$-$C_1$.

When the sensor contact has been closed almost continuously for a lengthy period, the mono time may be a little shorter when the MMV is enabled for the first time after this period. If this is found inconvenient, the recovery time may be lengthened by increasing the value of $R_2$

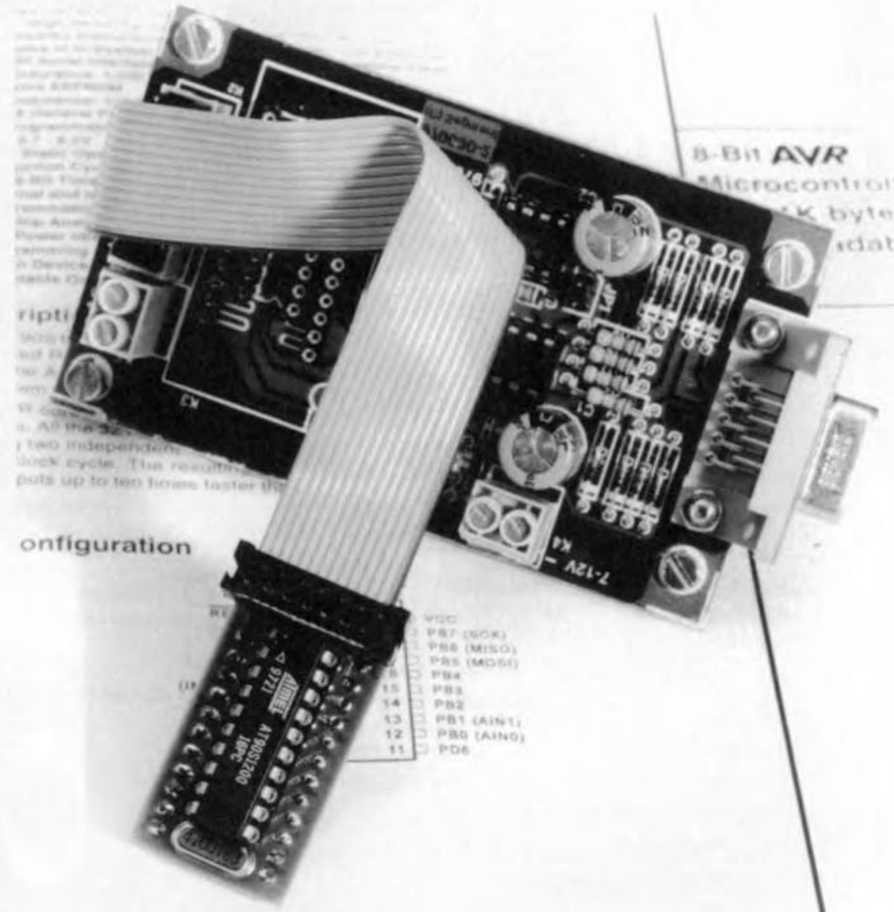
The circuit draws a current of 1–2 mA, which increases to 13–14 mA (via $R_1$) when the relay contact is closed, and to 15–16 mA when the buzzer is actuated.

[Looymans – 974007]

# Programmer for Electronic Handyman & AT90S1200

## *hardware and PC software for programming Atmel RISCs*

All microcontrollers have to be programmed, be it by means of a 'mask' during their production, or by means of a special programmer. If you want to use just two or three microcontrollers of a certain type, then having them mask-programmed is really out of the question, while a dedicated programmer may still be too expensive. For the Electronic Handyman described elsewhere in this issue, we present a small docking programmer which is actually an adapter for connecting to the RS232 interface on your PC. Using the software developed for the programmer, you can start programming AVR chips at assembler level.



By Dipl. Ing. Bernard C. Zschocke

In the spring of 1997, Atmel announced its 'AVR' series of microcontrollers, which, they claimed, were sure to find applications in many future projects. The AT90S1200 device arrived on the market by the summer of 1997. One remarkable thing about this series of controllers is their ability to be programmed via four pins. The present project, Handyman and its docking programmer, was on paper before the first samples of the AT90S1200 arrived. The Electronic Handyman is inexpensive, simple to build, easy to program, yet powerful. All of these characteristics should also apply to the associated programmer, without breaking the bank, of course.

### Four lines between PC and AVR

As with many low-budget programmers, the PC works in unison with a programming adapter. It is no coincidence that the relevant link is by way of the RS232 interface. Because the AT90S1200 requires a current of just 1 mA per MHz of clock frequency, both the adapter and the microcontroller are easily powered by the RS232 interface during programming. Broadly speaking, the programmer has two functions: providing the 5-volt supply voltage, and arranging the level conversion on three signal lines between the PC and the AVR chip (RTS → MOSI, DTR → RESET and TxD → SCK), and one return line from the AVR to the PC (MISO → CTS).

Unfortunately there are no three freely controllable RS232 lines on the PC. This problem is solved with a trick. While RTS and DTR may be made logic high and low by means of individual bits, the TxD line is normally logic low, changing to high only when a character is being transmitted (depending on the actual data). A solution to achieving similar control over the TxD line was found after studying the databooks. One of the three programming lines acts as the CLK line with 'low' as the non-active level, just like TxD. Transmitting a zero generates a pulse on the TxD line with a length which equals nine times the programmed baudrate.

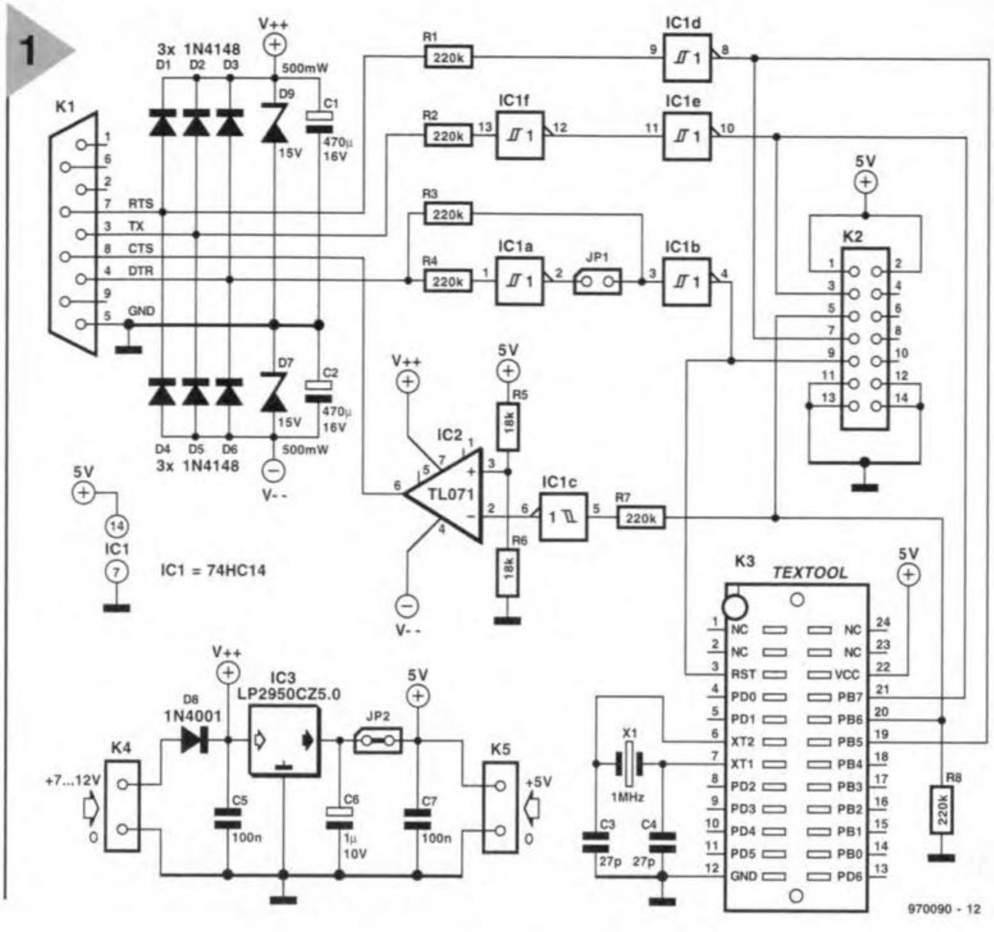



***Figure 1. Circuit diagram of the docking programmer. To program an AT90S1200 directly or on a Handyman shuttle board, you need three RS232 lines from the PC to the programming adapter, and one for the other direction.***

## Voltages and levels

The RTS, TxD and DTR lines taken from the RS232 socket are decoupled by diodes D1-D6 to give a positive and a negative supply voltage. Electrolytic capacitors C1 and C2 act as buffers, while zener diodes D7 and D9 limit the voltages to ±15 V. Current limiting is not needed here because an RS232 interface is normally short-circuit resistant, and only capable of supplying a few milli-amps anyway. With ordinary PCs, nothing untoward should happen in any case, because the maximum swing on any RS232 line is ±12 V. Only with interfaces which are not RS232 compliant, the short-circuit current through D7 and D9 may become too high. If that is a risk, current limiting is required to protect the zener diodes.

The unregulated supply voltages V++ and V-- directly power opamp IC2, which raises the MISO signal received from the AVR chip to the symmetrical RS232 level. The positive supply voltage is applied to low-drop voltage regulator IC3, which turns it into a stable 5-volt rail. Other low-drop regulators than the one specified will not work here because of their high starting current. C6 stabilizes the regulation behaviour. Jumper JP2 allows the regulated voltage to be removed from the AVR in case an external power supply is connected by way of K5 or K2. In that case, C7 acts as a noise suppression capacitor. If the jumper is fitted, the output voltage of the regulator is available at connector K5. In case the interface can not supply sufficient current, an external power supply (7 to 12 V) may be connected to connector K4. Because D9 is a direct shunt, a higher supply voltage than the zener voltage would destroy the diode. Diode D8 provides protection against any reverse-polarized input voltage.

## The signal paths

By way of resistors R1-R4, the signals travel from the RS232 interface to the inputs of Schmitt trigger gates (74HC14). Together, the resistors and the input capacitance of the gates act as low-pass filters (1 $\mu$s), while the input current is also limited when the signal voltages are clipped to 5 V by the internal protection diodes of the Schmitt-trigger gates. This slightly unusual circuit is expressly allowed by Philips Components in their databooks on HC logic. So, stick to a 74**HC**14!

Jumper JP1 allows you to select between a true or an inverted RESET signal. A hardware solution had to be used here because the DTR line has to provide a constant positive supply level during programming. If the jumper is installed, the low-impedance output of IC1a ensures that R3 remains inactive. Spurious oscillation is not expected because the internal resistance of the DTR line is much lower than the value of R3. The same for the TxD line, which acts as a clock line (SCK). Because both lines return to zero in the inactive state, two inverters are connected in series.

The outputs of the inverters are either taken to pins on pinheader K2, to which the Electronic Handyman is connected via a (not too long) flatcable, or directly to zero-insertion (ZIF) socket K3, into which the controller IC is inserted.

Programming of an AVR controller requires a clock signal which is generated by quartz crystal X1, parallel-load capacitors C3 and C4, and the oscillator on board the AT90S1200. The Electronic Handyman already has its own quartz crystal. It should be noted that the current consumption of the controller may rise beyond the capacity of the RS232 interface if relatively high oscillator frequencies are used (up to 16 MHz). In that case, it is recommended to first program the microcontroller using a lower oscillator frequency, and then actually use it with a higher frequency. The signal from the AVR to the PC travels via a resistor and a Schmitt trigger gate to an opamp which works as a level con-

2

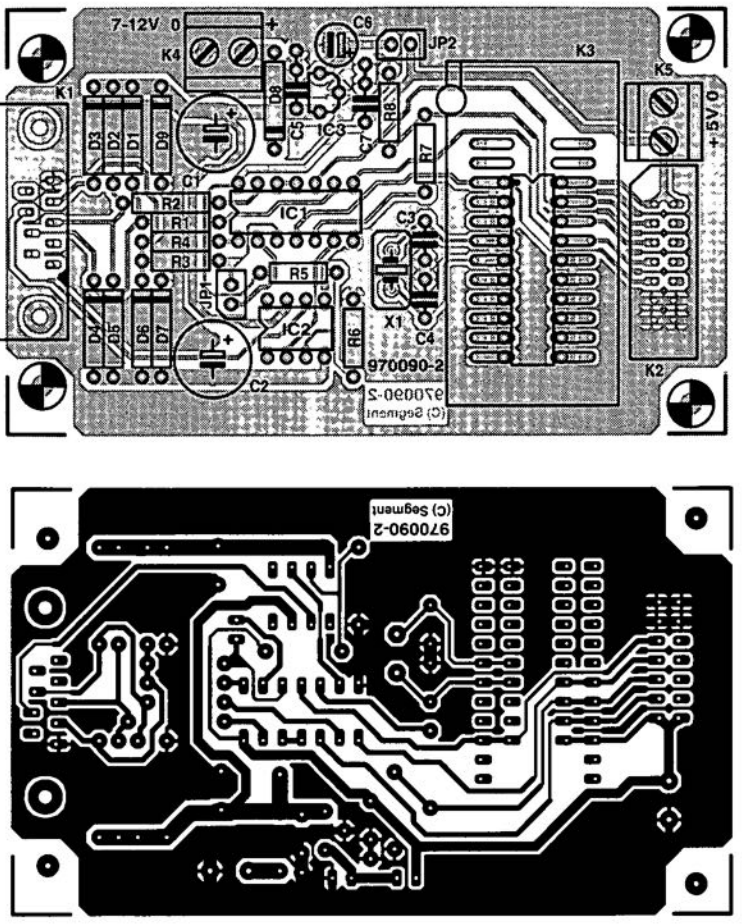



***Figure 2. PCB artwork (board available ready-made through the Readers Services). A Handyman shuttle may be programmed in K3 or on K2, or any AT90S1200 chip in K3.***

**COMPONENTS LIST**

**Resistors:**
R1-R4,R7,R8 = 220kΩ
R5,R6 = 18kΩ

**Capacitors:**
C1,C2 = 470µF 16V
C3,C4 = 27pF
C5,C7 = 100nF Sibatit (miniature ceramic)
C6 = 1µF 10V

**Semiconductors:**
D1-D6 = 1N4148
D7,D9 = zener diode 15V 0.4W
D8 = 1N4001
IC1 = 74HC14 (Philips)
IC2 = TL071
IC3 = LP2950CZ5.0

**Miscellaneous:**
K1 = 9-way sub-D socket, PCB mount, angled pins.
K2 = 14-way boxheader, straight
K3 = 24-way ZIF socket, for IC widths from 0.3 to 0.6 inch (Aries/Farnell).
K4,K5 = 2-way PCB terminal block, pitch 5mm
JP1,JP2 = pinheader with jumper
X1 = 4MHz quartz crystal
Note: PCBs 970090-1 (Handyman shuttle), 970090-2 (Handyman docking programmer) and disk 976017-1 (project software) are also available as a package under order code **970090-C**.

verter. R8 guarantees proper termination of the MISO port. The level converter uses voltage divider R5-R6 as its reference. These two resistors also form a load for the supply voltages so that the voltage remains below 5 V even if all inputs are held logic high.

The docking programmer should be easy to build. The dimensions of the single-sided printed circuit board (**Figure 2**) allow the circuit to be installed in a commercially available enclosure. Be sure to stick to the exact part numbers mentioned in the components list. The trick with the protection diodes may cause a lot of problems if no-name components are used!

## A TEST PROGRAM

The correct operation of the programming adapter is conveniently verified with the aid of a program called **HM_CHECK**. Like the actual programming utility, HM_PROG, HM_CHECK is a pure DOS application! Remember, Windows 95 does not allow direct access to the RS232 ports without a host of special tricks, not even if a regular DOS box is used. To enable the programs to be run from Windows 95, the DOS box has to be set up to reflect true MS-DOS mode. This is done by creating a link with each program. Select the executable file, click the right-hand mouse button and select Properties, then Program, Advanced, and MS-DOS Mode. Next, press the OK buttons until you are back at the beginning.

### HM_CHECK

This program is launched with the desired RS232 interface as an appended parameter, so, for instance, HM_CHECK /COM1. The following menu appears:

| | | | | | |
|---|---|---|---|---|---|
| A: | Power | ON | B: | Power | OFF |
| C: | Set | RESET | D: | Clear RESET | |
| E: | MOSI | HIGH | F: | MOSI | LOW |
| G: | DTR | HIGH | H: | DTR | LOW |
| I: | RTS | HIGH | J: | RTS | LOW |
| K: | SCK's | ON | L: | SCK's | OFF |
| M: | Status | ON | N: | Status | OFF |
| 0: | Loop Test | | P: | Prog. enable | |
| S: | One SCK | | T: | Device code | |
| Q: | Quit | | | | |

| | | | |
|---|---|---|---|
| Port => | 1: COM1 | 2: COM2 | |
| | 3: COM3 | 4: COM4 | |
| Baudrate => | 5: 19200 | 6: 9600 | |
| | 7: 4800 | 8: 2400 | 9:300 |

Most functions may be tested with the aid of a multimeter. The individual menu options are:

- **A:** The RS232 lines are configured such that the maximum voltage is available across C1, enabling IC3 to supply 5 V.
- **B:** Switches off the voltage across C1.
- **C:** Activate the Reset line (level depends on jumper JP1).
- **D:** De-activate the Reset line.
- **E-J:** Switch the corresponding line to high or low respectively.
- **K:** Apply a continuous clock signal to the SCK line.
- **L:** Switch off continuous clock on SCK.
- **M:** Display the status of the MISO line. Apply 5 V to check that the MISO signal actually arrives.
- **N:** Switch off MISO status indication.
- **P:** Transmit programming-enable sequence to the microcontroller. Useful when a controller has to be programmed manually (bit-by-bit).
- **S:** Put a clock pulse on he SCK line.
- **T:** Read the controller's Device Code, and display it. If this function returns the correct value, the system is probably okay.
- **Q:** Quit program

The numbers 1 through 4 enable you

to pick a free interface, while numbers 5 through 9 determine the baudrate which, in turn, determines the length of the clock pulse (nine times the baudrate). The delays to be observed by the program are always multiples of the baudrate. The underlying goal is to generate delays which do not depend on the processor's clock frequency.

And now for a menu option not discussed so far: ***O: Loop Test.*** For this test you have to link the MISO and MISI lines either at K2 or at the ZIF socket. In this way, you enable the software to read back its own transmission. The transmitted and the received byte are displayed. A sub-menu appears:

| | |
|---|---|
| 0 | : Set byte to be sent to 0 |
| 1 | : Set byte to be sent to $AA (= 170) |
| 2 | : Set byte to be sent to $55 (= 85) |
| C | : Count-up byte to be sent (cyclic) |
| D | : Decrement byte to be sent |
| I | : Increment byte to be sent |
| R | : Random value for byte to be sent |
| N | : No wait |
| W | : Wait 50 clock times after each byte |
| Q | : Quit test |

If you have an oscilloscope available, the Loop Test is a great help when investigating the operation of a circuit.

## PROGRAMMING

The programmer described here allows Electronic Handyman shuttles as well as the target circuit to be programmed. The Electronic Handyman is hooked up via a flatcable link. If the Handyman is installed in the application circuit during programming, jumper JP2 must be removed, and the supply voltage of the application circuit switched on. If the Handyman is programmed individually, JP2 has to be fitted.

The jumper is also fitted if an AT90S1200 chip has to be programmed directly. A tip: if you would like to omit the power supply on your prototypes, employ the voltage regulator on the programmer board by applying the supply voltage (peak value: <15 V, also for a.c.!) to connector K4, and power your construction by way of connector K5. In that case, jumper JP2 has to remain in place. Jumper JP1 always remains open whenever a handyman shuttle or an AT90S1200 is being programmed.

The programming utility proper, **HM_PROG**, may be used on the assumption that the data to be burned into the AVR chip is available in *generic format* as supplied by the Atmel assembler called WAVRASM (AVR Assembler for Windows). Neither the Intel-Hex nor the Motorola format is supported. The Atmel assembler is included on the project diskette which may be obtained through our Readers Services under order code **976017-1**. Readers with access to the Internet may also obtain it by downloading the self-extracting archive AVR.EXE, which may be found on this page at Atmel's Internet site:
*http://www.atmel.com/atmel/products/prod203.htm.*
Unpacked and installed, AVR.EXE supplies the AVR Assembler for Windows (WAVRASM.EXE), an AVR Simulator for Windows, a host of programming examples, and AVR datasheets in Acrobat Reader format.

Like HM_CHECK, the programming utility, **HM_PROG**, is run either under plain DOS or in a Win95 DOS box with a link made as outlined above. All instructions to the program are conveyed by means of parameters ('switches') which you type when launching the program. These switches are examined and executed in the order in which they are appended. The general format of the program call is:

HM_PROG /COMc /Bbbbbb
/x [<filename>] [/x] [<filename>]

*Example:*
HM_PROG /COM1 /B9600 /RDC
/CE /WM MYPROG.ROM
/VM MYPROG.ROM

For this example, it is assumed that the programmer is connected to the COM1 port. The programmed baudrate is 9600 bits/s, which equals a clock pulse of about 1 ms. Initially, RDC is used (Read Device Code), whereupon the chip is erased (CE). Next, the file MYPROG.ROM is written (WM) into the program memory of the device. This activity is finished with a Verify operation (VM).

The first parameter that must be communicated is the communication port, where **/COMc** stands for COM1, COM2, COM3 or COM4, depending on the port you wish to use. All other switches are optional. As with the test program, the switch **/Bbbbbb** allows the baudrate and with it the clock duration to be programmed. Do not use other values than the ones indicated by the menu. You get the menu if you launch the program without switches. The **/RDC** parameter causes the Device Code to be read. It is recommended to use RDC before other switches to make sure the programmer addresses the chip in the correct way. The Device Code for the AT90S1200 is $1E $90 $01. The parameter **/CE** causes the controller to be erased. The program, read and verify parameters should always be followed by a proper filename. Using **/RM <filename>** the contents of the program memory is written into the file called <filename>. Similarly, **/WM <filename>** causes <filename> to be written into the program memory. Once again: the expected data format is the generic format as supplied by the Atmel assembler! The **/VM** switch tells the program to verify the program memory contents against the contents of <filename>.

The parameters **/RE, /VE and /WE** differ from /RM, /VM and /WM in that they operate on the internal EEPROM instead of the program memory. Two undocumented parameters, **/PM <filename>** and **/PE <filename>** program first and then perform a Verify. Finally, the parameters **/WLB1, /WLB2 and /WLB21** allow you to program the Lock bits.
Finally, note that HM_CHECK and HM_PROG are available on disk 976017-1 only, i.e., they are **not** included in the AVR.EXE file which may be downloaded from the Atmel Internet site.

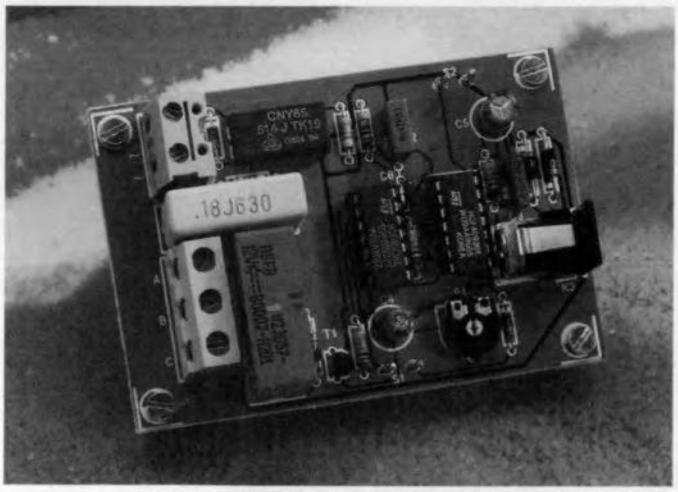
(970090-2)

## Call parameters for HM_PROG

*Call: HM_PROG /COMc /Bbbbbb /x [<filename>] [/x [<filename>]]n*

| | | |
|---|---|---|
| */COMc* | *c = 1\|2\|3\|4* | *Example: /COM1 for COM Port 1* |
| */Bbbbbb* | *bbbbb = 38400\|19200\|9600\|4800\|2400* | *Example: /B9600 for 9600 Baud* |
| */x = /RM* | *<filename>* | *Read device memory to <filename>* |
| */x = /VM* | *<filename>* | *Verify device memory against <filename>* |
| */x = /WM* | *<filename>* | *Program device memory against <filename>* |
| */x = /RE* | *<filename>* | *Read device EEPROM to <filename>* |
| */x = /VE* | *<filename>* | *Verify device EEPROM against <filename>* |
| */x = /WE* | *<filename>* | *Program device EEPROM against <filename>* |
| */x = /RDC* | | *Read device code* |
| */x = /WLB1* | | *Program Lock Bit 1* |
| */x = /WLB2* | | *Program Lock Bit 2* |
| */x = /WLB21* | | *Program Lock Bit 1 and Lock Bit 2* |
| */x = /CE* | | *Erase device* |

# PIR controlled shop-bell

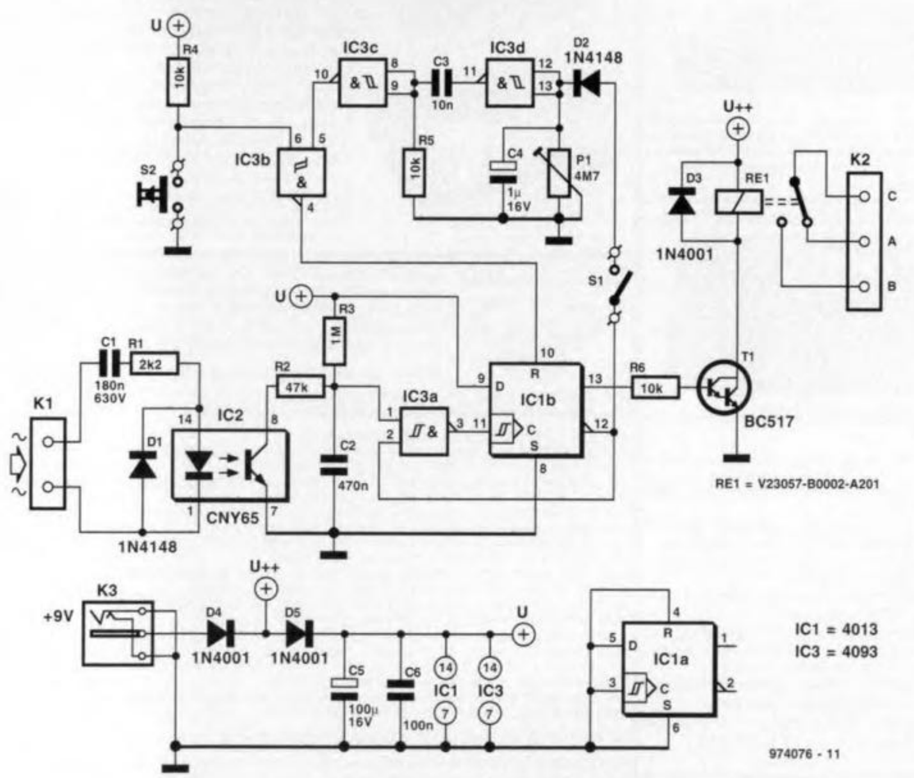


A PIR (passive infrared) detector coupled with an electric light is now widely used for intruder protection. PIR detectors are also available as stand-alone units which usually have a switched output for controlling external loads. The Argos 431/5595, for example, has a switching capacity of 2,000 watts.

This circuit will work with stand-alone PIR units as well as combined lamp units. In the latter case, you only use the PIR section, which usually contains a control to set the 'on' time. In this case, the shortest possible on-time should be set (usually about 15 seconds).

Most electronic shop-bells are based on light barriers. The disadvantage of these units is that their vertical range is limited, giving shop-lifters a chance to dodge the (invisible) beam by crawling across the doorstep. The PIR controlled shop bell shown here offers better security.

When the PIR detects a person, it supplies the mains voltage to connector K1. The resulting low voltage at the collector of the phototransistor



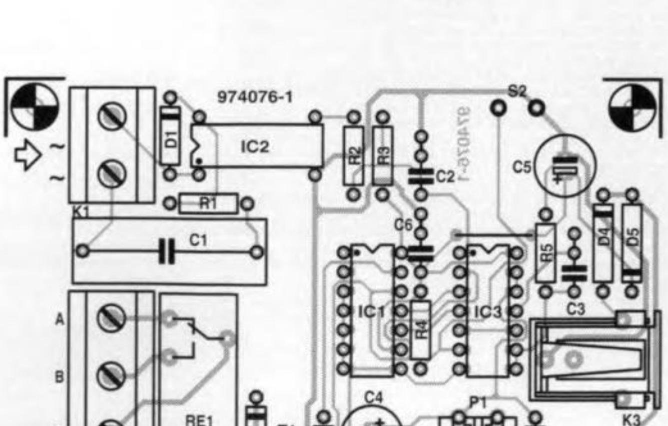

### COMPONENTS LIST

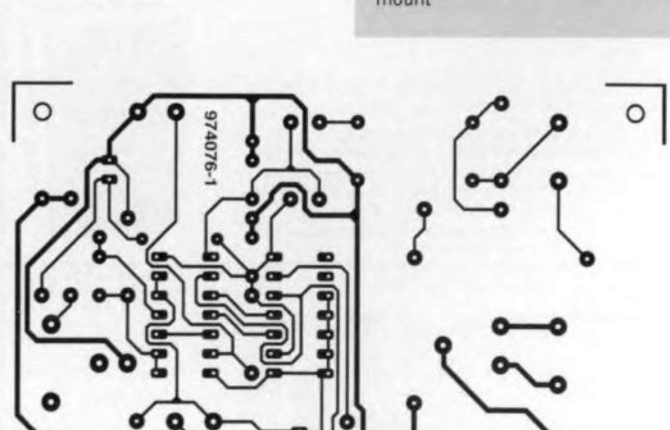
**Resistors:**
R1 = 2kΩ2
R2 = 47kΩ
R3 = 1MΩ
R4,R5,R6 = 10kΩ
P1 = 4MΩ7 (5MΩ) preset H

**Capacitors:**
C1 = 180nF 630VDC class X2
C2 = 470nF
C3 = 10nF
C4 = 1µF 16V radial
C5 = 100µF 16V radial
C6 = 100nF

**Semiconductors:**
D1,D2 = 1N4148
D3,D4,D5 = 1N4001
T1 = BC517
IC1 = 4013
IC2 = CNY65 (Temic)
IC3 = 4093

**Miscellaneous:**
S1 = on/off switch, miniature
S2 = pushbutton, 1 make contact
Re1 = V23057-B0002-A201 (Siemens)
K1 = 2-way PCB terminal block, pitch 7.5mm
K2 = 3-way PCB terminal block, pitch 7.5mm
K3 = mains adaptor socket, PCB mount



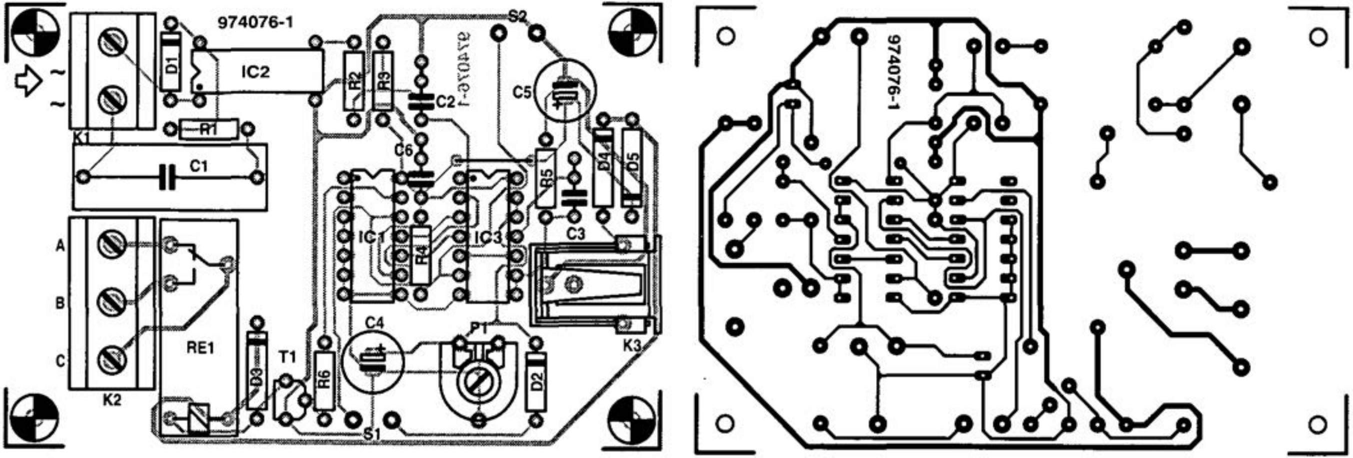
inside opto-isolator IC2 is first cleaned in a low-pass filter, R2-C2, to prevent interference and false detection. The resultant pulse at the CLK input of IC1b causes a '1' to be clocked by this bistable. Because the Q output goes high, the bell relay is energized via darlington transistor T1. If switch S1 is closed, a timer, IC3d, determines the delay before the bistable is reset and the bell is switched off. The length of the delay is adjustable with preset P1. This delay (max. 8 s) is also useful to discourage children from toying with the shop bell. If S1 is open, the bell sounds until the shopkeeper presses the other switch (a push-button), S2.

The circuit is powered by a 9-VDC mains adaptor. Current consumption is about 25 mA with the relay energized. The control input is designed for a drive voltage of 230 V, 50 Hz.

Finally, to enable the PIR detector to work in daylight also, you have to cover the internal light/darkness sensor (usually an LDR).

Unfortunately, the printed circuit board shown here is not available ready-made.

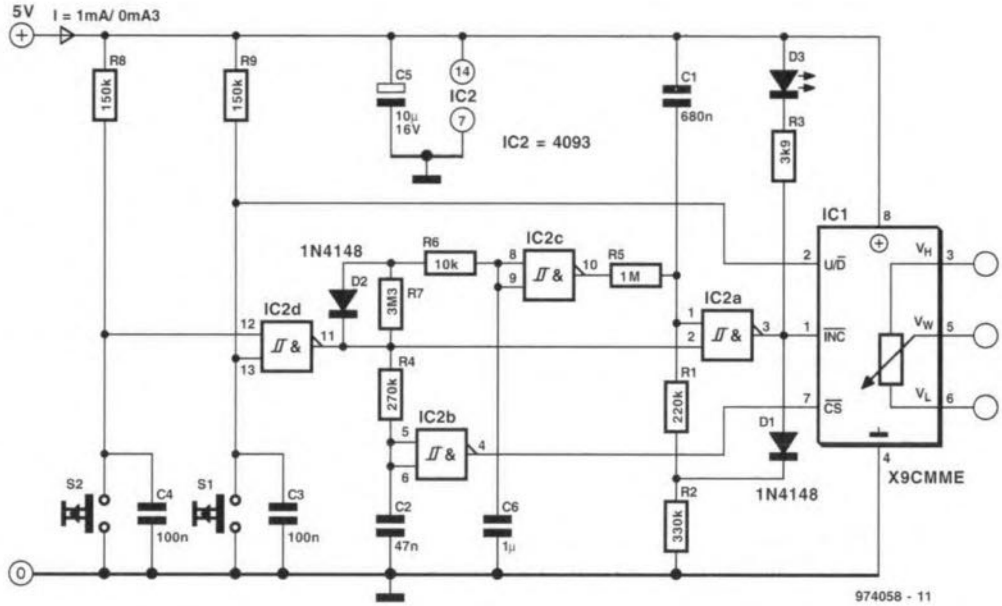
(974076 - H. Bonekamp)


974076-1
S2
IC2
D1
R2
R3
C2
C5
K1
R1
C1
C6
R5
D4
D5
IC1
R4
IC3
C3
A
B
C
K3
RE1
C4
P1
T1
R6
D3
D2
K2
S1
974076-1

# digital potentiometer

Xicor's digitally controlled E²POT ICs provide ergonomic and long-lasting alternatives to mechanical potentiometers. The ICs in the X9CMME series have a 7-bit counter with reversible count direction and a decoder that enables one of the 100 analogue switches.

The outputs of the analogue switches serve as the wiper of a potentiometer, while the inputs are linked to a potential divider composed of 99 equal resistors. The counter state may be stored in a non-volatile EEPROM, so that it can serve as the output value at a subsequent start.



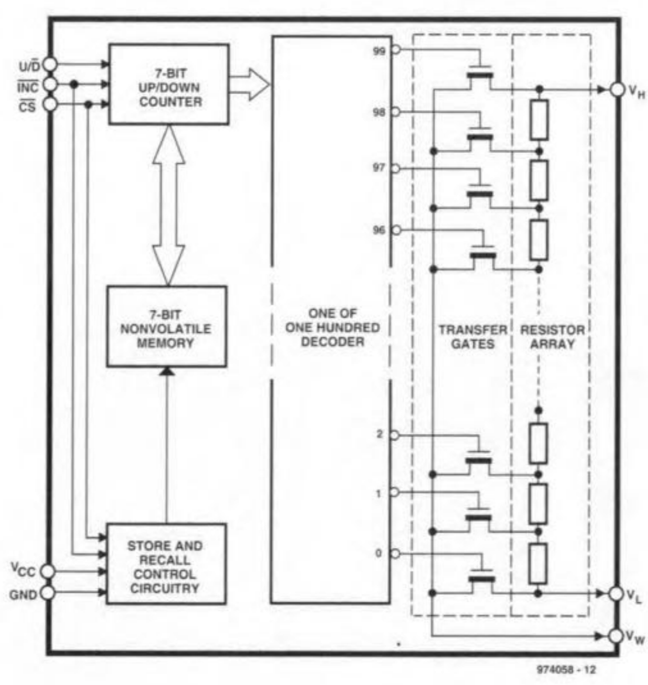

The X9CMM series is designed to operate from 5 V supply lines. The potential across the resistive divider must not exceed 10 V (only 4 V in case of the X9C102). The ON resistance of the analogue switch is about 40 Ω, so that the current through the wiper is limited to 1 mA.

E²POT ICs have three inputs for the digital drive. The level at U/D determines whether a trailing edge at clock input $\overline{INC}$ lowers or raises the counter state. This action only takes place if chip select input $\overline{CS}$ is low. A leading edge at CS arranges for the counter state to be stored when $\overline{INC}$ is high. When $\overline{CS}$ is high, the IC is in the standby mode.

The circuit diagram shows a complete digital potentiometer based on a Type X9CMME. It is provided with two controls, $S_1$ and $S_2$, an optical indicator and a delayed frequency change-over of the clock generator.

When keys $S_1$ and $S_2$ are open, resistors $R_8$ and $R_9$ hold the inputs of $IC_{2d}$, a NAND, as well as the U/D input of $IC_1$ high. The low level at the output of $IC_{2d}$ disables clock generator $IC_{2a}$. Frequency determining capacitor $C_1$ is discharged in the quiescent state.

When one of the keys is pressed ($S_1$ firmly, $S_2$ gently), the output of $IC_{2d}$ changes state, so that the clock generator and $IC_1$ (via $IC_{2b}$) are enabled. Capacitor $C_1$ is then charged via $R_1$ and $R_2$ until the input level of $IC_{2a}$ goes low, whereupon the gate output linked to the clock input of $IC_1$ changes state (from low to high). When this happens, $C_1$ is discharged via $R_1$ and $D_1$ until the upper trigger level of $IC_{2a}$ is attained. The gate then changes state again and the above action repeats itself.




The clock signal is optically monitored by $D_3$.

When the output of $IC_{2c}$ is high, the gate draws a portion of the charging current from $C_1$, which results in the clock frequency at $\overline{INC}$ being relatively low.

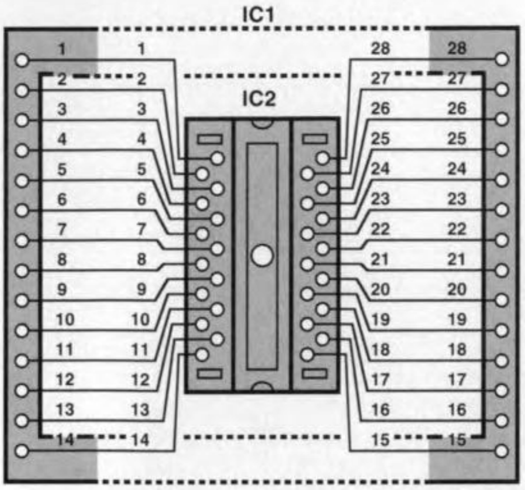
At the same time that the generator is enabled, $C_6$ begins to be charged gradually via $R_6$ and $R_7$ until $IC_{2c}$ changes states (from high to low). Circuit $IC_2$ then contributes to the charging current to $C_1$, whereupon the clock frequency increases: in the prototype, the frequency rose in four seconds from 1.3 Hz to 3.1 Hz.

When the keys are released, the clock generator stops. At the same time, $C_6$ is discharged rapidly via $R_6$ and $D_2$, so that the frequency is low again when the keys are operated anew.

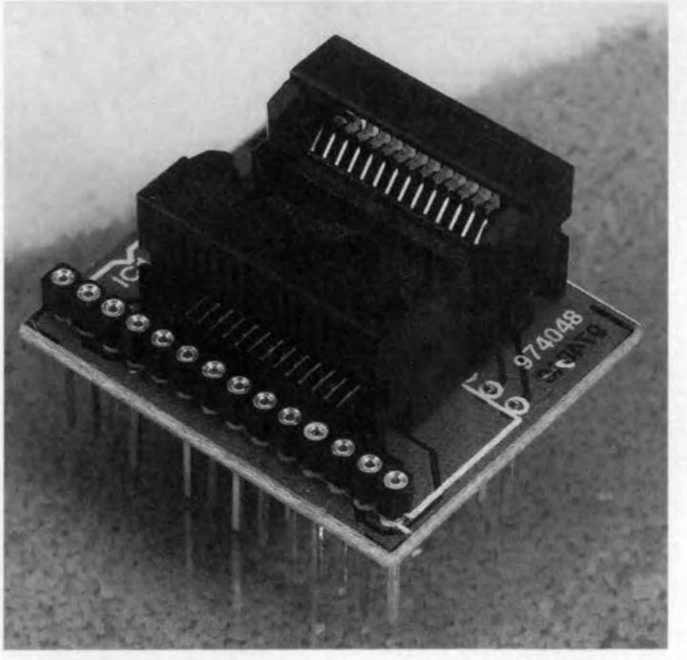
The switch-off delay owing to $R_4$-$C_2$ enables the actual counter state to be stored by the internal logic.

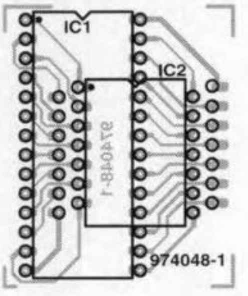
The circuit draws a current of 0.3–1.0 mA. [Kühne – 974058]

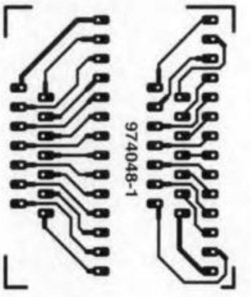
# SMD adaptor



974048 - 11




EPROM and microcontroller programmers are invariably provided with a ZIF socket to hold the component to be programmed. However, surface mounted devices (SMDs), which are used more and more often, have an SOJ or SOP case, so that they cannot be programmed in existing programmers without a special adaptor.

This article proposes such an adaptor which enables a programmer intended for devices with a 28-pin DIL case to be used for components with a 28-pin SMD case. (The ST62 programmer published in the November 1996 issue of this magazine is one).

The adaptor consists of a small, single-sided printed-circuit board with a 28-pin DIL socket fitted at its track side and a ZIF adaptor for 28-pin SMD cases at the component side.

Start by soldering two 14-pin single-row headers at the track side. Take care that nothing protrudes at the component side, because then there would be insufficient space for the ZIF socket. Next, mount a standard 28-pin IC socket onto the header pins. Finally, solder a 28-pin ZIF socket suitable for SMDs at the component side.

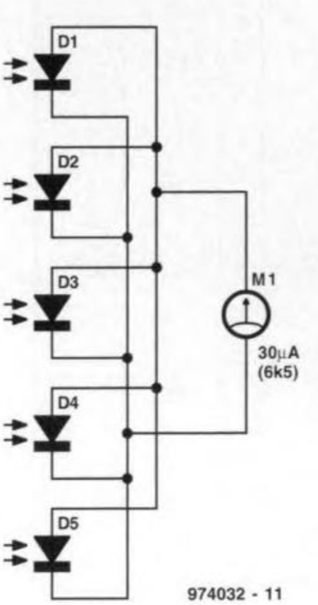
[Lemmens – 974048]

# infra-red-illuminance meter

When a photodiode is illuminated, it produces a significant photocurrent whose value depends on the level of illuminance*.

When the drop across a photodiode is measured, it appears that this is normally ≤ 500 mV. This voltage is not, or hardly, dependent on the photocurrent. If therefore a low-value resistor is placed in parallel with the diode, the drop across the parallel combination remains below the diode (forward) voltage. The potential across the resistor is then directly proportional to the illuminance.

A high-impedance digital ammeter set to its lowest d.c. μA range will show that the diode voltage hardly varies with the light intensity. If a suitable d.c. μA range is not available on the meter, connect a resistor of a few kΩ across the meter input.



974032 - 11

In the diagram, the shunt resistance of the diodes is formed by moving-coil ammeter with 30 μA full-scale deflection. Its internal resistance is 6.5 kΩ.

Calibration of the circuit and graduation of the scale must be carried out with the aid of a light source of well-defined luminous intensity. Even without calibration the meter may be used to compare the emission of an infra-red headphone transmitter with that of incident daylight. It may also be used to verify whether a remote controller is still working properly.

