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CONTENTS

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

16-PAGE SUPPLEMENT P18

HIFI LOUDSPEAKERS
Between pages P120-123

cumulative Index 1997
Centrefold

reader enquiry
Centrefold

International Microprocessor Contest
List of winners: page 16

APPLICATION NOTE
68 HUSH stereo noise reduction system SSM2000r

AUDIO & HIFI
22 220 decibel adaptor
25 Digital audio input selector
53 High-quality oscillator for digital audio
62 Bass extension for surround sound
64 Automatic volume control
87 Mullard/Wilkinson detector
89 Low-cut/limiter
90 D.C. detector

COMPUTERS & MICROPROCESSORS
1 Handyman: a pocket-size controller
29 Handyman programmer
33 SMD adaptor
56 Smart-card reader/writer
72 Inexpensive isolator for RS232
84 Simple position sensor
101 Mitsubishi shift register
102 Mac-PC-VGA adaptor
80 Adaptor board for 16-pin PIC
81 Two-way 20-pin/40-pin adaptor/buffer
89C020/1202

FOCUS ON
46 Automobile navigation systems

GENERAL INTEREST
20 Revolution counter
21 Linear optoisolator
23 Intruder alarm
32 PIC-controlled shredder
33 Digital potentiometer
54 Christmas running light
65 Simple crystal oscillator
74 Variable-pulse generator
76 Octopush
82 PIC-controlled light barrier
83 Voltage inverter/doubler
86 Object protection
88 150 watt lamp dimmer

POWER SUPPLIES & BATTERY CHARGERS
78 Auto on/off switch for power supplies

RADIO & TELEVISION
76 Wideband VHF preamplifier

TEST & MEASUREMENT
34 Infra-red-illuminance meter
68 MilliAmp meter for DVM
75 VCO continuity tester

MISCELLANEOUS INFORMATION
83 Data sheets
111 Electronics now
52 Electronics on line: Build your own loudspeaker
102 Index of advertisers
58 & 59 New Books
102 Next month in Elektor Electronics
50 Readers' letters: P.O.Box 2141
20 Readers' services

December 1997
Volume 23
Number 261
ISSN 0268/4519
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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 operated properly and that consumers who continue to use MDF 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 Matsushita, Thomson and Zenith) will also play standard disks.

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.

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.

The Greenwich Dome is being launched into cyberspace with an interactive site costing £150,000 for the National Olympic Conference Centre, London, on 10-12 December. Details from Customer Service Manager, IIR Ltd, 6th Floor, 29 Bressenden Place, London SW1E 5DR; telephone +44 (0)171 950 6111; fax +44 (0)171 950 5056.

REMOTE ACCESS

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 access 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 & 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 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 outs 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 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 news-groups, 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.

For 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 34 per cent willing to use the Internet to make a purchase. The next most popular is software (55 per cent) or entertainment, that is, CDs and videos (52 per cent).

The number of Internet users has now reached four million, including 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

MILLENIUM 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.

Elektor Electronics 7/97 11
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 involving all areas of the country in the 'Experience'. When the 'Experience' is open, the site will have time-tabled live links 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. Phone +44 (0)171 880 8200; fax +44 (0)171 880 2019.

Longitude0 Consortium, 10 barley Mow Passage, London W4 5PH. Telephone +44 7000 583383; Fax +44 7000 583329

BANK PIONEERS ELECTRONIC MONEY

A new electronic money service avoids being tested at Barclays, 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 10 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 Barclayscard account. Later, they can transfer money from the Barclayscard or any other card account into the electronic wallet, which in turn can be used for online shopping.

Dr. Simon Sherrot of the university's Electronic Engineering and Information Technology Department has developed a system that allows the problem of 'ghosting' on television screens to be solved. In terrestrial television transmission, multiple paths occur to 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 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.
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.

Dr Simon Sherrot, Electronic Engineering Group, Reading University, Whiteknights, PO Box 227 Reading RG6 6AB. Telephone +44 118 931 8293; fax +44 118 031 0279. E-mail: ssherrett@reading.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 an 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 SUS10bn this year.

Supporting the launch of CopyLok, some game software manufacturers are now claiming that up to four illegal copies are made of software 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: metalcastanotechnologies.com

CHEAPER, FASTER NET ACCESS

Ionica, a Cambridge-based telecommunications 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, 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 users to connect to the Net with a particular service provider. Although modems operate fast, they can be slowed down by the maximum bandwidth of the telecommunication network they send through. Ionica says that its radio-based system offers extremely fast access because it does not rely on getting through all telephones 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 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 telephone service. 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 online to 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 festival. Users will be able to use LiquidAudio's high-quality sound software to listen to near-CD-quality sound clips downloaded from the site and vote online for their favourite unsigned bands.

Sony plans a month-long banner campaign to promote its new M16 OHQ. Telephone +44 161 873 8000. Internet: 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: infobooks.co.uk

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

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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 365 000. 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 push-buttons to be hooked up to implement a powerful, versatile controller system.

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-
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 boxheaders) 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-μF 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...
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 Iamesch 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.

<table>
<thead>
<tr>
<th>Prize</th>
<th>Description</th>
<th>Name</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number One Systems Software suite</td>
<td>Ben de Waal</td>
<td>PIC on the rocks</td>
</tr>
<tr>
<td>2</td>
<td>Proteus IV (Labcenter Electronics)</td>
<td>Alberto Ricci Bitti</td>
<td>Video DVM</td>
</tr>
<tr>
<td>3</td>
<td>680X0 ANSI C Compiler (Crossware Electronics)</td>
<td>Tony Kemp</td>
<td>Simple programmable controller</td>
</tr>
<tr>
<td>4</td>
<td>ADC-200 (Pico Technology)</td>
<td>John Kokkoris</td>
<td>Digital PLL synthesizer 1-200 MHz</td>
</tr>
<tr>
<td>5</td>
<td>Electronic Workbench 5 (Robinson Marshall)</td>
<td>Christopher Morris</td>
<td>The AVR parallel programmer</td>
</tr>
<tr>
<td>6</td>
<td>80C537 Microcontroller kit (C-1 Electronics)</td>
<td>Panagiotis Tsironis</td>
<td>Stepper motor controller using the PIC16C54</td>
</tr>
<tr>
<td>7</td>
<td>Ecosin NC software (Swift Designs)</td>
<td>Jan Szymanski</td>
<td>PIC based indicator board</td>
</tr>
<tr>
<td>8</td>
<td>Micro-ISIP programming system (Equinox Technologies)</td>
<td>M. Alexandre Wiatraine</td>
<td>Using the Net for remote experiments with 8052AH-BASIC</td>
</tr>
<tr>
<td>9</td>
<td>AVR Starter System (Equinox Technologies)</td>
<td>Anthony Williams</td>
<td>AGET102D mains monitor/genet controller</td>
</tr>
<tr>
<td>10</td>
<td>ADC43 PC based oscilloscope (Pico Technology)</td>
<td>Robert Kiss</td>
<td>Intelligent stepper motor controller</td>
</tr>
<tr>
<td>11</td>
<td>CH-19 autoranging DMM (Cirkit Distribution)</td>
<td>Ágostos Dimitriadi</td>
<td>Central heating consumption timeskeeper</td>
</tr>
<tr>
<td>12(1)</td>
<td>Book/subcription/CD-ROM (Elektor)</td>
<td>Peter Friend &amp; Gareth Evans</td>
<td>Five function bike light</td>
</tr>
<tr>
<td>12(2)</td>
<td>Book/subcription/CD-ROM (Elektor)</td>
<td>Nicos Chalkias</td>
<td>CNC machine interface</td>
</tr>
<tr>
<td>12(3)</td>
<td>Book/subcription/CD-ROM (Elektor)</td>
<td>Hayssam Serhan</td>
<td>Billboard project</td>
</tr>
<tr>
<td>12(4)</td>
<td>Book/subcription/CD-ROM (Elektor)</td>
<td>Gordon Serff</td>
<td>Motorised security gate controller</td>
</tr>
<tr>
<td>12(5)</td>
<td>Book/subcription/CD-ROM (Elektor)</td>
<td>L. Kok Kiong</td>
<td>6809 based security system</td>
</tr>
<tr>
<td>12(6)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>Andrew Early</td>
<td>Safety interlocked rocket launching system</td>
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<td>12(7)</td>
<td>Book/subcription/CD-ROM (Elektor)</td>
<td>Anthony Williams</td>
<td>Electric gate controller</td>
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<tr>
<td>12(8)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>Watchara Chantang</td>
<td>SB-31 single-board microcontroller</td>
</tr>
<tr>
<td>12(9)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>M. Hewitt</td>
<td>Ignition system</td>
</tr>
<tr>
<td>12(10)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>Chiang Tak Meng</td>
<td>Microcontroller based MOSFET variable PSU</td>
</tr>
<tr>
<td>12(11)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>Frank Martin</td>
<td>BCD indicator</td>
</tr>
<tr>
<td>12(12)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>Dusko Lolic</td>
<td>DDSI</td>
</tr>
<tr>
<td>12(13)</td>
<td>Book/subscription/CD-ROM (Elektor)</td>
<td>Jeremy Crook</td>
<td>Z80 interactive disassembler V1.0</td>
</tr>
</tbody>
</table>

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!
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, show '6') 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.

