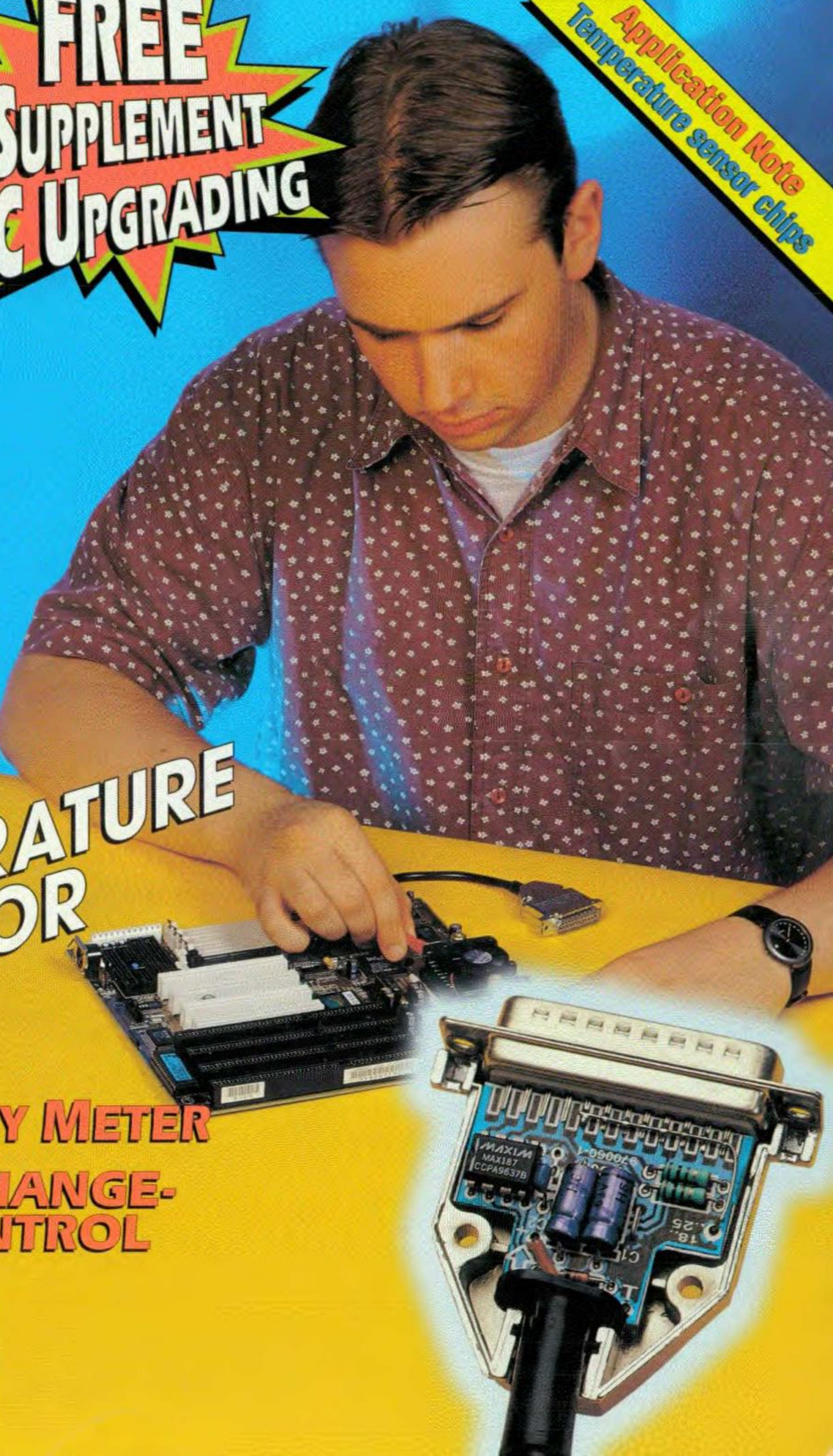
THE ELECTRONICS & COMPUTER MAGAZINE

ELEKTOR ELECTRONICS

OKTOBER 1997
£ 2·75

FREE SUPPLEMENT PC UPGRADING

Application Note
Temperature sensor chips



CPU TEMPERATURE MONITOR

COMPACT FREQUENCY METER

RS232 CHANGE-OVER CONTROL

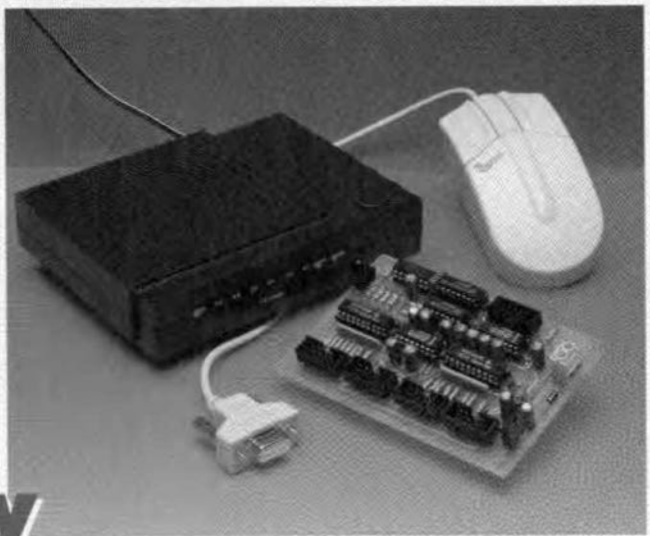
10

9 770268 451067

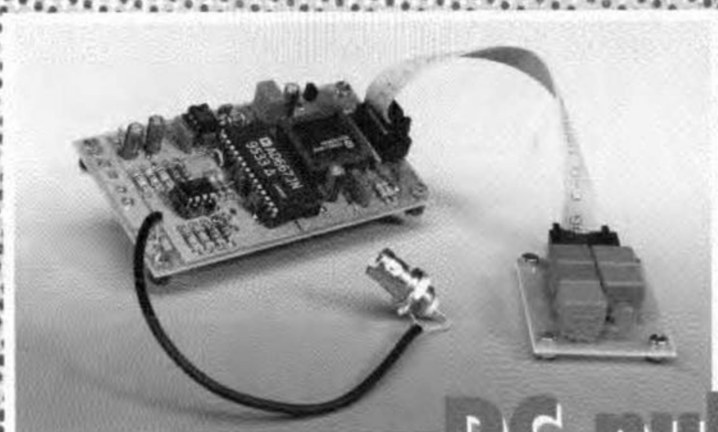
ELEKTOR ELECTRONICS

CONTENTS

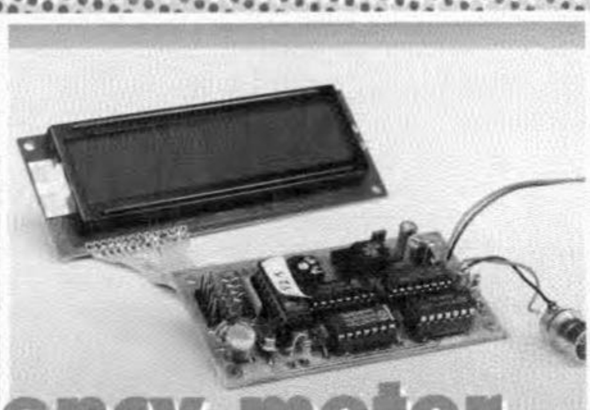
October 1997 Volume 23
Number 259 ISSN 0268/4519



28
4-way
serial port switch



44
DC nullifier
for oscilloscope input

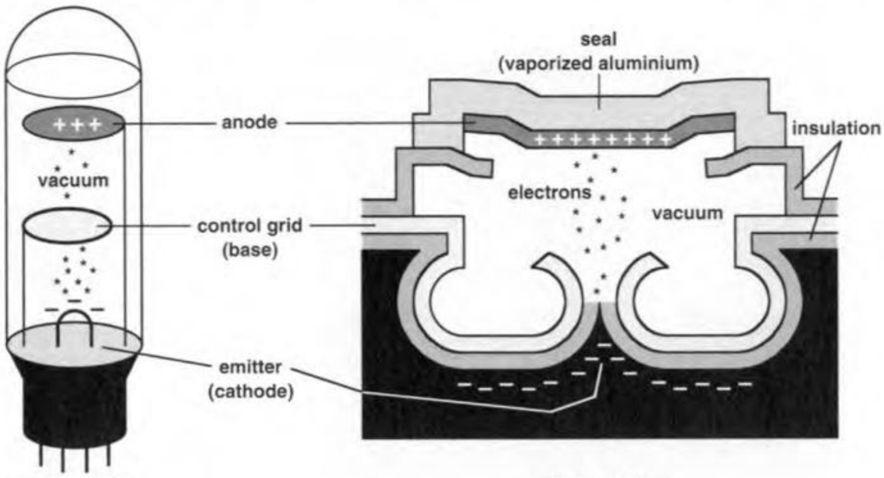


16
frequency meter
and
event counter module

16-page SUPPLEMENT on
PC upgrading
and allied information
Centrefold

ABC
AUDIT BUREAU OF CIRCULATIONS
CONSUMER PRESS

RETURN OF THE THERMIONIC VALVE ... IN MICRO FORM



triode valve (true size)

micro-valve (< 5μm across)

975063-11

Source: Technische Universiteit, Delft, the Netherlands

For three or four generations the thermionic valve (or electron tube) reigned supreme in radio receivers, audio amplifiers, television sets and a host of industrial equipment, until it had to give way to the transistor, and later the integrated circuit in the 1970s and 1980s. True, it survived in applications where semiconductor technology does not do too well, for instance, in r.f. transmitters and wideband oscillators operating at frequencies into the 100 GHz range. Moreover, it is much better able to withstand high temperatures than semiconductor devices.

The special properties of the valve prompted Jens Foerster, a researcher at the Technical University of Delft in the Netherlands to investigate whether thermionic valves could be produced in solid-state technology. He argued that the valve has al but disappeared largely because of its physical characteristics rather than its electrical properties. After all, a current through a valve flows through a vacuum but in a transistor through a semiconductor, which makes it more susceptible to interference.

A thermionic valve consists of several basic parts: a cathode (synonymous to the emitter in a transistor) which emits electrons; an anode (collector) which collects the electrons; a control grid (base) which enables the electron flow to be influenced. The Foerster 'valve' is constructed on a microscopic scale and can therefore be integrated on a silicon chip. It is made from silicon in such a way that the fabrication of wafers in the cleanroom is not affected.

A notable difficulty was the emission of electrons. Such an emission from silicon becomes possible only at a temperature >3000 °C, which is way above the melting point of silicon. Other suitable materials, such as caesium or lanthanide compounds cannot be used in a cleanroom.

Since thermionic emission was a non-starter, Foerster chose field-emission, in which an electric field of a few million volts per metre 'sucks', as it were, electrons from the crystal. Since the emission take place from a pin-point area of only 1 μm^2, the field is so concentrated that even at relatively low voltages very high fieldstrenghts can be achieved.

Foerster has developed a technique whereby the desired three-dimensional structure is obtained with the aid of etching procedures used in the semiconductor industry.

The control electrode (grid) consists of a ring around the pin-point area. In view of the microscopic dimensions, the correct positioning of the various elements is a demanding task, but if the two elements are produced together, correct positioning is automatic.

One of the essential aspects of a thermionic valve is the vacuum cavity. In the Foerster valve, this is created by etching a 'hollow' in the silicon chip and sealing it with vaporized aluminium. The vacuum is obtained in an economic way, because the aluminium is vaporized at low pressure; once the seal has been put into place, the low pressure inside is retained.

The current flowing from the needle-point emitter is small: about 1 μA. But it is perfectly possible to fit a few thousand emitters together to obtain a practical current, and still have a micro-valve.

[977188]

VULKAN P200 CORDLESS SOLDERING IRON

A cordless, gas-powered soldering iron and precision heating tool that delivers up to 135 W of output, manufactured by B S Manufacturing, is available from Wordsun. It is produced in lightweight plastics, weighs only 100 g and provides a light easily manipulated, highly versatile tool that can be carried on a belt or in a pocket. Ideal for field personnel or any factory staff that need mobility, it enables technicians working away from electrical power sources, or in difficult circumstances such as restricted spaces, to achieve high productivity.

A wide range of attachments allows the tool to perform functions as diverse as fine or silver-soldering, shrink wrapping, hot knife cutting, or even blow torch heating. This makes it a versatile addition to the toolkit of electronics or electrical personnel working in assembly, commissioning, maintenance or repair departments, as well as model-makers and other technicians – there's even an attachment to configure the tool for 'dehorning' animals, extending its application potential to veterinary practices.

Dubbed the Vulkan P200, the tool uses catalytic conversion for the majority of its applications, delivering heat to the tip by infra-red radiation. The fuel is liquid butane/propane gas stored in the translucent handle of the tool. The tank is refilled with a squirt from a gas refill canister – a low-cost item around the world. Each refill provides up to three hours of continuous use at a typical setting for electronics soldering.

Gas is ignited by means of a piezoelectric spark from a crystal incorporated inside the casing. Gas flow is regulated by a slider, allowing adjustment from typically 400 °C to 1200 °C. With the exception of the blow torch, all the tip attachments incorporate a platinum catalyst which converts the gas flame to infra-red radiation once the 'light-off temperature' of around 130 °C is reached.

One of the important advantages of gas power is is the carbon-dioxide-rich atmosphere around the tip which minimizes oxidation, making the P200 an ideal tool for repairing dry joints.

Further information from *http://www.wordsun.com/mp1*

Wordsun Limited, The Old Post Office, Gaunt's Common, Wimborne BH21 4JN. Phone +44 (0)1258 840 999; fax +44 (0)1258 840 960.

SCOTLAND THE BRAVE PC USER

Scottish computer owners are the most proficient in the UK and more likely to be female, but most have never accessed the Internet according to the Home PC User Report.

The report, published by VNU Business Publications, shows that although the average user is a male earning between £20,00 and £25,000, the chances of users being women are greater in Scotland than in other parts of the UK.

[ITN7/16/2]

OFFICE WORKERS TO SHOP FROM THEIR DESKS

A supermarket chain and a computer company have joined forces in a four-month electronic shopping scheme for office workers.

Staff at IBM's Hampshire development laboratory will be able to shop from their desks, picking goods from the Somerfield supermarket at nearby Alton. Orders placed before nook will be dispatched the same afternoon and delivered to the office for the shoppers to take home.

Each order is made by accessing an Internet site and choosing from a range of 20,000 different goods. Prices and stock levels are constantly updated by the computer.

The mains aims of the trial are to find out how shoppers acclimatize to the online environment, whether they shop in the same way, and how much they are prepared to pay to use it.

[ITN7/15/3]

CD-ROM AND INTERNET: PRODUCT INFORMATION PER MOUSE CLICK

The new edition of the CD-ROM from the Passive Components and Electron Tubes Group at Siemens Matshushita Components has been revised and considerably extended. Data Book Library 1997 contains all data books as well as related publications with a total volume of around 5000 pages. Newly included are additional search functions, software tools and calculation programs for the designer. With the use of the integrated Internet link the latest information on any component can be called up directly from the CD-ROM.

Search functions have been revised and extended for the Data Book Library 1997 allowing the user to find the wanted component much easier and faster than in the past.

Extended Search is a new function supplementing the functions Retrieval (a tool for accessing technical data on selected components), Book Structure (electronic data catalogues) and Online News (for accessing latest information via the Internet). This new search function can be used to search for order numbers, type designations or key words to cover the complete product publications.

Enquiries to Siemens Infoservice, P O Box 2348, D-90713, Fürth; Fax +49 911 978 3321.

More information on the passive components and tubes division as well as on Siemens Matshushita Components may be found at *http://www.siemens.de.pr.index.htm*

REMOTE CONTROL FOR PCS

A software system that allows computers to be left on 're-mote control' via the Internet has been developed by Steinkrug Publications. It allows computers to operate via the Internet without being connected to it at all times. Instead, the machines are instructed to connect to the Net automatically when required. The first application of the software has been in the security industry, where it can be used to enhance security over, say, a large building.

At the moment, the system is available only for developers, so that further applications can be created.

Steinkrug Publications, 20 Leaden Hill, Orwell, Royston, Hertfordshire SG8 5QH. *http://www.steinkrug.demon.co.uk*

[ITN7/16/4]

SONY JOINS RUSH TO CAMBRIDGE

Sony is buying Cambridge games company Millennium in a deal worth £6m. The company said its long-term plan was to 're-invent' multimedia as a concept for entertainment, using the popular Playstation as starting point.

Playstation, Sony's flagship games product, has sold over one million units in the UK, pushing former market leader Nintendo into second place. Nintendo is now fighting back with the more powerful – but more expensive – N64.

Cambridge's location and atmosphere as a city, and its links with the academic world, are important aspects for the many companies moving there.

[ITN7/15/1]

UK CALL CENTRES

Twenty-four hour service, computerized answering and recording, and database management are just a few of the special features that BT and its competitors offer companies planning new call centres in the UK. The very high standards of these centres provide a testament to their success.

No other European country has such a choice of telecommunications providers: no fewer than 150 in all, including Mercury, AT&T, and many cable operators, as well as BT itself.

The telecommunications structure in Britain is high liberalized compared with those in the rest of Europe and this, together with the available sophisticated phone services, enables companies to offer a faster and better service than elsewhere. With many call centres offering any-distance calls at local rates, it is hardly surprising that more than 15 million toll-free international and domestic calls are made every week on BTs network alone.

Merchants Group, one of many specialists bureaux that operate call centres on behalf of firms from overseas, runs a technical support call centre for US printer manufacturer Tektronix, covering 33 countries in Europe and the Middle East. Its 300 employees handle calls in nine different languages.

American Express set up its European call centre in Brighton in the early 1980s. Several of its operators speak four or five languages, including Japanese. If, for instance, a person loses travellers cheques in Europe, Africa or the Middle East, all he/she has to do is ring a local freephone number and be transferred to Brighton where the problem is dealt with.

Everyone at AT&T's London customer service centre, which is its flagship operation in Europe, speaks at least two languages.

Some years ago, Apple Computer awarded a large contract to BT to install and operate a number of multilingual customer support services throughout Europe on its behalf. These support centres now provide Apple customers, personal and corporate, with support and access to Apple's database of technical and product information.

[F7/4/0143]

MULTIMEDIA TECHNOLOGY

The term 'multimedia', generally accepted as consisting of a mix of video, audio, three-dimensional animation, text , and graphics, has been around for almost ten years, but not until 1990 did the technology become a tangible reality apparent in a plethora of applications. Companies are struggling to get a strong hold of the market, which is expanding in North America, Europe, and the Pacific Rim.

By all accounts, North America is a few years ahead of the other regions of the world in terms of multimedia deployment and this lead is expected to continue for the next several years. Europe, however, is closing in fast in terms of the number of hardware and software manufacturers and application developers.

[F&S2891-64]

INTERNET SERVICE FOR HOME LEARNING

An Online education service aimed at children revising for exams or doing homework has been launched by entrepreneur Richard Branson – head of the Virgin Group. The Virgin Net Education Service is made up of controlled Internet sites providing specific content for children and parents.

Reference sources available to customers of the service include the Oxford English Dictionary (OED), news from Mirror Group newspapers, Letts study guides, and more than 5,000 Web sites with content directly related to National Curriculum subjects.

Additionally provided are a photographic archive with 2,000 images, a thesaurus, a dictionary of quotations, encyclopedia, careers information, mock exam questions, and an exclusive section for parents offering guidance on subjects like drugs and bullying at school, and how to help a child with homework.

The service is aimed at home users who are doing extra schoolwork, and is not an Internet service for schools themselves.

Virgin Net Limited, 120 Campden Hill Road, London W8 7AR. Phone 0171 479 4400.

[ITN7/14/4]

US CONSUMER ELECTRONICS INDUSTRY TODAY

The annual review of the Consumer Electronics Manufacturers Association (CEMA), *US Consumer Electronics Industry Today* is now available.

The 120-page booklet includes highlights and updated statistics from 1996, along with a look ahead to the trends of tomorrow.

The booklet contains chapters on Video, Audio, Mobile Electronics, Multimedia, Communication and Information, Integrated Home Systems, and Accessories. It also includes a detailed history of the industry, a list of CEMA members, and contact information for related associations. Copies of the booklet can be ordered from Communications Department, CEMA, 2500 Wilson Boulevard, Arlington, Va 22201-384, USA. Phone +1 703 907 7674; fax +1 703 907 7690.

RADIO AMATEUR NAMED GPT ENGINEER OF THE YEAR

David Stoney (G8PTN), a 35-year old senior consultant engineer, who has played a key role in GPT's rise to world leadership in telecomms transmission technology, has been named GPT Engineer of the Year. The award is in recognition of his own and his section's outstanding work in developing a semi-custom ASIC chip for telecomms equipment that helped GPT win two Queen's Awards earlier this year and has seen the company, with its partner Siemens, capture a third of the world market in its sector.

This work was mission-critical to the timely introduction of GPT's new world-beating Combiner product, which represents the state of the art in Synchronous Digital Hierarchy (SDH) transmission systems. David's 15-strong team managed to design the ASIC from scratch and release it to full-scale production stage in just eight months instead of the normal 12 or more. Moreover, they achieved this one month early and significantly below budget.

Further information from the GPT Press Office on +44 (0)115 943 3687 or write to press_office@ncp.gpt.co.uk by e-mail.

[GPT075/97-8]

INTERNET ON THE BOX

TV viewers in the UK will soon be able to 'tune in' to the Internet and the World Wide Web from the comfort of their living rooms – without the need for any sort of personal computer.

Europe's first exciting new TV-based Internet service is called NetChannel, run by Net Channel UK, Europe's first mass market TV Service Provider.

NetChannel is a totally new TV channel which provides live access to the Internet via a domestic TV set linked to a low-cost set-top box and a standard telephone line. The system is operated by either a small alphanumeric keypad (similar to a TV remote control) or an optional, compact, infra-red, QWERTY keyboard. In addition, users can send and receive electronic mail from the comfort of their armchairs.

It is expected that the new Internet service will be in full retail distribution in time for Christmas.

Net Channel UK Ltd, 195 Knightsbridge, London SW7 1RE. Phone 0171 591 7000; fax 0171 591 7001.

COMMERCE FEARS COMPUTER SABOTAGE MOST

Computer sabotage is the crisis most feared by large companies, according to a survey commissioned by Insurance company AIG Europe. The survey found that 70 per cent of company directors felt an attack on their organization's in formation technology infrastructure was the most serious crisis they could envisage.

Te threat of computer chaos beat other possible crises, such as fraud (52 per cent), hostile takeover (54 per cent) and extortion (50 per cent) to top the list of corporate nightmares.

Potential sabotage can range from a disgruntled employee deleting data, to external attack from hackers causing irreversible damage to files.

[ITN7/14/5]

NETWORK MANAGEMENT

A new service for routeing circuits in Synchronous Digital Hierarch (SDH) networks has been perfected by Cambridge Consultants Limited (CCL). In an increasingly competitive market, telecommunication companies are looking for opportunities of making better use of their SDH networks. CCL's new circuit router uses an intelligent algorithm to choose the best paths, resulting in improved customer service and increased revenue for the operator. Current path and circuit managers are quite basic and often route calls simply by choosing the shortest path between two nodes. This does not always make the best use of the network or give the foremost match with customer requirements. They want a route path that gives them the most efficient service while network operators want a path that makes optimal use of resources avoiding restricting future routeing options.

CCL's router uses an advanced algorithm to find the path that best meets these conflicting requirements. It works to maximize availability to customers while minimizing latency and restoration time. For the operator, the router minimizes the extent of reconfiguring nodes and unnecessary fragmentation of resources. SDH uses resources efficiently by reserving protected lines for customers who want and pay for them by choosing routes that do not limit future routeing options. By managing their networks more efficiently, operators can accommodate more services and price them more effectively.

[STN7/14/6]

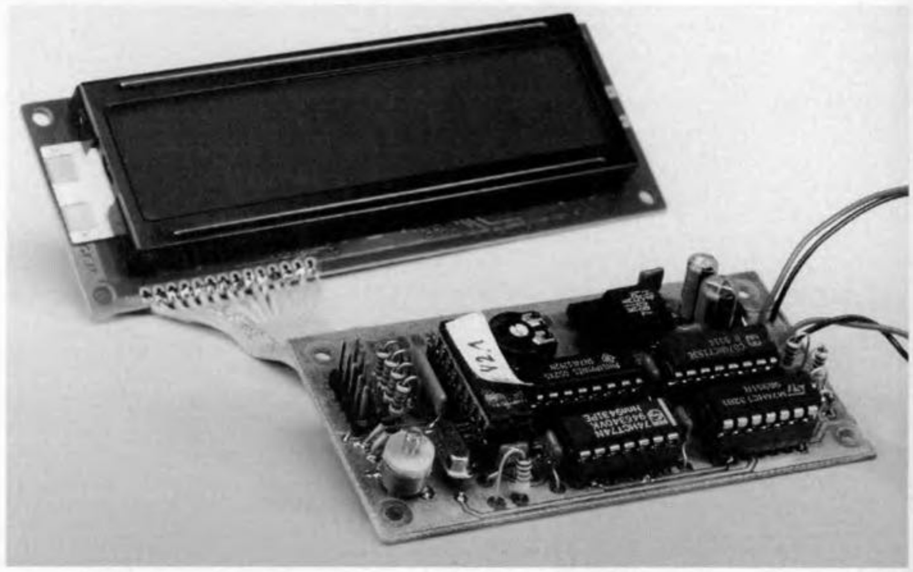
CCL, Science Park, Milton Road, Cambridge, United Kingdom CB4 4DW. Telephone +44 (0)1223 420 024; fax +44 (0)1223 423 373.

frequency meter and event counter module

provides fast, accurate period measurement

LCD panel meters, temperature or event counter modules are readily available in many electronics retail shops at reasonable prices. But try to find a practical, efficient, and value-for-money frequency meter module and you will be disappointed. In that case, this article will, no doubt, be welcome. It describes a module based on a RISC (Reduced Instruction Set Computer) microcontroller, which guarantees accurate measurements over a wide frequency range for a reasonable outlay.

Design by H. Kutzer



Features of the frequency meter/ event counter module

- *Schmitt-trigger input*
- *Compact construction with only six ICs*
- *Small PCB enables incorporation in, say, a function generator*
- *2×16 digit liquid-crystal display*
- *Power derived from unregulated mains adaptor*
- *Low current drain (50 mA)*

Frequency and period measurement

- *Reciprocal frequency count principle with counter and programmable divider*
- *Simultaneous display of frequency (5 digit) and period*
- *Alphanumeric notation*
- *±1 error (5 ppm)*
- *Measurement rate 1.4 Hz at f_{in} >3 Hz, otherwise f/2*
- *Measurement range 0.1 Hz – 50 MHz, 10 s – 20 ns*
- *5-digit frequency display*
- *Suppression of superfluous zeros*
- *Auto range (9 ranges) with hysteresis*

Event counter

- *Event count from 0 000 001 to 9 999 999*
- *Maximum counting frequency about 40 kHz*
- *Triggering at leading edge*
- *Display rate 5 Hz*

1

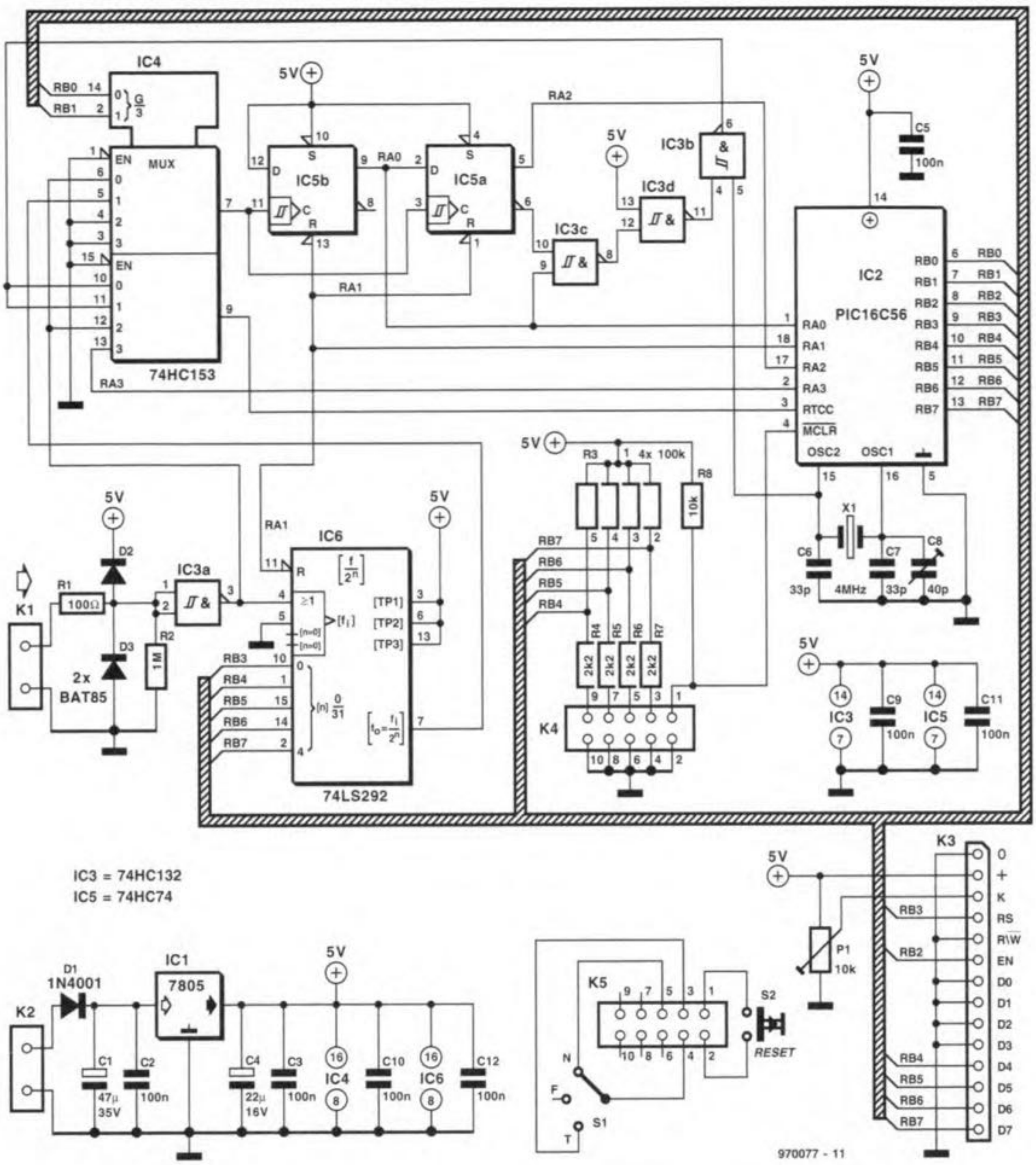


Figure 1. The circuit of the frequency meter/event counter is based on a RISC microcontroller Type PIC16C56.

INTRODUCTION

The frequency meter module may form the basis of a laboratory measuring instrument or be used as an extension to an existing instrument such as a frequency generator. It provides a wide frequency range extending from 0.1 Hz to 50 MHz and shows the measurement result – frequency and period simultaneously – clearly on a liquid-crystal display (LCD) with an error not exceeding 5 ppm. Moreover, the module may be used as an event counter over an indefinite period of time.

DIVIDE AND RULE

The design of the module is straightforward since virtually all functions are driven by IC_2, a microcontroller Type PIC16C56 (**Figure 1**).

The measurand (that is, the input signal to be measured) is applied to Schmitt trigger gate IC_{3a} via protection network R_1-D_2-D_3 and pull-up resistor R_2. The gate ensures steep signal edges and clearly defined level ratios.

Then follows a programmable frequency scaler, IC_6, a Type 74LS292, whose scaling factors at inputs 0–4 can be set between 2^2 and 2^{31}. The controller resets the scaler (and the remainder of the circuit) to zero by applying a low level to the 'Clear' input.

In the *frequency mode*, multiplexer IC_4 applies the scaled down measurand to pin 5 or the original signal to pin 6. This is unavoidable as the scaling factor cannot be set to 1 or less. Since the microprocessor controls both the multiplexer and the scaler, it has information as to the actual scaling factor applied to the measurand at pin 7 of the multiplexer.

The scaler is followed by two bistables (flip-flops), arranged as 2-bit shift registers, which filter out exactly one period from the measurand. To this end, the microcontroller first applies a high logic level to the reset inputs.

The first leading edge at the clock input starts the measurement process via IC_{5b} (port line RA_0), while the second sets the second bistable and limits the measurement window (RA_2).

During the period gate IC_{3b} is enabled so that the clock pulses at pin 15 (OSC2) of the PIC are applied to count input RTCC of the PIC via the second multiplexer in IC_4.

The *real time clock/counter* in **Figure 2**, an 8-bit counter which has a programmable 8-bit prescaler and stores the measurement result into two software registers. This arrangement makes a 4-byte counter register available, whose content is increased by 1 every 250 ns and can, at least in theory, measure time lapses of up to 1073 s. In the present module, this range is limited to 10 s.

Control bits RTE (leading/trailing edges), RTS (internal/external count

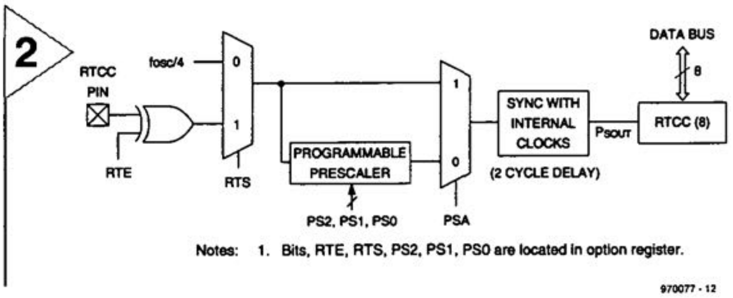


Figure 2. The Real Time Clock/Counter contained in the module functions as a 4-byte counter register.

signals), PS_0–PS_2 (prescaler ratio 2^n, where n = 1–8) and PSA (with/without prescaler) are placed in the *option register*.

Since the 8-bit prescaler cannot be read, but its content is essential for computing the frequency, the RTCC remains clocked after the actual measurement has taken place. This is done via RA_3 and a multiplexer (pin 13 to pin 9 of IC_4). The controller counts these pulses, until the prescaler overflows, whereupon the RTCC register is increased by 1. From this information it is possible to compute the content of the prescaler. For instance, when after x clock pulses the RTCC memory is increased by 1, the prescaler content is $n_0 = 256 - x$.

All this is true in the *frequency mode*. In the *event count mode*, the bistables, gates and oscillator (in its function as reference frequency source) are irrelevant since the output (pin 7) of the multiplexer is at ground potential.

In the event count mode, the input signal is applied directly to the RTCC gate. Also, PSA is enabled and the prescaler is by-passed. The overflow of the counter causes the 3-byte software register to be extended so that the measurement range is 9,999,999. The counter state is actuated every 200 ms. The maximum counting rate, determined primarily by the display routine and the overflow process, is 40 kHz.

CONSTRUCTION

The module is best built on the printed-circuit board shown in **Figure 3.** This is a double-sided board that is slightly more expensive than a single-sided one, but it results in a very compact construction.

The ICs should be fitted in IC sockets.

Make sure that the crystal case does not short-circuit underlying circuit tracks; it is advisable to place a small, thin cardboard disk between it and the tracks.

The specified display matches the board exactly, both electrically and mechanically. The contrast of the display is set with P_1.

The specified type for IC_6 is an HC292. In some cases, this may be difficult or impossible to obtain, in which case an LS292 may be used. Although this draws a slightly higher current, it works marginally better at the upper

Parts list

Resistors:
R_1 = 100 Ω
R_2 = 1 MΩ
R_3 = 4×100 kΩ array
R_4–R_7 = 2.2 kΩ
R_8 = 10 kΩ
P_1 = 10 kΩ preset potentiometer

Capacitors:
C_1 = 47 µF, 35 V, radial
C_2, C_3, C_5, C_9–C_{12} = 0.1 µF
C_4 = 22 µF, 16 V, radial
C_6, C_7 = 0.033 µF
C_8 = 40 pF trimmer

Semiconductors:
D_1 = 1N4001
D_2, D_3 = BAT85

Integrated circuits:
IC_1 = 7805
IC_2 = PIC16C56-XTP (Order no. 976505-1)*
IC_3 = 74HC132
IC_4 = 74HC153
IC_5 = 74HC74
IC_6 = 74HC292 or 74LS292 (see text)

Miscellaneous:
K_1, K_2 = made up of solder pins
K_3 = single 14-pin terminal strip
K_4 = dual 5-pin terminal strip
X_1 = crystal, 4 MHz
S_1 = on/off/on toggle switch (Miyama Type MS500C)
S_2 = miniature push-button switch with single 'on' contact
LCD = 2×16 digit (Hitachi LM016L) or supertwist with background lighting (Hitachi LM093XMLN)
PCB Order no. 970077-1*
* See Readers Services toward the end of this issue

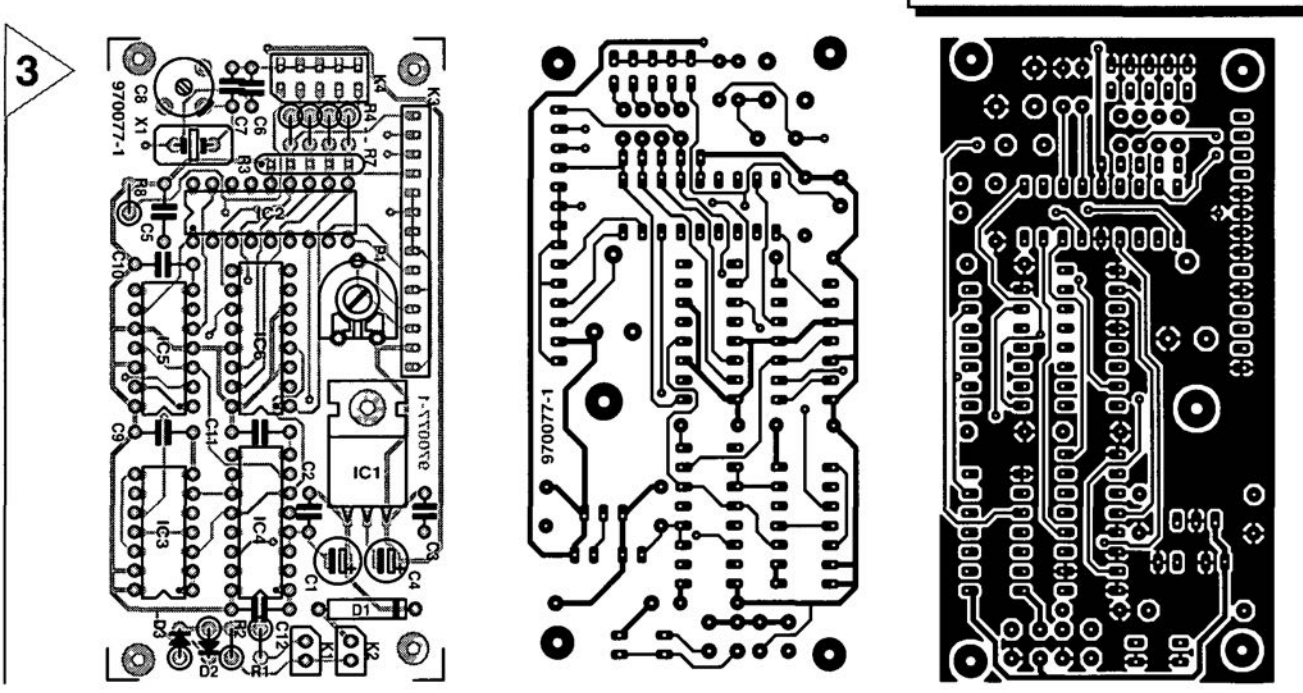


Figure 3. The double-sided board for the module enables a compact construction of the module.

frequency limit of 50 MHz.