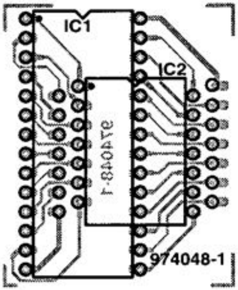
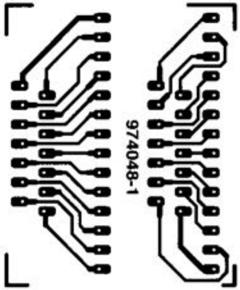
The prototype was built with photodiodes Type BP104, which appeared to have the best sensitivity of a number of different types. With five photodiodes in parallel as in the diagram, the infra-red light from a remote controller at a distance of 100 mm from the meter gives a reasonably clear deflection of the pointer.

If light sources emitting light of different frequency must be checked, appropriate photodiodes must, of course, be substituted for the BP104s.

Note that the meter does not need a power supply.

[Giesberts – 974032]

**Illumination = illuminance = the quantity of light or luminous flux falling on unit area of a surface.*


IC1
IC2
974048-1

974048-1

# digital-audio-input selector

As the name indicates, the selector is intended to choose one of up to eight digital audio signal inputs, which it does with the aid of a multiplexer.

The multiplexer, $IC_6$ is controlled by preset up/down counter $IC_2$. The counter is set with DIP switch $S_3$ (note that the MSB switch is not used in this application).

The various inputs are selected with press-keys $S_1$ and $S_2$. Gates $IC_{1d}$ and $IC_{1e}$, in conjunction with networks $R_1$-$C_1$ and $R_3$-$C_2$, provide effective debouncing of the keys.

Resistor $R_5$ and capacitor $C_3$ ensure that when the power is switched on, the counter is set.

If fewer than eight inputs are needed, the number can be reduced to four by resetting jumper $J_1$ so that pin 9 of $IC_6$ is linked to a fixed level. The non-used inputs of the multiplexer, pins 1, 2, 4, and 5, must be strapped to earth.

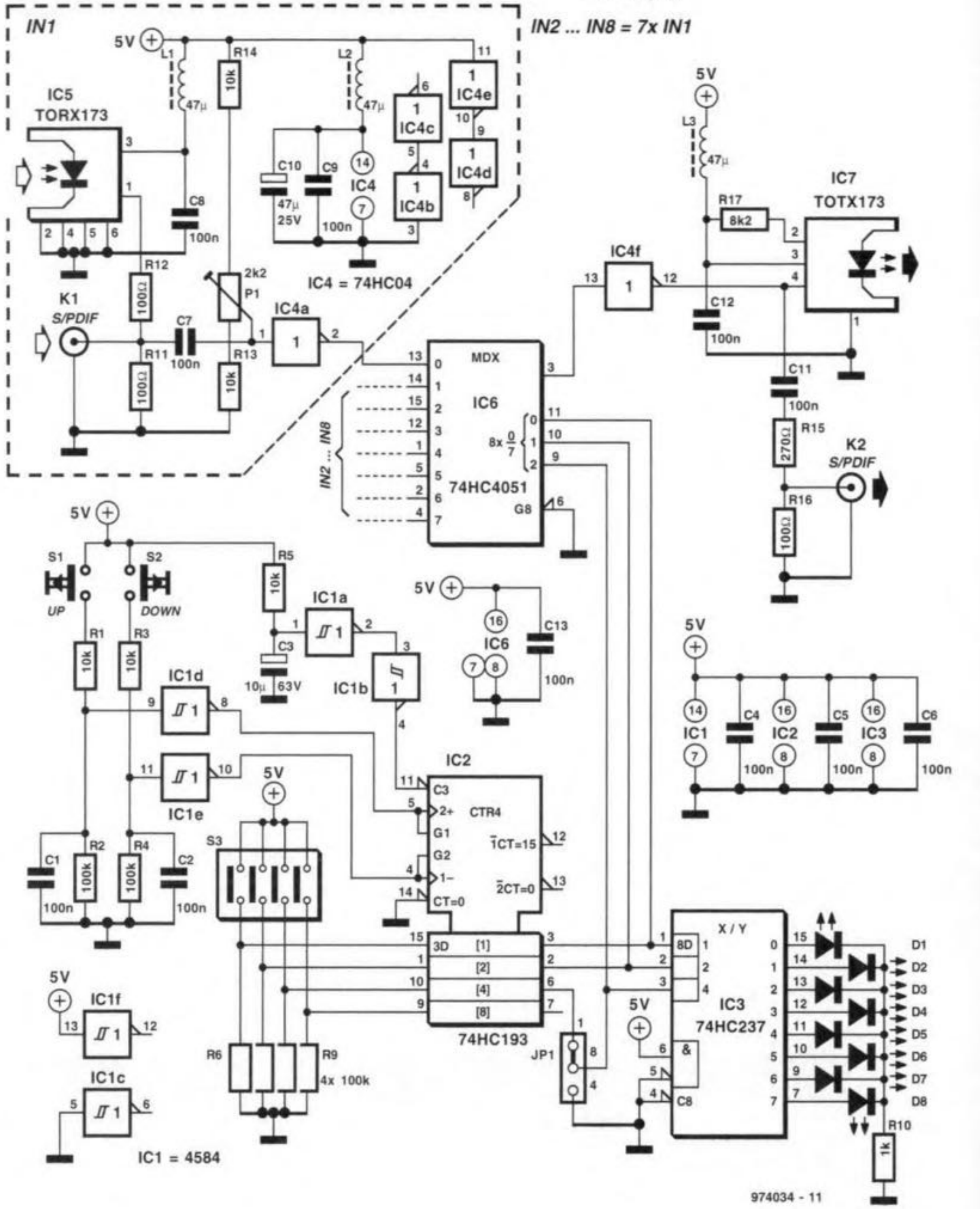
Which of the inputs is selected is indicated by one of four or eight LEDs that are controlled by 3-to-8 decoder $IC_3$ at the outputs pf $IC_2$. If four inputs are used, $D_5$–$D_8$ must be omitted.

Since the digital-audio- input circuits are identical, only one is shown (in dashed lines at the top left-hand side of the diagram). Each has an optical input ($IC_5$) and a coaxial input ($K_1$). It needs only one inverter (here $IC_{4a}$); the others ($IC_{4b}$–$IC_{4e}$) are strapped to earth.

The output of the selector also has an optical output ($IC_7$) and a coaxial output ($K_2$).

The current drawn by the selector depends primarily on the number of optical modules (each of which draws 20–25 mA).

If standard LEDs instead of high-efficiency types are used, the value of $R_{10}$ should be lowered to 220 Ω. The total current drain then rises by about 10 mA. [Giesberts – 97034]



# smartcard reader/writer

## *part 1*


**Although they look like any ordinary plastic chipcard of the synchronous type, Smartcards are functionally very different because they have an internal microprocessor rather than just an amount of non-volatile memory. A complete microprocessor system by itself, the Smartcard can only function by means of an asynchronous dialogue with a special reader unit. This article describes such a reader, which, as you may have guessed, works in combination with a PC.**

Far less expensive than commercially available 'development kits', the simplified Smartcard reader described in this first instalment of a two-part article mainly enables you to read and write from/to the majority of Smartcards currently on the market.

### High-security cards

Much dearer than your typical (synchronous) chipcard, cards with an internal microprocessor are reserved for applications requiring either complex functionality, stiff security, or both, so we're talking about credit cards, cards for pay-TV, cellular radio, etc.

The drawing in **Figure 1** shows an internal structure which is used for nearly all Smartcards. Although the microprocessor at the heart of the circuit may be a special type, it is usually just a 'lesser' member from a well-established family.

As with just about any other chipcard, the Smartcard's main function is to guarantee the security of the data stored in its non-volatile memory.

This security is achieved by disabling any kind of direct access (from the outside) to the contents of the card memory, as well as any read operation, write operation, or temporary authentication by the internal microprocessor, which is the one and only element capable of physical access to the memory.

In practice, an instruction is sent to the Smartcard, and it is up to the microprocessor on the card to decide whether the instruction is executed or not. For this decision the microprocessor looks at the security rules it has been programmed to enforce.

The reply of the card to an instruction typically consists of a kind of report giving details of what happened after the instruction was received (and accepted as valid), possibly followed by a block of data which may be encrypted.

Using present-day technology, the above exchange of information between the card reader and the Smartcard follows a half-duplex protocol using a single input/output line (contact ISO7 on the card).

Although the ISO7816 standard covers a number of different communication protocols, the card/reader dialogue is usually based on the following parameters: 9600 bit/s, 8 data bits, 1 parity bit (even), and the equivalent of at least 2 stop bits.

Although we would all very much like to connect these Smartcards straight to the PC's RS232 port, that is, alas, not possible, and there's no way to go round a unit called 'card coupler'

Design by Patrick Gueulle

to ensure compatibility between the PC port on the one hand and the Smartcard on the other.

## A simplified coupler

In insiders' jargon, the term 'coupler' is often used to describe a function which **Figure 2** attempts to illustrate.

A coupler has to manage all interfacing, electrically and functionally, between the Smartcard and a 'host system', which is typically a PC sporting an RS232 port.

Apart from the circuits that handle the electrical control of the card contacts, a coupler can't work without an internal microprocessor.

So, an integrated interface circuit without a microprocessor (or microcontroller) is not, strictly speaking, a coupler, with due respect to some manufacturers, while a coupler fitted with a card connector is not just a coupler but a 'card reader'. The current tendency is towards building couplers by linking a microcontroller to an interface circuit which may take the form of an ASIC, or, in a simpler way, a dedicated building block such as the Philips TDA8000.

There is no doubt that Smartcard technology will eventually evolve towards a single-chip coupler which integrates a mask-programmed microcontroller and a couple of interface circuits.

By contrast, there is no reason why all card control functions can not be handled by the processor in the host system. After all, all you have to do is give the host system a suitable interface, which may be a matter of a couple of discrete components.

The problem is that writing coupler control software that complies with all standards is highly specialised work, not within the capacity of most software developers whose aim is just to add a card reader function to a certain project.

As far as we are concerned, the goal is very clear: being able to perform the highest possible number of manipulations (of an experimental character) on the highest possible number of Smartcards, using any ordinary PC.

Because it would be wasteful to use such a powerful computer as a dumb terminal only, we decided to make the coupler as simple as possible, and shift (in a manner of speaking) a number of its functions to the software which runs on the PC. This approach facilitates the development of the resulting combination without calling the 'firmware' part into question.

The microcontroller in the coupler circuit, a PIC16C84, performs a number of crucial functions: switching the card contacts on and off in the proper way, supplying the card clock signal, and interfacing between the bidirectional data line of the card and the TxD/RxD lines on the RS232 port.

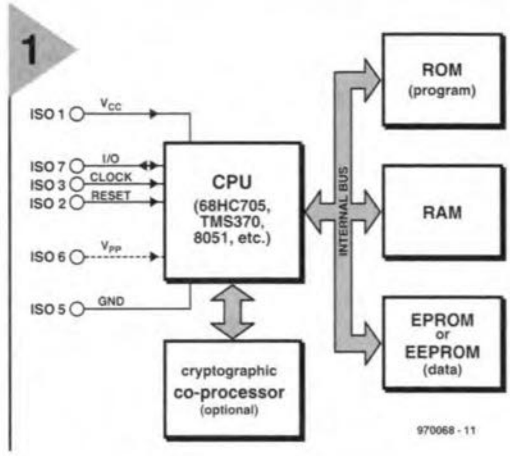



***Figure 1. Internal structure of a typical Smartcard (asynchronous intelligent chipcard). This type of chipcard may be controlled by different types of microprocessor.***

Rather than employing a specific integrated circuit which may suddenly go obsolete and then into silicon oblivion, the functionality of the electrical interface is vested in a handful of discrete parts which handle their tasks just fine within this context.

## Circuit description

All of the definitely original choices discussed above contribute to the circuit diagram shown in **Figure 3**. Let's look at the schematic in some detail.

It is possible to run the circuit off a single +5 V supply rail (available on pin 1 of the 15-way sub-D style joystick connector), in which case you don't fit diode D7 and capacitor C5 (provided for mains adaptor powering), omit regulator IC4, and install a wire link between the anode of D5 and the output of IC4. The circuit has a separate input marked $V_{pp}$ for an optional (external) programming voltage supply.

You should be aware of the fact that all Smartcards may, in principle, be read if the $V_{pp}$ line is held at 5 volts. Consequently, the present circuit arranges for this 'default' voltage to be applied to the $V_{pp}$ input. Note, however, that some very old cards (notably those manufactured in NMOS EPROM technology) require a higher voltage for write operations and for the retrieval of confidential codes.

Only if necessary, a simple laboratory supply is connected to the $V_{pp}$ pins. The output voltage of the supply is then set to the programming voltage required by the Smartcard (21 V in most cases).

As far as the clock signal applied to the card is concerned, this is 'stolen' from the PIC oscillator output which supplies a frequency of 3.579 MHz (a cheap NTSC crystal is used). This clock frequency sets an ETU (elementary time unit) of 104 $\mu$s for most Smartcards, and, consequently, a fixed data transfer speed of 9600 bits per second.

According to the ISO7816 standard, the microprocessor in the coupler should be in charge of setting up the programming voltage, $V_{pp}$, the clock frequency, and various other parameters which depend on requirements 'formulated' by the Smartcard. These parameters, by the way, even allow the system to negotiate a certain protocol.

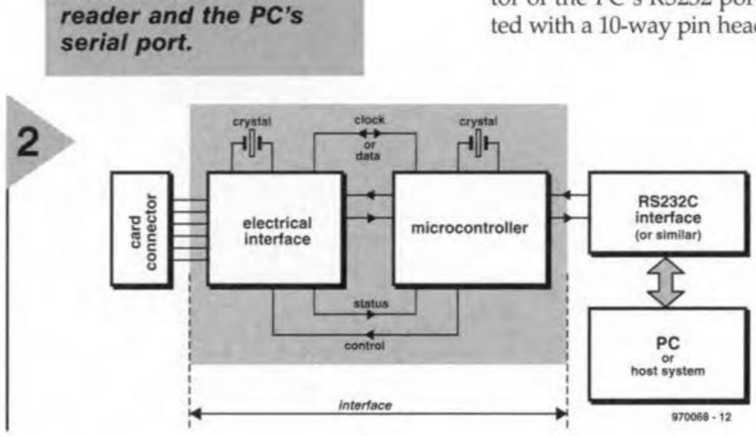
As far as the author is concerned, the ability to control these parameters directly provides an interesting degree of liberty, because it enables certain manipulations to be performed which are off the beaten track because they are not normally possible on ready-made couplers.

## Construction

Rather than fitting the Smartcard connector on the same printed circuit board as the coupler (interface circuit) proper, we decided to split the present card reader module into two boards:

- a coupler which is directly compatible with the 9-way sub-D connector of the PC's RS232 port, and fitted with a 10-way pin header ready

***Figure 2. Functional diagram of the coupler which forms the link between the Smartcard inserted into the reader and the PC's serial port.***



## 3

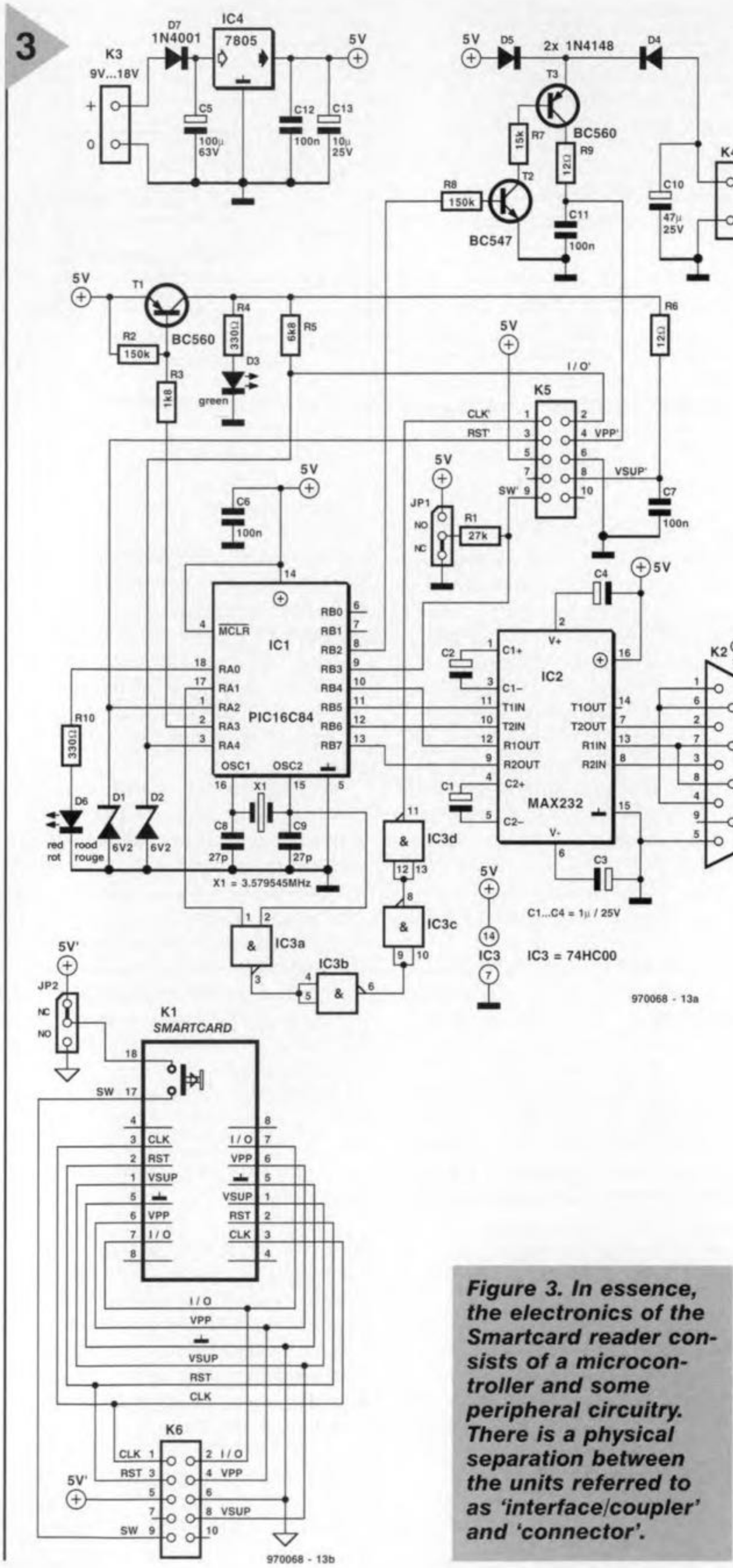



***Figure 3. In essence, the electronics of the Smartcard reader consists of a microcontroller and some peripheral circuitry. There is a physical separation between the units referred to as 'interface/coupler' and 'connector'.***

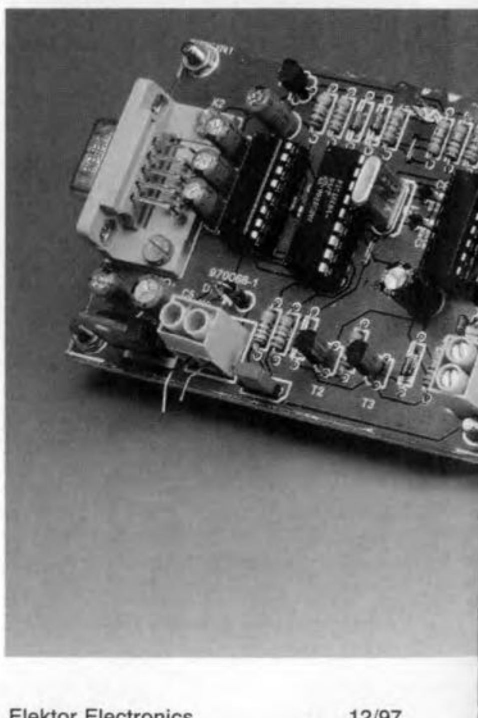
### COMPONENTS LIST

**Resistors:**
R1 = 27kΩ
R2,R8 = 150kΩ
R3 = 1kΩ8
R4,R10 = 330Ω
R5 = 6kΩ8
R6,R9 = 12Ω
R7 = 15kΩ

**Capacitors:**
C1-C4 = 1µF 25V radial
C5 = 100µF 63V radial
C6,C7,C11,C12 = 100nF
C8,C9 = 27pF
C10 = 47µF 25V radial
C13 = 10µF 25V radial

**Semiconductors**
D1,D2 = zener diode 6V2 400mW
D3 = green LED
D6 = red LED
D4,D5 = 1N4148
D7 = 1N4001
T1,T3 = BC560
T2 = BC547
IC1 = PIC16C84 (order code 976512-1)
IC2 = MAX232 (Maxim)
IC3 = 74HC00
IC4 = 7805

**Miscellaneous:**
K1 = Smartcard connector, ISO7816 layout, with card detection switch. ITT Cannon code 160-5230, or RS Components code 453-791.
X1 = 3.579545MHz quartz crystal
K2 = 9-way sub-D socket, PCB mount, angled pins.
K3,K4 = 2-way PCB terminal block, pitch 5mm
K5, K6 = 10-way boxheader, straight.
Length of 10-way flatcable with 10-way IDC socket at either end.
JP1,JP2 = 3-way pinheader with jumper
PCB, disk and programmed PIC: order code 970068-C
Disk only: order code 976014-1



to accept a mating IDC socket.

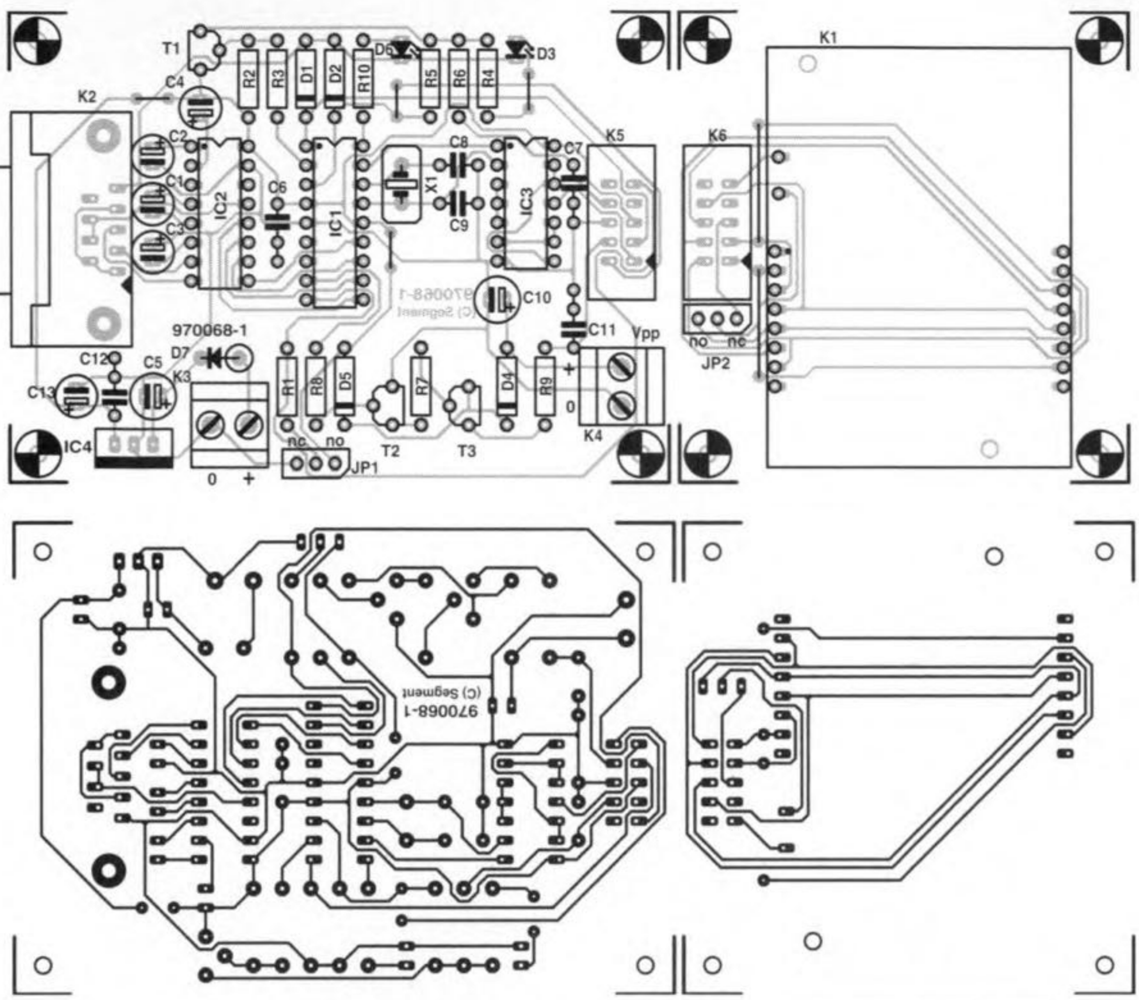
- a chipcard connector module which is compatible with ISO and (rare) AFNOR format cards, also having a 10-way pinheader for the link to the coupler card.

So, you get a complete Smartcard reader simply by connecting the corresponding pin numbers on the two sub-boards by 10 cm or so of flatcable fitted with an IDC socket at either side.

The advantage of this arrangement is that the original card connector module is easily replaced by other models, for example, a miniature type as used for GSM telephones.

In the not too distant future, you

**4**

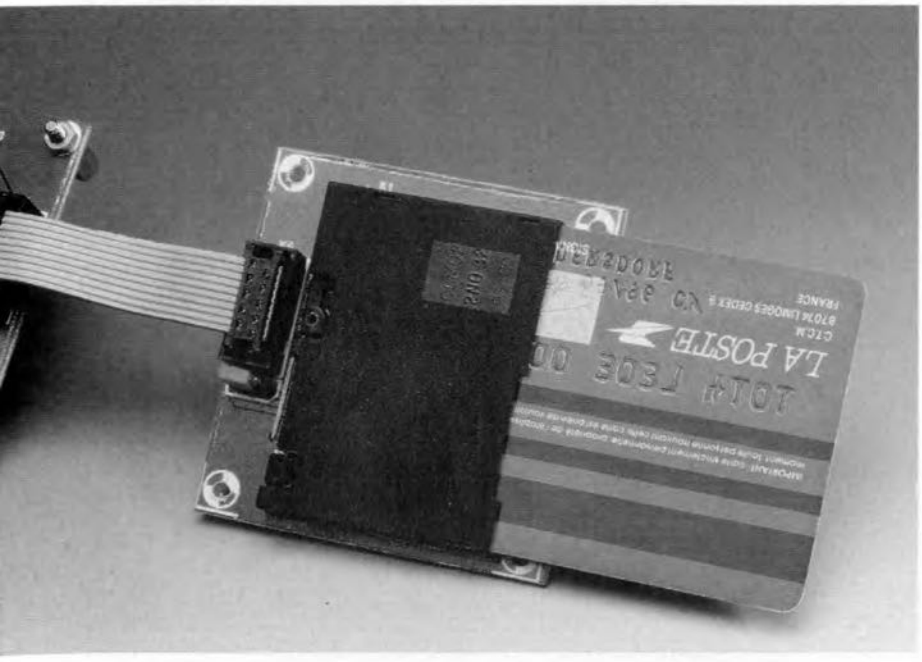



may even be able to replace the connector with a receiver/transmitter unit capable of communicating with contactless chip cards which are rapidly gaining acceptance.

**Figure 4** supplies the copper track layout and component location plan of the single-sided printed circuit board designed for the Smartcard reader. This board is available ready-made through our Readers Services, together with the pre-programmed PIC16C84 and the software utilities diskette, as order code **970068-C**. The three components may also come as part of a kit supplied to you by one of our advertisers.

As you can see, the board consists of two sections: to the right, the sub-board with the card connector module (ITT-Cannon) on it; to the left, the sub-board with the coupler (interface) circuit on it and the rest of the electronics.

***Figure 4. Copper track layout and component mounting plan of the single-sided printed circuit board designed for the Smartcard reader (board available ready-made). Before you start fitting the parts, cut the board in two to separate the 'interface/coupler' section from the 'connector' section.***



There is little to say about the actual construction of this project. As a matter of course, you start by separating the two sub-boards. Fitting the components onto these boards should be mostly plain sailing. Be sure, however, not to overlook any of the six (4 and 2) wire links on the two boards. Also concentrate on the polarity of the polarised components (capacitors, diodes, LEDs and integrated circuits). Some components are mounted upright.

The 3-way pinheaders identified as **JP1 and JP2** allow you to choose between two versions of the card connector module. The difference arises from the internal card detector switch, which is either a normally open (n.o.) or a normally closed (n.c.) type. Note that the actual jumper positions for n.o. and n.c. are not the same on the two pinheaders!

The PIC microcontroller comes preprogrammed through our Readers Services or your kit supplier. If you need it as a separate part, its order code is **976512-1**.

## Answer to Reset (ATR)

To be able to actually use the present circuit and the associated software utilities, it is essential to know the 'language' used by Smartcards to communicate with reader units.

Although full details of this language are specified at length in the ISO7816 standard, there are only a couple of really essential points to observe.

The first, rather fundamental, principle involves a term you have to know because it is frequently used: **ATR** for Answer to Reset.

After a suitable signal is applied to the RESET contact of the card (ISO2) with the supply voltage and a clock signal present, a Smartcard normally complies with the standard by transmitting a message consisting of up to 33 bytes. This message contains a certain amount of normalised information which serves to enable the coupler circuitry to recognize the characteristics of the card it will be communicating with shortly.

The very first character of the ATR word is especially interesting because it indicates if the ensuing traffic (exchange of data) is compliant with the straight-ISO or inverted-ISO conventions.

Using the 'straight' convention, bytes are transmitted sequentially, LSB (least significant bit) first, via the ISO7 contact, with a logic 1 represented by a 'high-impedance' state.

The 'inverted' convention, by contrast, rules that the bytes are headed by the MSB (most significant bit), while logic 1s are encoded as 'low' levels (0 volt).

If we use the symbol 'Z' to indicate the high-impedance state, and 'A' to indicate the logic low level, then the first character of the ATR word (including start bit and parity bit) may be written as follows:

– AZZAAAAAAZ

for cards of the 'inverted-ISO' type, or

– AZZAZZZAAZ

for cards of the 'straight-ISO' type.

After conversion to hexadecimal, and observing the relevant standard, these characters read $3F_H$ and $3B_H$ respectively.

Any other character heading the ATR sequence, or no ATR at all, should be taken to mean that the card is either faulty, non-standard, or of the synchronous type.

## About the software

The suite of small programs (utilities) to be described here and in next month's final instalment is available in the form of executable files on a floppy disk which you may obtain through our Readers Services, or as part of a kit. The order code of the 3.5-inch diskette is **976014-1**.

The utility **ATREAD** was written with the aim of (1) capturing the ATR of any Smartcard which is inserted into the reader module, (2) determining its standard, and (3) building a disk file (ATR.CAR) which reflects the contents of the card.

Like all other programs in the 'toolkit' on the disk, ATREAD is provided with a security function which prevents any risk of voltage being untimely applied to the card. This security provision works on the following principles:

- As long as the program is not started, the coupler is disabled from applying any voltage to the card, even if a card is inserted and removed several times.
- Once the program is up and running, inserting a card into the reader causes the supply voltage to be applied. If a card is already present in the reader unit the moment the program is launched, it has to be removed and re-inserted.
- Once the program has completed its task (or if it is interrupted), it arranges for the card supply to be switched off completely.
- If a card is pulled from the reader unit before a communication is finished, the coupler still arranges for the card to be switched off properly.

When a Smartcard has finished transmitting its Answer to Reset message, the program displays the applicable format and the complete ATR message in hexadecimal notation.

For example, in the case of a bank card using the inverted-ISO format, the resulting message may read

```
3F 65 25 08 31 04 6C 90 00.
```

By contrast, a Smartcard for a GSM phone using the straight-ISO format may produce a message like this:

```
3B 7B 11 00 00 29 C1 01 05 00 1E 55 00 00 90 00.
```

Often, but not always, the ATR message ends with 90 00. This pair of bytes generally indicates that all is well inside the Smartcard.

In fact, the significance of the last two characters of the ATR is not regulated by the ISO standard. These characters are 'historic remnants', and their use is not regulated. Consequently, the characters may differ depending on the application of the Smartcard.

The decoding of the really meaningful part of the ATR message is handled by a second software utility called **ATRDEC**, which employs the data stored in the file **ATR.CAR** (which is basically an ASCII text reproducing the ATR message in binary form).

In this way, you may discover (from the TB1 parameter) the value of the external programming voltage (if applicable) which the card may require for write operations into the memory. The information also includes the type of protocol (parameter T) to use for the rest of the dialogue.

**T=0** is the most commonly found information, indicating the oldest half duplex protocol laid down in the ISO 7816-3 standard (clause 8 to be precise). In any case, it is the default protocol which is applied when none is specified, and also the one supported by our software utilities. A specific feature of the T=0 protocol is that bytes are transmitted one by one.

Certain recent applications start to make use of the **T=1** protocol, which is based on transmission by the block, and, consequently, potentially faster than the T=0 protocol.

**T=4** is reserved for a future, improved half-duplex protocol while the values **T=2** and **T=3** indicate half-duplex protocols yet to be defined.

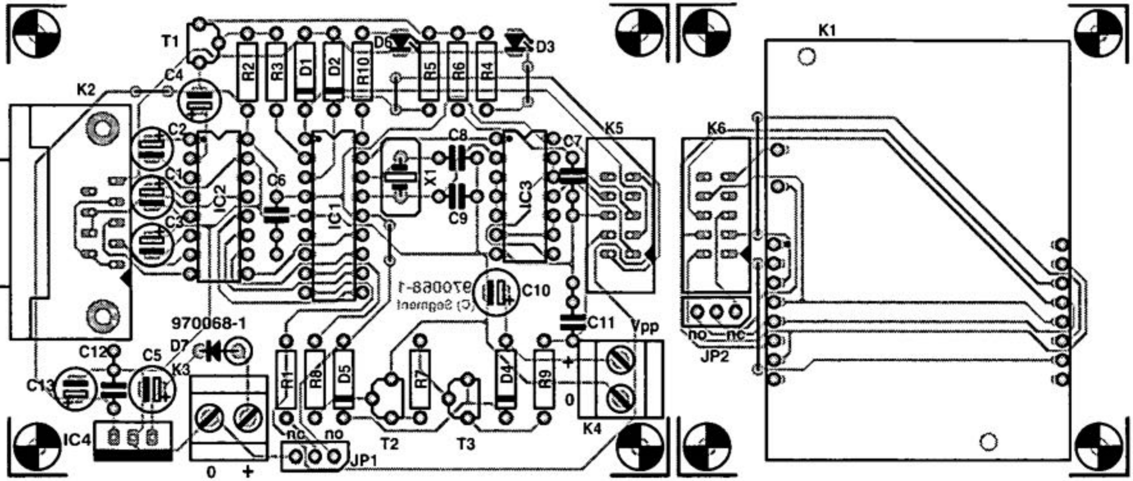
**T=14** bundles all non-standard ISO protocols, which, in practice, are few and far between.

The appearance of a **TA1** character may indicate that the Smartcard you have inserted needs a particular clock frequency, and/or a communication speed other than 9600 bits/s. In either case, you should consult the ISO 7816 standard to check for compatibility with the default characteristics of the reader unit.

Finally, a **TC1** character may impose a 'guard delay', which means a delay to be inserted between the transmission of two successive bytes.

That bring us to the end of the first instalment of this article. In the second instalment, to be published next month, we will be looking at the 'software' aspect of this project, discussing the various utilities which are available on the diskette mentioned earlier on. These utilities allow you to strike up a conversation with the Smartcard inserted into the reader unit.

(970068-1)



T1
R2
R3
D1
D2
R10
D6
R5
R6
R4
D3
K1
K2
C4
C2
C1
C3
IC2
C6
IC1
C8
X1
C9
IC3
C7
K5
K6
C10
970068-1
(C) Segment
C11
Vpp
970068-1
D7
C12
C5
K3
C13
R1
R8
D5
R7
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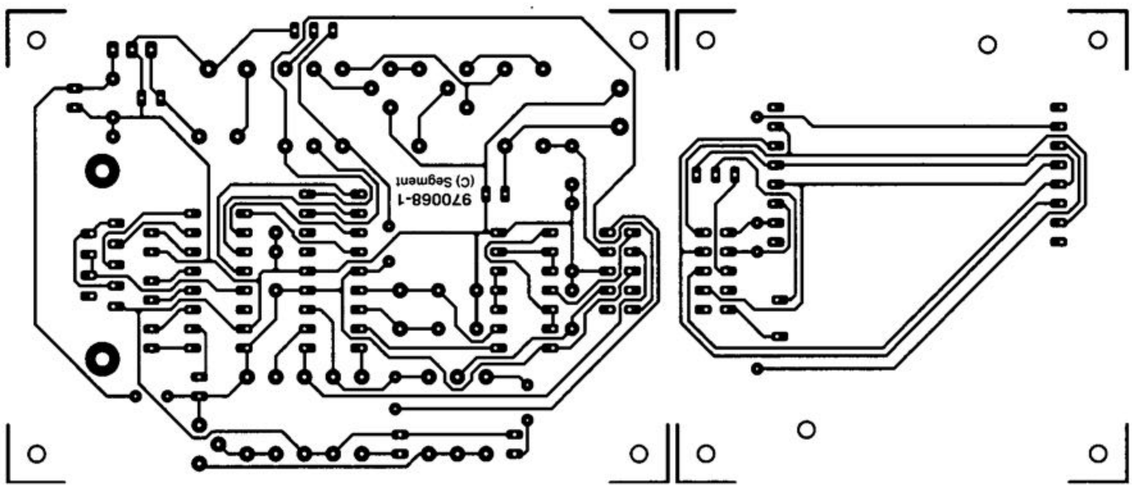
JP1
0
+
no
nc
JP2

(C) Segment
970068-1

# automobile navigation systems

## *based on the Global Positioning System (GPS)*


**A CD-ROM containing the equivalent of a trunk full of maps can provide the database for a computer-controlled navigation system in motor vehicles. As such, it may be used with the global positioning system (GPS) and suitable software to give an accurate fix.**

By E. Krempelsauer

### THE SYSTEM

Automotive electronics keeps on advancing at a high rate, thanks to the power, reliability and, last but not least, the steadily decreasing cost of its components. Microelectronics has reached the stage where it has become possible to use systems in motor vehicles that are far more complex than the track control and antilock braking systems (ABS) of yesteryear. Electronic distance control based on radar measurements is already in production. Active steering control and electronic brake-by-wire (no hydraulics required) are in an advanced stage of development. Automatic vehicle control on motorways is beginning to look a practical proposition. To prevent the driver getting bored, the on-board multimedia PC provides entertainment, information and worldwide communication via digital video disk (DVD) and mobile connection to the Internet.

One of the most interesting developments is the availability of a satellite-controlled automatic positioning system. This has been in operation for some time, but has only recently become available on the consumer market.

The system is NAVSTAR, a highly complex navigation system, originally developed by the US Department of Defense for military purposes, but which can now also be used by civilian operators. NAVSTAR uses the propagation delay of the signals transmitted by a number of satellites. Each satellite carries a highly accurate atomic clock that controls the transmission of digitally coded time signals at a frequency of 1575.420 MHz. The satellites are identified by a unique code.

Each code, referred to as the C/A (coarse acquisition) code is 1023 bits long and repeated 1000 times a second, producing a rate of 1.023 Mbit/s.

In order to obtain a fix in three dimensions, it is necessary to obtain data from three satellites. Since positional accuracy will not be uniform across the earth's surface, a fourth satellite is always used to provide a cross-reference.

Differential GPS improves the accuracy of fixes to within 1 m by the additional use of a fixed GPS receiver located at an accurately known position.

The computer in this reference receiver compares its position with that obtained from GPS so that it can calculate a correction factor. This is then transmitted to all suitably equipped mobile GPS receivers, where it can be applied to the coarse fix to calculate a position accurate to better than 5 m.

With the advent of small computers, a whole new family of GPS devices has appeared on the market. A laptop personal computer (LPC) can easily be fitted with a Sat-Nav receiver and a small external antenna to provide a small, mobile navigation system.

Active antennas now available for use in motor vehicles allow the receiver to track up to eight satellites simultaneously. With the processing power of the LPC, it is possible to obtain location fixes accurate to within 25 m.

When a car speed sensor, a vibration gyroscope, and some suitable software are added, the computer, in conjunction with the maps contained in the CD-ROM, is able to calculate the most favourable route to follow, regularly provide fixes, and provide the driver with road information – visibly via an LCD display and audibly via a small loudspeaker. Soon the driver will be able, thanks to RDS (radio data services, called RBDS for radio broadcast data system in the USA), and DAB (digital audio broadcasting), to obtain information on the traffic situation ahead and take appropriate action.

Complete systems already available are 'Travel Pilot' from Blaupunkt, 'Route Planner' from Magneti Marelli, 'CARiN' from Philips, as well as a system from Alpine. Recently, Siemens decided not to make its IDIS (integrated driver information system) available other than to car manufacturers. It is available on Porsche cars as an optional item under the name PCM (Porsche Communication Management). The system includes not only the navigation equipment, but also the car's audio installation, a mobile telephone, and an on-board computer.

The map data contained on the navigation CD-ROM for European areas are provided, at the time of writing, by only two concerns: NavTech and TeleAtlas.

## EQUIPMENT

The block diagram of a typical car navigation system is shown in **Figure 1**.

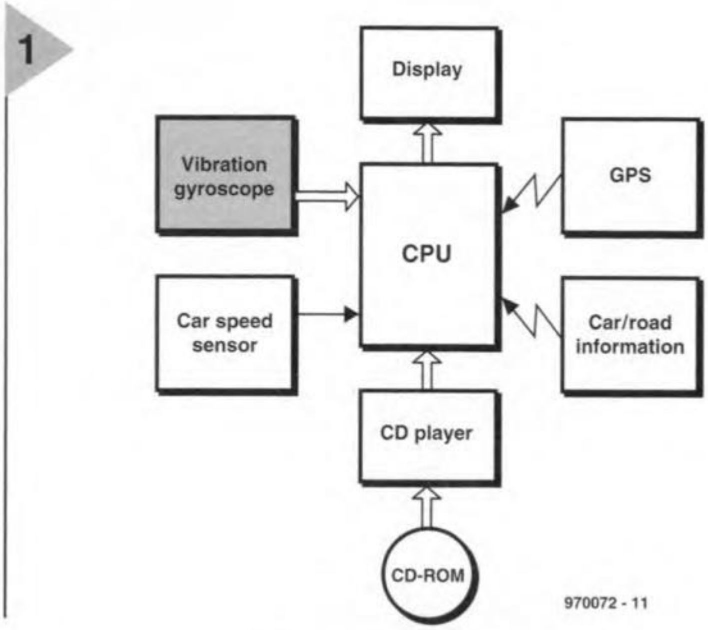



***Figure 1. The constituents of an autonomous navigation system for use in motor vehicles. The CD-ROM drive, variation gyroscope, and GPS receiver, are incorporated in the enclosure of the navigation computer.***

The system consists of the equipment already mentioned plus an RDS-to-TMC (traffic message channel) interface (car/road information).

The car/road data are derived by all manufacturers from the pulses provided by the electronic rev counter (in the few rare cases that the car has a mechanical rev counter, a pulse generator is added). The wheel sensors used by Blaupunkt are rather too intricate for the present purpose. Until recently, Blaupunkt provided an electronic compass with the relevant magnetic-field sensor fitted to the rear window. This has been replaced by a small gyroscope (also fitted by the other suppliers). Blaupunkt uses one based on a tuning-fork sensor from Panasonic, whereas the others have chosen a piezo-electric model ('Gyrostar') from Murata.

Like the GPS receiver, the computer, and the CD-ROM drive, the gyroscope is incorporated in the central processing unit. The only external items are the antenna, the LC (liquid crystal) display, the loudspeaker, and the control unit (see **Figure 2**).

The monitor is a colour LCD with an active four or five digit (10 cm or 12.5 cm) TFT (thin-film transistor) dis-


***Figure 2. Practical realization of the CARiN system from Philips. The external components, the control unit, LCD monitor and GPS antenna are shown in the foreground.***

3


***Figure 3. Navigation display in a combined dashboard instrument from Mannesmann-VDO, which is linked to a central computer.***

play. There are also small monochrome displays which can indicate direction and distance by means of appropriate symbols, but these are not suitable for displaying maps (see **Figure 3**).

The cost of these systems is still prohibitive for most car owners (but not owners of heavy-goods vehicles). The simple distance-and-direction systems cost from about £2,000 upwards, depending on specification. The CD-ROM with maps costs close to £100, but 6-monthly up-dates are needed (advisable?) at about £75.

Speech reproduction need not be by a separate loudspeaker, but can be arranged via the car's radio/cassette player. Some suppliers, e.g., Philips and Alpine, fit the loudspeaker in the monitor.

The control unit is normally of the remote variety in case of a retrofit, but is usually mounted in the instrument panel in case of a factory-fitted installation.

## NAVIGATING

The systems are all based on dead reckoning.This is an estimation of the position based on the direction and the speed of travel and the time elapsed since the last position was established. These quantities are measured by the relevant sensors and the estimated position is based on these and the CD-ROM maps.

Owing to the inadequate accuracy (better than 5 m) of the GPS system for automobile purposes, it is used to establish an approximate fix. Then, the computer couples this to the dead reckoning information and the maps in the CD-ROM to establish a much more accurate position. Note that this is a continuous process. When the computer receives data indicating that the vehicle does not follow the correct outline of the road it is on (as indicated on the electronic map), it corrects the position until the movement of the vehicle is righted.

The fix can be made even more accurate on the basis of a bend in the road or a change of direction at a cross-roads. The map matching, that is the continuous comparison of the evaluated sensor outputs with the data on the electronic maps, results in an accuracy of better than a few metres. This accords with the accuracy of the electronic maps, which in towns and cities is of the order of 2–5 metres and out of town within 25 metres.

## HARDWARE AND SOFTWARE

In most systems the software for the computer is contained on the map CD-ROM. This ensures that when the disk is updated, the latest version of the software is available. This saves some money, because the computer has no hard disk. On the other hand, it has a relatively large RAM; for instance, 4 Mbyte in the TravelPilot RGS06 from Blaupunkt. The CPU in this system is a 16-bit microprocessor from NEC's V50 family. The software is programmed in 'C' or 'C++'.