**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**

```assembly
; Electronic dice
.include "1200def.inc"
.device at90s1200
; Bit 7:6543210
.equ WZ6 = 0b10001000
.equ WZ5 = 0b10000100
.equ WZ4 = 0b10101010
.equ WZ3 = 0b11100011
.equ WZ2 = 0b10101110
.equ WZ1 = 0b10111011
.equ key = 0x00
.dif Dice_Reg = r17
.dif Dice_Reg = r16

; All LEDs
.out DORB, Temp
.out PortB, Temp

Loop: LDI: ldi Temp, Wza
        out DORB, Temp
        ldi Temp, OxFF
        out PortB, Temp
        LDI: ldi Temp, Wza
        out PortB, Temp
        jmp L04

LD6: ldi Dice_Reg, WZ6
        sbis PIND, key
        out PORTB, Dice_Reg
        rjmp LD5

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

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

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

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

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

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<table>
<thead>
<tr>
<th>Component Type</th>
<th>Value</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistor</td>
<td>1K</td>
<td>100</td>
</tr>
<tr>
<td>Capacitor</td>
<td>10uF</td>
<td>50</td>
</tr>
<tr>
<td>Inductor</td>
<td>10mH</td>
<td>20</td>
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<tr>
<td>Diode</td>
<td>1N4148</td>
<td>5</td>
</tr>
<tr>
<td>Transistor</td>
<td>2N2222</td>
<td>10</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>78L05</td>
<td>5</td>
</tr>
<tr>
<td>MOSFET</td>
<td>2N7000</td>
<td>10</td>
</tr>
<tr>
<td>Crystal</td>
<td>10MHz</td>
<td>1</td>
</tr>
</tbody>
</table>

**Notes:**
- Components are precision-grade for optimal performance.
- All parts are RoHS-compliant for environmental safety.
- Order by placing your request with our sales team.
The proposed circuit is a general-purpose revolution 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 puls. 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 K1. Any unwanted peaks are removed by low-pass filter R3-C6, while the level is held to a safe value by D1.

The signal is subsequently amplified by T1 and then applied to a monostable multivibrator (MMV) IC1. This stage converts the signal into a series of regular pulses, which are integrated by C1. 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 IC3. This circuit has four BCD outputs and three digit-drives and, in conjunction with IC4, a BCD-to-7-segment decoder, drives displays LD1-LD3.

The number of engine cylinders is determined by correcting the potential across C1 with the aid of divider R4-R5. Four-cylinder engines

### Parts list

**Resistors:**
- R1, R4-R9 = 1 kΩ
- R2 = 470 kΩ
- R9, R12 = 22 kΩ
- R10 = 150 kΩ
- R11, R14, R16 = 10 kΩ
- R13 = 6.2 kΩ
- R15 = 100 kΩ
- R17-R19 = 330 kΩ
- P1, P2 = 10 kΩ, multturn preset for vertical mounting
- P5 = 50 kΩ, multturn preset for vertical mounting

**Capacitors:**
- C1 = 1 µF, 25 V, radial
- C2, C3 = 4.7 µF, 25 V, radial
- C4 = 0.27 µF
- C6, C10-C15 = 0.1 µF
- C7 = 0.047 µF

**Semiconductors:**
- T1-T4 = BC557
- Integrated circuits:
  - IC1 = CA3161E
  - IC2 = CA3162E
  - IC3 = 7411C221
  - IC4 = 7805

**Miscellaneous:**
- HD1105-1108 = HD1105
- JP1-JP4 = jumper
- K1-K5 = 2-way terminal block for board mounting
- K2, K3 = 12-pin SIL header, right-angled
- PCB Order no. 974072

---

The image contains a schematic diagram of the revolution counter circuit with labeled components and connections. The text describes the operation and components of the circuit in detail.
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, JP3 is short-circuited and the potential across $C_1$ is applied to $IC_3$. With six-cylinder engines, JP3 is short-circuited so that the voltage across $C_1$ is divided by 4/6, and with eight-cylinder engines, JP1 and JP4 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 $IC_1$, 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 flexible between $K_4$ and $K_5$.

In case it is desired to get a display of 3400' instead of 340 when the number of revolutions is 3400, add LD4. When only three displays are used, place JP1 as indicated. This causes the decimal point of LD1 to light to show that the display reading must be multiplied by 1000.

---

**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 Vpp 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 $C_1$, 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.
Judging by the cacophony 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 inefficient, 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...
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 K1 and K2 and buffered and amplified by an op amp in each channel. The amplification may be set between x1.5 and x22 with P1 and P2 respectively. These levels should be more than adequate for most situations. The peak output voltage is 2 Vrms.

The output in each channel 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 P3.

Regulator IC1 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 P3 remains accessible.

intruder alarm

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

The contact of the relay in the pyro sensor 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 and output terminals are audio sockets for board mounting.

The circuit draws a current of 1-2 mA, which increases to 13-14 mA (via R3) when the relay contact is closed, and to 15-16 mA when the buzzer is actuated.

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- KTLA Morning News
  - "Orly, matchmaker in action..."

- Jewish TV, Newark
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- AM Philadelphia Show
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- Cleveland Tonight Show
  - "Orly, a touch of class..."

- Orange County News Channel
  - "Orly is champagne wishes..."

- AM Northwest Show, Oregon
  - "Orly, the one and only matchmaker:"

- Good Evening Seattle Show
  - "Orly's clients are the cream de la cream..."

- The Dingy Petty Show, Canada
  - "Orly has a sixth sense..."

- National Enquirer
  - "Orly has a dream date for you..."

- Orange County Register
  - "Orly has a match for the sincere singles..."

- The Heritage Weekly
  - "Orly is nationally and internationally known..."

- Los Angeles Times
  - "Orly matches the rich and successful..."

- Dallas Morning Newspaper
  - "Orly made countless introductions..."

- Beverly Hills Today
  - "Orly is the Rolls Royce of matchmaking..."

- KFI Talk Radio
  - "Orly is the Rolls Royce of matchmaking..."

- WLCV Nashville Radio
  - "Orly is a matchmaker with a sixth sense..."

- AM Philadelphia Show
  - "Orly's clients are simply top of the line..."

- Cleveland Tonight Show
  - "Orly, a touch of class..."

- Orange County News Channel
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Elektor Electronics 12/97
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.

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.

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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.

**Voltagés 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 K3 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 (1/8), 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. The programmer has 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) flexible, 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-
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.

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 non-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_PROC, 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:

1: Power ON
2: Power OFF
3: Clear RESET
4: MOSI HIGH
5: MOSI LOW
6: DTR HIGH
7: DTR LOW
8: RTS HIGH
9: RTS LOW
10: SCK's ON
11: SCK's OFF
12: Status ON
13: Status OFF
14: Loop Test
15: Prog. enable
16: One SCK
17: Device code
18: Quit

Port =>

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 SAA (= 170)
2 : Set byte to be sent to SSS (= 85)
C : Count-up byte to be sent (cyclic)
D : Decrement 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 has to 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 the looping 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-archiving extract 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 /Bbbbb 〈filename〉

Example:

HM_PROG /COM1 /B9600 /RDC

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 /b bbbb 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 S1E 590 50L. 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, /NE 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 /AVL1, /AVL2 and /AVL21 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.

Call parameters for HM_PROG

Call: HM_PROG /COMc /b bbbb /x /〈filename〉〉 /〈filename〉〉

/x 〈filename〉〉

Example: /COM1 for COM Port 1

/bb bb bb bb = 38400119200196001480012400

Example: /9600 for 9600 Baud
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OMP MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 720 watts R.M.S. into 4 ohms, frequency response typical 0.001%, 1000W, 0.5% distortion, 3dB. Damping Factor > 300, Slow Rate 75V/F, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. >108 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 320 x 170 x 115mm.

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NOTE: Mos-Fet Modules are available in two versions: Input Level 200mV, Band Width 10KHz; Input Level 100mV, Band Width 5KHz, 60WATTS (200V) TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND.

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PRICE £132.85 - £16.00 P&P
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 shoplifters 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 supplies power to IC1 and IC2. The resulting high voltage switches K2.

Components List:

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

Capacitors:
- C1 = 180nF 630VDC class X2
- C2 = 470µF
- C3 = 100µF 16V radial
- C5 = 100µF 16V radial

Semiconductors:
- D1,D2 = 1N4148
- D3,D4,D5 = 1N4001
- T1 = BD517
- IC1 = 4013
- IC2 = CNY65 (Temic)
- IC3 = 4093

Miscellaneous:
- S1 = on/off switch; miniature
- S2 = pushbutton, 1 make contact
- Re1 = V23057-8002-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
The circuit diagram shows a complete digital potentiometer based on a Type X9CMME. It is provided with two controls, S1 and S2. When keys S1 and S2 are open, the output of IC3a changes state (from low to high). When this happens, C1 is charged via R3 and D1 until the upper trigger level of IC2a is attained. The gate then changes state again and the above action repeats itself.

The clock signal is optically monitored by D2.

When the output of IC2a is high, the gate draws a portion of the charging current from C1, which results in the clock frequency at INC being relatively low. At the same time that the generator is enabled, C6 begins to be charged gradually via R6 and R7 until IC3 changes states (from high to low). Circuit IC3 then contributes to the charging current to C1, whereupon the clock frequency increases; in the prototype, the frequency rose in four seconds from 1.5 Hz to 3.1 Hz.

When the keys are released, the clock generator stops. At the same time, C6 is discharged rapidly via R6 and R7, so that the frequency is low again when the keys are operated above.

The switch-off delay owing to R6, C2 enables the actual counter state to be stored by the internal logic.

The circuit draws a current of 0.3–1.0 mA.

Ejektor Electronics 12/97
SMD adaptor

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 ST92 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.

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.

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.

In the diagram, the shunt resistance of the diodes is formed by a 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.

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.

*Illumination = illuminance = the quantity of light or luminous flux falling on unit area of a surface.
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 IC6 is controlled by preset up/down counter IC3. The counter is set with DIP switch S3 (note that the MSB switch is not used in this application).

The various inputs are selected with press-keys S1 and S2. Gates IC1e and IC1f, in conjunction with networks R1-C1 and R2-C2, provide effective debouncing of the keys.

Resistor R5 and capacitor C3 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 jumpers J1, so that pin 9 of IC3 is linked to a fixed level.

Which of the inputs is selected is indicated by one of four or eight LEDs that are controlled by 3-to-8 decoder IC3 at the output of IC5. If four inputs are used, D3-D6 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 (IC2) and a coaxial input (K1). It needs only one inverter (here IC2), the others (IC3b-IC3e) are strapped to earth.

The output of the selector also has an optical output (IC6) and a coaxial output (K2).

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 R10 should be lowered to 220 Ω. The total current drain then rises by about 10 mA.