If a mixture of HC and LS devices is used, the module draws a current of some 50 mA, which necessitates the use of an 8–15 V (non-regulated) mains adaptor.

The only calibration needed concerns C_8. Its precise setting can, however, only be carried out with a calibrated standard frequency meter. The crystal frequency is available at pin 15 (OSC2) of the PIC.

TEST AND USAGE

The program is started when reset button S_2 is pressed. The display is then initialized and shows the mode of operation set at K_4.

An unusual but effective circuit configuration is that port lines RB_4–RB_7 have 100 kΩ pull-up resistors as well as 2.2 kΩ protection resistors. The protection resistors may be earthed with switch S_1. In position N of this switch, the module functions as event counter; in the centre position as well as in position T, as a frequency meter. In position F, the frequency is displayed on the first line of the display and the period on the second line, but the other way around in position T.

If, during the initialization of the display RB_5 is earthed, then irrespective of the position of S_1 the number of the software version and the date of its manufacture are displayed.

Before any actual measurements are undertaken, it is necessary to carry out a few tests to determine the correct step-by-step procedure. During these tests, the software sets an increasingly larger scaling factor in IC_6 as a few examples will show.

(1) A frequency of about 10 Hz is to be measured with a precision of five digits (display 10.000 Hz). The measurement time is (as always) one period, that is, in this case 0.1 s. The scaler is not operating and so the measurand is applied directly to the RTCC input. During one period of the measurand the internal 4 MHz oscillator generates 400,000 pulses. This number of pulses may be converted easily and accurately into a frequency.

(2) A frequency of 1 MHz is to be measured with a precision of five digits. The measurement time in this case is 1 μs, in which the internal oscillator generates 4 pulses. This points to a fairly inaccurate measurement, because in view of the rounding error of ±1, there might have been three or five pulses, corresponding to a measurement result of 750 kH, 1 MHz, or 1.25 MHz. It is clearly necessary to scale down the measurand in IC_6. If, for instance, a scaling factor of 2^{16} is used, the measurand is scaled down to 15 Hz, corresponding to a period of 65 ms. In that time, the oscillator generates 262,144 pulses so that the rounding error of ±1 can be ignored.

This example shows that it is imperative that the measurement time of one period of the measurand is not so short as to result in a small number of pulses in the measurement window.

Fortunately, the software arranges a suitable scaling factor by trial and error. In the second example, a test measurement without scaler is carried out. If a counter content of at least $40000_{HEX}=262{,}144_{DEC}$ is not reached (that is, the measurement time is shorter than 65.5 ms), the scaling factor is is increased in a number of test measurements until the reference value is reached or exceeded.

To speed up the process of finding a suitable scaling factor, the software not only increases the factor but also halves the reference value if the counter content is too small. This means that in practice only four test measurements are necessary: with scaling factors of 0, 2, 8 and 16.

Once the scaling factor has been determined, the final measurement is carried out. Of course, the oscillator does not generate exactly 262,144 pulses, since there may be a deviation of up to –25% (which means that all values above 196,608 pulses are valid). This gives the software a measurement accuracy of 5.1 ppm (1/196,608). The software recognizes a change in the measurand during the measurement and signals an error.

The software does not start any computation until 500 ms have elapsed since the start of the measurement. This arrangement ensures a constant display independent of the number of approximation steps and the duration of the measurement.

Multiplication and division routines average the decimal value of the frequency from the counter content and the scaling factor. This value is rounded off and converted into a sequence, arranged in one of nine measurement ranges, given a decimal point and unit value, shorn of any superfluous zeros, and finally displayed.

Any slight fluctuations of the measurand at or near the limits of the measurement range are nullified by an hysteresis of ±0.5%.

The period of the measurand is computed in a similar manner. An asterisk is displayed for about 200 ms before the measurement result is shown. There is a time lapse of 500 ms between the start of the measurement and the onset of the computation. So, if the time taken for the computation is ignored, the display rate is about 1.4 Hz.

[970077]

Principle of period measurement

*In the gate-time method the number of periods (cycles) of the measurand within a defined gate time determine the measurement result (**Figure A**). The measured value is computed with the stated equation, in which ±1 is the measurement error. The longer the period, T_m, compared with the gate time, T_g, the larger the ±1 error, the indeterminable effect of the final period. To ensure good accuracy even at low frequencies the gate time would have to be lengthened to an impractical value.*

*A much more effective way of measuring the period of low frequencies is the period measurement (**Figure B**). This requires a stable reference oscillator running at a higher frequency whose pulses are summed by a counter. The counter is started and stopped by the measurand, so that the counter reading is a measure of the frequency of the measurand. The error of this ±1 method increases with the frequency of the measurand.*

The present module operates with a 5-digit display. If a ±1 error of 5 ppm is desired, the frequency of the measurand, f_m, must be

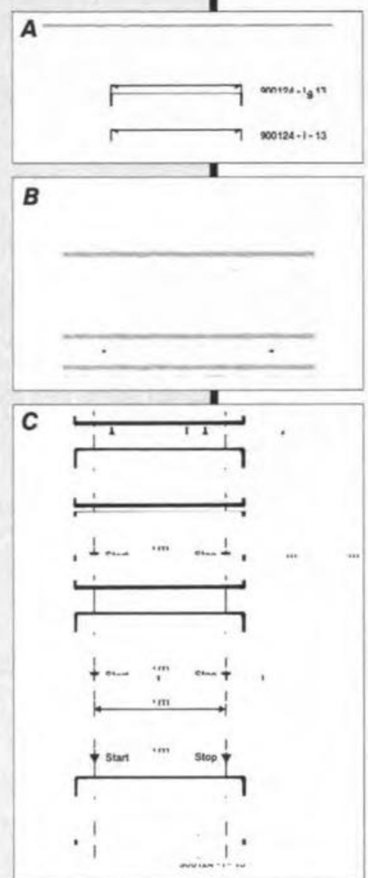
$$f_m << 5 \times 10^{-6} \times f_o$$

*where f_o is the reference frequency, here, 4 MHz. This means that the maximum value of f_m is 20 Hz. If f_m is higher than this, it must be scaled down (scaling factors between 2^2 and 2^{31}) (**Figure C**) before it is measured. Exponent n must comply with the condition*

$$n > \log_{10}(f_m/20)/\log_{10}2$$

to ensure that the desired accuracy is obtained.

In practice, f_m is normally known approximately and this is sufficient to determine the necessary scaling factor (if any). Otherwise, a rough value may be obtained by a stepped approximation.



CORRECTIONS & UPDATES

The Wall Box

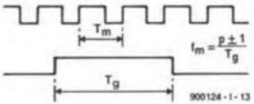
November 1997 - 970091

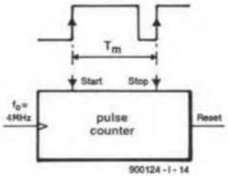
The outside diameter of the PVC tube for the bass reflex port should be 40mm, not 44mm.

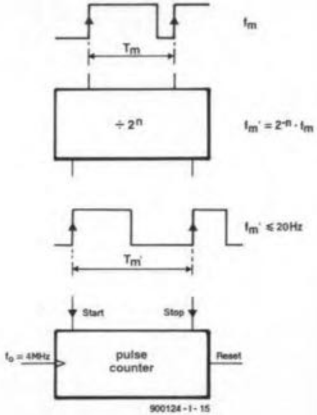
Frequency Meter and Event Counter Module

October 1997 - 970077

The drawings in the inset 'Principle of measurement' were mangled by our phototypesetting machine. The correct drawings are reproduced here.



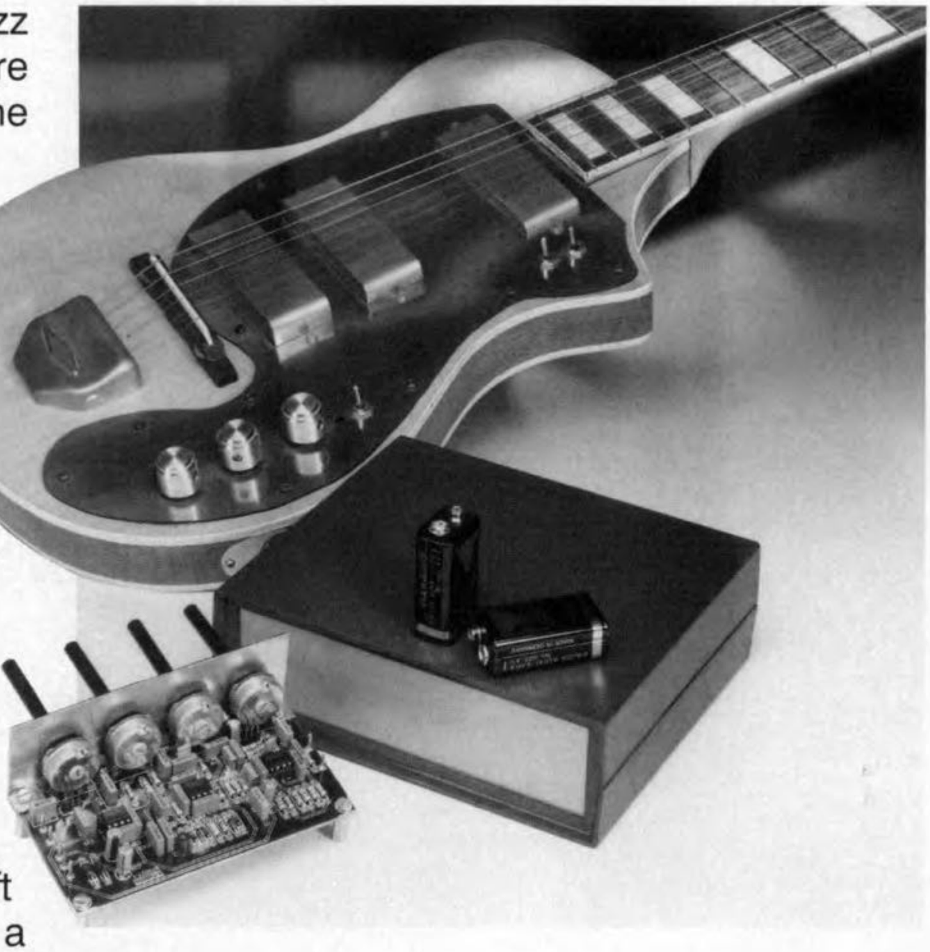




distortion (fuzz) unit

for electric guitars

Distortion, or fuzz effect, units are almost as old as the electric guitar itself. The unit described in this article produces soft clipping, which gives an effect reminiscent of that produced by valve amplifiers. Soft clipping means merely that the signal is not permitted to exceed a certain voltage level. Most listeners feel that soft clipping produces a much more musical sound than hard clipping (in which the tops of the positive and negative signals are chopped off). The unit is intended to be inserted between the guitar and its amplifier.



Design by M. Radler

INTRODUCTION

The designer of audio frequency circuits normally aims at signal processing that is as linear as possible. The exception to this rule is the design of guitar amplifiers – and it is a specific exception. At the same time, there is no specified definition of the shape of the output the circuit should produce. Only one thing is certain: it must definitely not be linear.

Designers of guitar amplifiers ceaselessly experiment with all kinds of effect unit and with the amplifier itself, of course. Here again, there is a virtually unanimous opinion among guitarists and listeners alike and that is that semiconductor amplifiers produce a cold, clinical sound, whereas valve (tube) amplifiers provide a warm and musical sound. The difference between the two lies primarily in the clipping behaviour of transistors and valves (tubes). The present unit aims at imitating the performance of a valve (tube) amplifier. This is manifested by a dynamic approach, richness of harmonics and soft clipping (which, strictly speaking, is not clipping at all, but rather a rounding off of the signal). Last but not least, the unit is virtually immune to crackling and scratching sounds.

CIRCUIT DESCRIPTION

The imitation of the performance of a valve (tube) amplifier, without using a single valve (tube) requires an inordinate amount of well-thought-out filtering. This means that the present unit contains rather more electronics than most other fuzz boxes (see **Figure 1**). However, the end justifies the means, but, all

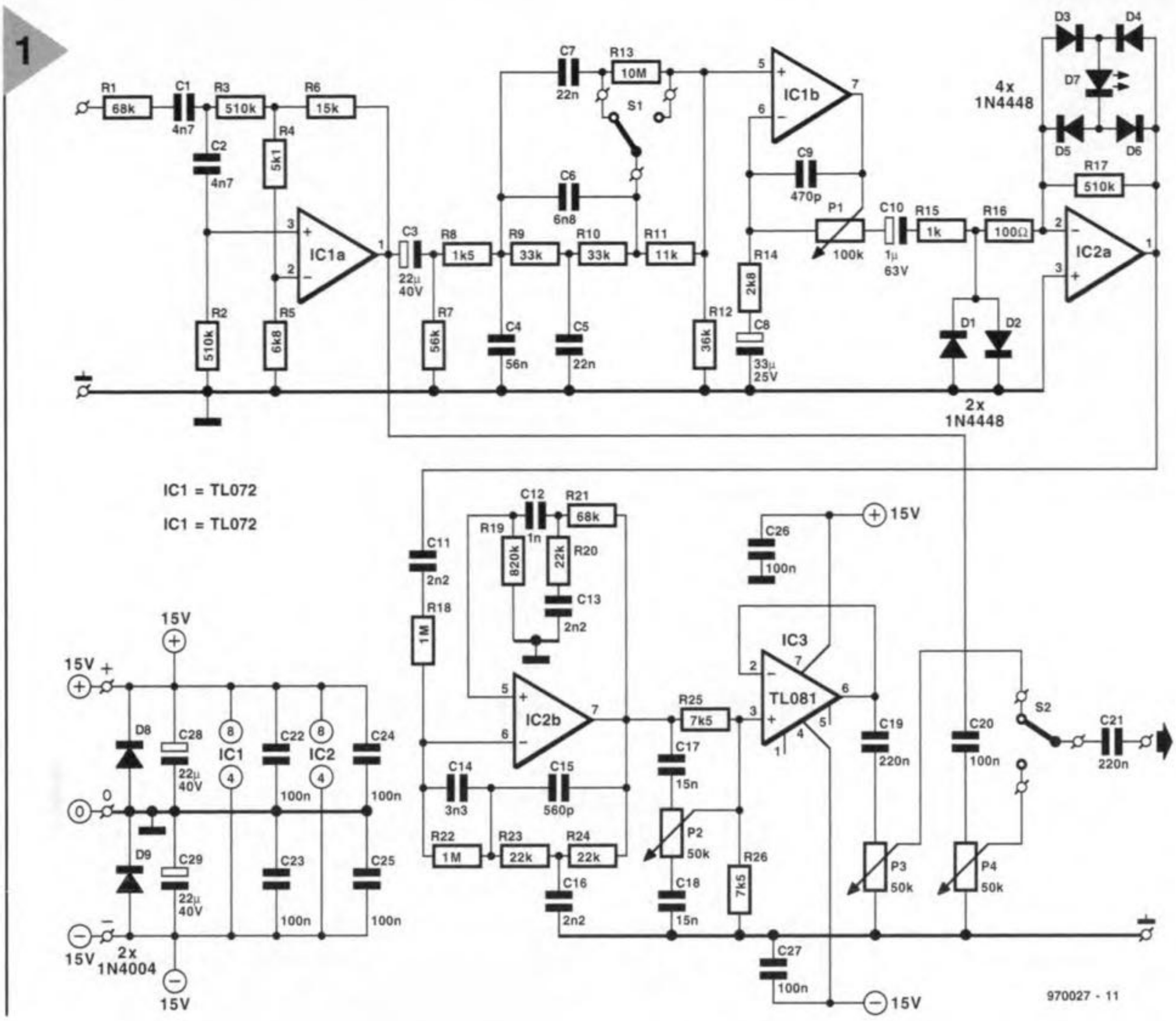


Figure 1. The circuit comprises an input amplifier, a low-frequency attenuator, variable clipper, an active low-pass filter, and an output buffer.

the same, with just three ICs, four potentiometers, and a small number of resistors and capacitors, the circuit is not that extensive.

Op amp IC_{1a} functions as impedance matcher and amplifier. The input impedance of 700 Ω is suitable for most electric guitars. The amplification is determined by $(R_6+R_4):R_5$ which with values as specified is about 3.

The input stage is followed by a passive filter consisting of R_7–R_{14} and C_4–C_7, which has a pass-band for the middle frequencies with a clear peak at 1 kHz. The lower frequencies may be further attenuated by switch S_1. When the contact of this switch is linked directly to pin 5 of IC_{1b}, the frequencies around 400 Hz are attenuated by an extra 6 dB.

Op amp IC_{1b} provides further amplification of the signal to a degree determined by P_1. This component does not operate as a standard volume control, but varies the level of the signal applied to the clipper following IC_{1b}.

The clipper consists of two parts. The first consists of a standard diode limiter, D_1-D_2, and the second comprises IC_{2a} and D_3–D_7. The level of both the negative and positive halves of the signal is limited by D_7. In conjunction with the earlier mentioned frequency correction, this circuit provides soft clipping. Since a large number of harmonics is generated at the same time, the overall effect is very reminiscent of that provided by valves (tubes).

The filtered and shaped signal is then applied to active low-pass filter IC_{2b}. This filter has steep slopes and a cut-off frequency of about 5.5 kHz. At the same time, the op amp provides additional amplification at around 100 Hz and 500 Hz.

The filter is followed by treble control P_2, which provides some correction of the high frequencies relative to the medium range.

Output buffer IC_3 ensures that cables of almost any length can be linked to the output without heavy signal losses or other problems.

SUMMARY OF THE CONTROLS

Switch S_1 gives an apparent boost to the middle frequencies (in fact, of course, it attenuates the lower frequencies with respect to the medium range). Although it is not, it may be termed mid-boost control.

Potentiometer P_1 provides control of the clipping effect.

Potentiometer P_2 is a treble control.

Potentiometer P_3 sets the level of the processed output signal.

Potentiometer P_4 functions as the output control of the linear signal.

Switch S_2 enables rapid switching between the distorted and original signals.

CONSTRUCTION

The distortion unit is best built on the printed-circuit board (not available ready-made) shown in **Figure 2**. If that is done, there is little hard wiring, since the potentiometers are all mounted on the board. Only switches S_1 and S_2, and the input and output jacks require to be linked to the board: the switches via short lengths of circuit wire and the jacks via short lengths of single-screened cable.

Parts list

Resistors:
R_1, R_{21} = 68 kΩ
R_2, R_3, R_{17} = 510 kΩ
R_4 = 5.1 kΩ
R_5 = 6.8 kΩ
R_6 = 15 kΩ
R_7 = 56 kΩ
R_8 = 1.5 kΩ
R_9, R_{10} = 33 kΩ
R_{11} = 11 kΩ
R_{12} = 36 kΩ
R_{13} = 10 MΩ
R_{14} = 2.8 kΩ
R_{15} = 1 kΩ
R_{16} = 100 Ω
R_{18}, R_{22} = 1 MΩ
R_{19} = 820 kΩ
R_{20}, R_{23}, R_{24} = 22 kΩ
R_{25}, R_{26} = 7.5 kΩ
P_1 = 100 kΩ
P_2 = 50 kΩ, linear
P_3, P_4 = 50 kΩ, logarithmic

Capacitors:
C_1, C_2 = 0.0047 μF
C_3, C_{28}, C_{29} = 22 μF, 40 V, radial
C_4 = 0.056 μF
C_5, C_7 = 0,022 μF
C_6 = 0.0068 μF
C_8 = 33 μF, 25 V, radial
C_9 = 470 pF
C_{10} = 1 μF, 63 C, radial
C_{11}, C_{13}, C_{16} = 0.0022 μF
C_{12} = 0.001 μF
C_{14} = 0.0033 μF
C_{15} = 560 pF
C_{17}, C_{18} = 0.015 μF
C_{19}, C_{21} = 0.22 μF
C_{20}, C_{22}–C_{27} = 0.1 μF

Semiconductors:
D_1–D_6 = 1N4448
D_7 = LED, red
D_8, D_9 = 1N4001

Integrated circuits:
IC_1, IC_2 = TL072CP
IC_3 = TL081CP

Miscellaneous:
S_1, S_2 = change-over switch
2 off 6.3 mm jack socket
Power supply: ±9 V or ±15 V mains adaptor or two 9 V batteries

2

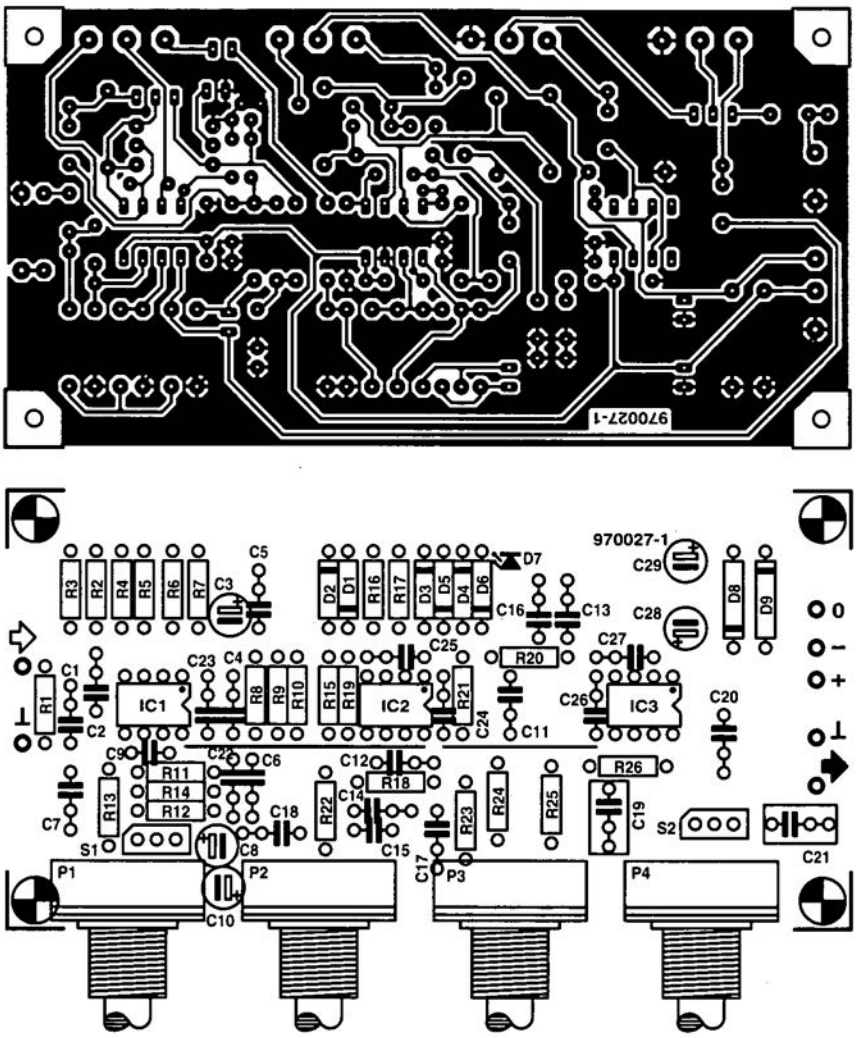


Figure 2. Printed-circuit board for the distortion unit, which is, however, not available ready-made.

Since the board is fairly small, it may be housed in a small, robust case, preferably of polythene. When choosing a case, bear in mind that it also has to house the power supply.

Although the circuit specifies symmetrical supply lines of ±15 V, lower levels (±9 V) may also be used. A small mains adaptor, in conjunction with suitable voltage regulators (7815 and 7915), may be used, but, since the current drain is only about 10 mA, battery operation is a very attractive alternative.

PERFORMANCE

A unit as described can be judged only by ear: figures and all sorts of characteristic curve do not mean all that much. Nevertheless, since it is of interest to a number of guitarists to see what roughly can be expected before construction is commenced, frequency response characteristics of the prototype are shown in **Figure 3**. The curves were obtained with P_1 and P_2 at the centre of their travel; the upper curve with S_1 linked to junction C_7-R_{13} and the lower one with it connected to pin 5 of IC_{1b}.

[970027]

3

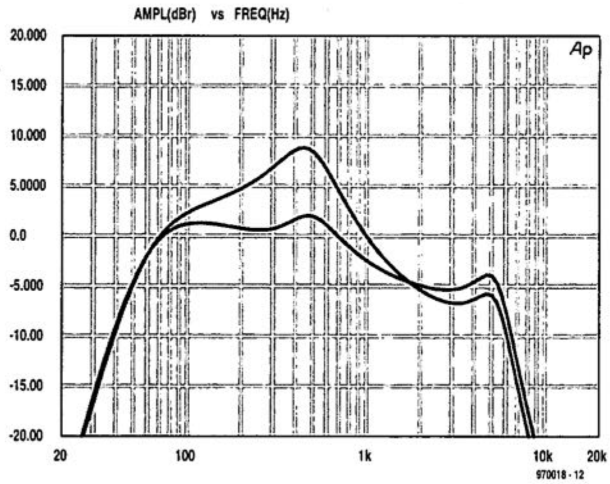


Figure 3. Frequency response curves of the distortion unit.

4-way serial port switch

from one to four RS232 ports

Although a PC can be equipped with four RS232 serial ports, only two of these are available on most machines. Worse, most laptops have just one serial port! The problems are obvious once a lot of equipment has to be hooked up to a serial port. The switch described in this article allows up to four peripheral devices to be connected to one and the same RS232 port.

Design by L. Lemmens

The serial port, available as a standard on any PC, is in popular demand. Apart from modems and mice, we see personal organizers, graphics tablets, chip card readers and label printers, all requiring a connection to the RS232 port. Moreover, many of you will have experimental circuits as well as programmers and emulators that also use the serial port. In practice, quite a bit of plugging and unplugging may be in order if you want to change from one serial device to another. Cumbersome, indeed, especially if the computer is installed in an awkward position. In these cases, the serial port switch comes to your rescue, allowing up to four serially controlled peripheral devices to be connected to it. The switch itself is then connected to the PC via a standard 9-way cable. Any one of the four peripherals may be connected through to the PC at the flick of a switch. LEDs on the front panel of the switch unit indicate which serial channel is being used.

Four times nine is nine

Although a 25-way connection was generally used for serial ports in the past, the smaller 9-pin variant is much more popular these days. For the sake of compatibility and simplicity, the port switch described here follows this trend and uses a 9-pin connection. If a 25-way connection is required, an adaptor (as supplied with most mice) may be used.

Assuming that the ground connection is shared between all peripheral devices, and that the 'ring indicator' (RI) is rarely used, seven signals remain which have to be taken into account: TxD, RxD, CTS, RTS, DCD, DSR and DTR. In practice, RTS and DTR (signals sent from the computer to the peripheral) may also be shared and thus interconnected without problems. Although peripheral devices which are not selected by the switch will then also receive these signals, this does no harm.

The block diagram in **Figure 1** shows the arrangement of the different signals. In addition to an array of electronic switches, the circuit contains a ring counter with four states, a number of level converters, a simple 5-volt supply and four LEDs acting as channel selection indicators.

The hardware

With the general structure of the circuit in mind, it is not too difficult to grasp the operation of the circuit shown in **Figure 2**. The supply uses an integrated voltage regulator type 7805 (IC1) with the usual satellite capacitors, here, C4, C5 and C6. Diode D2 has been added as a polarity reversal protection device, while D1 will short out any voltage surge that may occur at the output of IC1.

Circuit IC6 is a four-state ring counter which is incremented one step every time S1 is pressed. As soon as output Q4 goes high, the reset input is pulled high. As a result, Q0 is actuated again. Components C20 and R24 provide a power-up reset pulse which ensures that Q0 is active when the circuit is first switched on.

The switching of the RI (ring indicator) flag is given a very simple implementation, because very few peripheral devices make use of this signal. A jumper block, JP1-JP4, allows you to select the device (one of four) which actually needs the RI signal. If the signal is not needed by any of the four peripherals you have in mind, the jumper is simply not fitted.

The TxD signal (approx. 12 V in most cases) supplied by the computer arrives at pin 5 of K6, and is stepped down to TTL level by resistor R22 and IC8a. With R22 acting as a current limiter, use is made of the internal protection diodes in the gate.

The electronic switching of the TxD has a different arrangement than that for DSR, CTS, RxD and DCD. The TxD signal is selected with the aid of four bilateral analogue switches before it is

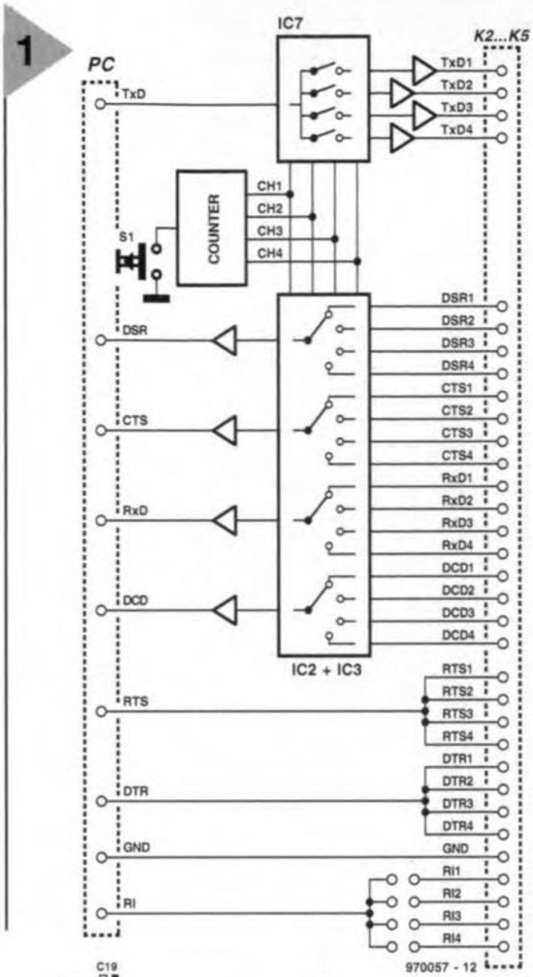


Figure 1. Block diagram of the serial port switch. It allows up to four serially controlled peripheral devices to be connected to a single RS232 port.

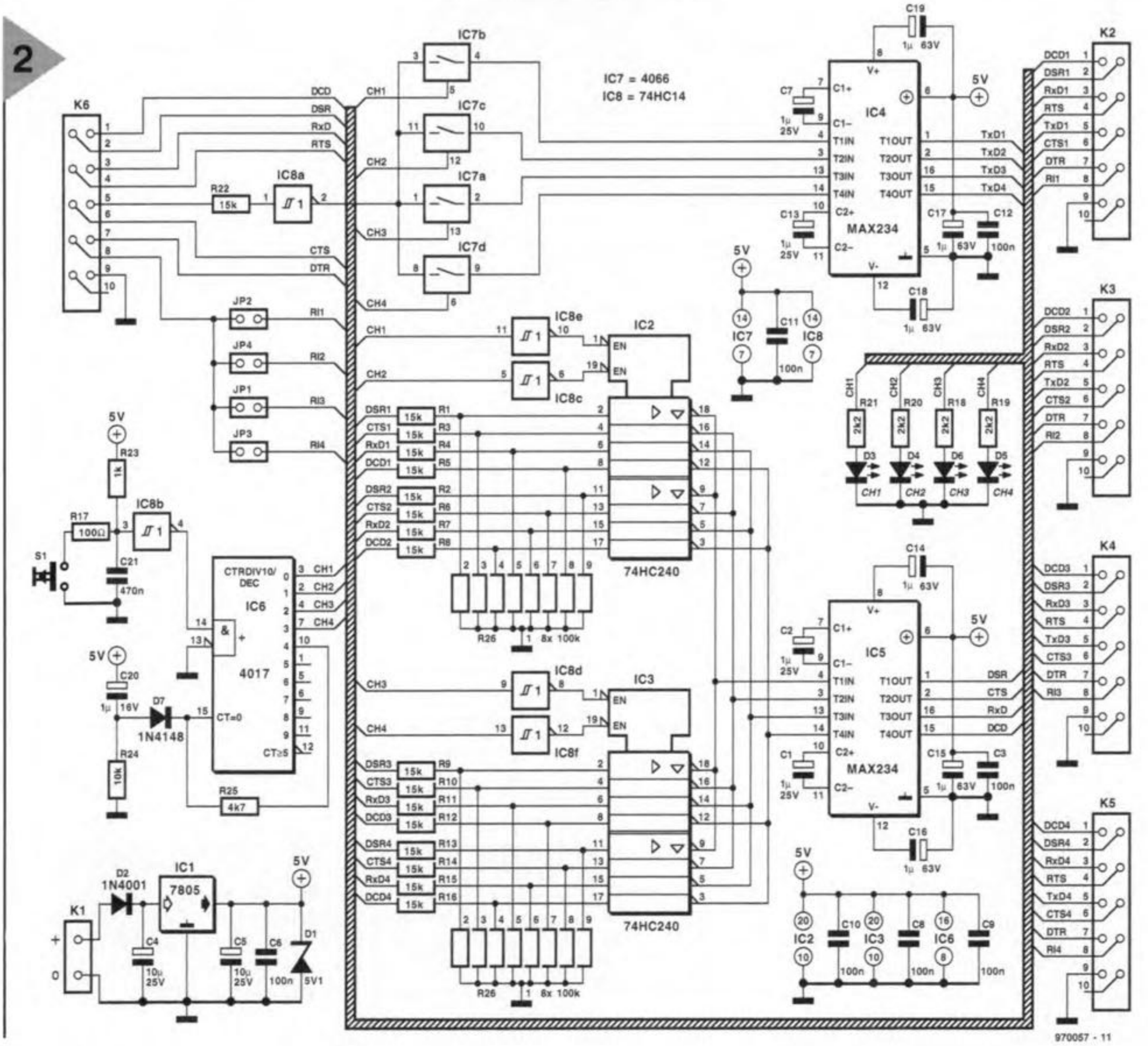


Figure 2. Circuit diagram of the four-way port switch. Basically, the project consists of five electronic multi-position switches, a number of level converters, and a counter.