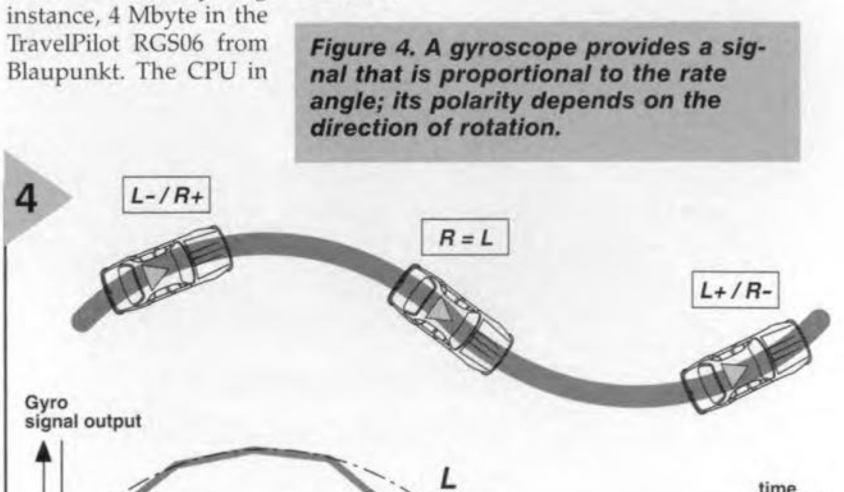
The power of the system depends really on the quality of the software and the data on the CD-ROM. It is, of course, important that the electronic maps are fully detailed as to traffic restrictions, such as 'no left' or 'no right' turns, pedestrian precincts, priority at crossings, and so on. Each update corrects and expands the database, but there is also a facility to correct or add a particular aspect via the software.

The standard function is a turn by turn indication via clear arrow symbols for the direction and a distance indication in metres or as a bar, combined with an audible message (see introductory photograph and **Figure 3**), which is in one of several languages.

The arrow indications may be replaced by relevant markings on the streetmap (see **Figure 6**). Distinctive features, such as crossings, street names, topographic symbols, wanted destination (typed in, chosen from a

***Figure 4. A gyroscope provides a signal that is proportional to the rate angle; its polarity depends on the direction of rotation.***

4



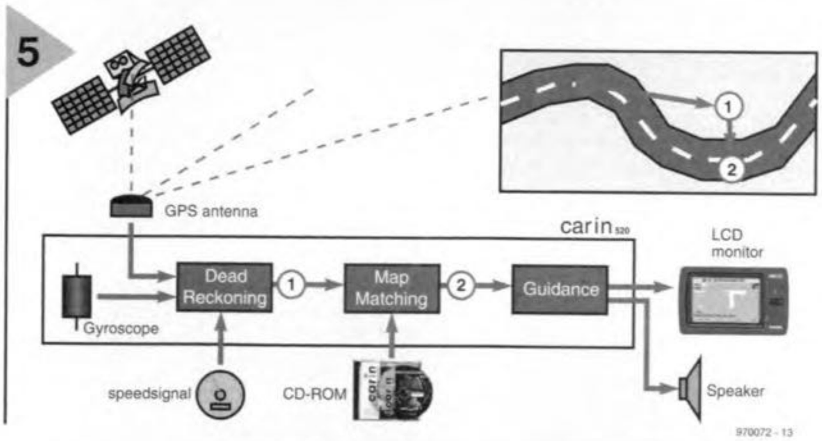



***Figure 5. Map matching of the positions established by GPS and dead reckoning (1) with the map data in the CD-ROM results in a fine adjustment (2), which enables the system to provide the driver with precise instructions.***


***Figure 6. It is possible to show a diagram of the route guidance on the electronic map on the LCD monitor.***


***Figure 7. The integrated driver information system (IDIS) from Siemens includes the control of the vehicle's audio system, mobile telephone and on-board computer. This system is offered as an optional extra on Porsche cars under the name Porsche Communication Management (PCM).***

list or clicked on), and so on, may be detailed by zooming in (automatically or manually).

The most accurate selection in town and city are crossroads in the area of the destination. To simplify the approach to the destination, all CD-ROMs contain data on particular locations, such as hotels, airports, railway stations, petrol stations, parking garages, parking places, hospitals, and so on. These can be selected directly. Even house numbers may be selected, although there may be restrictions on these owing to incompleteness of data.

At present, entire streets and squares can only be found in bigger towns and cities, but with every update, more and more detail becomes available. There are special CD-ROMs available – at a price – with travel, restaurants and hotel guides (Merian-Scout), or golfclubs!

## TELEMATICS*

The best navigation system does not help much when you are stuck in a traffic jam. If, however, you are warned of such a jam before you get there, it can be of great help, because it can compute an alternative route within seconds. A recent addition to the radio data system is the traffic message channel (TMC), which is already incorporated in the latest car radios. This channel makes it possible for the navigation system to process traffic information directly and provides dynamic guidance via the RDS-to-TMC link.

A similar link may be used in future DAB radios. In principle, DAB car radios, even without being linked to a navigation system, will be able to display on a separate colour monitor actual and individual traffic news.

The combination of a mobile telephone and a small GPS terminal in a motor vehicle supplies the traffic computer with data on the GPS fix , which enables it to assume the function of dynamic guidance. If this proves successful, the autonomous navigation system with CD-ROM may well remain a niche market. The future will then belong to the integrated information and communication system in the vehicle, that is, telematics, used as an aid to navigation.

[970072]

** Telematics is the integration of computer-processing applications with telecommunications capabilities.*


**We can only answer questions or remarks of general interest to our readers, concerning projects not older than two years and published in *Elektor Electronics*. In view of the amount of post received, it is not possible to answer all letters, and we are unable to respond to individual wishes and requests for modifications to, or additional information about, *Elektor Electronics* projects.**

## Handing on to the very young

Dear Editor: I am concerned about the shortage of young engineers in this technological age.

During the 1920s, many became interested through building wireless sets. When I was a student during the 1950s, there was a pioneering interest in home-built television and tape recorders. But looking though current kit catalogues I find few projects which are simple and attractive enough to interest children under, say, 10 years of age.

The following describes an approach to overcoming these problems. I believe that you must have a number of readers who are parents and would find it of interest.

Having met with some success in introducing technology to my three grandsons, I would like to explain our practical activities over the past few years so that others may benefit. My experience is with boys aged up to 7 -- I see no practical reason why girls should not benefit too.

It all came about because of the following.

1. My daughter and son-in-law needed back-up in keeping three lively youngsters occupied, particularly during the school holidays. They were therefore keen for any help to be a success.
2. Such young boys have such a keen appetite for new experiences that it seemed a pity not to channel this drive into a useful direction.
3. I was aware of the fact that society needs a more plentiful supply of keen, practical engineers for the future.

Early efforts to involve the eldest child presented few problems. I found that up to the age of about 5, play takes the simple form of a desire to 'bash things up'. I have a small workshop in the house, and an ample supply of old printed circuit boards that would respond to the old wire cutters or hammer. We have a convention that grandpa keeps any valuable salvaged components.

For safety, it is necessary to accompany the child continuously, pointing out how to avoid injuring the hands or eyes. No child wants to be hurt, but the enthusiasm is likely to get the better of him at times. Up to the age of 6, I allowed him to use wire cutters, pliers without the shearing cutters used on electrician's pliers, light hammer, wire strippers, and screwdrivers. It is problem when the second child arrives on the scene, wanting to join in. After some worrying sessions with two or three, I had to conclude that it is only possible to supervise one child a a time. That way, it has been possible to limit injury to minor scratches needing nothing more than an adhesive plaster to clear away the tears.

When he was 6, I began to step up the inducement to start a constructive project. Note here that broadcasters and school staff are obsessed with the word 'science'. This implies theoretical principles rather than functional hardware, and is a passport to a child's apathy. What I sought was a battery-driven device (for safety) which was rather unusual, but would play a part in the children's play when complete. The solution came from the eldest child. He wanted a traffic signal. The specification soon fell together, with the help of the Maplin catalogue. It is very important to prepare each session before the child arrives.

**Specification for chosen project**

PP3 battery.

4 sets of red, amber and green LEDs, large, one of the sets in each of the four faces of a single signal head.

4-position rotary switch which, turned clockwise, is hard-wired via diodes to give the correct signal-light sequence for a pair of intersecting roads.

Battery switch.

Signal head made from pieces of oak. Post of brass tube, supported on an aluminium box for controls and stability.

It is as well to buy some 20% spare components. They tend to get lost or damaged.

Total height 24 cm.

Construction is proceeding apace, the mechanical part being completed first. It is practical to use most hand tools, guiding his hand with saws and files. When the electrical construction follows, it teaches him a good deal if much testing is done. It is stimulating as he likes to see the facilities springing to life. At this early stage there is no need for Ohm's law and other theory, but I have shown or told him the following.

1. What happens if too much current is passed through a wire. This was done by shorting an old car battery with a piece of mains cable, with child standing well back.
2. How some components have to be connected the right way round, while others do not matter. The clearest example is an LED.
3. How too much current will run a battery down fast, for instance, with a short circuit. An analogue voltmeter is best, although the units and numbers do not yet mean much to him.
4. How getting involved with the mains can lead to severe shock or even death. Death stories appeal to the very young.
5. How other metal parts as well as wires can conduct current.

Bear in mind that the whole involvement is a kind of practical play, and it is wise to get junior to do as many of the processes as possible. This makes him feel keenly involved.

We now come to soldering. I first showed him how the iron quickly reached the temperature where it would boil water (spit), and how it continued to heat up until it would melt metal (solder). I then went on to state how parts of the iron became hot enough to cause burning, insisting that I and only I should handle the iron. Danger appeals and concentrates the junior's attention. I repeated the description of the dangers as they occurred, of remaining with the iron for all the time while it was hot. It is important to demonstrate that soldered items take time to

continued on page 51

cool down. The actual soldering is done thus: I hold the parts in contact and apply the iron, while junior applies the solder. This works well, as he provides the oft wanted 'third hand'.

Using the methods described above, it should be possible to construct a device that is reliable. Do not worry too much about the finished appearance. It is an achievement to complete the project at all. Glues like white wood glue, clear Bostik and Plastic Padding have great appeal, and paint is no exception; but be ready with plenty of clean rags and solvent. Remember that mothers are particular about paint on clothes, and that solvents may well cause temporary damage to junior skin unless it is washed off immediately afterwards.

The time span of interest for the very young varies from child, but be ready for him to start playing at almost any stage. He will probably come back in a while.

When the project hardware has been completed and tested, it must be given to junior to keep. This is a powerful inducement to complete it.

I have no doubt that there can exist a vast difference between the psychology of one child and the next. This letters should therefore be taken as general guidance only. Nevertheless, I wish you well in initiating new, keen and practical engineers. An early start can be the best basis for a lifetime interest.

**J.M. Bentley, Loughborough**

*Congratulations on your marvellous endeavours! Efforts like yours will hopefully do much to restore the strength of (electronics) engineering in our country. Comments from other parent readers are welcome. [Ed.]*

## Pioneer of Computing

Dear Editor, as an amateur who occasionally dabbles in electronics, I have recently become intrigued by some of the early pioneers of computing. Especially interesting is the work of Conrad Zuse who built a calculating machine constructed from several thousand electromagnetic telecommunications relays in Germany around 1934. I believe a working example still exists in a museum there and fills a whole room. I am attracted to the possibility of building a device along these lines as logical thought and patience are the main requirements, the individual components being straightforward. There is also the satisfaction of making such a device function without the use of a single semiconductor.

Circuit diagram for such a machine are a little hard to come by! My own design for a modest device capable of performing additions of two, eight digit, decimal numbers and multiplication by serial addition, requires about 200 relays. Whilst it should work, I wonder if anyone else has experimented in this way for their own amusement in recent times, and if they would be prepared to correspond with me. It may be that my design can be made more efficient before I begin the rather laborious task of construction.

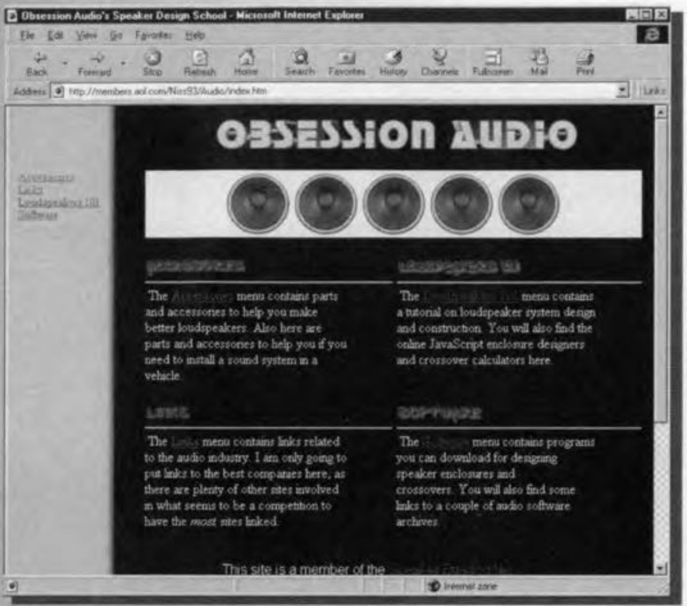
**John Dingly, Swansea.**

*Anyone interested in this undertaking, please get in touch with the Editor.*

# electronics on-line

# build your own loudspeakers

**Having read this month's Supplement on hi-fi loudspeakers you may feel inclined to start experimenting with loudspeaker construction. Fortunately, there are many sites on the Internet offering really interesting information on DIY loudspeaker building.**




A remarkable aspect of loudspeaker building using the Internet as a publishing medium is that many hobbyists who have been successful at building their own loudspeaker system(s) are keen to share information with others. In many cases, complete designs are shown, including schematics, construction drawings, photographs, measurement results and extensive texts. Below we mention a few examples.

**Bill Eckle's Speaker Projects**
*http://www.qnx.com/~danh/eckle.html*

**A "Do-It-Yourself" Speaker Project**
*http://www.qnx.com/ ~danh/speakers.html*

Tips and useful suggestions for speaker construction also abound on the Net. For instance, have a look at

**The Subwoofer DIY Page**
*http://www.spiceisle.com/audiodiy/*

**Wayne's Speaker Building Page**
*http://www.netheaven.com/~wlarmon/speak/speak.htm*

Electostat fans should not miss

**How to Make Electrostatic Loudspeakers**
*http://www.york.ac.uk/~mjgw100/es1/esl/esl-howto.htm*

Home construction 'clubs' are also active on the Internet. A nice example is the

**Lowther Club Holland**
*http://home.pi.net/~doppenbg*

An extensive site covering loudspeaker construction is

**Obsession Audio**
*http://www.members.aol.com/Niss93/Audio/index.htm*

On the index page of this site, you are greeted by five moving woofers. The information found on these web pages includes loudspeaker accessories, loudspeaker construction tips and an extensive list of links to addresses of (mainly) audio component manufacturers. A number of box calculation programs (demos and shareware programs) are available for downloading. There is also an online Javascript box and filter calculation program which may be used free of charge via the Net.

Riveting stuff, so far? Then you should also visit

**The Speaker Building Page**
*http://www.speakerbuilding.com/*

Here you find various designs, complete articles, filter schematics, data on individual driver units, kits, measurement results, and software. In short, a real treasure-trove for all anything related to loudspeaker construction.

Finally, we would like to mention the site

**ISD (Interactive Speaker Designer)**
*http://orion.pspt.fi/~jhartika/index.html*

which is run by Juha Hartikainen from Finland. An on-line program at his site allows you to perform calculations and simulations on loudspeaker boxes and filters, without having to buy or even download the program. You can enter your own loudspeaker parameters, or choose from a vast database which contains all relevant information.

As you can see, there's a lot of information to be found on the Internet if you are interested in home construction of loudspeakers.

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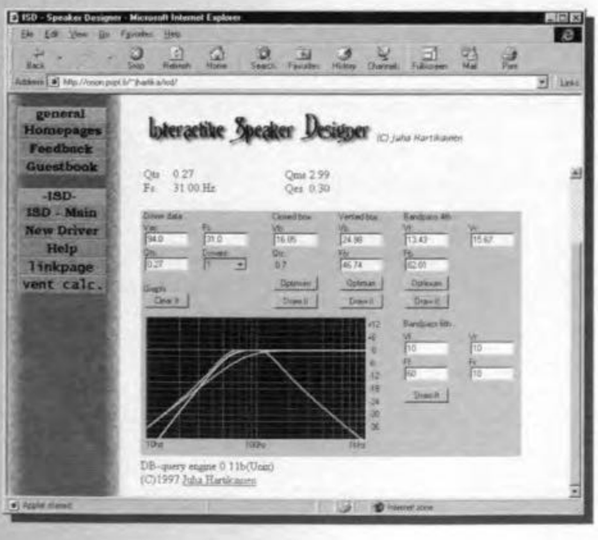
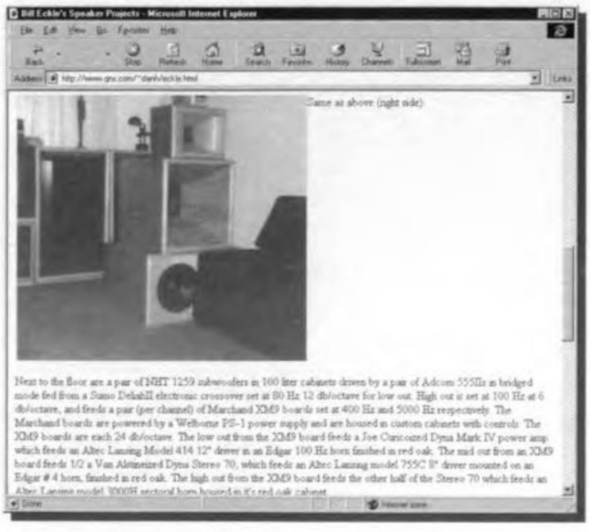


# high-end oscillator for digital audio

Jitter (phase noise) is a serious problem in the linking of two or more audio units. It is invariably caused by poorly designed oscillators in the recording equipment when this operates in the slave mode, that is, when it reproduces the system clock of the source equipment with the aid of a phase-locked loop (PLL).

The high-end oscillator may be used to replace such a poor reproduction or as a high-quality master oscillator. In the prototype no frequency shift was detected under all kinds of operating conditions.

The high-end oscillator has these advantages over a usual design.

- The crystal is operated in the series mode instead of in the parallel mode as usual, since the resistance of the crystal at the resonance frequency is a minimum, while external resistances do not affect the *Q* factor to the same degree.
- The stability is enhanced by the use of an additional *LC* circuit ($L_1$-$C_1$-$C_3$) tuned to the fundamental frequency.
- The crystal is shunted b y an inductor to compensate for its parasitic parallel capacitance. The inductor also short-circuits any low-frequency noise. The value of the inductor is critical, but can be determined empirically.
- In the slave mode, the oscillator is detuned by varactor $D_1$, which is part of an external PLL. With the varactor used, whose capacitance changes from 4–50 pF by an applied voltage of 1–25 V, the frequency can be shifted by about ±150 ppm. Since even small interference signals cause fairly large changes in capacitance, the desired capacitance range should be kept as narrow as possible by choosing a difference varactor, or by connecting a smaller capacitor in series with it. When used as a master oscillator, when the slightest jitter is noticeable, the varactor is replaced by a fixed capacitor. The apparatus with which it is used must be equipped for genlock operation, that is, must have a separate clock input.

With reference to the com-plete circuit diagram of the high-end oscillator, some additional points should be noted.

Much attention has been paid to the decoupling of the supply lines. Also, the oscillator and buffer circuits have separate supply lines to ensure interference-free oscillator performance.

The clock is buffered by three stages of the non-buffered $IC_1$. The first stage, $IC_{1a}$, is arranged as a low-gain amplifier. Too much gain might cause feedback of harmonics into the oscillator. The clock is available at the output via $R_{15}$.

Diode $D_2$ ensures that the output of the final buffer is high when the oscillator is off. This arrangement enables several oscillators, providing various sampling frequencies, to be used over one clock line via an AND or NAND gate. The desired oscillator is enabled by applying 6.5 V to it.

Components $R_7$, $R_8$ and $C_9$ are part of the PLL, which determines their values. Surface mount devices (SMDs) $T_1$ and $T_2$ may be replaced by standard transistors Type BF494.

The relationship between the sampling frequency, $f_{sa}$, the crystal frequency, $f_c$, and the value of $C_2$ in pF is

| $f_{sa}$ | $f_c$ | $C_2$ |
|---|---|---|
| 32 | 12.288 | 47 |
| 38 | 14.592 | 27 |
| 44.1 | 16.9344 | 15 |
| 48 | 18.432 | 10 |

If the oscillator does not work owing to too high a tolerance of L1, the parallel capacitance may be balanced by altering the value of $C_3$. It may also be necessary to alter the value of $C_2$.

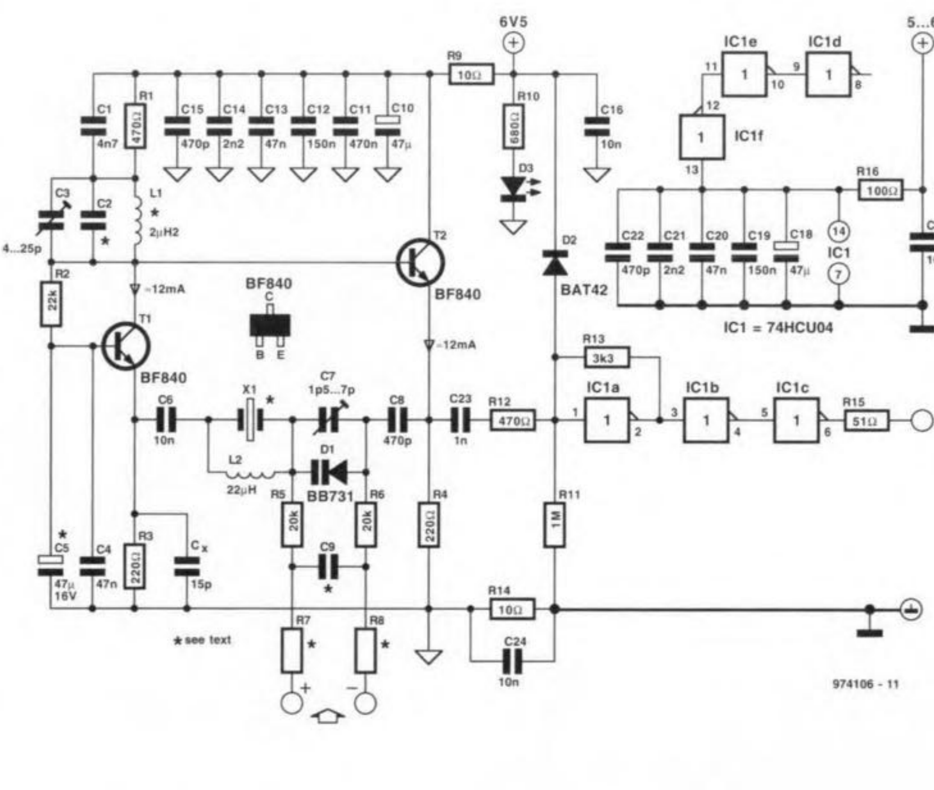
Adjust trimmer $C_7$ to give a voltage of $\frac{1}{2}U_{var}$ in PLL operation.

Capacitor $C_x$ extends the nominal frequency range of the oscillator downwards.

The completed oscillator is best housed in a small tin plate enclosure.

The oscillator draws a current of about 40 mA.

[Gottschalk – 974106]



# running lights for Christmas

## *a state-of-the-art, microprocessor-controlled Christmas decoration*

With the Festive Season approaching rapidly, many of you will be thinking hard how to give this coming Christmas a very personal touch. The glittering and ever-lively ornament described in this article is highly original and we hope it contributes to a joyful Christmas for you and your family.

Over the years, *Elektor Electronics* has published a number of special circuits for Christmas in the December magazine. Faithful readers may recall simple but innovative circuits published in the seventies that used a fluorescent tube starter to make the Christmas tree lighting flash vividly. Later, many other designs appeared in the magazine, all of which based on flashing or running lights. A microprocessor was, however, never used for this. Here, we part with that tradition by placing a type 8751 microcontroller at the heart of the circuit. Of course, some of you may wonder if it is really necessary to use a CPU at all. Admittedly, our approach may seem fairly drastic at first glance. However, in the end you will probably agree with us that the final result would have been difficult to match with simple means.

Before giving some thought to the hardware, a brief description of the final result. The running lights circuit is built on a round PCB which holds a total of 32 LEDs. Nine of these are always on at the same time, distributed across three groups of three LEDs each. These groups form running lights, describing circular motions with different speeds. Both the speed and the direction (clockwise or anti-clockwise) are random. At certain intervals, however, the parameters are modified, creating a different impression all the time.

To make the 'movement' of the lighting LEDs as natural as possible, a speed control is implemented which creates an 'afterglow' effect using a number of LEDs. The first LED in a group is always a high-intensity type. This is followed by two LEDs whose

Design by K. Walraven

brightness has been reduced to a third and a ninth, respectively, of the maximum brightness. Well, the final result is a colourful ornament which will not fail to attract a lot of attention.

## SIMPLE HARDWARE

One of the advantages of microcontrollers is that the component count can remain very low indeed. In the present circuit, the control program is stashed away in the processor, together with all the necessary I/O functionality and, of course, the working memory. So, apart from the clock generator and the power supply, no external components are required. These elements are easily found back in the circuit diagram shown in **Figure 1**.

The power supply, including the rectifier, consists of just five parts: D33, IC2, C4, C5 and C6. Any alternating or direct voltage between 8 and 12 V is stepped down to give a stable and properly regulated supply voltage of 5 V d.c.

The heart of the circuit is formed by IC1, a type 8751 microcontroller which operates at a clock frequency of 6 MHz, executing a control program which has been 'burned' into the chip by the Publishers. The order code of the ready-programmed microcontroller is **976517-1**. The on-chip clock oscillator works in conjunction with three external components: quartz crystal X1 and parallel-load capacitors C2 and C3.

Capacitor C1 arranges for the microcontroller to be automatically reset when the power supply is switched on.

All available and suitable I/O port lines of the 8751 are used as digital outputs in the present application. The upshot is that the microcontroller is capable of switching 32 LEDs. A resistor in series with each LED limits the respective current. The anodes of all LEDs are joined at the positive supply rail.

## CONSTRUCTION, IN A JIFFY

The copper track layout and component location aid are shown in **Figure 2**. As you can see, the board is fairly large. Not because of a complex circuit, by no means, but rather because the LEDs had to be fitted in a circle. The circle on the component overlay clearly indicates the outline of the ornament. While building up one of our prototypes, we used a jigsaw to cut off three corners. The result is a pear-shaped board with a hole in the remaining corner to allow the decoration to hang from a Christmas tree branch.

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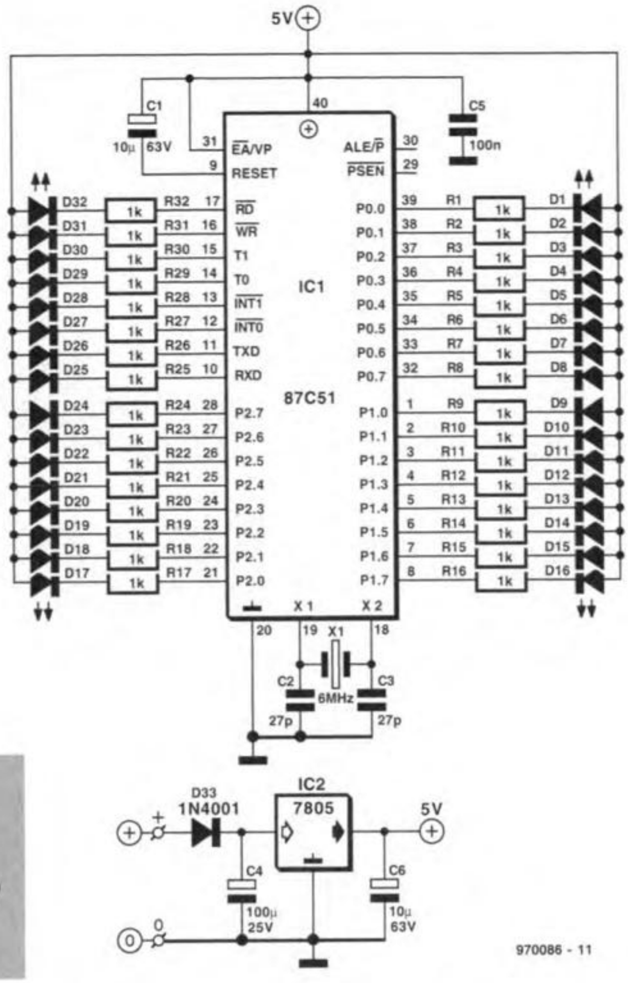


**Figure 1. Circuit diagram of the running-lights for Christmas. The circuit is downright simple thanks to the use of a microcontroller chip.**

The construction of this Christmas decoration is not expected to cause undue problems. Current consumption will be of the order of 25 mA. In the unlikely case that the circuit refuses to start, an oscilloscope should be used to check for oscillator activity at pin 19 of the controller chip. If a proper signal is found, the circuit should work. If you only have a multimeter available, then a voltage of about 1.5 V should be measured at pin 19.

Obviously, you have to use the ready-programmed microcontroller which is supplied through our Readers Services or a kit dealer. This part carries an adhesive stating the previously mentioned order number. A new, blank 8751 will **not** work in this circuit.

The technically inclined among you will probably want to show off their skills at electronic construction by leaving the components and the board fully visible. In that case, the LEDs have to be fitted at the same side as the other components. Other users may want to throw in more creativity by decorating the board, or by fitting a photograph or a drawing between the LEDs. In that case, you may also mount the LEDs at the copper side of the board.

Once all components are in place on the board, the running-lights effect should start straight away after the supply voltage is switched on.

## CONTROL SOFTWARE

As already mentioned, all light effects are created by a small control program executed by the microcontroller. This control program is stored in the controller's internal read-only memory. The program employs an internal 2-ms repetitive interrupt for its timing.

The LEDs are driven using a principle called brightness modulation. The first LED in a group lights at maximum brightness, the second one, at one-third, and the third one, at one-ninth of the maximum brightness. The optical illusion of a moving light is obtained in this way: the first LED is the brightest in the group, while the last one lights only dimly. Here, too, interrupts provide brightness modulation. Nine interrupt pulses form one unit. The first and brightest LED lights during all nine periods, the second LED, during three periods, and the third LED, during one period only.

There are two important factors which contribute to the apparent circular motion of the LED groups: speed and direction. The principle used here is relatively simple. An LED is situated at a certain location, and each location is linked to a certain number which is randomly determined. Let's assume that the number for LED1 is 15. Con-

2

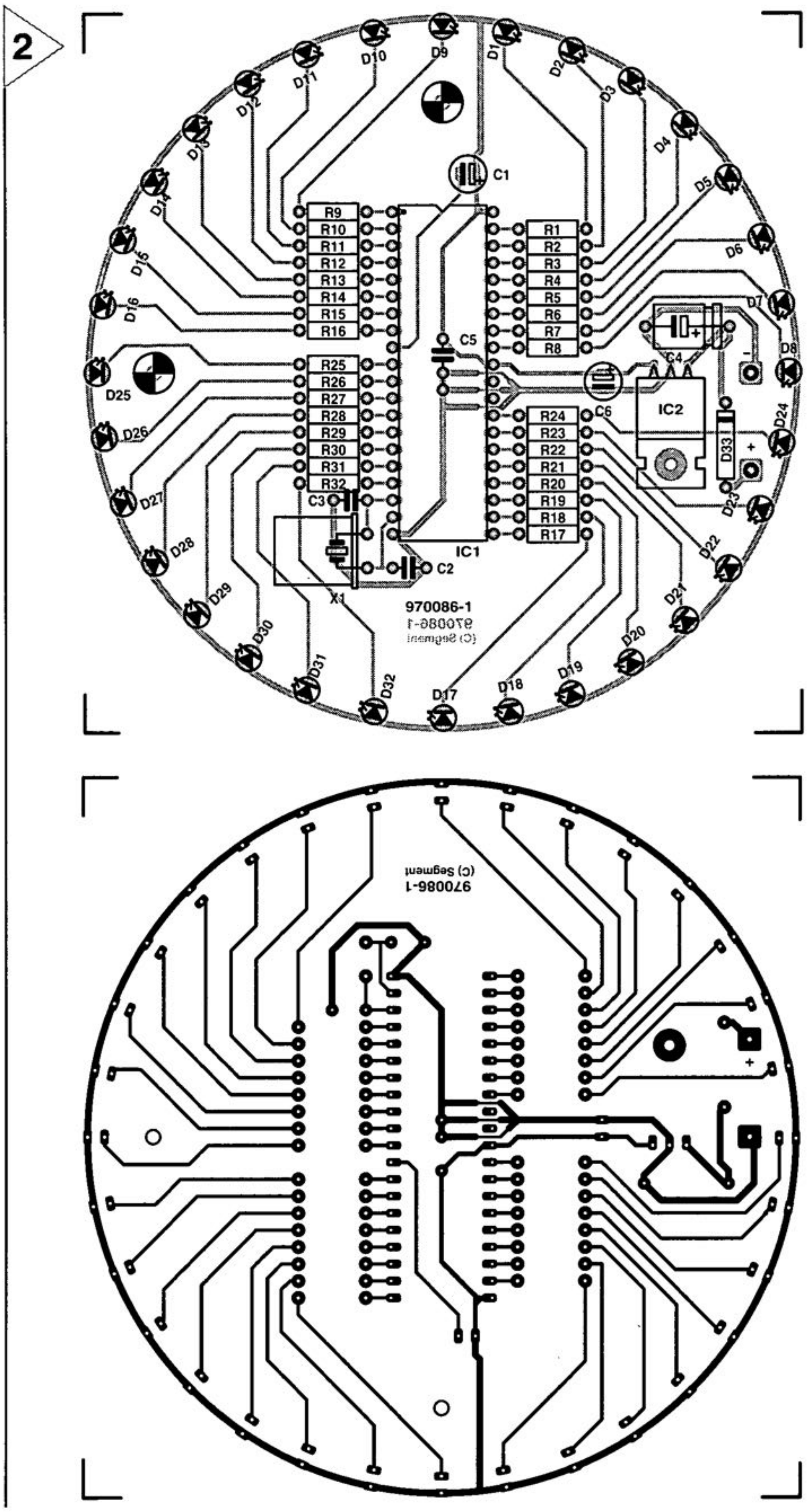


***Figure 2. Copper track layout and component mounting plan of the PCB designed for the digital ornament (board available ready-made through our Readers Services).***

**COMPONENTS LIST**

**Resistors:**
R1-R32 =1kΩ

**Capacitors:**
C1,C6 = 10 μF 63V radial
C2,C3 = 27pF
C4 = 100μF 25V
C5 = 100nF

**Semiconductors:**
D1-D32 = LED, high efficiency
D33 = 1N4001
IC1 = 8751 (order code 976517-1)
IC2 = 7805

**Miscellaneous:**
X1 = 6 MHz quartz crystal
PCB and programmed 8751, order code 970086-C (see Readers Services page)

sequently, all LEDs in group 1 shift one position after 15 interrupts. Clockwise or counter-clockwise, that is determined by the status of a bit which indicates, you guessed it, the direction.

The starting point of the LED and the step size (that's the number of interrupts which have to pass before an increment actually takes place) are determined in random fashion with the aid of an internal random-number generator. This function employs shift registers with a feedback path, and is essentially similar to typical random-number generators implemented in hardware. Every 256 interrupts, the program counter returns to the main routine, where a random number is determined. Since the width of the number is eight bits, one of 256 numbers is picked. In practice, however, fewer numbers are allowed because those below a certain value would result in a too high speed of the running-lights.

When a random number has been picked seven times, the speed of group 0 is adapted. After 13 random numbers, the speed of group 1, and after 19 random numbers, the speed of group 2. Next, the cycle starts all over again. The use of three prime numbers adds to the randomness of the pattern, resulting in different light effects appearing all the time.

As already mentioned, 32 LEDs (locations) are available. Of these LEDs, three groups of three LEDs each are 'running'. From a computing point of view, the program only looks at the 'leading' LED in a group. Once the location of this LED has been computed, the locations of the second and third LED are also known.

Once the program has calculated which nine LEDs should light at a particular intensity, the status of all 32 LEDs is copied to the I/O ports using four bytes. The result is a very vivid running-lights effect.

(970086-1)

# NEW BOOKS FOR CHRISTMAS

## Encyclopedia of Acoustics

Edited by Malcolm J. Crocker
ISBN 0 471 80465 7
Four volumes – 2018 pages
Price £355·00(Hardback)
(Wiley)

Acoustics, sound and vibration relate to everything from the design of a concert hall to the intricacies of the human ear. For the first time ever, all aspects of acoustic are brought together into one encyclopedic reference.

The work represents the contribution of more than 200 experts in all areas related to acoustics. It is the only reference of its kind and covers the whole scope of this area of science from an applications perspective, rather than theoretically.

Volumes One and Two cover the fundamentals of acoustics and vibration, while Volumes Three and Four examine the applications, such as the auditory function, psychological speech perception and musical acoustics.

Anyone interested in acoustics, that is, the science of sound waves, including generation and propagation properties, should have this large, valuable work to hand. Historically speaking, acoustics is, of course, a fairly new science. Much of this science was really developed in the past fifty years or so. This has, no doubt, a lot to do with the enormous steps forward in other natural sciences, particularly physics and the physiology of human hearing. In fact, acoustics now covers such a wide field that no one can embrace all of its details. And this is where a work such as *Encyclopedia of Acoustics* is so very valuable, nay, indispensable.

It is not only the subject matter that is covered so ably by so many distinguished contributors that is of value, it is also the enormous amount of reference material. Each of the 166 chapters contains a comprehensive list of reference works. This reviewer found the vast number of references almost as valuable as the encyclopedia itself.

The *Encyclopedia of Acoustics* is undoubtedly going to be *the* reference work in its field for many years to come. As such it should find a place in all libraries, public as well as those of academic institutions and music schools.

## Commercial Satellite Communication

By Stephan C. Pascal & David J. Withers
ISBN 0 7506 1235 5
442 pages – illustrated
Price £75·00 (Hardback)
(Focal Press)*

*Commercial Satellite Communications* gives a comprehensive coverage of all aspects of satellite communications: from the design of the radio link to the technology used within orbiting satellites and the construction of the satellite earth station. The technology is set within the context of the telecommunications industry as a whole, and important regulatory issues are also included.

The book is intended for students on telecommunications engineering or electronics courses and postgraduate MSc or MEng courses in satellite communications. Practising professional telecommunications engineers wishing to extend their knowledge of satellite communications will also find it invaluable as a comprehensive reference source.

## Multimedia and Virtual Reality Engineering

By Richard Brice
ISBN 0 7506 2987 8
320 pages – illustrated
Price £25·00(Hardback) includes CD-ROM
(Newnes)*

This is the complete practical introduction to virtual reality and multimedia for those wishing to build systems. It covers the foundations and engineering needed to design and construct project incorporating video, audio and textual elements and including the use of the latest hardware to create an artificial world for education, information or entertainment.

Production and authoring platforms are described, computer animation and hypertext are covered, but those looking for pages of software listings and computerspeak will be disappointed. This book is about the nuts and bolts: sound and video cards, head mounted displays, CrystalEyes glass, other 3D glass for entertainment, audio and video production, and realistic auditory and visual stimulation including stereoscopy. The creation of Cyberspace, and strategies to achieve a complete Cyberatmosphere are presented.

This is a book for engineers and technicians in the multimedia and computer hardware and accessories industries, multimedia production houses, electronics and computing undergraduates.

## Handbook of Microwave and Optical Components (1)

Edited by Kai Chang
ISBN 0 471 18442 X
908 pages – illustrated
Price £45·00(Paperback)
(Wiley)

This is the paperback edition of the handbook originally published in 1989. It is intended as a compendium of principles and design data for practising microwave and optical engineers, but should also be of considerable value to engineers in other disciplines who wish to understand the capabilities and limitations of microwave and optical systems. The book covers almost all important components in microwave, millimetre wave, submillimetre wave, infrared and optical frequency spectrums. Theoretical discussions and mathematical formulations are given only where essential.

## Setting up and Trouble-shooting Windows PCs

By Michael Hordeski
ISBN 0 7506 9772 5
448 pages – illustrated
Price £25·00(Paperback)
(Focal Press)*

*Setting up and Troubleshooting Windows PCs* will make your life as a Windows user easier and more productive, whether you are using Windows 95 or Windows 3.1. It contains the information you need on Windows applications, multimedia cards, and configuration files so you can detect and fix PC problems fast. It is also a ready source of useful mailing address, phone numbers, BBSs, and CompuServe Forum locations for Microsoft sources where you can obtain additional information.

The book teaches you to: clear up General Protection Faults, check and reset internal parameters, troubleshoot network setups and configurations, optimize your settings to boost PC performance, and safeguard your system from security breaches and viruses.

## *Telephone Installation Handbook*

By Stephen Roberts
ISBN 0 7506 3427 8
160 pages – illustrated
Price £19·99(Paperback)
(Newnes)*

Until recently, in many parts of the world, all telephone wiring was the responsibility of the Public Telecommunications Operator, such as AT&T in the USA or British Telecom in the UK. Only PTOs or their agents were permitted to install, alter or remove telephone wiring within premises.

Fortunately, in most progressive countries anyone is now permitted to do such work provided the appropriate regulations and codes of practice are followed. This book provides a practical guide to the installation of telephone wiring, from the simple, single extension socket to the Private Automatic Branch Exchange (PABX).

First the functioning of the telephone system, with particular emphasis on the Local Loop connecting the subscriber and the local exchange, is described. Then the various sockets, connection devices and cables are shown. The chapter on installation techniques describes how to apply these components. Methods are suggested for implementing various schemes for single-line and multiple-line installations, from planning stage to commissioning.

The next chapter deals with fault-finding and fault prevention, including fault-finding tables. Functional descriptions of all common types of apparatus designed to be connected to the telephone system are then given, including simple telephones, fax machines and modems. This chapter includes a wide range of accessories.

## *Telecommunications and Networks*

By K.M. Hussain
ISBN 0 7506 2339 X
350 pages – illustrated
Price £25·00(Paperback)
(Focal Press)*

Telecommunications is an old and stable technology if you think only of telephones and telegraph. But in the 1960s came computers and the processing of data. Soon, we needed data communications to transmit data to remote PCs connected by networks. Later, these points of communications increased in number, with the transmission being no longer limited to data but included text, voice, and even images and video.

This book explains in clear and simple language the development of this technology, the management of telecommunications and the many applications that are now possible because of telecommunications.

This is an excellent beginners guide to telecommunications. It explains, in a manner that is non-baffling to the novice, both the technology in use and its implications for working practices today.

## *Filter Design*

By Steve Winder
ISBN 0 7506 2814 6
256 pages – illustrated
Price £30·00 (Paperback)
(Focal Press)*

Why do most books on filters contain so much mathematical complexity? Because the authors are trying to show how clever they are? This book is written for a purpose – to cut through the guff and show readers how to design effective and working electronic filters.

Steve Winder is a team leader at BT's Martlesham Heath Laboratories. His work has included the design and building of prototype specialist transmission systems for high speed data or radio transmission. His experience of circuit design includes work on optical fibre transmission systems. He has also written several design computer programs that are in commercial use, and is a regular contributor to magazines such as *Electronics World*.

## *Audio IC Users Handbook*

By R.M. Marston
ISBN 0 7506 3006 X
192 pages – illustrated
Price £19·99 (Paperback)
(Focal Press)*

A vast range of audio and audio-associated ICs are readily available for use by design engineers and technicians. This handbook is a comprehensive guide to the most popular and useful of these devices, including about 370 circuits with diagrams. It deals with ICs such as low-frequency linear amplifiers, dual pre-amplifiers, audio power amplifiers, charge-coupled device delay lines, bar-graph display drivers, and power supply regulators. It shows how to use these devices in circuits ranging from simple signal conditioners and filters to complex graphic equalizers, stereo amplifier systems, and echo/reverb delay line systems

Not only does this handbook contain a huge selection of circuits using state-of-the-art and readily available ICs, but it also gives a thorough grounding in theoretical information relating to the various aspects of modern audio systems and to various dedicated types of audio IC.

*Audio IC Users Handbook* is a volume in the Circuits Manual Series, which covers a wide range of electronic subjects in an easy-to-read and non-mathematical manner, presenting the reader with many practical applications and circuits. They are written specifically for the practising design engineer, technician, and experimenter, as well as the electronics students and amateurs. The ICs and other devices used in the practical circuits are modestly priced and readily available types, with universally recognized type numbers.

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By Clyde Herrick
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## *Domestic Security Systems*

By A.L. Brown
ISBN 0 7506 3235 6
154 pages – illustrated
Price £12·99 (Paperback)
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House break-ins have increased dramatically over the past 20 years. Few people have not been touched by the effects, even if only through the experience of family and friends who have suffered a burglary.

There is a way to reduce significantly the chances of being targeted by thieves: fit an alarm. But isn't that expensive and complicated? Not if you build your own system. This book shows you how, with common sense and basic do-it-yourself skills, you can protect your home. It also gives tips and ideas which will help you to maintain and improve your home security, even if you already have an alarm.

Every circuit in this book is clearly described and illustrated, and contains components that are easy to source. Advice and guidance are based on the real experience of the author, who is an alarm installer, and the designs themselves have been rigorously put to use on some of the most crime-ridden streets in the world.

The principles described in this book are illustrated by the use of two houses, one a typical semi-detached home and the other an average three-bedroomed detached bungalow (for which designs would also suit an apartment).