Great News for you!

Over the past 11 years ULTimate Technology supplied more than 20,000 commercial versions, but also thousands of educational versions, which, having no Gerber Interface (high resolution photoplotter) are not suitable for commercial use, but are otherwise identical to the naturally far more expensive, commercial versions. After a worldwide test on Internet the ULTiboard Studio evolved, with the same well-considered limitation, at a price at which everybody can afford a professional design system.
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<tbody>
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<td>(Continued)</td>
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<td>E81CC Gold Pin</td>
<td>KT88 (Gold Lion/Plus) 60.00</td>
<td>7 Pin (For 6L6GC-6) 4.50</td>
<td></td>
</tr>
<tr>
<td>E82 CC Gold Pin</td>
<td>PL509/519 9.00</td>
<td>5 Pin (For EL34 etc) 5.00</td>
<td></td>
</tr>
<tr>
<td>E83CC Gold Pin</td>
<td>2A3 (6 or 8 Pin) 14.50</td>
<td>8 Pin (For EL34 etc) 5.00</td>
<td></td>
</tr>
<tr>
<td>E88CC Gold Pin</td>
<td>211 22.00</td>
<td>9 Pin (For EL34 etc) 5.00</td>
<td></td>
</tr>
<tr>
<td>6EU7 6.00</td>
<td>300B 50.00</td>
<td>13E1 110.00</td>
<td></td>
</tr>
<tr>
<td>6SL7GT 4.50</td>
<td>6C53C-B 27.00</td>
<td>12AT7WA MULLARD 5.00</td>
<td></td>
</tr>
<tr>
<td>6SN7GT 4.50</td>
<td>6L6GC 6.50</td>
<td>12AX7WA MULLARD 5.00</td>
<td></td>
</tr>
<tr>
<td>6922 5.20</td>
<td>6L6WGQ5881 8.00</td>
<td>6805A CERION 50.00</td>
<td></td>
</tr>
<tr>
<td>7025 6.50</td>
<td>6V6GT 5.00</td>
<td>6805A CERION 50.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6080 11.50</td>
<td>12AU7 GE 15.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6146B 10.50</td>
<td>12AX7 GE 15.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7102 9.00</td>
<td>12AX7 GE 15.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7105 11.50</td>
<td>12AX7 GE 15.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7106 10.50</td>
<td>12AX7 GE 15.00</td>
<td></td>
</tr>
</tbody>
</table>

### Rectifier Tubes

<table>
<thead>
<tr>
<th>POWER TUBES</th>
<th>POWER TUBES</th>
<th>POWER TUBES</th>
<th>SOCKETS ETC</th>
</tr>
</thead>
<tbody>
<tr>
<td>6A4 20.00</td>
<td>6B4G 27.00</td>
<td>89A (Ch. or PCB) Gold Plated 3.00</td>
<td></td>
</tr>
<tr>
<td>5R4G KYC STC</td>
<td>7.00 6B6V MULLARD 5.00</td>
<td>805 CERION 50.00</td>
<td></td>
</tr>
<tr>
<td>5R4G KYC STC</td>
<td>7.00 6B6V MULLARD 5.00</td>
<td>805 CERION 50.00</td>
<td></td>
</tr>
<tr>
<td>5R4G KYC STC</td>
<td>10.00 6B6G MULLARD 5.00</td>
<td>805 CERION 50.00</td>
<td></td>
</tr>
<tr>
<td>5R4G KYC STC</td>
<td>12.00 6C53C-B 27.00</td>
<td>6400W TUNGSOG 12.50</td>
<td></td>
</tr>
<tr>
<td>5R4G KYC STC</td>
<td>5.00 6C53C-B 27.00</td>
<td>6550A GE 22.00</td>
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</tr>
<tr>
<td>5R4G KYC STC</td>
<td>12.00 6C53C-B 27.00</td>
<td>6146B GE 17.00</td>
<td></td>
</tr>
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</table>

### And a few "Other Brands" (inc. Scarce types).

<table>
<thead>
<tr>
<th>POWER TUBES</th>
<th>POWER TUBES</th>
<th>POWER TUBES</th>
<th>SOCKETS ETC</th>
</tr>
</thead>
<tbody>
<tr>
<td>5AR4/G234 MULLARD</td>
<td>20.00 6B4G MULLARD 27.00</td>
<td>6SN7GT MULLARD 5.50</td>
<td>13E1 STC 110.00</td>
</tr>
<tr>
<td>5AR4/G234 MULLARD</td>
<td>7.00 6B6V MULLARD 5.00</td>
<td>6SN7GT MULLARD 5.50</td>
<td>13E1 STC 110.00</td>
</tr>
<tr>
<td>5MVGY CHATTHAM USA</td>
<td>10.00 6B6X MULLARD 5.00</td>
<td>6SN7GT MULLARD 5.50</td>
<td>13E1 STC 110.00</td>
</tr>
<tr>
<td>5MVGY CHATTHAM USA</td>
<td>12.00 6C53C-B 27.00</td>
<td>6SN7GT MULLARD 5.50</td>
<td>13E1 STC 110.00</td>
</tr>
<tr>
<td>5MVGY CHATTHAM USA</td>
<td>5.00 6C53C-B 27.00</td>
<td>6SN7GT MULLARD 5.50</td>
<td>13E1 STC 110.00</td>
</tr>
<tr>
<td>5MVGY CHATTHAM USA</td>
<td>12.00 6C53C-B 27.00</td>
<td>6SN7GT MULLARD 5.50</td>
<td>13E1 STC 110.00</td>
</tr>
</tbody>
</table>

Please note carriage extra + VAT (EEC only) - When ordering state if matching required (add £1.00 per tube).

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**Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!**

<table>
<thead>
<tr>
<th>Kit Name</th>
<th>Feature</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTX Ultra-miniature Transmitter</td>
<td>Smallest room transmitter kit in the world. Incredible 10mm x 20mm including mic.</td>
<td>£16.45</td>
</tr>
<tr>
<td>MTX Micro-miniature Transmitter</td>
<td>Best-selling micro-miniature Room Transmitter</td>
<td>£13.45</td>
</tr>
<tr>
<td>STX High-performance Transmitter</td>
<td>Hi-performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range</td>
<td>£15.45</td>
</tr>
<tr>
<td>VT500 High-power Room Transmitter</td>
<td>Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm, 9-12V operation, 300m range</td>
<td>£16.45</td>
</tr>
<tr>
<td>VXT Voice Activated Transmitter</td>
<td>Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm, 9V operation, 1000m range.</td>
<td>£19.45</td>
</tr>
<tr>
<td>HVX400 Male Power Room Transmitter</td>
<td>Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm, 500m range.</td>
<td>£19.45</td>
</tr>
<tr>
<td>SCRX Scrub &amp; Scramble Room Transmitter</td>
<td>Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm, 9V operation, 1000m range.</td>
<td>£22.95</td>
</tr>
<tr>
<td>SCLX Subcarrier Telephone Transmitter</td>
<td>Connects to telephone line anywhere, requires no batteries. Output scrambled so receiver does not respond to signal. Size 33mm x 27mm, 1000m range.</td>
<td>£23.95</td>
</tr>
<tr>
<td>SCDM Subcarrier Decoder Unit for SCRX</td>
<td>Connects to receiver earphone socket and provides decoded audio output to headphones. Size 20mm x 67mm, 9-12V operation.</td>
<td>£22.95</td>
</tr>
<tr>
<td>ATR2 Micro Size Telephone Recording Interface</td>
<td>Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm, Powered from line.</td>
<td>£13.45</td>
</tr>
<tr>
<td>DTX/DLX Radio Control Switch</td>
<td>Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output. Variable rate and sensitivity. Built-in timer. Micro FET switches on both boards set your own unique security code. TX size 45mm x 45mm, RX size 35mm x 90mm. Both 9V operation. Range up to 250m.</td>
<td>£50.95</td>
</tr>
<tr>
<td>Individual Transmitter DLX</td>
<td>£19.95</td>
<td></td>
</tr>
<tr>
<td>Individual Receiver DLRX</td>
<td>£37.95</td>
<td></td>
</tr>
<tr>
<td>MXX-1 Hi-Fi Micro Broadcaster</td>
<td>Not technically a surveillance device but a great idea! Connects to the headphones output of your Hi-Fi or TV and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage when you can't put up with the DJ's choice and boring waffle. Size 27mm x 60mm, 9V operation, 250m range.</td>
<td>£60.95</td>
</tr>
</tbody>
</table>

**Specifics**

- **UTX Ultra-miniature Telephone Transmitter**
  - Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm!
  - Connects to line (anywhere) and switches on and off with phone use.
  - All conversations transmitted. Powered from line. 500m range.
  - £15.95

- **TLX700 Micro-miniature Telephone Transmitter**
  - Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTX.
  - Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.
  - £13.45

- **STX High-performance Telephone Transmitter**
  - High performance transmitter with a buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1500m range.
  - £16.45

- **TXX900 Signalling/Tracking Transmitter**
  - Transmits a continuous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 22mm x 22mm, 9V operation.
  - £99.95

- **CDX600 Pocket Bug Detector/Locator**
  - LED and piezo bleeper pulse slowly, rate of pulse and pitch of tone increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm, 9V operation.
  - £30.95

- **CDE900 Professional Bug Detector/Locator**
  - Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFIRM mode to distinguish between localised bug transmission and normal legitimate signals such as pages, cellphones, fridge etc. Size 70mm x 160mm, 9V operation.
  - £99.95

- **QTX180 Crystal Controlled Room Transmitter**
  - Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRTX180 kit (see catalogue). Size 20mm x 67mm, 9V operation, 1000m range.
  - £40.95

- **QLX180 Crystal Controlled Telephone Transmitter**
  - As per QTX180 but connects to telephone line to monitor both sides of conversation. Size 20mm x 67mm, 9V operation. 1000m range.
  - £90.95

- **QSD180 Line Powered Crystal Controlled Phone Transmitter**
  - As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 32mm, Range 500m.
  - £35.95

- **QRX180 Crystal Controlled FM Receiver**
  - For monitoring any of the Q range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Output to headphones. 60mm x 75mm, 9V operation.
  - £90.95

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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 1507 on the card).

Although the ISO 7816 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'...
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 Smartcard manipulations to be performed which 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 104115 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
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

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’.

<table>
<thead>
<tr>
<th>COMPONENTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors:</td>
</tr>
<tr>
<td>R1 = 27kΩ</td>
</tr>
<tr>
<td>R2,R8 = 150kΩ</td>
</tr>
<tr>
<td>R3 = 1kΩ</td>
</tr>
<tr>
<td>R4,R10 = 33kΩ</td>
</tr>
<tr>
<td>R5 = 6kΩ</td>
</tr>
<tr>
<td>R6,R9 = 120Ω</td>
</tr>
<tr>
<td>R7 = 15kΩ</td>
</tr>
<tr>
<td>Capacitors:</td>
</tr>
<tr>
<td>C1-C4 = 1μF 25V radial</td>
</tr>
<tr>
<td>C5 = 10μF 63V radial</td>
</tr>
<tr>
<td>C6,C7,C11,C12 = 10μF</td>
</tr>
<tr>
<td>C8,C9 = 22μF</td>
</tr>
<tr>
<td>C10 = 47μF 25V radial</td>
</tr>
<tr>
<td>C13 = 10μF 25V radial</td>
</tr>
<tr>
<td>Semiconductors:</td>
</tr>
<tr>
<td>D1,D2 = zener diode 6V2 400mW</td>
</tr>
<tr>
<td>D3 = green LED</td>
</tr>
<tr>
<td>D6 = red LED</td>
</tr>
<tr>
<td>D4,D5 = 1N4148</td>
</tr>
<tr>
<td>D7 = 1N4001</td>
</tr>
<tr>
<td>T1,T3 = BC5500</td>
</tr>
<tr>
<td>T2 = BC547</td>
</tr>
<tr>
<td>IC1 = PIC16C84 (order code 976512-1)</td>
</tr>
<tr>
<td>IC2 = MAX232 (Maxim)</td>
</tr>
<tr>
<td>IC3 = 74HC00</td>
</tr>
<tr>
<td>IC4 = 7805</td>
</tr>
<tr>
<td>Miscellaneous:</td>
</tr>
<tr>
<td>K1 = Smartcard connector, ISO7816 layout, with card detection switch. ITT Cannon code 180-5230, or RS Components code 453-791.</td>
</tr>
<tr>
<td>X1 = 3.579545MHz quartz crystal</td>
</tr>
<tr>
<td>K2 = 9-way sub-D socket, PCB mouni, angled pins.</td>
</tr>
<tr>
<td>K3,K4 = 2-way PCB terminal block, pitch 5mm</td>
</tr>
<tr>
<td>K5,K6 = 10-way boxheadcf, straight</td>
</tr>
<tr>
<td>Length of 10-way flatcable with 10-way IDC socket at either end. JP1,JP2 = 3-way pinheader with jumper.</td>
</tr>
<tr>
<td>PCB, disk and programmed PIC: order code 970066-C. Disk only: order code 976014-1.</td>
</tr>
</tbody>
</table>
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.

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 con-
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**E200**
Elektor Electronics 12/97
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 ISO/IEC 7816 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 0 are encoded as 'low' levels (0 volts).

One should use the symbol 'Z' to indicate the high-impedance state, and 'N' 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:

- **Z** for cards of the 'inverted-ISO' type, or
- **A** for cards of the 'straight-ISO' type.

After conversion to hexadecimal, and observing the relevant standard, these characters read 3F₁₄ and 3B₁₄ 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 installment 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 976104-1.

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 at 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 bankcard 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 9B 11 00 29 CD 01 08 00 1E 55 80 00 98 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 TBI 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 halfduplex 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 T41 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 brings us to the end of the first installment of this article. In the second installment, 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.'

---

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automobile navigation systems
based on the Global Positioning System (GPS)

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 option 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 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 piezoelectric 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) display.
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 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).

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.