COMPONENTS LIST

Resistors:
R1-R16,R22 = 15kΩ
R17 = 100Ω
R18-R21 = 2kΩ2
R23 = 1kΩ
R24 = 10kΩ
R25 = 4kΩ7
R26,R27 = SIL resistor array 8x100kΩ

Capacitors:
C1,C2,C7,C13-C20 = 1µF 25V
C3,C6,C8-C12 = 100nF
C4,C5 = 4µF7 25V, radial
C21 = 470nF

Semiconductors:
D1 = 5V1 400mW
D2 = 1N4001
D3-D6 = LED
D7 = 1N4148
IC1 = 7805
IC2,IC3 = 74HC240
IC4,IC5 = MAX234CPE
IC6 = 4017
IC7 = 4016
IC8 = 74HC14

Miscellaneous:
JP1-JP4 = jumper
K1 = 2-way PCB terminal block, raster 5 mm
K2-K6 = 10-way boxheader
S1 = single-pole switch
5 IDC sockets, 10-way
4 IDC style 9-pin sub-D plug (male)
1 IDC-style 9-pin sub-D socket (female)
Mains adaptor 9V, 25mA
PCB: order code 970057-1 (see Readers Services page)

3

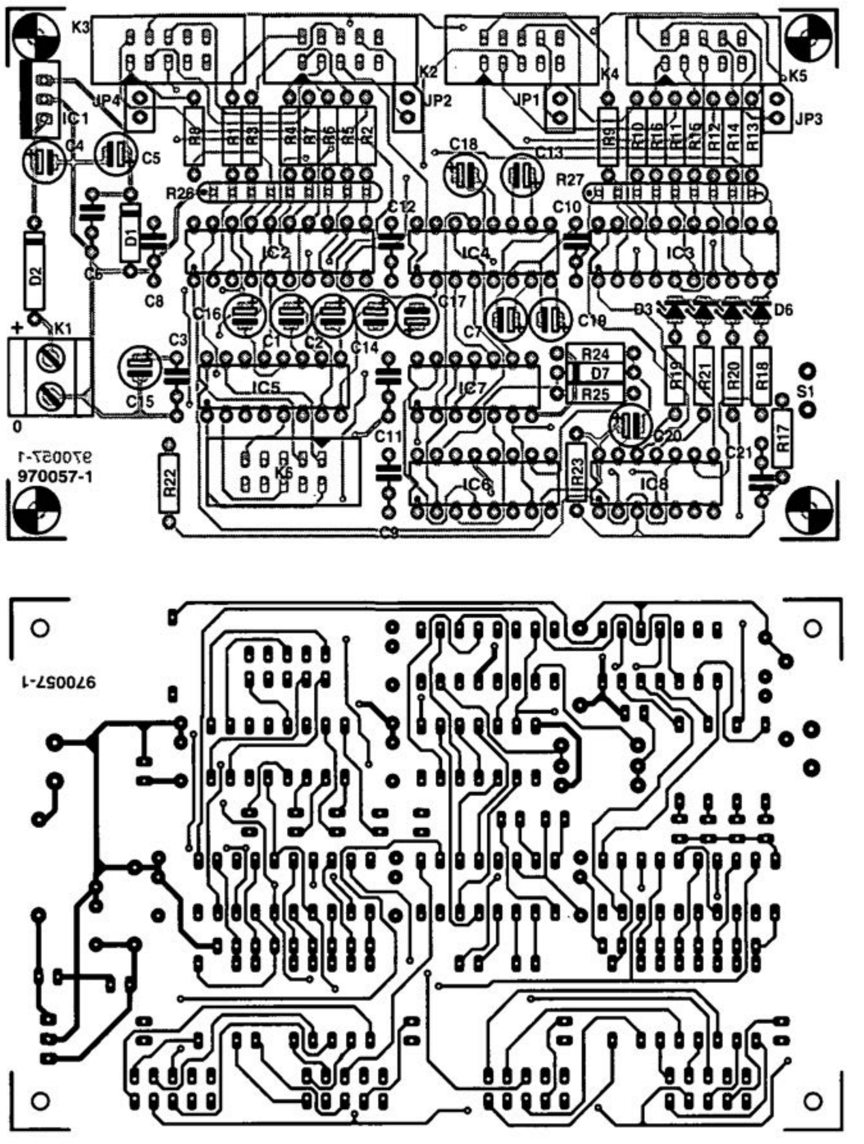


Figure 3. Copper track layouts and component mounting plan of the double-sided, through-plated board (available ready-made through the Readers Services).

applied to one of the level converter inputs. The state of counter IC6 determines which switch is closed. The output signals from the switches are converted from TTL swing to true RS232 levels. This is done by IC4, a MAX234CE from Maxim. This IC contains a charge pump which uses C7 and C13 to convert the 5-V supply voltage into a symmetrical ±12-V rail.

The remaining signals DSR, CTS, RxD and DSR are switched by IC2 and IC3. Each of these demultiplexers contains two digital four-to-one line converters. The corresponding outputs of all four converters are joined. Next, the switched signal appears at the input of the second MAX234CE, IC5. Here, too, the TTL level is changed into a true RS232 signal. Next, the signals are fed to connector K6 and, from there, to the serial port inside the PC.

Recapitulating: Depending on the counter state of IC6, the PC is automatically connected to K2 (CH1), K3 (CH2), K4 (CH3) or K5 (CH4).

Construction

You should be able to build this circuit on a rainy afternoon. There are no exotic or expensive components, and the layout of the printed circuit board for the project is given in **Figure 3**. This board is double-sided, through-plated and available ready-made through our Readers Services.

The component overlay indicates that a PCB terminal block is used in position K1, while 10-way boxheaders are applied for the remaining connections. The connection between each boxheader and the associated 9-way sub-D connector may be home-made using a short piece of flatcable. This is easiest done with the aid of a header and a sub-D connector of the insulation-displacement connector (IDC) type, components which require no soldering at all. An advantage of using these short cables is that you have a larger choice of enclosures for the circuit board to fit in.

For clarity's sake, the jumper that determines whether or not the RI signal is passed sits right next to each boxheader. In this way, you have an instant indication about a device which is actually capable of processing this signal.

The push-button and the LEDs are mounted on to the front panel of the case. The supply voltage may be delivered by a small mains adaptor unit (9 V at 25 mA).

Press to switch

As you might have expected, this switching unit is really simple to use. The computer is connected to K6, the peripheral devices to K2, K3, K4 and K5. LED D3 lights after switching on the power supply, indicating that K6 is effectively connected to K2, allowing the peripheral device on that channel to communicate with the PC. If you press the button once, the next peripheral is hooked up to the PC. Press four times and you're returned to the initial state. Now, isn't that simple?

(970057-1)

Corrections & Updates

4-way serial port switch

October 1997 - 970057

The correct value for capacitors C4 and C5 is 10µF, 25V, not 4.7µF, 25V as stated in the Components List on page 31.

PIC-controlled home alarm system

April 1997 - 970022

In some cases, D7 starts to flash rapidly although the alarm should go off. Normally, rapid flashing of D7 indicates an alternating-voltage fault. The problem may be solved by increasing the value of C2 to 33µF.

Function Generator

June 1995 - 950068

If the decimal point and the colon (:) are not displayed correctly, IC2 (in the frequency meter section) has to be replaced by a type 74HC7266.

ADC for Centronics port

July/August 1997 - 974088

Lines 130 and 140 in the program printed with this design generate a clock pulse too early. Once CS has dropped low, D7 is available on D-out (IC2). Lines 130 and 140 however cause D7 to be overwritten by D6, thus killing the MSB. This happens again in line 150 as a result of the assignment i=1.

The recommended remedy is to (1) delete lines 130 and 140 from the program, and (2) change line 150 to read: FOR i = 0 to 7.

dual output low-power thermostat Type LM56

The LM56 is ideally suitable for:

- Microprocessor thermal management
- Appliances
- Portable battery-powered 3.0 V or 5.0 V systems
- Fan control
- Industrial process control
- HVAC system
- Remote temperature sensing
- Electronic system protection

A National Semiconductor Application

GENERAL DESCRIPTION

The LM56 is a precision low-power thermostat. Two stable temperature trip points (V_{T1} and V_{T2}) are generated by dividing down the device's 1.250 V bandgap voltage reference with the use of three external resistors.

The LM56 has two digital outputs: OUT_1 goes low when the temperature exceeds T_1 and goes high when the temperature goes below (T_1–*Hyst*). Similarly, OUT_2 goes low when the temperature exceeds T_2 and goes high when the temperature goes below (T_2–*Hyst*). *Hyst* is an internally set 5 °C typical hysteresis.

The trip point accuracy (including V_{REF}, comparator offset, and temperature sensitivity errors) is within ±2–4 °C (depending on the version) over the temperature range –40 °C to +125 °C.

The switching points of the device are shown graphically in **Figure 1**.

Apart from the switching outputs, the LM56 also has an independent linear sensor output voltage, V_{TEMP}, which is

$$V_{TEMP} = (6.20\ \text{mV/°C} \times T) + 395\ \text{mV}.$$

The LM56 needs a power line of 2.7–10 V which, since the maximum current drawn is only 230 μA, is easily provided by batteries.

The LM56 is available in an 8-lead mini SO8 surface mount package or in an 8-lead small outline package.

TRIP POINT CALCULATION AND ERROR

The functional diagram of the LM56 is shown in **Figure 2**. Potential divider R_1–R_3 determines the trip points:

$$V_{T1} = (6.20\ \text{mV/°C} \times T_1) + 395\ \text{mV} = 1.250 \times R_1/(R_1+R_2+R_3),$$

and

$$V_{T2} = (6.20\ \text{mV/°C} \times T_2) + 395\ \text{mV} = 1.250 \times (R_1+R_2)/(R_1+R_2+R_3).$$

1

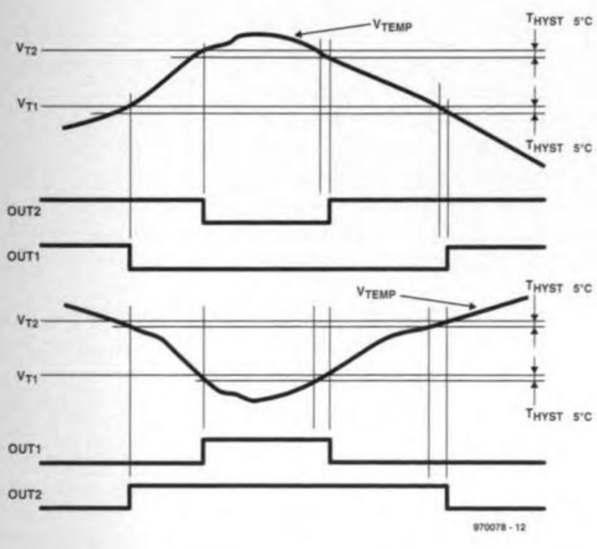


Figure 1. Switching behaviour of the LM56 when the temperature rises above the upper trip point or drops below the lower trip point.

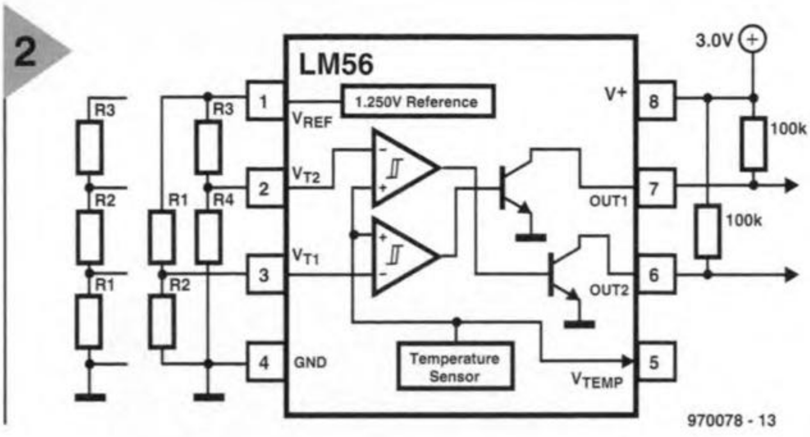


Figure 2. Internal circuit of the LM56 and a basic application. Isolated potential dividers for V_{T1} and V_{T2} ensure accurate trip points.

The data sheet gives the sum of the three resistors as 27 kΩ. This value is the optimum compromise between minimum current drain and minimum error.

Higher accuracy may be obtained by the use of two independent potential dividers, each consisting of two resistors only. The reason for this lies in the input current of the comparator. As long as the temperature lies below the trip point, virtually no current flows into the inverting input of the comparator. When the trip temperature is reached, the input current rises to 150 nA, and when the temperature rises even further, the current increases to a maximum of 300 nA. Even at the lower values of the current, it is easily calculated that the upper trip temperature in particular is affected by this additional current through the divider. This is especially true when the two trip values are close together. It is clear that in applications where accuracy is imperative the setup with two independent potential dividers should be used.

TYPICAL APPLICATION

The circuit for a simple overtemperature detector for power devices in **Figure 3** shows that an application using only one comparator is feasible. Here, an audio power amplifier is bolted to a heat sink and an LM56 temperature sensor is mounted on a PC board that is bolted to the heat sink near the power amplifier.

To ensure that the sensing element is at the same temperature as the heat sink, the sensor's leads are mounted to pads that have feed-throughs to the back side of the board. Since the LM56 is sensing the temperature of the actual PC board, the back side of the board has a large ground plane to help conduct the heat to the device.

The comparator's output goes low if the heat sink temperature rises above a threshold set by R_1, R_2, and the voltage reference. This fault detection output from the comparator can be used to turn on a cooling fan. In the figure, the fan is turned on when the heat sink temperature exceeds 80 °C and is turned off again when the heat sink temperature drop below about 75 °C. [970078]

Pin descriptions (Figure 2)

1.	*(V_{REF})*	***This is the 1.250 V bandgap voltage reference output pin. In order to maintain trip point accuracy, this pin should source a 50 µA load.***
2.	*(V_{T2})*	***This is the input pin for the low-temperature trip point voltage for OUT_2.***
3.	*(V_{T1})*	***This is the input pin for the low-temperature trip point voltage for OUT_1.***
4.	*(GND)*	***This is the ground pin.***
5.	*(V_{TEMP})*	***This is the temperature sensor output pin.***
6.	*(OUT_2)*	***This is an open-collector digital output, which is active low. It goes low when the temperature is greater than the T_2 set point and goes high when the temperature is less than T_2 - 4 ∞C. This output is not intended to drive a fan motor directly.***
7.	*(OUT_1)*	***This is an open-collector digital output, which is active low. It goes low when the temperature is greater than T_1 and goes high when the temperature is less than T_1 - 4 ∞C. This output is not intended to drive a fan motor directly.***
8.	*(V+)*	***This is the positive supply voltage. It should be bypassed with a 0.1 µF capacitor to ground.***

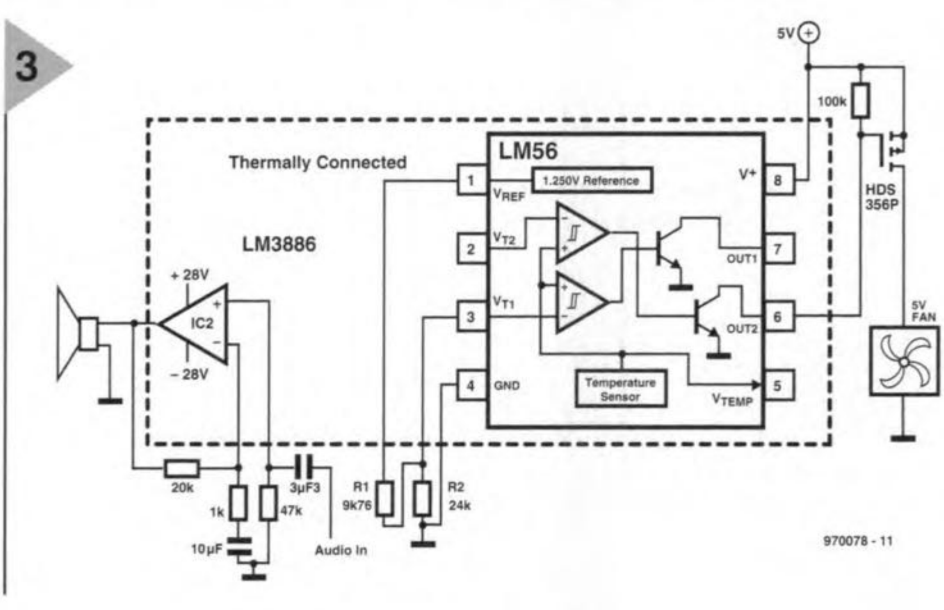
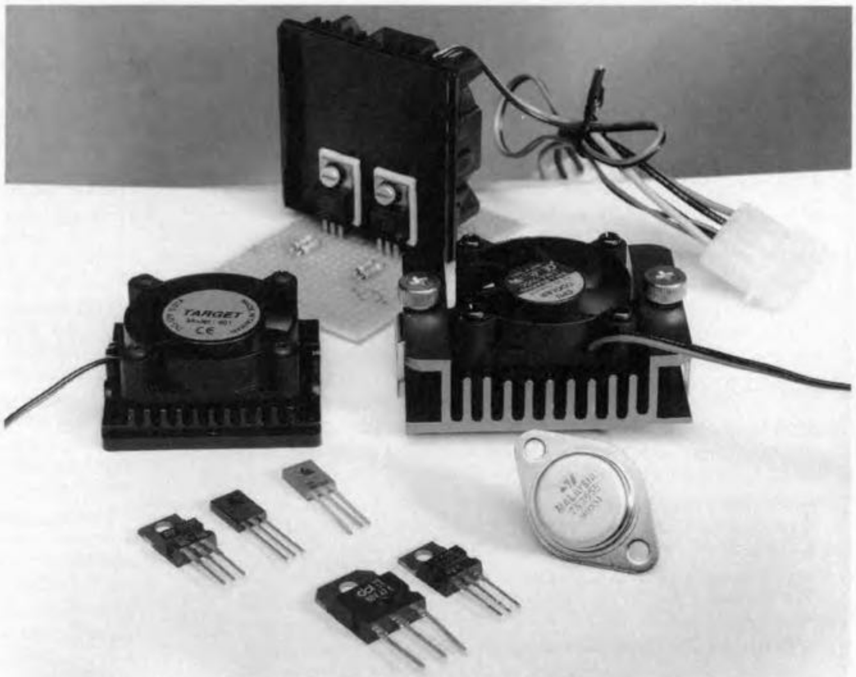


Figure 3. Overtemperature detector for an audio power amplifier. Note that the fan must be driven via a switching transistor, not directly by the comparator

active heat-sink

a different application for CPU coolers

For most electronics projects that require some form of cooling we make use of the classic heat-sink which employs the principle of passive or natural convection. In today's computers, the processor is cooled by means of a heat-sink which uses active convection. By adding a miniature ventilator, such a processor heat-sink achieves a thermal resistance which is very low relative to its size. This article shows how a low-cost CPU cooler may be used for different applications, and how its thermal resistance may be measured empirically.



Manufacturers of heat-sinks strive to keep the thermal resistance of their products as low as possible. That's why a physical shape is chosen which enables the flow of ambient air to 'accept' excess heat as quickly and efficiently as possible. Normally, the principle of natural convection is used, which means that the airflow which results from the heat developed by the heat-sink extracts the excess energy. For this, it is necessary to give the heat-sink a physical design which makes the effective area in direct contact with ambient air as large as possible. So now you know why heat-sinks are large, bulky and pricey!

Applications in which space is at a premium, for example, a computer or an amplifier, call for an extractor fan to increase the flow of air around the heat-sink. Although such a fan requires some extra energy and space, and also causes extra noise, it does provide a considerable increase in efficiency of the heat-sink.

CPU coolers were developed to keep the operating temperature of energy-hungry processors like the Intel 486 and Pentium within limits. Such a cooler consists of a compact heat-sink with a small fan secured on top of it. The size of the heat-sink matches that of the processor for which it is intended.

With some dexterity, such a cooling device may be used in combination with power transistors, voltage regulators and other heat dissipating components in electronic equipment. Because the thermal resistance of a CPU cooler is usually not stated by the manufacturer (who would want to know?) you have to measure it yourself using an experimental setup described below.

Design by H. Bonekamp

Measure it!

As some of you may have discovered the hard way, CPU coolers come in various shapes and ratings. These variants are necessary to match the vastly different electrical, thermal and physical specifications of the CPU types you can get at present.

Although most CPU coolers are designed for a specific processor type, information on their thermal resistance is sadly lacking in most, if not all, cases. Fortunately, this interesting specification is fairly easy to measure. The drawing in **Figure 1** shows an experimental setup which allows you to measure the thermal characteristic of the CPU cooler. The starting point is a small, thermally isolated space made from polystyrene, having one open side onto which the CPU cooler is fitted. Mount a power resistor, say, a 10-Ω 10-watt type, against the heat-sink, in such a way that it is encapsulated by the isolated 'case' when the heat-sink is secured to the open side. In this way, practically all heat dissipated by the resistor is transferred to the heat-sink. The wires connecting the resistor to the power supply are fed through one polystyrene wall.

Switch on the fan, apply about 12 volt to the resistor, and measure the current it carries. Calculate the power dissipated by the resistor, i.e., the amount of energy which is turned into heat. With forced cooling as applied here, a power of about 10 watts is a good starting point. Allow the resistor to heat up over a considerable period (at least 30 minutes), so that you are sure that a stable situation is reached as regards thermal behaviour. Now use a thermometer to measure the heat-sink temperature, and that of the ambient air. In this experiment, the heat-sink temperature should not exceed 50 to 50 degrees Celsius. If higher temperatures are measured, reduce the voltage across the resistor so that less power is dissipated. The thermal resistance of the heat-sink is the temperature difference between heat-sink and ambient air, divided by the amount of dissipated power.

Practical example

Voltage: 12 volt
Resistor: 15 Ω
Current: 800 mA
Power: 9.6 watts

Temperature
Air: 24°C
Heat-sink: 47°C

Thermal resistance R_{th}
$R_{th} = (47-24)/9.6 = 2.4$ K/W

A DIFFERENT APPROACH

If you know the brand of the CPU fan (look at the carton it came in) it may be possible to trace the manufacturer via the Internet. Many PC hardware manufacturers use a web site to provide an overview of their product line. In the case of CPU coolers, all essential component data are shown, including thermal resistance. Information on CPU coolers from TennMax Inc., for example, may be found at *http://www.tennmax.com*. Similarly, if you have a Design & Technology cooler, go to *http://www.destechinc.com*.

PRACTICAL USE

If the CPU cooler is used in an application for which it is not intended (but very suitable), then you have to remove all special clips and retainers which normally keep the device clamped on to the CPU. The special feed-through connector which is used to power the fan is also removed. The two fan wires are connected to the 12-V supply of the circuit in which the active cooler is applied. In most cases, the fan will happily work at a much lower voltage, say, 8 volts, but do remember that the thermal resistance derates, i.e., it goes up. However, the actual thermal resistance at the lower operating voltage may still be known if this voltage is also used in the experiment described above.

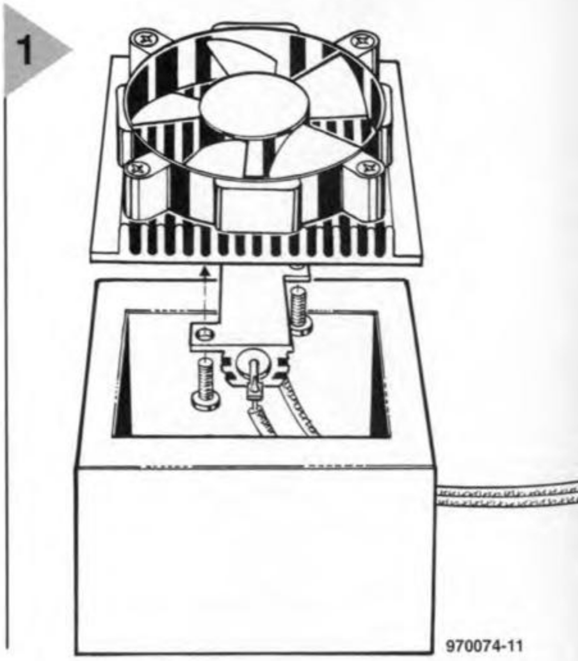


Figure 1. Suggested test setup to measure the thermal resistance of a CPU cooler.

The photograph in **Figure 2** shows how transistors or, for example, voltage regulators may be fitted on an active heat-sink. The results may be improved considerably if you apply some heat-conducting paste. Also ensure that the complete assembly is securely mounted to prevent fan vibration putting strain on IC terminals, which may break or come loose.

Finally, a practical example. Let's assume we want to build a linear power supply with an output voltage of +12, −12 and +5 V. all outputs should be capable of supplying a current of 1 A. The design is to employ three voltage regulators: a 7812, a 7912 and a 7805. The 12-volt regulators receive an input voltage of 20 volts, which results in a maximum dissipation of 8 watts per regulator. The 7805 receives an input voltage of 15 V, so that its maximum dissipation works out at 10 watts. So, when the supply is fully loaded, the voltage regulators dissipate a total power of 26 watts. If an active heat-sink is used with a thermal resistance of 1.5 K/W, this dissipation causes a temperature rise of 39 °C. If a passive heat-sink were used to achieve the same specification, you would have to go for a type like the Fischer SK 133 with a size of 150×40×50 mm and a thermal resistance of 1.7 K/W. Thanks to the modified CPU cooler, the power supply can be designed into a much smaller case than would have been possible using a passive heat-sink.

Figure 2. After removing the CPU mounting clips and other bits and pieces, you are left with a flat heat-sink to which a small fan is attached. The thermal resistance of this 'active cooler' is usually very low at less than 2 K/W.

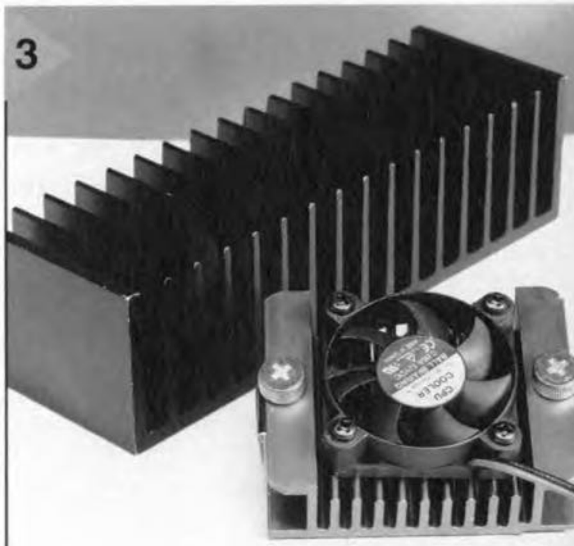


Figure 3. The difference is obvious. The passive heat-sink has a thermal resistance of about 1.7 K/W, while the much smaller active CPU cooler achieves 1.3 K/W.

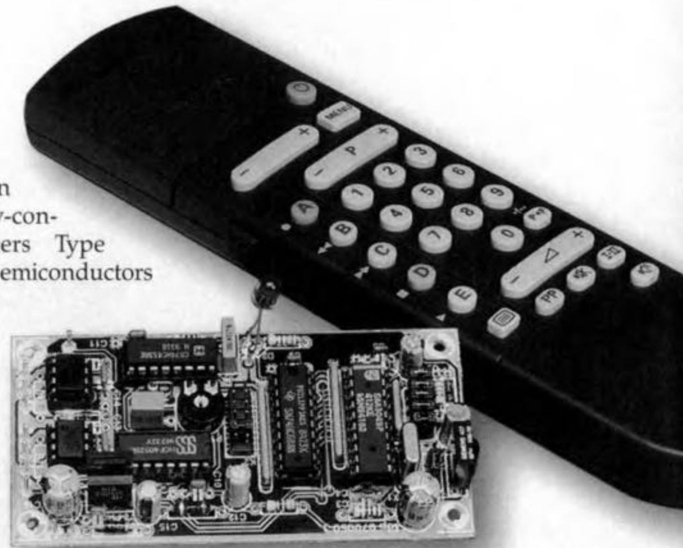
(970074-1)

infra-red-controlled noiseless volume control

with Type DS1669 electronic potentiometer

The circuit described in this article is eminently suitable for those who appreciate comfort as well as sound quality. In the circuit two integrated electronic potentiometers are operated by an RC5 infra-red remote controller to provide a volume control that is not only free of crackles and other annoying noises, but is also free of wear and tear. It is intended to be built on a small printed-circuit board that can be conveniently built into almost any existing amplifier.

Design by T. Giesberts



ELECTRONIC POTENTIOMETER

The design is based on two electronically-controlled potentiometers Type DS1669 from Dallas Semiconductors that were described in the January 1997 issue (page 38) of this magazine.

Briefly, these potentiometers consist of a resistance track tapped at 64 positions separated in equal steps, a 64:1 multiplexer, control circuits, and an EEPROM. The devices are available in a DIP case (Type DS1669), or an SMD (SO8) case (Type DS1669S). Both types are available in one of three values: 10 kΩ, 50 kΩ, or 100 kΩ. The value is identified by adding the number 10, 50, or 100, as the case may be, to the type coding.

The 64 outputs of the resistance track are fed to the multiplexer, which determines which of the outputs is required; the relevant data is then stored in the EEPROM. This ensures that even when the supply to the device is switched off, the set value of resistance is retained.

The control circuits are driven by (1) an up/down switch connected between UC and earth (input DC is connected to the supply line), or (2)

1

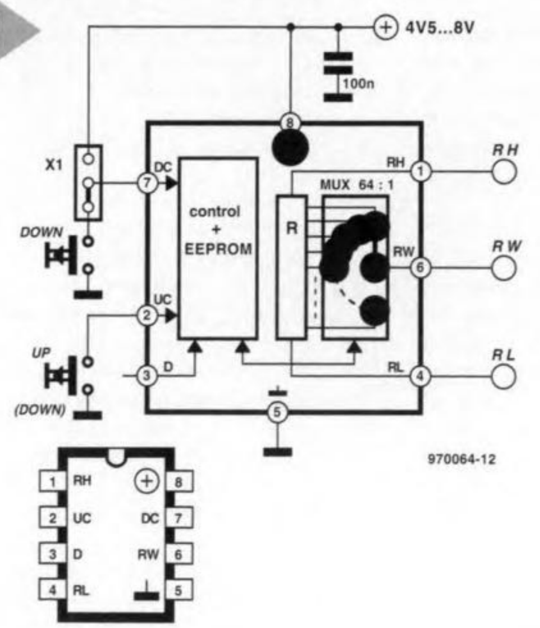


Figure 1. Block schematic of the Type DS1669 electronic potentiometer. The device is controlled by pulses provided by a microcontroller or generated manually.

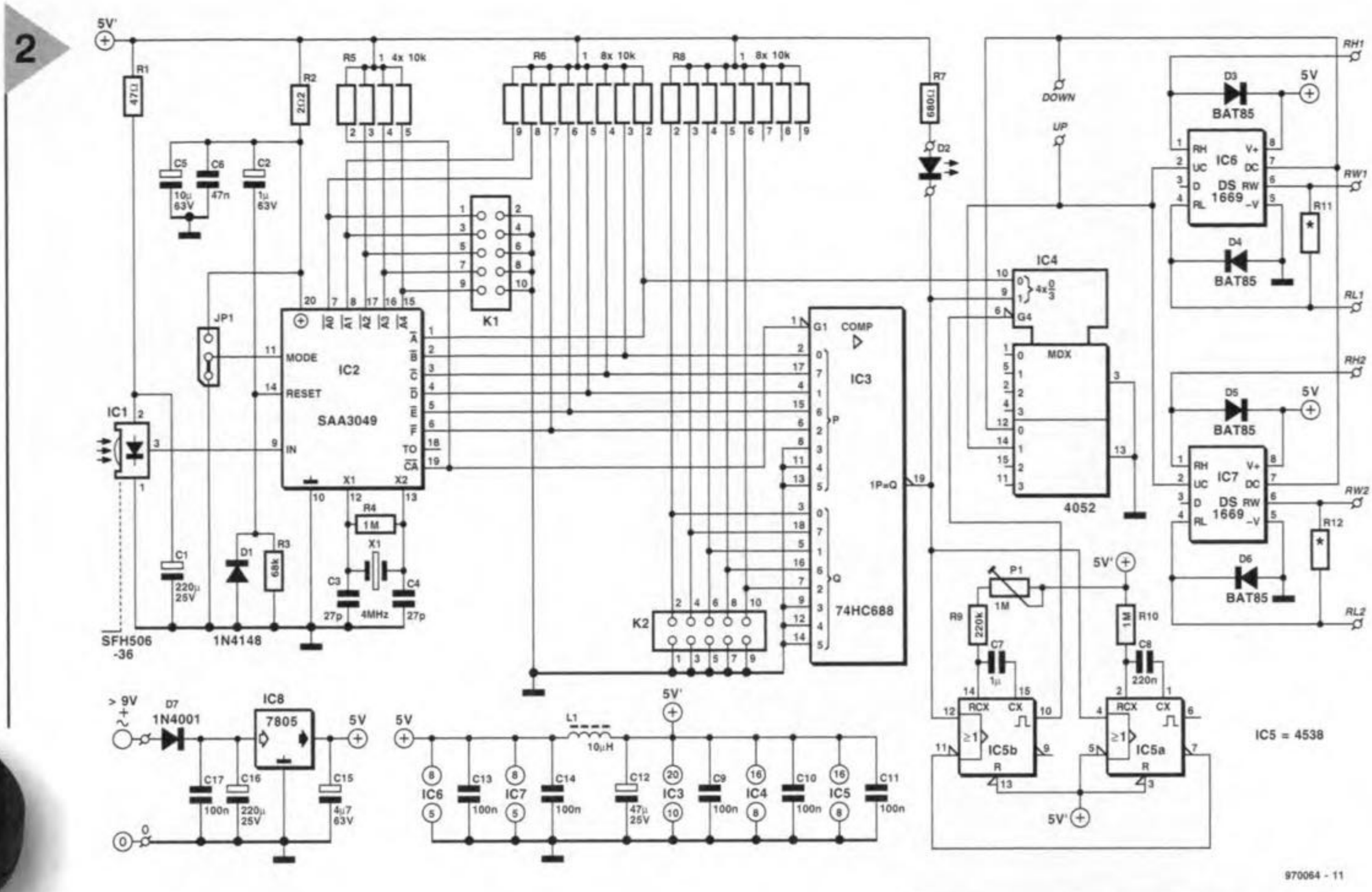


Figure 2. The circuit diagram of the volume control in which IC_6 and IC_7 are the actual potentiometers controlled by IC_4 and IC_5. The infra-red control signals are processed by IC_1–IC_3.

two down/up switches connected between DC and earth and UC and earth respectively, or (3) a microcontroller. The resistance track, *R*, is terminated into pins 4 (RL = *R* low) and 1 (RH = *R* high) (see **Figure 1**). In single-switch operation, when the switch is pressed, the imaginary wiper moves towards one end of the resistance track; when that is reached, it reverses direction and moves towards the other end. The same happens when the circuits are controlled by pulses from a microcontroller. In two-switch operation, when the 'down' switch is pressed, the imaginary wiper moves towards RL and when the 'up' switch is pressed, towards RH.

The D(igital) input intended for microcontrollers is internally debounced. For this purpose, the IC does not react immediately to a switch being pressed, but only after 1 ms. When a switch is pressed for less than 1 s, this is considered as one action. When the switch is held down longer than 1 s, the wiper is advanced one step every 100 ms; this is called the auto-repeat function. The wiper takes about 7 s to travel from one end of the track to the other.

The UC and DC inputs of the two potentiometers, IC_6 and IC_7 (see **Figure 2**) are switched by IC_4. In this, IC_{5a} and IC_{5b} perform a special function which will be reverted to later.

INFRA-RED CONTROL

The infra-red (IR) signal emitted by an RC5 controller contains two important data: the system address and the actual command. According to the RC5 code, the system address of a preamplifier is '16'. If this address is already occupied, or if the potentiometer is not fitted in a preamplifier but in another type of equipment, a different address may be used.

The address is set via inputs A_0–A_4. For address '16', inputs A_0–A_3 must be logic 0, which is arranged by short-circuiting pins 1 and 2, 3 and 4, 5 and 6, and 7 and 8, on K_1, and leaving 9 and 10 open. Address '0', reserved for television receivers, is set by short-circuiting all five sets of terminals. It is clear that the choice of key on the RC5 controller is determined by which of the pairs of terminals is short-circuited.

The signal from the RC5 controller is received by IC_1. This is a special device from Siemens which contains an IR photodiode and a complete receiver. The demodulated signal at its output, pin 3, is applied to decoder IC_2, which converts it into a digital signal. This signal is available as a logic level at outputs A–F. In the present circuit, only two commands are of interest:

address	F	E	D	C	B	A	command
16	0	1	0	0	0	0	louder
17	0	1	0	0	0	1	softer

Outputs B–F of IC_2 are linked to five of the P-inputs of digital comparator IC_3; the remaining three P-inputs are strapped to earth. The output, pin 19, of the comparator is low when the data word at the P-inputs is the same as that set at the Q-inputs via K_2. In that case, D_2 lights.

Output A of IC is purposely not linked to one of the comparator inputs, since the state of this bit (LSB) is different with commands 'louder' and 'softer' and might therefore upset the correct functioning of IC_3.

The receiver IC is decoupled by network R_1-C_1, and the decoder IC by network R_2-C_5-C_6.

Network R_3-C_2 provides a power-on reset for IC_2.

Jumper JP_1 enables decoder IC_2 to process RECS80 or RC5 codes. Normally, this will be the RC5 code, in which case the jumper must be between pin 11 and earth.

Crystal X_1, in conjunction with R_4, C_3 and C_4, ensures that the clock for IC_2 is correct.

Resistance arrays R_5, R_6, and R_8, function as pull-up resistors for the various inputs and outputs.

3

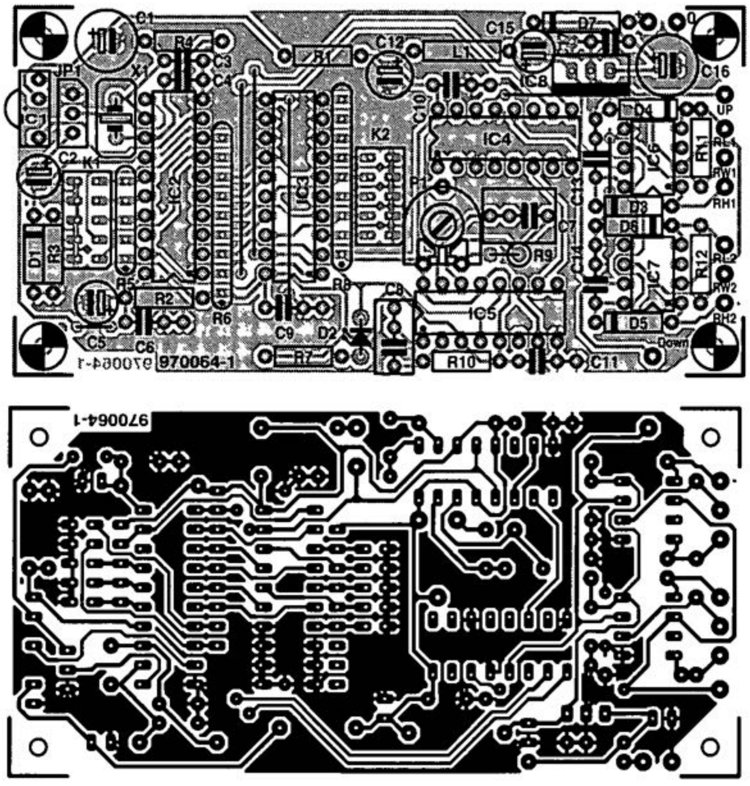


Figure 3. The printed-circuit board for the volume has been kept as small as possible to facilitate its being built into an existing equipment. Make sure that IC_1 is exposed to the outside world.