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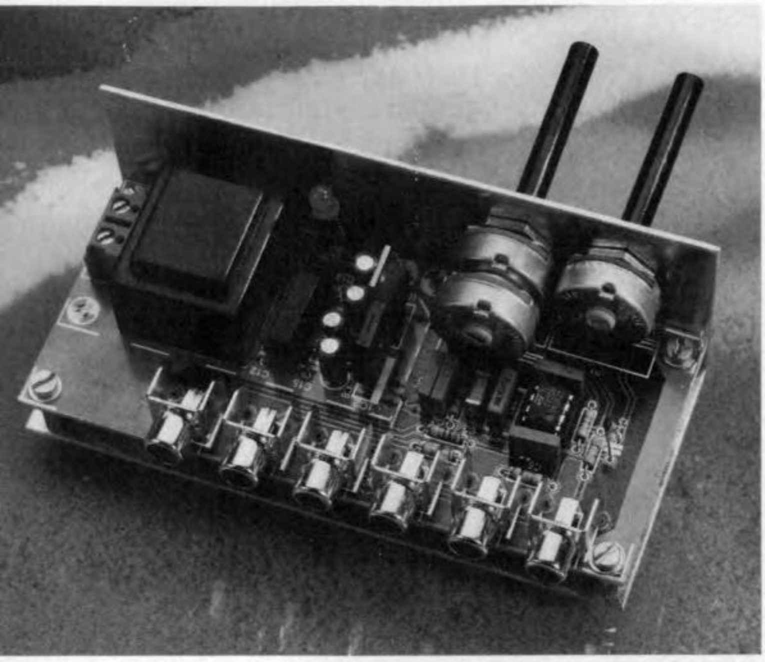
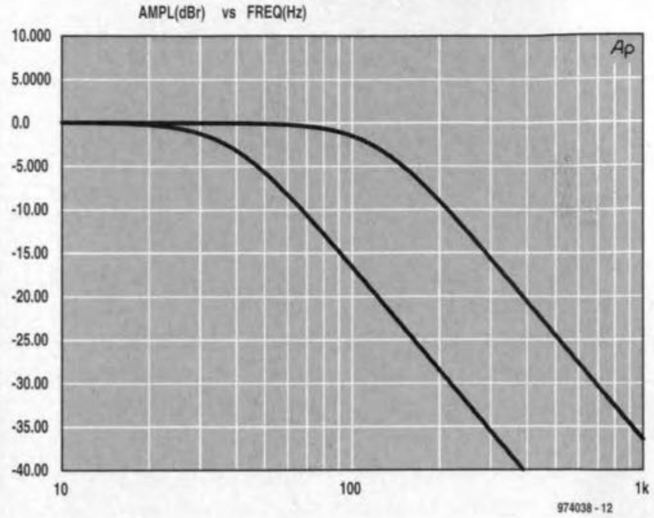
# bass extension for surround sound






The extension is intended primarily for surround-sound installations that need some boosting of the bass frequencies but where an additional subwoofer cannot be afforded. It is based on a disused mono a.f. amplifier and loudspeaker. If these provide reasonable bass performance, they can be converted into a fairly good subwoofer with the aid of an active low-pass filter—see Figure 1.

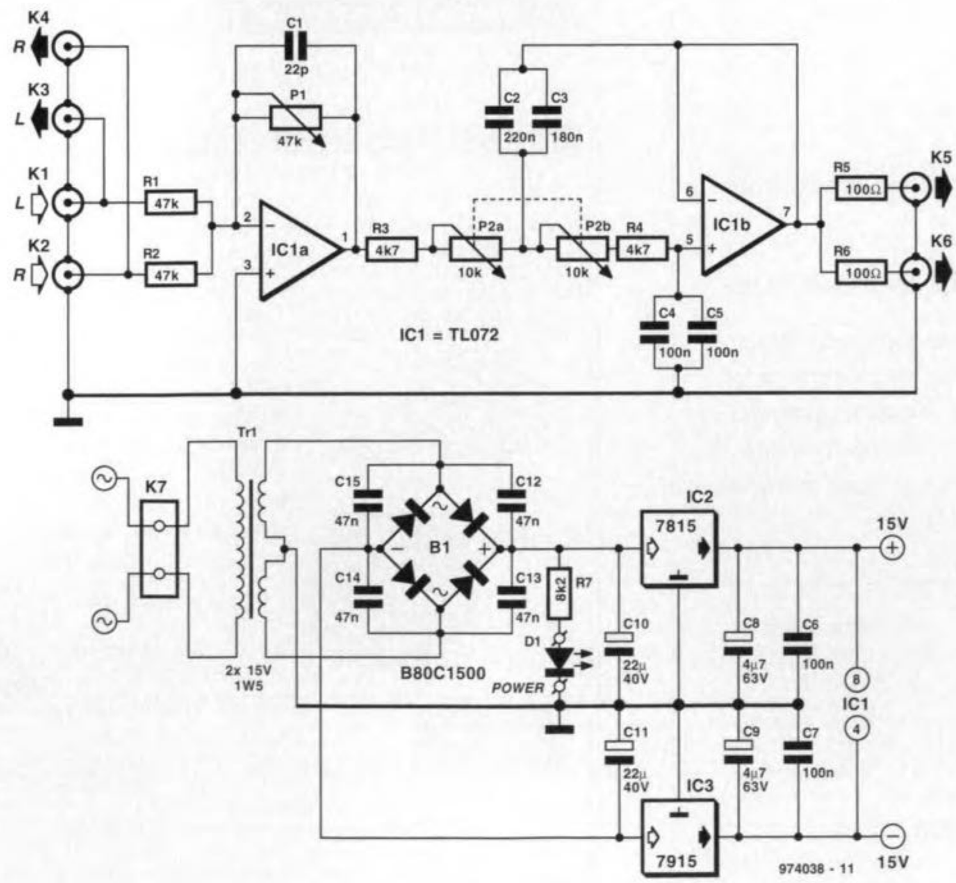
The input signals for the left-hand and right-hand channels are applied to audio sockets $K_1$ and $K_2$ respectively. They are output via audio sockets $K_3$ and $K_4$ to which the surround-sound decoder is connected.

The signals of the two channels are summed in $IC_{1a}$, which also functions as input amplifier. The amplification, and therefore the sensitivity of the 'subwoofer', can be adjusted with $P_1$.

The output of $IC_{1a}$ is applied to a 2nd-order Butterworth low-pass filter. The cut-off frequency of this active filter can be set between 40 Hz and 120 Hz with stereo potentiometer $P_2$. The response characteristic of the filter at both these frequencies is shown in Figure 2. The actual cut-off point depends on individual taste.

The said mono amplifier is connected to audio output sockets $K_5$ and $K_6$.

The power supply for the circuit is simple and consists of a small mains transformer, $Tr_1$, a




**Parts list**

Resistors:
$R_1$, $R_2$ = 47 kΩ
$R_3$, $R_4$ = 4.7 kΩ
$R_5$, $R_6$ = 100 Ω
$R_7$ = 8.2 kΩ
$P_1$ = 47 kΩ logarithmic potentiometer
$P_2$ = 10 kΩ, linear stereo potentiometer

**Capacitors:**
$C_1$ = 22 pF
$C_2$ = 220 nF
$C_3$ = 180 nF
$C_4$–$C_7$ = 100 nF
$C_8$, $C_9$ = 4.7 µF, 63 V, radial
$C_{10}$, $C_{11}$ = 22 µF, 40 V, radial
$C_{12}$–$C_{15}$ = 47 nF ceramic

**Semiconductors:**
$D_1$ = LED, high efficiency

**Integrated circuits:**
$IC_1$ = TL072CP
$IC_2$ = 7815
$IC_3$ = 7915

**Miscellaneous:**
$K_1$–$K_6$, $K_8$–$K_9$ = audio socket for board mounting
$K_7$ = 2-way terminal block, pitch 7.5 mm
$B_1$ = B80C1500
$Tr_1$ = mains transformer, 2 × 15 V secondaries, 1.5 VA

bridge rectifier, $B_1$, antihunt capacitors $C_{12}$–$C_{15}$, a number of smoothing and decoupling capacitors, and two integrated voltage regulators, $IC_2$ and $IC_3$.

The filter circuit is best built on the printed-circuit board shown in Figure 3, which is, however, not available ready made.

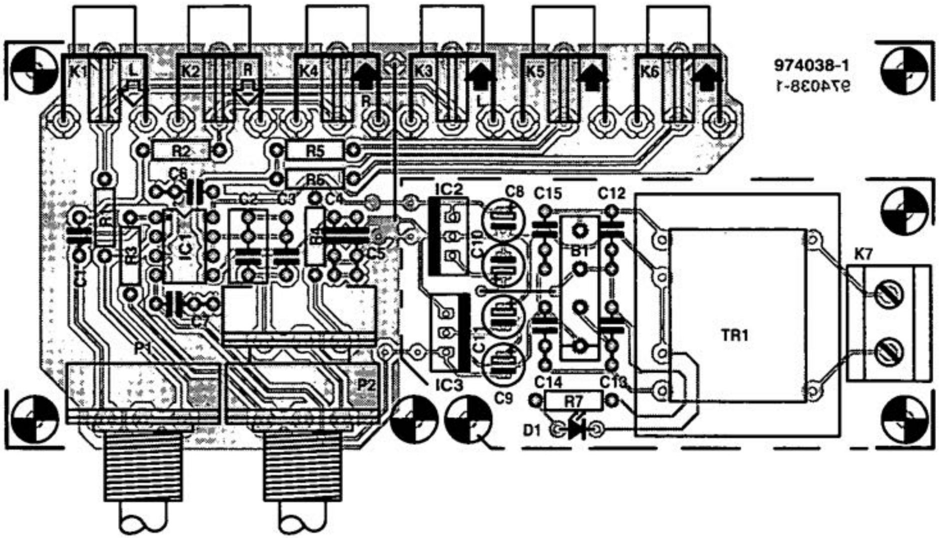
The filter should be housed in a metal case. Moreover, $P_1$ and $P_2$ should preferably be types with a metal enclosure. Hum is prevented by earthing the case and the enclosures.

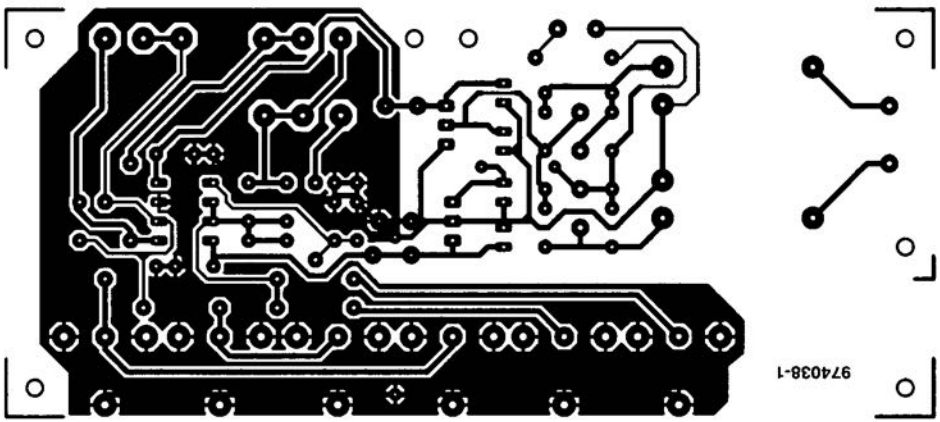
The harmonic distortion, with two input signals of 200 mV and a bandwidth of 22 kHz, is 0.0016% at 30 Hz.

Although not of prime importance at low frequencies, the polarity of the 'subwoofer' should be the reverse of that of the remainder of the system since the present circuit inverts the signals.

[974038]

| ELEKTOR | |
|---|---|
| 240V ~ | 50Hz |
| No. 974038 | |
| P = 1VA5 | |



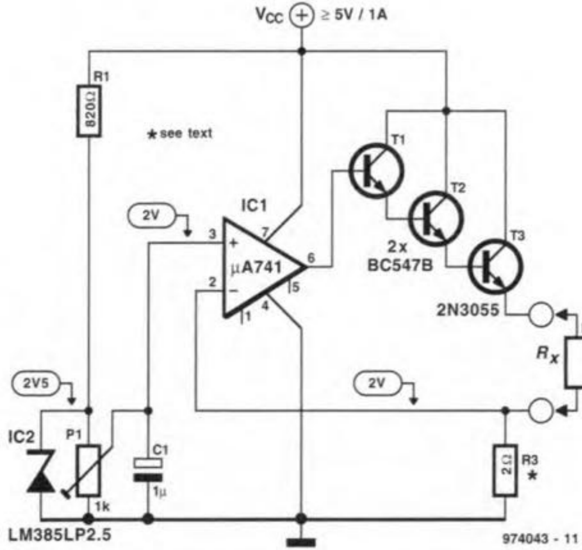



# milliohm adaptor for DVM

Most DVMs (digital voltmeters) offer a resolution of only 0.1 Ω in the lowest resistance range. This does not allow the measurement of low-value resistors or the transfer resistance of plug-and-socket connections. The adaptor offers a solution to this problem.

The adaptor send a constant current through the device or connection on test, whereupon the resulting potential drop across it is measured with the DVM.

The circuit is based on a 2.5 V voltage reference source, $IC_1$. Part of the reference voltage, 2.0 V, is applied to the non-inverting (+ve) input of the op amp via $P_1$. The op amp will attempt to hold the potential at its inverting (–ve) input also at 2.0 V. Consequently, it functions in combination with 'super darlington' $T_1$–$T_3$, the resistance to be measured, $R_2$, and $R_3$ as a constant-current source. The level of the current is determined by $R_3$. If the value of this resistor is 2 Ω (five 10 Ω, 0.5 W, resistors in parallel), the current is exactly 1 A. This enables the DVM, set to its 200 mV range, to measure resistances of 200 mΩ with a resolution of 0.1 mΩ.

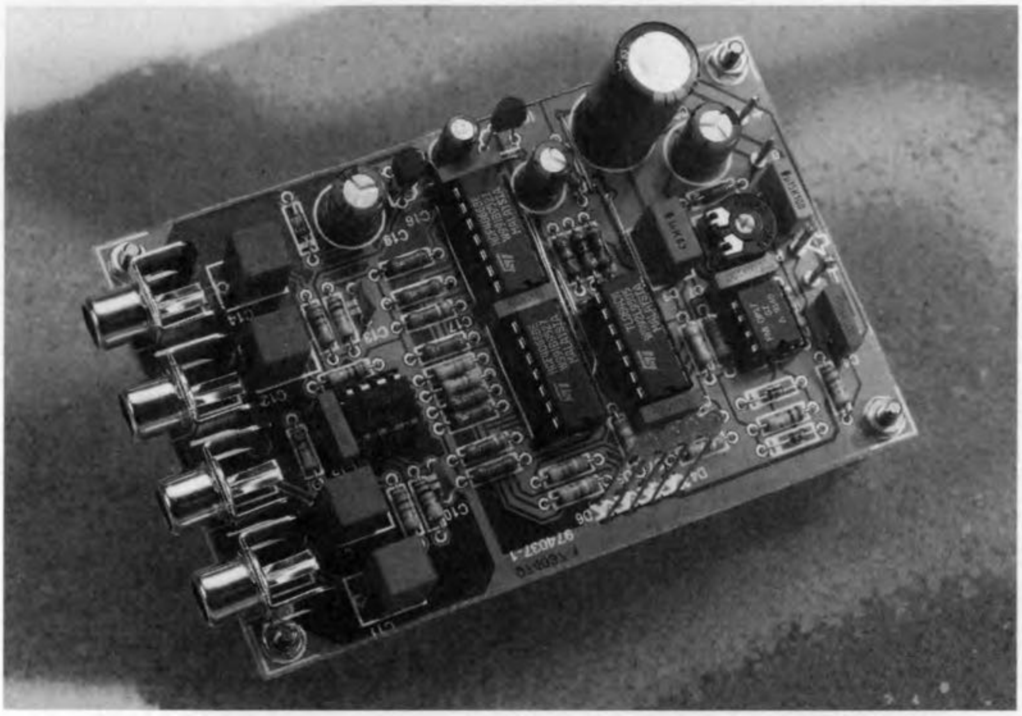



A drop of 2 V across $R_3$ results in a dissipation of 2 W. This means that with a supply voltage of 5 V, the dissipation in $T_3$ is $(5–2)\times 1 = 3$ W. If this is found rather too much, the value of $R_3$ may be increased to 20 Ω (or 200 Ω). The level of the constant current then drops to 100 mA (or 10 mA). The resistance range with the DVM set to the 200 mV range is then 2 Ω (or 20 Ω). This means that the resolution degrades to 1 mΩ (or 10 mΩ).

The 5 V power supply must, of course, be able to sustain the constant current.

Remember the cooling of $T_3$ (heat sink!) and make the connections to the resistance on test as short as possible. [Hiske – 974043]

# auto volume control



The volume control is intended primarily for insertion between a car radio and its booster. It automatically adapts the volume to the amount of road and engine noise. This is done in four 5 dB steps based on the measured sound pressure in the interior of the car. This means that the volume can be increased by up to 20 dB with respect to the set volume level. This implies that care should be taken that the booster and loudspeakers do not become overloaded.

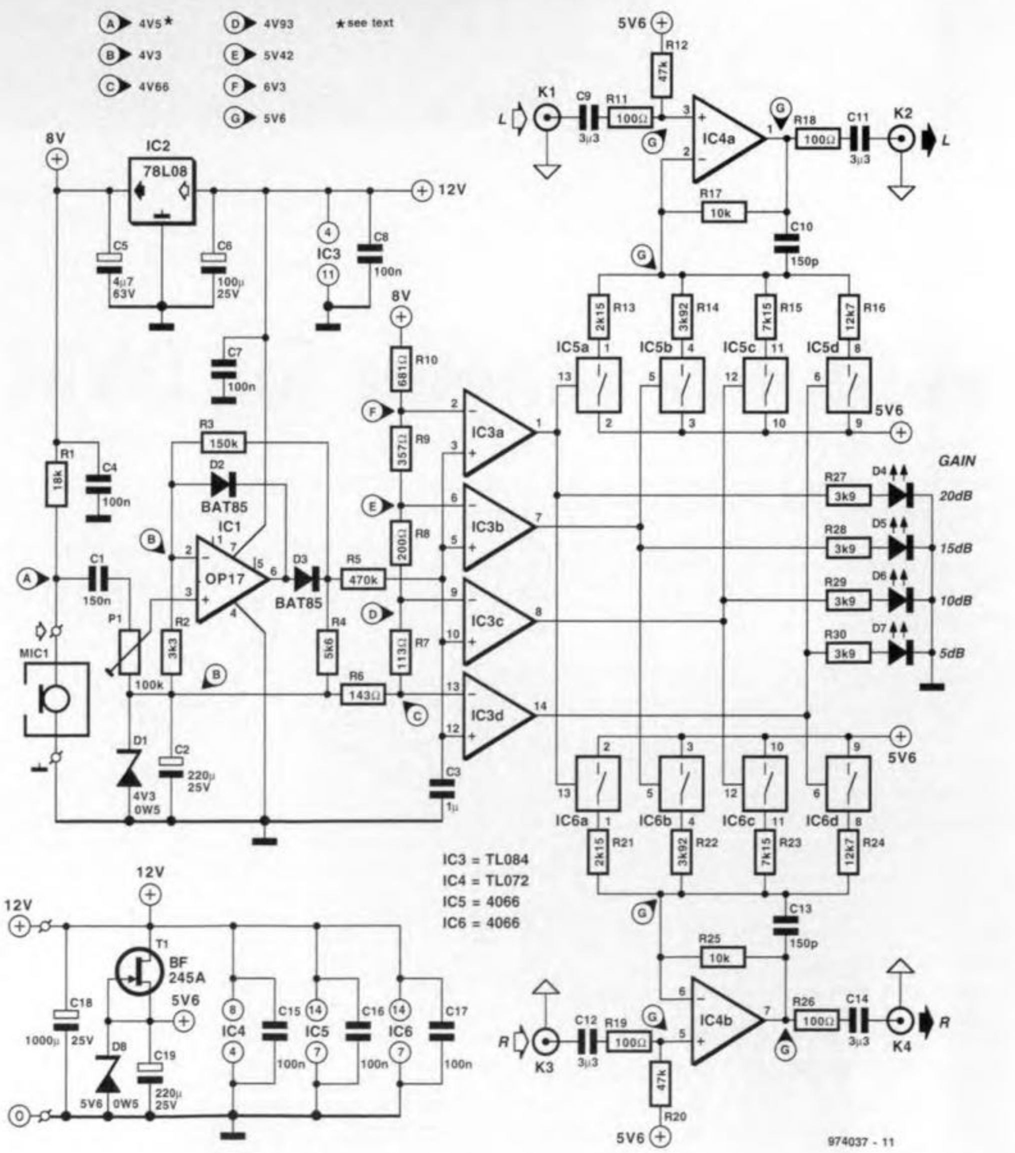
In the diagram in Figure 1, $IC_{4a}$ and $IC_{4b}$ operate as control amplifiers. The audio signal is input via $K_1$ and $K_3$ and applied to the booster via $K_2$ and $K_4$. The basis level is that registered with the electret microphone $MIC_1$.

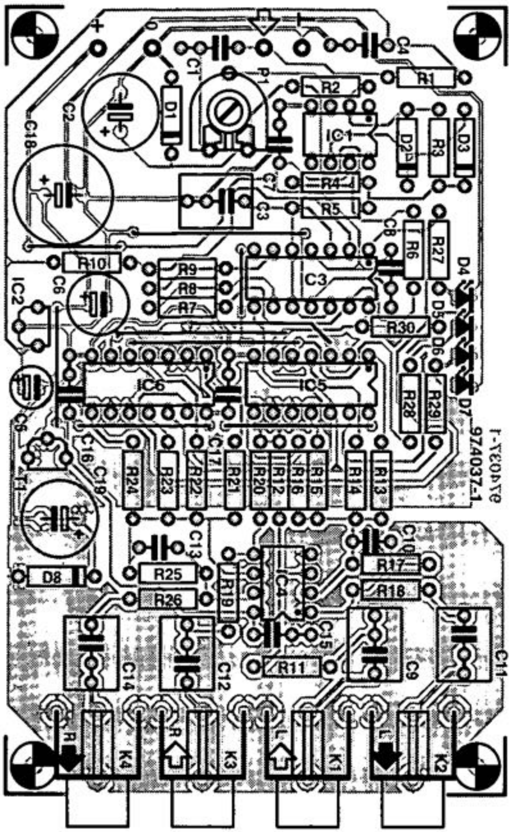
The microphone should not be too sensitive to avoid overdrive and acoustic coupling between it and the loudspeakers. Its d.c. setting is arranged with resistor $R_1$ while its sensitivity is set with $P_1$.

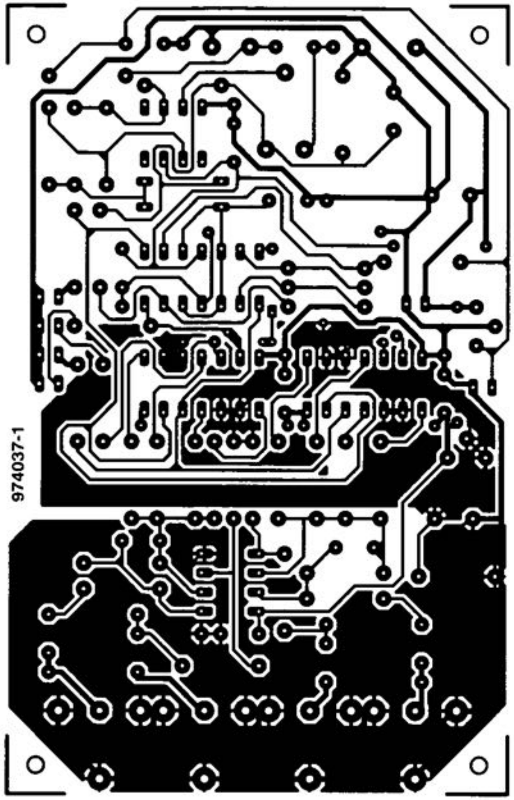
The output of the microphone is applied to fast op amp $IC_1$ via the wiper of $P_1$. The op amp, arranged as a rectifier/amplifier, provides an amplification of ×45. Its output is averaged by $R_5$-$C_3$ and then applied to comparators $IC_{3a}$–$IC_{3d}$. These liken the amplified signal and averaged signal, $U_{AA}$, with the potentials at the junctions of divider $R_6$–$R_{10}$. Each of these potentials differs by 5 dB from the preceding or next one as the case may be.

The comparators control electronic switches $IC_{5a}$–$IC_{5d}$ and $IC_{6a}$–$IC_{6d}$, which modify the degree of feedback of $IC_{4a}$ and $IC_{4b}$ on the basis of the control input. For instance, if none of the comparators in $IC_3$ has changed state, $IC_{4a}$ operates as a voltage follower with unity gain. When $U_{AA}$ exceeds the level at junction $R_6$-$R_7$, the gain of $IC_{4a}$ is raised by 5 dB. When with increasing road and engine noise it exceeds the level at junction $R_9$-$R_{10}$, the switches are all closed so that $R_{13}$–$R_{16}$ are in parallel, whereupon the gain of $IC_{4a}$ is raised by 20 dB. The position of the automatic volume control is indicated by light-emitting diodes $D_4$–$D_7$.

The circuit is powered by the car battery. It is recommended that the battery voltage is well filtered.






The supply lines for the microphone and the voltage divider are held at 8 V by regulator $IC_2$. That for $IC_4$ is held at 5.6 V by $T_1$-$D_8$, irrespective of the battery voltage.

The circuit draws a current of 40 mA when the LEDs light.

The distortion of 0.0025% is well within the requirements for car hi-fi equipment.

The volume control is best built on the printed-circuit board in Figure 2, which is, however, not available ready made.

[974037]

**Parts list**

**Resistors:**
$R_1$ = 18 kΩ
$R_2$ = 3.3 kΩ
$R_3$ = 150 kΩ
$R_4$ = 5.6 kΩ
$R_5$ = 470 kΩ
$R_6$ = 143 Ω
$R_7$ = 113 Ω
$R_8$ = 200 Ω
$R_9$ = 357 Ω
$R_{10}$ = 681 Ω
$R_{11}$, $R_{18}$, $R_{19}$, $R_{26}$ = 100 Ω
$R_{12}$, $R_{20}$ = 47 kΩ
$R_{13}$, $R_{21}$ = 2.15 kΩ, 1%
$R_{14}$, $R_{22}$ = 3.92 kΩ, 1%
$R_{15}$, $R_{23}$ = 7.15 kΩ, 1%
$R_{16}$, $R_{24}$ = 12.7 kΩ, 1%
$R_{17}$, $R_{25}$ = 10 kΩ
$R_{27}$–$R_{30}$ = 3.9 kΩ
$P_1$ = 100 kΩ preset

**Capacitors:**
$C_1$ = 150 nF
$C_2$, $C_{19}$ = 220 μF, 25 V, radial
$C_3$ = 1 μF, MKT (metallized polyester), pitch 5 or 7.5 mm
$C_4$, $C_7$, $C_8$, $C_{15}$–$C_{17}$ = 100 nF
$C_5$ = 4.7 μF, 63 V, radial
$C_6$ = 100 μF, 25 V, radial
$C_9$, $C_{11}$, $C_{12}$, $C_{14}$ = 3.3 μF, MKT (metallized polyester), pitch 5 or 7.5 mm
$C_{10}$, $C_{13}$ = 150 pF
$C_{18}$ = 1000 μF, 25 V, radial

**Semiconductors:**
$D_1$ = zener, 4.3 V, 500 mW
$D_2$, $D_3$ = BAT85
$D_4$–$D_7$ = LED, high-efficiency
$D_8$ = zener, 5.6. V, 500 mW
$T_1$ = BF245A

**Integrated circuits:**
$IC_1$ = OP17
$IC_2$ = 78L08
$IC_3$ = TL084
$IC_4$ = TL072
$IC_5$, $IC_6$ = 4066

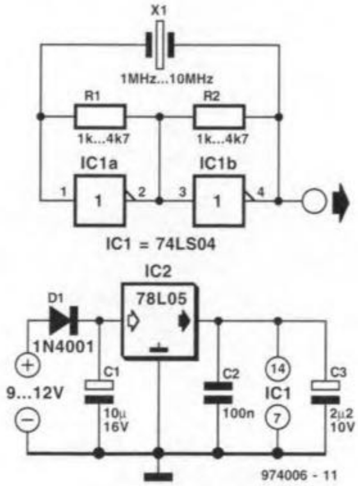
**Miscellaneous:**
$K_1$–$K_4$ = audio socket for board mounting
$MIC_1$ = electret microphone

# simple crystal oscillator

Here is a very easy and inexpensive way of building a crystal oscillator from a single IC. Only two of the inverters contained in the IC are used. The design is reminiscent of a traditional rectangular-wave generator in which a crystal and two resistors replace the *RC* network. The oscillator frequency may be made variable by replacing the crystal with a trimmer of 22–68 pF.

The crystal frequency may have a value of 1–10 MHz. The value of resistors $R_1$ and $R_2$ may be 1–4.7 kΩ (but they must be the same).

The prototype was tested with crystals of 1 MHz, 3.579 MHz, and 8 MHz.




The IC may be an LS, HC or HCT mode, but not TTL.

The oscillator draws a current of only a few milliamperes from a 5 V supply line.

The simplicity of the design has a drawback in that the frequency stability and the stability with temperature variations are not very good. This is because the oscillations depend to a large extent on the parallel capacitance of the crystal.

[Pradeep – 974006]

APPLICATION NOTE

# HUSH stereo noise reduction system SSM2000

## *up to 25 dB noise reduction from almost any audio source*

HUSH® SYSTEMS

**The SSM2000 is an advanced audio reduction system based on proprietary HUSH® circuitry. HUSH combines a dynamic filter and downward expander to provide a high level of effectiveness without the sonic artifacts normally associated with noise reduction systems. In addition, an adaptive threshold circuit detects nominal signal levels and dynamically adjusts both thresholds, thereby providing optimal results regardless of program source. The SSM2000 can be used with Dolby B® encoded sources with excellent results.**

### GENERAL DESCRIPTION

The SSM2000 is a dual channel audio noise reduction IC which reduces noise through a combination of variable filtering and downward expansion in conjunction with a unique adaptive noise threshold detector. These two techniques yield an overall noise reduction of up to 25 dB on AM and FM radio, open-reel and cassette tape, CD, Dolby B encoded programming, broadcast studio-transmitter links, telephone lines, and other audio sources without the need for any additional manual adjustment. The HUSH Noise Reduction System as implemented in the SSM2000 has been shown to substantially reduce noise in PC multimedia, intercom system, teleconferencing systems, mobile communications, automotive audio, home stereos and televisions, while preserving full signal fidelity and transparency.

### THE NATURE OF AUDIO SIGNALS

Audio signals have both amplitude and frequency content. Music and voice are created by changing both the amplitude and frequency of sound waves.

The highest audio signal peaks typically occur at low frequencies (100–1000 Hz) and taper off exponentially as frequency increases.

When an audio signal is re-corded, audio noise is also generated. This noise is the white noise 'hiss' or waterfall sound that is easily heard on taped material. Audio noise for a given source and bandwidth does not, in general, change with frequency or amplitude. However, noise levels do change between different sources because of differences in recording equipment, media, and the surrounding environment.

Psychoacoustic effects mask noise that occurs at or near the frequency of the audio signal.

Audio noise is usually considered to be most objectionable in the 3–8 kHz band.

### NOISE REDUCTION SYSTEM REQUIREMENTS

An analogue noise reduction system must first distinguish between the desired source material and the undesirable noise. It must then attenuate the noise while leaving the source material unaffected.

One approach to noise reduction is to assume that signal below a predetermined amplitude is noise, and then to attenuate the noise by using a voltage-controlled amplifier (VCA) – see **Figure 1**. A variation of this noise reduction method is found in Dolby B cassette tape systems. This method achieves about 10 dB of improvement in signal-to-noise ratio (SNR). This system incorporates a high-frequency compressor on the recording side, and a high-frequency expander during playback.

Another noise reduction technique senses and reduces noise by measuring the frequency content of the audio signal and filtering noise that occurs above the highest signal frequency – see **Figure 2**. This noise reduction method uses a Voltage Controlled Filter (VCF) and is the basic method of operation in the DNR® system, which provides about 10 dB of noise reduction.

The HUSH system combines elements of both these techniques to achieve up to 25 dB of noise reduction, and also has significant improvements.

Since the noise floor changes with different audio sources owing to recording equipment, media, and the environment, the fixed threshold approaches cannot yield optimal results. The HUSH Noise Reduction System incorporates an automatic noise threshold detector that senses

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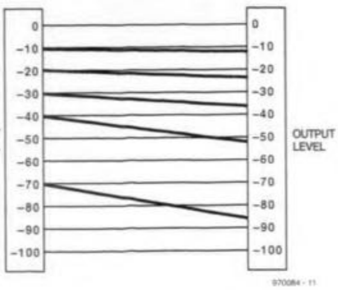
*Dolby B is a registered trademark of Dolby Laboratories, Inc.*

*HUSH is a registered trademark of Rockwell Corporation.*

An Analog Devices Application

**Figure 1. Downward expander attenuation characteristic (in dBt; 0 dBt = threshold).**




these changes and adapts the VCA and VCF to become more or less aggressive depending on the amplitude of the noise floor. To determine this amplitude, the SSM2000 assumes that the averaged amplitude during short periods of no audio is equal to the noise floor. This assumption works well in audio applications

## VARIABLE LOW-PASS FILTERING

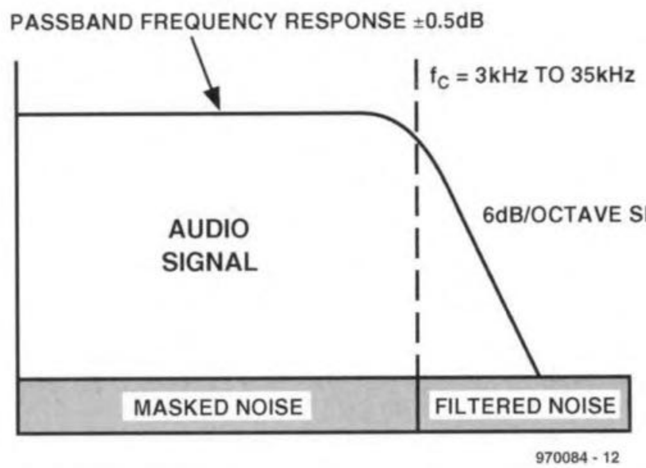
The audio signal is first passed through a single low-pass Voltage Controlled Filter (VCF) – see **Figure 3**. Both the left and right VCFs are controlled by a detector which places their cutoff frequencies just beyond the highest audio signal frequency. Since the highest audio signal frequency constantly changes, the VCF's cutoff frequency must also change in concert with the audio signal to avoid attenuating the desired signal.

For example, with signal levels below the filter threshold (presumed to be mostly noise), the VCF shuts down to about 1 kHz, providing noise reduction in the critical 3–8 kHz band. The VCF progressively 'opens up' as higher frequency amplitudes are detected at the inputs. The VCF's cutoff reaches 20 kHz when the high-frequency signal amplitude is 30 dB above the threshold. At this points, the VCF is acoustically transparent. The VCF's cutoff frequency range is 1–35 kHz. The minimum range of the VCF is limited to 1 kHz for two reasons: (a) to avoid high-frequency loss at the leading edge of transients, because the lower the minimum cutoff, the longer it takes the VCF to slew 'open', and (b), noise is most objectionable at mid- and high-range frequencies.

The SSM2000 has been designed to minimize control feed-through, since this may cause an audible output as the internal control lines of the VCAs and VCFs are changed rapidly. Feedthrough is the cause of many of the unpleasant artifacts prevalent among noise reduction systems and is often due to parasitic capacitance and mismatches within the IC. This specification is important for both the VCA and the VCF, but the VCF is the more susceptible because it operates at constant gain.

The solution incorporated in the SSM2000 to reduce control feedthrough has been to convert from single-ended to full differential at the signal input and convert back again at the output buffer. Because the audio paths through through the VCA and the VCF is fully differential, control feedthrough is determined purely by mismatches with no systematic errors. The slight penalty to be paid for a fully differential system, besides extra complexity, is that the external VCF capacitors (1 nF recommended) now require two pins each instead of one. Careful attention to VCF capacitor matching and layout symmetry reduces control feedthrough to better than 40 dB through the signal path.

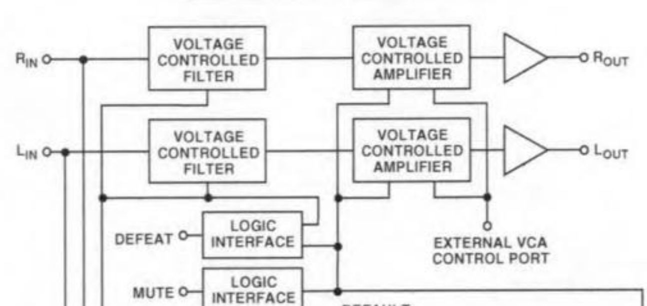
**Figure 2. Dynamic filter characteristic (for $C_F$ = 0.001 µF defeat mode).**




## DOWNWARD EXPANDER

After the audio signal has passed through the VCF, it is sent differentially to the VCA. The VCA is characterized by a downward expander transfer function. Attenuation begins at output levels below the internal threshold at an effective rate of 2.2 dB/decade. Therefore, audible noise is attenuated when source material is not present. Conversely, when audio source levels are at or above the threshold, the VCA is set to unity again. Because of psychoacoustic effects, it is valid to assume that at high audio amplitudes audio noise is masked by the audio material. The control information that is required for the downward expander to function properly is provided by the internal

**Figure 3. Block diagram of the SSM2000 noise reduction system.**



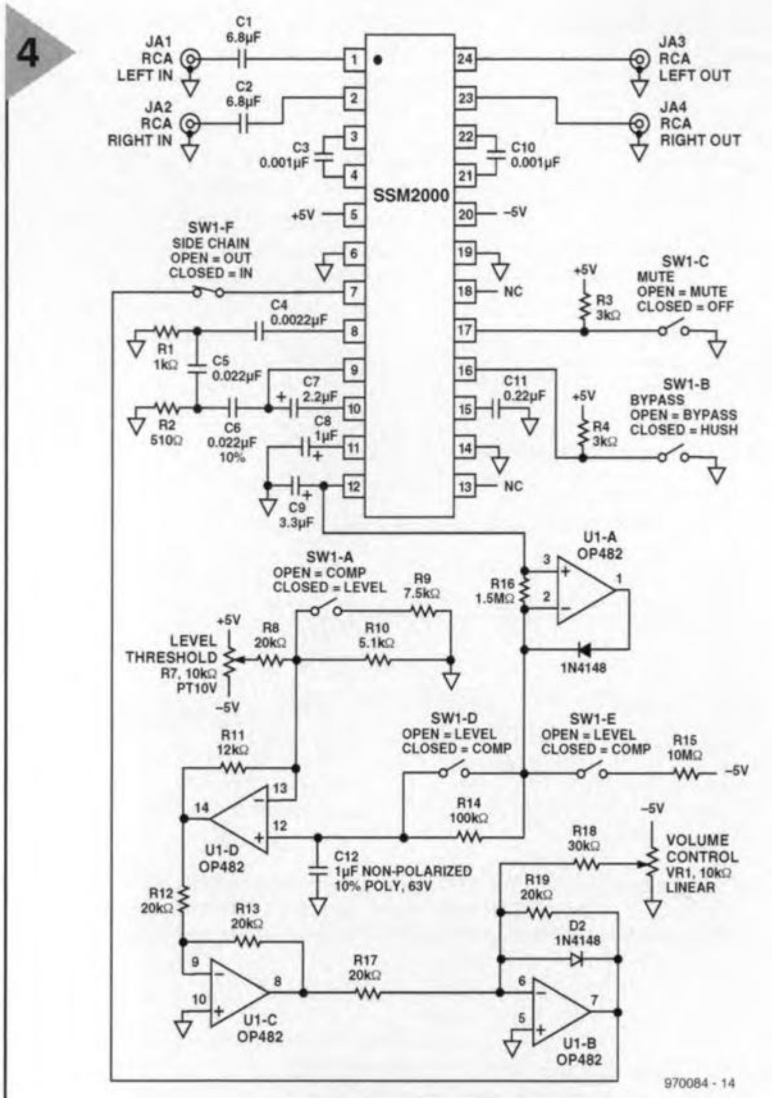



**Figure 4. Typical dual supply application and test circuit.**

VCA detector side-chain circuitry common to both the L and R channels.

The Mute function (pin 17) can override the VCA controls. When mute is active (high), it pulls the VCA to maximum attenuation. An 85 dB professional-quality mute under worse-case conditions can be expected over most of the audible frequency range. Mute overrides both the internal VCA control coming from the VCA detector and the external VCA control port (pin 7). The external VCA control port is additive in nature to the internal VCA control signals; therefore, noise reduction and volume control may occur simultaneously in the SSM2000. The VCA control port allows the gain of the VCA to be changed externally at about 22 mV/dB, where 150 mV is equal to 0 dB.

## VCF DETECTOR

Both the VCA and VCF detectors are amplitude detectors and identical in every way. The input signals applied to the detectors must be preconditioned for the detector circuitry to give the information that is required by the L and R VCFs and VCAs.

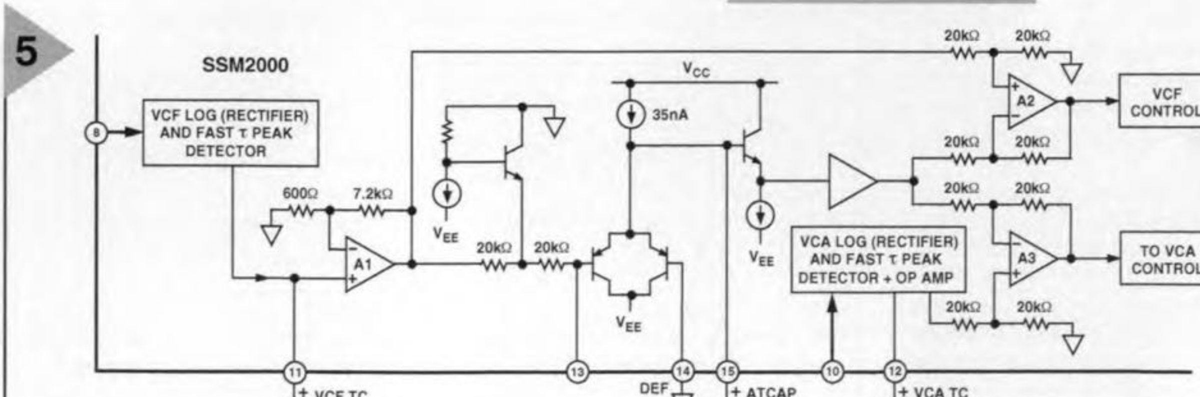
The VCF detector is fed by a 3×(L+R)/2 averaged input signal processed by a three-pole high-pass filter with a –15 dB point at 10 kHz. The VCF preconditioning filter performs two functions: (a) it eliminates the large amplitude, low-frequency audio which would otherwise mask the high-frequency signals, and (b), it becomes increasingly sensitive throughout most of the VCF's frequency range of interest (660 Hz to 20 kHz), compensating for the effect of most audio signals which typically decrease in amplitude as frequency increases.

The attack time of the VCF control is set internally and cannot be decreased; however, the release time constant is directly proportional to the value of the capacitor VCF DET CAP (pin 11). Signals above the potential at this pin cause the emitter diode of $Q_3$ to turn on, thus rapidly charging the VCF DET CAP.

When the audio signal has dropped below the level at pin 11, the emitter diode of $Q_3$ is turned off. During this condition, an internal 1.1 $\mu$A current source sets the release time by discharging the VCF DET CAP. The release time constant of the VCF detector is about ¥10 that of the Auto Threshold Detector. This ratio should not be decreased, because the output of the VCF detector is negative peak detected to arrive at the Auto Threshold level.

The output of the VCF detector (pin 11) is multiplied by 13 after which the noise threshold is subtracted to arrive at the actual control voltage for the L and R VCFs. Diode $D_1$ and transistor $Q_4$ are used to set limits on the output of

**Figure 5. Schematic diagram of the adaptive noise threshold and related circuitry.**



the detector circuitry to ensure that the detector remains responsive to pulsed high-frequency signals.

## VCA DETECTOR

The VCA and VCF detectors are identical; therefore, refer to the previous section for detailed information about the internal operation of these detectors.

The VCA detector is used to detect the audio band signal amplitude (20 Hz to 20 kHz). Usually, the lower frequencies, 50 Hz to 2 kHz, contain the highest peaks. Therefore, the VCA's preconditioning filter must allow low-frequency signals to be presented to the VCA detector. A single-pole filter is used to accomplish this function. This filter is formed by a 2.2 μF capacitor and the internal input impedance (pin 10) of 6 kΩ.

## ADAPTIVE NOISE THRESHOLD

The threshold level chosen for both the variable filter and downward expander is of prime importance in differentiating between signal and noise. In an automotive environment, for example, the audio sources are generally AM and FM radio, tape and CD. Setting the noise threshold at a value suitable to improve a noise FM station could easily wipe out most of the dynamic range of a CD. FM station threshold setting is compounded by the vast variations in signal strength in any given location, and the fact that many FM receivers will revert to monaural operation with a greatly improved SNR when signal strengths become weak. It is also unreasonable to expect the driver of an automobile to fiddle with panel controls in order to improve the threshold tracking. The patented adaptive noise threshold in the SSM2000 solves these problems, maintaining the transparency of the noise reduction system under most operating conditions while not introducing cumbersome end-user controls.

Since noise is most objectionable at frequencies in the range 3–8 kHz, only the VCF detector output signal is used to determine the adaptive noise threshold. Figures 6a–c show several circuits that illustrate how the noise threshold is derived. It is important to remember that the signal applied to the noise threshold detector circuitry has already been rectified and averaged. Hence, the lowest potential over a set period of time corresponds to the noise floor. Node A corresponds to the output of the VCF detector and node B is proportional to the adaptive noise threshold.

Figure 6a illustrates the condition where the potential at node A is above the maximum possible potential for node B. The maximum noise threshold is set by the potential placed on pin 14. If the potential at node B rises to a diode drop above Pin 14, $Q_1$'s emitter-base junction turns on and clamps node B. This is represented by current $I_2$.