* Telematics is the integration of computer-processing applications with telecommunications capabilities.
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 through 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 grandchildren, 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 of 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 a 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 at 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 induction 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 appetite. 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.
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 cool before attempting to use them.

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.
2 Premium 33
A top-class Danish loudspeaker

6 Tolomeo
An elegant three-way loudspeaker system

9 New books & useful addresses

10 Fontana
An all-rounder from Visaton

14 Voigt tapered pipe
A special low-frequency loudspeaker
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

<table>
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<tr>
<th>Brief specification</th>
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<tbody>
<tr>
<td>Name</td>
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<tr>
<td>Design</td>
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<td>Enclosure</td>
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<td>Net volume</td>
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<td>Dimensions</td>
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<td>Drive units</td>
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<td>Nominal impedance</td>
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<tr>
<td>Power handling capacity</td>
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<td>Sound pressure level* (SPL)</td>
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* 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 PL18W0-09/08PL 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-
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.

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...
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 constructor's personal preference. The prototype box is spray-painted black, followed by another layer of black paint and finally sprayed with a neutral lacquer.

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 L1, the lower woofer, LS1, reproduces frequencies up to about 200 Hz. Inductor L1 is a top-quality component to ensure that the distortion remains low even at high output powers.

The upper woofer, LS2, reproduces frequencies up to about 2 kHz. After that, its response rolls off at 12 dB/octave owing to circuit L2-C1. Frequencies above 2 kHz are reproduced by the tweeter, LS3. The relevant 12 dB/octave high-pass filter is formed by C2-C4-L3. Capacitors C2 and C3 are special thin-film components that give marginally better performance than polypropylene (MKP) types. Resistors R1-R3 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 R2 and R3 may be changed marginally by trial and error.

The optional impedance matching circuit consists of three branches. Inductor L4 and capacitor C4 attenuate the 60 Hz resonance peak of the enclosure and woofers. Inductor L5 and capacitor C5 attenuate the impedance peak near the cut-off point. Capacitor C6 counters the increase in impedance at high frequencies. Resistors R4-R7 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 impedance magnitude.

![Figure 3: Circuit diagram of the crossover network and the (optional) impedance correcting circuit.](image)

![Figure 4: Frequency response characteristic and impedance curve (measured with and without the correcting circuit) of the Premium 33.](image)
Figure 5. The terminals for connecting the external loudspeaker cable(s) are heavy duty types, which also make bi-wiring possible.

anance 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.

Part list (one loudspeaker)

Drive units:
- LS1, LS2 = PL18W0-09/08PL (Vita)
- LS3 = D2905/9500 (Scan-Speak)

Crossover network:
- R1 = 1.5 Ω, 4 W
- R2 = 2.2 Ω, 4 W
- R3 = 47 Ω
- C1 = 10 µF, polypropylene (MKP)
- C2 = 2.2 µF tin-film (KPSn)
- C3 = 4.7 µF tin-film (KPSn)
- L1 = 8.2 mH, 0.3 Ω, HO core
- L2 = 2.2 mH, air-cored, 1.4 mm dia. enamelled copper wire
- L3 = 0.22 mH, air-cored, 0.71 mm dia.

Impedance matching circuit (optional):
- R5 = 10 Ω, 20 W
- C4 = 330 pF, 35 V, bipolar electrolytic
- C6 = 82 µF, 35 V, bipolar electrolytic
- C7 = 3.3 µF, metallized polyester
- L4 = 22 mH, 4.3 Ω, Corobor core
- L5 = 0.22 mH, air-cored, 0.71 mm dia.

Enclosure:
- Medium-density fibreboard (MDF) or high-density chipboard
- 2 of 1050 x 240 mm (41.34" x 9.45"), 25 mm (1") thick (side panels)
- 1 of 1050 x 210 mm (41.34" x 8.27"), 32 mm (1.26") thick (front panel)
- 2 of 240 x 160 mm (9.45" x 6.30"), 25 mm (1") thick (top panel and partition)

Base:
- 1 of 240 x 160 mm (9.45" x 6.30"), 25 mm (1") thick
- 2 of 160 x 75 mm (6.30" x 3"), 25 mm (1") thick
- 2 of 190 x 110 mm (7.48" x 4.33"), 32 mm (1.26") thick (rear panel)

Miscellaneous:
- 1 off heavy-duty terminal box (if required, suitable for bi-wiring)
- 1 bass reflex port, 70 mm (2.76") inner dia., 140 mm (5.51") long
- 2 off flow resistance (Scan-Speak)
- Lead-impregnated bituminous material (supplied in sheet form)
- About 1 m² of 42 mm (1.65") thick latex foam sheet
- About 0.5 m² (5 sq. ft.) acoustic wadding
- Sand as required for filling the base.

LOUDSPEAKERS & PARTS

Vita PL18W0-09/08 £ 52,-
Scan-Speak D2905/9500 £ 62,-
Eton 8/472/39 "hex £ 116,-
Peerless CSC-1456 £ 24,-
Seas K2110 (H589) £ 17,-
Scan-Speak flow resistance £ 27,-
Premium-PCB without parts £ 5,-

Audio Components BV
Ussenstraat 2a, PO-box 554
5340 AN OSS, Netherlands
Tel.: +31-172.682217
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LOUDSPEAKERS & PARTS

HIFI LOUDSPEAKERS
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

<table>
<thead>
<tr>
<th>Name</th>
<th>Tolomeo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>InterTechnik (IT)</td>
</tr>
<tr>
<td>Enclosure</td>
<td>vented</td>
</tr>
<tr>
<td>Net volume</td>
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</tr>
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<td>Drive units</td>
<td>20 cm (8&quot;) woofer</td>
</tr>
<tr>
<td></td>
<td>14 cm (5.50&quot;) midranger</td>
</tr>
<tr>
<td></td>
<td>19 mm (0.75&quot;) dome tweeter</td>
</tr>
<tr>
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<td>100 W (150 W music)</td>
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<td>Nominal impedance</td>
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</tr>
<tr>
<td>Sound pressure level* (SPL)</td>
<td>87 dB (1 W m⁻¹)</td>
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</tbody>
</table>

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 tweeter 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 type 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

The 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 $R_1C_1$ 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 $L_2C_3$. If the best performance of this driver is desired, impedance-correcting network $R_2L_4C_5C_6$ may be added.

The tweeter should, of course, reproduce only the high frequencies, and this is ensured by high-pass section $L_3C_4$.

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.
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 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 midrange.

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 (S63)
- $R_1 = 8.2$, $20$ W
- $R_2 = 8.2$, $20$ W (optional - see text)
- $C_1 = 33\mu F$, $80$ V, bipolar electrolytic
- $C_2 = 68\mu F$, $35$ V, bipolar electrolytic
- $C_3 = 3.9\mu F$, metallized polyester (MKT)
- $C_4 = 3.3\mu F$, metallized polypropylene (MKP)
- $C_5 = 68\mu F$, $35$ V, bipolar electrolytic
- $C_6 = 100\mu F$, $35$ V, bipolar electrolytic
- $L_1 = 8.2$ mH (with HO core)
- $L_2 = 1.8$ mH, all-cored, $1$ mm dia., enamelled copper wire
- $L_3 = 0.39$ mH, air-cored, $0.71$ mm dia.
- $L_4 = 10$ mH (with HO core)
- $L_5 = 100$ mH, all-cored, $0.63$ mm dia., enamelled copper wire
- $L_6 = 0.39$ mH, all-cored, $0.71$ mm dia., enamelled copper wire

**Crossover network:**

1. Off terminal box
2. Off bass reflex port, inner dia. $70$ mm, length $250$ mm
3. Polyester wadding, about $1$ m$^2$

**Medium-density fibreboard (MDF) or high density chipboard, $19$ mm thick:**
- 2 off $1000 \times 315$ mm ($39.37'' \times 12.40''$) (side panels)
- 2 off $962 \times 142$ mm ($37.48'' \times 5.59''$) (front & rear panels)
- 2 off $315 \times 142$ mm ($12.40'' \times 5.59''$) (top & bottom panels)
- 2 off $288 \times 142$ mm ($11.34'' \times 5.59''$) (partition)
- 1 off $142 \times 50$ mm ($5.59'' \times 2''$) (brace)
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.

The Wall Box
November 1997 - 970091
The outside diameter of the PVC tube for the bass reflex port should be 40mm, not 44mm.

Frequency Meter and Event Counter Module
October 1997 - 970077
The drawings in the inset 'Principle of measurement' were mangled by our phototypesetting machine. The correct drawings are reproduced here.

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WANTED Operation manuals for Tascam244 Portastudio recorder and Aki: 1721L, reel tape recorder. Photocopy will do. Phone J.S. Mundell on (0181) 2418188.

FOR SALE Tektronix 7904 oscilloscope, 2x dual trace amps, delaying timebase & logic analyzer with manuals. £250. Tel. 01844 338359. Mr G. Morgan.

FOR SALE Barco large-screen video projector, believed to be complete but untested and likely to need attention.

FOR SALE Circuit diagram or service manual details. Phone Angus MacKenzie on (01590) 8495124.

FOR SALE Tektronix 7904 oscilloscope model VP-513A manuals or diagram. Wishing to buy John S. Syros, 26 Kyprou Str., Athens 141-22, Greece.

WANTED National cathode-ray oscilloscope model VP-513A manuals or diagram. Wishing to buy. Send to LH. Ashim, 591 141-22, Greece.

FOR SALE EPROM programmer, built (no case). £ software. Elektor Switchboard Kit 6616 (Dec 1992). Unmatched project. Kit includes EPROM, pick, LCD, front panel, drilled case, all parts and description. Few available, ultra-low price C£5 each. Anda, Stebekestraat 100, NL-5301-AW Valkenswaard, Netherlands. Email techtext@worldonline.nl.
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.

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/audio/diy/
Wayne's Speaker Building Page http://www.netheaven.com/~wlarmon/speak/speak.htm
Electrostat fans should not miss How to Make Electrostatic Loudspeakers http://www.wark.ac.uk/~miiae100/est/est.htm

Home construction 'clubs' are also active on the Internet. A nice example is the Lowther Club Holland http://home.pi.net/~dappennh
An extensive site covering loudspeaker construction is Obsession Audio http://www.members.aol.com/Nisse93/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.fic/~pietrika/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.
We should be grateful if you could spend ten minutes in answering the following questions (or ticking the relevant box), which are intended to help us to help you in getting a publication that is geared to readers' wishes. Send the completed enquiry form (or photocopy of it) before 1 January 1998 to:

Elektor Electronics (Publishing)
P O Box 1414
Dorchester
England DT2 8YH

As a token of our appreciation for this help, the senders of the first 10 completed enquiry forms taken from the postbag will be sent an Elektor Electronics wristwatch and the next 25 a solder-tin suction cleaner. The lucky ones will be advised of their good fortune. So, make sure that you don't miss a prize by giving your name and full address below, although completed forms without that information are also welcome.

Name
Address
Post code

1. How did you get to know about Elektor Electronics?
   - through school/college/training
   - through an electronics/computer retailer
   - through paper/book shop
   - through another reader (or friend/family) of Elektor Electronics
   - otherwise (specify)

2. What, in your opinion, is the strongest point of Elektor Electronics? (One only!)...

3. What, in your opinion, is the weakest point of Elektor Electronics? (One only!)...

4. Do you subscribe to Elektor Electronics?
   - Yes, since 19...
   - No

5. What is your age group?
   - <16
   - 16-20
   - 21-30
   - 31-40
   - 41-50
   - 51-60
   - >60

6. For which of the following is Elektor Electronics of importance? (Several answers possible)
   - Studies/training
   - Job
   - Hobby/interest

7. Why do you read Elektor Electronics? Please answer in order of importance
   (1 = most important, 2 = less important, and so on).
   ... To engage in electronics/computer technology in a practical way (building projects or part(s) thereof)
   ... To remain informed of electronics/computer technology through practical advice contained in the construction projects.
   ... To remain informed about new products and electronics/computer technologies.