SYNCHRONOUS CONTROL

It was stated earlier that the potentiometers are controlled by linking the UC and DC inputs to earth. This is effected by an analogue multiplexer, two of which are contained in IC_4. The use of a multiplexer makes it possible for two switches to be added if desired. For this purpose, pins 'up' and 'down' are provided on the printed-circuit board. The Type 4052 used for IC_4 has the added advantage of not needing additional logic circuits for the correct decoding of the rotary direction.

The address of the multiplexer is a combination of the decoded LSB (output A of IC_2) and the output of IC_3.

As mentioned earlier, when the UC or DC input of IC_6 or IC_7 is actuated longer than 1 s, their wiper is shifted automatically one step every 100 ms. In the present circuit, in which the ICs are controlled in parallel, the wipers may not always move in synchrony, and this is why the auto-repeat function is disabled. Instead, the ICs are driven by discrete pulse trains available at the CA output of IC_2. When the signal from the RC5 controller is sustained, a 15 ms wide pulse appears at the CA output every 120 ms. Both the width and the repetition frequency of these pulses are eminently suitable for repeated actuation of the potentiometers. More importantly, synchrony of operation is guaranteed.

DEAD TIME

The output of comparator IC_3 remains low as long as the CA output of IC_2 is active, which makes it difficult to ensure that the wipers of IC_6 and IC_7 do not move more than one defined step. Therefore, a dead time is provided by IC_5, which may be set between 0.22 s and 1.22 s with P_1. The arrangement is that the first wiper movement takes place immediately IC_3 outputs a pulse. Then follows the dead time, and then the pulse train.

The dead time is actuated by triggering monostable IC_{5b} at the leading edge of the first pulse output by IC_3. The Q-output of IC_{5b} is then high and prevents any further wiper movement by disabling the inhibit input of IC_4.

Since the Type 4538 used for the monostable is retriggerable, IC_{5a} has been added to prevent unwanted lengthening of the dead time. Both monostables are triggered simultaneously, so that IC_{5a} at once disables the trigger input of IC_{5b} by making pin 11 low. Since the mono time of IC_{5a} is longer than the repetition time of IC_3, any pulses repeated at the output of the comparator have no effect.

The length of the dead time is best determined empirically; normally, it will be sufficient to set P_1 to the centre of its travel.

Parts list

Resistors:

R_1 = 47 Ω
R_2 = 2.2 Ω
R_3 = 68 kΩ
R_4, R_{10} = 1 MΩ
R_5 = array 4×10 kΩ
R_6 = array 8×10 kΩ
R_7 = 680 Ω
R_9 = 220 kΩ
R_{11}, R_{12} = optional, see text
P_1 = 1 MΩ preset potentiometer

Capacitors:

C_1, C_{16} = 220 μF, 25 V, radial
C_2 = 1 μF, 63 V, radial
C_3, C_4 = 27 pF
C_5 = 10 μF, 63 V, radial
C_6 = 0.047 μF, ceramic
C_7 = 1 μF, MKT (metallized polyester), pitch 5 mm or 7.5 mm
C_8 = 0.22 μF
C_9–C_{11}, C_{13}, C_{14}, C_{17} = 0.1 μF, ceramic
C_{12} = 47 μF, 25 V, radial
C_{15} = 4.7 μF, 63 V, radial

Inductors:

L_1 = 10 μH

Semiconductors:

D_1 = 1N4148
D_2 = LED, high efficiency
D_3–D_6 = BAT85
D_7 = 1N4001

Integrated circuits:

IC_1 = SFH506-36 (Siemens)
IC_2 = SAA3049P (Philips)
IC_3 = 74HC688
IC_4 = 4052
IC_5 = 4538
IC_6, IC_7 = DS1669 (Dallas Semiconductors)
IC_8 = 7805

Miscellaneous:

JP_1 = 3-way terminal strip with jumper
K_1, K_2 = dual 10-way terminal strip with 5 jumpers
X_1 = crystal, 4 MHz
PCB Order No. 970064 (see Readers Services toward the end of this issue)

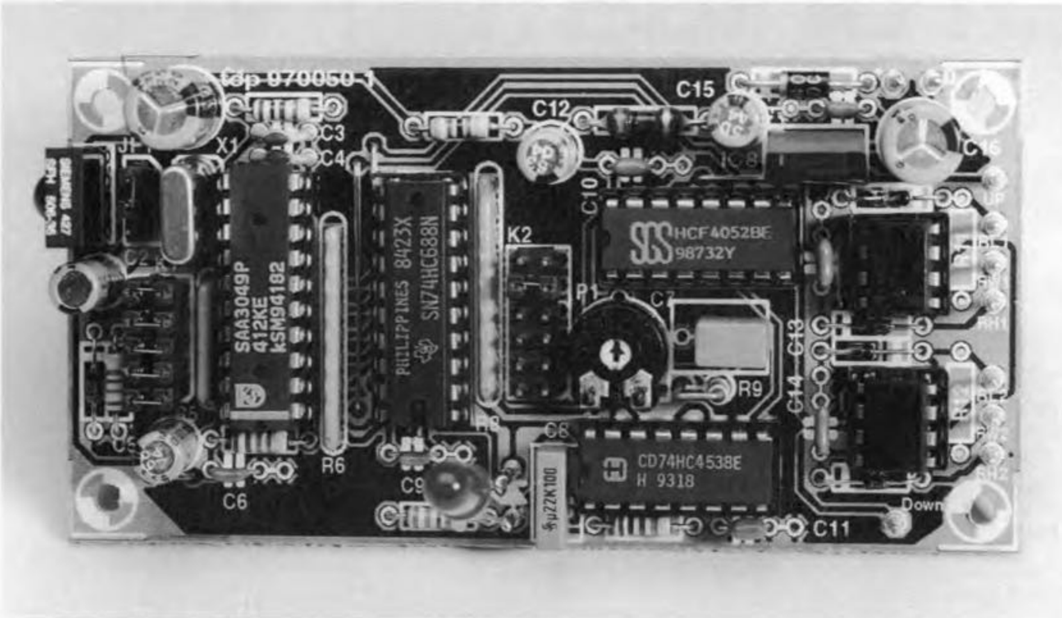
PRINTED-CIRCUIT BOARD

The circuit is best constructed on the printed-circuit board shown in **Figure 3**, which has been kept as small as possible since it is expected that most constructors will want to built it into an existing equipment to replace the volume control(s) in this. The connections to this control must be cut and linked to terminals RH, RW, and RL on the board.

FINALLY...

Although IC_6 and IC_7 are protected against high input voltages by diodes D_3–D_6, the applied input signal should not exceed 1.5 V r.m.s.

The linear characteristic of the potentiometers may be given a rather more logarithmic aspect by connecting



resistors R_{11} and R_{12} between the RW and RL terminals as shown in Figure 2. The value of these resistors should be ¼–1/16 of the value of the potentiometer. Be careful, however, not to damage the ICs, because the current flowing through the wiper must not exceed 1 mA. This means that the resistors should only be used with 100 kΩ potentiometers.

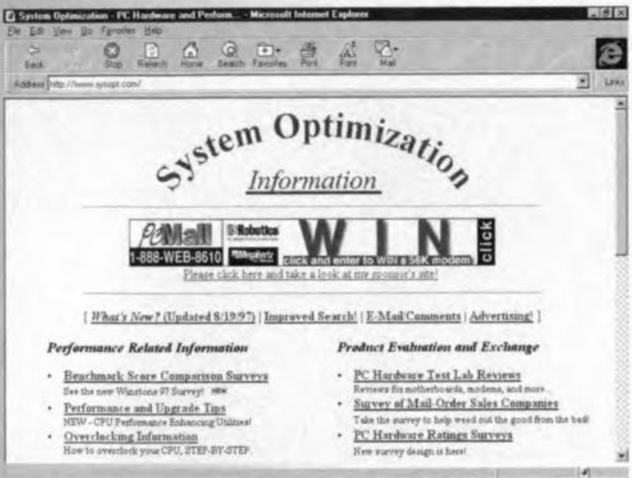
When the circuit is built into an existing equipment, it must, of course, be done in such a way that the IR receiver is exposed to the outside world. It may be necessary in some cases to extend the terminals of the IC with three short lengths of insulated circuit wire.

Since the circuit has its own rectifier (D_7) and regulator (IC_8), the input power supply may be any a.c. or d.c. source providing 9 V or more. This may be a mains adaptor, but it may also be possible to draw it from the equipment into which the volume control is to be fitted.

(970064)

electronics on-line

upgrading



Your faithful editorial staff scoured the Internet for interesting sites that link to the subject of this month's Supplement: PC Upgrading. If, after reading the articles in the Supplement, you can't wait to have a go at PC tuning and upgrading, read this page, too, because it provides useful links to additional information about the subject.

There are lots of people on the Internet, individual enthusiasts as well as company workers, who are involved in building, upgrading and extending computers. Most companies use their webbed information to promote sales of hardware to interested clients. Manufacturers of, for example, motherboards and processors are generally more interesting because they are able to present really useful information on their products. None the less, the most gratifying sites, in our opinion, are the ones designed and run by private individuals.

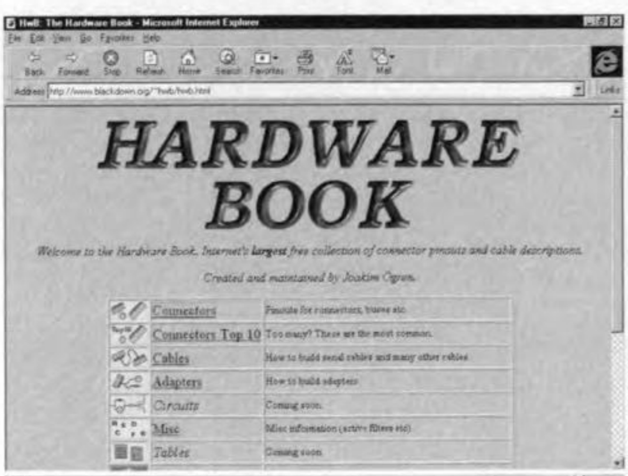
A very extensive site covering computer systems is the **System Optimisation Web Site** (*http://www.sysopt.com/*) where you find test programs, information about upgrading and overclocking, hardware and software data and hardware tests. Well worth prying into.

The second favourite on our list is **Tom's Hardware Guide** (*http//www.sysdoc.pair.com/*) which is a real treasure trove for computer-related information. It contains tests of various recently introduced PC mainboards, news snippets on the latest technologies and processors, and an extensive story on overclocking. Tom also organizes a couple of surveys covering mainboards and overclocking. Here, long lists may be found in which site visitors state their findings with these subjects.

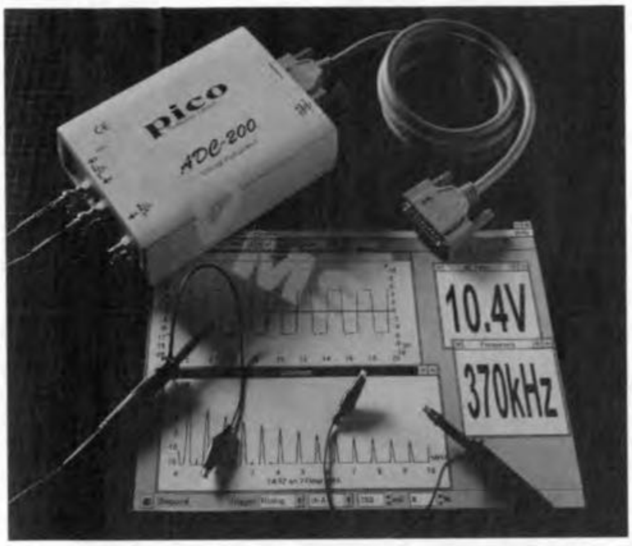
Beginners as well as experienced computer tuners will find lots of data on home construction and upgrading of PCs in **The Upgraders' Workshop** (*http:///www.computernerd.com/workshop.htm*). If you are interested in building your own PC, the site called **Build Your Own PC** (*http://www.verinet.com/pc/*) is also worth a visit. Here you find A-to-Z information on everything you should be aware of if you want to assemble a PC yourself. If your hunger for information is still not satisfied, then take a look at the **Build a Computer** site (*http://www.geocities.com/Siliconvalley/lakes/7903/assembly.html*).

Another good site for the PC builder is called **PC Mechanic** (*http://www.pcmech.pair.com*). As implied by its name, this web site provides a lot of information on all hardware in and around the computer. But that's not all, because the PC Mechanic pages also deliver a lot of other useful information like error codes and DMA usage.

Finally, an address which is not just of interest for building or upgrading a computer. **The Hardware Book** (*http://www.blackdown.org/~hwb/hwb.html*) contains one of the largest collections of connector and cable data ever seen on the Internet. We say it's definitely worth adding to your list of Favourite Sites! (975065-1)



New 100 MS/s PC based oscilloscope from Pico



Pico Technology's new ADC 200-100 virtual instrument combines 100 MS/s dual channel oscilloscope with a 50 MHz spectrum analyser for a fraction of the cost of comparable benchtop instruments.

The latest model in the popular ADC200 range offers all the functionality of a normal benchtop scope together with all the advantages of PC connection such as the ability to annotate, save and print waveforms. Other benefits are context sensitive help and the ability to 'copy and paste' waveforms straight into a word processor. In applications such as education and training where groups of people have to see the screen at once, the use of a PC colour screen provides a vast improvement over a benchtop scope display.

The Picoscope software provides advanced facilities such as simultaneous views of scope, spectrum and meters, and displays of both live and reference signals in the same window. It also features two trigger modes to capture intermittent one-off events: a *Display Over-write* mode which highlights differences from the normal waveform, and a *Write to Disk* on trigger mode which saves the waveform to disk (with a time/date stamp) each time the trigger event occurs.

Having a spectrum analyser is fast becoming a 'must have' option for many scope purchasers. Applications such as tracking down noise on power lines are difficult on a scope display, but on a spectrum analyser noise from mains hum, switching power supplies and microprocessor clocks can be quickly identified. The 50 MHz range (compared with 25 MHz on the ADC200-50) also covers the whole range required for EMC conducted noise tests.

For users who wish to write their own software for the ADC200, drivers are included for DOS and Windows (16 and 32 bit). Also included is a macro to allow data to be collected straight into MS Excel spreadsheet.

At £549, complete with cables and power supply, Pico's new, even more capable virtual instrument combines the PC's capability in data acquisition and manipulation with the traditional with the traditional functions of 'benchtop' instruments at an unbeatable price.

Pico Technology, Broadway House, 149–151 St Neots Road, Hardwick, Cambridge CB3 7QJ. Telephone +44 (0)1954 211 716; fax +44 (0)1954 211 880.

INNOVATIVE AND INTERACTIVE TEACHING/TRAINING AID

TecQuipment, the educational equipment manufacturer, recently added the CE300 Logic Circuit Trainer to their well-established range of control engineering products the. This is an innovative yet low-cost interactive software and hardware solution for the effective teaching and training of logic circuits and digital system development.

What sets the CE300 apart from its competitors is the accessibility and usefulness of its intuitive Windows-based graphical operating software with its easy-to-use drag-and-drop interface. The CE300 provides the essential facilities for students to quickly create and investigate an unlimited selection of digital devices and circuits – from the characteristics of logic gates to full-size representation of commercial logic devices and beyond.

The CE300 provides step-by-step signal analysis using dynamic colour-coded signal paths: an ingenious solution to one of the fundamental teaching problems of how to demonstrate to a student, and how to obtain an understanding of what actually happens between the input and output of a logic circuit.

The CE300 is suitable for courses delivering the basic principles of individual logic devices through to ad-advanced logic applications and project work. It is also highly suitable for industry project, research and development work and is ideal for distance/open learning.

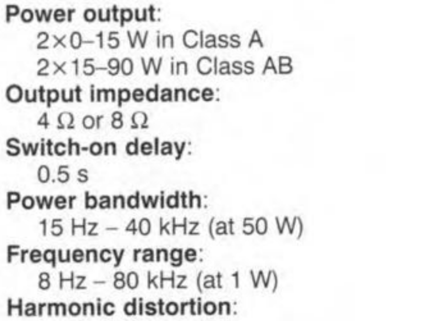
TecQuipment Ltd, Bonsall Street, Long Eaton, Nottingham NG10 2AN. Telephone +44 (0)115 954 0133; fax +44 (0)115 973 1520.

VELLEMAN K4040

Velleman's well-known valve amplifier Type K4000 has been succeeded by a new model Type K4040. Because of its chromium finish, the new model does not only look good, but also incorporates several sensible improvements. For instance, the bottom panel has been made removable to facilitate easier assembly and servicing. The wiring has been simplified, polypropylene capacitors replace earlier types and the unit itself has been fitted with gold-plated loudspeaker terminals. The new amplifier has a standby facility and a soft start for the mains power transformer. Finally, the quiescent-current setting has been simplified by the addition of a special LED meter.

Brief technical data

Power output:
2×0–15 W in Class A
2×15–90 W in Class AB
Output impedance:
4 Ω or 8 Ω
Switch-on delay:
0.5 s
Power bandwidth:
15 Hz – 40 kHz (at 50 W)
Frequency range:
8 Hz – 80 kHz (at 1 W)
Harmonic distortion:
0.1% (1 Khz; 1 W)
0.7% (1 kHz; 90 W)
Signal-to-noise ratio:
>105 dB (A-weighted w.r.t.90 W)
Channel separation:
>75 dB w.r.t. 90 W
Input impedance:
34 kΩ
Input sensitivity:
1 V r.m.s. for 90 W
Damping factor:
≥ 10 (100 Hz)



DC nullifier for oscilloscope input

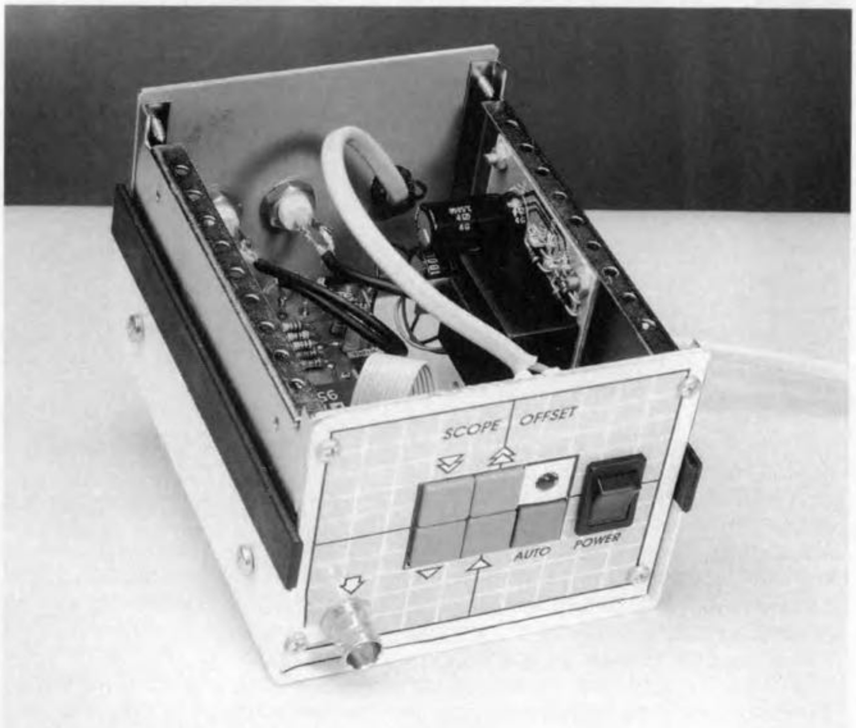
accurate input adaptor

Features

Input impedance	1 MΩ
Amplification	Unity
Nullifying voltage	±10 V
With 1:10 probe	±100 V
Auto setting	<100 mV
>: key	+4.88 V step (+1)
<: key	–4.88 V step (–1)
>>: key	+156 mV step (+32)
<<: key	–156 mV step (–32)

Inspecting and analysing low-frequency signals superimposed on a fairly high-level direct voltage with an oscilloscope, set to its a.c. position, is not as straightforward as you might wish as anybody who has ever tried it will testify. One satisfactory way of performing such tests is by removing the direct voltage from the input signal to the oscilloscope. The adaptor described in this article was designed to do just that.

Design by H. Bonekamp



INTRODUCTION

In practical measurements, low-frequency signals superimposed on a direct voltage frequently pose an awkward problem. This is the case, for instance, with certain sensors and in drift measurements. It is also true when the ripple on the (wanted!) direct-voltage output of a power supply needs to be inspected or analysed.

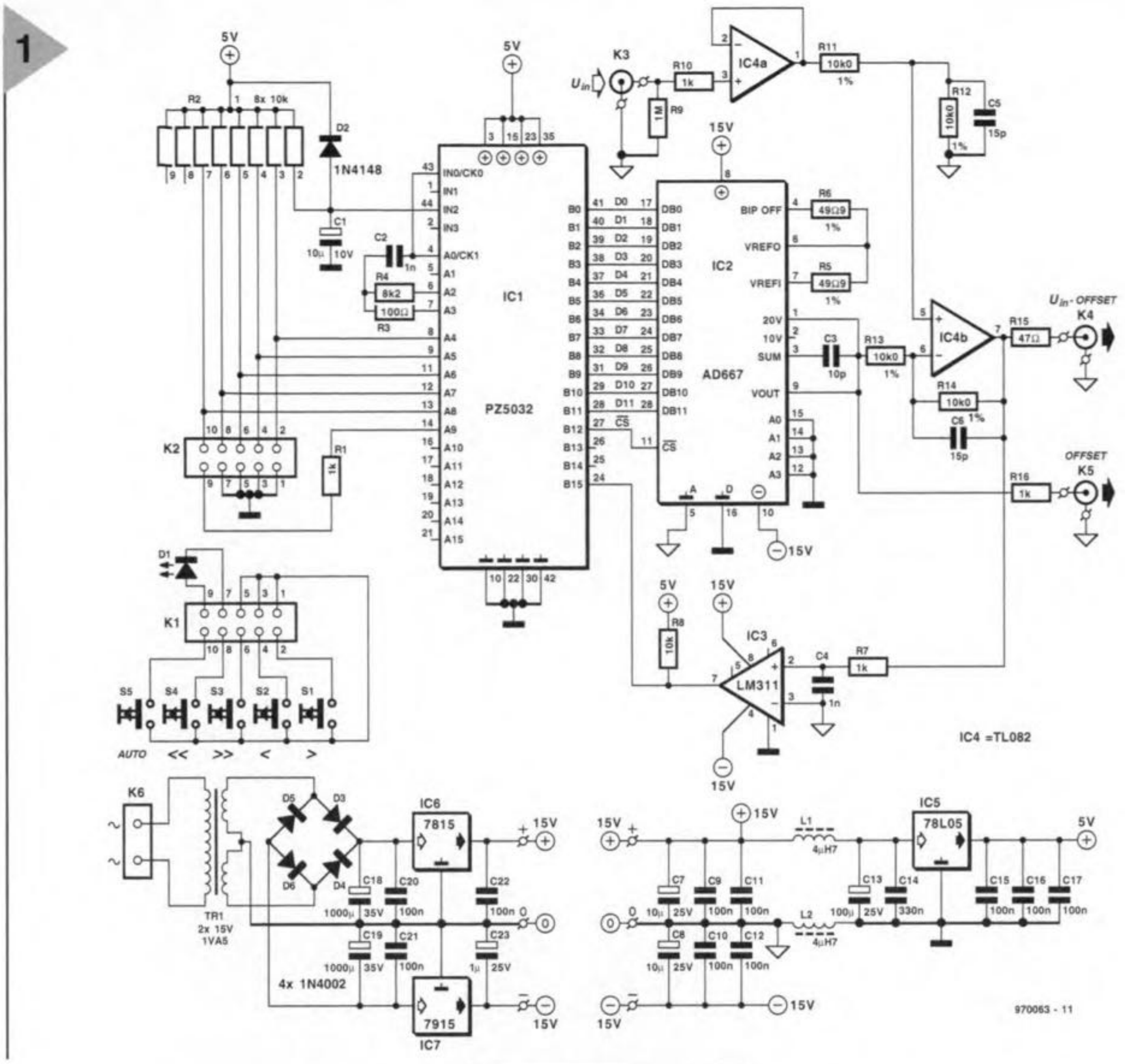
The adaptor nullifies the direct voltage, whether wanted or not, by externally subtracting from it an equal direct-voltage but of opposite sign before the signal is presented to the oscilloscope. It consists of three parts: (1) a stable reference voltage source; (2) an attenuator that can be varied with great precision; and (3) a suitable summing circuit that adds the externally provided direct voltage at correct polarity to the input signal.

There are, of course, a number of ways in which such circuits may be designed. The most obvious of these is to use a discrete reference-voltage source whose output is applied to, for instance, three decade attenuators. This setup provides a reasonably accurate, variable direct voltage. However, because it is so obvious, it would hardly be an original design. In the present circuit, therefore, a different approach has been used.

PROGRAMMABLE DIGITAL-TO-ANALOGUE CONVERTER (DAC)

The external, nullifying direct voltage is provided by a 12-bit digital-to-analogue converter (DAC). This has a range from –10 V to +10 V, so that the smallest discrete step is $20 \times 2^{-12} = 4.88$ mV. The converter is controlled by a Complex Programmable Logic Device (CPLD), which keeps the circuit fairly simple.

In **Figure** 1, the measurand(that is, the input signal to the oscilloscope) is applied to K_3 and then buffered by IC_{4a}. The buffered signal is applied to differential amplifier IC_{4b} where the direct-voltage component is nullified. The nullifying direct voltage needed



for this is provided by output V_{out} of DA converter IC_2 This stage is driven by the logic device, IC_1, which in turn is controlled by the instructions from the control panel connected to K_2. Switches S_1–S_4 enable very accurate setting of the nullifying direct voltage in small or large steps. Setting may also be automatic by switch S_5 – this will be reverted to later.

Comparator IC_3 determines whether the direct voltage on which the signal is superimposed is positive or negative and on the basis of this applies a 'direction bit' to the 12-bit up/down counter in IC_1. The low-frequency signal from which the direct voltage has been removed is available at K_4. The nullifying direct voltage is also available externally via K_5 to enable it being measured and used for computation.

The supply lines are obtained with the aid of three integrated voltage regulators. The symmetrical ±15 V lines are provided by Tr_1, rectifier D_3–D_6 and IC_6 and IC_7. The +5 V line for IC_1 is derived from the +15 V line via regulator IC_5. Inductors L_1 and L_2 improve the noise suppression to ensure that the signal to the oscilloscope is as clean as possible.

Figure 1. The circuit diagram of the DC nullifier for oscilloscope inputs.

COMPLEX PROGRAMMABLE LOGIC DEVICE

As mentioned earlier, the digital-to-analogue converter, IC_2, is controlled by complex programmable logic device (CPLD), IC_1, detailed characteristics of which are given in the Datasheet elsewhere in this issue. **Figure 2** shows the block schematic of the internal circuit of the device. In essence, the device consists of three sections: an oscillator, a control circuit with debounce and repeat facilities, and a 12-bit up/down counter.

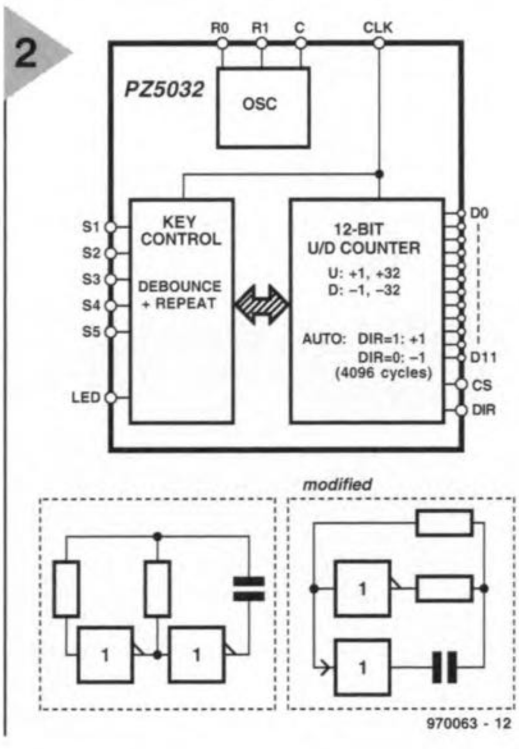


Figure 2. Block schematic of the CPLD Type PZ5032. The traditional configuration of the oscillator is modified to obviate transit time problems.

3

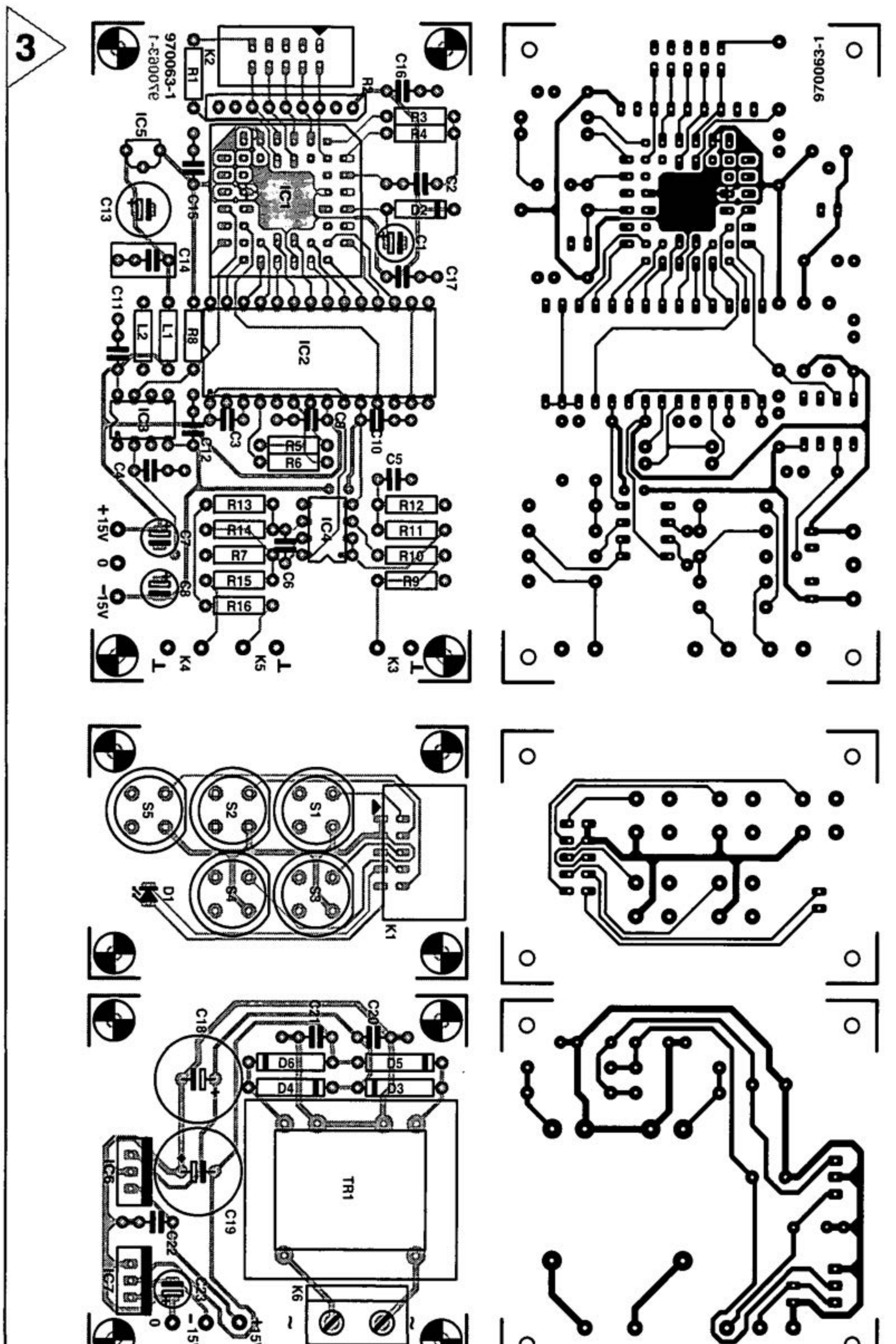


Figure 3. The board consists of three parts, one for the main circuits, one for the key switches, and one for the power supply.

Parts list

Resistors:
R_1, R_7, R_{10}, R_{16} = 1 kΩ
R_2 = SIL array, 8×10 kΩ
R_3 = 100 Ω
R_4 = 8.2 kΩ
R_5, R_6 = 49.9 Ω, 1%
R_8 = 10 kΩ
R_9 = 1 MΩ
R_{11}–R_{14} = 10.0 kΩ, 1%
R_{15} = 47 Ω

Capacitors:
C_1 = 10 μF, 10 V, radial
C_2, C_4 = 0.001 μF, metallized polyester (MKT)
C_3 = 10 pF, ceramic
C_5, C_6 = 15 pF, ceramic
C_7, C_8 = 10 μF, 25 V, radial
C_9–C_{12}, C_{15}–C_{17}, C_{20}–C_{22} = 0.1 μF, high stability
C_{13} = 100 μF, 25 V, radial
C_{14} = 0.33 μF, metallized polyester (MKT)
C_{18}, C_{19} = 1000 μF, 35 V, radial
C_{23} = 1 μF, 25 V, radial

Inductors:
L_1, L_2 = 4.7 μF choke

Semiconductors:
D_1 = LED, high efficiency
D_2 = 1N4148
D_3–D_6 = 1N4002

Integrated circuits:
IC_1 = PZ5032 (Order no. 976513-1)
IC_2 = AD667JN
IC_3 = LM311N
IC_4 = TL082CP
IC_5 = 78L05
IC_6 = 7815
IC_7 = 7915

Miscellaneous:
S_1–S_5 = 5-key board D6-R-RD with cap D6Q-RD-CAP (ITT)
K_1 = 10-way box header, right-angled
K_2 = 10-way box header, straight
K_3–K_5 = BNC connector
K_6 = 2-way terminal block, pitch 7.5 mm
Tr_1 = mains transformer, secondary 2×15 V, 1.5 VA (e.g., Monacor VTR-1215, Block VV1215; Velleman 2150018M)
sockets for ICs as required
10 cm 10-way flatcable
2 off 10-way flatcable connector
20 cm single screened cable
Enclosure, e.g., Telet LC730

PCB Order no 970063-1
Diskette (with source code) Order no. 976016-1

The oscillator, two possible versions of which are shown at the bottom of Figure 2, runs at a frequency of about 68 kHz. At the left in the figure is the traditional arrangement based on the well-known principle of two cascaded inverters. It has a drawback in that the transit time through the inverters delays the positive feedback via the capacitor. This results in a number of pulses near the switch-over point.

A better arrangement is shown at the right. In this complex programmable logic device, the inverter has the same delay time as a buffer. The use of a buffer and a single inverter obviates the transit time problem in the earlier configuration. An added bonus is that the two gates switch simultaneously.

As an aid to debouncing the control keys linked to the key control, a 14-bit synchronous counter has been included in the CPLD. When any one key is pressed, this counter is started from zero. When a value of 1000 is reached (after $1000 \times 1/68 \times 10^{-3} = 15$ ms), the key operation is accepted as valid. This arrangement effectively kills any bounce effects. When the key remains pressed, the value 1000 will be reached again after 2^{14} clock pulses, that is, after $2^{14} \times 1/68 \times 10^{-3} = 240$ ms.

When the key is released, the counter is reset to zero. The counter is designed in Philips Hardware Description Language (PHDL).

The up/down counter is controlled with key switches S_1–S_4. There is a choice between adding and subtracting and between step sizes 1 and 32.

The nullifying voltage may be determined automatically with key 'auto' (S_5). When this function is selected, the up/down counter will add or subtract depending on the output state of comparator IC_3. This will happen for 4096 cycles to ensure that the DA converter applies the correct voltage to IC_2.

Program for the CPLD

Complex programmable logic device Type PZ5032 uses XPLA (Special Programmable Logic Array) architecture in which various logic arrays are interconnected via a Zero-power Interconnect Array (ZIA). An associated XPLA program enables the desired functions to be set in a CPLD. The program is available on CD-ROM, see Internet page http://www.semiconductors.philips.com The program for the present applications consists largely of two blocks which are shown below. Note that the defined processes all work in parallel in contrast to a program for a microprocessor.
The first part of the key control is:

```
"KEY CONTROL"
ct=[ct13..ct0];
ct.c=!clk;
auto.c=clk;
when
(sw u==0)#(sw d==0)#(sw fu==0)#(sw fd==0)#(sw auto==0)#(auto=
=1) then
    {
    ct.d:=ct.q+1;
    when (ct==1000) then
        {
        key=1;
        auto.d:=!sw auto;
        }
    else
        {
        key=0;
        when  (ct==5096) then auto.d:=0;
        else auto.d:=auto.q;
        }
    }
else {
    ct.d:=0;
    }
```

S1: sw u= switch up — *S3: sw fu=switch fast up*
S2: sw d= switch down — *S4: sw fd=switch fast down*
S5: sw auto=swicth auto offset

key= key flag: This is set during a clock cycle when a pressed key is accepted as valid.
auto=auto flag: This is set when the auto key is accepted as valid. The flag remains active during a complete analogue-to-digital conversion cycle (4096 cycles) so that even when a key is pressed briefly an entire AD cycle is completed.
ct.q: q outputs of a counter consisting of 14 registers.
db.q assumes the state of the ct.d on the edge of the clock (data input d-bistable)

The number of bistables composing the counter is defined on the first line. Line 2 shows on the basis of the when statement whether a key has been pressed (the relevant input is then low). If this is not the case, the counter is held at 0. As soon as the condition is met, the counter is increased by 1 for each leading edge of a clock pulse. This is done on the line ct.d:=ct.q+1. When the counter state is 1000, the flag 'key' will be high for a clock cycle. The flag is needed to increase, in the unit DAC CONTROL, the counter synchronously as soon as a key is active. If key sw_auto is pressed, the up/down counter will be enabled for 212 clock pulses, irrespective of the length of time the key is pressed, so that in the end the DA converter shows the correct voltage. If key sw_auto is low for 1000 clock pulses, register auto.q will be set at the leading edge of the next clock pulse. This ensures that the counter remains enabled until the counter has reached 5096 even when the auto switch is released before then.