However, if node B has not yet risen to the maximum noise threshold level, both $Q_1$ and $Q_2$ are off and the 35 nA current source is charging $C_1$. The auto threshold capacitor should be a ceramic or equivalent low-leakage type, because the charging current could otherwise be of similar amplitude to the capacitor leakage current.

Figure 6b illustrates the conditions where the potential at node A is between the maximum and minimum potentials for node B. When node A falls below node B, the emitter-base junction of $Q_2$ turns on, causing node B to follow node A. Current $I_2$ illustrates how the discharge current from $C_1$ and the 35 nA current source are directed through $Q_2$.

$Q_2$ shuts off the moment that node A rises above node B. This forces the 35 nA current source to begin charging $C_1$ at a constant rate set by the value of $C_1$ at pin 15.

Figure 6c illustrates the condition where the potential at node A is below the minimum potential for node B. In this case, the internal minimum noise potential causes a diode to turn on. This clamps the node A potential to the minimum noise threshold level. Current $I_1$ represents the current flow in this condition. In addition, the 35 nA flows through $Q_2$'s emitter-base junction as shown by $I_2$.

Simply subtracting the noise threshold from the average VCF HF control signal plus noise threshold and the average VCA control signal plus noise threshold will yield the final VCF and VCA control signal. This operation is accomplished with two internal differential amplifiers. [970084]

6

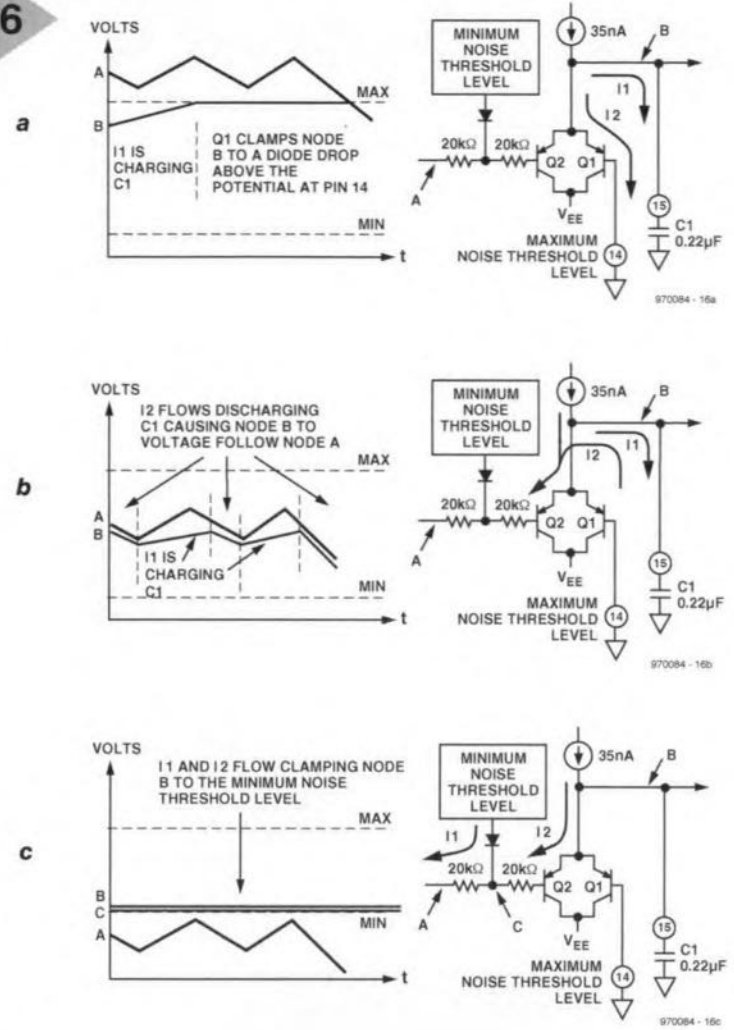



***Figure 6a. Condition where the actual noise threshold is above the maximum noise threshold level setting (pin 14).***
***Figure 6b. Condition where the noise level is between the maximum and minimum noise threshold level settings.***
***Figure 6c. Condition where the noise level is below the minimum noise threshold level settings.***

# inexpensive isolator for RS232

The isolator is intended to provide electrical isolation between a computer and the equipment connected to its serial port. For instance, users of the BASIC Stamp want to link the microcontroller to electrical loads only if there is no risk of damage to the PC. In such cases, the isolator described in this article may be of help.

Connector $K_1$ is linked to the serial port of the PC and derives from one of the lines, here the TxD line, a symmetrical supply voltage. The DTR and RTS lines may also be used, provided they are regularly switched between a positive and a negative voltage.

The other side of the isolator carries TTL levels. This side is powered by a low voltage. Since most microcontroller circuits have their own power supply, powering a few more gates should not present any difficulties.

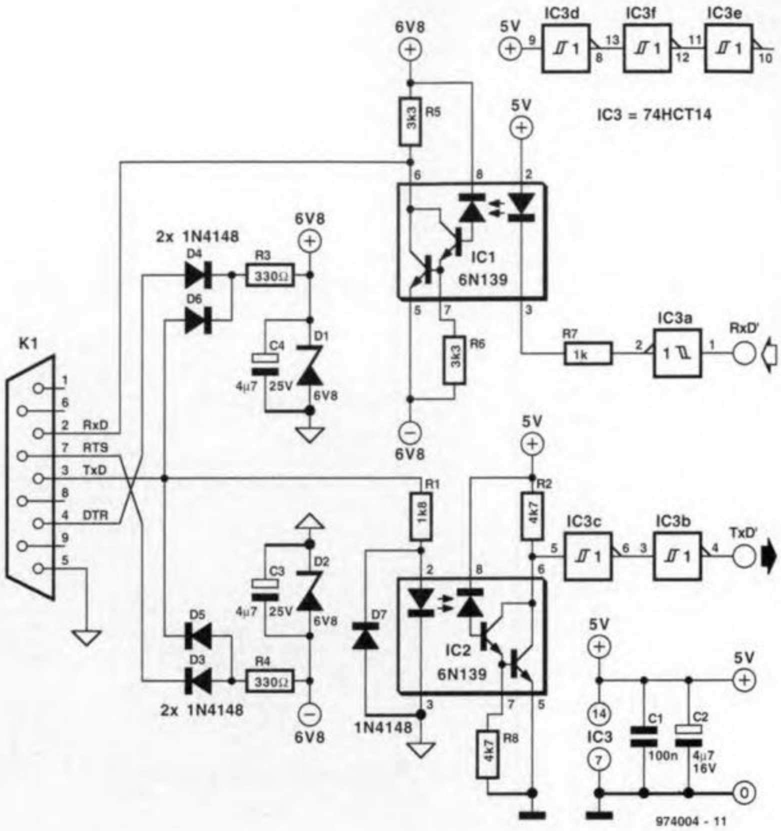
The potential at the TxD line is converted into a symmetrical direct voltage of ±6.8 V by $D_5$ and $D_6$. This voltage is used to supply $IC_1$.

The TxD signal is also applied to the LED in $IC_2$. Diode $D_7$ prevents the LED being damaged by a negative input voltage.

The LED in the optoisolator will flash in rhythm with the applied data, while the digital code appears at pin 6 of the IC.

Buffers $IC_{3b}$ and $IC_{3c}$ magnify the digital signal to full TTL level.

The send signal of the microcontroller system is applied to optoisolator $IC_1$ via $IC_{3a}$ and, after optical transfer, also appears at pin 6. There, it switches between ±6.8 V, a swing large enough to drive a standard RS232 link.




[Kersten – 974004]

# VCO continuity tester

Although the tester could hardly be simpler, it has a fixed place in the tool box of the designer. The test voltage is derived from a standard 9 V battery and is applied to a test probe via $D_1$ and $S_1$. This probe is linked to one end of the line whose continuity is to be tested. A second probe, whose output is applied to the input of a VCO (voltage-controlled oscillator) is connected to the other end of the line.

The range of oscillation of the VCO is determined by $C_2$ and $R_1$ (top of the range) and the resistance at pin 12 (bottom of the range), which in this application is left open.

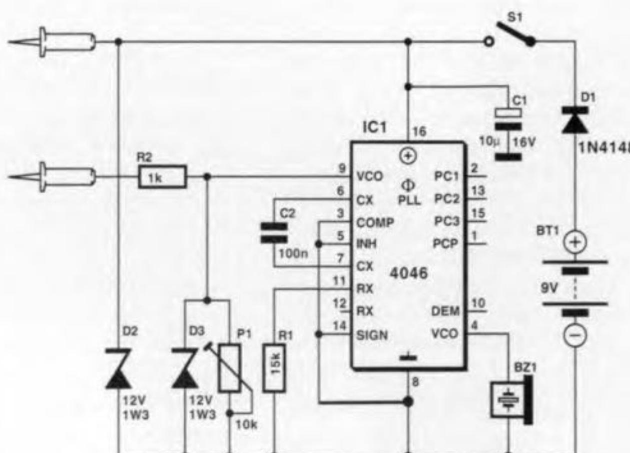
In the absence of a voltage at the input of the VCO, the oscillator does not oscillate. When the test voltage reaches pin 9 (line is all right), the VCO oscillates at the maximum frequency of 1.2 kHz. This signal is made audible via a piezobuzzer, $Bz_1$.

Because of its discrete supply, the tester can also be used for tests on active circuits. Zener diodes $D_2$ and $D_3$ prevent damaging voltages from reaching the input of the VCO.

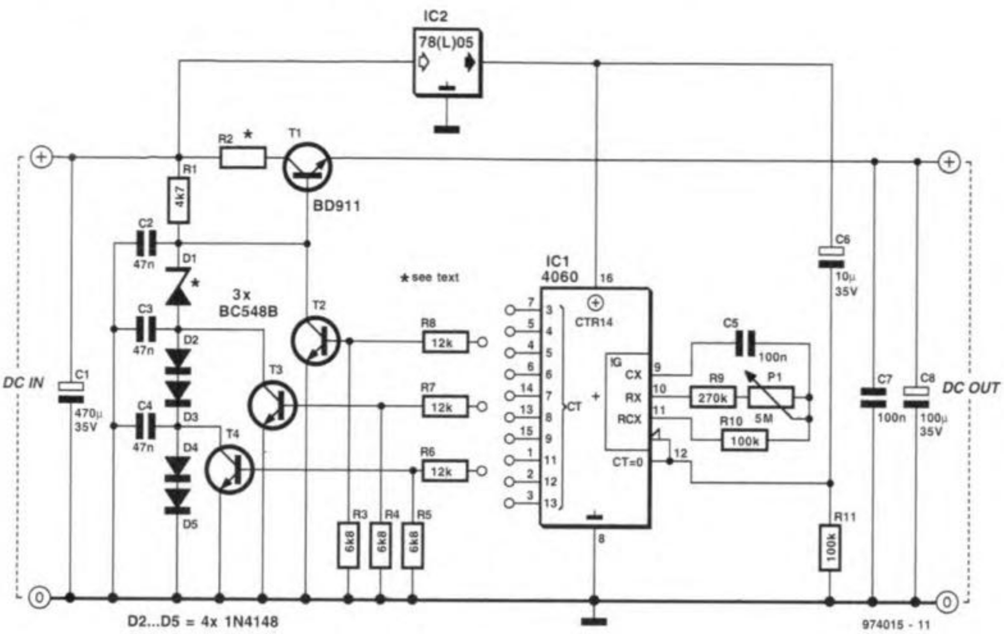
The level of the test current is set with $P_1$, which is useful when the connection to be tested is a high-impedance one.

The tester draws a current of around 3 mA.

[Dittmann – 974046]



# auto on/off switch for power supplies




In the testing of circuits, there is sometimes a need for the supply voltage to be switched on at a given time or in steps.

The auto on/off switch presented is based on $IC_1$, an oscillator/binary counter. The frequency of the oscillator is determined by $R_9$-$R_{10}$-$P_1$-$C_5$. The IC has ten outputs that become high sequentially and which may be used to drive identical transistor stages (three of which are shown in the diagram). Each of these stages consists of a potential divider and a BC548B transistor that functions as a switch.

The actual power supply, in conjunction with power transistor $T_1$, functions as a parallel regulator. The output voltage is determined by the zener voltage of $D_1$ less the drop across the base-emitter junction of $T_1$ plus the drop across those diodes that are not short-circuited by a transistor.

For example, if the zener diode is a 12 V type, and $T_3$ and $T_4$ are cut off, the output voltage is $12+4\times0.7-0.7=14.1$ V. The zener voltage is discretionary, but depends on the minimum output voltage plus $U_{be}$ of $T_1$.

When $T_2$ is switched on, the zener diode is short-circuited, so that the power supply is switched off.

Resistor $R_1$ limits the current through the series of diodes.

Although the IC can operate from a wide range of supply voltages, it is recommended to use a 5 V regulator, $IC_2$. If the load current is in excess of 100 mA, $T_1$ must be mounted on a suitable heat sink. The transistor must not get so hot that it cannot be touched. If it does, the load current must be reduced, a higher rated heat sink used, or $R_2$ added. The value of this resistor in ohms is the numerical difference between the input and output voltage in volts divided by the numerical value of the peak load current in amperes. Its rating is the product of these quantities.

Finally, note that the on/off switch is not short-circuit-proof.

[Dittmann - 974015]

# wideband VHF preamplifier

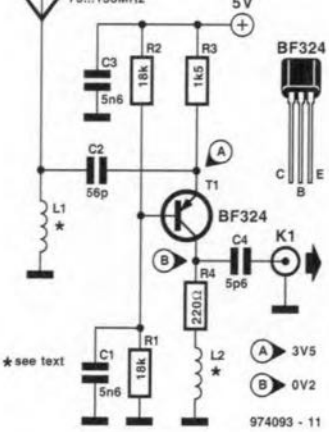
This inexpensive VHF preamplifier uses the BF324 TO92 style pnp transistor in a grounded-base configuration. The circuit may be used as a signal booster with VHF receivers whose front end suffers from low sensitivity (such as many valved and army surplus types). The frequency range of the preamplifier is roughly from 75 MHz to 150 MHz.

The two inductors in the circuit are home made. $L_1$ consists of 10 turns of 24SWG enamelled copper wire; the internal diameter is 3 mm, no core. Inductor $L_2$ has 13 turns of the same wire, and an internal diameter of 5 mm; no core is used either. A construction tip: close-wind the inductors using 3 and 5 mm drill bits respectively as temporary formers.

The prototype of the preamplifier was successfully used with an 88-108 MHz FM broadcast receiver and a 2-metre VHF ham receiver.

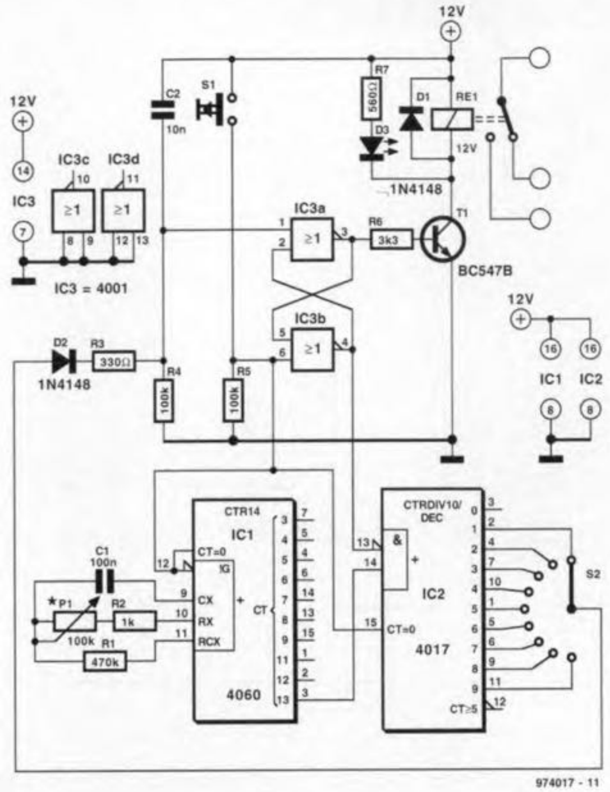
The preamplifier draws about 2.5 mA from a 5-volt supply.

(974093 - Pradeep G.)



# variable-pulse generator

In electronics, there is often a requirement for a generator that provides variable-width pulses. Examples abound: stair lighting; time/interval switch in private and commercial vehicles; time switch for room lighting, radio or stereo equipment, or ventilators. The integrated timer very often used is the 555. This has a drawback, however, in not being able to provide very long pulse-widths. Moreover, long pulse-widths cannot be set accurately with a potentiometer.




In the present circuit, the pulse-width can be set very accurately over a wide range. The circuit is controlled by an RS bistable consisting of gates $IC_{3a}$ and $IC_{3b}$. It is set by operating switch $S_1$ at the Set input (pin 6).

The output of the bistable (pin 3) trips the output relay via $T_1$. Freewheeling diode $D_1$ protects the circuit against inductively induced surges. The status of the circuit is indicated by $D_3$.

The bistable is returned to its output state via the Reset input (pin 1). A reset also occurs on switch-on via $R_4$-$C_2$.

The Reset input is driven by the output of of a counter/ oscillator. In the quiescent state, decade counter $IC_2$ is disabled via its Enable input while $IC_1$ oscillates and counts. This does not matter, however, since a push on the button resets both counters to zero. The oscillator pulses are then starts to count and when the 16348th pulse arrives at pin 3, the decimal counter is clocked.

Thereupon $S_2$, which may be a rotary switch, a DIP switch or a jumper, enables one of the next ten pulses to be selected and applied to the reset line of the multivibrator. Diode $D_2$ prevents any feedback to the outputs of $IC_2$.

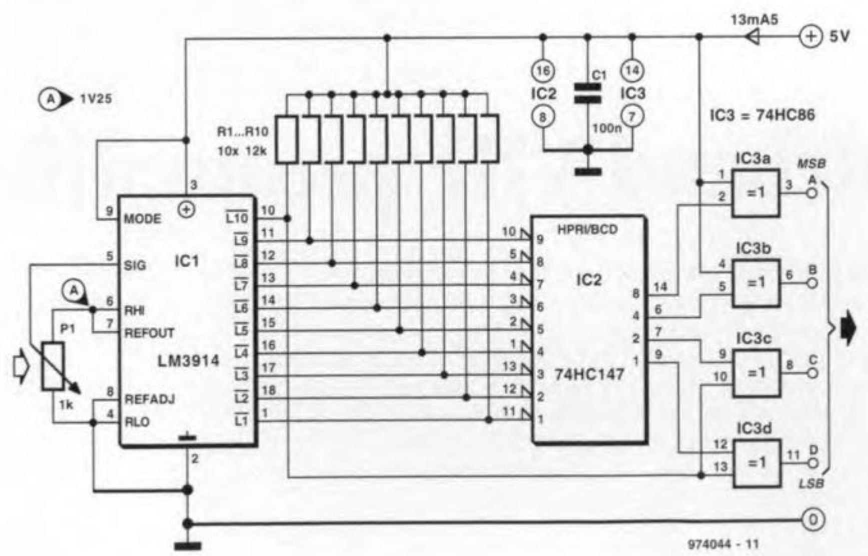
The time elapsing until 16348 or 163480 pulses are generated depends, of course, on the oscillator frequency and, therefore, on the setting of $P_1$. A 1 kΩ preset makes switching times up to 2 s possible. Resistance and pulse duration are virtually directly proportional.

The circuit draws a current of 15 mA (mainly on account of the LED), excluding the relay current.

[Lay - 974017]

# simple position sensor

This circuit converts the wiper position of a potentiometer (slide or rotary) into one of 11 binary values (0 through 10). The author designed and used this 'digital potentiometer' to provide an interface between a microcontroller and the arm assembly of a robot.




The familiar LM3914 is used here as an analogue-to-digital converter (ADC) which translates the (analogue) wiper voltage into a corresponding digital value. The LM3914 is used in bar mode in the present circuit for reasons outlined below.

The ten open-collector outputs of the LM3914, $\overline{L1}$ through $\overline{L10}$, are connected to the inputs of a 10-to-4 priority encoder, IC2, a 74147. Only the input bit with the highest significance appears in 4-bit binary code at the outputs of the encoder. The ten encoder inputs allow the codes 0000 through 1001 to be made (that's decimal 0 through 9). XOR gates IC3c and IC3d have been added to enable the value '10' or 1010 to be produced also. Their function is as follows: if the '147 encoder is at the value 1001 (9), and $\overline{L10}$ of the LM3914 goes low (active), then the XOR gates will invert the two least significant bits, creating the binary word 1010.

However, that only works if $\overline{L9}$ remains active when $\overline{L10}$ is actuated, hence the use of the 'bar' mode rather than the 'dot' mode on the LM3914.

(974044 - K.M. Reddy)

# RS232-driven shift register

The circuit, which consists of only a few gates and a latched shift register, is eminently suitable for driving several outputs via a two-wire RS232 connection. An example is the 'stepper-motor control' elsewhere in this issue. It may also prove useful when, for instance, all the gates of a microcontroller are occupied.

The program was used to drive eight LEDs via the prototype.

The RS232 interface must be set to 9600 baud, no parity, eight data bits, one stop bit. So, to send a bit via the RS232 bus, a data block of ten bits (eight data bits plus one stop bit plus one start bit) must be sent.

A logic 1 is sent as $FF_{HEX}$, which is eight ones and a logic low is sent as $00_{HEX}$, that is eight zeros.

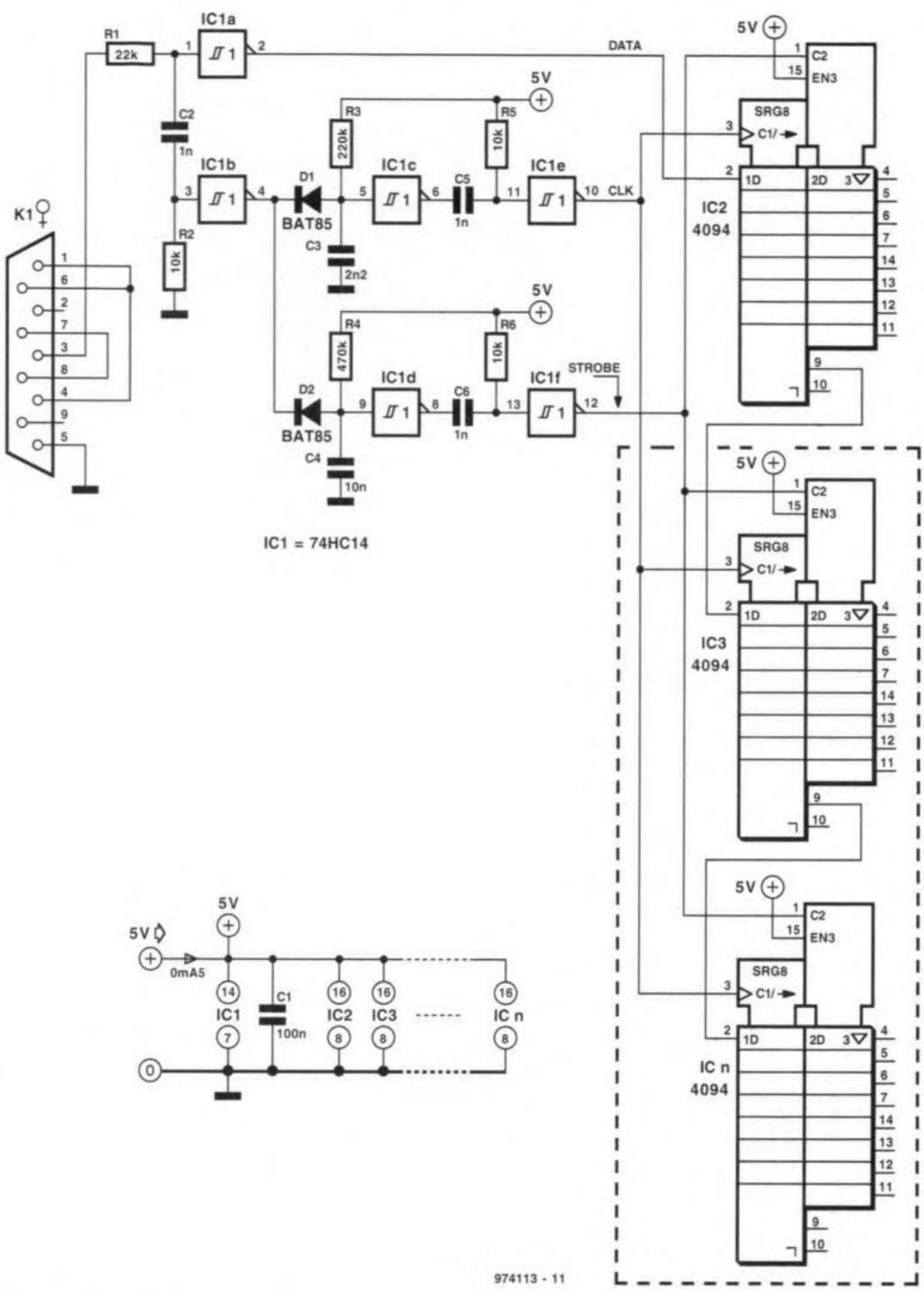
In the quiescent state, the output of the RS232 interface is –12 V. A logic 1 is represented by –12 V and a logic 0 by +12 V.

The internal protection diodes in $IC_1$, in conjunction with $R_1$, limit the input voltage to about 600 mV.

The DATA line (pin 2 of $IC_2$) carries the same signal as the RS232 bus, but converted to 0 V (logic low) and +5 V (logic 1).

A leading edge at the input of the circuit, such as that of the start bit of a new data block, causes a positive pulse at the input of $IC_{1b}$, which then enables the Schmitt trigger.

Capacitor $C_3$ is then discharged via $D_1$. During the discharge time, the output of $IC_{1c}$ is high. As soon as $C_3$ is discharged, the output of $IC_{1b}$ goes high, whereupon $C_3$ is charged again via $R_3$. After about 530 $\mu$s, the potential across $C_3$ is high enough to trigger $IC_{1c}$, whereupon the output changes from 1 to 0. The consequent trailing edge causes the input of $IC_{1e}$, which is normally held high by $R_5$, to become low. This in turn results in a leading edge at the CLK input of $IC_2$, enabling the information on the DATA line to be written.




The lower branch in the diagram ($IC_{1d}$ and $IC_{1f}$, functions in a similar manner, but the time constant $R_4$-$C_4$ is about ten times as long. When for 5.16 ms no signal is sent over the RS232 line, the STROBE signal becomes active, whereupon the data in the shift register is latched to the output.

As shown in the diagram, the circuit may be expanded by linking the carry out of $IC_2$ to a second (and subsequent) register ($IC_3$, $IC_4$, ...).

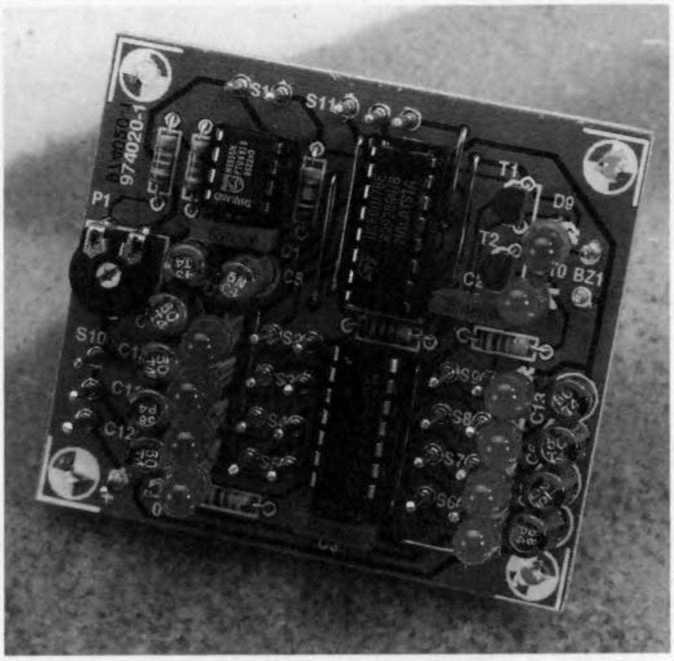
[Willaert – 974113]

# octopush

Pit your reaction and coordination skills against an opponent with this electronic push-button game.

The game is intended for two players (or teams) identified as red or green. There are two rows of push-buttons, four red and four green, with adjacent LEDs. These flash sequentially between red and green at a speed that can be manually adjusted. The object is for a player to press his or her associated push-buttons during the brief time that the player's LEDs are alight. Each push-button enables an energy store to be tanked up during this period. However, any push-button pressed when its LED is not on will drain off energy. When all four energy states are tanked up, the output of a 4-input NAND gate switches on a transistor and a red/green jumbo LED in its collector circuit indicates the winner. A buzzer also confirms that the game is over.

Control of the timer speed (by the referee only!) enables the game to be played with varying degrees of skill to satisfy both young and old.

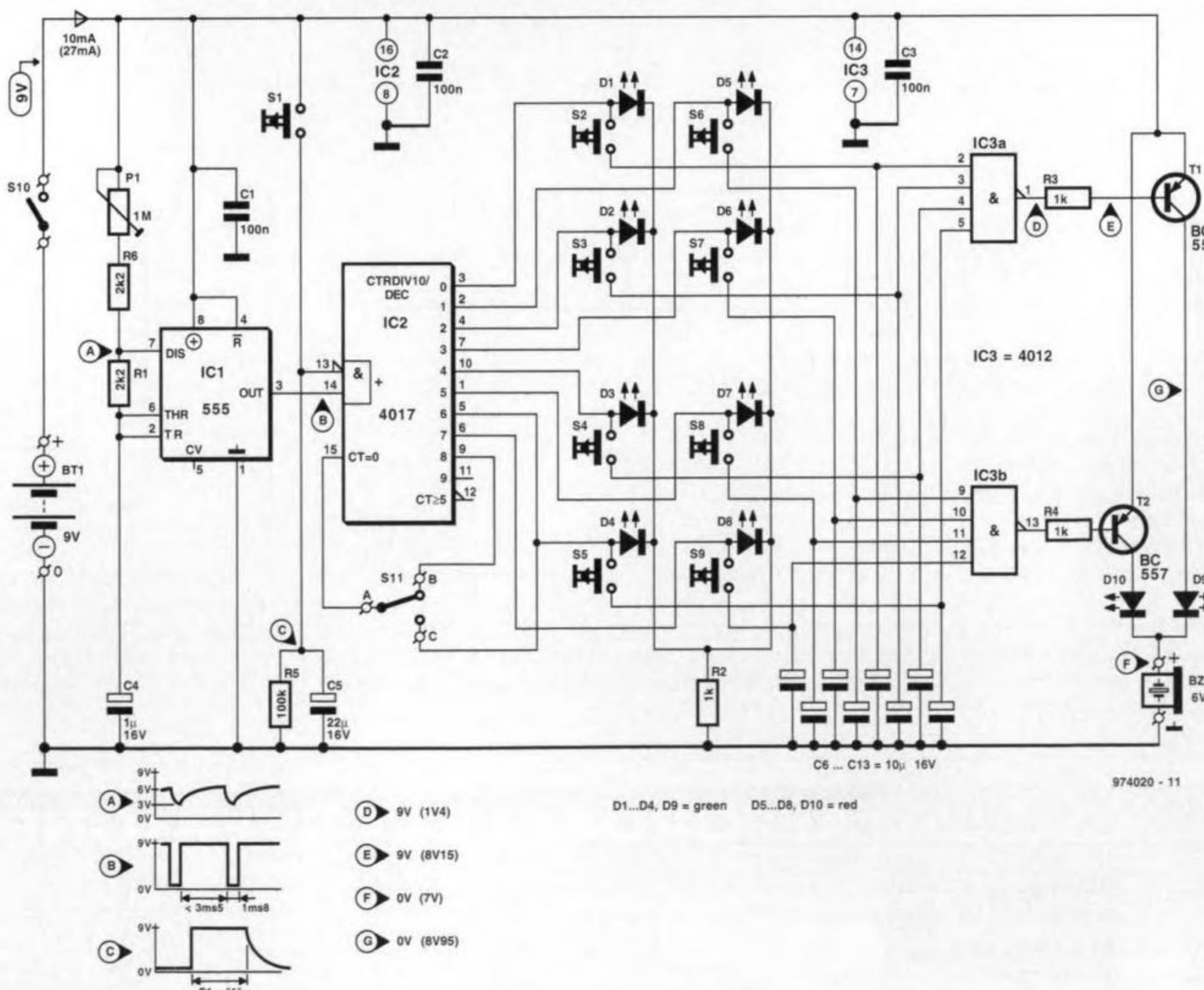


A 'freeze' button, which pauses the display on one of the LEDs for about two seconds can provide a more leisurely method of play. Again, a slower timer speed will introduce an element of skill, players taking turns to choose which LED may be targeted for storage.

A dice facility, using six of the LEDs, also quasi-random or skill-dependent (slower speed), is provided for use with other games. For some games, a heads/tails facility can be employed by choice of red and greens. For four-a-side games, quizzes for example, all eight LEDs can be used, together with the freeze button.

Now for the circuit. Counter clock pulses are provided by IC1, a 555 timer wired in astable mode. Timing components P1, R1, R6 and C4 enable any pulse speed to be set between 1 and 180 per second (test points *a* and *b*).

At switch-on, the output of IC1 cycles eight of the decoded outputs of IC2 (a 4017 Johnson counter), as the reset pin, 15, is connected to pin 9 via S11. The resulting high output on pin 9 provides a reset pulse after the eighth output. The positive output pulses energize LEDs



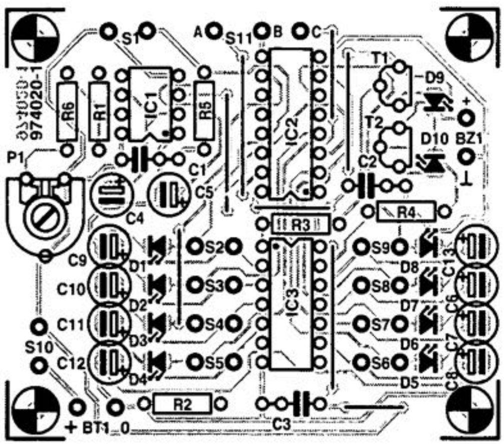
D1 to D8 in turn, causing them to cycle at a speed determined by the setting of P1.

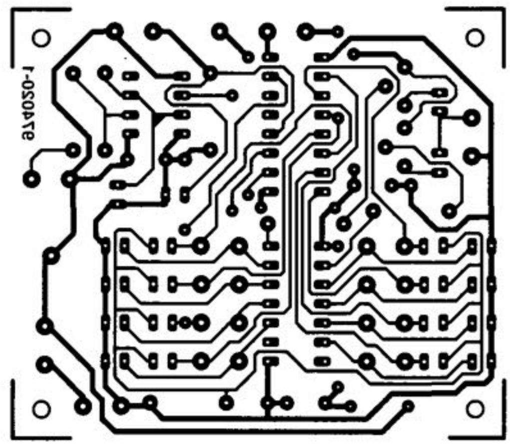
The red push-buttons S6-S9 each connect a counter output to inputs 9-12 of a 4-input NAND gate in IC3. Similarly the green push-buttons S2-S5 go to the inputs of the other NAND gate. Electrolytic capacitors C6-C13 (one at each input of IC3) serve as the tank circuits. Although any of these can be charged up instantly by pressing the associated push-button when the LED indicates that the output pulse is present, it will also discharge instantly if the push-button is actuated when the pulse is absent.

If all 'red' inputs of IC3 are high, output pin 13 goes low and switches on T2. This in turn switches on red LED D9 and brings on solid-state buzzer Bz1. Conversely, if all green inputs are high, output pin 1 of IC3 goes low and T1 switches on to energize the green LED, D10 (test point *d*).

The freeze button, S1, takes the clock inhibit input of IC2 (pin 13) high, and the charge on C5 holds the displayed LED momentarily (test point *c*). The stated value of C5 gives a display of about two seconds, which seems adequate for dice or capture purposes, but this can be varied as desired.

Unfortunately, the printed circuit board shown here is not available ready-made through our Readers Services. (974020 - R. Bebbington)




**COMPONENTS LIST**

**Resistors:**
R1,R6 = 2kΩ2
R2,R3,R4 = 1kΩ
R5 = 100kΩ
P1 = 1MΩ linear potentiometer

**Capacitors:**
C1,C2,C3 = 100nF
C4 = 1µF 16V radial
C5 = 22µF 16V radial
C6-C13 = 10µF 16V radial

**Semiconductors:**
D1-D4,D9 = green LED
D5-D8,D10 = red LED
T1,T2 = BC557
IC1 = 555
IC2 = 4017
IC3 = 4012

**Miscellaneous:**
S1 = push-button, 1 make contact
S2-S5 = red push-button, 1 make contact
S6-S9 = green push-button, 1 make contact
Bt1 = 9V PP3 battery with holder and clip
Bz1 = active buzzer, 6V
S10 = switch, 1 make contact
S11 = switch, 1 change-over contact

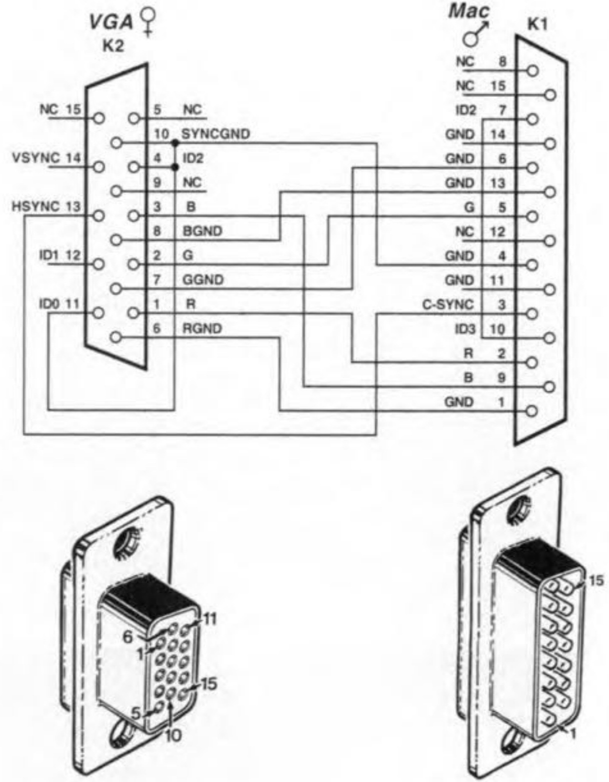
# Mac-to-VGA monitor adapter

Irrespective of their size, Apple (compatible) monitors are nearly always more expensive than the ones commonly identified as VGA or S-VGA by PC users. As Apple computers are usually sold without a monitor (the catalogues say 'CPU only') it is possible to reduce the cost of a complete system somewhat by using a VGA monitor. If you do so, the ensuing plug incompatibility problem is solved by the circuit shown here, which consists of a 15-way high-density sub-D VGA socket at one side and a standard 15-way sub-D plug at the other. The indicated pins of these two connectors are connected by short wires, and Bob's your uncle.

Note that this adapter also passes the monitor-ID bits to the Mac computer. Consequently, you should be able to choose from a number of available screen resolutions if you go to the Monitor settings on the Mac (use the Control Strip if you have System 7.5.3).

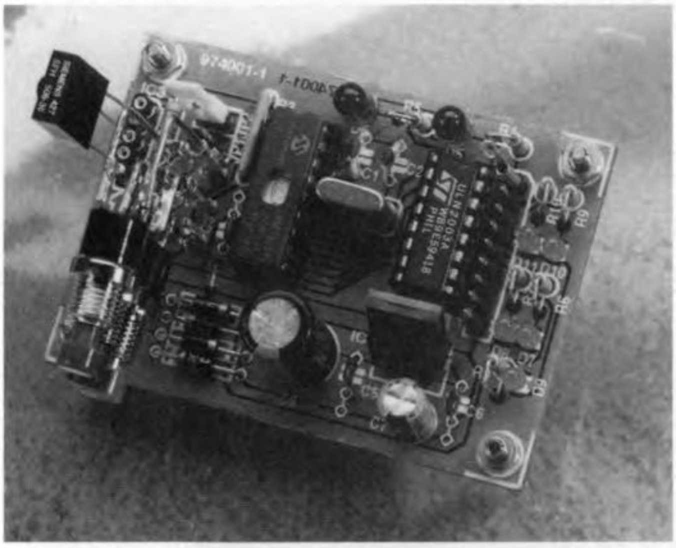
The adapter is also suitable for those of you who wish to share a VGA monitor between a Mac and a PC without swapping video cables and plugs all the time. Provided the monitor has separate RGB and sync inputs on BNC sockets, the PC can use these, while the Mac is connected to the sub-D socket via the adapter shown here.

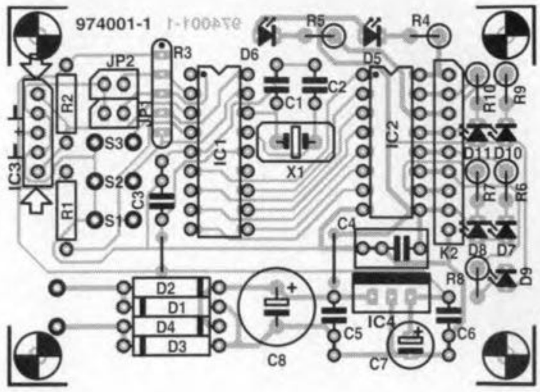
(974056 - L. Lemmens)

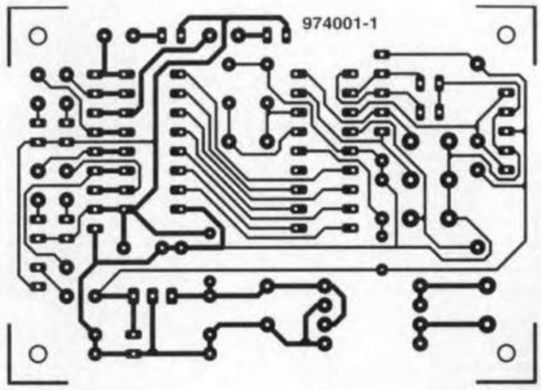



974056 - 11

# PIC-controlled light barrier






The microcontroller-driven light barrier operates with two infra-red senders which, if set up correctly, provide a measure of directivity.

The senders, $D_5$ and $D_6$, may be standard infra-red models whose beam is directed on to an infra-red receiver, $IC_3$. Since the senders operate with a 36 kHz carrier, the receiver may be an inexpensive, easily available model with integrated demodulator, filter and amplifier, such as used in IR remote control systems. LEDs $D_7$–$D_{11}$ function as status, operation and position indicator.

The light barrier is controlled by a Type 16C54 microcontroller, $IC_1$, which is clocked by a 1 MHz crystal. The outputs of $IC_1$ are buffered by an integrated octal power driver, $IC_2$. This enables a buzzer, relay or lamp rated at up to 500 mA to be driven in addition to, or instead of, the LEDs.

The PIC contains two programs. After switch-on, the operating program starts with a routine which initializes the port lines and the various registers. Thereupon, ports $PB_0$ and $PB_1$, to which the IR senders are linked, alternately generate four pulses each.

These pulses are detected by the receiver and read via the real-time clock (RTCC). If fewer than four pulses are received, the PIC repeats the process twice to ensure that no pulses are lost or that no spurious pulses are received. If during none of the three processes four pulses are received, the program interprets this as an interruption (break) in the light beam.

Whether this arrangement ensures that the system does not react to spurious pulses can be checked by closing jumper $JP_1$ or $JP_2$, which disables the control process. The PIC then reacts to the second ($JP_1$) or first ($JP_2$) spurious pulse. This action is, however, useful only if the IR beam is set up accu-

Parts list:

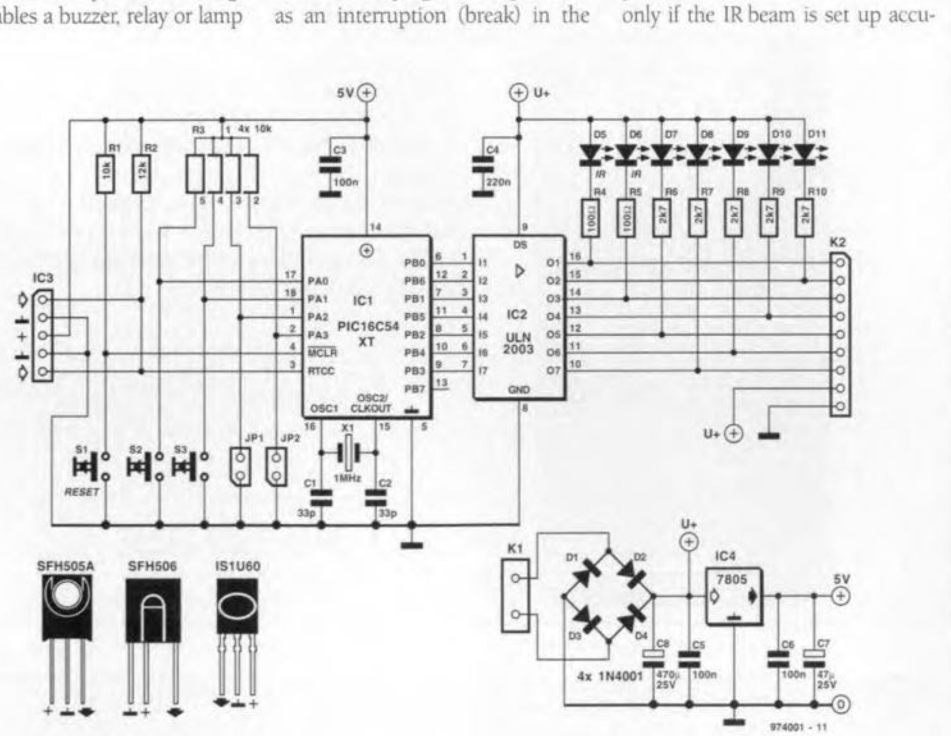
Resistors:
- $R_1$ = 47 kΩ
- $R_2$ = 12 kΩ
- $R_3$ = 4 × 10 kΩ array
- $R_4$, $R_5$ = 100 Ω
- $R_6$–$R_{10}$ = 2.7 kΩ

Capacitors:
- $C_1$, $C_2$ = 33 pF
- $C_3$, $C_5$, $C_6$ = 0.1 μF
- $C_7$ = 47 μF, 25 V, radial
- $C_8$ = 470 μF, 25 V, radial

Semiconductors:
- $D_1$–$D_4$ = 1N4001
- $D_5$, $D_6$ = infra-red LED, e.g. LD271
- $D_7$–$D_{11}$ = LED

Integrated circuits:
- $IC_1$ = PIC16C54 (programmed with EPS 976503-1)
- $IC_2$ = ULN2003 (Sprague)
- $IC_3$ = SFH505 or SFH506-36 or ISU60 (36 kHz)
- $IC_4$ = 7805

Miscellaneous:
- $JP_1$, $JP_2$ = jumper for board mounting
- $K_1$ = soldering pin
- $K_2$ = 9-pole PCB mounting block
- $S_1$–$S_3$ = single-pole switch with on contact
- $X_1$ = crystal, 1 MHz



rately and screened cable is used.