   ... Other reason (please specify)...

8. The subject matter in Elektor Electronics may be broadly divided into three categories:
   construction projects, informative/educative articles, and news about the world of electronics and computers and electronic/computer products. If you could change the make-up of the magazine, which of these three would you like to see given more space? (Several answers possible)
   - I like the make-up as it is (go to question 10)
   - I would like more construction projects.
   - I would like more informative/educative articles.
9. If you would like to see an extension in one or more of the categories in question 8, which would you like to see reduced? (Several answers possible).
   - I would like fewer construction projects.
   - I would like fewer informative/educative articles.
   - I would like fewer news items.
   - Other (please specify).

10. Each of the three categories in 8. deals with a variety of subjects. Which of the following is important to you? Indicate the order of importance (1 = most important; 2 = less important, and so on).
   - Audio & hi-fi, Television & video, RF technology
   - Loudspeakers, Model building, Test & measurement
   - Extensions/applications for the PC, Microprocessor systems

11. What is your opinion about the free supplement added to the magazine since the June 1997 issue?
   - It makes the magazine more interesting.
   - It makes the magazine slightly more interesting.
   - It does not make the magazine more interesting (go to question 13).

12. What is your opinion about the subjects covered in the supplement? Indicate the order of importance (1 = most important; 2 = less important, and so on).
   - Microprocessors (June 1997 issue), Audio (September 1997)
   - PC upgrading (October 1997), Test & measurement (November 1997)
   - Loudspeakers (December 1997)

13. Do you own a personal computer?
   - No
   - Yes (IBM/compatible, Macintosh, Other (specify)).
   - CD-ROM drive?
   - Internet connection?

14. Would you like Elektor Electronics to pay more attention to personal computers (all types)?
   - Yes (go to question 15).
   - No, there is already enough (go to question 16).
   - No, there is too much already (go to question 18).

15. If you answered ‘yes’ to question 14, what further attention would you like?

16. What subjects do you miss in Elektor Electronics?

17. Any other comments?
<table>
<thead>
<tr>
<th>Electronic Component or System</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto on/off switch for power supplies</td>
<td>4</td>
</tr>
<tr>
<td>AC-DC converter</td>
<td>4</td>
</tr>
<tr>
<td>Voltage inverter/doubler</td>
<td>4</td>
</tr>
<tr>
<td>The small workshop (1)</td>
<td>4</td>
</tr>
<tr>
<td>Simple crystal oscillator</td>
<td>4</td>
</tr>
<tr>
<td>Pinpointer</td>
<td>4</td>
</tr>
<tr>
<td>PIR controlled shopbell</td>
<td>4</td>
</tr>
<tr>
<td>Programmable logic VHDL and other new ways</td>
<td>4</td>
</tr>
<tr>
<td>Quasi-digital bandpass filter</td>
<td>4</td>
</tr>
<tr>
<td>Radio-controlled door opener</td>
<td>4</td>
</tr>
<tr>
<td>RC biaswitch</td>
<td>4</td>
</tr>
<tr>
<td>Revolution (counter)</td>
<td>4</td>
</tr>
<tr>
<td>Running lights for Christmas</td>
<td>4</td>
</tr>
<tr>
<td>Selective door chime</td>
<td>4</td>
</tr>
<tr>
<td>Scarecrow</td>
<td>4</td>
</tr>
<tr>
<td>Simple inductance meter</td>
<td>4</td>
</tr>
<tr>
<td>The small workshop (2)</td>
<td>4</td>
</tr>
<tr>
<td>SMD adapter</td>
<td>4</td>
</tr>
<tr>
<td>Speed regulator for model trains</td>
<td>4</td>
</tr>
<tr>
<td>Swimp security system</td>
<td>4</td>
</tr>
<tr>
<td>Talking doorbell</td>
<td>4</td>
</tr>
<tr>
<td>Thermocouple: a brief introduction</td>
<td>4</td>
</tr>
<tr>
<td>Touch-free lights switch</td>
<td>4</td>
</tr>
<tr>
<td>Using the pin diode</td>
<td>4</td>
</tr>
<tr>
<td>Valves on the Internet</td>
<td>4</td>
</tr>
<tr>
<td>Variable-pulse generator</td>
<td>4</td>
</tr>
<tr>
<td>Voltage inverter/doubler</td>
<td>4</td>
</tr>
<tr>
<td>5. Power Supplies &amp; Battery Chargers</td>
<td>7-8</td>
</tr>
<tr>
<td>13.5V power supply for mobile rigs</td>
<td>7-8</td>
</tr>
<tr>
<td>78KX replacement</td>
<td>7-8</td>
</tr>
<tr>
<td>78KX replacement</td>
<td>7-8</td>
</tr>
<tr>
<td>AC-DC converter</td>
<td>7-8</td>
</tr>
<tr>
<td>Auto on/off switch for power supplies</td>
<td>7-8</td>
</tr>
<tr>
<td>Charging booster</td>
<td>7-8</td>
</tr>
<tr>
<td>General-purpose electronic fuse</td>
<td>7-8</td>
</tr>
<tr>
<td>General-purpose power supply</td>
<td>7-8</td>
</tr>
<tr>
<td>LM2576 switch-mode power supply</td>
<td>7-8</td>
</tr>
<tr>
<td>PLLs on delay circuits</td>
<td>7-8</td>
</tr>
<tr>
<td>Single-chip ac/dc inverter</td>
<td>7-8</td>
</tr>
<tr>
<td>Supply board for output amplifiers</td>
<td>7-8</td>
</tr>
<tr>
<td>Voltage-independent 2A battery charger</td>
<td>7-8</td>
</tr>
<tr>
<td>6. Radio, TV and Communications</td>
<td>7-8</td>
</tr>
<tr>
<td>80-metre receiver</td>
<td>7-8</td>
</tr>
<tr>
<td>AF spectrum analyzer</td>
<td>7-8</td>
</tr>
<tr>
<td>Blanketing level clamp</td>
<td>7-8</td>
</tr>
<tr>
<td>Microwave tools</td>
<td>7-8</td>
</tr>
<tr>
<td>RGB video amplifier</td>
<td>7-8</td>
</tr>
<tr>
<td>Saldabase tool</td>
<td>7-8</td>
</tr>
<tr>
<td>Transistor decoder for PCs</td>
<td>7-8</td>
</tr>
<tr>
<td>Video contrast expander</td>
<td>7-8</td>
</tr>
<tr>
<td>Video copy processor</td>
<td>7-8</td>
</tr>
<tr>
<td>Widespread YHF preamplifier</td>
<td>7-8</td>
</tr>
<tr>
<td>7. Test &amp; Measurement</td>
<td>7-8</td>
</tr>
<tr>
<td>8-channel memory oscilloscope</td>
<td>7-8</td>
</tr>
<tr>
<td>Advanced LCR meter</td>
<td>7-8</td>
</tr>
<tr>
<td>Advanced LCR meter (2)</td>
<td>7-8</td>
</tr>
<tr>
<td>Advanced LCR meter (3)</td>
<td>7-8</td>
</tr>
<tr>
<td>AF spectrum analyzer</td>
<td>7-8</td>
</tr>
<tr>
<td>Audio spectrum analyzer</td>
<td>7-8</td>
</tr>
<tr>
<td>Battery-operated AF signal generator</td>
<td>7-8</td>
</tr>
<tr>
<td>Battery simulator</td>
<td>7-8</td>
</tr>
<tr>
<td>Cool Edit</td>
<td>7-8</td>
</tr>
<tr>
<td>Data acquisition system</td>
<td>7-8</td>
</tr>
<tr>
<td>DC nullifier for oscilloscope input</td>
<td>7-8</td>
</tr>
<tr>
<td>Digital tester</td>
<td>7-8</td>
</tr>
<tr>
<td>Dual continuity tester</td>
<td>7-8</td>
</tr>
</tbody>
</table>

**Datasheets**

<table>
<thead>
<tr>
<th>Device</th>
<th>Company</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>7W15 / 10.1 (Nesiod)</td>
<td></td>
<td>12-93</td>
</tr>
<tr>
<td>8243 (Intersil)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>AD 333 (Analog Devices)</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Advanced LCR meter (1)</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>AT 89C2051 (Atmel)</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>CNY 65 (Tesco/Telicolor)</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>DS 1610 (Dallas Semiconductor)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>KTI65 (EL 34)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>LT 1353 (Linear Technology)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MAX 815 (Maxim)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MC 68HC11A1/E (Motorola)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>NH 3 (Ferrol)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>PZ 5002 (Philips)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>SSI 1200 (Analog Devices)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Valves, miscellaneous</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

**Correction, Updates, Letters**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>7-8</td>
</tr>
</tbody>
</table>
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 when this operates in the slave mode. 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.

The relationship between the sampling frequency, \( f_s \), the crystal frequency, \( f_c \), and the value of \( C_2 \) in pF is

\[
\frac{f_s}{f_c} = \frac{1}{C_2 \cdot R_2}\]

If the oscillator does not work owing to too high a tolerance of \( C_2 \) or the parallel capacitance may be altered by the value of \( C_2 \). It may also be necessary to alter the value of \( R_2 \). To determine \( R_2 \) to give a voltage of \( V_{in} \) in PLL operation.

Capacitor \( C_6 \) 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.

---

**Diagram Description:**

The oscillator circuit diagram shows the components and connections. Key components include ICs, transistors (BF494, BF840), diodes (D1, D2), capacitors (C1, C2), and resistors (R1, R2). The oscillator is configured in a PLL (Phase-Locked Loop) design with a crystal oscillator and a high-end oscillator. The circuit includes a buffer stage and a clock line via an AND or NAND gate. The completed oscillator includes a buffer, a clock line, and the necessary connections for interference-free operation.

---

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**PROFESSIONAL HOBBYISTS:**

The Studio Lite consists of ULTicop schematic capture, ULTiboard PCB design and ULTiboard SDR automation, both Windows 95 and DOS versions are included with the CD-ROM. Actually you only pay for the 5 manuals (in which, besides tutorials and manuals, even shapes are described) ideal for hobby and study and with sufficient capacity (600 pgs). If higher capacity is desired, you can opt (now or later) for an upgrade to the Studio Unlimited, with full capacity limits, for £69 (incl VAT). There are no further options or hidden extras, the ULTiboard Studio program is complete.

Elektor Electronics 12/97
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 were 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
By Martin Colloms
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For anyone working in, or just interested in, audio engineering with special emphasis on loudspeaker design, this book is an absolute must on the bookshelf. There simply cannot be a better work explaining the intricacies, the theory, and the practical aspects of loudspeakers, certainly not at the price.

In this completely revised and updated 5th edition of the widely acclaimed High Performance Loudspeakers (is it really twenty years ago that the 1st edition appeared?) Martin Colloms, the world renowned audio design engineer, outlines and explains the changes in technology that affect loudspeaker design, and reviews the many new applications and materials that are changing the industry.

The book includes an impartial overview of multi-media and Home Theatre, Dolby PROLOGIC™, Dolby AC-3 THX, and multi-channel surround sound.

There is a major section on digital loudspeaker design, optimized digital filters, system requirement, and digital active speakers.

Furthermore, there are profiles on new approaches to short-path, low-order crossover network design, and sections on subjective and objective tests on loudspeakers.

There is a new chapter covering ‘Home Theatre Systems’, taking account of their special acoustic requirements, Dolby PRO-LOGIC, THX, and the more recent AC-3, DTS and MPEG digital, discrete, multi-channel systems.

The review of the computer-aided design has been extended, including the new generation of low-cost audio instrumentation.

The theoretical aspects of the subject are complemented by a new section that gives much practical advice for real-world loudspeaker design.

There are several new topics in the chapter on ‘Systems and Crossovers’: 2½ way design, external crossover, d’Appolito types, distortion analysis of inductors, digital active loudspeakers and low-order system design.

A major expansion in the book is the section on sub-woofers, with particular reference to the Home Theatre where, as the author says: “subs are almost mandatory”.

Martin Colloms is a leading figure in the international high-fidelity audio industry. In 1973 he co-founded Monitor Audio, where he designed and developed a complete range of high-fidelity loudspeaker systems. With the company successfully established, he left to set up an independent consultancy, Colloms Electroacoustics, specializing in audio equipment evaluation and test technology as well as high-fidelity product design.

In addition to writing a number of books, he has written extensively for audio journals and magazines, including Hi Fi for Pleasure, Hi Fi Choice, Hi Fi for Pleasure, Hi Fi News and RR and is a regular contributor to the US journal, Stereophile.

Colloms is a member of the Audio Engineering Society. He also acts as an expert witness in technology and patent law.

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Germany
Telephone +49 2129 5520
Fax +49 2129 55210

Enquiries as to the availability in the UK of various loudspeaker drive units should be made to the following regular advertisers in Elektor Electronics (also see advertisement of Audio Components on page 5 of this supplement):
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**

<table>
<thead>
<tr>
<th><strong>Name</strong></th>