The second part provides the control for the DAC:

```
"DAC CONTROL"

db=db[11..0];
db.c=clk;
when (auto==0) then
    {
    when (key==1) then
            {
            cs=key;
            when (sw u==0) then db.d:=db.q+1;
            else
                {
                when (sw d==0) then db.d:=db.q-1;
                else
                    {
                    when (sw fu==0) then db.d:=db.q+32;
                    else
                        {
                        when (sw fd==0) then db.d:=db.q-32;
                        else db.d:=db.q;
                        }
                    }
                }
            }
    else
        {
        db.d:=db.q;
        cs=0;
        }
    }
else
        {
        cs=clk;
        when (dir==1) then db.d:=db.q+1;
        else db.d:=db.q-1;
        }
```

cs: chipselect of the DA-converter

The first check in DAC CONTROL is to ascertain whether the register auto has been set or not. If the register is not set, the manual nullifying voltage setting with S1–S4 is enabled. If key=1, that is, if the previous count is equal to 1000, the underlying key demand of S1–S4 is active. This process works in parallel with the process 'KEY CONTROL'. Differing priorities are given to the key switches with the aid of a when-else arrangement. Depending on which of the four keys is pressed, the counter db will be increased or reduced by a step of 1 or 32 on the leading edge of the clock pulses.
If the register auto is set, then depending on the direction bit 'dir', counter db is increased or reduced by 1. This happens at the leading edge of every clock pulse as long as auto=1 (that is, 4096 times).

4

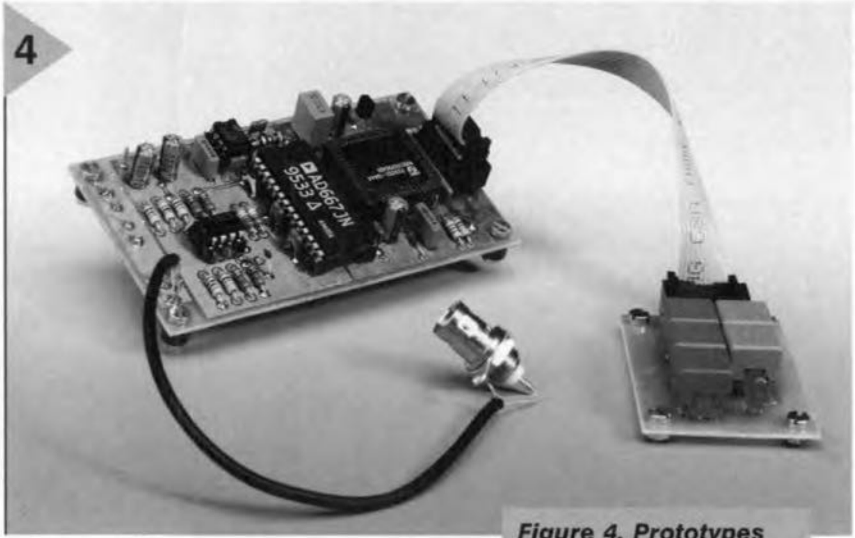


Figure 4. Prototypes of the completed boards. Their construction is simplicity itself.

PRINTED-CIRCUIT BOARD

The printed-circuit board in **Figure 3** consists of three parts which should be separated before any construction work is undertaken.

The left-hand part of the board is intended for the majority of the circuits, including the 5 V regulator, the centre part to house the keyboard, and the right-hand part, the power supply.

Since the centre part is intended to be fitted to the front of the enclosure, it houses the on/off indicator (D_1). This LED flashes rapidly when one of the keys is pressed.

The power supply board also houses mains transformer Tr_1. Since the circuit draws a current of not more than 20–25 mA, regulators IC_6 and IC_7 do not need heat sinks.

The integrated circuits should be fitted in IC socket. Particularly that for IC_1 needs to be of prime quality.

The programmed CPLD is available via our Readers Services (see towards the end of this issue).

The mains transformer may be one of several types: Monacor, Block, Velleman (Maplin), all of which fit on the board.

Inductors L_1 and L_2 are standard available miniature 4.7 μH chokes.

The completed prototype boards are shown in **Figure 4.**

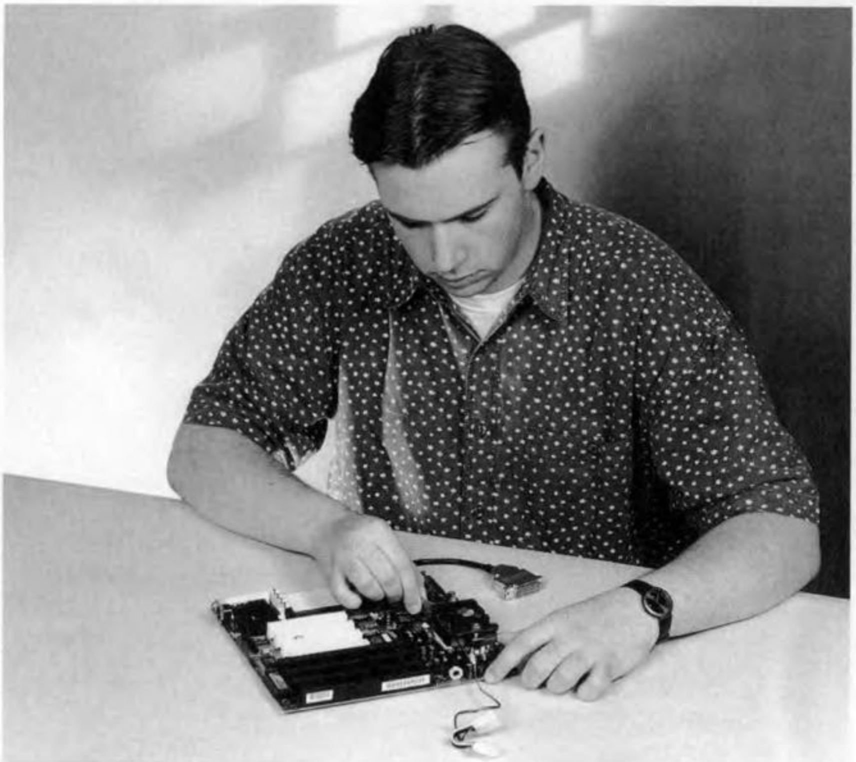
The boards are interconnected by linking the +15 V, 0, and –15 V terminals on the supply board and those on the main board via insulated circuit wire. The key-board is connected via a short length of 10-core flatcable, two box headers and two flatcable connectors. BNC connectors are used for input K_3 and output K_4. and these are linked to the board via short lengths of screened cable. The same applies to nullifying voltage output socket K_5.

The small dimensions of the boards make the choice of a suitable enclosure easy. The prototype boards are housed in a Type LC730 from Telet.

The boards must be bolted to the enclosure with the aid of insulated (nylon or polyester) spacers. The mains entry must be linked to K_6 via good-quality, not too thin, insulated circuit wire. [970063]

12-bit ADC interface

Analogue measurements via a PC's printer port



The Type MAX187 +5 V, low-power, 12-bit ADC (analogue-to-digital converter) chip from Maxim enables a PC to be provided with an analogue input via which analogue voltages may be measured with a high degree of accuracy. The interface designed for this is connected to the parallel printer port, so it can be used with all PCs, including laptops. Demonstration software (for Windows) available through our Readers Services makes getting acquainted with the interface a straightforward matter.

Brief specification

Input voltage range	0–5 V
Resolution	12 bit (4096 steps)
Step width	1 mV (measuring range 0–4.096 V)
Interface	printer port
Software	Windows 3.1 and 95
Current drain	2 mA (reduces to 2 μA in the shutdown mode)
Power supply	+5 V (via the computer printer port)
Permissible current drain by external sensor	2 mA maximum

Design by J. Schröder

INTRODUCTION

Modern technologies make it possible to integrate a large number of functions on a single chip in a small enclosure. The present interface is based on a Type MAX187 analogue-to-digital converter (ADC). This device operates from a single +5 V supply and accepts analogue inputs of 0–5 V. It features 8.5 μs successive approximation, fast track/hold (1.5 μs), an on-chip clock, and a high-speed 3-wire serial interface.

The MAX187 has an integral 4.096 V voltage reference, which ensures that, at 12-bit resolution, each step in the conversion is exactly 1 mV.

The device digitizes signals at a 75 ksps throughput (sampling) rate. An external 5 MHz clock is used to drive the 3-wire interface.

Power consumption is only 7.5 mW, which reduces to 10 μW in the shutdown mode.

The MAX187 is ideally suited for use in remote DSP and sensor applications, in circuits where power con-

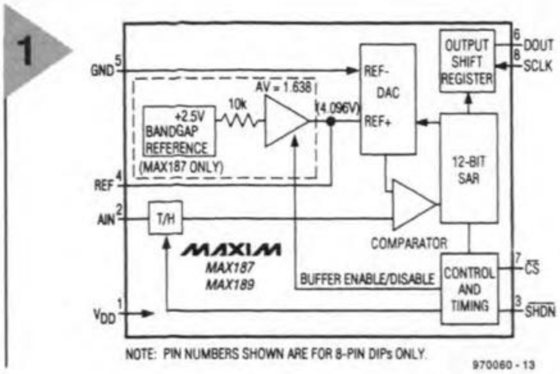


Figure 1. Functional diagram of the MAX187. Note that the pin numbers are shown for an 8-pin DIP.

sumption and space are crucial, in portable data logging, isolated data acquisition, and high-accuracy process control.

FUNCTIONAL DESCRIPTION

The functional diagram of the MAX187 is shown in **Figure 1**, from which the pinout is obvious.

The +5 V supply line (V_{DD}) is linked to pin 1.

The measurand, that is, the signal to be measured, is applied to pin 2 (AIN), from where it is passed internally to a track & hold (T/H) circuit.

The IC is controlled via pin 3 ($\overline{SHDN}$). If the logic level at this low, the IC is placed in the shutdown mode, during which it draws a current of only 2 μA. If the logic level is made high, or the pin is left open, the IC is enabled. The difference between a high logic level and an open pin is that in the latter condition the internal reference is switched off to enable an external one to be used.

The internal 4.096 V voltage reference is available at pin 4 (REF). If this reference is switched off, a potential of 2.5–5.0 V may be applied to this pin.

The earth, digital as well as analogue, is linked to pin 5 (GND).

The digital output signal is available at pin 6 (D_{OUT}) on command of an external clock signal (maximum 5 MHz).

If the logic level at pin 7 ($\overline{CS}$) is low, a conversion is initiated at the trailing edge of the clock signal. If the level is high, the digital output (pin 6) is disabled and attains a high impedance. The correlation of these signals is seen in the timing sequence diagram in **Figure 2**.

The external clock is connected to pin 8 (SCLK).

CIRCUIT DESCRIPTION

The circuit diagram of the interface is shown in **Figure 3**, from which it is clear that apart from the ADC chip few external components are needed. Capacitors C_1–C_3 provide the necessary decoupling of the reference voltage and supply voltage.

Network R_1-D_1 ensures a defined input impedance of 1 MΩ and protect the input (pin 2) against wrongly polarized input signals.

The measurand is applied across network R_1-D_1.

There is a facility to connect the +5 V supply to an external sensor. If this facility is used, pins 18–25 must be linked to the earth terminal of the sensor, and the +ve supply line to the +terminal of the sensor. The current drawn by the sensor should not exceed 2 mA.

The interface and the computer are linked via K_1; the various interconnections are summarized in **Table 1**.

When pins 5 and 6 of K_1 are made high, the MAX187 is provided with a supply voltage via R_2 and R_3. Because of the low current drain, this will not pose problems in most cases.

The D_1 signal at pin 2 of K_1 is used as the clock for the converter chip.

The D_3 signal at pin 3 of K_1 is the $\overline{CS}$ signal which enables the analogue-to-digital conversion.

The digital data at pin 6 (D_{OUT}) of the MAX187 is applied to pin 10 of K_1 and thence to the $\overline{ACK}$ input of the computer.

CONSTRUCTION

The interface is best built on the printed-circuit board shown in **Figure 4**. The dimensions of this board are so small that the complete interface can be housed in the D25 connector (K_1) linking it to the computer. This presupposes that all components used are as specified in the parts list. The super-

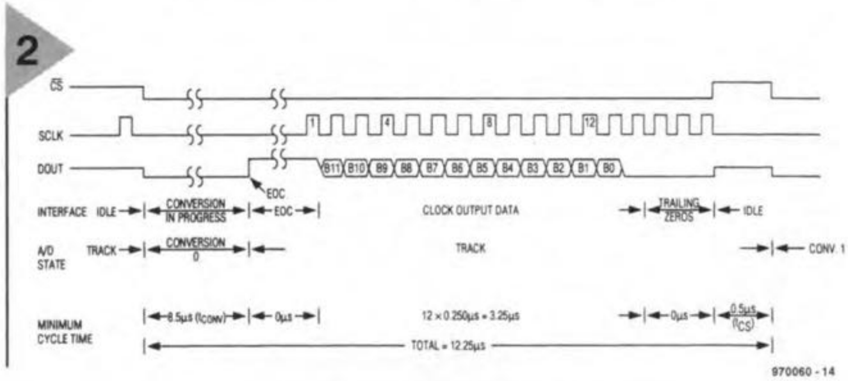


Figure 2. Interface timing sequence diagram of the MAX187.

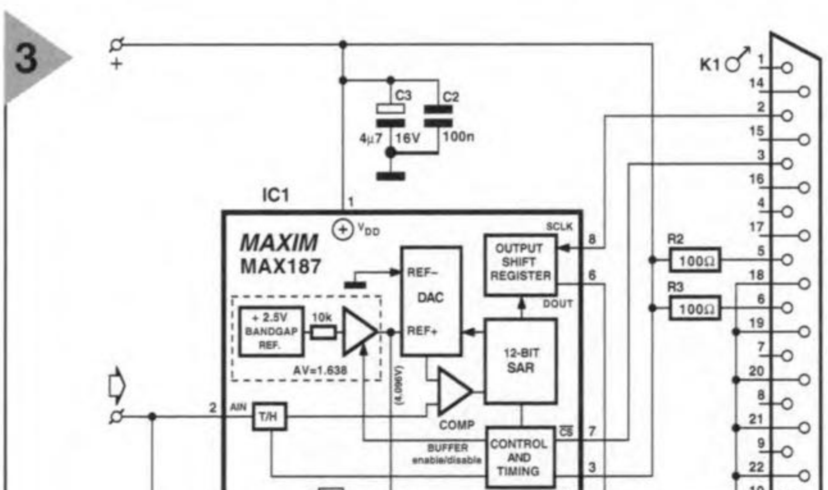


Figure 3. Circuit diagram of the 12-bit ADC interface.

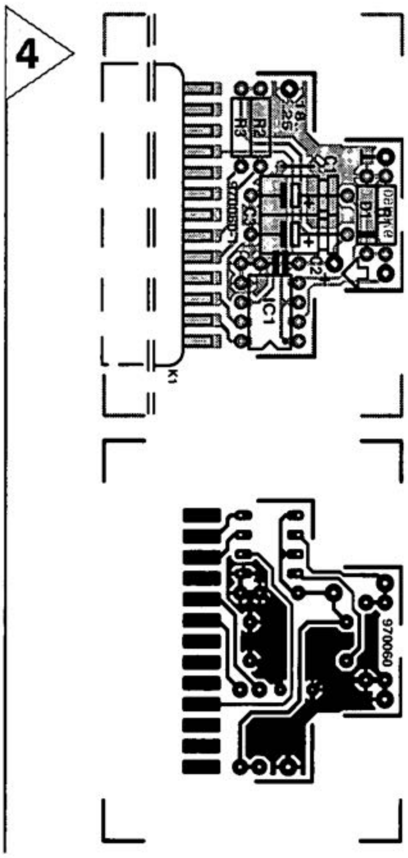
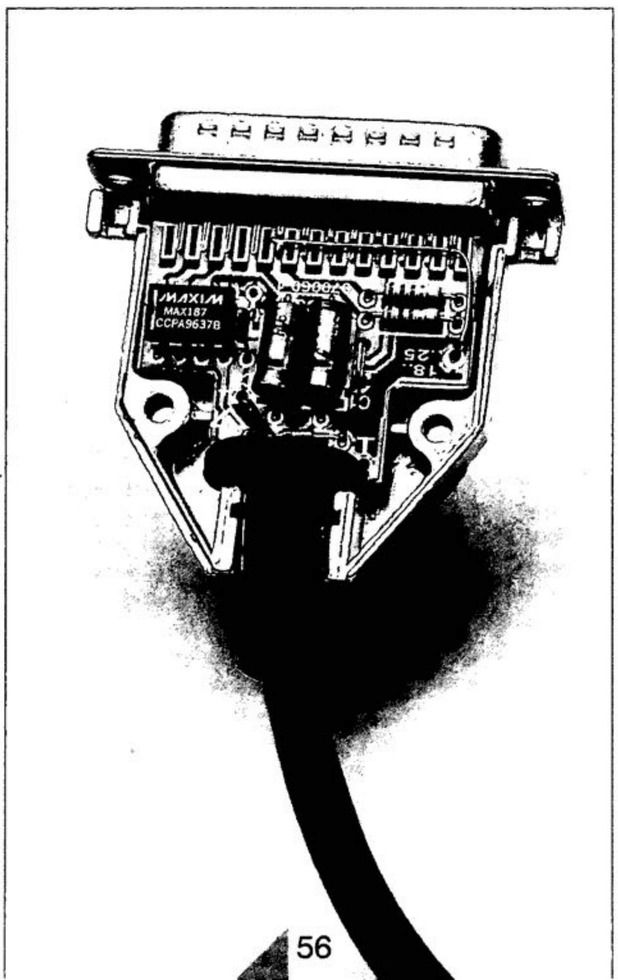


Figure 4. The printed-circuit board for the interface has been designed to facilitate its incorporation in a D25 plug.



Parts list

Resistors:
R_1 = 1 MΩ
R_2, R_3 = 100 Ω

Capacitors:
C_1, C_3 = 4.7 μF, 16 V, axial
C_2 = 0.1 μF

Semiconductor:
D_1 = 1N4148

Integrated circuit:
IC_1 = MAX187BCPA (Maxim)

Miscellaneous:
K_1 = D25 plug, male, with steel, zinc passivated housing
PCB Order no. 970060-1 *
Diskette with demonstration software and source code, Order no. 976011-1 *
* These may be purchased as a package Order no. 970060-C.

fluous parts of the board should be removed with a fret saw (US: jig saw). The etched rectangular solder pads should, of course, be slid in between the rows of pins on K_1 (track side of the board upwards: facing pins 1–13 of K_1). When it has been ascertained that the connector and board fit neatly together, solder pins 1–13 of K_1 to the relevant solder pads. When that is done, interconnect pins 18–25 of K_1 and link them via a short length wire to the solder pad marked 18–25.

The remainder of the board can then be finished. Link the analogue input signal to the two solder pads to the left and right of R_1. It may be possible to use a mini audio socket for this and fit it in the entry to K_1.

SOFTWARE

The interface is intended for use with the aid of suitable DIY software. To start the user on the design of this, a demonstration program for use with Windows is available (see Parts list). This software is written in Delphi and shows the value of the measurand in a window on the computer monitor.

In the Supplement at the centre of this issue, an article about overclocking of CPUs describes how temperature may be measured with the aid of a separate sensor. In the same article, a program is described that may be used to guard the temperature of the CPU in the computer with the aid of the present interface and a temperature sensor. Construction of this sensor is also described in this article.

Basic operation of the demonstration software is straightforward.

- Enable the interface by making pins 3, 5 and 6 of the selected printer port (K_1) high.
- Make pin 3 of K_1 ($\overline{CS}$) low to start the A-D conversion.
- When the conversion is completed, make pin 10 of K_1 ($\overline{ACK}$) high.
- Make the clock high and then low again. The start bit will be replaced by the first data bit. on the trailing edge of the clock.
- Make the clock high and then low again twelve more times: each time a data bit will appear at the trailing edge of the clock pulse.
- When the twelve bits have been read, the software computes the digital value into a decimal value and causes this to be displayed on the monitor.

This process can be seen in graphic form in Figure 2. This and the summary just given facilitate the development of a program suited to personal requirements.

[970060]

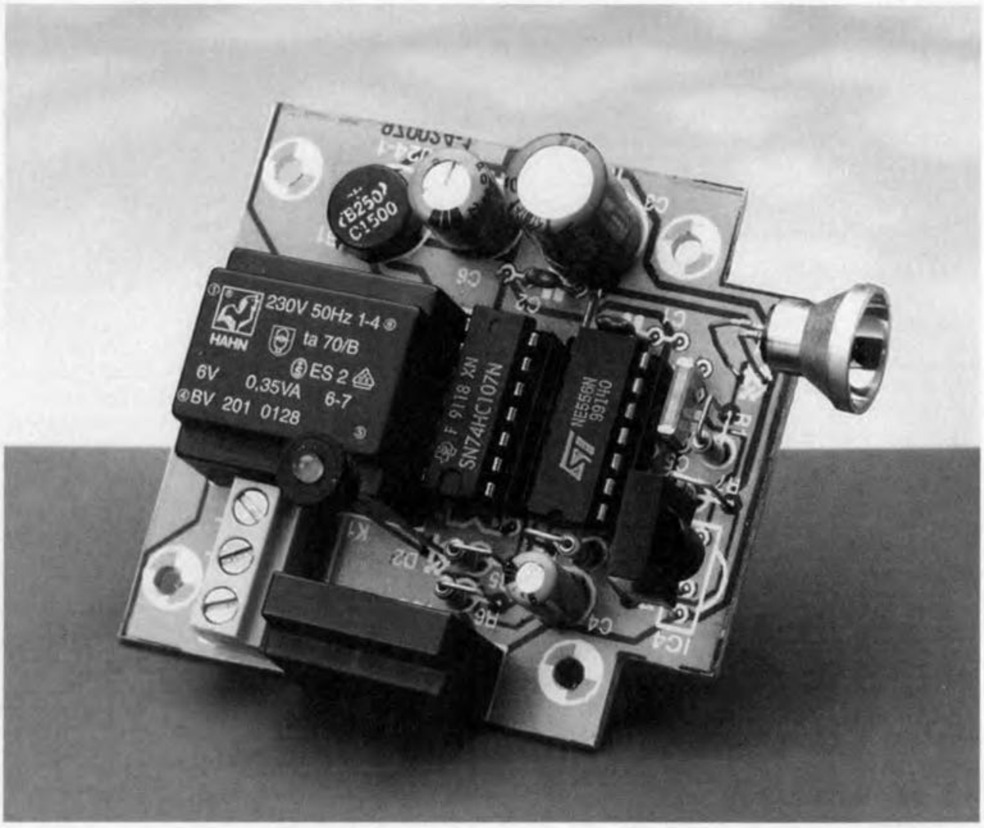
Table 1

Correlation of printer port pin and function and MAX187 pin and function

Printer port		*Max187*	
pin	*function*	*pin*	*function*
2	D_1	8	clock
3	D_2	7	$\overline{CS}$
5	D_4	1	V_{DD}
6	D_5	1	V_{DD}
10	$\overline{ACK}$	6	D_{OUT}

touch-free lights switch

wave the lights on and off!



This article describes a lights switch which is operated by moving your hand in front of it. This is achieved by detecting infrared light reflected by your hand onto a receiver device. Alternatively, you may use an infrared remote control unit to switch the lights on and off. Based on a solid-state relay, the switch itself is contactless.

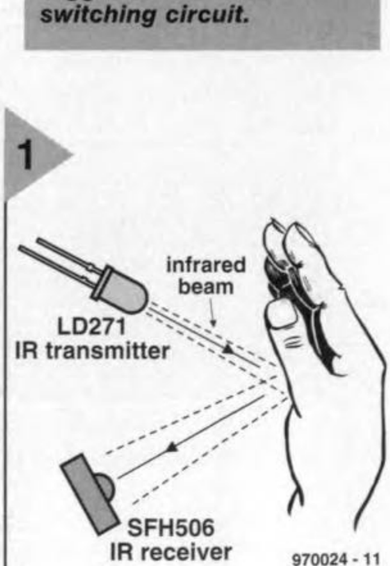
Design by F. Michiels

Push or turn the knob to switch the lights on and off, it seems so usual! This circuit, however, presents an interesting variety: you no longer have to actually touch the lights switch – all you have to do is waive your hand in front of it! The advantages? No more dirty fingerprints on the lights switch in the cellar or garage, and no more danger of an electrical jolt if you operate a lights switch in a bathroom or other 'moist' area.

PRINCIPLE OF OPERATION

The (simple) principle of operation of the touch-free lights switch is illustrated in **Figure 1**. The infrared light emitted by a special IRED (infrared emitting diode) is not normally detected by a receiver because both devices 'look' virtually in the same direction. If the transmitted beam hits an object, however, a small portion of the infrared light will be reflected onto

Figure 1. Principle of operation. A hand reflects enough infrared light to trigger an electronic switching circuit.



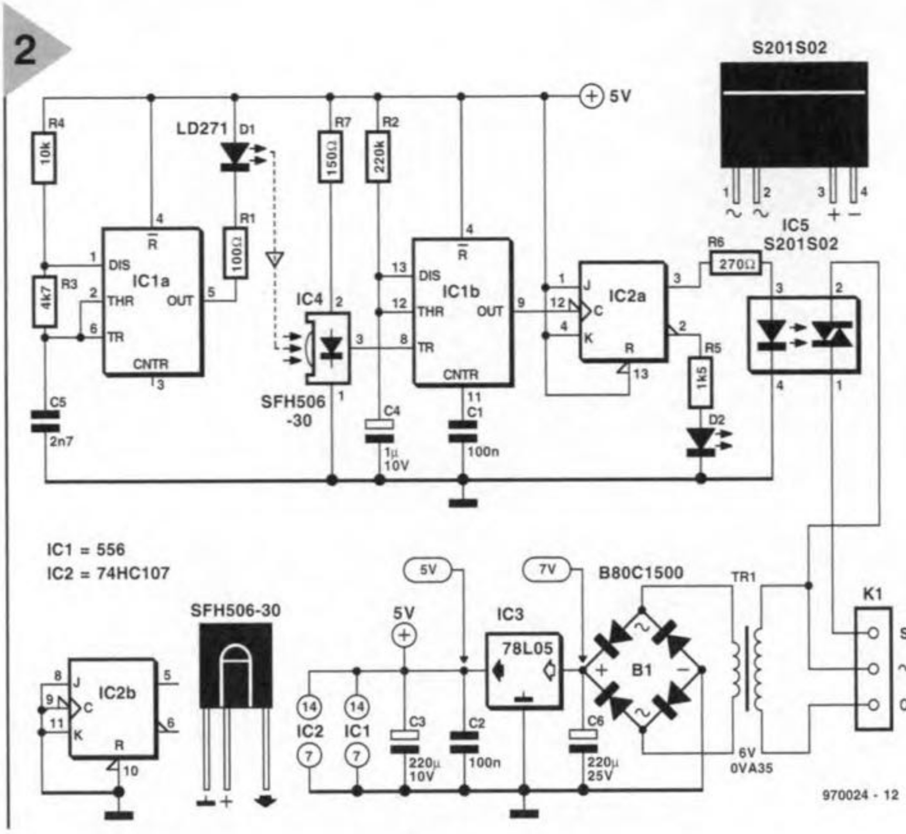


Figure 2. Circuit diagram of the touch-free lights switch. One half of the 556 dual timer chip is used in the transmitter, the other, in the receiver. Note the use of a solid-state relay (SSR) for contactless, silent and zero-wear-and-tear switching of a mains load.

the receiver. The resultant change in incident IR light is evaluated by a special circuit which responds by actuating a solid-state relay.

If you don't believe that your hand reflects infra-red light, try this: hold your TV remote control above or beside the TV set, and point it into the room. Press a few buttons and aim the control until a position is found where the TV no longer responds to commands. Now form your other hand into an angled reflector (bend your fingers towards the TV set) and try again. Although a very small portion of the (invisible) light is actually reflected (most of it is absorbed by your hand), the IR receiver in the TV set will still be able to detect the (weakened) signal. None the less, you may have to conduct this little experiment quite close to the infrared receiver window on the front of the TV.

Note that the circuit does not use a constant IR carrier as suggested above. For better noise immunity (and to reduce the current consumption...), the IR beam is modulated with short pulses. This does not, however, change the principle of operation in any way.

Circuit description

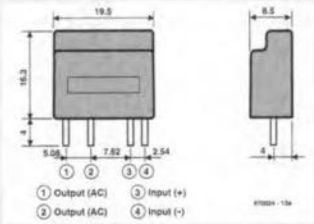
The power supply is traditional, consisting of a small (0.35-VA) mains transformer, Tr1, a bridge rectifier, B1, a three-pin voltage regulator, IC3, and a pair of decoupling capacitors for high and low frequency noise suppression, C2 and C3. The unregulated voltage at the input of IC3 is about 7 V. The circuit draws about 16 mA in the standby state, and about 10 mA more if the SSR (solid-state relay) is actuated.

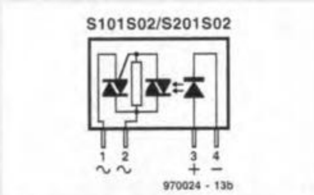
The load (usually a light bulb) to be switched is connected to the 0 ('neutral') and S ('switched live') terminals of K1.

The **transmitter** is based on IC1a, one half of a 556 which is wired to operate in astable multivibrator (AMV) mode. D1 is the IRED. Here, the ubiquitous LD271 is used, it has a 100-Ω series resistor to ensure that the average current consumption of the transmitter is not out of kilter. Mind you, the output of the 556 is capable of sourcing (and sinking) up to 200 mA,

solid-state relays

The S201S02 SIP type solid-state relay (SSR) from Sharp has a built-in zero-crossing detector which minimises dissipation and mains-induced noise. According to Sharp, applications of SSRs may be found in TVs, air conditioners and programmable controllers. An extract of the main design data on the S201S01/02 devices is given below. Note that the S01 and S02 versions do not incorporate a current-limiting resistor for the internal LED, while the S01 and S03 types do not have an internal zero-crossing detector. The S04 version has a LED resistor as well as a zero-crossing detector.





S201S01/S201S02 Electrical Characteristics						
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input forward voltage	V_F	I_F=20mA	-	1.2	1.4	V
Input reverse current	I_R	V_R=3V	-	-	10^{-4}	A
Input signal voltage	V_{IN}	$T_a=T_{opr}$	4	5	6	V
Input resistance	R_{IN}		117	130	143	Ω
Pick-up voltage	V_{pu}	V_D=6V, R_M=30Ω	-	-	4	V
Drop-out voltage	V_{do}	V_D=200V	1	-	-	V
Output repetitive peak off-state current	I_{DRM}	$V_D=V_{DRM}$	-	-	10^{-4}	A
Output on-state voltage	V_T	I_T=1.5A_{rms}, R load	-	-	1.5	V_{rms}
Holding current	I_H		-	-	50	mA
Output zero-cross voltage	V_{ox}	I_F=15mA	-	-	35	V
Isolation resistance	R_{iso}	DC500V, R_H=40-60%	10^{10}	-	-	Ω
Turn-on time	t_{on}	AC 50Hz	-	-	10	ms
Turn-off time	t_{off}	AC 50Hz	-	-	10	ms

so an extra driver is not required.

The pulse on and off times, t_{on} and t_{off}, are determined by components R3, R4 and C5, in the following way:

$$t_{on} = 0.639 \cdot R3 \cdot C5 = 8.1\,\mu s$$

$$t_{off} = 0.639 \cdot (R4+R3) \cdot C5 = 25.4\,\mu s$$

The resulting period of 33.5 μs (8.1+25.4) corresponds to a switching frequency of 29.9 kHz. This 'tunes' the transmitter to the infrared detector type SFH506-30 used in the receiver (the suffix -30 indicates the frequency, in kHz, of optimum sensitivity).

As already mentioned, the short 'on' time of the transmitter keeps the overall current consumption of the circuit within reason.

The IRED has to be fitted with a reflecting hood to ensure that it does not radiate too much to the sides.

The heart of the **receiver** is IC4, an SFH506-30 integrated infrared receiver/demodulator. If a short burst of IR pulses is received (because you wave your hand in front of the switch), the demodulated pulses are fed to the second half of the 556, IC1b, which responds by briefly dropping its output low. This, in turn, causes bistable IC2a to toggle. If the lights were off (Q output logic low), they are switched on via SSR IC5. Conversely, if they were on, the burst turns them off. An LED, D2, is provided to signal the output status of the circuit. Because the LED is controlled by the $\overline{Q}$ output of IC2a, it will be on when the light controlled by the SSR is off. In this way, the LED enables you to locate the switch in the dark.

As indicated by its name, a solid-state relay (SSR) is the all-electronic replacement of the good old mechanical relay. The SSR is compact, easy to use, economical as regards current consumption and totally free from wear and tear. Potted data on the Sharp S201S02 used here is given in the inset.

The 30-kHz centre frequency of the SFH506-30 is not absolute. In fact, the device will also respond to 36-kHz signals received from RC5 (compatible) remote controls as used with Philips TV sets and audio equipment. Whether this property is an advantage or a disadvantage is difficult to tell as it will depend on the application you have in mind for the light switch. For obvious reasons, the switch is best not installed in the same room as the family's TV set!

Construction

A very compact printed circuit board has been designed for the circuit to allow it to be built into the compact Bopla case specified in the parts list.

COMPONENTS LIST

Resistors:
R1 = 100Ω
R2 = 220kΩ
R3 = 4kΩ7
R4 = 10kΩ
R5 = 1kΩ5
R6 = 270Ω
R7 = 150Ω

Capacitors:
C1,C2 = 100nF
C3 = 220μF 10V radial
C4 = 1μF 10 V radial
C5 = 2nF7
C6 = 220μF 25V radial

Semiconductors:
B1 = B80C1500
D1 = LD271 (IRED, 950nm) with reflecting cap
D2 = high-efficiency LED
IC1 = 556
IC2 = 74HC107
IC3 = 78L05
IC4 = SFH506-30 (Siemens)
IC5 = S201S02 (Sharp)

Miscellaneous:
K1 = 3-way PCB mount terminal block, raster 5mm
TR1 = 6V/0.35VA mains transformer, PCB mount, e.g. Hahn type BV.201.0128
Enclosure = Bopla SE-432 (for Euro-style mains socket only)

Alternatively, the unit may be built into a mains switch enclosure or a mains junction box.

As already mentioned, the IRED, D1, should be fitted with a reflecting cap which is given a recessed position in the box panel. The dome-shaped face of the SFH506-30 should also have a 'free view' from the box panel. Finally, the status LED should be fitted with a collar or a round clip to enable it to protrude slightly from the case.

Use heavy-duty, mains-rated wire for the connections on the 0 (neutral), ~ (live) and S (switched live) terminals on the board. The Bopla SE-432 case allows the mains wiring to be kept very simple because it has a moulded mains plug, and a mains socket in the top panel (it does not seem to be available with a UK style socket). It allows the lamp(s) you want to switch to be connected to the circuit by means of an ordinary mains plug.

As the circuit has no adjustment points it is immediately ready for testing. To prevent unwanted reflection of the infrared light beam, the unit should be mounted such that it does not face a nearby wall.

(970024-1

3

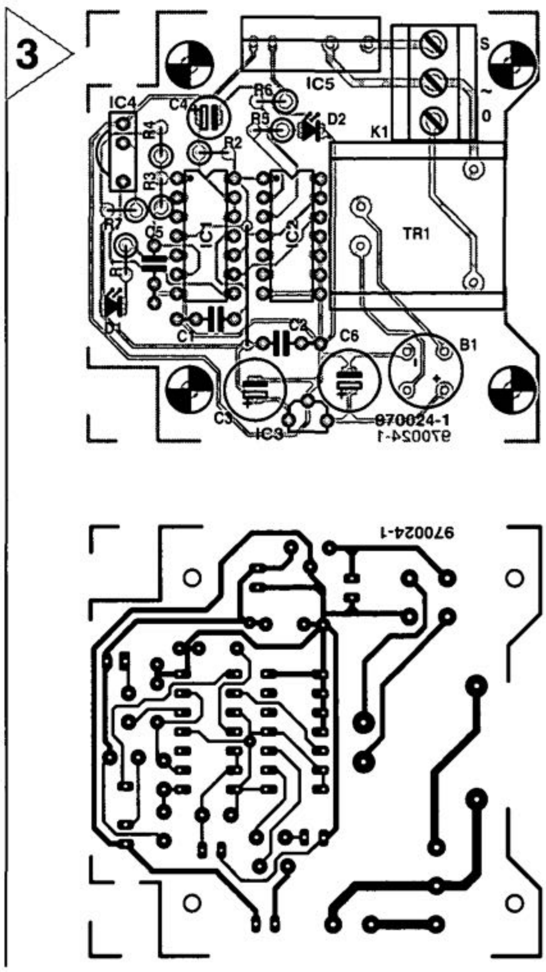
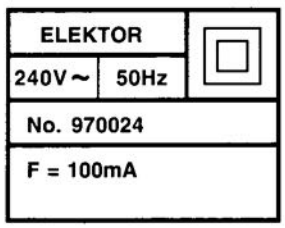


Figure 3. Track layout and component mounting plan of the single-sided printed circuit board designed for the switch (board not available ready-made).



directional microphone

without parabolic reflector

Directional microphones such as used by, say, outdoor-recording specialists and bird-watchers, are invariably provided with a conspicuous parabolic reflector. This captures an almost parallel beam of sound waves and so reduces the angle of incidence of the microphone. The same action may be obtained in a completely different manner as described in this article.

Design by G. Baars

INTRODUCTION

A directional microphone may be constructed in several ways. The most frequently encountered is that in which the transducer is provided with a mechanical aid that functions as a kind of acoustic lens. This greatly amplifies the narrow beam of sounds in line with the axis of the microphone and usually takes the shape of a parabolic reflector.