When the light beam from $D_5$ is interrupted, $D_8$ and $D_{11}$ light for 2 seconds, $D_7$ for about 8 s, and $D_9$ for around 20 s. In case of $D_6$, $D_{10}$ lights for about 2 s and $D_9$ for around 20 s. With the use of an appropriate evaluation circuit, it may be determined in which sequence, or in which direction, the light barrier was interrupted.

The clearly different switching times permit various uses of the alarm outputs. After the last LED has gone out, the program starts anew, so that the light barrier cannot be disabled by covering the IR diodes.

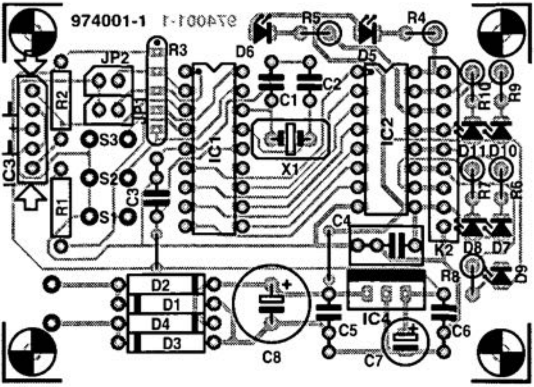
The position program is an important aid during the setting up of the (invisible) infra-red beams. It starts when $S_2$ (for $D_5$) or $S_3$ (for $D_6$) is held down at the same time as $S_1$ is pressed for a reset. As long as there is no IR link established, $D_{11}$ flashes (for $D_5$) or $D_{10}$ (for $D_6$). When the link has been established, the relevant LED lights continuously. A return to the operating program is effected by another reset.

The circuit draws a current of about 25 mA plus that through the load connected to $IC_2$. The power supply may be a 9 V mains adaptor, which need not be regulated.

The light barrier may be constructed on the printed-circuit board shown, which is, however, not available ready-made.

[Dittmar – 974001]

Dithmann


974001-1
R5
R4
R3
JP2
D6
D5
C1
C2
R2
S3
S2
S1
IC1
X1
IC2
R10
R9
D11
D10
R7
R6
D8
D7
D9
C3
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C4
K2
R8
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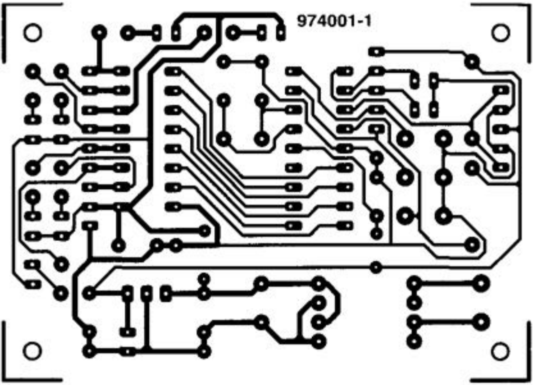
D1
D4
D3
C8
C5
IC4
C6
C7


974001-1

# voltage inverter/doubler

The circuit in **Figure 1** consists of a charge pump which can be switched for use as a voltage inverter or a voltage doubler. It requires two CMOS ICs Type 74HC14, but Type 40106 may also be used, although this provides a rather smaller current.

Circuit $IC_{1a}$ is arranged as an oscillator operating, with components as specified, at a frequency of about 160 kHz.

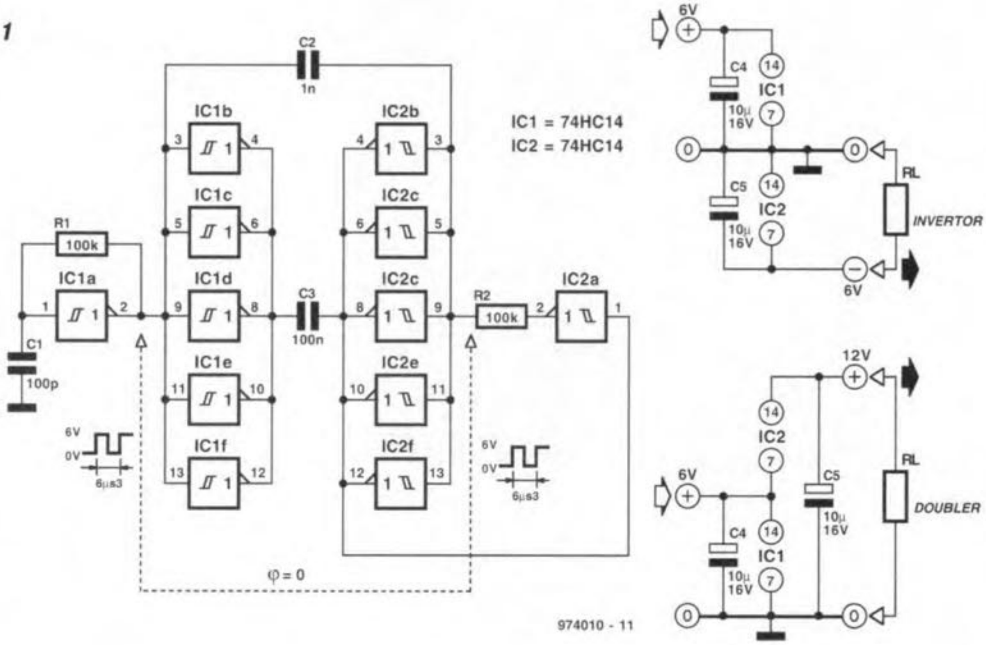
Inverters $IC_{1b}$–$IC_{1f}$ are in parallel to ensure sufficient output current.

The signal is also applied to a second group of inverters in parallel, $IC_{2b}$–$IC_{2f}$ via $C_2$. Since this capacitor passes a pulse only at the edges of the oscillator signal, this group of inverters is augmented by positive feedback provided by $IC_{2a}$. Resistor $R_2$ ensures that the feedback circuit is triggered via $C_2$.

Capacitor $C_3$ is the charge pump that transfers the requisite energy. Because of the relatively high frequency, the value of this capacitor need not be high.

Adjacent to the diagram is shown how the circuit can be used as either a voltage in-verter or a voltage doubler. Note that the inverted or doubled voltage is taken from the +ve supply pin of $IC_2$ and the –ve supply pin of $IC_1$.

1



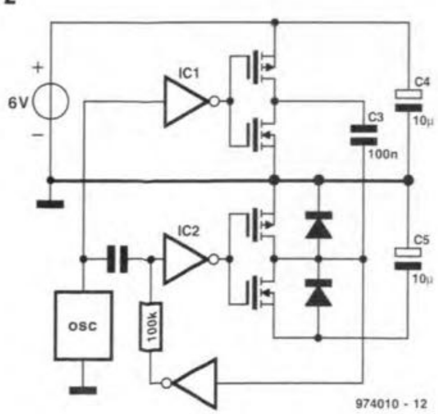

The operation of the circuit is best understood with reference to the output stage of a CMOS IC as shown in **Figure 2**.

Both groups of inverter switch in phase. In case of a voltage inverter this results in $C_3$ being charged during one half-period (in parallel with the supply line—see **Figure 3a**), whereas during the other half-period the capacitor is in parallel with $C_5$, so that this capacitor is also being charged—see **Figure 3b**. During voltage-doubling, virtually the same happens, but in this case the potential across $C_2$ is superimposed on the output of $IC_1$.

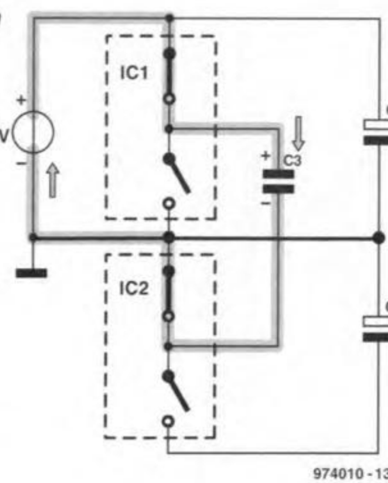
The unloaded output voltage is virtually double the supply voltage (when the circuit is acting as a doubler). When the output current is 10 mA and the supply voltage is 6 V, the output voltage drops to –5 V (inverter) or rises to +11 V (doubler). When the circuit is unloaded, it draws a current of only 1.5 mA.

[Kuppens – 974010]

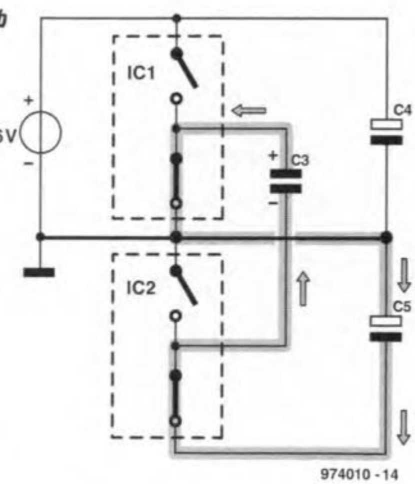
2



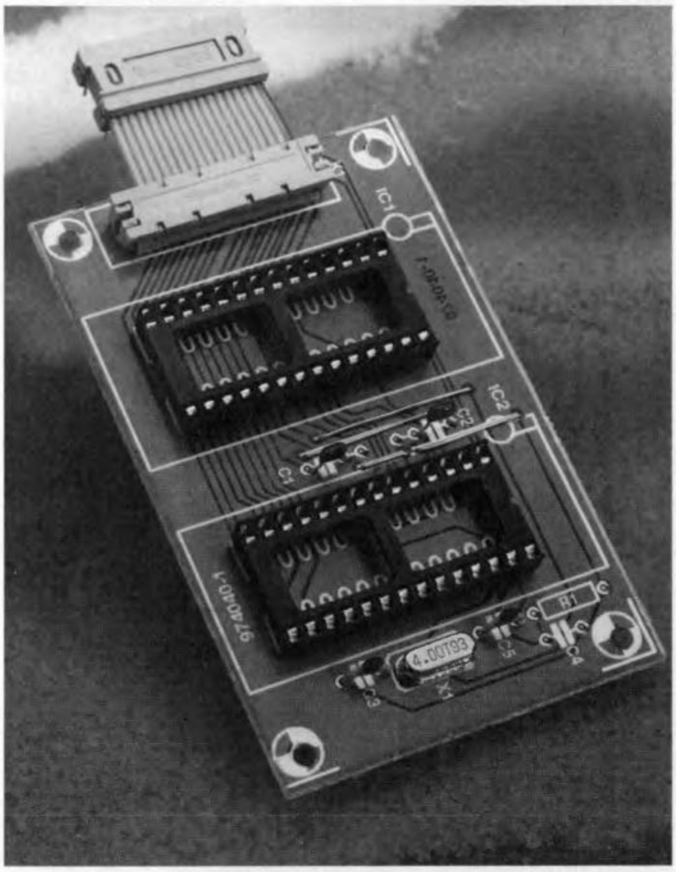

3a

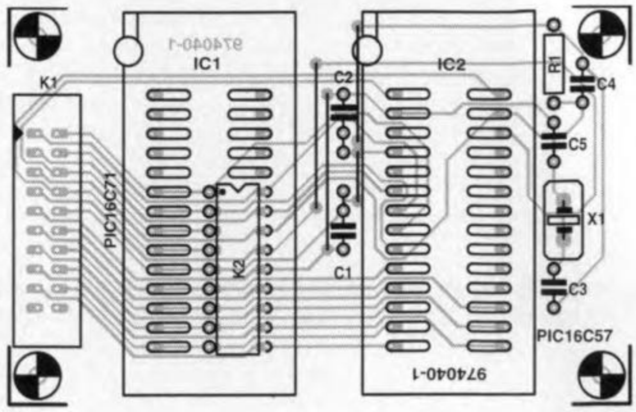


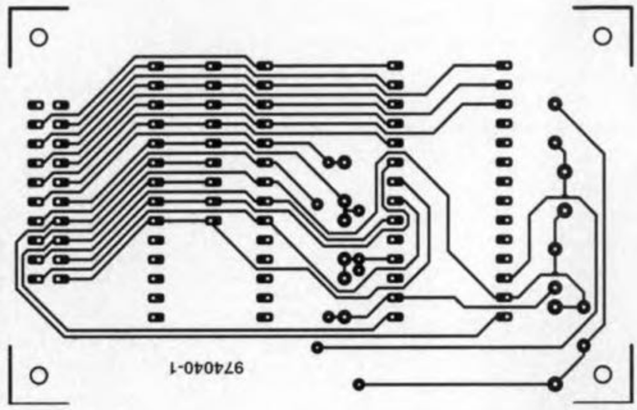

3b



# adaptor board for 18-pin PICs



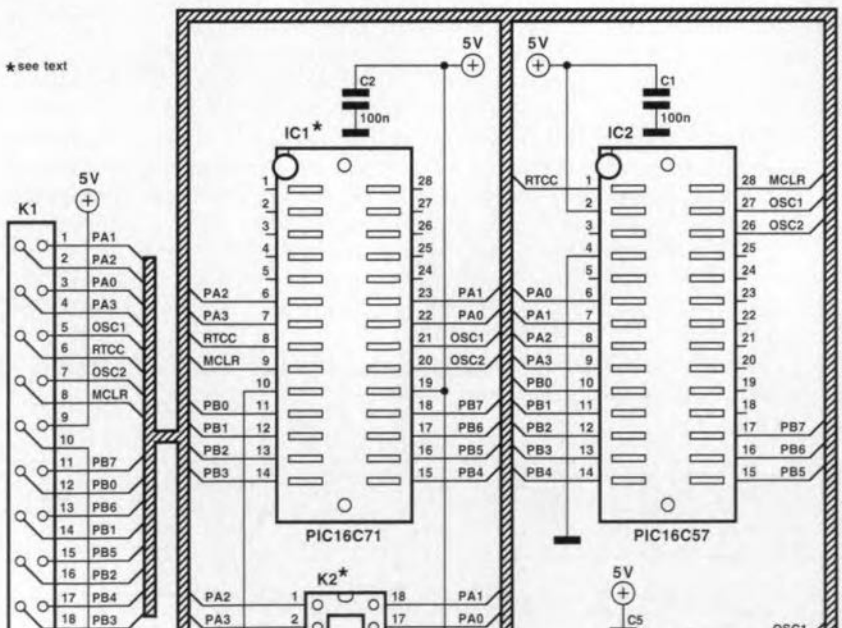



Microchip's PICSTART-16B1 kit comes with two PIC controllers: an 18-pin PIC16C71 and a 28-pin PIC16C57. Both controllers have an internal EPROM, with the obvious disadvantage that the time needed to erase them is, well, annoying if you want to stay in the fast lane with code development.

This adapter allows you to simulate a 16C71 by means of a larger PIC device, the 28-pin PIC16C57. In this way, you can continue developing PIC code, not wasting time counting hairs on your arm, twiddling thumbs or just fidgeting as you have to wait for the UV eraser to do its thing with the 16C71.

The circuit is connected to a target system by means of a flatcable and an 18-pin DIL plug which is inserted in the socket normally occupied by a PIC16C71. Although the present




**COMPONENTS LIST**

**Resistor:**
R1 = 3kΩ3 - 100kΩ *

**Capacitors:**
C1,C2 = 100nF
C3,C4 = 22pF *
C5 = min. 27pF *

**Miscellaneous:**
IC1,IC2 = 28-pin ZIF socket, see text
K1 = 20-pin boxheader or pin-header
K2 = see text
X1 = quartz crystal, 32kHz - 20MHz *
18-pin DIL plug, IDC style (Eurodis 35633010T)

* optional, value depends on application, consult PIC datasheets

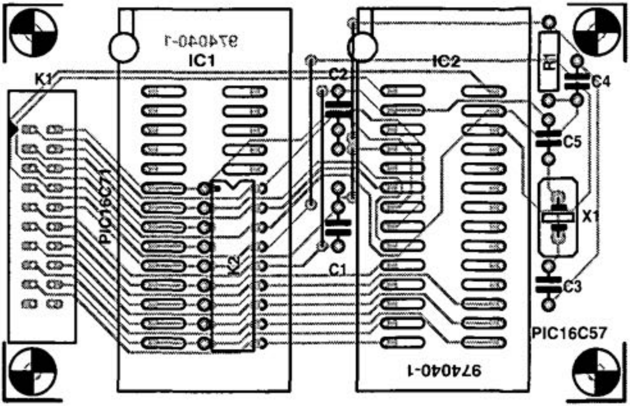
board also offers a crystal and ancillaries to operate the PIC's internal oscillator, these parts will seldom be required as they will be available on the target system board in most cases. For oscillator configurations, consult the PIC's datasheets.

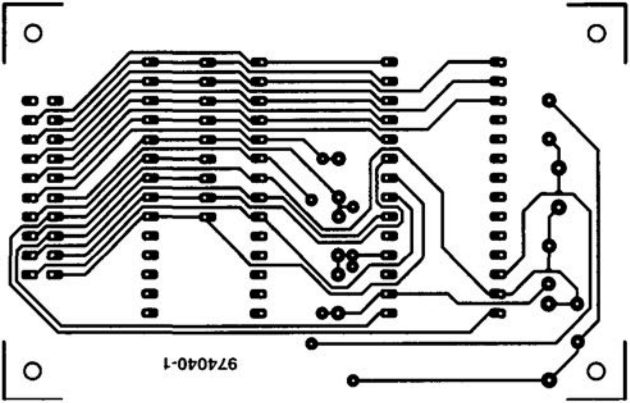
If you want to be able to fit 18-pin 16C71's on the present board, two options are available. The first is to fit an 18-pin narrow-DIL ZIF socket, which, alas, is a rare bird and frightfully expensive, too. If you happen to have one, email us, and use the 18-pin DIL shape shown on the board to fit it. A low-cost alternative is to mount an 18-pin socket with turned pins on the board in which you insert another, inexpensive, socket, and then the PIC.

The board is connected to the target system by a flatcable with an 18-pin IDC-style DIL plug at one side, and a 20-way IDC socket at the other. The latter is connected to boxheader K1. Note that pins 19 and 20 are not used.

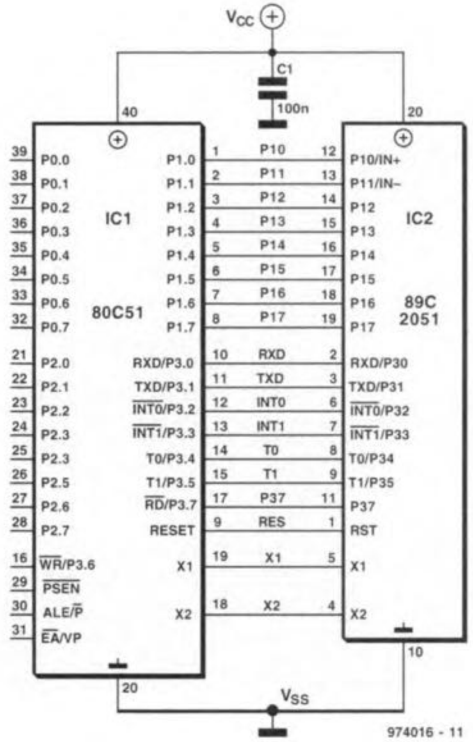
Regrettably, the printed circuit board shown here is not available ready-made through our Readers Services.

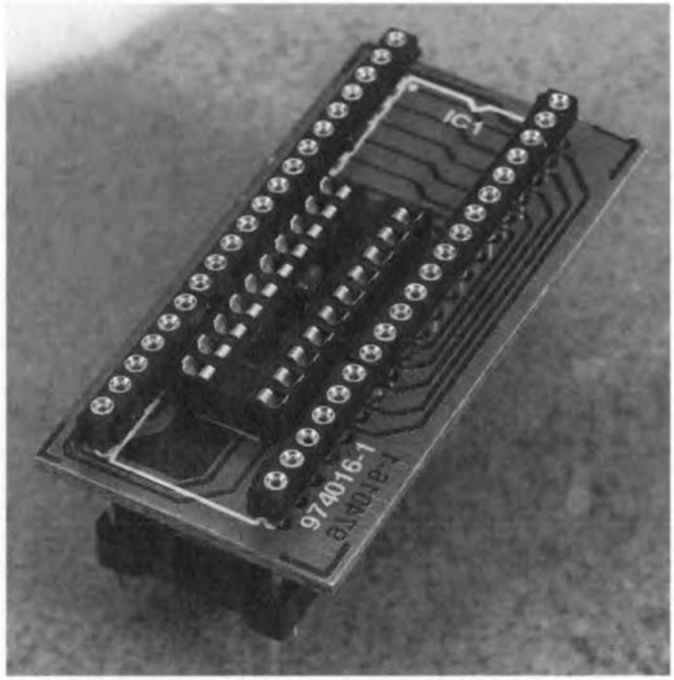
(974040 - D. Dittmann)

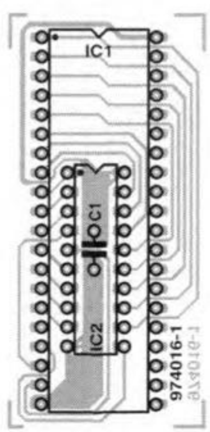

974040-1
IC1
IC2
K1
C2
C4
R1
C5
X1
C1
C3
K2
PIC16C71
PIC16C57
974040-1

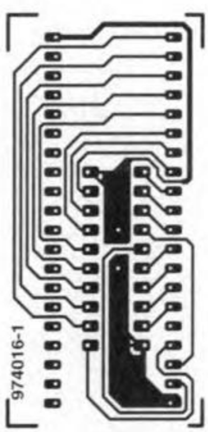

974040-1

# two-way 20-to-40 pin adapter board for 89C1051/2051




All change! This adapter board maps the pins of the 20-pin PDIP AT89C1051/2051 microcontrollers from Atmel to the corresponding pins in a 40-pin DIL 80C51 footprint. The board is essential if you want to use or emulate an Atmel controller in a circuit having a 40-pin DIL socket (for an 80C51). It's also possible to use the adapter the other way around, that is, if you want to use an 80C51 in a circuit which is physically designed to accept an Atmel controller. Do remember, however, that the 80C51 has no comparator on pins P11 and P12, while the 89C2051 has the output of this comparator located internally on P36, in other words, the output is not bonded out to a pin.

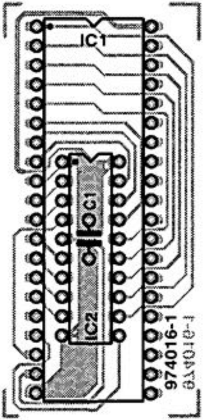
The construction of the adapter board depends on what you want to do with it. If you want to change from a 40-pin DIL socket (on the target system board) to a 20-pin socket (for an Atmel controller or emulator), then IC1 on the adapter board receives a 40-pin DIL socket with long pins, while position IC2 receives a regular 20-pin DIL socket. For the reverse footprint conversion, use a 20-pin socket with long pins, and a regular 40-pin socket.

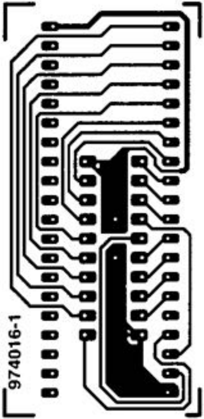
Unfortunately, IC sockets with long, thin, pins are not easy to find. An alternative is to use a wire-wrap socket. The two problems created by a wire-wrap socket are easy to solve. The first is that the plastic cross supports have the be removed. The second is more serious: wire-wrap pins are too thick! When inserted into a normal IC socket, they make perfect contact, but cause permanent deformation of the spring contacts. The latter problem may be overcome by stacking a regular IC socket on to the wire-wrap socket, and use the thinner pins for the connection with the target system socket.

The supply decoupling capacitor, C1, should be a miniature type which can be dropped inside the 20-pin IC socket. If necessary, solder the cap at the track side of the board, or, even better, use an SMA device.

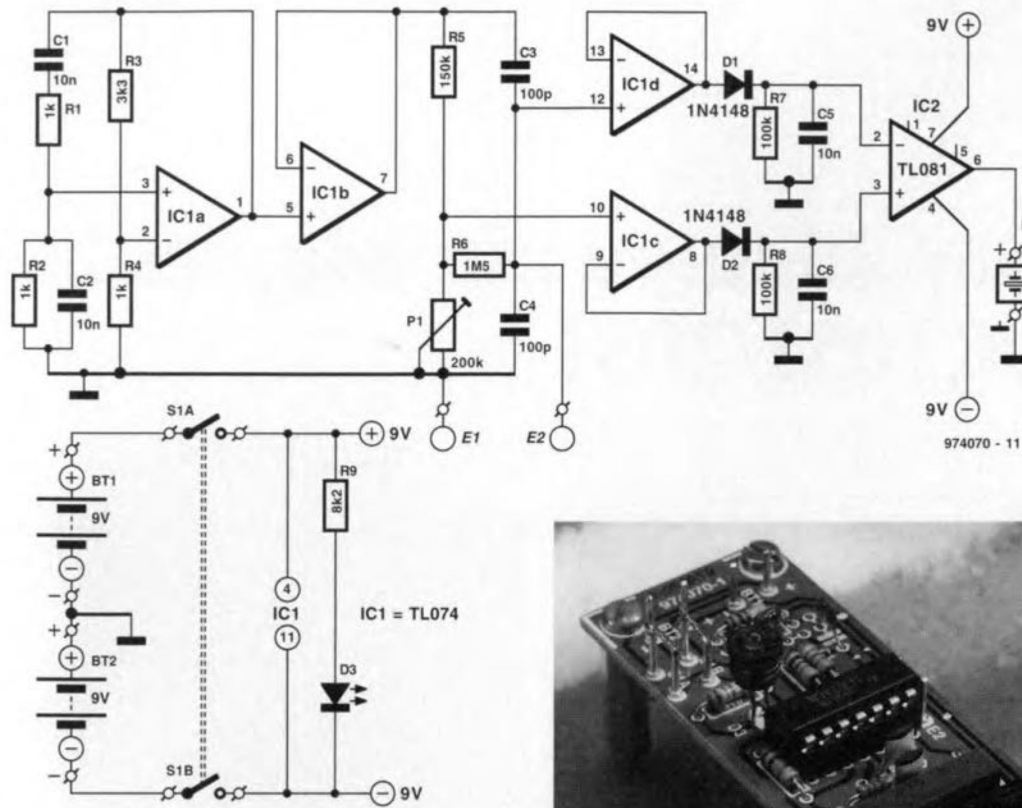
The printed circuit board shown here is, regrettably, not available ready-made through the Readers Services.

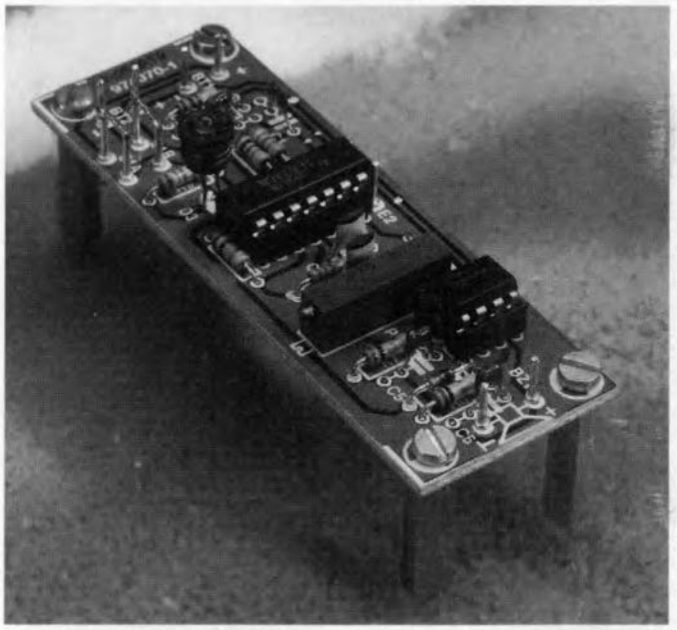
(974016)


IC1
C1
IC2
974016-1


974016-1

# object protection

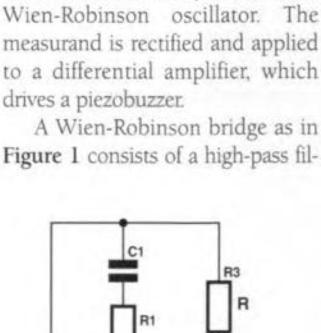


Valuable items are best protected against theft by a customized alarm system. The protection system described here can not only protect that valuable vase in the hall, but also windows, doors or closed spaces, such as rooms or hallways. If anything or anybody approaches the protected item or space, an alarm sounds.

The circuit is based on a measuring bridge and proximity sensor which is controlled by a traditional Wien-Robinson oscillator. The measurand is rectified and applied to a differential amplifier, which drives a piezobuzzer.

A Wien-Robinson bridge as in **Figure 1** consists of a high-pass filter and low-pass filter in series, and the whole shunted by potential divider R-½R. The divider provides a signal at a level of $1/3U_e$ in the pass band. The output voltage at the resonance frequency




**Parts list**

**Resistors:**
$R_1$, $R_2$, $R_4$ = 1 kΩ
$R_3$ = 3.3 kΩ
$R_5$ = 150 kΩ
$R_6$ = 1.5 MΩ
$R_7$, $R_8$ = 100 kΩ
$R_9$ = 8.2 kΩ
$P_1$ = multiturn preset, 200 kΩ, horizontal

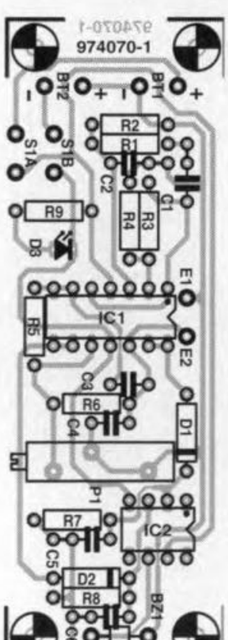
**Capacitors:**
$C_1$, $C_2$, $C_5$, $C_6$ = 0.01 μF

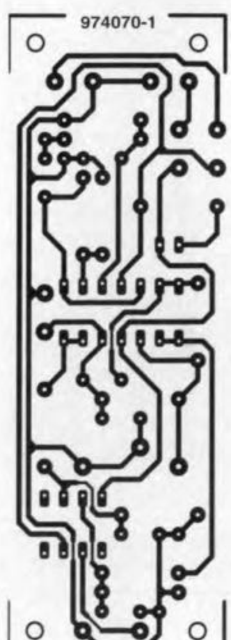
$C_3$, $C_4$ = 0.1 μF

**Semiconductors:**
$D_1$, $D_2$ = 1N4148
$D_3$ = LED, high efficiency

**Integrated circuits:**
$IC_1$ = TL074CN
$IC_2$ = TL081CP

**Miscellaneous:**
$Bt_1$, $Bt_2$ = 9 V dry battery
$S_1$ = double-pole on/off switch
$Bz_1$ = piezobuzzer



$f_R = 1/2\pi RC$ drops to a minimum (theoretically 0). The bridge has a frequency response reminiscent to that of a notch filter and an instantaneous phase shift from −90° to +90° at the resonance frequency.

Such a phase shift is a prerequisite for the use of the filter in a stable oscillator. Unfortunately, the output of the bridge at the resonance frequency is zero or very nearly so, which prevents any feedback by a factor $\varepsilon$ unless the divider is altered slightly. The smaller $\varepsilon$, the more stable the oscillator is. However, a good frequency response requires a large $\varepsilon$ and a high output voltage at the resonance frequency, so that the following amplifier can compensate for the losses caused by the bridge. So, if $\varepsilon$ is too small, the oscillator does not work, and if $\varepsilon$ is too large, the output becomes so large that it overdrives the system. A precisely arranged $\varepsilon$ is not easily obtained, whence a Wien-Robinson oscillator is normally provided with an output control.

This is not needed, however, in the oscillator in the circuit in **Figure 2**. Here, $\varepsilon = 1.3$, which ensures that the oscillator works reliably but overdrives so that it behaves as a square-wave oscillator. Its frequency is 15.9 Hz.

After the signal has been buffered in $IC_{1b}$, it is applied to a measurement bridge consisting of a resistive and a capacitive potential divider.

The proximity sensor connected across $E_1$ and $E_2$ is in parallel with $C_4$. It consists of two metal strips (aluminium foil or tin plate) that are arranged in parallel to form a kind of capacitor.

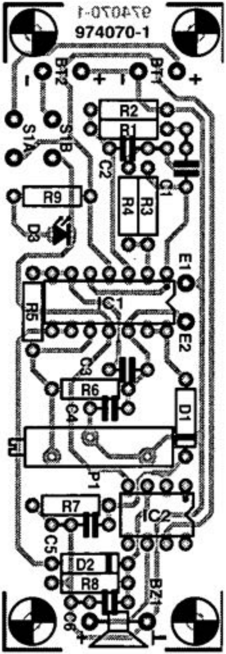
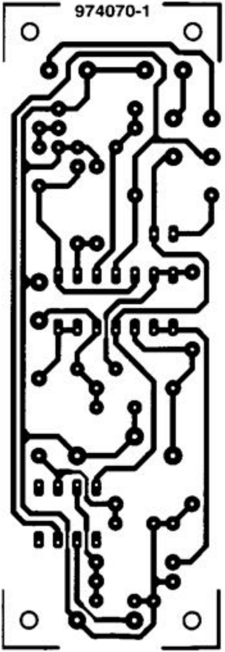
The sensor is located near the item to be protected. As long as nothing or nobody approaches the item, the capacitance of the sensor is small. Preset $P_1$ is then adjusted until the voltage across $C_3$-$C_4$ is slightly higher than that across $R_5$-$P_1$.

The situation changes when somebody, or an animal, or an object comes into the vicinity of the item and acts as the dielectric of the sensor capacitance. This increases the value of the capacitance, whereupon the potential at the junction of the capacitive divider drops, while that across the resistive divider remains constant.

The measurand is buffered by $IC_{1c}$-$IC_{1d}$ and rectified and smoothed by $D_1$-$C_5$ or $D_2$-$C_6$ as the case may be. The output of the rectifier is applied to comparator $IC_2$ which actuates the piezobuzzer when the voltage from the capacitive divider (at its inverting input) drops below that of the resistive divider (at its non-inverting input).

The circuit, except the sensor, is best built on the printed-circuit board in **Figure 3**, which is, however, not available ready made.

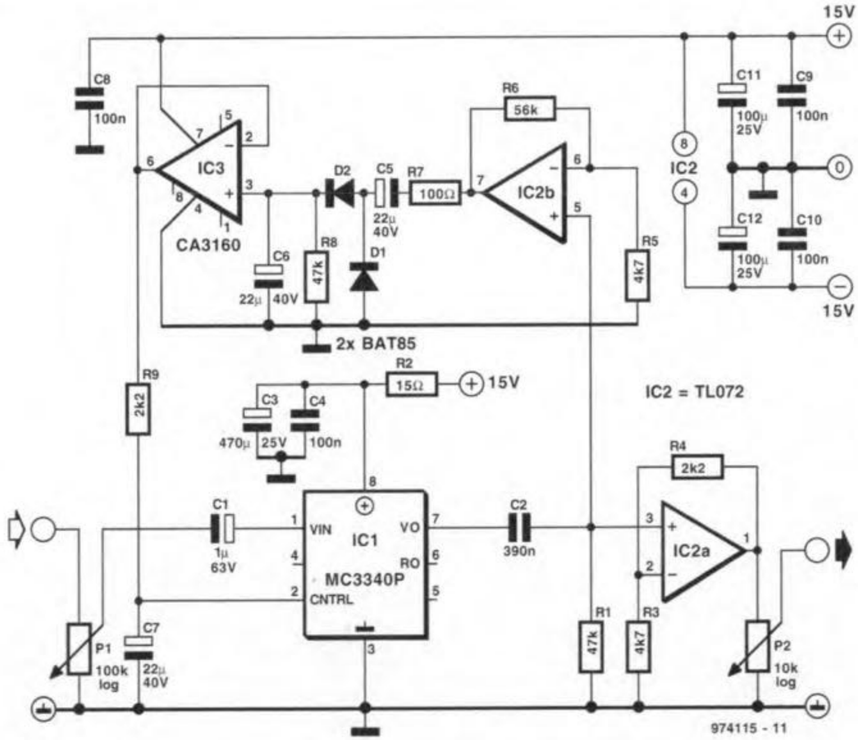
[Lay - 974070]


974070-1
974070-1
BT2
BT1
S1A
S1B
R2
R1
C2
C1
R4
R3
R9
D3
E1
IC1
R5
E2
C3
R6
C4
D1
P1
R7
IC2
C5
D2
R8
BZ1
C6

974070-1

# attenuator/limiter

This circuit is not the very latest in hi-fi, but it may be of interest to those of you involved in producing sound tracks with (small-scale) films (home movies, perhaps), or producing sound samples using 'performers' (including animals) whose dynamic range is a little too large.

The signal to be processed arrives on the input terminals shown at the left-hand side of the circuit diagram. Potentiometer $P_1$ allows the input signal to be adjusted before it reaches the input of $IC_1$, an MC3340P from Motorola. The level adjustment is necessary to prevent sudden variations in the input signal level from reaching the output of the circuit. The MC3340P is an electronic attenuator which offers an attenuation range of up to 80 dB for frequencies up to 1 MHz. The distortion introduced by the chip is smaller than 1% if the attenuation does not exceed 15 dB, or 3% for an attenuation of 40 dB.




The value of the *RC* networks at the input and the output is such that the lower cut-off frequency of the total circuit does not exceed 12 Hz. Resistor $R_8$ defines the time constant of the rectifier formed by diodes $D_1$ and $D_2$. Its value prevents the distortion from increasing when the input signal frequency decreases. The current supplied by the MC3340 via pin 2 produces a voltage across $R_8$. Without the action of buffer op amp $IC_3$, the voltage swing on $R_8$ would cause a too large attenuation.

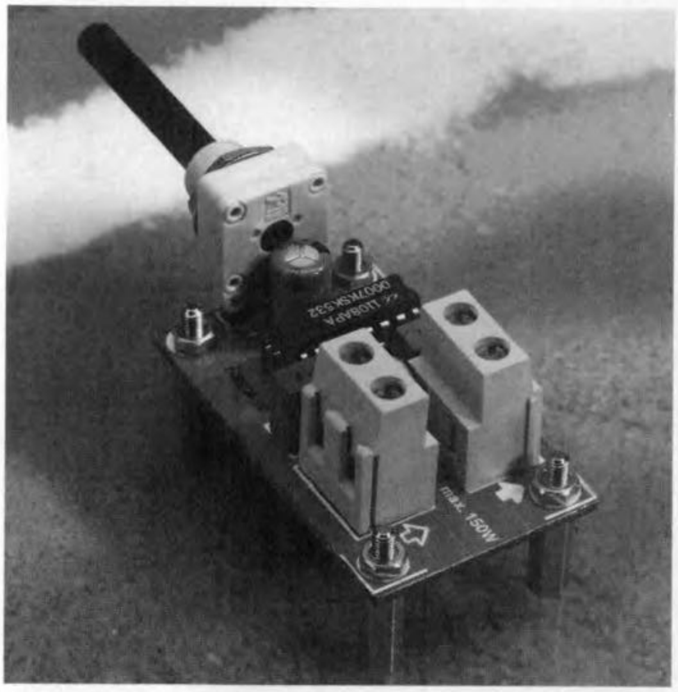
The two op amps in $IC_2$ form a kind of level adaptor. The conditioned signal is now available at the output terminals.

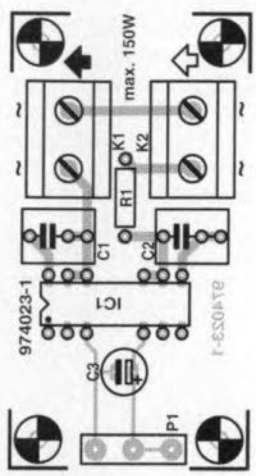
The circuit draws a current of about +18 mA and –4 mA. If you are forced to build a dedicated power supply for this circuit, you may confidently rely on the 'standard' concept based on two integrated voltage regulators powered by a bridge rectifier, smoothing and filtering capacitors, and a mains transformer with a centre tap.

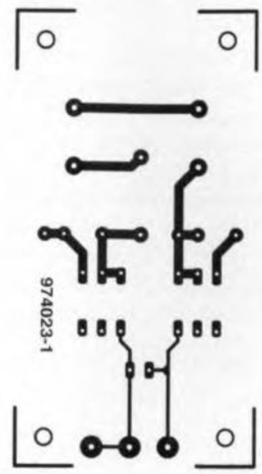
The circuit has a small additional advantage: it can help to reduce the audio level of commercials and advertising on radio and TV. As you may have noticed, these are often broadcast at a higher sound level than the programmes they rudely interrupt. This attenuator circuit makes them fall into line again.

[Anselme – 974115]

# 150-watt lamp dimmer




The $\alpha$1108APA from Alpha Electronics is a lamp dimmer circuit which requires a very small number of external parts. The IC provides soft-start and soft switch-off options to protect the filament of incandescent bulbs.

An NTC type S234/10/M is connected in series with the load to protect the IC against high inrush currents which may occur as the dimmer is turned on, or when a lamp is changed while the dimmer is on. Without the NTC, the circuit is only suitable for lamps with a power of 75 watts or less.

The brightness of the lamp increases with the resistance presented by potentiometer P1.

Inside the $\alpha$1108APA are two anti-parallel SCRs (thyristors). These are connected in series with the load, and switched by the internal phase control circuit. The control circuit is run off the mains voltage, and also realizes the necessary protection functions including complete SCR shut-off in case of thermal overloading, turn-on of the SCSs in case of a voltage surge between anode and cathode, and disabling of the SCRs the first time the circuit is closed (as a result of a fast *dv/dt* peak or compensation currents caused by parasitic capacitance). The voltage on capacitors C1 and C2 is proportional to the voltage between the control inputs C+ and C−. These capacitors are discharged at each zero crossing of the mains input voltage, and they are charged again (depending on the control voltage) to the firing voltage of the SCRs. The range of the control voltage is about 6 V, where 0 V means total phase blanking, and 6 V no phase blanking. These values correspond to minimum and maximum brightness of the lamp, respectively.

The choke-capacitor filter between the dimmer IC and the mains input is obligatory in applications where EMI suppression is a design requirement.

The $\alpha$1108APA is suitable for use with a.c. voltages between $80V_{rms}$ and $276\ V_{rms}$. The device is available through Unitronic GmbH, P.O. Box 350252, D-40444 Düsseldorf, Germany, tel. (+49) 211 9511-(0), fax (+49) 211 95111-111.

Unfortunately the printed circuit board shown here is not available through the Readers Services.