<th>Fontana</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td>Visaton</td>
</tr>
<tr>
<td><strong>Enclosure</strong></td>
<td>omni-directional, vented</td>
</tr>
<tr>
<td><strong>Net volume</strong></td>
<td>23 litres</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>1020x240x240 mm (40.15&quot;x9.45&quot;x9.45&quot;)</td>
</tr>
<tr>
<td><strong>Drive units</strong></td>
<td>17 cm woofer/midranger, 25 mm dome tweeter</td>
</tr>
<tr>
<td><strong>Nominal impedance</strong></td>
<td>8 Ω</td>
</tr>
<tr>
<td><strong>Power handling capacity</strong></td>
<td>70 W (100 W music)</td>
</tr>
<tr>
<td><strong>Sound pressure level (SPL)</strong></td>
<td>80 dB (1 W m⁻¹)</td>
</tr>
</tbody>
</table>

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 driver units of their 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 dri-
ver 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 ALI 70 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 ALI 70 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 unidirectional 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 $L_3-C_3-C_4$...
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 C2 to the low-pass section. Another is the conversion of C4 to an RLC network by the addition of L4 and R2. Finally, resistor R1 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 x 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.

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 x 25 mm (1" x 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.

**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...
down without becoming boomy and
down without becoming boomy and
the high frequencies are bright and
the high frequencies are bright and
sharp, almost gritty. If desired, the grittiness
critical, but it is recommended not to
critical, but it is recommended not to
place them closer than 50 cm to
place them closer than 50 cm to
1 metre to walls and corners.
1 metre to walls and corners.
A final note: although the specified
A final note: although the specified
sound pressure level (SPL) is fairly low,
sound pressure level (SPL) is fairly low,
in practice this is not very noticeable.
in practice this is not very noticeable.

This is because the reflections in a
This is because the reflections in a
normal living room are rather
normal living room are rather
stronger in the case of an omni-
stronger in the case of an omni-
directional radiator than with a con-
directional radiator than with a con-
tentional one.
entional one.

Figure 7. The octagonal box requires great woodworking skills.

Figure 8. The overall frequency response characteristic of the Fontana is reasonably smooth. The impedance does not drop
down below 5 Ω, so that almost any power amplifier may be used.

Parts list (one loudspeaker)

Drive units: AL170 and DT94 (both from Visaton)

R₁ = 5.1 Ω, 9 W
R₂ = 22 Ω, 5 W
C₁ = 10 μF, 35 V, dipolar electrolytic
C₂ = 22 μF, 35 V, bipolar electrolytic
C₃ = 3.3 μF, metallized polyester (MKT)
C₄ = 4.7 μF, metallized polyester (MKT)
L₁ = 2.2 mH, air-core, wire dia. 1 mm
L₂ = 1.0 mH, air-core, wire dia. 1 mm
L₃ = 1.4 mH, air-core, wire dia. 0.6 mm
L₄ = 0.3 mH, air-core, 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 m²

Medium-density fibreboard or high-density chipboard:
8 off 840 x 96 mm (33.07" x 3.74"), 16 mm (0.63") thick
2 off 240 x 240 mm (9.45" x 9.45"), 19 mm (0.75") thick
4 off 25 x 25 mm (1" x 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.

Figure 8. The overall frequency response characteristic of the Fontana is reasonably smooth. The
Figure 8. The overall frequency response characteristic of the Fontana is reasonably smooth. The
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-loading 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-sectional area increases exponentially from throat to mouth. 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, \( f_o \), is calculated from

\[ f_o = \frac{c}{4l} \]

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 \(i\) is the length of the line in metres. So, a line 2 metres long has an \(f_i\) 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 isothermal 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.

### Voigt tapered pipe

The VIP 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 VIP is known under the names 'Monolith' and 'Basset'. A recent commercial version of a folded VIP is the 'Howard Castle'.

The VIP loudspeaker consists of a tapered pipe on to which the woofer is mounted at 1/3 of its length. As in the TL, stuffing the VIP 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 this frequency. 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 VIP

As in the TL, stuffing the VIP 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 VIP 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 driver in a 14-litre closed box, while curve B is that of the same driver fitted into a 180 cm VIP. 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 varioint. Drive units suitable for this design are, among others, the Davis KLV8A, the Focal 8V412, and the Focal 8KS16J.

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 or electrostatic drive unit.

Materials for a 180 cm VTP

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 900x400 mm (35.43"x15.75") (side panels)
1 off 900x2091 mm (35.43"x8.23") (rear panel)
1 off 645x2091 mm (25.39"x8.23") (front panel)
1 off 383 x2091 mm (15.08"x8.23") (bottom panel)
1 off 364x2091 mm 14.33x8.23") (top panel)
1 off 255x245 mm (10"x9.65") (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 237x20 mm (9.33"x0.8") (for fixing damping panel)
2 off 169x20 mm (6.65"x0.8") (for fixing damping panel)

18 mm chipboard for inner panels
1 off 644 x209* mm (25.35"x8.23")
1 off 491x209* mm (19.33"x8.23")
1 off 284x209* mm (11.18"x8.23")
1 off 143 x209* mm (5.63"x8.23")

If a 17 cm (6.70") woofer is used, the

Damping material
600 grammes long-fibre wool (600 grammes if a 17 cm (6.70") woofer is used)
rightness 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.

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-
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56
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 970095-6 (see Readers Services page)

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.
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By Stephen Roberts ISBN 0 7506 427 8
160 pages – Illustrated
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*Newnes*

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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 multiplex-line installations, from planning stage to commissioning.

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**Audio IC Users Handbook**

By R.M. Morston ISBN 0 7506 3006 X
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By A.L. Brown ISBN 0 7506 3235 6
154 pages – Illustrated
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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- and right-hand channels are applied to audio sockets K1 and K2, respectively. They are output via audio sockets K3 and K4 to which the surround-sound decoder is connected. The signals of the two channels are summed in IC1a, which also functions as input amplifier. The amplification, and therefore the sensitivity of the 'subwoofer', can be adjusted with P1.

The output of IC1a 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 P2. 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 K5 and K6.

The power supply for the circuit is simple and consists of a mains transformer, Tr1.

Parts list

Resistors:
- R1, R2 = 47 kΩ
- R3, R4 = 2.2 kΩ
- R5, R6 = 100 kΩ

Capacitors:
- C1 = 22 pF
- C2 = 220 nF
- C3 = 100 µF
- C4-C7 = 100 nF
- C8-C9 = 4.7 pF, 63 V, radial
- C10, C11 = 22 pF, 40 V, radial
- C12-C15 = 47 nF ceramic

Semiconductors:
- D1 = LED, high efficiency

Integrated circuits:
- IC1 = TL072CP
- IC2 = 7815
- IC3 = 7915

Miscellaneous:
- K1-K4, K5-K8 = audio socket for board mounting
- K9 = 2-way terminal block, pitch 7.5 mm
- B1 = B80C1500
- Tr1 = mains transformer, 2 x 15 V secondaries, 1.5 VA
bridge rectifier, B1, antihunt capacitors C12-C15, a number of smoothing and decoupling capacitors, and two integrated voltage regulators, IC2 and IC3.

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, P1 and P2 should preferably be types with a metal enclosure. Hum is prevented by earthing the case and the enclosure.

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.

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 sends 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, IC1. Part of the reference voltage, 2.0 V, is applied to the non-inverting (+ve) input of the op amp via P1. 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' T1-T3, the resistance to be measured, R3, and R3 as a constant-current source. The level of the current is determined by R3. 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 R3 results in a dissipation of 2 W. This means that with a supply voltage of 5 V, the dissipation in T3 is (5-2) x 1 = 3 W. If this is found rather too much, the value of R3 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 mΩ (or 20 mΩ). 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 T3 (heat sink) and make the connections to the resistance on test as short as possible.
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, IC4 and IC6 operate as control amplifiers. The audio signal is input via K1 and K3 and applied to the booster via K2 and K5. The basis level is that registered with the electret microphone MIC1.

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 R1 while its sensitivity is set with P1.

The output of the microphone is applied to fast op amp IC1 via the wiper of P1. The op amp, arranged as a rectifier/amplifier, provides an amplification of X 45. Its output is averaged by R13-C3 and then applied to comparators IC3a-IC3d. These then amplify the signal and averaged signal, \( U_{av} \), with the potentials at the junctions of divider R9-R10. Each of these potentials differs by 5 dB from the preceding or next one as the case may be.

The comparators control electronic switches IC5a-IC5d and IC6a-IC6d, which modify the degree of feedback of IC4 and IC6 on the basis of the control input. For instance, if none of the comparators in IC3 has changed state, IC4 operates as a voltage follower with unity gain. When \( U_{av} \) exceeds the level at junction R9-R10, the gain of IC4 is raised by 5 dB. When with increasing road and engine noise it exceeds the level at junction R9-R10, the switches are all closed so that R13-R16 are in parallel, whereupon the gain of IC4 is raised by 20 dB. The position of the automatic volume control is indicated by light-emitting diodes D4-D7.

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

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Elektor Electronics 12/97
The supply lines for the microphone and the voltage divider are held at 8 V by regulator IC2. That for IC3 is held at 5.6 V by T1-D8, 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.

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 milliamperees 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.

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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 R1 and R2 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 milliamperees from a 5 V supply line.

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HUSH stereo noise reduction system SSM2000

up to 25 dB noise reduction from almost any audio source

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.

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 stereo and televisions, while preserving full signal fidelity and transparency.

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 incorporates an automatic noise threshold detector that senses 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
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 to VCF capacitor matching and layout symmetry reduces control feedthrough to better than 40 dB through the signal path.

**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. Therefor, 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

**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 speci-
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 worst-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.

Figure 4. Typical dual supply application and test circuit.

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 pre-conditioned 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 x (L + R) / 2 averaged input signal processed by a three-pole high-pass filter with a -15 dB point at 10 kHz. The VCF pre-conditioning 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 Q3 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 Q3 is turned off. During this condition, an internal 1.1 μA current source sets the release time by discharging the VCF DET CAP. The release time constant of the VCF detector is about 1/10 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 D1 and transistor Q4 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 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, Q4's emitter-base junction turns on and clamps node B. This is represented by current I2.