The angle of incidence of the sounds may also be narrowed in a different way. In this, the sounds in line with the axis of the microphone are not amplified, but those at an angle to this line are attenuated in proportion to the size of the angle to give the same effect. In this case, of course, the in-line sounds need to be magnified by electronic means,. that is, in an amplifier.

DESIGN CONSIDERATIONS

In the present circuit, yet another approach is used, which depends on the phase of the incident sounds. Speech signals of identical frequency arrive at the microphone with different phases, depending on the location of the source of the sounds. It is therefore possible to select from the mass of sounds arriving at the microphone just one or a specific range that have the same frequency but differ in phase. This cannot be done with a single microphone, however, but with two microphones the results are highly satisfactory. The two microphones are not mounted side by side, as would be expected, but one behind the other, at a specific distance, along their respective axes as in **Figure 1**.

If the two microphones are separated by a half-wavelength of the wanted sound, the sounds will arrive at them with opposite phase. This is because the microphone at the left receives the falling edge of the signal and the microphone at the right the rising edge. If these signals are amplified and then subtracted from one another in a differential amplifier, the output of that amplifier will be a strong signal at the wanted frequency.

Signals arriving at the microphones in phase (that is, at an angle to the line joining the axes of the microphones) oppose one another in the differential amplifier and will thus be strongly attenuated.

A bonus of this approach is that interfering low-frequency signals, such as traffic noise or wind noise, invariably arrive at the microphones in phase and will thus be greatly attenuated.

It is obvious that the distance between the microphones is of crucial importance for effective directional operation. After many experiments, a distance of 20 cm (8 in) was found to be the best compromise. This distance corresponds to the half-wavelength of a signal at 850 Hz, which is at a convenient point in the speech band of 200–3000 Hz. The electronic circuits associated with the microphone are therefore designed for selective amplification of this band.

CIRCUIT DESCRIPTION

The diagram in **Figure 2** makes it clear that the circuit is not very complicated. It consists of input amplifiers IC_{1b} and IC_{1c}, differential amplifier IC_{1d}, and a simple headphone amplifier consisting of IC_{1a} and T_1 and T_2.

The outputs of microphones MIC_1 and MIC_2 are applied to IC_{1b} and IC_{1c} respectively. The microphones are electret types, whose supply voltage is derived from the supply lines via R_1 and R_2 respectively. Since the sensitivity of these microphones, especially inexpensive types, has a wide tolerance, preset P_1 is provided to match that of MIC_1 to MIC_2.

The *RC* networks associated with the input amplifiers limit the bandwidth of the input as stated earlier to 200–3000 Hz. Networks R_6-C_6, R_7-C_7, R_1-P_1-C_1, and R_2-C_2, form low-pass sections, whereas R_3-C_3, R_4-C_4, and R_5-C_5, are high-pass sections.

The amplified signals are subtracted from one another by differential amplifier IC_{1d}. Here also, networks R_8-R_9-C_8 and R_{11}-C_9 serve to keep the bandwidth within the stated limits.

The level of the differential signal at the output of IC_{1d} may be adjusted with P_2. The signal at the wiper of this potentiometer is applied to the input of the simple headphone amplifier, which consists of IC_{1a} and transistors T_1 and T_2. Again, networks R_{13}-C_{11} and R_{12}-C_{10} serve to keep the bandwidth within the earlier stated limits.

Resistor R_{15} ensures that output current of the headphone amplifier is kept within certain limits to avoid overloading of the battery at low output impedances. Bear in mind that the impedance of many small headphones, even with both ear-pieces in series, is of the order of only 16 ohms.

The operational amplifier used is a low-noise type which has the added advantage of needing only a low supply voltage. Also, it draws a current of not more than 7.5 mA. This enables the microphone to be powered by a single 9 V battery (dry or rechargeable).

Potential divider R_{16}-R_{17} arranges the supply lines to the input amplifiers at half the battery voltage. The supply lines are well decoupled by capacitors C_{13}–C_{16} to make certain that there is no feedback of spurious signals along these lines. This is particularly important when the battery reaches the end of its life (or charge, as the case may be), and then has a high internal impedance. The supply lines to the microphones are additionally decoupled by R_{18}-C_{17}.

FINALLY ...

The electronic circuits are best built on the printed-circuit board shown in **Figure 3**, which is available ready-made through our Readers Services. Constructing the board is a very simple affair, indeed.

The completed board and the 9-V battery can be housed conveniently in a small case. Connect the microphones to the assembly via screened microphone cable.

The final shape of the directional microphone assembly depends largely on the constructor's preferences and ingenuity. It is important, however,

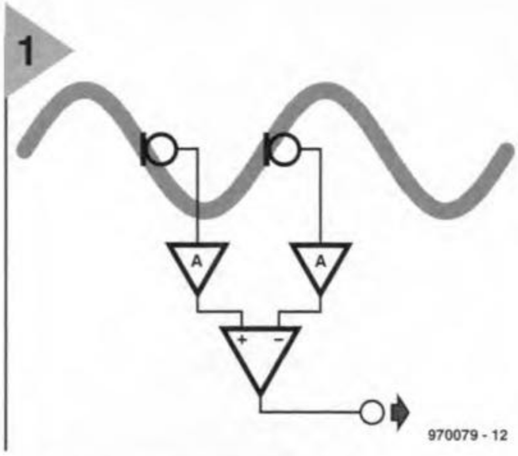
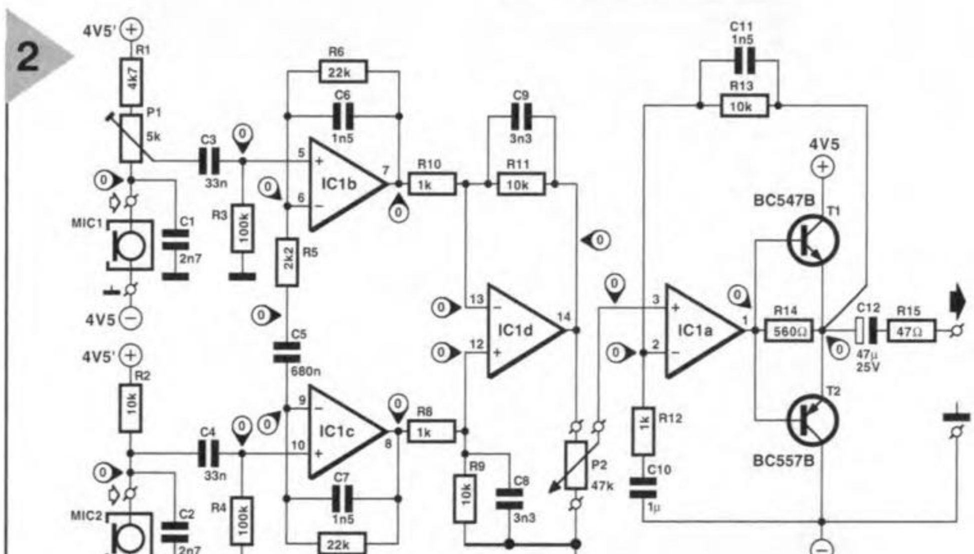


Figure 1. Basic setup of the directional microphone. A signal is passed to the output only if the sounds picked up by one microphone are out of phase with those picked up by the other microphone.

Figure 2. The circuit diagram of the requisite electronics for the directional microphone.



3

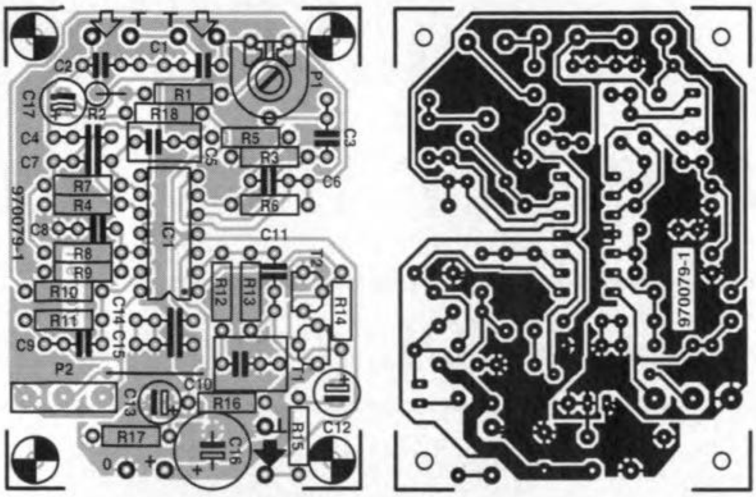
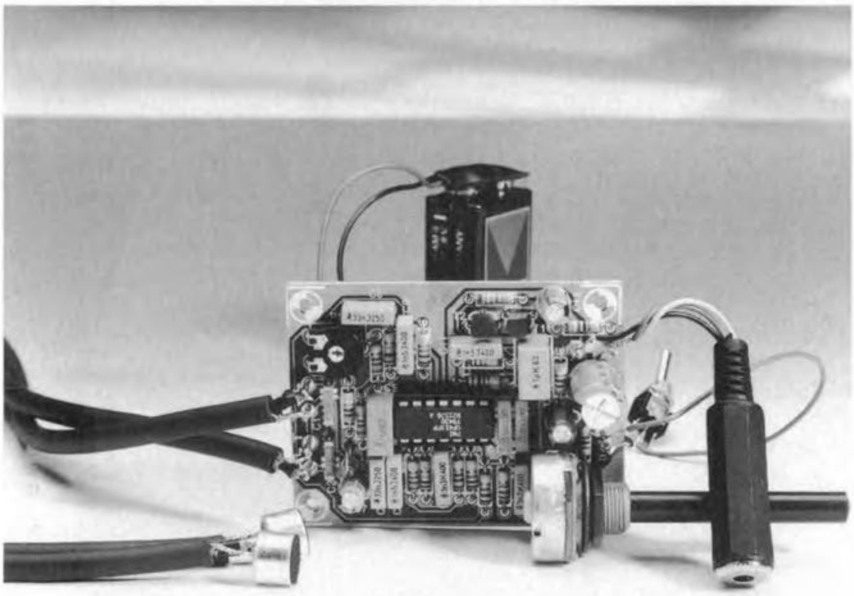


Figure 3. The printed-circuit board for the directional microphone is available ready-made.



Parts list

Resistors:
R_1, R_{16}, R_{17} = 4.7 kΩ
R_2, R_9, R_{11}, R_{13} = 10 kΩ
R_3, R_4 = 100 kΩ
R_5 = 2.2 kΩ
R_6, R_7 = 22 kΩ
R_8, R_{10}, R_{12} = 1 kΩ
R_{14} = 560 Ω
R_{15} = 47 Ω
R_{18} = 220 Ω
P_1 = 4.7 kΩ (5.0 kΩ) preset
P_2 = 47 kΩ log potentiometer

Capacitors:
C_1, C_2 = 0.0027 μF
C_3, C_4 = 0.033 μF
C_5 = 0.68 μF
C_6, C_7, C_{11} = 0.0015 μF
C_8, C_9 = 0.0033 μF
C_{10} = 1 μF, metallized polyester (MKT), pitch 5 mm or 7.5 mm
C_{12} = 47 μF, 25 V, radial
C_{13} = 10 μF, 63 V, radial
C_{14}, C_{15} = 0.1 μF
C_{16} = 1000 μF, 16 V, radial
C_{17} = 100 μF, 10 V, radial

Semiconductors:
T_1 = BC547B
T_2 = BC557B

Integrated circuit:
IC_1 = OP413FP (Analog Devices)

Miscellaneous:
MIC_1, MIC_2 = electret microphone
BT_1 = 9 V battery, dry or rechargeable, with connecting clips
PCB Order no 970079-1 (see Readers Services elsewhere in this issue)

that the microphones are fixed 20 cm apart on some sort of carrier.

SOME TECHNICAL DATA

The characteristic of the pass-band of the directional microphone assembly is shown in **Figure 4**. As mentioned in the text, the –3 dB cut-off points are at 200 Hz and (just below) 3000 Hz The centre frequency may be assumed at about 850 Hz.

The overall voltage amplification of the circuit is about ×1800 (65 dB).

The harmonic distortion is <0.1% measured at a frequency of 750 Hz with a load impedance of 600 Ω.

[970079]

4

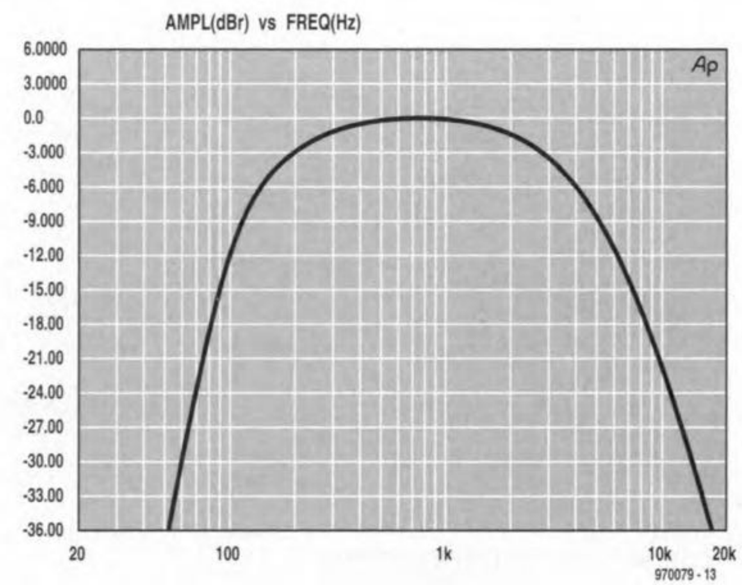
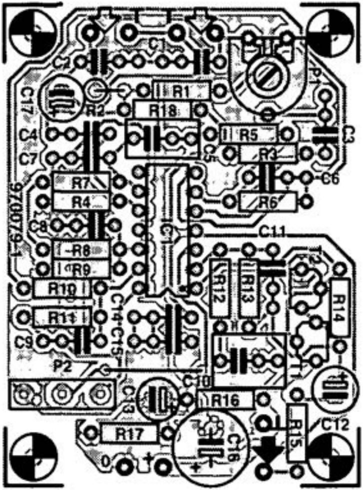
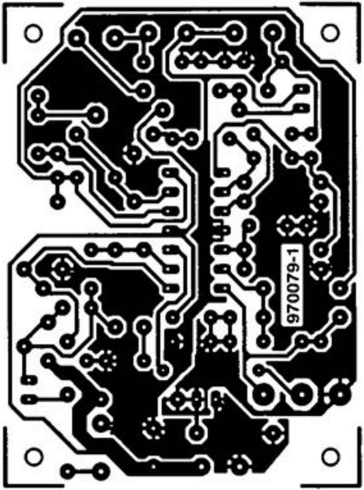


Figure 4. The pass-band of the directional microphone covers the normal speech band.

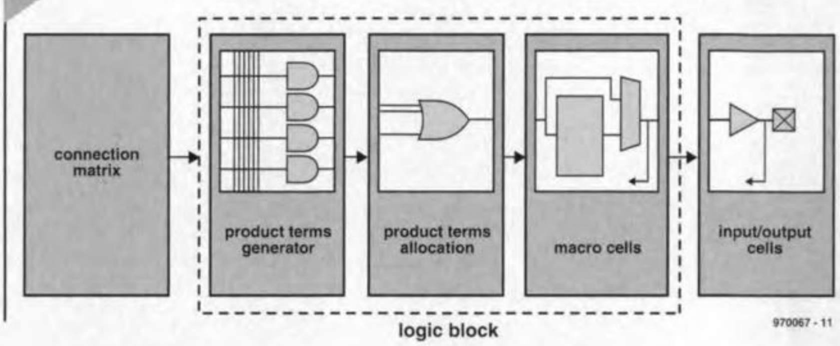

C1
C2
C17
R2
R1
R18
P1
C3
C4
C7
C5
R5
R3
C6
R7
R4
R6
970079-1
C8
IC1
C11
R8
R9
R10
R11
R12
R13
R14
T2
C14
C15
C9
P2
C10
T1
C13
R16
C12
R15
R17
C16
0
+

970079-1

programmable logic: VHDL and other new ways

the choice between VHDL and in-circuit

Until recently, TTL circuits from the 74xx family were a panacea for the realization of a wide variety of simple logic functions like multiplexers, decoders, state machines and other registers.

Figure 1. Internal structure of a CPLD.



Today, most of you will be convinced of the advantages of programmable logic in all its forms: PALs, PLDs, CPLDs and FPGAs. Indeed, one simple PAL type 22V10 already replaces half a dozen of TTL circuits while also reducing PCB size and current consumption. The new families of in-circuit programmable PLDs and CPLDs allow, by themselves, applications to be realized which used to be restricted to well-equipped laboratories, because of the prohibitive cost of development utilities or requisite programmers. Henceforth, thanks to in-circuit programming and the appearance of software which allows programmable circuits to be designed in VHDL on a PC, any user is finally capable of realizing his/her own application from start to finish.

Not-so-complex CPLDs

The CPLD (*Complex Programmable Logic Device*) raises the concept of PAL or PLD to a higher level of integration. Instead of adding inputs/outputs, or creating product terms with multiple elements (the logic expression 'A and B and C' is a product term with 3 elements: A, B and C), a CPLD is a unity of logic blocks which are interconnected by a matrix. As shown in **Figure 1**, each logic block, equivalent to a PLD, consists of a product-term generator followed by an allocator which routes each of the product terms to one or several logic ORs. The expres-

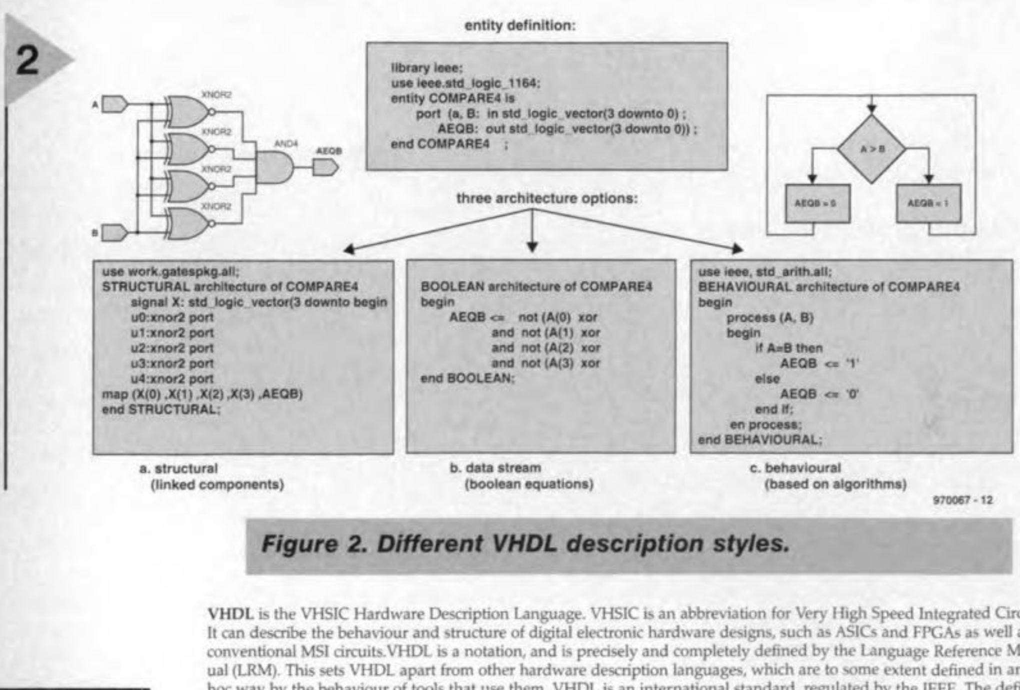


Figure 2. Different VHDL description styles.

VHDL is the VHSIC Hardware Description Language. VHSIC is an abbreviation for Very High Speed Integrated Circuit. It can describe the behaviour and structure of digital electronic hardware designs, such as ASICs and FPGAs as well as conventional MSI circuits.VHDL is a notation, and is precisely and completely defined by the Language Reference Manual (LRM). This sets VHDL apart from other hardware description languages, which are to some extent defined in an ad hoc way by the behaviour of tools that use them. VHDL is an international standard, regulated by the IEEE. The definition of the language is non-proprietary. *Source:* UK VHDL Users page.

by P. Olszewski (Cypress France)

sion obtained in this way is fed to a macrocell consisting of a flip-flop, multiplexers and a three-state output ahead of an input/output terminal. By cascading logic blocks, it is possible to make the logic expressions even more complex than those created by a simple trip in the AND-OR structure. CPLDs by themselves only differ in respect of the product allocator and the number of OR inputs before the macrocells. The internal architecture of CPLDs should allow the pin-out chosen for the component mounting to be preserved as much as possible, even if logic to be fitted has been modified or extended a couple of times, thus avoiding any unnecessary changes to the copper track layout. The most widely used package styles are the PLCC 44, 68 and 84, which may be mounted in sockets.

The Tower of Babel

The progress in the field of integration, density or flexibility of use of these components would be useless if there were no hardware description language capable of exploiting all available resources. Today, incontestably, the VHDL language presents itself. Originally only developed to allow US army electronic engineers and their suppliers to communicate along strict protocols, VHDL has slowly invaded all levels of electronic design. Even if it seems overkill for the design of simple PALs, using it allows you to overcome many realistic problems. Its first and foremost advantage is that of being a standard which is watched over by powerful IEEE standardisation committee. This implies that the survival of this language, or the tools that use it, does not depend on one or several manufacturers. Moreover, this language is a melting pot of different points of view and requirements of its designers. The resulting compromises allow one and the same function to be described with the aid of your preferred point of view. The essential point, of course, remains that the component does what you expect it to do.

Do your own thing

Concerning the design of programmable logic, you could uphold that that there are three 'schools'. The first gives privilege to the schematic-oriented approach, which means that functions are described with the aid of a collection of interconnected elements, chiefly logic ports (OR, NAND, XOR) and bistables (flip-flops and latches). This approach, called 'structural' has the advantage of showing clearly the amount of resources to throw in to realize this function, and to better exploit the possibilities of the component. On the down side, the description is tied to the final technology, and changing a component may produce worse results. The second approach draws on Boolean equations. Each output is 'expressed' with the aid of an equation in which inputs and component-internal nodes come together. To users of other design languages for programmable logic, this is the most natural approach. With some effort at code rewriting from PalASM or Abel into VHDL, it becomes possible to rehash old programs produced for components which are now obsolete. The third school favours an algorithm-based approach. Descriptions which are called 'behavioural' cause different processes to meet. The execution of these processes is event-conditioned (for example, a rising edge in a clock signal). Once activated, a process launches a series of instructions which closely resemble those used in the classic programming languages. You will find a miscellany of structures which are *conditional* like IF-THEN-ELSE, CASE-WHEN; *iterative* like FOR-LOOP, or *repetitive* like WHILE-LOOP. An important advantage of this approach is that it yields a global understanding of the function. However, being farther removed from the final component mounting, it is essential for the utility which synthesises the description, that is, compiles it and plants it in the device, to provide equally good results. VHDL and its designers has, at last, tried to reconcile these approaches and succeeded in doing so. Even better, it is possible to employ these different approaches within one and the same project. Typically, a state machine is best described using an algorithm, while it is easier to express the functions of its outputs in Boolean terms.

Employing three examples, **Figure 2** illustrates each of the approaches mentioned above. Each VHDL description consists of two parts. The first, called 'entity definition' serves to define the inputs/outputs of the function, without bothering about details regarding the actual implementation. It is the second part, the 'architecture', which indicates how to realize this function: interconnected components, Boolean equations or algorithms.

On programming

The last barrier associated with the programming of these components has been lifted. Thanks to the latest techniques in electrical erasing which gave us Flash and EEPROM devices, manufacturers have been able to finalize the details of programmable or reprogrammable components *in-circuit*, that is, without removing these components from the board. In this way, the use of in-circuit (re)programmable devices allows you to totally forget about a special programmer and a costly set of adaptors. A simple cable hooked up to the parallel port of a PC allows programmable data to be downloaded into the component. The input/output pins which convey the programming signals, generally four or five, have a double function, and may, therefore, be used again when the component is returned to its 'normal' mode of operation. Eventually, the card has only minor changes as compared with a version that does not support in-circuit programming: it is sufficient to add a simple connector (10 contacts are enough) and to provide for a few extra programming wires to pass. Sure, it is also possible to create a simple card which is designed for the sole purpose of programming the component – doing so results in your very own low-cost programmer.

Figure 3 shows the main aspects of in-circuit reprogramming (ICR, also called ISR, for *in-situ programming*). If necessary, two or several components may be cascaded and programmed in series, in parallel, or one by one. Effectively, in-circuit programming is based on the principle of the JTAG bus used for card testing. It also uses the same principle for the addressing and for the dialogue with the components mounted on the card.

3

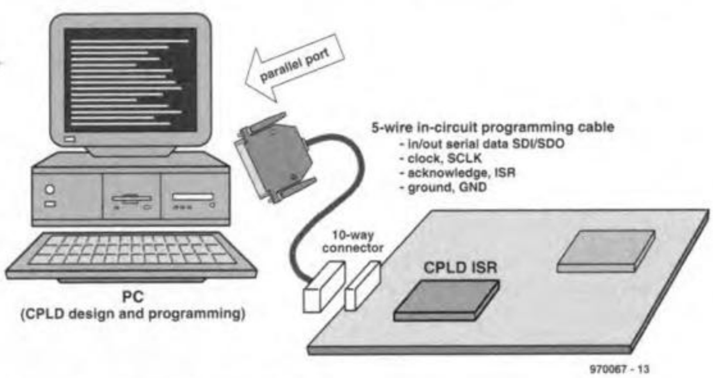
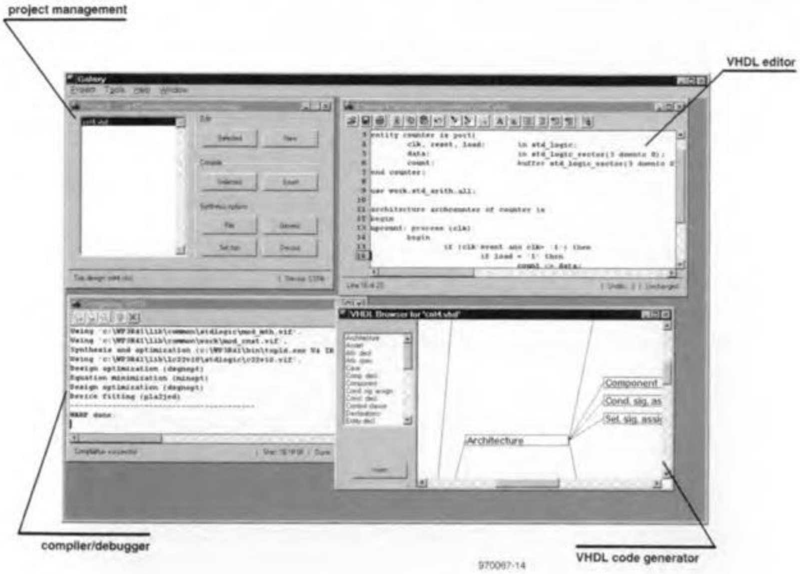


Figure 3. Direct reprogramming of a complex logic component with the aid of ICR (in-circuit reprogramming).

4

Figure 4. VHDL design environment (Warp™ v. 4.2 from Cypress)



VHDL OR IN-CIRCUIT PROGRAMMING? BOTH!

Cypress Semiconductors proposes a new development kit under reference number CY3620. It consists of an ICR programming kit for Flash370i CPLDs, and the Warp2™ VHDL design software for Windows 3.x, 95 or NT, which includes a project manager and an integrated VHDL editor/debugger (**Figure 4**). Thanks to a functional simulator which is also included (**Figure 5**), it becomes possible to create stimuli in the form of timing diagrams, and so facilitate making finishing touches to any application based on PALs, PLDs and CPLDs from 8 to 256 macrocells. Supplied with Kevin Sahill's excellent book on VHDL[1], and a compilation of exercises and practical solutions, the CY3620 kit will no doubt convince enlightened electronics designers to jump the bandwagon when programmable logic is involved.

(970067-1)

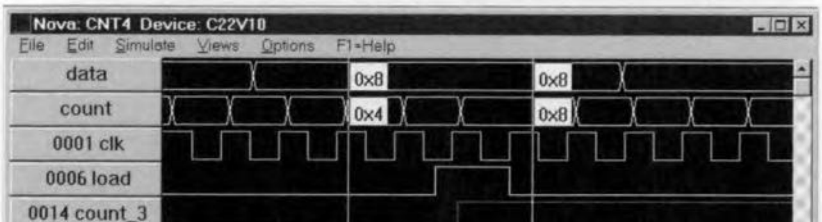
Reference

1 *VHDL for Programmable Logic*, by Kevin Sahill, published by Addison Wesley, ISBN 0-201-89573-0.

Further information on VHDL may be found on the **UK VHDL Users pages** starting at:
www.vhdluk.org/contents.htm

5

Figure 5. Verification phase using a functional simulator (Warp™ 4.2 from Cypress).



in passing ...

Since I spend quite a few hours behind the computer at home as well as in the office, I recently decided that the time had come to replace my ancient monitor by a new 17 inch model. As usual when I buy new hardware, I look through the various computer magazines to see what is available, before I rush to the shops to see for myself what prices are and what models are readily available. Reading through the magazines I was struck by the fact that the various reviewers often have quite different opinions. These differences are not so marked in the case of hard disk and CD-ROM drives, but definitely so when it comes to monitors. One monitor was at the top of the list in one magazine and at the bottom in another! I decided therefore that it would be best to test a number of monitors myself (in the shops, that is).

It soon became apparent that the reviews can be trusted only partly. Of course, certain aspects, such as bandwidth, controls, screening, type of display, are the same in most reviews. But when it comes to picture quality and geometry, you cannot do better than trust your own eyes and judgment. In the course of my quest, I tested some 20 monitors, and some of these, although they scored well in the reviews, did not satisfy me at all. Several suffered from line distortion and annoying deviations in the corners of the display. Unfortunately, these are matters that you cannot eradicate with the standard controls, but which could have been remedied during the quality test in the factory.

The quality or lack thereof had nothing to do with the price – some economy models were slightly better than some expensive ones. It seems that you just need luck to buy one that has been set up and adjusted properly in the factory.

I was lucky and now have a 17 inch colour monitor (black-and-white ones are no longer available) that was set up in the factory to specification and, what's more important, to my satisfaction.

My advice to prospective buyers of a monitor is to convince your own demands as to quality and test it thoroughly in the shop. If a shop does not allow you to do so, go to another!

[HB - 975068]

Absolute Maximum Ratings[1]				
Symbol	**Parameter**	**Min.**	**Max.**	**Unit**
V_{DD}	Supply voltage	0.5	7.0	V
V_I	Input voltage	1.2	$V_{DD}+0.5$	V
V_{OUT}	Output voltage	0.5	$V_{DD}+0.5$	V
I_{IN}	Input current	30	30	mA
I_{OUT}	Output current	100	100	mA
T_J	max. junction temperature	40	150	°C
T_{str}	Storage temperature	−65	150	°C

[1] Stresses above those listed may cause malfunction or permanent damage to the device. This is a stress rating only. Functional operation at these or any other condition above those indicated in the operation al and programming specification is not implied.

applied to implement counters. All CoolRunner™ family members provide both synchronous and asynchronous clocking, and provide the ability to clock off either the falling or the rising edges of these clocks. There are two clocks (CLK0 and CLK1) available on the PZ5032 device. Clock 0 (CLK0) is designated as the synchronous clock, and must be driven by an external source. Clock 1 (CLK1) can either be used as a synchronous clock (driven by an external source) or as an asynchronous clock (driven by a macrocell equation).

Two of the control terms (CT0 and CT1) are used to control the preset/reset of the macrocell's flip-flop. The preset/reset feature can also be disabled. The other four control terms (CT2-CT5) can be used to control the Output Enable of the macrocell's output buffers.

The reason that there are as many control terms dedicated for the Output Enable of the macrocell is to ensure that all CoolRunner™ devices are PCI compliant. The macrocell's output buffers can also be disabled or enabled at any time. All CoolRunner™ devices also provide a Global Tri-State ($\overline{GTS}$) pin, which, when pulled low, will 3-state all the outputs of the device. This pin is provided to support in-circuit testing or bed-of-nails testing.

There two feedback paths to the ZIA: one from the macrocell, and one from the I/O pin. The ZIA feedback path before the output buffer is the macrocell feedback path, while the ZIA feedback path after the output buffer is the I/O pin ZIA path. When the macrocell is used as an output, the output buffer is enabled, and the macrocell feedback path can be used to feed back the logic implemented in the macrocell. When the I/O pin is used as an input, the output buffer will be 3-stated, and the input signal will be fed into the ZIA via the I/O feedback path, and the logic implemented in the buried macrocell can be fed back to the ZIA via the macrocell feedback path.

PZ5032
32-macrocell Complex Programmable Logic Device (CPLD)
(CoolRunner™ series)

Manufacturer

Philips Semiconductors, 811 East Arques Avenue, P.O. Box 3409, Sunnyvale, CA 94088 3409.
Internet: *www.semiconductors.philips.com*

Features

- Industry's first TotalCMOS™ PLD to use both CMOS design and process technologies
- Fast Zero Power (FZP™) design technique provides ultra-low power and very high speed
- High speed pin-to-pin delays of 6ns
- Ultra-low static power of less than 75 μA
- Dynamic power at 50 MHz 70% lower than competing devices
- 100% routable with 100% utilization while all pins and all macrocells are fixed
- Extremely simple to use deterministic timing model
- 2 clocks with programmable polarity at every macrocell
- Support for complex asynchronous clocking
- Innovative XPLA™ architecture combines high speed with extreme flexibility
- 1000 erase/program cycles guaranteed
- 20 years data retention guaranteed
- Logic expandable to 37 product terms
- PCI compliant
- Advanced 0.5μ E^2CMOS process
- Security bit prevents unauthorized access
- Design entry and verification using industry standard and Philips CAE tools
- Reprogrammable using industry standard device programmers
- Innovative Control Term structure provides either sum terms or product terms in each logic block for
  - Programmable 3-state buffer
  - Asynchronous macrocell register preset/reset
- Programmable global 3-state pin facilitates bed-of-nails testing without using logic resources
- Available in both PLCC and TQFP packages
- Available in both Commercial and Industrial grades.

Device Classification Data

Usable gates:	1000
Max. no. of inputs	36
Max. no. of I/Os	32
No. of macrocells	32
I/O macrocells	32
Buried macrocells	0
Propagation delay (ns)	6.0
Packages	44-pin PLCC, 44-pin TQFP

Application Example

DC nullifier for oscilloscopes, *Elektor Electronics* October 1997.

XPLA™ Architecture

The XPLA™ architecture shown in **Figure 1** consists of logic blocks that are interconnected by a Zero-power Interconnect Array (ZIA). The ZIA is a virtual cross-

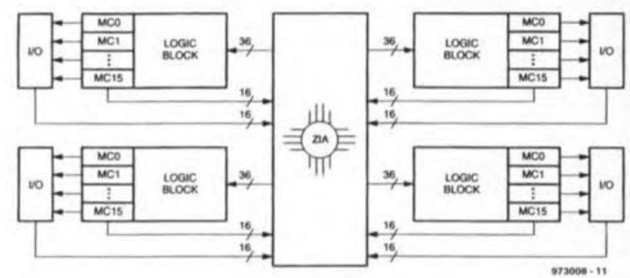


Figure 1. Philips XPLA CPLD Architecture

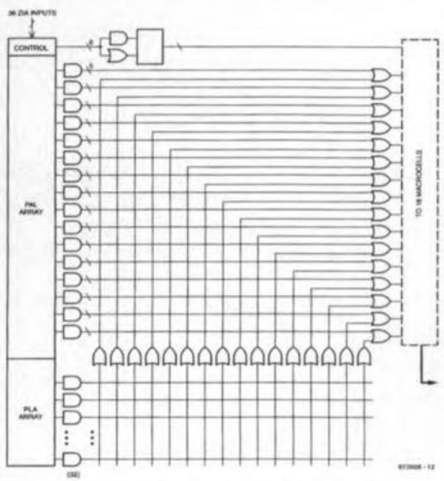


Figure 2. Philips Logic Block Architecture

point switch. Each logic block is essentially a 36C16 device with 36 inputs from the ZIA and 16 macrocells. Each logic block also provides 32 ZIA feedback paths from the macrocells and I/O pins.
So far, this architecture is very similar to that of other CPLDs. What makes the CoolRunner™ family unique is the contents of each logic block and the design technique used to implement the blocks themselves.

Logic Block Architecture

Figure 2 shows that each logic block contains control terms, a PAL array, a PLA array, and 16 macrocells. The 6 control terms can be configured individually as either SUM or PRODUCT terms, and are used to control the preset/reset output enables of the 16 macrocell flip-flops. The PAL array consists of a programmable AND array with a fixed OR array, while the PLA array consists of a programmable AND array with a programmable OR array. The PAL array provides a high speed path through the array, while the PLA array provides increased product term density.
Each macrocell has 5 dedicated product terms from the PAL array. The pin-to-pin t_{PD} of the Z5032 device through the PAL array is 6ns. This performance is equivalent to the fastest 5-volt CPLD available today. If a macrocell needs more than 5 product terms, it simply gets the additional product terms from the PLA array. The PLA array consists of 32 product terms, which are available for use by all 16 macrocells. The additional propagation delay incurred by a macrocell using 1 or all 32 PLA product terms is just 2ns. So the total pin-to-pin t_{PD} for the Z5032 using 6 to 37 product terms is 8ns (6ns for the PAL plus 2ns for the PLA).