(974023)

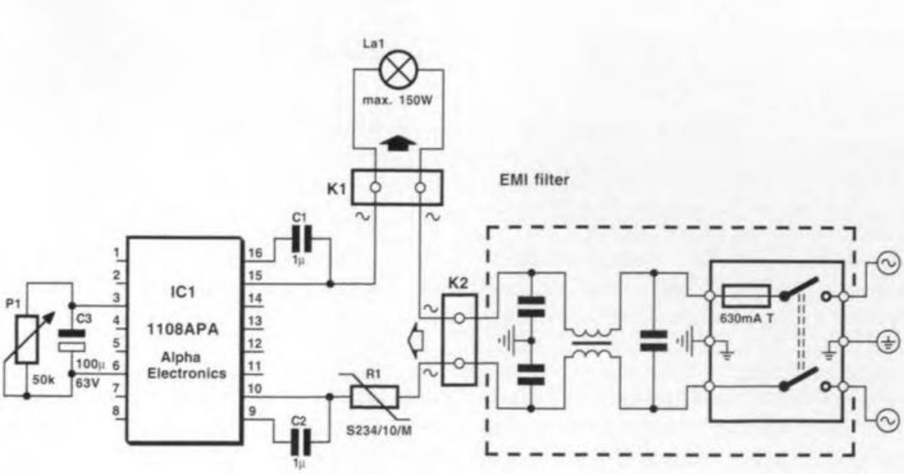
**COMPONENTS LIST**

**Resistors:**
R1 = NTC 10Ω (Siemens S234/10/M)
P1 = 50kΩ linear potentiometer, plastic shaft

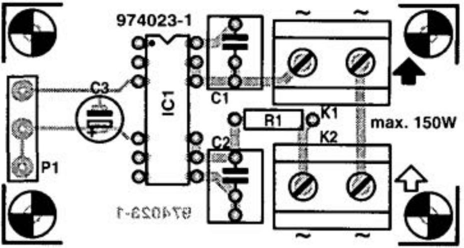
**Capacitors:**
C1,C2 = 1µF
C3 = 100µF 63V radial

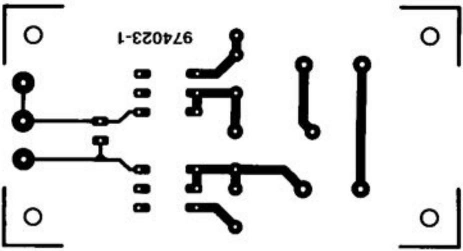
**Semiconductors:**
IC1 = $\alpha$1108APA (Alpha Electronics)

**Miscellaneous:**
K1,K2 = 2-way PCB terminal block, pitch 7.5mm
EMI filter, e.g. Belling-Lee type L2777
Fuse, 630mA




974023 - 11

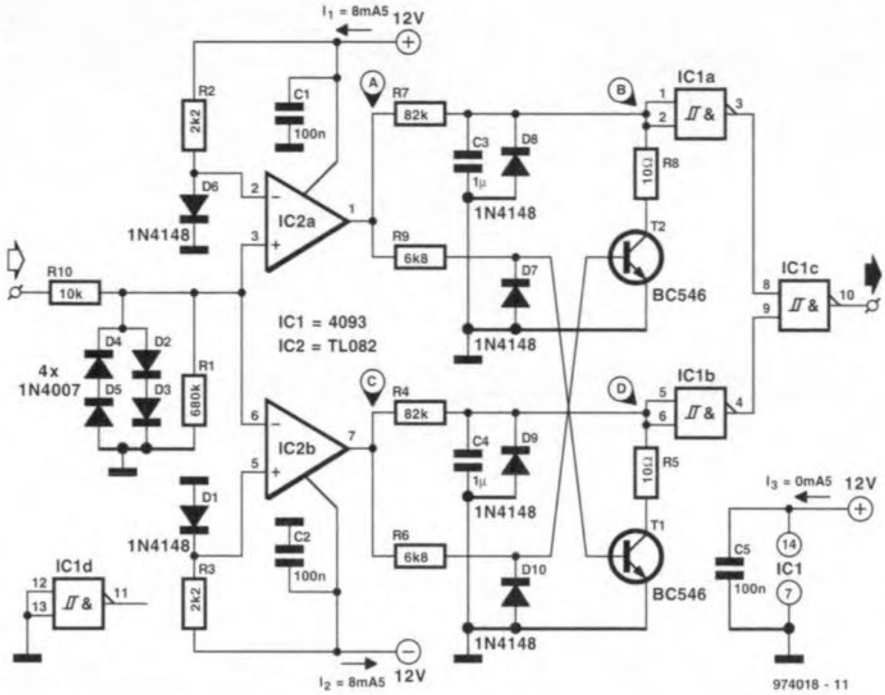

974023-1
C1
IC1
C3
R1
K1
K2
max. 150W
C2
P1
~

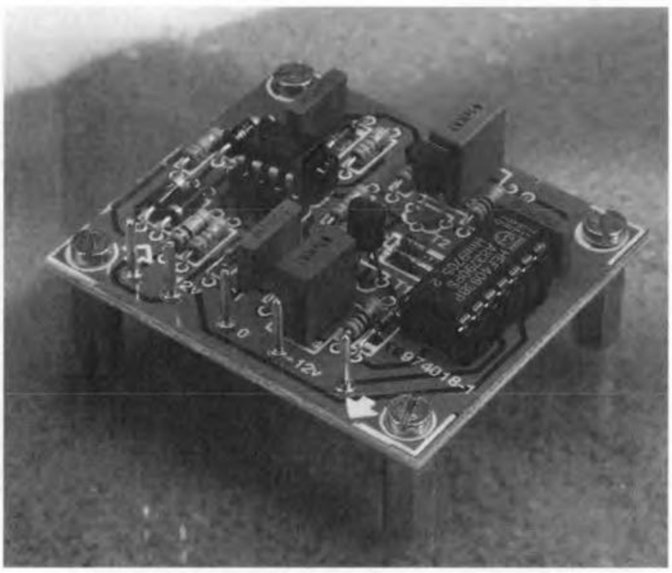

974023-1

# d.c. detector

The detector is intended primarily to sense direct voltages at the output of power amplifiers. The signal so detected may be used to enable a protection circuit that, for instance, disconnects the loudspeakers from the amplifier. The circuit has the advantage of reacting at whatever level of direct voltage: always within 75 ms. It also reacts to signals >600 mV at very low frequencies below about 4 Hz, which are likely to damage the loudspeakers.

The circuit is configured symmetrically and may therefore be split into two. The upper part in the diagram processes positive input signals, and the lower part, negative signals.



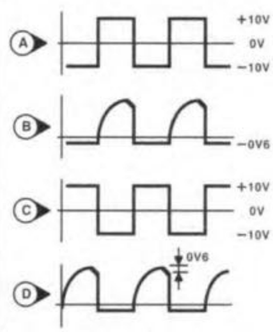
The signal from the amplifier is applied to the sensor via $R_{10}$. Its level is limited by diodes $D_2$–$D_5$. The trip levels of comparators $IC_{2a}$–$IC_{2b}$ are set to +600 mV and -600 mV by $R_2$-$D_6$ and $R_3$-$D_1$ respectively. This means that the output of $IC_{2a}$ goes high when the input voltage is higher than +600 mV and that of $IC_{2b}$ when the input voltage is lower than -600 mV.

It follows that the signals at the outputs of the comparators together form a square wave. This is used to charge $C_3$ and $C_4$ alternately to a potential that does not exceed the trip levels of the comparators. This situation changes, however, if, for instance because of a positive offset, the output of $IC_{2a}$ remains high longer than usual. This causes $C_3$ to be charged to a higher potential, while at the same time $T_1$ is switched on via $R_9$ and $C_4$ is short-circuited. This causes $T_2$ to be blocked via $R_6$, so that the potential building up across $C_3$ cannot be removed via this transistor. This means that the trip level of $IC_3$ will be exceeded so that the output of the circuit changes from low to high.

The same kind of action occurs if because of a negative offset the output of $IC_{2b}$ remains high longer than usual. It is then $C_4$, however, that is charged, while $IC_{1b}$ functions as the trigger.

Diodes $D_7$ and $D_{10}$ protect $T_1$ and $T_2$ by preventing their base voltage dropping below -700 mV.

Clearly, the response time of the sensor depends not only on the trigger level of $IC_{1a}$ and $IC_{1b}$, but also on the time constants $R_4$-$C_4$ and $R_7$-$C_3$. The HEF4093 used in the prototype triggered at 7.5 V ($V_{DD}$ = 15 V), which resulted in a response time of 57 ms. However, the spread of trigger voltages in the 4093 series is appreciable and it may, therefore, be necessary to lower the values of $R_4$ and $R_7$.




**Parts list**

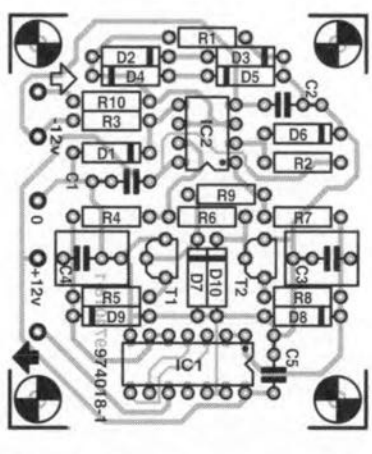
**Resistors:**
$R_1$ = 680 kΩ
$R_2$, $R_3$ = 2.2 kΩ
$R_4$, $R_7$ = 82 kΩ
$R_5$, $R_8$ = 10 Ω
$R_6$, $R_9$ = 6.8 kΩ
$R_{10}$ = 10 kΩ

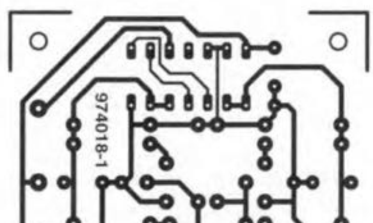
**Capacitors:**
$C_1$, $C_2$, $C_5$ = 0.001 µF
$C_3$, $C_4$ = 1 µF, MKT (metallized polyester)

**Semiconductors:**
$D_1$, $D_6$–$D_{10}$ = 1N4148
$D_2$–$D_5$ = 1N4007
$T_1$, $T_2$ = BC546

**Integrated circuits:**
$IC_1$ = 4093
$IC_2$ = TL082CP

**Miscellaneous:**
5 off board pins



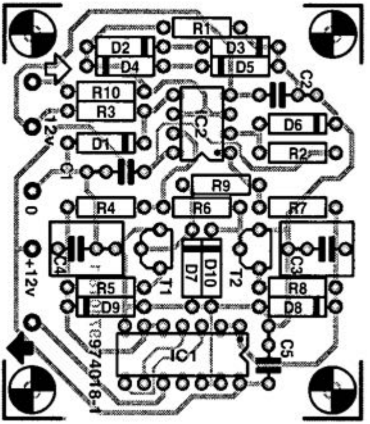



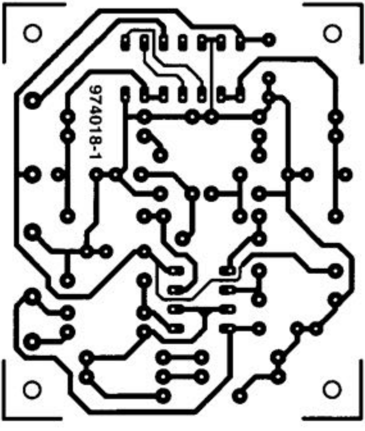

The detector is best built in the printed-circuit board shown, but this is not available ready made.

The symmetrical power supply may have an output between ±10 V and ±18 V. The prototype draws a current not exceeding 10 mA.

[Wolff – 974018]

Th. Riesten!


R1
D2
D3
D4
D5
R10
R3
IC2
C2
D6
-12V
D1
R2
C1
R9
0
R4
R6
R7
C4
D7
D10
T2
C3
+12V
T1
R5
R8
D9
D8
IC1
C5
974018-1


974018-1

## 10.1

**ELEKTOR ELECTRONICS**

## Inductor Assemblies

## Passive Components, Inductors

**DATASHEET 12/97**

### RF coil assemblies 10.1

**Manufacturer** NEOSID

Neosid Pemetzrieder GmbH & Co. KG, PO Box 1354, D-58543 Halver, Germany.
Tel. (+49) 2353 71-0. Fax (+49) 2353 7154.

**Application Example**

80-Metres Receiver, *Elektor Electronics* November 1997.

**Applications**

The assemblies are suitable for the frequency range from 5 to 200 MHz. They can be used for RF input and oscillator circuits in radio equipment, filters in telecommunication equipment, resonant circuits in high-class measuring instruments and in frequency-selective circuits.

**Design and data**

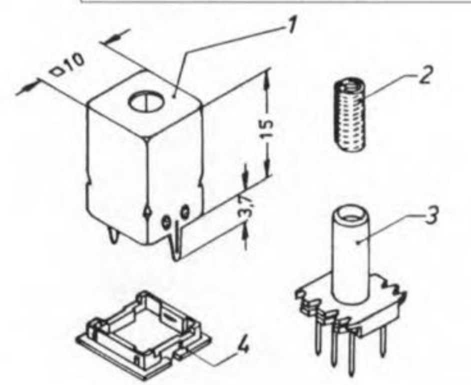
Assemblies type 10.1 consist of a copper screening can, which may be supplied with special plating finish, a former, a base with 5 pins and a screw core. The base is made of glass fibre reinforced hard plastics and can withstand high temperatures, for instance, in dip soldering. The design of the former flange allows thicker wire ends to run straight through to the printed circuit board, and may be used as terminations. Adjustment may be carried out from the top or the underside. When double-sided printed circuit boards are used, it is advisable to include the insulation yoke type Ir10, placed under the can rim.
The $A_L$ values shown in the table are for guidance only, and for a preliminary calculation of the number of turns.

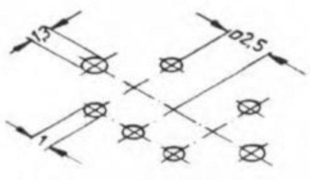
| assembly type | range [MHz] | Q | ferrite grade | $A_L$ [nH] | part number |
|---|---|---|---|---|---|
| 10F1 | 5-12 | 50-100 | F10b | 6-8 | 05955100 |
| 10K1 | 10-25 | 50-100 | F20 | 4-6 | 03955100 |
| 10T1 | 20-60 | 60-120 | F40 | 3-5 | 02955100 |
| 10V1 | 20-200 | 80-150 | F100b | 2.5-3.5 | 15955100 |

**Components**

| no. | description | type | material | part number |
|---|---|---|---|---|
| 1 | screening can | B10 | Cu | 94453800 |
| 2 | screw core | Fk3 x 0.5B x 8 | ferrite | ..040712 |
| 3 | coil former with base | Ks313b | PBTP[1] | 70952700 |
| 4 | insulation yoke | Ir10 | PPOM[2] | 57411700 |

[1] Polybuthylene-theraphtelate (Crastin S600)
[2] Polyphenyloxide (modified) (Noryl 731)




**Holes for connecting pins**

973010 - 13

## SSM2000

**ELEKTOR ELECTRONICS**

## Integrated Circuits

## Analogue, Special Function

**DATASHEET 12/97**

**SSM2000**

**HUSH™ stereo noise reduction system with adaptive threshold**

**Manufacturer**

Analog Devices, One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel. (617) 329-4700, fax (617) 326-8703.
Internet: http://www.analog.com

**Absolute Maximum Ratings**

| | |
|---|---|
| Supply Voltage | +18 V |
| Audio Input Voltage | Supply Voltage(s) |
| Control Port Voltage (pin 7) | Positive Supply |
| Default Override (Pin 14) | V+ |
| Defeat (Pin 16) | V+ |
| Mute Override (Pin 17) | V+ |
| Operating Temperature Range | −40°C to +85°C |
| Storage Temperature Range | −65°C to +150°C |
| Junction Temperature ($T_J$) | +150°C |
| Lead Temperature (soldering, 60 s) | +300°C |

**ESD Ratings**

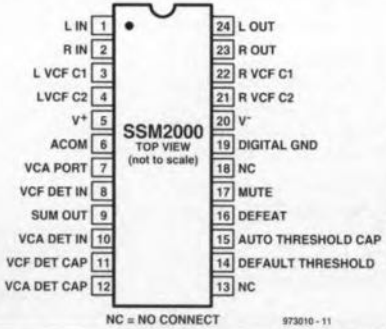
883 (Human Body) Model 2.5 kV
EIAJ Model 300 V

**Application Example**

Application Note, *Elektor Electronics* December 1997.

**Specifications** ($V_S$ = +8.5 V, ACOM = $V_S/2$, f = 1 kHz, $R_L$ = 100 kΩ, 0 dBu = 0.775 $V_{rms}$, $T_A$ = 25°C, Noise Reduction and Adaptive Threshold enabled (pin 14 at $V_S/2$, unless otherwise noted).

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **AUDIO SIGNAL PATH** | | | | | | |
| Signal to Noise Ratio | SNR | $V_{IN}$ = 0 V, 20 Hz to 20 kHz (flat) | 80 | 86 | | dB |
| Headroom | HR | Clip Point, THD = 1% | | 4.5 | | dBu |
| Dynamic Range | | Clipping to Noise Floor | | 91 | | dB |
| Total Harmonic Distortion | THD+N | $V_{IN}$ = 300 $mV_{rms}$, 2nd & 3rd Harmonics[1] | | 0.02 | 0.04 | % |
| Effective Noise Reduction | | 20 kHz Bandwidth (Flat)<br>Downward Expander Section<br>Dynamic Filter Section | | <br>15<br>10 | | dB |
| Input Impedance | $Z_{IN}$ | Pins 1 and 2 | 6 | 8 | | kΩ |
| Output Impedance, Dynamic | $Z_{OUT}$ | Pins 23 and 24 | | 7 | | Ω |
| Capacitive Load | | No Oscillation | | 300 | | pF |
| Channel Separation | | f = 1 kHz, $V_{IN}$ = 300 $mV_{rms}$ | | 60 | | dB |
| Mute Output | | $V_{IN}$ = 300 $mV_{rms}$ | | −85 | | dB |
| Gain Matching, L & R Channels | | VCA at $A_V$ = 0 dB | | ±1 | | dB |
| Gain Bandwidth | GBW | NR Disabled | | 37 | | kHz |
| **DYNAMIC FILTER** | | | | | | |
| Minimum Bandwidth | $BW_{MIN}$ | VCF C = 0.001 μF | | 3 | | kHz |
| Maximum Bandwidth | $BW_{MAX}$ | | | 37 | | kHz |
| **VCA CONTROL PORT** | | | | | | |
| Input Impedance | | Pin 7 | | 3.8 | | kΩ |
| VCA Voltage Gain Range | $A_V$ | $V_{IN}$ = 300 mV rms (Pin 7 = 2.0 V & 0 V) | −70 | | +1 | dB |
| Gain Constant | | | 20 | 22 | 26 | mV/dB |
| Control Feedthrough | | Pin 7 | | 1 | 10 | mV |
| **POWER SUPPLY** | | | | | | |
| Voltage Range | $V_S$ | | +7.0 | | 18 | V |
| Supply Current | $I_{SY}$ | | | 7.5 | 11 | mA |
| Power Supply Rejection | PSSR+ | | | 70 | | dB |
| **VCA, VCF DETECTOR** | | | | | | |
| Input Impedance | $R_{IN}$ | Pins 8 and 10 | 4.0 | 5.4 | 7.0 | kΩ |
| *Notes* | | [1] *NR in defeat mode.*<br>*Specifications subject to change without notice.* | | | | |




## Pin description

| Pin # | Name | Function and Explanation |
|---|---|---|
| 1 | L IN | Left Audio Input. |
| 2 | R IN | Right Audio Input. |
| 3 | L VCF C1 | Left VCF Filter Cap Port. |
| 4 | L VCF C2 | Left VCF Filter Cap Port. |
| 5 | V+ | Positive Supply. |
| 6 | ACOM | Analog Common Voltage. Internal Circuit Ground Point. Must be held to a voltage approximately halfway between V+ and V−. Should be a clean low impedance voltage source capable of at least 4 mA, such as from a buffer driven off a supply-splitting voltage divider. |
| 7 | VCA PORT | Input to VCA Control Port. Allows external adjustment of attenuation with a +22 mV/dB slope. Zero volts relative to ACOM gives zero additional attenuation. Should be connected to ACOM if function not required. |
| 8 | VCF DET IN | Input to VCF Detector. |
| 9 | SUM OUT | Combined Left Plus Right Output. |
| 10 | VCA DET IN | Input to VCA Detector. |
| 11 | VCF DET CAP | Voltage Controlled Filter. Time Constant Capacitor Port. |
| 12 | VCA DET CAP | Voltage Controlled Amplifier. Time Constant Capacitor Port. |
| 13 | NC | Make no connection to this pin. |
| 14 | DEFAULT THRESHOLD | Default Threshold Adjustment Port. Allows reduction of noise reduction action if signal source is relatively clean such as CD sources. Normally connected to Analog Common. −1.2 V is recommended for CDs; −2 V completely defeats noise reduction. |
| 15 | AUTO THRESHOLD CAP | Automatic Threshold Detector Capacitor Port. |
| 16 | DEFEAT | Logic High; defeats Noise Reduction. |
| | | Logic Low; normal action. |
| | | Connect to ground if not used. |
| 17 | MUTE | Logic High: Mute. |
| | | Logic Low: normal action. |
| | | Connect to ground if not used. |
| 18 | NC | Make no connection to this pin. |
| 19 | DIGITAL GND | Digital Logic Reference (Logic Zero). |
| 20 | V− | Negative Supply. |
| 21 | R VCF C2 | Right VCF Capacitor Port. |
| 22 | R VCF C1 | Right VCF Capacitor Port. |
| 23 | R OUT | Right Audio Output. |
| 24 | L OUT | Left Audio Output. |



**RF coil assemblies 7.1S**

**Application**

This assembly can dispense with the screening can, or (at higher frequencies) with its cup core, if stray fields can not be harmful.

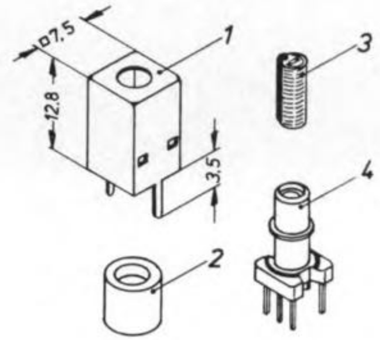
**Design and data**

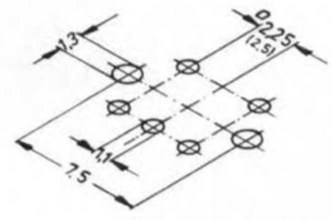
The 7.1S assembly consists of a dip-solderable former with 5 square pins, a screw core with silicon rubber brake, a copper can and a cup core. Core adjustment is possible from the top or the underside. For frequencies above, say, 15 MHz, only the screw core is needed. In the case of particularly high requirements regarding the Q value, a cup core (optimized in ferrite) may be fitted. The $A_L$ values shown in the table are for guidance only, and for approximate estimation of the number of turns.

| assembly type | range [MHz] | Q | ferrite grade cup core | screw core | $A_L$ (nH) | part number |
|---|---|---|---|---|---|---|
| 7M1S | 0.1-1 | 50-100 | F08 | F08 | 14 | 11955500 |
| 7A1S | 0.1-5 | 50-110 | F2 | F2 | 13 | 06955500 |
| 7F1S | 5-15 | 60-125 | F10b | F10b | 12 | 05955500 |
| 7K1S | 15-25 | 80-110 | - | F20 | 6.5 | 03955500 |
| 7T1S | 20-60 | 60-110 | - | F40 | 5.5 | 02955500 |
| 7V1S | 50-200 | 50-120 | - | F100b | 4.5 | 15955500 |

| Components | | | | |
|---|---|---|---|---|
| no. | description | type | material | part number |
| 1 | screening can | B7s | Cu | 94454000 |
| 2 | cup core | Ka7 | ferrite | ..115300 |
| 3 | screw core | Fk3 x 0.5B x 8 | ferrite | ..040712 |
| 4 | coil former for grid 2.25 | Ks312 | PBTP-GV[1] | 70955400 |
| 4.1 | coil former for grid 2.5 | Ks312e | PBTP-GV[1] | 70958500 |

[1] Polybuthylene-theraphtelate GV (Crastin SK605)




Holes for connecting pins

973010 - 14

The designer of a loudspeaker needs the knack of being able to choose a number of drive units that match and complement each other. In the design presented in this article, this was achieved by marrying two Vifa woofers to a Scan-Speak tweeter. Vifa is a large Danish concern well-known for its quality loudspeakers, while ScanSpeak is a small producer, also Danish, of high-end loudspeakers.

By our Editorial Staff



# Premium 33

## a top-class Danish loudspeaker

**Brief specification**

| | |
|---|---|
| Name | Premium 33 |
| Design | R. Smulders |
| Enclosure | vented |
| Net volume | 33 litres |
| Dimensions | 1080×210×297 mm (42.52"×8.27"×11.69") |
| Drive units | 2 off 18 cm woofer<br>28 mm tweeter |
| Nominal impedance | 4 Ω |
| Power handling capacity | 200 W (600 W music) |
| Sound pressure level* (SPL) | 88 dB (1 W $m^{-1}$) |

* Sometimes called sensitivity.

There are no clear-cut rules or recipes for designing a top-class loudspeaker, since the quality of reproduction depends on a number of factors. A good designer has the ability to choose all the correct parts and weld these together in such a way that a perfectly balanced unit results.

The drivers chosen for the Premium 33 are the Type D2905/9500 dome tweeter from Scan-Speak and two Type PL18WO-09/08PL woofers from Vifa. Listening tests show that these form an excellent match.

### box design

The starting point of the design of the Premium 33 was a slender enclosure about one metre high in which a number of first-class drivers were to be fitted for natural reproduction of sound. The final choice fell on two 18 cm woofers and a 28 mm tweeter configured as a 2.5-way system. This means that one woofer and the tweeter cover the entire audio frequency range; the other woofer has a supporting role in the bass range.

The design of the box is a Briggs configuration, which combines the good impulse performance of a closed box with the extended low-frequency range of a vented enclosure. The enclosure is divided into two by a partition. The resulting upper chamber, which houses one of the woofers, is arranged as a closed box with a Q factor of 0.5. The lower chamber, housing the second woofer, is vented. The two chambers are linked by two flow resistances in the partition.

### drive units

Traditionally, Vifa has always produced drive units at affordable prices. Of late, the firm has, however, also begun mar-

Ferrofluid, developed in the USA, is often applied to the magnet gap of drive units. It consists of a stable, inert organic diester base containing a colloidal, that is, non-settling, dispersion of ferromagnetic material. The liquid is sufficiently magnetic to remain firmly trapped in the regions of greatest field-strength, that is, the gap.

keting top-class drivers whose price takes second place after quality. The eleven drivers in this Premium line are elegant units with outstanding specifications, both electrical and acoustical.

Of the eleven drivers the Type PL18WO-09/08PL was chosen for use in the Premium 33 (see **Figure 1**). This is an 18-cm cone-diaphragm woofer, which has a straight, smooth frequency response.

The sound radiating element (diaphragm) is manufactured from handmade, air-dried paper.

Figure 1. The drive units used in the Premium 33. The woofers are part of Vifa's Premium line, while the tweeter comes from the Scan-Speak catalogue.

The 40 mm motor coil (voice coil) can produce a linear deflection of ±8 mm – the maximum deflection is 14 mm!

The magnet has a diameter of 113 mm to provide the requisite powerful field in the magnet gap.

A sturdy cast frame (chassis) ensures the necessary rigidity of the drive unit.

Vifa specifies a power handling capacity of 100 W continuous, 300 W with a 1-minute signal and 2-minute interval, which are very high values for an 18-cm unit.

The tweeter is a dome model Type D2905/9500 from Scan-Speak. This is an improved version of the Type 9300, which has been provided with the magnet assembly and anti-resonant plug in the rear cavity already used in the well-known Revelator.

With a dome diameter of 28 mm, the tweeter is large by modern standards, but ideally suited for use in two-way systems. Its resonant frequency is low (550 Hz).

High-viscosity ferrofluid in the magnet gap ensures good linear performance of the magnet coil.

The thick metal front plate makes it possible to countersink the fixing screws.

## box construction

Top-class drive units need a top-class enclosure to give of their best. So, the enclosure

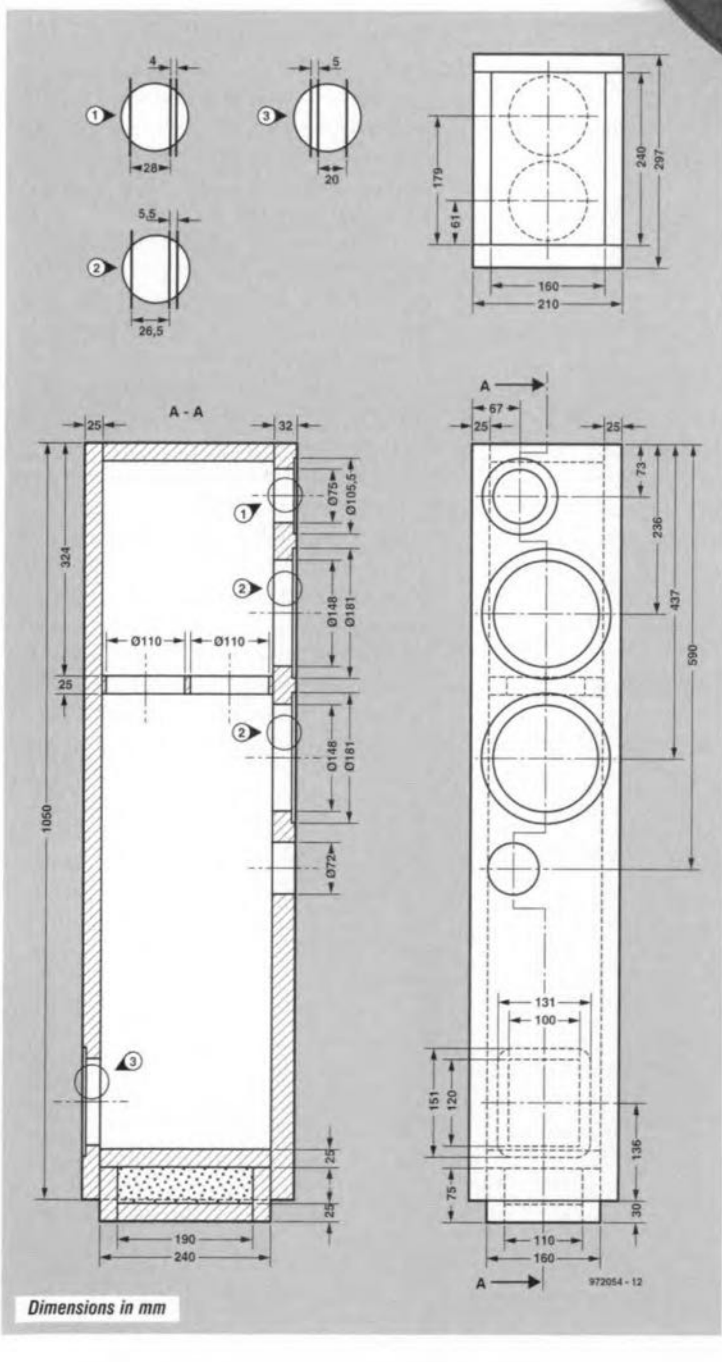



Figure 2. Construction diagram of the enclosure which is divided into two chamber by means of a partition that holds two flow resistances.

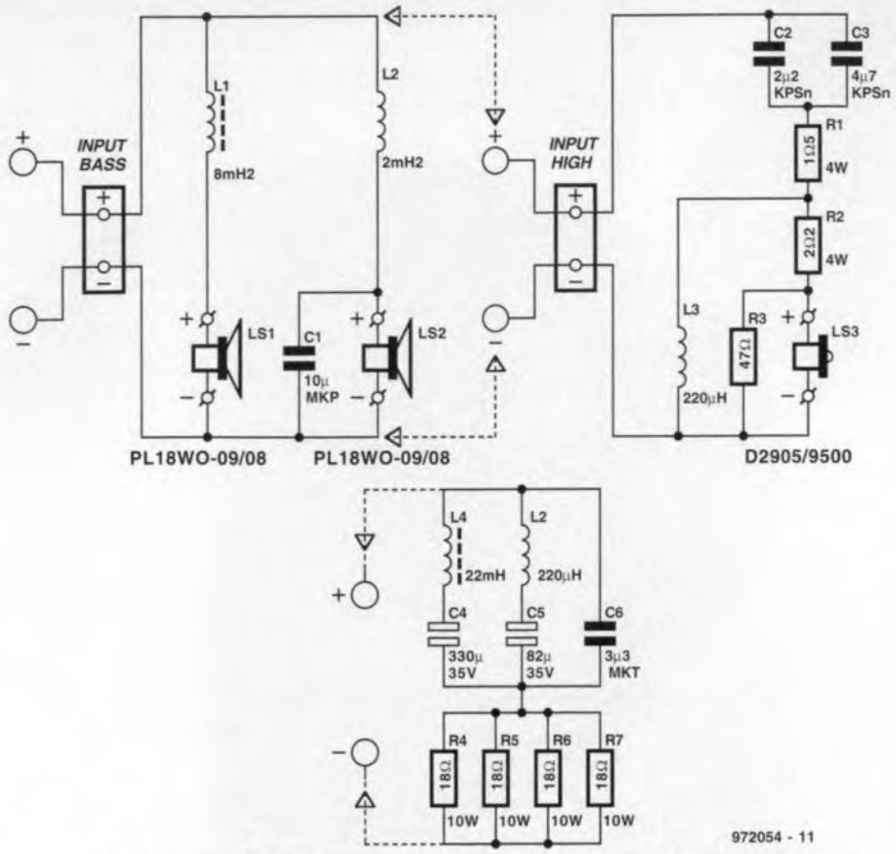



Figure 3. Circuit diagram of the crossover network and the (optional) impedance correcting circuit.

walls are made of 25 mm (1") thick medium-density fibreboard (MDF), while the front panel is 32 mm (1.26") thick MDF. Moreover, the inner walls are clad with lead-impregnated bituminous material to prevent any wall vibration. This cladding is covered with 42 mm (1.65") thick latex foam.

The construction diagram of the enclosure is shown in **Figure 2.** Note that the partition is at about 2/3 of the height of the box. As mentioned earlier, two flow resistance provide controlled coupling between the two chambers.

The front of the enclosure is clad with thin black felt as a further measure to dampen reflections.

The base of the enclosure is filled with sand to prevent any vibrations being transmitted to the floor.

The final finish of the enclosure is left to the constructors personal preference. The prototype box is spray-painted black, followed by a another layer of black paint and finally sprayed with a neutral lacquer.

## crossover network

The crossover circuit (Figure 3) consists of two sections: the filters proper and an optional impedance-equalizing network. The optional network is particularly useful when a valve power amplifier is used. The impedance curve is given in **Figure 4**.

Aided by inductor $L_1$, the lower woofer, $LS_1$, reproduces frequencies up to about 200 Hz. Inductor $L_1$ is a top-quality component to ensure that the distortion remains low even at high output powers.

The upper woofer, $LS_2$, reproduces frequencies up to about 2 kHz. After that, its response rolls of at 12 dB/octave owing to circuit $L_2$-$C_1$.

Frequencies above 2 kHz are reproduced by the tweeter, $LS_3$. The relevant 12 dB/octave high-pass filter is formed by $C_2$-$C_3$-$L_3$. Capacitors $C_2$ and $C_3$ are special tin-film components that give marginally better performance than polypropylene (MKP) types. Resistors $R_1$–$R_3$ attenuate the output of the tweeter by a few decibels so as to equalize it with that of the woofers. If a higher tweeter output is desired, the values of $R_2$ and $R_3$ may be changed marginally by trial and error.

The optional impedance matching circuit consists of three branches. Inductor $L_4$ and capacitor $C_4$ attenuate the 60 Hz resonance peak of the enclosure and woofers.

Inductor $L_5$ and capacitor $C_5$ attenuate the impedance peak near the cut-off point.

Capacitor $C_6$ counters the increase in impedance at high frequencies.

Resistors $R_4$–$R_7$ ensure that the minimum resistance of the correction networks does not drop below a certain value.

The frequency response of the Premium 33 is shown in Figure 4; that of the vented chamber is given separately. Below the characteristic is the imped-

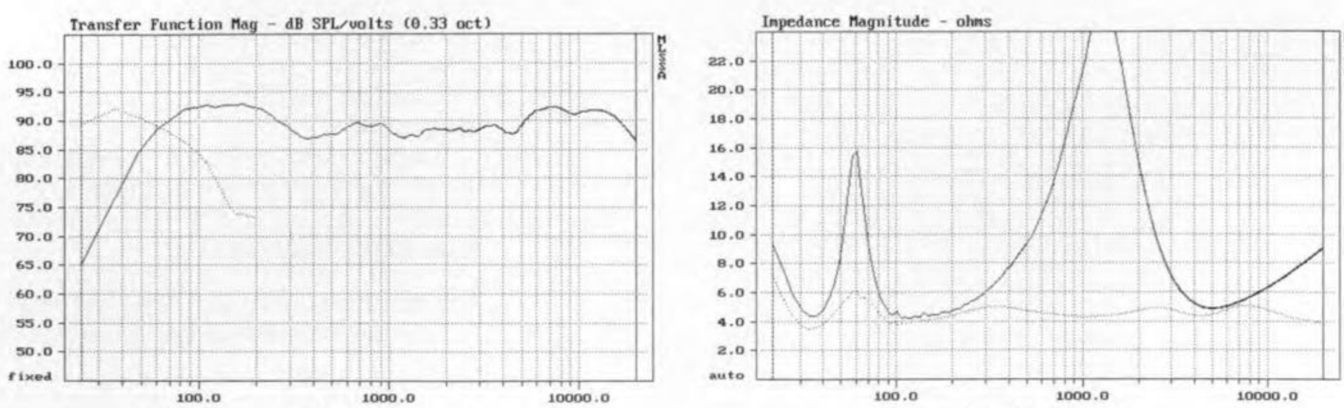



Figure 4. Frequency response characteristic and impedance curve (measured with and without the correcting circuit) of the Premium 33.

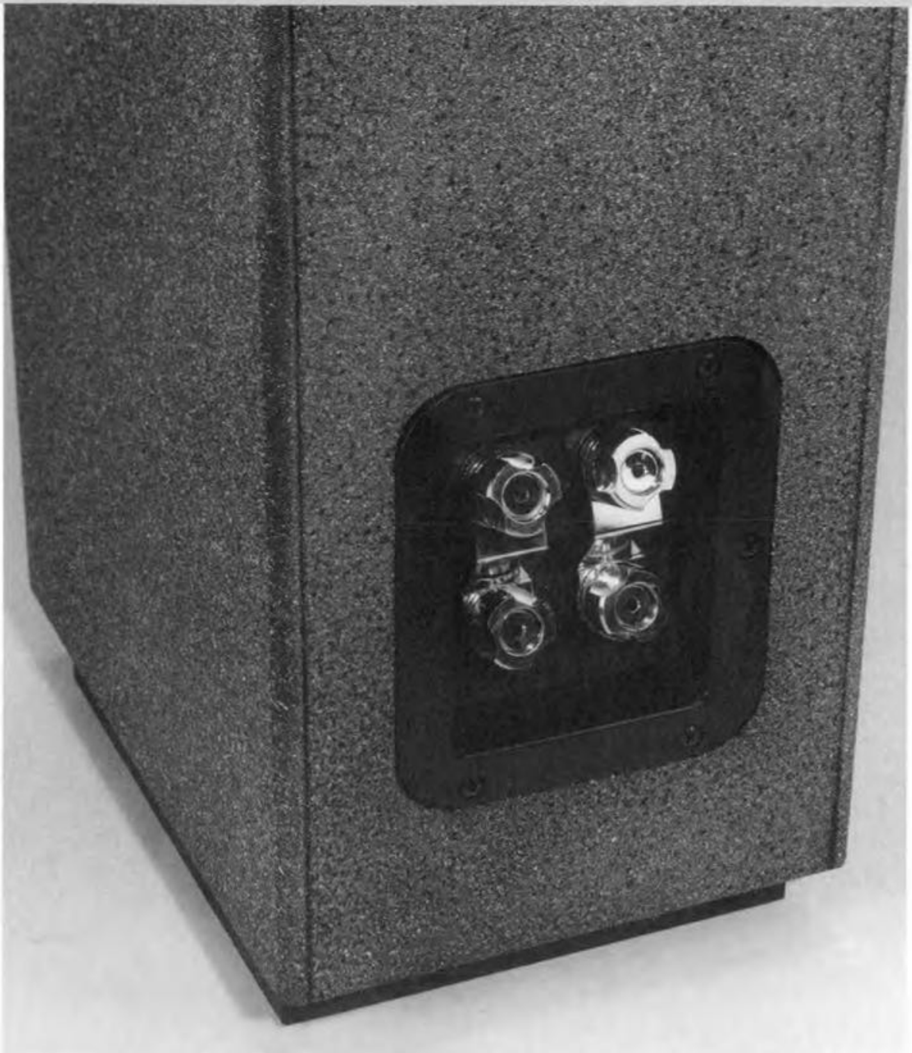


Figure 5. The terminals for connecting the external loudspeaker cable(s) are heavy duty types, which also make bi-wiring possible.

**Part list** (one loudspeaker)

Drive units:
$LS_1$, $LS_2$ = PL18WO-09/08PL (Vifa)
$LS_3$ = D2905/9500 (Scan-Speak)

Crossover network:
$R_1$ = 1.5 Ω, 4 W
$R_2$ = 2.2 Ω, 4 W
$R_3$ = 47 Ω
$C_1$ = 10 μF, polypropylene (MKP)
$C_2$ = 2.2 μF tin-film (KPSn)
$C_3$ = 4.7 μF tin-film (KPSn)
$L_1$ = 8.2 mH, 0.3 Ω, HQ core
$L_2$ = 2.2 mH, air-cored, 1.4 mm dia. enamelled copper wire
$L_3$ = 0.22 mH, air-cored, 0.71 mm dia. enamelled copper wire

Impedance matching circuit (optional):
$R_1$–$R_7$ = 10 Ω, 20 W
$C_4$ = 330 μF, 35 V, bipolar electrolytic
$C_5$ = 82 μF, 35 V, bipolar electrolytic
$C_6$ = 3.3 μF, metallized polyester
$L_4$ = 22 mH, 4.3 Ω, Corobar core
$L_5$ = 0.22 mH, air-cored, 0.71 mm dia. enamelled copper wire

Enclosure:
Medium-density fibreboard (MDF) or high-density chipboard
2 off 1050×240 mm (41.34"×9.45"), 25 mm (1") thick (side panels)
1 off 1050×210 mm (41.34"×8.27"), 25 mm (1") thick (rear panel)
1 off 1050×210 mm (41.34"×8.27"), 32 mm (1.26") thick (front panel)
2 off 240×160 mm (9.45"×6.30"), 25 mm (1") thick (top panel and partition)
Base:
1 off 240×160 mm (9.45"×6.30"), 25 mm (1") thick
2 off 160×75 mm (6.30"×3"), 25 mm (1") thick
2 off 190×75 mm (7.48"×3"), 25 mm (1") thick
1 off 190×110 mm (7.48"×4.33"), 25 mm (1") thick

Miscellaneous:
1 off heavy-duty terminal box (if required, suitable for bi-wiring)
1 bass reflex port, 70 mm (2.76") inner dia., 147 mm (5.79") long
2 off flow resistance (Scan-Speak)
Lead-impregnated bituminous material (supplied in sheet form)
About 1 $m^2$ of 42 mm (1.65") thick latex foam sheet
About 0.5 $m^2$ (5 sq. ft.) acoustic wadding
Sand as required for filling the base

ance curve: the upper line is measured without, and the lower line with, the correction circuit.

## subjective evaluation

Although the quality of the Premium 33 is clear from the choice of drive units, the design of the crossover network, the quality of the filter components, and the care taken in the construction of the enclosure (with special emphasis on the internal damping), it is ultimately the listening pleasure that makes a loudspeaker wanted, loved or cherished.

Listening evaluations (with different audiences) confirm that the sound reproduction of the Premium 33 is well-balanced with a well-defined bass and good high-frequency presence with little or no colouration. The stereo image depth gives good dimensional quality.

It is felt that the Premium 33 at a price of about £ 350 per box will prove irresistible to the hi-fi enthusiast.

[972054]

In this design, the German firm InterTechnik (IT) has combined three drive units from different manufacturers. The rectangular enclosure is kept very small by placing the woofer at the side of the box. The use of two slanted grilles, one at the side and one at the front gives the enclosure a distinct identity.

By our Editorial Staff

# Tolomeo

## an elegant three-way loudspeaker system

**Brief specification**

| | |
|---|---|
| Name | Tolomeo |
| Design | InterTechnik (IT) |
| Enclosure | vented |
| Net volume | 30 litres |
| Dimensions | 1000×180×315 mm (39.37"×7.09"×12.40") |
| Drive units | 20 cm (8") woofer<br>14 cm (5.50") midranger<br>19 mm (0.75") dome tweeter |
| Power handling capacity | 100 W (150 W music) |
| Nominal impedance | 8 Ω |
| Sound pressure level* (SPL) | 87 dB (1 W $m^{-1}$) |

* Sometimes called sensitivity

The first thing one notices about the Tolomeo is the very narrow front panel of only 18 cm (7.09"). This normally means one of two things: small bass drivers have been used, or the designer has devised an unusual way to obtain good low-frequency performance.

In the Tolomeo, the woofer has been placed at the side of the enclosure – a method currently used by a number of manufacturers. It allows the use of a woofer whose diameter is larger than the width of the front panel (the Tolomeo uses a 20 cm or 8" bass driver).

The volume of the vented enclosure is 30 litres. The bass reflex port is located at the rear of the box.

The mid-range driver and twee-ter are fitted conventionally to the front panel. The midranger has its own chamber of about 3 litres.

### drive units

The woofer is a Type 8-472/32 HEX from the German manufacturer Eton. This firm was better known a few years ago when it introduced Hexacone diaphragms, which consist of two layers of fibre-glass separated by a honeycomb reinforcement.

Eton is currently making a comeback in the loudspeaker market and has a catalogue of top-grade drive units which all use Hexacone diaphragms.

In the woofer used, the Hexacone diaphragm is suspended from a strong cast supporting basket chassis). An unusual aspect is the so-called heat pipe, a metal pipe that protrudes from the front of the diaphragm to provide adequate heat transfer from the motor coil. Because of this, the manufacturer quotes power handling capacities of 250 W (music) and 500 W (impulse).

The mid-range driver is a Type CSC-145G from the Danish firm Peerless, which has a diameter of 14.5 cm 5.71"). Its frequency response is very smooth, which is attributable mainly to the diaphragm material. This consists of three layers of polypropylene that have been heat-pressed together. The result is a diaphragm of uniform thickness and better internal damping than would be obtained with a single layer of polypropylene.

The tweeter is a Type K21FD from the Norwegian manufacturer Seas. This has a dome diaphragm made from an aluminium alloy. The suspension consists of a soft layer of PVC – poly (vinyl chloride). Ferrofluid* in the magnet gap provides the requisite cooling and damping of the motor coil.

The unit combines a very linear frequency response from 2 kHz upwards with an excellent radiation pattern.

### enclosure

Te design of the 1-metre (39.37") high enclosure, whose construction diagram is shown in **Figure 3**, is straightforward. Basically, it is a rectangular box that is rather narrower and deeper than the standard ones usually encountered. It has a reinforcing brace at the centre and slanting partition towards the top. The slanting partition serves to provide a separate closed chamber with a volume of a few litres for the mid-frequency driver.

The enclosure obtains its distinct

Ferrofluid, developed in the USA, is often applied to the magnet gap of drive units. It consists of a stable, inert organic diester base containing a colloidal, that is, non-settling, dispersion of ferromagnetic material. The liquid is sufficiently magnetic to remain firmly trapped in the regions of greatest field-strength, that is, the gap.

character from the grilles shown in the construction diagram. The lower slant of that the side meets the upper slant on the front panel. Constructors may, of course, incorporate their own preference here.

The enclosure, including the chamber for the midranger, should be damped by filling it loosely with polyester wadding to suppress standing waves.

The bass reflex port located at the back of the enclosure has an inner diameter of 70 mm and is 250 mm long.

## crossover network

The crossover network ensures correct frequency change-over between the three drivers. Its circuit diagram is shown in **Figure 4**.