However, if node B has not yet risen to the maximum noise threshold level, both Q3 and Q4 are off and the 35 nA current source is charging C1. 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 condition 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 Q3 turns off, causing node B to follow node A. Current I3 illustrates how the discharge current from C1 and the 35 nA current source are directed through Q2. Q2 shuts off the moment that node A rises above node B. This forces the 35 nA current source to begin charging C1 at a constant rate set by the value of C1, at pin 15.

Figure 6c illustrates the condition where the potential at node A is below the minimum noise threshold level settings.

---

*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 K1 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 D5 and D6. This voltage is used to supply IC1.

The TxD signal is also applied to the LED in IC2. Diode D2 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 IC3b and IC3c magnify the digital signal to full TTL level. The send signal of the microcontroller system is applied to optoisolator IC1 via IC3a, 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.

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 D1 and S1. 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 C3 and R5 (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, B1.

Because of its discrete supply, the tester can also be used for tests on active circuits. Zener diodes D2 and D3 prevent damaging voltages from reaching the input of the VCO.

The level of the test current is set with P1, which is useful when the connection to be tested is a high-impedance one.

The tester draws a current of around 3 mA.
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 IC1, an oscillator/binary counter. The frequency of the oscillator is determined by \( R_2 \cdot R_10 \cdot \frac{1}{C_9} \). 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 \( 12 + 4 \times 0.7 - 0.7 = 14.1 \) V.

The zener voltage is discretionary, but depends on the minimum output voltage plus \( U_{BE} \) of \( T_1 \). When \( T_3 \) 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, IC3. 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 \( R_1 \) 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.

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 valued and army surplus types). The frequency range of the preamplifier is roughly from 25 MHz to 150 MHz.

The two inductors in the circuit are homemade. \( L_1 \) 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 3-volt supply.

Elektor Electronics 12/97

73
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 IC3a and IC3b. It is set by operating switch S1 at the Set input (pin 6). The output of the bistable (pin 3) trips the output relay via T1. Freewheeling diode D1 protects the circuit against inductively induced surges. The status of the circuit is indicated by D3. The bistable is returned to its output state via the Reset input (pin 1). A reset also occurs on switch-on via R1-C2. The Reset input is driven by the output of of a counter/oscillator. The quiescent state.

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 (analogous) 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, L1 through 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 a 4-bit binary code at the outputs of the encoder. The ten encoder inputs allow the codes 0000 through 1001 to be produced also. Their function is as follows: if the ‘147 encoder is at the value 1001 (9), and L10 of the LM3914 goes low (active), then the NOR gates will invert the two least significant bits, creating the binary word 1010. However, that only works if L9 remains active when L10 is actuated, hence the use of the ‘bar’ mode rather than the ‘dot’ mode on the LM3914.

In summary:

- The LM3914 output is decoded to a 4-bit code (L1-L4).
- The 74147 encoder detects the highest bit.
- The 74HC147 creates the binary word 1010.
- The LED is lighted when the circuit is in its quiescent state.
**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, which is eight ones and a logic low is sent as 00, 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 IC1, in conjunction with R1, limit the input voltage to about 600 mV.

The DATA line (pin 2 of IC3) 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 IC1b which then enables the Schmitt trigger.

Capacitor C3 is then discharged via D1. During the discharge time, the output of IC3 rises high. As soon as C3 is discharged, the output of IC1b goes high, whereupon C3 is charged again via R3. After about 530 μs, the potential across C3 is high enough to trigger IC1b, whereupon the output changes from 1 to 0. The consequent trailing edge causes the input of IC1b to become high by R4, to become low. This in turn results in a leading edge at the CLK input of IC1e enabling the information on the DATA line to be written.

As shown in the diagram, the circuit may be expanded by linking the carry out of IC1 to a second (and subsequent) register (IC3, IC4, ...).
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 green. For four-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) at the reset pin, 15, is connected to pin 9 via 511. The resulting high output on pin 9 provides a reset pulse after the eighth output. The positive output pulses energize LEDs...
DI 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 Osi0, AOsil0, OC. This in turn switches on red LED D9 and brings on solid-state buzzer Bzl. 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.

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 SVGA 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.

Components List

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

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

Semiconductors:
- D1-D4, D9 = green LED
- D5-D8, D10 = red LED

Miscellaneous:
- S1 = push-button, 1 make contact
- S2-S5 = red push-button, 1 make contact
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The microcontroller-driven light barrier operates with two infrared senders which, if set up correctly, provide a measure of directivity.

The senders, D5 and D6, may be standard infrared models whose beam is directed onto an infrared receiver IC3. 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 D7–D11 function as status, operation and position indicator.

The light barrier is controlled by a Type 16C54 microcontroller, IC1, which is clocked by a 1 MHz crystal. The outputs of IC1 are buffered by an integrated octal power driver, IC2.

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 opening program starts with a routine which initializes the port lines and the various registers. Thereupon, ports PB0 and PB1, 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 JP1 or JP2, which disables the control process. The PIC then reacts to the second (JP2) or first (JP1) spurious pulse. This action is, however, useful only if the IR beam is set up acu-

---

**Parts list:**

**Resistors:**
- R1 = 47 kΩ
- R2 = 12 kΩ
- R3 = 4 x 10 kΩ array
- R4, R5 = 100 n
- R6–R10 = 2.7 kΩ

**Capacitors:**
- C1, C2 = 33 pF
- C3, C4, C5, C6 = 0.1 μF
- C7 = 47 μF, 25 V, radial
- C8 = 470 μF, 25 V, radial

**Semiconductors:**
- D1–D4 = 1N4001
- D5, D6 = infra-red LED, e.g. LD271
- D7–D11 = LED

**Integrated circuits:**
- IC1 = PIC16C54 (programmed with EPS 976503-1)
- IC2 = ULN2003 (Sprague)
- IC3 = SFH505 or SFH508-36 or ISU60 (36 kHz)
- IC4 = 7805

**Miscellaneous:**
- JP1, JP2 = jumper for board mounting
- K1 = soldering pin
- K2 = 8-pole PCB mounting block
- S1–S3 = single-pole switch with on contact
- X1 = crystal, 1 MHz
rately and screened cable is used. When the light beam from D6 is interrupted, D7 and D11 light for 2 seconds, D8 for about 8 s, and D9 for around 20 s. In case of D6, D10 lights for about 2 s and D9 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 S5 (for D5) or S3 (for D6) is held down at the same time as S1 is pressed for a reset. As long as there is no IR link established, D11 flashes (for D5) or D10 (for D5). 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 IC2. 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.

---

**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 IC1a is arranged as an oscillator operating with components as specified, at a frequency of about 160 kHz.

Inverters IC1b-IC1f are in parallel to ensure sufficient output current.

The signal is also applied to a second group of inverters in parallel, IC2b-IC2f via C5. 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 IC23. Resistor R3 ensures that the feedback circuit is triggered via C2.

Capacitor C3 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 inverter or a voltage doubler. Note that the inverter or doublings voltage is taken from the +ve supply pin of IC2 and the -ve supply pin of IC1.

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 C3 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 C5, 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 C3 is superimposed on the output of IC1.

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.
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 flat cable and an 18-pin DIL plug which is inserted in the socket normally occupied by a PIC16C71. Although the present}

### COMPONENTS LIST

**Resistor:**
- R1 = 3kΩ - 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 pinheader
- K2 = see text
- X1 = quartz crystal, 32kHz - 20MHz
- 18-pin DIL plug, IDC style (Eurodis 358330101T)

*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.

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 which is physically designed to accept an 80C51. 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 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.
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 \( R_1/R_2 \). The divider provides a signal at a level of \( 1/3U \) in the pass band. The output voltage at the resonance frequency.

### Parts list

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors:</td>
<td></td>
</tr>
<tr>
<td>( R_1, R_2, R_4 )</td>
<td>1 kΩ</td>
</tr>
<tr>
<td>( R_3 )</td>
<td>3.3 kΩ</td>
</tr>
<tr>
<td>( R_5 )</td>
<td>150 kΩ</td>
</tr>
<tr>
<td>( R_6 )</td>
<td>1.5 MΩ</td>
</tr>
<tr>
<td>( R_7, R_8 )</td>
<td>100 kΩ</td>
</tr>
<tr>
<td>( R_s )</td>
<td>8.2 kΩ</td>
</tr>
<tr>
<td>( P_1 )</td>
<td>multturn preset, 200 kΩ, non-potential</td>
</tr>
<tr>
<td>Capacitors:</td>
<td></td>
</tr>
<tr>
<td>( C_1, C_2, C_5, C_6 )</td>
<td>0.01 μF</td>
</tr>
<tr>
<td>( C_3, C_4 )</td>
<td>0.1 μF</td>
</tr>
<tr>
<td>Semiconductors:</td>
<td></td>
</tr>
<tr>
<td>( D_1, D_2 )</td>
<td>1N4148</td>
</tr>
<tr>
<td>( D_3 )</td>
<td>LED, high efficiency</td>
</tr>
<tr>
<td>Integrated circuits:</td>
<td></td>
</tr>
<tr>
<td>( IC_1 )</td>
<td>TL074CN</td>
</tr>
<tr>
<td>( IC_2 )</td>
<td>TL081CP</td>
</tr>
<tr>
<td>Miscellaneous:</td>
<td></td>
</tr>
<tr>
<td>( B_{10} ), ( B_{12} )</td>
<td>9 V dry battery</td>
</tr>
<tr>
<td>( S_1 )</td>
<td>double-pole on/off switch</td>
</tr>
<tr>
<td>( B_{21} )</td>
<td>piezobuzzer</td>
</tr>
</tbody>
</table>
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 usually broadcast at.

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, except the sensor, is best built on the printed-circuit board in Figure 3, which is, however, not available ready made.
The α1108APA 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 α1108APA 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 SCRs 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 short 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 α1108APA is suitable for use with a.c. voltages between 80 V_{min} and 276 V_{max}. The device is available through Unimonic GmbH, PO. Box 350252, D-40444 Dusseldorf, Germany. Tel. (+49) 211 951140, fax (+49) 211 95111-111.

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

**COMPONENTS LIST**

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

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

**Semiconductors:**
- IC1 = α1108APA (Alpha Electronics)

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

Elektor Electronics 12/97
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 R10. Its level is limited by diodes D6-D10. The trip levels of comparators IC2a-IC2b are set to +600 mV and -600 mV by R2-R7 and R3-R8 respectively. This means that the output of IC2a goes high when the input voltage is higher than +600 mV and that of IC2b 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 C3 and C4 alternately to a potential that does not exceed the trip levels of the comparators. This means that the trip level of IC3 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 IC2b remains high longer than usual. It is then C4 that is charged, while IC2a functions as the trigger. Diodes D7 and D10 protect T1 and T2 by preventing their base voltage dropping below ~700 mV.