Macrocell Architecture

As shown in **Figure 3** each macrocell consists of a flip-flop that can be configured as a D or a T type. A D-type flip-flop is generally useful for implementing state machines and data buffering, while a T type is usually

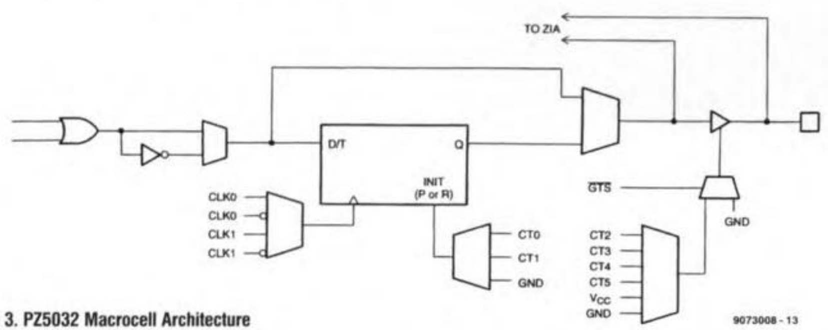


Figure 3. PZ5032 Macrocell Architecture

PZ5032
Integrated Circuits
Digital, Complex Logic
ELEKTOR ELECTRONICS
DATASHEET 10/97

Extract from a PZ5032 source code listing (example)

```
Module DSO_offset
Title 'automatic DSO offset for slow signals'

DECLARATIONS

clk          pin 43;
key          pin 25;
auto         pin 16 istype 'reg';
phase_1 pin 7;
out_1        pin 6;
out_2        pin 4;
reset        pin 44;
sw_f         pin 8;
sw_ff        pin 11;
sw_b         pin 9;
sw_fb        pin 12;
sw_auto      pin 13;
led          pin 14;
dir          pin 24;
db11..db0    pin 28,29,31,32,33,34,36,37,38,39,40,41 istype 'reg';
cs           pin 27 istype 'buffer';
ct13..ct0 node istype 'reg';

db=[db11..db0];
dr=[db10..db0];
dp=db11;
ct=[ct13..ct0];

equations

db.c= clk;
ct.c= !clk;
auto.c= clk;

dr.ar= !reset;  "reset DAC to 0V (100000000000)"
dp.ap= !reset;

ct.ar= !reset;          "reset key control counter"
auto.ar=!reset;         "reset auto_flag"


"TIMEBASE OSCILLATOR"

out_1= !phase_1;
out_2= phase_1;


"KEY CONTROL"

when (sw_f==0)#(sw_b==0)#(sw_ff==0)#(sw_fb==0)#(sw_auto==0)#(auto==1) then
```

Encyclopedia of Acoustics

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

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

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

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

A full review of this massive work will appear in a forthcoming issue of this magazine.

Television Microprocessor IC Data Files

By J Edwards
ISBN 0 7506 3335 2
240 pp – 200+ pinout drawings
Price £14·99 (Paperback)
(Newnes)*

Microprocessor ICs are the most complicated part of TV equipment and present special problems to the engineer when fault finding. Following on from the first volume in this series, Television IC Data Files, the most popular microprocessor ICs used in television receivers are covered. Each device is presented graphically with the relevant data information given against each pin which allows the engineer to quickly compare voltage measurements and signal in/out data on a faulty device, with those in the book. All the measurements and signal data in the book were taken under actual working conditions.

The purpose of the book is to provide the workshop engineer and the field engineer with a valuable and convenient method of fault finding without the need to consult workshop manuals which are often expensive or out of stock. As such, it will also be of interest to those on television training courses.

Electronics Made Simple

By Ian Sinclair
ISBN 0 7506 2842 1
208 pp – Line illustrations
Price £12·99 (Paperback)
(Focal Press)*

If you are just about to embark upon a course which involves electronics, or are interested in the subject but do not know where to start, or simply need a quick and straightforward revision of the basics, then this book is for you.

Assuming no prior knowledge, the aim of this book is to present an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. Waveforms, graphs and block diagrams are used to show the effect of a circuit on its input.

Practical Analog Electronics for Technicians

By W A Kimber
ISBN 0 7506 2952 5
256 pp
Price £12·99
(Focal Press)*

Practical Analog Electronics for Technicians not only provides an accessible introduction to electronics, but also supplies all the problems and practical activities needed to gain hands-on knowledge and experience. This emphasis on practice is surprisingly unusual in electronics texts, and has already gained Will Kimber popularity through the companion volume *Practical Digital Electronics for Technicians*.

Written to cover the Advanced GNVQ optional unit in electronics, this book is also ideal for BTEC National, A-level electronics and City & Guilds courses. Together with *Practical Digital Electronics for Technicians*, this text comprises a complete practical electronics course designed for students with little prior knowledge of the subject.

* Focal Press and Newnes books may be ordered from:
Customer Services Department
Heinemann Publishers Oxford
P O Box 382
Halley Court
Jordan Hill
Oxford OX2 8RU
Telephone: 01865 314301
Fax: 01865 314029

Books from Elektor Electronics

Build your own Electronic Test Instruments (0 905705 37 8)	£ 15·95	$US38.25
Build your own AF valve amplifiers (0 905705 39 4)	£ 14·95	$US36.00
Build your own high-end audio equipment (0 905705 40 8)	£ 14·95	$US36.00
Short Course 8051/8032 Microcontrollers & Assembler (0 905705 38 6)	£ 9·95	$US24.00
SMT Projects (0 905705 35 1)	£ 9·95	$US24.00
306 Circuits (0 905705 43 2)	£ 15·95	$US38.25
305 Circuits (0 905705 36 X)	£ 14·95	$US36.00
304 Circuits (0 905705 34 3)	£ 12·95	$US31.00
303 Circuits (0 905705 26 2)	£ 10·95	$US26.25
302 Circuits (0 905705 25 4)	£ 9·95	$US24.00
301 Circuits (0 905705 12 2)	£ 9·95	$US24.00
Microprocessor Data Book (0 905705 28 9)	£ 10·95	$US26.25
Data Sheet Book 2 (0 905705 27 0)	£ 9·95	$US24.00
Data Book 3: Peripheral Chips (0 905705 30 0)	£ 10·95	$US26.25
Data Book 4: Peripheral Chips (0 905705 32 7)	£ 10·95	$US26.25
ST62 Microcontrollers (0 905705 42 4)	£ 24·95	$US60.00
SCSI: The Ins and Outs (0 905705 44 0)	£ 24·95	$US60.00
PICs in Practice (0 905705 51 3)	£ 24·95	$US60.00
I^2C Bus (0 905705 47 5)	£ 24·95	$US60.00
PC Service & Repair (0 905705 41 6)	£ 29·95	$US72.00
Lasers: Theory and Practice (0 905705 52 1)	£ 19·95	$US48.00

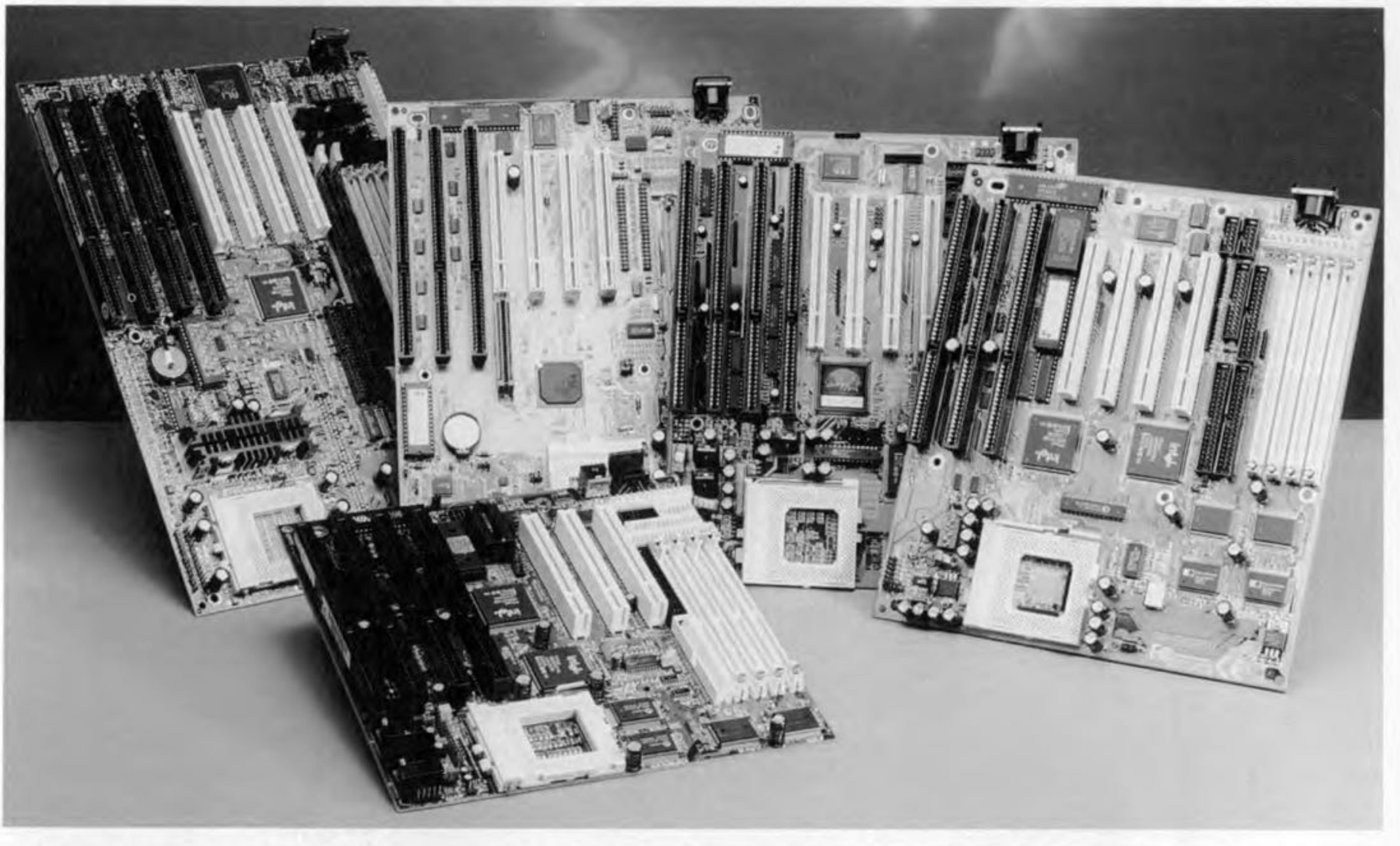
Planned for publication:

The CD-ROM System (0 905705 46 7) – October 1997
Matchbox Single Board Computer (0 905705 53 X) – November 1997
Designing Audio Circuits (0 905705 50 5) – December 1997
Handbook for Sound Technicians (0 905705 48 3) – January 1998
Satellite Radio & TV Receivers (0 905705 49 1) – February 1998

As suggested by the prominent place it receives at the beginning of this free Supplement on the subject of upgrading old PCs, the motherboard is without doubt the most essential part of a PC because a fair number of options depend on it. In this article we have a close look at the modern motherboard in all its different varieties, with particular attention to those aspects you should really be aware of before opening your wallet.

motherboard upgrading

avoid those pitfalls



Picture shows, left to right, an AB-IT5H supplied by AMOR Computers (Venlo, NL), an Asus TX97-E (IMA Electronics, Oosterhout, NL), a Soyo 5VD5 (Soyo Europe b.v., NL), a Gigabyte ATV and (in front) a BMG TVX-8500 (both from Orbit Computers, Aachen, G).

Over the past three months or so, several members on our laboratory and editorial staff have been very busy in their struggle to replace PC components like the motherboard, video card, CD-ROM player or hard disk. The pitfalls noticed in some of these activities, we thought, would be worthwhile to put on paper and share with our readers.

Act 1: (saddened) owner of an 486SX33 becomes aware of the fact that new versions of programs for which he/she just obtained an update run very slowly, or not all. Starts to scratch his head. Let's try to put the problem into the proper perspective: what's the use of embarking on an undertaking as complex as upgrading the PC?

Act 2: he/she is off to the nearest WH Smith store and buys a couple of special interest magazines. Few however cover the complex subject of PC upgrading, leaving the SX33 owner no alternative but to work out a strategy for himself.

One phase you can't avoid in the process of upgrading a PC (which, by the way, is more complex than one would imagine) involves replacing the 'engine' of an existing system. One of the first things that strikes you when examining the specifications of various PC motherboards is that there are in fact fewer manufacturers around than one would have thought given the number of board names you come across in the quest for the motherboard of your dreams. In the world of PC system assembly, some of the most frequently heard manufacturer names are (in alphabetical order) Abit, Asus, Boston, Genoa, Gigabyte, Intel, Microstar, Mitac, QDI, Soyo, Supermicro and Tyan. This list is not exhaustive!

Why change the motherboard?

One of the major reasons for replacing the motherboard in your trusty PC is to reap the benefits of higher speed than the previous generation. This speed gain is mostly due to the faster CPU on the new motherboard. That brings us to one of the other essential points you have to pay attention to: to be sure about the processor you wish to use. This choice should be given some thought because there are a few motherboards around that do not accept all currently available processors like the Pentium (MMX), Cyrix/IBM 150+/166+, AMD K5 and K6 and IBM PR200+.

The choice of the processor has important ramifications for the CPU supply voltage which has to be furnished by the motherboard: 3.3 V (for the Pentium and the Sxx versions of the 686 from Cyrix/IBM); 3.35 V (Pentium and Vxx versions of the 686; 2.8/3.3 V (Pentium MMX and Cyrix M2); 2.9/3.3 V (AMD's K6 166 and 200 MHz) or 3.2/3.3 V (AMD's 233-MHz K6). Fortunately, in practice you only have to ascertain that the motherboard you have in mind can work with the processor of your choice. For this check there is really no need to go into technical details regarding the CPU supply voltage.

The K6 from AMD is a remarkable component which will not fail to interest many owners of a motherboard of recent make (not older than 6 months or so) mainly because this processor can be fitted in the 'Socket 7'-style CPU holder, and is supported by many existing motherboards. So you may want to contemplate upgrading to a K6 without even changing the motherboard. And that leads us to the next question:

Intel Inside or not?

Contrary to what you might think, the first action to take in the upgrading process is to make an informed choice regarding the processor which is to be at the heart of the new (or souped-up) computer. This is because the CPU type determines to a large extent what can be done next, even if you are able to keep using (a number of) your existing cards, and even if your PC is not a type with just a VLB (*Vesa Local Bus*), a standard now totally eradicated and replaced by PCI.

These days, the PC owner is confronted with a bewildering number of processors to choose from, and the 'latest' type is always 'faster and better'. One of the best known CPUs is without doubt the Pentium II (originally known as the Klamath, this is a Pentium Pro endowed with MMX functionality). The main disadvantage of the Pentium II is that it marks a complete departure from the Socket 7 standard, its physical outline requiring a specific motherboard which offers a specially designed *single-edge connector* (SEC). At this point, we will not discuss the K5 and other 586 CPUs which are fast upgrades for those wonderful 486-based motherboards many of you can't think of being separated from as yet (but do read the last paragraph on Overdrives).

Everybody seems to agree that the 6x86 from IBM/Cyrix was the first CPU to make a tiny dent in the virtual monopoly held by Intel. In the aftermath of this (relative) success, Cyrix recently launched the M2, a direct competitor of the Pentium II.

AMD, another 'David' in the arena (assuming that Intel is Goliath), and not resting on its laurels either, introduced its K6 a few months ago. In the case of the M2 and the K6, it is correct to speak of worthy competitors of the Pentium II. Both the Cyrix and the AMD CPU have the full MMX instruction set. Unlike the Pentium II however, these newcomers are happily seated in the familiar Socket 7, which obviates the need for a new motherboard. Assuming that Intel does not grant us large price cuts, the AMD and Cyrix CPUs are about 50% cheaper for comparable performance. The only (small) disadvantage of the new rival CPUs is that their use may require some modifications (minor ones, says AMD) to the BIOS on the motherboard. These processors are also representative of the ongoing trend towards ever higher speeds, AMD having announced the release of a 300-MHz version of the K6 within the next few months. Looking a little further into the future we see Intel developing out and introducing their MMX 2, the Katmai. Although the P7 (code name Merced) is scheduled four launching in 1998, you should not be surprised if fierce competition causes an earlier release. And then we don't even mention the Deschutes, a special version of the Klamath aimed at the server market, or the Tillamook, a module designed for use in portable computers.

Very likely, when you read this, the MMX concept makes a fierce attack on the market, putting considerable pressure on PC users who are as yet unsure about the benefit of upgrading. Reportedly, the use of an MMX CPU yields a 10% increase in performance of regular (i.e., non-multimedia) software, while a much greater speed boost is said to be in store for software which is specifically written to run on an MMX processor. The prices of the slowest MMX processors (166 and 200 MHz) are sure to drop when the 233, 266 and 300 MHz versions arrive. You may therefore have to decide for yourself whether or not to splash out on an MMX CPU if you are already in the process of buying a new motherboard. Remember, the concept of MMX is not restricted to Intel CPUs: AMD's K6 and Cyrix's 6x86MX also offer full MMX support.

Which motherboard?

Basically, there are two types of motherboard: (1) the classic type which has jumpers which enable a certain number of settings to be selected such as processor speed and bus speed, and (2) the jumperless motherboard, which allows all settings to be made by means of software. The ABIT IT-5H is a good example of this class (see inset).

Let's have a look at some of the technical aspects you have to examine when choosing a motherboard.

Board size

There exist two motherboard footprints: Baby-AT and ATX. Each of these has its own power supply connector: 12-way in-line on Baby-AT boards, and two rows of 10 contacts on ATX boards. Cards having both type of connector are few and far between. The ATX version is easily recognized by the fact that the CPU is never in the way of extension cards. Choosing the wrong card in respect of size may mean that you have to buy a new case (which is usually supplied with an integral power supply). The Baby-AT format seems to be open to free interpretation: while the width is usually 22 cm, the length can be anything between 22 cm and 33 cm. An ATX board measures about 30.5×24.5 cm, although exceptions also occur (e.g. 21.2 cm for the TX97-X(E) from Asus).

Exploring the Motherboard

Over the years, the motherboard has become a single, large, printed circuit board. Although today's motherboards contains fewer components than the one fitted in a vintage IBM XT PC, its structure is far more complex. Time for a quick tour of the system!

BIOS

The function of the BIOS is to act as an interface between the user software and the electronics available on the motherboard and extension cards. The electronics, in turn, control the various peripheral devices installed in the PC or connected to it. PC tuners/tweakers will want to update the BIOS quite frequently to keep up with continuous technological development. A flashable BIOS with an associated control program and data file is preferred in this respect because it can be updated by 'soft' action only (i.e., no need to extract and insert an expensive EPROM).

Extension connectors

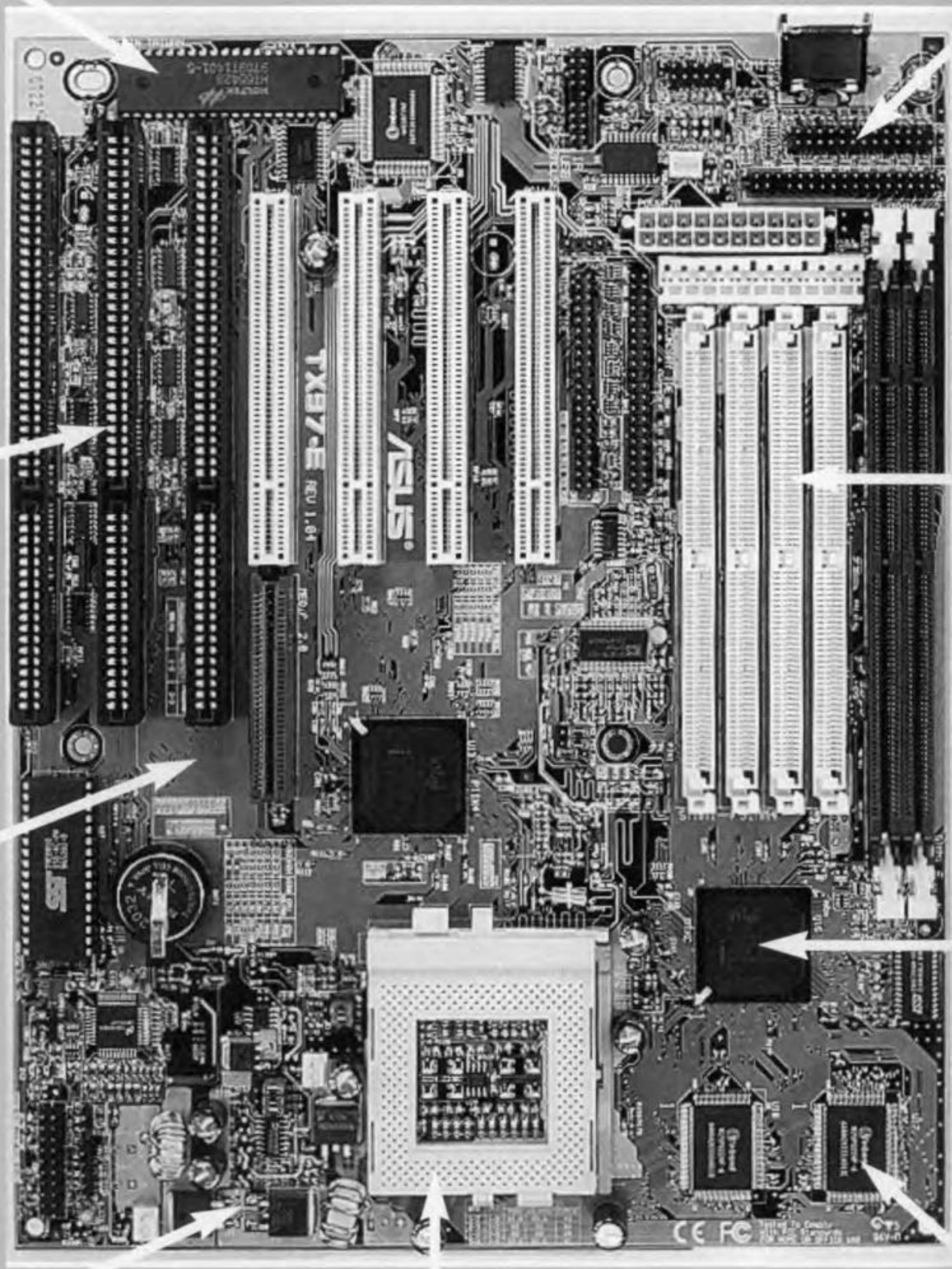
Nearly all modern motherboards keep offering a number slots of the ISA type, a format which has been around ever since the first PC. Its younger and faster counterpart is the PCI bus (*peripheral component interconnect*). Having a width of 32 bits, the PCI bus allows much higher data transfer rates to be achieved.

Physical size

As mentioned elsewhere in this article, motherboards come in two sizes: Baby-AT and full-size ATX. These differ in respect of the CPU position, or the location of connectors for peripheral devices. The shape of the power supply connector is also different: 12 pins for the Baby-AT board, and 20 pins for the ATX.

Voltage regulators

These components, of very rudimentary design at the beginning of the PC age, are rapidly becoming more and more sophisticated, the most recent models employing switch-mode power switching principles. There are vast differences in the supply characteristics of Pentium processors: some require 3.3 V, others 2.9 V, 2.5 V or even a combination of these ('split CPU voltage'). You can easily identify a switch-mode power supply by the presence of one or two ferrite ring cores in the direct vicinity of the regulator proper.



CPU socket

All recently produced motherboards have a ZIF (zero insertion force) socket for the CPU. Most Pentium compatible motherboards have a 'Socket 7'. The Pentium Pro CPU requires a physically larger socket with more pins, called 'Socket 8'.

Input/output connectors

On the most recent motherboards, the I/O (input/output) connectors are regrouped. The absolute minimum to have is a keyboard socket, an FDD (floppy disk drive) connector, one (or two) E-IDE hard disk drive connectors (also for a CD-ROM drive), one parallel port, and two serial ports. On some cards you may also find an IrDA port, a PS/2 mouse connector and an USB pin header.

Memory connectors

The classic SIMM module (30 contacts, 8 bits + parity in some cases) has virtually disappeared from the market. The replacement was a 32/36-bit module with 72 contacts. The arrival of CPUs with a 64-bit bus caused yet another memory variant to be thrown at us: the 168-pin DIMM module. In contrast with 72-pin style sockets, the 168-pin DIMM version is polarized to prevent any risk of a DIMM being fitted the wrong way around.

Chipset

The function of this set of very complex integrated circuits is to arrange the data and control signal traffic on the motherboard, relieving the CPU of this time-intensive task. The most frequently applied chipsets are from Intel, and they go by type numbers like 82430FX/HX/TX/VX.

Cache memory

This is basically a buffer memory between the processor and the system RAM. The processor itself already has a certain amount of internal memory (the internal cache). A memory with a far greater capacity, the cache RAM, is often soldered directly on to the motherboard. While the difference in performance between 0-k cache and 256-k cache is remarkable, there is little or no point in installing more than 512 kbyte of cache.

It should be noted that there is also a less well known format around called mini-ATX (19×30.5 cm).

Today, it looks as if the ATX shape is becoming the standard, mainly because it has sufficient space for the CPU in combination with (full-size) extension cards. Another advantage is that some of the extra contacts on the power supply connector have been given very useful functions. One of these is a sleep/awake detector which allows certain extension cards like a modem to receive a supply voltage while the PC is actually switched off (provided, of course, the mains plug is still in the socket).

Another aspect to pay attention to is that the connectors for the keyboard, mouse and other peripherals are properly aligned with the respective holes in rear panel of the PC case.

BIOS

One of the technical characteristics you have to take into account is the BIOS used on the motherboard, or, more precisely, the BIOS manufacturer (Award, AMI, Phoenix and others) and the type (regular EPROM or Flash EPROM, the latter can be reprogrammed in-circuit with the aid of a small control program and suitable data). The chip set and the BIOS belong together, the BIOS making the best possible use of the features offered by the chip set. If you are courageous enough to have a go at changing the BIOS contents yourself, you should choose a motherboard with a Flash BIOS as that will enable you to perform an upgrade if and when necessary.

Memory

Less than ten years ago, everybody, including Bill Gates, agreed that 640 kBytes was a more than ample amount of memory. Today, the minimum amount seems to be 16 Mbytes, while 32 MBytes is recommended if you want to get any serious work done. Everybody is now in favour of using EDO memory. "So what can I do with my eight 1 Mbyte × 9 bit SIMM modules?" Developments in the PC memory scene are so fast nowadays that there it makes no sense, in our opinion, to invest in two adaptor boards (one for every four SIMMs) which, together with two additional 4-Mbyte modules, would produce the 'bare minimum' memory amount of 16 Mbytes. Even if you would decide to pursue this course, you may have to think again because problems may arise from the combination of 'grouped' SIMMs and the two 4-Mbyte modules you bought (the lot may not fit on your motherboard, or the motherboard may not recognize the combination). Some of the latest motherboards, including those from Asus, do not even have SIMM sockets any more, making it impossible to re-use your old memory modules.

Input/output connectors

We're now definitely past the times of special insertion cards for driving peripheral devices, diskette drives, hard disk drives, parallel and/or serial ports. Today, all the necessary electronics are available on the motherboard, and the relevant connectors are available at that level, so to speak. A modern motherboard should at least have an FDD (floppy disk drive) port for a 1.44 Mbyte drive; most of these ports are ready for working with two of these drives, and capable of reading any disk format you can think of (360/720 kB, 1.1/1.44/2.88 MB). Further, there should be an E-IDE port for a hard disk and/or CD-ROM player, a parallel port (supporting SPP, EPP and ECP modes), two RS232 serial ports (fully 16550 compatible). Welcome extras in this respect include a USB port, a PS/2 mouse port and a connection for an IrDA module.

Extension slot connectors

The VLB bus is dead, long live PCI. It is important to make sure that the motherboard you have in mind has extension slots which are compatible with the extension cards you already (or still?) have: video card, sound card, etc. If you own a system with a VLB bus, upgrading may become a bit of a problem because modern motherboards no longer have VLB connectors. In most cases, that means you have to invest in a PCI video card. ISA slots, fortunately, remain available on all motherboards we examined for this article, and they are indispensable for the good old sound card.

An increasing number of motherboards are combination types, integrating, for example, video and sound. This approach has advantages as well as disadvantages: while the motherboard may have the latest technology at the time of introduction on the market, it is quickly obsolete again because it can not keep up with the extremely fast developments in the field of sound and video chip sets and drivers.

You should, therefore, prefer a 'bare' motherboard which is open to extension with your own insertion cards for video, sound, communication, etc. as required.

Chipsets, the story

Although there exist other manufacturers of chipsets for PC motherboards (AMD for its K6, Opti, SiS, ETEQ and others), Intel rules in this area. Its firmly established Triton chipset comes in four flavours called (82)430FX, 430VX, 430HX and 430TX.

The 430FX was the first chipset from Intel. It is no longer used for new design.

The 430VX was the first to support SDRAM as well as DIMM, which allows individual memory banks to be filled rather than pairs as required for conventional SIMMs.

The 430TX is the latest Triton chipset. Integrated into just two large ICs, the 430TX regroups all chipset functions known from previous versions, including multitasking, USB bus control, and slotted timing for EDO RAM. The 430TX chipset is optimized for MMX-savvy CPUs, and incorporates DPMA (dynamic power management architecture), a system which reduces the overall power consumption of the system, using intelligent power reduction strategies. It also supports the new Ultra-DMA protocol.

If you are after the very latest, go for a system with a 430TX chipset, even if that means that the relevant motherboard will set you back a little further.

The 430HX chipset falls between the 430VX and the 430TX. Currently, the HX set is found on many motherboards in the US$150 price class. Not the slowest, and not the fastest or latest either, this chipset, but reliable and worth its salt. Unfortunately, The Triton HX chipset does not support DIMM modules with SDRAM.

You may come across the chipset designations '82439HX' and '82437VX/FX' in the documentation supplied with some motherboards. These numbers refer to the system controller only, not to the chipset as such.

Checklist

Below are the main aspects to pay attention to

- Right from the start, choose the processor representing the best trade-off between computing power and your budget.
- Make sure there are enough memory banks (four), unless, of course, you opt for a motherboard with DIMM sockets only.
- Look at the position of the extension sockets; these should not be in the way of memory banks or other components on the board, including the CPU with a fan on top of it.
- Check the number of extension slot connectors (3 PCI and 4 ISA slots recommended).
- Verify the presence of cache memory (256 kB minimum).
- Go for a Triton 430HX or 430VX chipset, or better.
- Verify that the motherboard has a BIOS of the Flash PnP (*plug and play*) type.
- Possibility to choose present-day bus speeds (66, 75 or 83 MHz).
- The motherboard should have all connectors for essential peripherals, E-IDE for hard disk(s) and CD-ROM player, parallel and serial ports.
- Check for the availability of the new bus system called USB, you never know if this is going to take off!

If, in spite of all this advice, you do not want to complicate your life with the PC, there's always the

Overdrive option

There is an interesting alternative for owners of 486 or 66/75/100-MHz Pentium computers with limited technical knowledge and financial means: put an Overdrive in your PC! Various options are available. For 486 machines, you can choose between the following:

- Evergreen 586/133 MHz
- Power Leap, also based on a 133 MHz 586
- An 83-MHz Intel Overdrive (not compatible with any other system)

Owners of a PC with a first-generation Pentium CPU running at 66, 75 or 100 MHz may consider buying an Intel Overdrive from a new series featuring MMX and running at 125, 150 and 166 MHz respectively. While we prepared this article, Intel rolled out 180 and 200 MHz Overdrive versions designed to replace 120 and 133 MHz Pentiums (yes, they are old already). In theory, these Overdrives would have the same power as the 180 or 200 MHz Pentium MMX types.

The net speed gain achieved by an Overdrive is reportedly of the order of 50%. Installing an Overdrive is a piece of cake. Having opened the computer case and extracted the original CPU from its socket, you simply plug in the Overdrive and connect the fan. It is not necessary to change the CPU clock or the bus clock, everything remains as before. The processor supply voltages are changed inside the Overdrive itself. If you have doubts as regards the compatibility of your motherboard, go to the Intel site on the Internet at *http://intel.com/overdrive/index.htm* for reassurance or tears. It is just possible that you have to update your BIOS. The cost of the operation will be between £200 and £250.

Important precaution

Although electronic components these days are well protected against static discharges, it is recommended to observe some simple precautions. Before you do any work on the motherboard or any other internal component, make sure the PC is connected to the mains earth, and use a metal wrist strap connected to the PC's internal frame.

DIMMs, SIMMs and other memories

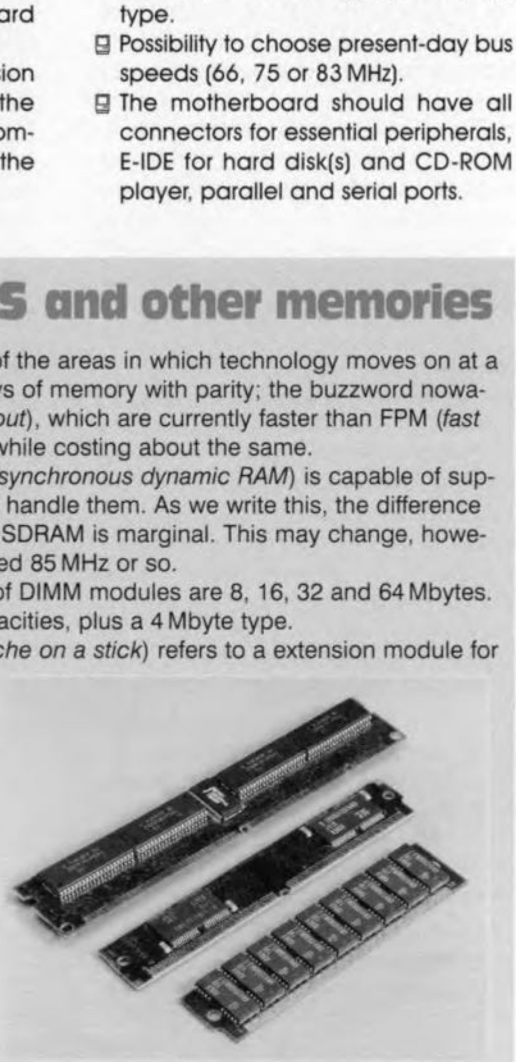
Like the CPU, the memory is one of the areas in which technology moves on at a staggering pace. Gone are the days of memory with parity; the buzzword nowadays is EDO RAM (*extended data out*), which are currently faster than FPM (*fast page memory*) memory modules, while costing about the same.

Another variant, SDRAM (*synchronous dynamic RAM*) is capable of supplying data as fast as the CPU can handle them. As we write this, the difference in performance between EDO and SDRAM is marginal. This may change, however, once bus speeds start to exceed 85 MHz or so.

The usual memory sizes of DIMM modules are 8, 16, 32 and 64 Mbytes. SIMM modules offer the same capacities, plus a 4 Mbyte type.

The acronym COAST (*cache on a stick*) refers to a extension module for the secondary cache memory.

The main problem in this area is that of standards. As a sad result there exist different COAST modules for Intel and Cyrix processors!



This photograph illustrates the evolution of memory modules. From the bottom to the top: a 30-pin 4-MByte SIMM, a 72-pin 8-Mbyte SIMM, and a 168-pin 16-Mbyte DIMM.

Future developments

As you will probably be aware of, there's no reducing the speed of developments in the world of microelectronics and information technology (IT). Only a decade ago, a PC would last about four years without suffering from ageing effects. Five years ago, this lifetime expectancy was halved to less than two years. These days, a PC bought six months ago is already obsolete. What does the future have in store for us? Clearly, developments can't continue to ride this exponential curve, which makes it impossible to properly market products before the arrival of a whole new product generation.

On this train of thought, let's mention some of the latest technology developments which may be expected to arrive within the next few months:

At the bus level: the **USB** (*universal serial bus*) is already implemented on nearly all motherboards of recent production.

Ultra DMA 33: this new protocol for IDE hard disk drives achieves much higher data transfer rates than traditional DMA methods, and appears on an increasing number of motherboards.

AGP (*advanced graphic port*): this new graphics port (announced about a year ago by Intel) is specifically aimed at 3D graphics cards. When AGP becomes the standard, video cards without it will be as obsolete as non-MMX motherboards in a couple of months' time.

The 100 MHz bus: here, too, developments are very fast. While you should count yourself lucky if your motherboard allows a bus speed of up to 85 MHz to be set, progress certainly does not stop there.

Conclusion

For the technically inclined among our readers (who isn't?), exchanging a motherboard and a processor is a very good alternative to purchasing a new no-name PC from a highstreet box-pusher. From experience, we can say that the exercise is not really difficult, although a lot depends on making informed choices before opening *any* case at all, and working *slowly*! Having successfully completed an upgrade operation, you have the advantage of actually knowing what's ticking inside the PC. At the same time, you reap the benefits of a unique opportunity to fine-tune the individual components in the system for the best possible performance.

The information presented in this article is not aimed to be exhaustive, and only manufacturers who have offered their co-operation in producing this article are mentioned. Special thanks are due to the commercial departments of Asus, Abit and Soyo for providing us with samples of their motherboards.

Finally, nobody seriously contemplating the purchase a new motherboard should forget to consult *Tom's Hardware Guide* on the Internet at *http://sysdoc.pair.com*.

(972031-1)

ABIT's IT-5H: Look, no jumpers!

PC motherboard ABIT manufacturer recently released the world's first jumperless mainboard that uses SOFT MENU™, a patented software technology that enables CPU parameters to be set from within the BIOS CMOS setup utility. Actually, the board has only one jumper which serves to totally clear the CMOS memory. Having no difficult hardware settings for you to grapple with, this board should be the ideal candidate for a 'drop-in and go' PC upgrade operation as described in this article. The IT-5H is the board at the far left in the introductory photograph.

The ATX-size IT5H has a Socket 7, and employs Intel's 430HX chipset (rev. 03) and three voltage regulators for the CPU. It also implements ECC, a DRAM checking algorithm which detects and corrects memory errors on the fly without user intervention or disruption of processing.

This board received a lot of praise in the computer press, and a good review may be found in *Tom's Hardware Guide*. There is also a version which uses the 430VX chipset, the IT-5V, this has basically the same specs as the 5H, only the on-board cache is 256 kByte (expandable with COAST).