Aided by inductor $L_1$, the woofer reproduces frequencies up to about 200 Hz. Circuit $R_1$-$C_1$ in parallel with the driver linearizes the impedance of the woofer at high frequencies. If this were absent, the inductance would not work into a resistance and consequently not perform its function correctly.

The mid-frequency driver reproduces the frequencies between 200 Hz and about 3 kHz, where the tweeter takes over. The cut-off frequency is determined by low-pass filter $L_2$-$C_3$. If the best performance of this driver is desired, impedance-correcting network $R_2$-$L_4$-$C_5$-$C_6$ may be added.

The tweeter should, of course, reproduce only the high frequencies, and this is ensured by high-pass section $L_3$-$C_4$.

As in all multi-way loudspeaker systems, mind the polarity of the drive units. In the Tolomeo, the mid-frequency driver is out of phase with the other two units.

## good balance

Obviously, the acoustic properties of the Tolomeo are at least as important as its physical appearance. When listening to a variety of different music, there appears to be a good balance between the three drivers in the Tolomeo, which results in a very well-balanced and natural reproduction. These subjective tests are confirmed

Figure 1. The bass driver from Eton, which has a layered diaphragm and heat pipe, is fitted in a side panel of the enclosure.

Figure 2. The mid-frequency driver from Peerless also has a layered (polypropylene) diaphragm, while the tweeter from Seas has an aluminium dome diaphragm.

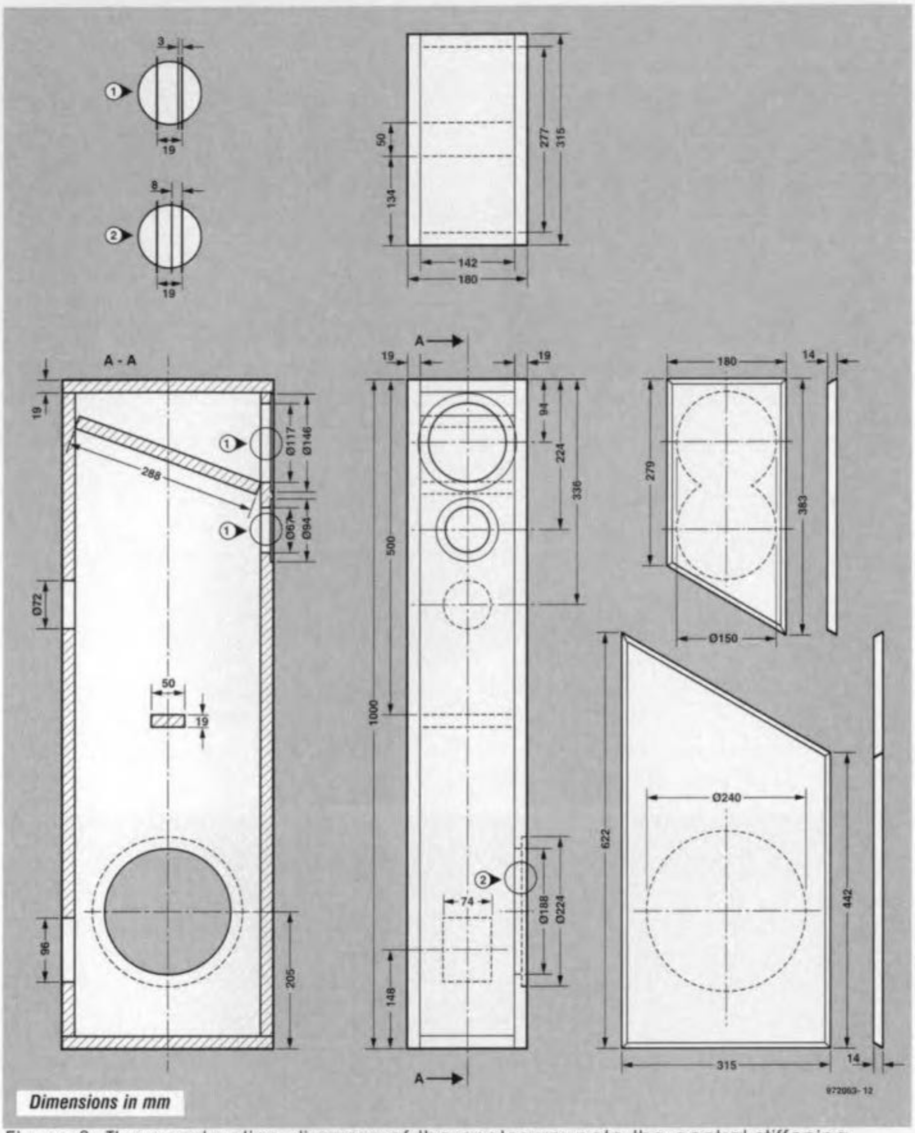


Figure 3. The construction diagram of the enclosure: note the central stiffening brace and the slanting partition towards the top.

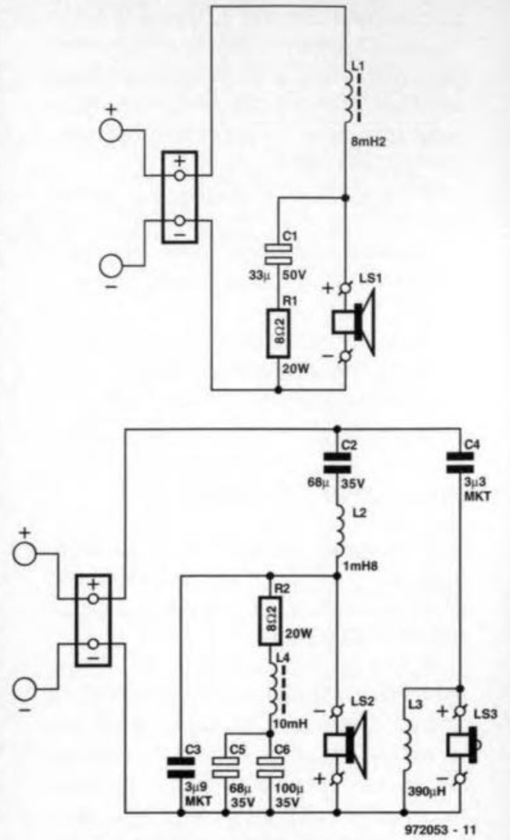


Figure 4. The crossover network provides a separate (and optional) impedance-correcting network for the midranger.

ularly suitable for classical music and jazz – but it also does well in respect of more modern music. In fact, the Tolomeo is something of an all-rounder. [972053]

by the objective tests represented by the smooth frequency response curve in **Figure 5**.

Particularly noticeable in the sound reproduction is the deep spatial impression coupled with a very low bass performance that is tight at all times. This makes the Tolomeo partic-

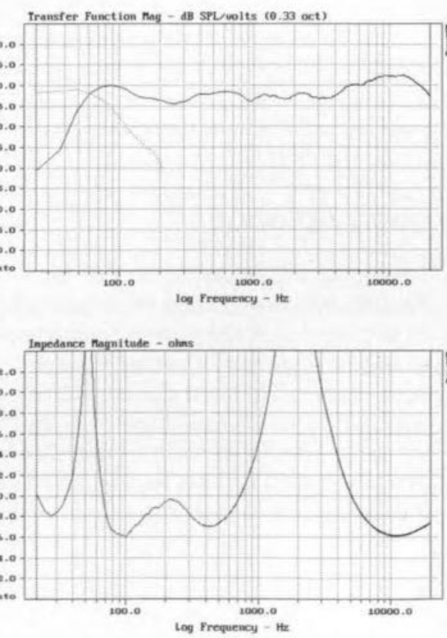


Figure 5. The smooth frequency response characteristic of the Tolomeo and below it the impedance curve.

**Parts list** (one loudspeaker)

Drive units:
- Eton 8-472/32 HEX (Eton); CSC145G (Peerless); K21FD (Seas).

$R_1$ = 8.2 Ω, 20 W
$R_2$ = 8.2 Ω, 20 W(optional - see text)
$C_1$ = 33 µF, 50 V, bipolar electrolytic
$C_2$ = 68 µF, 35 V, bipolar electrolytic
$C_3$ = 3.9 µF, metallized polyester (MKT)
$C_4$ = 3.3 µF, metallized polypropylene (MKP)
$C_5$ = 68 µF, 35 V, bipolar electrolytic (optional - see text)
$C_6$ = 100 µF, 35 V, bipolar electrolytic (optional - see text)
$L_1$ = 8.2 mH (with HQ core)
$L_2$ = 1.8 mH, air-cored, 1 mm dia. enamelled copper wire
$L_3$ = 0.39 mH, air-cored, 0.71 mm dia. enamelled copper wire)
$L_4$ = 10 mH (with pot core)
1 off terminal box
1 off bass reflex port, inner dia. 70 mm, length 250 mm
Polyester wadding, about 1 $m^2$

Medium-density fibreboard (MDF) or high density chipboard, 19 mm thick
2 off 1000×315 mm (39.37"×12.40") (side panels)
2 off 962×142 mm (37.48"×5.59") (front & rear panels)
2 off 315×142 mm (12.40"×5.59") (top & bottom panels)
1 off 288×142 mm (11.34"×5.59") partition)
1 off 142×50 mm (5.59"×2") (brace)

Every designer and manufacturer of loudspeakers is sure to maintain that his design is unique. Now, unique can mean 'unequalled' or 'remarkable, unusual'. There is not much, if any, equipment to which the first meaning can be applied. The second meaning is the much more common one and it can certainly be applied in this sense to the Fontana loudspeaker from Visaton, particularly as regards its appearance.

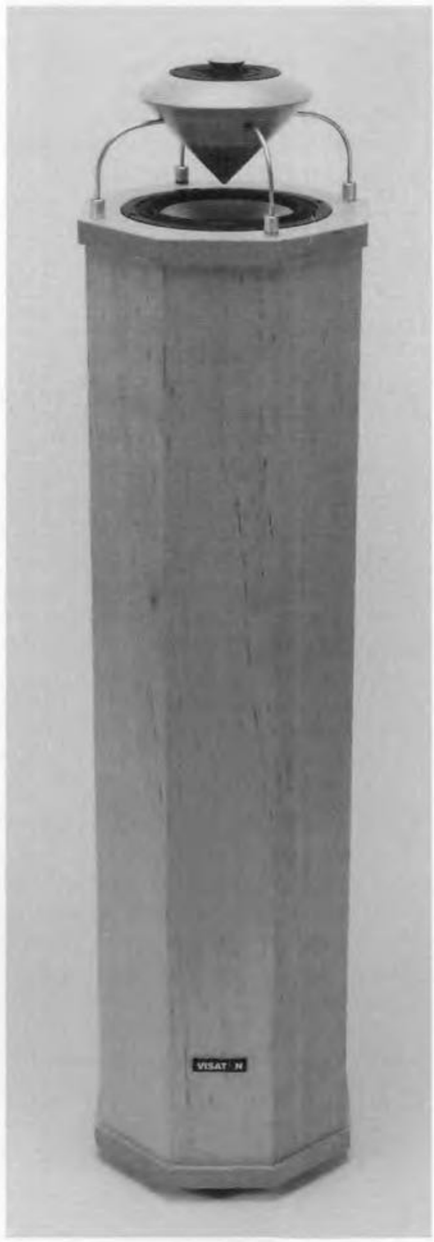
# Fontana

## an all-rounder from Visaton

**Brief specification**

| | |
|---|---|
| *Name* | *Fontana* |
| *Design* | *Visaton* |
| *Enclosure* | *omni-directional, vented* |
| *Net volume* | *23 litres* |
| *Dimensions* | *1020×240×240 mm (40.15"×9.45"×9.45")* |
| *Drive units* | *17 cm woofer/midranger 25 mm dome tweeter* |
| *Nominal impedance* | *8 Ω* |
| *Power handling capacity* | *70 W (100 W music)* |
| *Sound pressure level*(SPL)* | *80 dB (1 W m$^{-1}$)* |

**Sometimes specified as sensitivity*




The Fontana is an odd-looking piece of furniture. Furniture, because its graceful shape strikes one at first sight as an artistic object or a decorative lamp.

The unusual shape is not an intentional design, but rather a consequence of the designer choosing a different approach from the usual. This is because the loudspeaker is an omni-directional radiator that propagates energy over 360°. This results in excellent spatial reproduction and obviates the limited listening angle that typifies a standard loudspeaker.

The interesting aspect is that the omni-directivity is not obtained by the use of special drivers, but with standard ones. This results, however, in a construction in which the drivers are directed upwards and the reproduced sound is reflected in all directions by special cones (see Figure 1). The design of the system, electrical as well as acoustic, is, of course, such that a reasonably straight frequency characteristic is obtained all around the enclosure.

### two-way combination

The standard drivers used in the Fontana are a 17 cm woofer /midranger and a 25 mm dome tweeter. This is a combination that is well suited to a two-way combination, since a cross-over frequency suitable for both drivers is possible; this is normally 2000–3000 Hz. This frequency is not too low for the tweeter, while the 17 cm unit is still able to radiate without noticeable bunching.

The designers at Visaton are, of course, in the fortunate position of being able to choose from a vast array of drive units of own make. They chose the DT94 tweeter, which has a polycarbonate diaphragm. Its frequency characteristic is substantially straight and, because of the ferrofluid* cooling of its motor coil, its power handling capacity is good. This is a unit that is used in many Visaton designs and has proved its excellent properties time and again.

The woofer/midranger is a new model, the AL170. This is a 17 cm driver from Visaton's high-end range. It has an attractive light-metal cast frame and stands out by its aluminium diaphragm. Often, a metal diaphragm gives rise to annoying resonances, but in the frequency characteristic of the AL170 these are conspicuous by their absence. The characteristic is exemplary up to 4 kHz; it is only at about 5 kHz that certain spurious effects begin to make themselves felt.

## reflector cones

To obtain a truly omni-directional performance, the drivers have to be mounted one above the other. How this is done may be seen in Figure 1. The woofer/midranger is mounted at the top of the enclosure. Immediately above it, a conical extension piece is mounted that serves also as the housing of the tweeter. The solid wooden cone has an angle of curvature of 90° and converts the AL170 into an omni-directional radiator. The precise dimensions of the cone are shown in Figure 2.

Making the cone is a tedious job that cannot be properly carried out without the requisite woodworking tools and a wood-turning lathe. The tolerances on the dimensions are very tight and the surface needs to be perfectly smooth. Many constructors may decide that it pays to have it made by a professional woodworker.

The tweeter also needs to be converted to an omni-directional transducer and again this is done by means of a cone. This one has a slightly differently shape and is smaller: the exact dimensions are given in Figure 3. The cone is designed to enable it being glued to the dust cap in front of the diaphragm. Although making it is rather less tedious than the bigger one, it is virtually impossible to do so without a wood-turning lathe.

The extension piece is fixed on to the woofer enclosure with the aid of four clips made from 3.5 mm diameter round brass (available from most builders' merchants). The clips are to be shaped as shown in Figure 4. One end is pushed into the relevant hole in the cone and the other end into one of the chassis sockets at the top of the box. This method of securing has the advantage that two of the clips serve as terminals for connecting up the tweeter.

Make sure that the cone is mounted in a position in which its vertex is exactly 1 cm above the surface of the top of the enclosure.

The side view in Figure 5 shows what the practical construction looks like (or should look like).

## crossover network

The designers have spent much time on the crossover filter for two good reasons. Firstly, the crossover frequency of 2000 Hz is fairly low, which means that the filter design must be such that the power handling capacity of the tweeter is not affected. Secondly, the change from uni-directional to omni-directional radiator is not without effects on the frequency characteristic, and the crossover network provides one of the few ways of correcting any consequent degrading of the curve.

The filter (see Figure 6) is a third-order configuration (18 dB/octave). Inductors $L_1$ and $L_2$, in conjunction with capacitor $C_1$, form the low-pass section for the woofer, and $L_3$-$C_3$-$C_4$

Figure 1. The drive units in the Fontana radiate sound upwards.

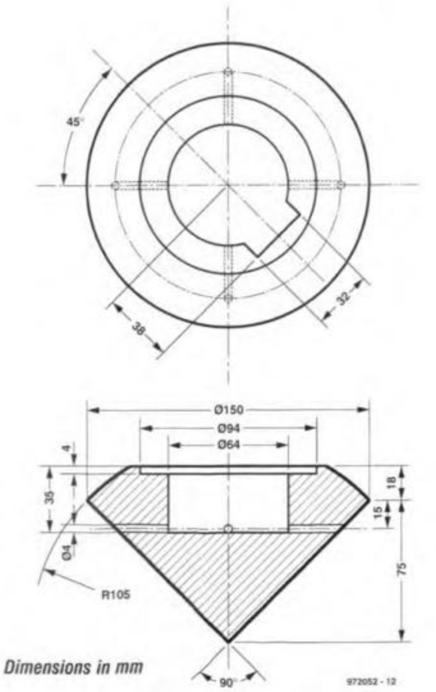



Figure 2. Construction diagrams of the reflector cone for the woofer. This cone also houses the tweeter.

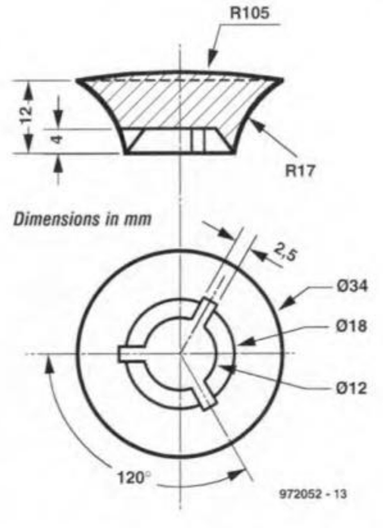



Figure 3. A small reflector cone is glued on to the dust cap of the tweeter.

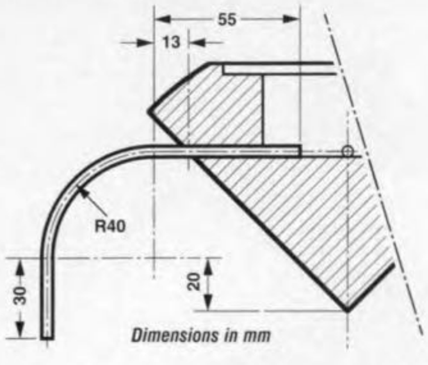



Figure 4. Brass clip for fixing the woofer cone on top of the enclosure.

the high-pass section for the tweeter.

Since the reflections of the sound by the cones affect the frequency response, some corrective measures were found necessary. One of these is the addition of shunt capacitor $C_2$ to the low-pass section. Another is the conversion of $C_4$ to an *RLC* network by the addition of $L_4$ and $R_2$. Finally, resistor $R_1$ matches the output level of the tweeter to that of the woofer/midranger. The value of this resistor may be varied (within limits) to personal taste.

Mind the polarity when connecting the filter: the woofer and tweeter are in phase!

## a slender column

The enclosure for the woofer/midranger is designed as a slender, almost cylindrical, column of about 90 cm high – the drivers in the top panel, the bass reflex vent and the terminal box in the bottom panel.

Of course, the design is not truly cylindrical ( although there is no objection to this as long as the volume remains 23 litres), since the woodworking to achieve this is very complicated. The prototypes are octagonal – the construction diagram is given in Figure 7.

The enclosure consists of eight 840×96 mm panels, which have been sawn lengthwise at an angle of 22.5°. The material is 16 mm (0.63") thick medium-density fibreboard (MDF) or high-density chipboard. The eight panels should be glued together in to a column in one operation.

Figure 5. Side view of the cone construction. Two of the brass clips are used as terminals for the tweeter.

The top and bottom panels are 19 mm thick MDF. Before these can be fitted, the requisite holes must be cut in them: in the top one a hole for the woofer/midranger, and in the bottom one two holes – one for the vent and the other for the terminal box. The vent has a diameter of about 66 mm (2.60") and is 147 mm (5.79") long. It will be clear that the port will be effective only if the bottom panel is well away from the floor on which the enclosure stands. The prototype is therefore fitted with four 25×25 mm (1"×1") square feet made from 22 mm thick MDF.

Four 3.5 mm chassis sockets are required in the top panel to hold the cone-fixing clips as discussed earlier.

The enclosure should be damped by stuffing it loosely with polyester wadding to suppress standing waves. If a sheet of acoustic wadding material is used, cover all surfaces directly behind, and adjacent to, the woofer.

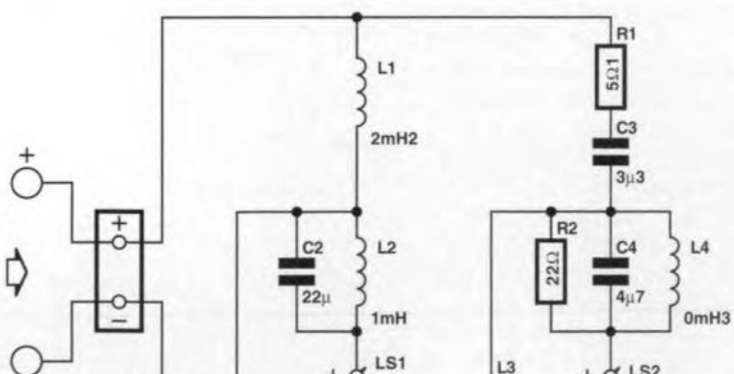
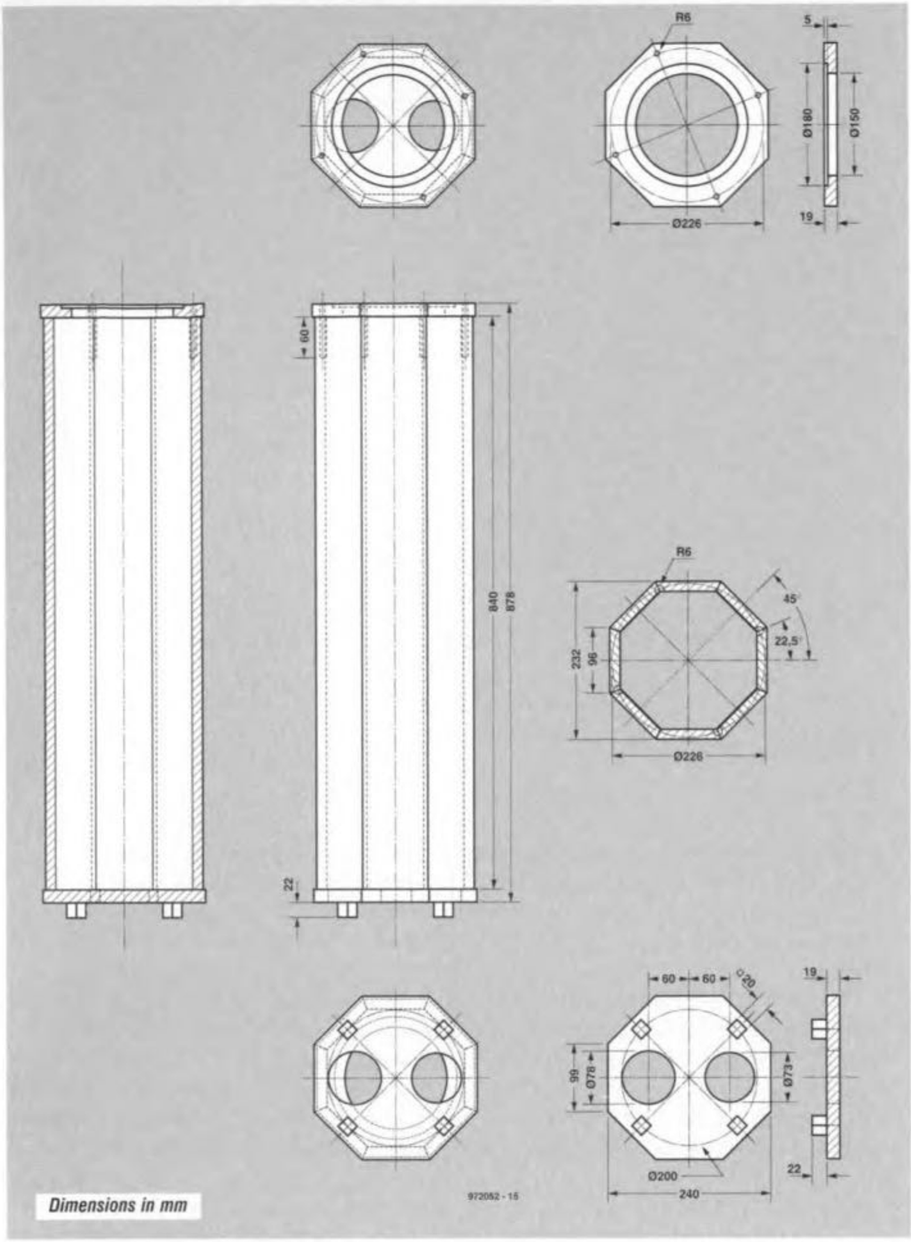



Figure 6. Circuit diagram of the cross-over filter.

## spatial quality

Listening to the Fontana for the first time is an exciting experience. It is clearly different from conventional transducers. The cone construction succeeds very well in giving the two-way system a very effective omnidirectional character. This means that the spatial quality is evident anywhere in the auditorium, which gives the listener much more freedom to move about than with traditional systems.

The Fontana's reproduction is peaceful and well-balanced. This is evident from the relatively smooth frequency response characteristic in Figure 8. The bass extends well




Parts list (one loudspeaker)

Drive units: AL170 and DT94 (both from Visaton)
$R_1$ = 5.1 Ω, 9 W
$R_2$ = 22 Ω, 5 W
$C_1$ = 10 µF, 35 V, bipolar electrolytic
$C_2$ = 22 µF, 35 V, bipolar electrolytic
C3 = 3.3 µF, metallized polyester (MKT)
$C_4$ = 4.7 µF, metallized polyester (MKT)
$L_1$ = 2.2 mH, air-cored, wire dia. 1 mm
$L_2$ = 1.0 mH, air-cored, wire dia. 1 mm
$L_3$ = 1.4 mH, air-cored, wire dia. 0.6 mm
$L_4$ = 0.3 mH, air-cored, wire dia. 0.6 mm
4 off brass fixing clips, dia. 3.5 mm, length 148 mm
4 off 3.5 mm chassis sockets
1 off bass reflex port, outer dia. 72 mm, length 147 mm
1 off small terminal box
Polyester wadding, about 0.5 $m^2$

Medium-density fibreboard or high-density chipboard:
8 off 840×96 mm (33.07"×3.74"), 16 mm (0.63") thick
2 off 240×240 mm (9.45"×9.45"), 19 mm (0.75") thick
4 off 25×25 mm (1"×1"), 22 mm (0.87") thick

Hardwood cones
1 off as in Figure 2
1 off as in Figure 3

Figure 7. The octagonal box requires great woodworking skills.

down without becoming boomy and the high frequencies are bright and sharp, almost gritty. If desired, the grittiness may be reduced by increasing the value of resistor $R_1$.

The position of the boxes is not too critical, but it is recommended not to place them closer than 50 cm to 1 metre to walls and corners.

A final note: although the specified sound pressure level (SPL) is fairy low, in practice this is not very noticeable. This is because the reflections in a normal living room are rather stronger in the case of an omnidirectional radiator than with a conventional one.

[972052]

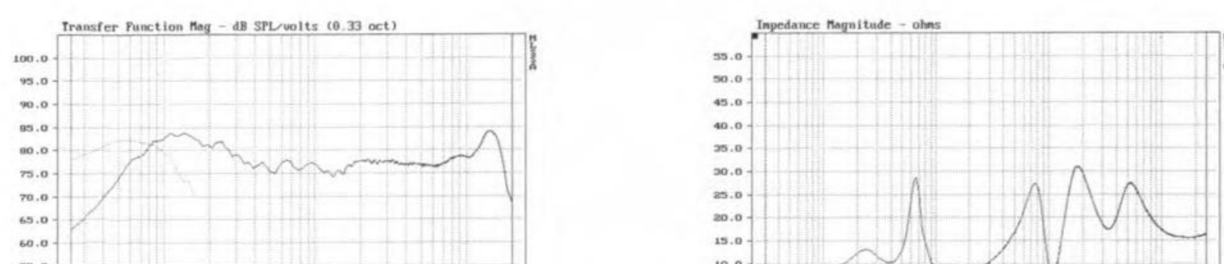


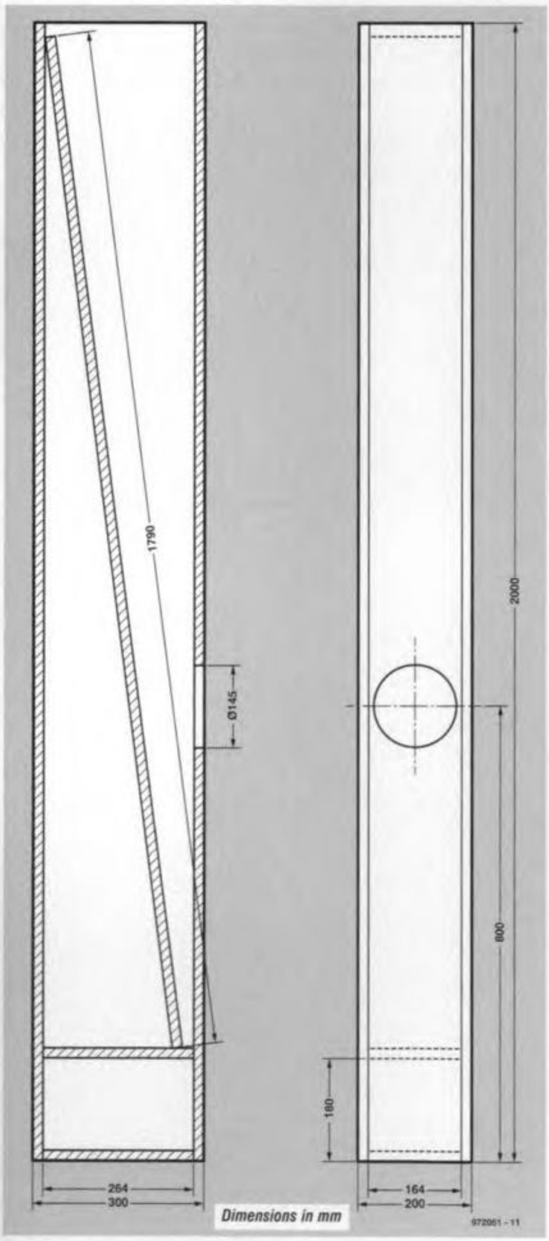

Figure 8. The overall frequency response characteristic of the Fontana is reasonably smooth. The impedance does not drop below 5 Ω, so that almost any power amplifier may be used.

Principally, there are several kinds of loudspeaker enclosure: closed box, vented box (sometimes called bass reflex), bandpass, transmission line, horn, and open pipe. For all sorts of reason, not the least of which is the difficulty of construction, the open pipe enclosure is not all that popular. This is a pity because the Voigt Tapered Pipe (VTP), which combines the properties of the horn and transmission line, deserves more attention from amateur constructors. This article takes a close look at the properties of this musical pipe.

By E. Fikiers

# Voigt tapered pipe

## a special low-frequency loudspeaker




### closed vs vented box

The low-frequency sound waves generated at the front and rear of the loudspeaker cancel each other, which means that the front and rear of the enclosure must be kept separated. This is effected in different ways by different enclosures. A closed box has the drawback that it raises the resonant frequency of the system. In a bass reflex design, the vent enables the box to be tuned to a low frequency. This is the reason that a vented box gives better bass performance than a closed box. On the other hand, its impulse response is not so good.

### horn enclosure

Some audio enthusiasts are fanatic about the horn loudspeaker. They swear by its high efficiency, its dynamics and its low distortion. Popular horn designs are those of Klipsch, Lowther, Webster and Wilson.

The horn flare normally has an exponential, hyperbolic or tractrix shape. In the exponential horn loudspeaker, the cross-sectional area increases exponentially from throat to mouth. A small deflection of the diaphragm causes a large pressure in the throat. At the mouth, this results in a large movement of air at low pressure.

Because of the improved acoustic matching, the efficiency may be as high as 50%. Since the built-in drive unit gives small deflections, the distortion is small.

A horn system for reproducing very low frequencies may have a cross-sectional mouth area of some square metres (20–25 sq. ft.). Since the dimensions may be very large, horns for domestic use are usually folded.

Many pundits feel that horn-loaded enclosures are not capable of hi-fi performance and are, in the main, inferior to direct radiator systems. Horn-lading is normally used in public-address systems where efficiency is of prime importance.

### transmission line system

Transmission lines (TLs) represent a class of supposedly non-resonant enclosures. In theory, it may be extended to infinity, providing a perfectly resistive termination to the driver by absorbing all the rear wave energy, except for frequencies below about 75 Hz.

Physically, a TL resembles an acoustic pipe, closed at one end, whose cross-section must be large so that the rear directed energy is not impeded. The absorption reduces as the cutoff frequency is approached. The frequency at which the air in the line oscillates in synchrony with the diaphragm of the drive unit depends on the length of the line. This frequency, $f_s$, is calculated from

$$f_s = c/4l,$$

Figure 1. A 180 mm long Voigt Tapered Pipe. The space behind the woofer may be filled with fine sand. The hollow foot provides space for a crossover network.

where c is the speed of sound (344 m $s^{-1}$), and $l$ is the length of the line in metres. So, a line 2 metres long has an $f_s$ of 344/8 = 43 Hz. It is clear from this that in order to reproduce very low frequencies, the line must be fairly long.

Since a line length of 2–3 m (7–10 ft) is quite normal for a TL, it is usually folded for domestic use, when it is normally known as a labyrinth.

## spurious line resonances

Practical lines normally have a fairly small cross-section to reduce the total volume; spurious resonances and reflections at higher frequencies may become a problem. The resulting peaks in the frequency characteristic are normally damped by filling the line with a damping material such as long-fibre wool. If a peak remains at the resonant frequency, more damping material needs to be added.

The damping material causes a large acoustic resistance at the rear of the woofer. This resistance causes an increase in the dynamic mass, which lowers the resonant frequency. Also, friction between the air and the damping material results in an isothermic effect, which causes the oscillatory energy of the sound waves to be converted into heat. Because of these effects, and depending on the density of the damping material, the speed of sound in the line is then reduced to 280–320 m $s^{-1}$ (propagation delay). This delay enables a shorter line to be used.

## pressure variations

An open-line enclosure is constructed from a round or rectangular pipe of which one side is closed. Apart from its self-resonance frequency, the pipe generates harmonics of this. Since air can easily enter or leave the enclosure, there is less pressure build-up in the enclosure than in other closed systems. This has several advantages: the tendency of the walls to resonate is much reduced, and the production of standing waves is limited.

In contrast to a TL, no damping material is used in a closed line, so that line resonances may in some cases cause an audible colouration of the sound. Also, the woofer is not, or hardly, damped. Therefore, the amplifier must provide the necessary damping. This means that the amplifier used with this type of loudspeaker needs a well-defined damping factor.

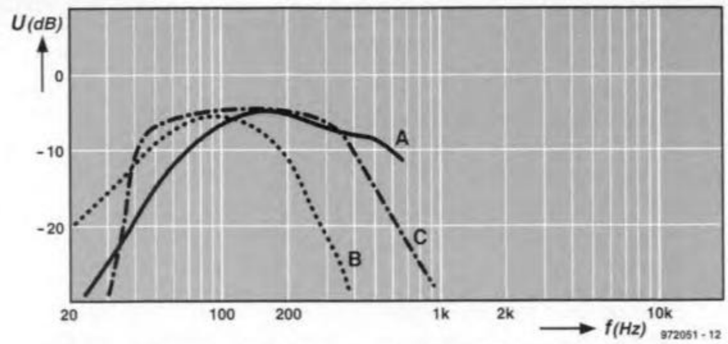


Figure 2. Frequency characteristic of a VTP fitted with a Seas WP171NP driver. Curve A refers to the sound level measurement at the woofer; B to that at the mouth of the pipe, while C is the combination of the sound pressures at the woofer and the mouth of the pipe.

## Voigt tapered pipe

The VTP is a variation of the open-line system (see Figure 1). Its principle of operation was developed by Paul Voigt in the early 1930s. In the UK, the VTP is known under the names 'Monolith' and 'Basset'. A recent commercial version of a folded VTP is the 'Howard Castle'.

The VTP loudspeaker consists of a tapered pipe on to which the woofer is mounted at 1/3 of its length. As in the TL, the resonant frequency of the pipe depends on its length. So as to keep the dimensions within reasonable limits, the pipe is usually folded. Just as the horn, the pipe, because of its tapered shape, behaves as an acoustic transformer. That is, a small deflection of the woofer results in an appreciable increase of air pressure in the throat of the pipe, while at the mouth of the pipe, there is a strong movement of air at low pressure. Because of the acoustic transformation, the efficiency increases rapidly with lower frequencies.

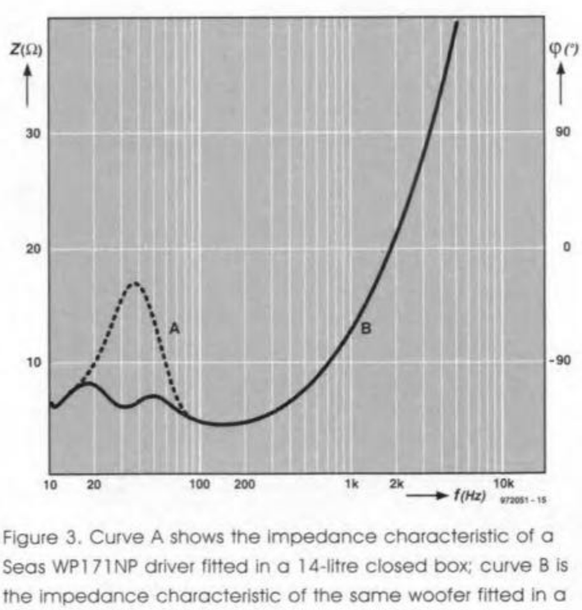


Figure 3. Curve A shows the impedance characteristic of a Seas WP171NP driver fitted in a 14-litre closed box; curve B is the impedance characteristic of the same woofer fitted in a 180 cm VTP.

The mounting of the woofer at 1/3 of the length of the line and the tapered shape ensure a good spread of the pipe resonances over a wide frequency range. Because of this, the frequency characteristic is flatter than that of a TL. Also, the tapered shape largely prevents the occurrence of standing waves.

Damping material is stuffed at the walls and at the woofer. Owing to the absence of acoustic damping, it is imperative that the amplifier driving the loudspeaker has a high damping factor.

## damping of the vtp

As in the TL, stuffing the VTP with long-fibre wool results in an increase of the dynamic mass and a consequent lowering of the resonant frequency. Also, the material damps the peak at the resonant frequency.

Figure 2 shows the traced measurement results of a Seas WP171NP fitted in a 180 cm (6 ft) long VTP shaped as in Figure 1. Curve A is the sound pressure measured near the woofer. It shows clearly that the sound pressure decreases by 6 dB per octave below 150 Hz.

Curve B is the sound pressure at the mouth of the pipe, which is clearly spread over a wide frequency range.

Curve C shows the combined sound pressures of the woofer and the mouth of the pipe. The –3 dB cutoff point is at about 30 Hz, which, for a 17 cm woofer, is excellent.

The impedance characteristic of the woofer is shown in Figure 3. Curve A is that of the same Seas drive unit in a 14-litre closed box, while curve B is that of the same driver fitted on to a 180 cm VTP. Curve B shows that the resonance frequency of the woofer is well damped. (In both measurements, an inductance of 2.7 mH was placed in series with the woofer).

Figure 4 shows the cumulative decay spectrum of the same woofer fitted on to the 180 cm VTP. It shows that the decay time is much shorter than that in a closed box: only 17 ms. Because of the open character of the VTP, there are fewer spurious resonances caused by vibrating enclosure walls and standing waves.

## construction and test

The 180 cm long VTP is a non-folded model, which makes construction very simple indeed. Used with a Seas WP171NP, the bass performance is tight with a faithful and detailed reproduction. The nuances of bass instruments such as timpani and snare drums are clearly distinguishable. At the same time, clarity of vocal sounds is excellent.

Not every constructor will be enchanted with such a long pipe in the living room. Therefore, it is also possible to construct a folded VTP (height 90 cm or 35.43") as shown in Figure 5. This model is suitable for use with a 20 cm woofer. The bass reproduction can be tuned by means of a damping panel which may be provided with a variovent. Drive units suitable for this design are, among others, the Davis KLV8A, the Focal 8V412, and the Focal 8K516J.

Both enclosures are suitable for housing a two-way or a three-way system. They can also be used for a subwoofer in conjunction with a dynamic of electrostatic drive unit.

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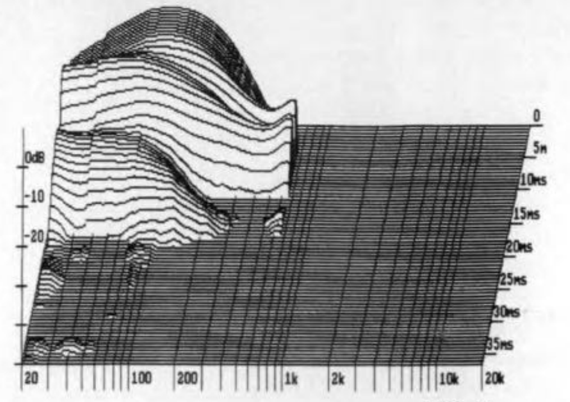

Figure 4. Cumulative decay spectrum of a Seas WP171NP fitted in a 180 cm long VTP.

**Materials for 180 cm VTP**

Medium-density fibreboard (18 mm)

2 off 2000×300 mm (78.74"×11.81") (side walls)

2 off 2000×164* mm (78.74"×6.46") (front and rear panel)

1 off 1790×164* mm (70.47"×6.46") (slanting inner panel)

2 off 263×164* mm 10.35"×6.46") (support panels)

* if a 20 cm (8") woofer is used, the width of 164 mm (6.46") wide panels must be increased to 210 mm (8.27")

Damping material
600 grammes long-fibre wool [800 grammes in case of a 20 cm (8") woofer]

**Materials for a 90 cm folded VTP**

Medium-density fibreboard (18 mm)

2 off 900×400 mm (35.43"×15.75") (side panels)

1 off 900×209† mm (35.43"×8.23") (rear panel)

1 off 645×209† mm (25.39"×8.23") (front panel)

1 off 383×209† mm (15.08"×8.23") (bottom panel)

1 off 364×209† mm 14.33"×8.23") (top panel)

1 off 255×245 mm (10"×9.65") (optional damping panel; all edges at one side of this panel should be chamfered to 45°; a Scanspeak acoustic resistance with a fitting aperture of 110 mm (4.33") dia may be fitted in this panel)

2 off 237×20 mm (9.33"×0.8") (for fixing damping panel)

2 off 169×20 mm (6.65"×0.8") (for fixing damping panel)

18 mm chipboard for inner panels

1 off 644×209* mm (25.35"×8.23")

1 off 491×209* mm (19.33"×8.23")

1 off 284×209* mm (11.18"×8.23")

1 off 143×209* mm (5.63"×8.23")

† If a 17 cm (6.70") woofer is used, the width of all 209 mm (8.23") wide panels must be reduced to 163 mm (6.42").

Damping material
800 grammes long-fibre wool (600 grammes if a 17 cm (6.70") woofer is used)

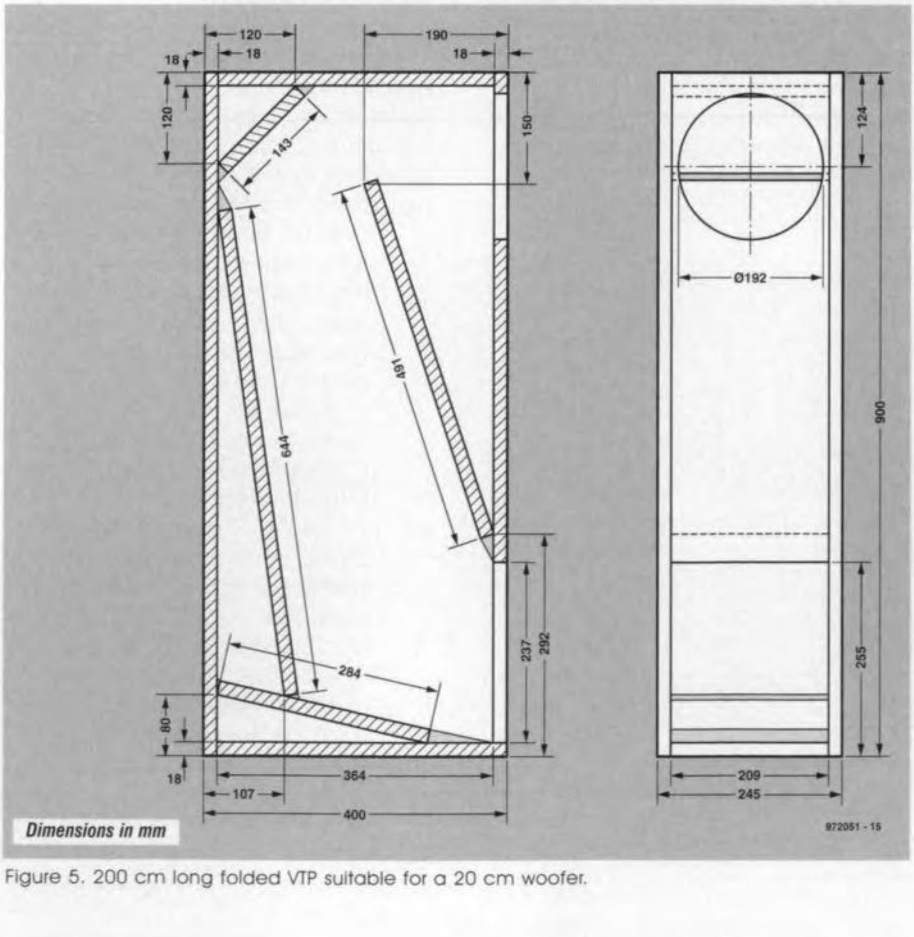

Figure 5. 200 cm long folded VTP suitable for a 20 cm woofer.