Clearly, the response time of the sensor depends not only on the trigger level of IC2a and IC2b, but also on the time constants R4-C4 and R7-C3. The HEF4093 used in the prototype triggered at 7.5 V (Vth = 13 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 R4 and R7.

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.
RF coil assemblies 10.1

Inductive Assemblies Passive Components, Inductors

![ELEKTOR ELECTRONICS DATASHEET 12/97](image)

**Design and data**

Assemblies type 10.1 consist of a copper screening can, which may be supplied with special plating finishes. The base is made of glass fibre reinforced hard plastics and can withstand high temperatures. The package can be adapted to 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.

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.

**Applications**

When double-sided printed circuit boards are used, it is advisable to include the insulation yoke type 100, placed under the can rim. The values shown in the table are for guidance only, and for a preliminary calculation of the number of turns.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Type</th>
<th>Material</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Screening can</td>
<td>B10</td>
<td>Cu</td>
<td>94453800</td>
</tr>
<tr>
<td>2</td>
<td>Ferrite</td>
<td>FK5</td>
<td>94453812</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Ferrite</td>
<td>94453813</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Ferrite</td>
<td>PBTP1</td>
<td>94453814</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Polyethylene-terephthalate (Crown 5000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Polyphenylene oxide (or similar)</td>
<td>(Box 4 731)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes for connecting pins:**

- Use screw type M3 for connections.
- Use A4 or B7 screw for mounting.
- Use ferrite for enhancing the performance.

**Manufacturer**

NEOSID

Neosid Pem衷心 ed GmbH & Co KG, PO Box 1534, D-58543 Halver, Germany.

Tel. (+49) 2353 71-0, Fax (+49) 2353 7154.

**Applications**

RF coil assemblies 10.1 consist of a copper screening can, which may be supplied with special plating finishes. 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 allows the wires 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 100, placed under the can rim. The values shown in the table are for guidance only, and for a preliminary calculation of the number of turns.

**Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio Signal Path</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Signal to Noise Ratio</td>
<td>SHR</td>
<td>Vs = 0 V, 10 kHz to 20 MHz (flat)</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>dB</td>
</tr>
<tr>
<td>Harmonic Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Dynamic Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dB</td>
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<tr>
<td>Channel Separation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Impedance</td>
<td>Zin</td>
<td>Pins 1 and 2</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>Ω</td>
</tr>
<tr>
<td>Output Impedance, Dynamic</td>
<td>Zout</td>
<td>Pins 3 and 4</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>Ω</td>
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<tr>
<td>Capacitive Load</td>
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<td></td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>pF</td>
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<tr>
<td>Channel Separation</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>dB</td>
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<tr>
<td>Mute Output</td>
<td>Vm</td>
<td></td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>dB</td>
</tr>
<tr>
<td>Gain Matching, L &amp; R Ch. Diffs</td>
<td>VCA</td>
<td></td>
<td>±1</td>
<td>±1</td>
<td>±1</td>
<td>dB</td>
</tr>
<tr>
<td>Gain Bandwidth</td>
<td>GBW</td>
<td></td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>kHz</td>
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<td>Minimum Bandwidth</td>
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<td>200</td>
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<td>kHz</td>
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<td>VCA Control Point</td>
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<td>Pin 7</td>
<td></td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
<td>kHz</td>
</tr>
<tr>
<td>VCA Voltage Gain Range</td>
<td>AV</td>
<td></td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>dB</td>
</tr>
<tr>
<td>Gain Control</td>
<td></td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>dB</td>
</tr>
<tr>
<td>Control Feedback</td>
<td>Pin 7</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>mV</td>
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<tr>
<td>Power Supply</td>
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<td></td>
<td></td>
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<tr>
<td>Voltage Range</td>
<td>Vcc</td>
<td></td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
<td>V</td>
</tr>
<tr>
<td>Supply Current</td>
<td>Is</td>
<td></td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>mA</td>
</tr>
<tr>
<td>Power Supply Rejection</td>
<td>PSSR</td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>W</td>
</tr>
</tbody>
</table>

**Notes**

- M23 shrunk pins.
- Specifications subject to change without notice.
### Pin Description

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
<th>Function and Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L IN</td>
<td>Audio input.</td>
</tr>
<tr>
<td>2</td>
<td>R IN</td>
<td>Right Audio Input.</td>
</tr>
<tr>
<td>3</td>
<td>L VCF C1</td>
<td>Left VCF Filler Cap Port.</td>
</tr>
<tr>
<td>4</td>
<td>L VCF C2</td>
<td>Right VCF Filler Cap Port.</td>
</tr>
<tr>
<td>5</td>
<td>V+</td>
<td>Positive Supply.</td>
</tr>
<tr>
<td>6</td>
<td>ACOM</td>
<td>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 battery-driven or supply-splitting voltage divider.</td>
</tr>
<tr>
<td>7</td>
<td>VCA PORT</td>
<td>Input to VCA Control Port, Allows external adjustment of attenuation with a +22 mV/decade slope. Zero volts relative to ACOM gives zero additional attenuation. Should be connected to ACOM if function not required.</td>
</tr>
<tr>
<td>8</td>
<td>DET IN</td>
<td>Input to VCF Detector.</td>
</tr>
<tr>
<td>9</td>
<td>SUM OUT</td>
<td>Combined Left Plus Right Output.</td>
</tr>
<tr>
<td>10</td>
<td>VCA DET IN</td>
<td>Input to VCA Detector.</td>
</tr>
<tr>
<td>11</td>
<td>VCF DET CAP</td>
<td>Voltage Controlled Filter, Time Constant Capacitor Port.</td>
</tr>
<tr>
<td>12</td>
<td>VCA DET CAP</td>
<td>Voltage Controlled Amplifier Time Constant Capacitor Port.</td>
</tr>
<tr>
<td>13</td>
<td>NC</td>
<td>Make no connection to this pin.</td>
</tr>
<tr>
<td>14</td>
<td>DEFAULT THRESHOLD</td>
<td>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.</td>
</tr>
<tr>
<td>15</td>
<td>AUTO THRESHOLD CAP</td>
<td>Automatic Threshold Detector Capacitor Port</td>
</tr>
<tr>
<td>16</td>
<td>DEFEAT</td>
<td>Logic High: defeats Noise Reduction. Logic Low: normal action. Connect to ground if not used.</td>
</tr>
<tr>
<td>17</td>
<td>MUTE</td>
<td>Logic High: Mute. Logic Low: normal action. Connect to ground if not used.</td>
</tr>
<tr>
<td>18</td>
<td>NC</td>
<td>Make no connection to this pin.</td>
</tr>
<tr>
<td>19</td>
<td>DIGITAL GND</td>
<td>Digital Logic Reference (Logic Zero).</td>
</tr>
<tr>
<td>20</td>
<td>V-</td>
<td>Negative Supply.</td>
</tr>
<tr>
<td>21</td>
<td>R VCF C2</td>
<td>Right VCF Capacitor Port</td>
</tr>
<tr>
<td>22</td>
<td>R VCF C1</td>
<td>Left VCF Capacitor Port.</td>
</tr>
<tr>
<td>23</td>
<td>R OUT</td>
<td>Right Audio Output.</td>
</tr>
<tr>
<td>24</td>
<td>L OUT</td>
<td>Left Audio Output.</td>
</tr>
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</table>

### Inductor Assemblies

**Passive Components, Inductors**

<table>
<thead>
<tr>
<th>Assembly Type</th>
<th>Range [MHz]</th>
<th>Ferrite Grade</th>
<th>AL (nH)</th>
<th>Part Number</th>
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</thead>
<tbody>
<tr>
<td>7M1S</td>
<td>0.1-100</td>
<td>Screw Core</td>
<td>50-110</td>
<td>F08</td>
</tr>
<tr>
<td>7F1S</td>
<td>5-15</td>
<td>Screw Core</td>
<td>60-125</td>
<td>F10b12</td>
</tr>
<tr>
<td>7K1S</td>
<td>15-25</td>
<td>Screw Core</td>
<td>80-110</td>
<td>F20</td>
</tr>
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<td>7T1S</td>
<td>20-60</td>
<td>Screw Core</td>
<td>60-110</td>
<td>F40</td>
</tr>
<tr>
<td>7V1S</td>
<td>50-200</td>
<td>Screw Core</td>
<td>50-120</td>
<td>F100b</td>
</tr>
</tbody>
</table>

**Components**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Type</th>
<th>Material</th>
<th>Part Number</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Screening Can</td>
<td>PS</td>
<td>Cu</td>
<td>94454000</td>
</tr>
<tr>
<td>2</td>
<td>Cup Core</td>
<td>Ka7</td>
<td>Ferrite</td>
<td>.115300</td>
</tr>
<tr>
<td>3</td>
<td>Screw Core</td>
<td>M407</td>
<td>Ferrite</td>
<td>.58 x 8</td>
</tr>
<tr>
<td>4</td>
<td>Coil Former for Grid 2.25</td>
<td>Ks312</td>
<td>PBTP-GV</td>
<td>70955400</td>
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<tr>
<td>5</td>
<td>Coil Former for Grid 2.5</td>
<td>Ks312o</td>
<td>PBTP-GV</td>
<td>70958500</td>
</tr>
</tbody>
</table>

**Dissipation**

With a given power, a certain current must not be exceeded by the coil to prevent overheating. The nominal power and dissipation of the coil is determined by the current through the coil (operating point) and the current through the coil (maximum point). The operating point is the point where the coil is most likely to be operating, and the maximum point is the point where the coil is likely to be overheating. The dissipation and power must be calculated in order to prevent overheating.
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<tr>
<th>Package</th>
<th>Price</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Kit</td>
<td>£89.00</td>
</tr>
</tbody>
</table>

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Index of Advertisers

<table>
<thead>
<tr>
<th>Advert Scientific</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asdel</td>
<td>36</td>
</tr>
<tr>
<td>Audio Components</td>
<td>95</td>
</tr>
<tr>
<td>Avishares</td>
<td>44,66</td>
</tr>
<tr>
<td>B &amp; K Electronics</td>
<td>44,66</td>
</tr>
<tr>
<td>Bell Aerospace</td>
<td>7</td>
</tr>
<tr>
<td>Cambridge Microprocessor Systems</td>
<td>67</td>
</tr>
<tr>
<td>Chequer Valve Company</td>
<td>36</td>
</tr>
<tr>
<td>CI Electronics</td>
<td>101</td>
</tr>
<tr>
<td>Circula Distribution</td>
<td>25</td>
</tr>
<tr>
<td>Confidential Communications</td>
<td>6</td>
</tr>
<tr>
<td>Conford Electronics</td>
<td>61</td>
</tr>
<tr>
<td>Crosswire Products</td>
<td>61</td>
</tr>
<tr>
<td>Display Electronics</td>
<td>60</td>
</tr>
<tr>
<td>Electromall</td>
<td>7</td>
</tr>
<tr>
<td>Elektor Electronics</td>
<td>6,98</td>
</tr>
<tr>
<td>Equinox Technologies</td>
<td>98</td>
</tr>
<tr>
<td>ESP Electronic Components</td>
<td>89</td>
</tr>
<tr>
<td>Forest Electronic Development</td>
<td>99</td>
</tr>
<tr>
<td>Grandata</td>
<td>78-81</td>
</tr>
<tr>
<td>Hartlich Electronic</td>
<td>95</td>
</tr>
<tr>
<td>Hart Electronics</td>
<td>95</td>
</tr>
<tr>
<td>Heeley (UK) Ltd</td>
<td>8</td>
</tr>
<tr>
<td>Labcenter Electronics</td>
<td>9</td>
</tr>
<tr>
<td>Leading Edge</td>
<td>45</td>
</tr>
<tr>
<td>Lanning Research</td>
<td>61</td>
</tr>
<tr>
<td>MOP Electronics</td>
<td>4</td>
</tr>
<tr>
<td>Nixdorf</td>
<td>101</td>
</tr>
<tr>
<td>Pyrell Technology</td>
<td>24,25</td>
</tr>
<tr>
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<td>95</td>
</tr>
<tr>
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<td>61</td>
</tr>
<tr>
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<td>10</td>
</tr>
<tr>
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<td>67</td>
</tr>
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<td>45</td>
</tr>
<tr>
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<td>37</td>
</tr>
<tr>
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<td>99</td>
</tr>
<tr>
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<td>45</td>
</tr>
<tr>
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<td>99</td>
</tr>
<tr>
<td>Telnet</td>
<td>100</td>
</tr>
<tr>
<td>The PC Solution</td>
<td>42</td>
</tr>
<tr>
<td>Tison (UK) Ltd</td>
<td>18,19</td>
</tr>
<tr>
<td>Ultimate Technology</td>
<td>24</td>
</tr>
<tr>
<td>Viewcom Electronics</td>
<td>5</td>
</tr>
<tr>
<td>VIP Matchmaking</td>
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</tr>
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<td>5</td>
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