Some recent motherboards

Soyo SY-5VD5

Featuring a Socket 7 this board accepts all Pentium processors of the P54CX/P55C type (75 to 233 MHz), the Cyrix 6x86 (PR100 to 166+), the K5 series (PR100 to 166) and the K6 from AMD.

It employs the 82430VX chipset, has four PCI sockets and four ISA sockets. The cache RAM has a size of 512 kBytes, and is of the SRAM burst-pipeline type.

This Baby-AT size board has two 168-pin DIMM sockets and four 72-pin SIMM sockets.

Its BIOS is one of the latest and most complete of the moment, stored in a 1-Mbyte Flash ROM. Note the contradiction between the term ROM (read-only memory) and the fact that this component may be reprogrammed electrically!

Among the special features of this board are intelligent CPU supply voltage detection, and Ultra-DMA 33 or E-IDE.

Soyo SY-5EA5

This board is virtually identical to the SY-5VD5 discussed above.

ASUS TX97-E

The Socket 7 on this board allows you to use Intel Pentium CPUs with any speed between 75 and 233 MHz, the AMD K5 and K6 processors, or the 6x86 types from Cyrix/IBM.

Using the 430TX chipset, this motherboard sports 512 kBytes of cache RAM. There are four 72-pin SIMM connectors and two 168-pin types for DIMMs. The BIOS is a PCI version from Award, supporting Symbios SCSI and running from a 1-Mbyte Flash EPROM. The ASUS Mediabus connector implemented on this board is a combination of the ISA and the PCI connector.

Special feats of this board include support for the Ultra-DMA/33 IDE standard, monitor systems for the supply voltage, temperature and fan state, and virus protection through the BIOS.

ABIT SM-5

This board accepts all Pentium processors, plus the P200+ from IBM, and is MMX compliant.

Excellent performance guaranteed by a new chipset from Intel, in combination with a flashable BIOS from Award.

Apart from the traditional input/output ports and channels the SM-5 also features USB and PS/2. The board has two DIIM sockets.

Remarkable points: has an integrated tapestreamer accelerator; five years free BIOS updating service.

GIGA-BYTE GA-586TX

Contrary to what we are lead to assume from its type designation, this motherboard is suitable for processors from the Pentium class! It is also suitable for the IBM/Cyrix M2 and the AMD K6. The GA-586TX is one of the first motherboards to support the new 120-Mbyte diskette drive.

Features automatic CPU type recognition and supply voltage definition, plus a system called A-COPS (*automatic CPU overheating protection system*). A-COPS issues a warning when there is a risk of CPU overheating, and switches on the cooling device (a temperature sensor is fitted underneath the CPU). In case of overheating, the system warns the user and cools the CPU without affecting the execution of the program.

Special feature: BIOS-based virus protection. The latest model is the GA-686FX.

Yes, those were dull times. But recently, the CPU market came alive. At long last, Intel was faced with small but serious competitors: AMD, Cyrix and IBM. And that's not the end of it, because a new competitor looks set to introduce Pentium-compatible CPUs which, reportedly, are dirt cheap. The new daredevil, IDT, has succeeded in making a hushed appearance in the CPU arena. In this article we examine the advantages and disadvantages of individual CPUs, as well as their best area of application.

by A. Meuser

CPUs – an overview

Intel Pentium

The Intel Pentium has been around for quite some time now, and it is still regarded as the mother of all CPUs in the Pentium class. It is, however, expected to disappear completely within the next few months as a result of a market force called MMX. The original Pentium processor works happily on all currently available motherboards, its excellent floating-point operation acting as a solid basis for many technical applications. But mind you, not all Pentiums are the same! Intel fabricates all CPUs on a single production line, and employs a series of performance tests to decide on the marking printed on the chip. In this way, CPUs are produced which are approved for different clock rates and operating voltages (for example, SSS = 3.3 V, VRE = 3.4 to 3.6 V). One of the shortcomings of the original Pentium CPU is its rather too small L1-cache, which has a size of only 16 kBytes.

Intel Pentium MMX

So far, it looks as if no one has actually understood why we should need this MMX CPU; after all, there is hardly any software available which supports the added instruction set. This is in spite of Intel's massive advertising campaigns aimed at convincing us of the immediate need of this technology. Fortunately, the MMX does contain a few really useful improvements over the original Pentium design: the size of the L1-cache has been doubled to 32 kBytes, there is a new *branch prediction unit*, and a couple of other, minor, tweaks. The result is a 10-20% improvement in performance over the classic Pentium. After a few price cuts, the MMX CPU has become an interesting upgrade alternative for many of you. It does, however, require two supply voltages: 2.8 V for the core, and 3.3 V for the I/O interface. Old Pentium Out, New MMX IN, alas, that will not work on many older motherboards which provide single CPU supply voltages only. However, here, too, you can make use of ready-made adaptor sockets (like the ones for 3.3-V 486 CPUs, remember?). These sockets, costing about £25, contain voltage regulators which provide the split supply voltages for the MMX CPU.

Intel Pentium Pro

If you can afford to do without MMX (and who can't?), Intel's Pentium Pro currently delivers the best floating-point performance. However, it is only in this respect that the overpriced Pro is worth its salt, because it too requires a new motherboard. The main applications of the Pentium Pro will be found in maths-intensive software used in research, design and network servers. The impres-

Table 1: CPU clock frequency and supply voltage selection chart.

CPU	Int. clock (MHz)	Ext. clock (MHz)	Multiplier (Jumper)	Core voltage (V)	I/O voltage (V)
AMD K5 PR75	75	50	1.5	3.52	*
AMD K5 PR90	90	60	1.5	3.52	*
AMD K5 PR100	100	66	1.5	3.52	*
AMD K5 PR120	90	60	1.5	3.52	*
AMD K5 PR133	100	66	1.5	3.52	*
AMD K5 PR166	116,66	66	1.75 (1.5)	3.52	*
AMD K6-166	166	66	2.5	2.9	3.3
AMD K6-200	200	66	3	2.9	3.3
AMD K6-233	233	66	3.5(1.5)	3.2	3.3
AMD K6-266	266	66	4(2)	3.2	3.3
Cyrix 6x86-P120+	100	50	2	3.3(C016)/3.52(C028)	*
Cyrix 6x86-P133+	110	55	2	3.3(C016)/3.52(C028)	*
Cyrix 6x86-P150+	120	60	2	3.3(C016)/3.52(C028)	*
Cyrix 6x86-P166+	133	66	2	3.3(C016)/3.52(C028)	*
Cyrix 6x86-P200+	150	75	2	3.3(C016)/3.52(C028)	*
Cyrix 6x86MX-PR166	150	60	2.5	2.8	3.3
Cyrix 6x86MX-PR166	166	66	2.5	2.8	3.3
Cyrix 6x86MX-PR166	188	75	2.5	2.8	3.3
IDT C6	200	66	3	?	?
Intel Pentium 75	75	50	1.5	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 90	90	60	1.5	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 100	100	66	1.5	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 120	120	60	2	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 133	133	66	2	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 150	150	60	2.5	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 166	166	66	2.5	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 200	200	66	3	3.3(SSS)/3.4-3.6(VRE)	*
Intel Pentium 166MMX	166	66	2.5	2.8	3.3
Intel Pentium 200MMX	200	66	3	2.8	3.3
Intel Pentium 233MMX	233	66	3.5 (1.5)	2.8	3.3
Intel Pentium Pro 166	166	66	2.5	3.3	*
Intel Pentium Pro 180	180	60	3	3.3	*
Intel Pentium Pro 200	200	66	3	3.3	*
Intel Pentium II 233	233	66	3.5	2.8	
Intel Pentium II 266	266	66	4	2.8	
Intel Pentium II 300	300	66	4.5	2.8	

*I/O voltage = Core voltage

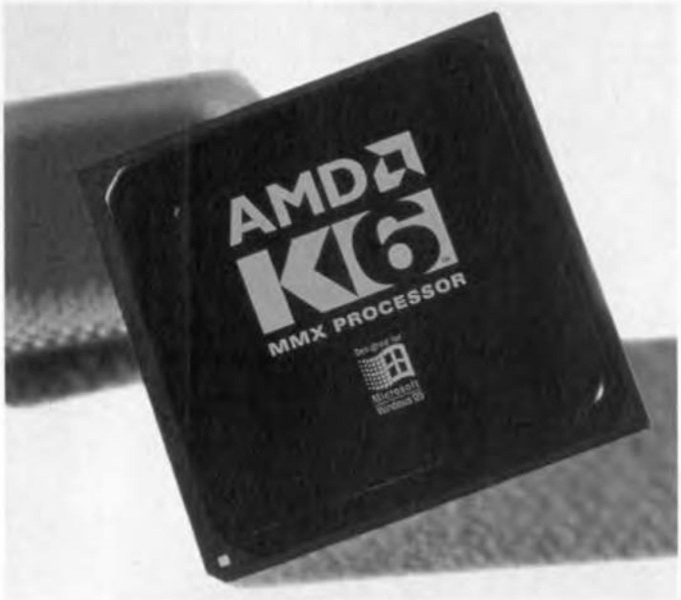
sive memory-performance achieved by the Pentium Pro is mainly due to the internal 256-kByte L2 cache. If you are lucky, you may even get your hands on versions with 512 kB and even 1 Mbyte of L2-cache.

Intel Pentium II

Developed out of the Pentium Pro and spiced up with MMX, this is currently Intel's flagship. Because of a too high dropout (production fault) rate, the internal L2 cache of 512 kByte was taken out of the chip and moved to the processor board. This change resulted in a small reduction in memory performance. This processor board (or rather module) calls for the SEC (*single-edge connector*) socket designed by Intel. Remarkably, Pentium Pro adaptors are available for the SEC. As you may have guessed, the Pentium II requires a new, SEC savvy, motherboard. The processor comes in 233, 266 and 300 MHz versions. Ticking at such high speeds, the 'II' is currently the fastest processor in the Pentium class.

AMD K5

After AMD changed its entire production line to the K6 CPU, K5 processors can be picked up cheaply from many computer hardware suppliers. This processor is of special interest to owners of an 'older' motherboard, mainly because its PR133 version can be employed on motherboards with a maximum CPU



vided by the latest motherboards only. The K6 also requires intensive, active, cooling to work reliably.

Cyrix/IBM 6x86

Because Cyrix obviously dreads the prospect of massive numbers of unsolds of this CPU as a result of the current MMX hype, the remaining stocks of the 6x86 are sold at bargain prices.

clock of 66 MHz and a fixed multiplier of 1.5. Although the PR133 actually runs at 100 MHz, it matches the overall performance (except floating-point) of an Intel Pentium operating at 133 MHz (hence, PR133 for 'p-rating'). This leap forward in performance goes mainly on account of the improved structure of the L1-cache. The K5 is available in versions right up to PR166, and only requires an 'external clock' jumper setting on the motherboard, the multiplier being fixed inside the CPU. None the less, AMD recommends the same jumper settings as for an Intel CPU.

AMD K6

High hopes were vested in this wonder weapon from Intel's first serious competitor. Based on a processor developed by NexGen, the K6 has lived up to its expectations. Like the K5, it has a few weaknesses in the floating-point area, but these are far less annoying. AMD has done quite a bit in this area. Being equipped with the MMX instruction set, the K6 is often compared with the Pentium MMX. In some applications, however, it reaches the performance of a Pentium Pro or a Pentium II. As opposed to these beasts, the K6 does fit in a Socket 7 on a standard (but up to date) Pentium motherboard. As such, it presents an extremely cost-effective alternative when it comes to upgrading existing systems. With this processor, too, there are a few peculiarities in respect of the supply voltage. Like the Pentium MMX, the 166-MHz and 200-MHz versions of the K6 require two voltages: 2.9 V for the core, and 3.3 V for the I/O circuitry. The 233-MHz and 266-MHz versions, however, call for an (unusual) core supply voltage of 3.2 V which is a rare value, and pro-

This CPU was aimed at the low end of the market right from the start. Its floating-point performance is even poorer than that of the AMD K5, although it still represents a good price/performance ratio. The latest version, a PR200+, can only be used on motherboards with an external 75-MHz clock speed, which were few and far between at the beginning of this year. As an upgrade CPU for older motherboards, the 6x86 is therefore only a practical candidate for performance levels up to PR166+.

Cyrix/IBM 6x86MX

As you may surmise from the MX suffix, this youngest child from IBM and Cyrix is MMX compliant. The CPU offers remarkable power. Under Windows 95, and running at 166 MHz, it achieves the performance of an AMD K6 clocked at 233 MHz! Not surprisingly, IBM/Cyrix stick to the P-rating convention for the type numbers. The CPU running at 188 MHz is therefore identified as a 6x86MX PR233 to make sure everybody understands the claim of like performance as an Intel Pentium II running at 233 MHz. The fact that the 6x86MX, a.k.a. M2, fits in the Socket 7, makes it the upgrade processor *par excellence*, **if** the motherboard you have is capable of providing the right supply voltages (2.8 and 3.3 V), and **if** its BIOS supports the 6x86MX.

IDT-C6

A new contestant recently entered the fiercely competitive marked for CPUs used in PCs. Without so much as a flourish, IDT (Integrated Device Technology) rolled out its very own development, a Pentium-compatible processor with MMX instruction set, low power consumption (only 2/3 of an Intel processor) and a 40 to 50% smaller die size (approx. 88 mm^2). Reportedly, the performance of the C6 is at the MMX level, but we were unable to verify this at the time of writing this article. It is also too early to be able to assess compatibility of the C6 with existing motherboards. Because the CPU is aimed at the huge markets for notebooks and low-cost PCs, this processor could well turn out to become a hit.

Epilogue

Choosing the right processor is harder than ever before. Intel's competitors are now aggressively offering fast processors which can be used on existing motherboards. In spite of this interesting and healthy development, Intel is still in front when it comes to raw processing power. Whatever choice you make, you should keep in mind that today's purchase may be obsolete tomorrow. Keeping some 'reserve' for the near future is far too expensive, while it is sufficient in most cases to simply get the most of an existing system. But that is the subject of another article...

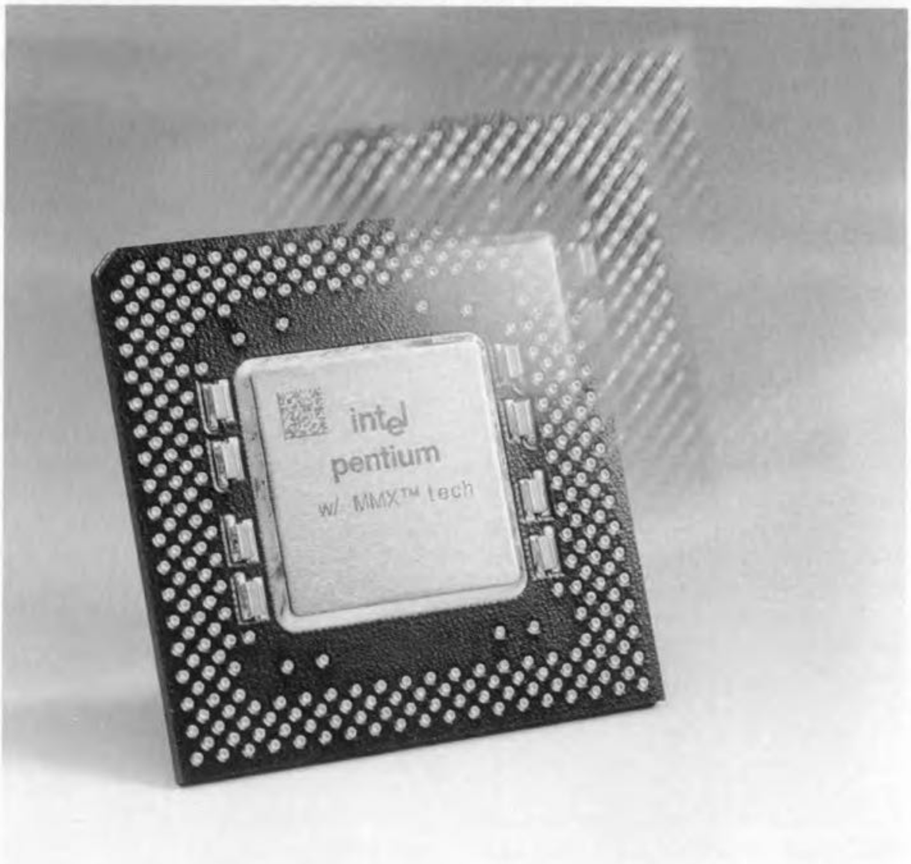
(972032-1)

There it is again, the perennial problem: my PC is too slow! I really should have a faster processor, but funds are dangerously low. The solution is called Overclocking. And a hot theme it is, because the temperature of your expensive CPU rises with the clock frequency! To be able to tell what's going on regarding CPU temperature, this article also presents an construction tip for a dedicated thermometer.

by A. Meuser

CPU overclocking

compute *faster* – until death by fire?

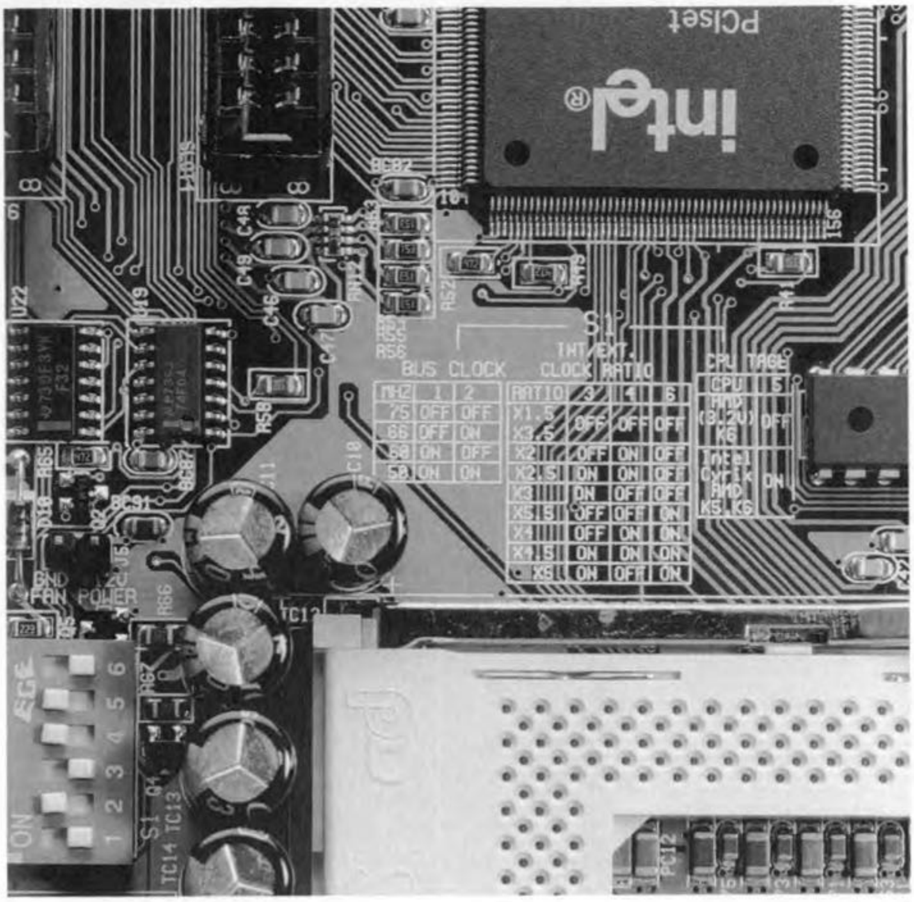


Overclocking the CPU and/or the chipset is the simplest and cheapest method of getting more speed from your PC. You should, however, always remember that the CPU is then operated outside its normal specifications. Overclocking exploits the fact that CPUs may show up a small margin when they pass the final checks performed in the factory. A 100-MHz Pentium processor, for example, may work happily at 110 MHz. If this were not so, the CPU would not live long. Sadly, this circumstance was exploited in the past by CPU forgers who sold 90-MHz CPUs as 100-MHz types after removing the original print from the device and replacing it with a new one. The fraud was hardly noticed because there are hardly CPUs around with an internal protection against overclocking.

Basically, there are two ways to speed up a PC by overclocking. To begin with, you may have a go at making the CPU run at a higher clock rate. Next, the second step is do the same with the chipset. In many cases, a combination of these two measures is not only possible but also very worthwhile.

Overclocking – goes like this

Most of today's Pentium motherboards have two jumper blocks to set the CPU clock speed. One of these is for the external clock frequency which is also used for the chipset. The available frequencies are usually 50, 55, 60, 66, 75 and 83 MHz. Although the latter two are not documented, and found on the latest motherboards only, they do provide the simplest way to put overclocking in practice. The second jumper block sets the internal multiplier for the CPU; you can usually choose between 1.5, 2, 2.5 and 3. It is the combination of the two jumper-based settings which results in the lowest and highest possible clock rates of 75 MHz (50×1.5) and 250 MHz (83.3×3) respectively. So, if you want to make a 200-MHz Pentium run at 225 MHz, you choose 75 MHz as the external clock frequeny, and 3 as the multiplier. This effectively increases the clock speed of the CPU and the chipset, as well that of the PCI bus because that runs at half the system speed (at least in systems based on an Intel chipset). In this way, not only the CPU but other important elements like the graphics card and the memory also benefit from the speed-up. Alter-



natively, speed up the CPU a little, and the rest of the system *a lot*, by selecting the following combination: 83 MHz system clock and a multiplier of 2.5. The CPU is then clocked at a 'moderate' 208 MHz, while the system components are whipped to run faster. Of course, a video card running at a bus speed of 37.5 MHz is operated outside the normal PCI clock specification of 33 MHz. In many cases, problems arise with SCSI controllers as well as with PCs having a lot of PCI cards. **Table 1** lists all possible combinations of external clock and multiplier, along with the respective PCI and CPU frequencies.

Which CPUs?

In principle, all CPUs may be overclocked, some to a considerable extent, others, less. All CPUs will happily accept an increase of 10%. The best CPUs in this respect are those from Intel, because they are subject to relatively large production tolerances. The author has heard of PC users who make a Pentium-75 run at 133 MHz (a speed-up of 77%!). Up to 25% seems to be normally possible with AMD's K5 and K6, as well as the 6x86 from Cyrix.

Table 1 Clock/Multiplier combinations

External clock (MHz)	Multiplier	Resulting CPU clock (MHz)	PCI bus clock (MHz)
50	1.5	75	25
50	2	100	25
50	2.5	125	25
50	3	150	25
55	1.5	83	28
55	2	110	28
55	2.5	138	28
55	3	165	28
60	1.5	90	30
60	2	120	30
60	2.5	150	30
60	3	180	30
67	1.5	100	33
67	2	133	33
67	2.5	167	33
67	3	200	33
75	1.5	113	38
75	2	150	38
75	2.5	188	38
75	3	225	38
83	1.5	125	42
83	2	167	42
83	2.5	208	42
83	3	250	42

A special class is formed by the MMX processors from Intel. Because these are not produced in 100 and 133 MHz versions (like the classic Pentium), they interpret a multiplier of 1.5 as 3.5, and 2.0 as 4.0, resulting in a theoretical maximum clock of 333 MHz (83.3 MHz × 4).

With some CPUs you have to raise the supply voltage to enable them to run at a clock speed which is higher than the specified one. An AMD K6-200 MHz, for instance, has to run off a 3.1 or 3.2-volt core supply, instead of 2.9 V, to make it work at 233 MHz.

Which motherboards?

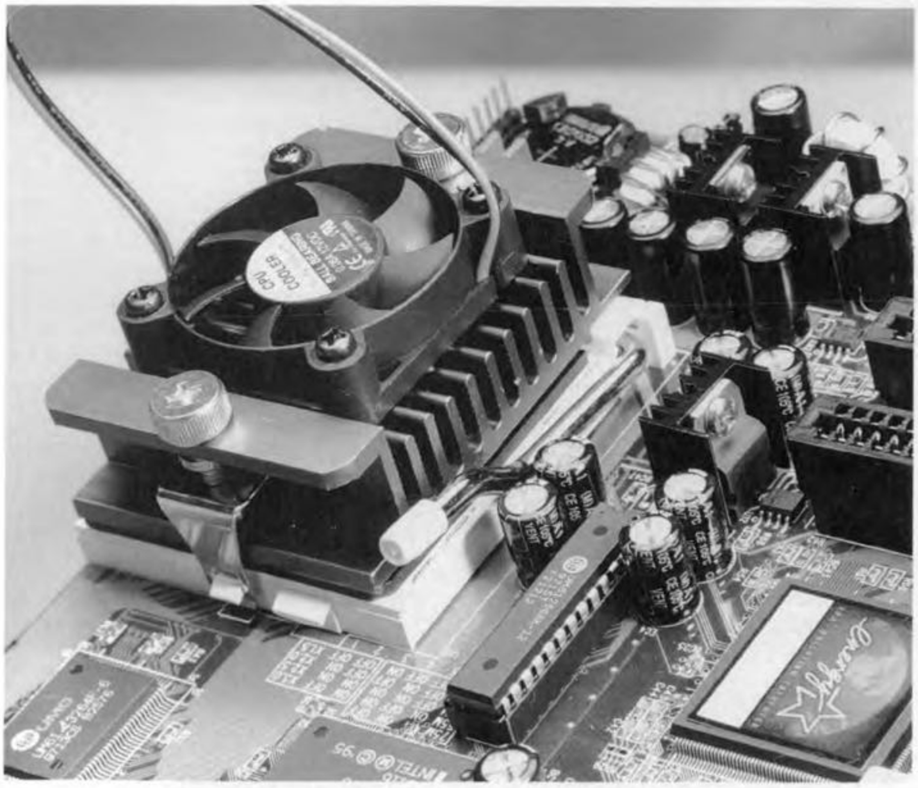
Motherboards supporting a system clock up to and including 83 MHz are the best candidates when you want to experiment with overclocking. A 'classic' motherboard is the Asus type P55T2P4, whose latest revision supports a system speed of 83 MHz as well as a 3.2-V core supply for the K6. The jumper settings for 75 and 83 MHz are as follows:

75 MHz: JP8 1-2; JP9 2-3; JP10 1-2.
83 MHz: JP8 1-2; JP9 1-2; JP10 2-3.

The clock frequency is extremely easy to select on motherboards from ABIT, which give full control to the BIOS in this respect. Motherboards having a TX chipset in addition allow the CPU temperature to be monitored via the BIOS.

Caution, Hot!

Elegant and inexpensive it may be, overclocking may also cause problems. The power dissipation and the chip temperature both rise with the clock frequency, reducing the life expectancy of all overclocked devices. In extreme cases, the use of a far too high clock frequency may cause the instant demise of your expensive CPU and/or the chipset. Usually, the chipset is designed to run at



a maximum speed of 66 MHz, which, obviously, makes applying 83 MHz a bit of a risk.

In many cases, a system which is tuned up in this way becomes unstable, suffering from unpredictable crashes, the cause of which can only be established by subjecting the PC to long and extensive tests (such as the ones described in the book *PC Service and Repair* by Dr. W. Matthes). An unexpected reset and reboot action in the midst of normal activities usually points to problems with the RAM, which may be too slow for the higher system clock. In systems which are clocked at up to 83 MHz you will need very good 60-ns RAMs, or, preferably, 50-ns EDO RAMs. SD-RAMs are an even better solution because they can keep up with system speeds up to 100 MHz.

Cooling

The above mentioned problems regarding the additional heat developed by the CPU as a result of overclocking can be avoided to a large extent by providing sufficient cooling for all components involved. A CPU cooler should have the largest possible cooling surface (the fins should be 7 to 10 mm long), and be equipped with a powerful fan with ball bearings. Also don't forget to use a little heat conducting paste. A CPU cooler with its own temperature checking system is of course ideal, and a suitable design is given in the inset. Because other components also run hotter as a result of the higher system clock, it is recommended to fit an extra extractor fan in the PC case.

Practical tips

If, in spite of the risks we've mentioned, you want to try out the effects of overclocking in a PC, observe these points:
- Increase the clock speed in the smallest possible steps to gauge the highest values that can be used in your system.
- After a change to the clock speed, if the system is restarted but you get no BIOS report, increase the core supply voltage and do a restart. If no BIOS report appears, you can forget about the system frequency you were after; it is too high.
- If the computer manages to launch your operating system, run a couple of applications. A number of programs such as Winstone are great for long-term stability tests. If no crashes occur (test at least for a couple of hours), then you may have been successful at overclocking the system.
- Keep it cool! If possible, a temperature increase caused by overclocking should be compensated by additional cooling. A useful indication may be had from the CPU thermometer which is described separately in this article.

The future

As this article is being produced, the first motherboards using the new VIA chipset are expected to hit the market. VIA supports a system clock of up to 100 MHz, and for the first time enables the memory performance to be considerably improved, provided SD-RAMs are used! With all PC tuning activities you should always remember one rule: an overclocked system, too, will rapidly turn out to be too slow, as the next processor is always sure to arrive!

(972033-1)

TUNING TIPS

In principle, you don't need DOS any more when running Windows 95. None the less, there are cases in which a complete set of DOS commands would be very useful. To have these, you don't have to install an old DOS, because a complete DOS version (7.0) may be found on the Windows 95 CD-ROM. Copy all files in the directory Other\Oldmsdos on the CD-ROM to the directory Windows\Command on the hard disk. The latter subdirectory then contains a complete DOS.

Dust is one of the biggest enemies of your computer. It's a good idea to open the computer case on a regular basis (say every three months) and clean out the interior with a (small) vacuum cleaner. Switch the computer off, and pull the mains cord. Be sure not to touch components, because they can be damaged.

Use Sysedit (mentioned above) to remove as many unneccessary commands as possible from Config.sys and Autoexec.bat. Doing so will make the computer start up much faster. Windows 95 normally uses the following settings and programs, so you don't have to load or call these when the computer starts up:

Himem.sys
Ifshelp.sys
Setver.exe
Dblspace.bin or Drvspace.bin
DOS=high,umb
Files=60
Buffers=30
Stacks=9,256
Lastdrive=z
Shell=command.com /p
Fcbs=4

With the DRAM settings, choose values which match the specs of the RAM modules you are using. Most EDO RAMs used today are 60-ns types (this specification is found on a label stuck on the module). A

A CPU Thermometer

Too much heat will kill your expensive CPU. This warning should be given to anyone causing the operating temperature of a CPU to come dangerously close to the absolute maximum, especially as a result of overclocking. To reduce the risk of 'death by overheating', take the following precautions:

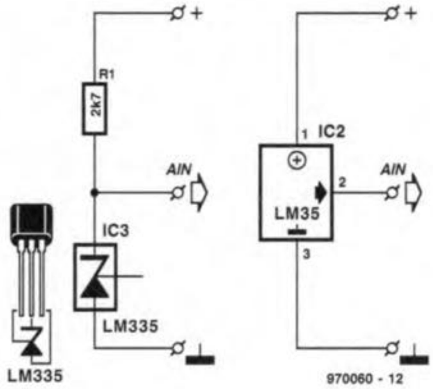
1. give the CPU the best active cooler you can get;
2. monitor the chip temperature to be able to detect imminent dangers.

A comfortable solution is presented for the second precaution: a small Windows measurement program monitors the CPU's case temperature with the aid of a temperature sensor which is connected to the parallel port. The CPU temperature is not only indicated as an exact value, but also relative to three bands: **green** ('cold'; lower than 30°C); **yellow** (warm; between 30°C and 50°C); and **red** ('hot'; higher than 50°C).

The temperature measurement is refreshed every second. To make sure you notice that the CPU becomes too hot, the thermometer window is automatically maximized when the measured temperature exceeds 50°C. However, before that can happen, you have to build the thermometer circuit and connect it to your computer.

A simple measurement

It's not accidental that an analogue-to-digital converter based on the MAX187 is described elsewhere in this issue! This circuit enables analogue values to be measured by way of the parallel printer port which is available on any PC. The printed circuit board (order code 970060-1) allows either the LM35 or the LM335 to be fitted. Both ICs are from National Semiconductor; the LM335 is second-sourced by SGS-Thomson. Both sensors supply an output voltage of 10 mV/°C. They only differ in respect of the zero-temperature reference, which is 0°C (273 K) for the LM35, and −273°C (0K) for the LM335. Also, the LM35 requires a little less current for itself. Consequently, it has a self-heating specification of only 0.1°C as opposed to 0.3°C for the LM335. As indicated by the circuit diagram, the three pins of the LM35 are directly connected to the PC5, PC6 and PC7 terminals of the ADC board. If you use the LM335, a 2.7-kΩ resistor has to be connected between terminals PC8 and PC9, while the LM335 itself is connected to PC9 and PC10. Note the pinouts of the two sensors! At 25°C, the LM35 supplies a voltage of 250 mV (10 mV/°C × 25°C) at its output (pin 2). At the same temperature, the LM335 supplies 2.98 V, which may be calculated from 10 mV/°C × (273K+25K).



The software has no problems converting these different scales.

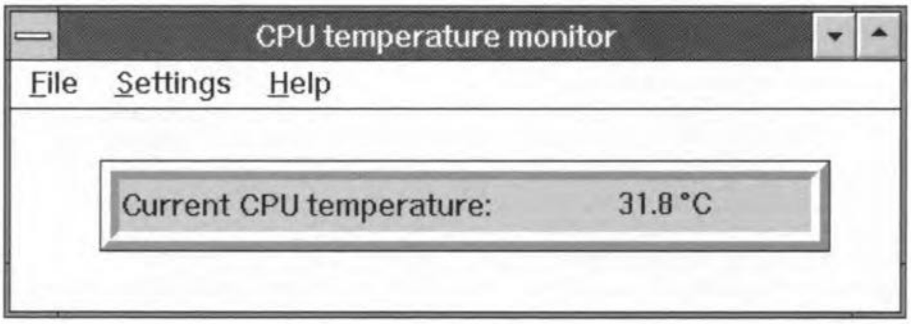
Construction and software

If the LM335 is used, you have to connect the 2.7-kΩ resistor as shown in the diagram. The LM335 or the LM35 is connected to the ADC board by means of a thin, flexible 3-wire cable. The IC terminals are best isolated using heat-shrink tubing.

What remains to be done is put the sensor in thermal contact with the CPU cooler. The simplest solution is to clamp it between the heat-sink fins, and secure it, if necessary, with a drop of instant glue. The main points to observe are mechanical stability and electrical isolation.

The Windows program for the CPU thermometer may be found on a diskette which is available through our Readers Services under order number **976011-1**. The subdirectory 'Tempmon' on the disk contains a program called TEMPMON.EXE which indicates the heat-sink temperature using the three traffic light colours, as described above. Another subdirectory on the disk, 'MAX187' contains a program called MAX187.EXE which enables the PC to display the measured temperature in °C and Kelvin. All programs have been written in Delphi V1.0. Interested readers may also find the source code files on the disk.

After installing and launching TEMPMON, all you have to do is select the right printer port and the sensor type used. Hopefully, you don't get a *red alert* straight away...



modern BIOS has a special setting for EDO RAMs which makes the reading phase faster than with normal RAMs. If everything works reliably, you can try out the effect of faster timing settings for the memory. In general, the lower the value you select, the faster the timing.

With Inkjet printers, ink in the miniature nozzles has a tendency to dry out if the printer is not used for some time. Make a habit of switching on the printer at least once a week, this will help to keep the nozzles open. Also make sure the printer head is always in the 'off' position before the printer is switched off.

A CPU Thermometer

Too much heat will kill your expensive CPU. This warning should be given to anyone causing the operating temperature of a CPU to come dangerously close to the absolute maximum, especially as a result of overclocking. To reduce the risk of 'death by overheating', take the following precautions:

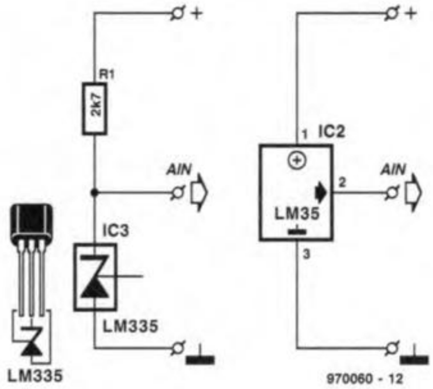
1. give the CPU the best active cooler you can get;
2. monitor the chip temperature to be able to detect imminent dangers.

A comfortable solution is presented for the second precaution: a small Windows measurement program monitors the CPU's case temperature with the aid of a temperature sensor which is connected to the parallel port. The CPU temperature is not only indicated as an exact value, but also relative to three bands: **green** ('cold'; lower than 30°C); **yellow** (warm; between 30°C and 50°C); and **red** ('hot'; higher than 50°C).

The temperature measurement is refreshed every second. To make sure you notice that the CPU becomes too hot, the thermometer window is automatically maximized when the measured temperature exceeds 50°C. However, before that can happen, you have to build the thermometer circuit and connect it to your computer.

A simple measurement

It's not accidental that an analogue-to-digital converter based on the MAX187 is described elsewhere in this issue! This circuit enables analogue values to be measured by way of the parallel printer port which is available on any PC. The printed circuit board (order code 970060-1) allows either the LM35 or the LM335 to be fitted. Both ICs are from



National Semiconductor; the LM335 is second-sourced by SGS-Thomson. Both sensors supply an output voltage of 10 mV/°C. They only differ in respect of the zero-temperature reference, which is 0°C (273 K) for the LM35, and −273°C (0K) for the LM335. Also, the LM35 requires a little less current for itself. Consequently, it has a self-heating specification of only 0.1°C as opposed to 0.3°C for the LM335. As indicated by the circuit diagram, the three pins of the LM35 are directly connected to the PC5, PC6 and PC7 terminals of the ADC board. If you use the LM335, a 2.7-kΩ resistor has to be connected between terminals PC8 and PC9, while the LM335 itself is connected to PC9 and PC10. Note the pinouts of the two sensors! At 25°C, the LM35 supplies a voltage of 250 mV (10 mV/°C × 25°C) at its output (pin 2). At the same temperature, the LM335 supplies 2.98 V, which may be calculated from 10 mV/°C × (273K+25K).

The software has no problems converting these different scales.

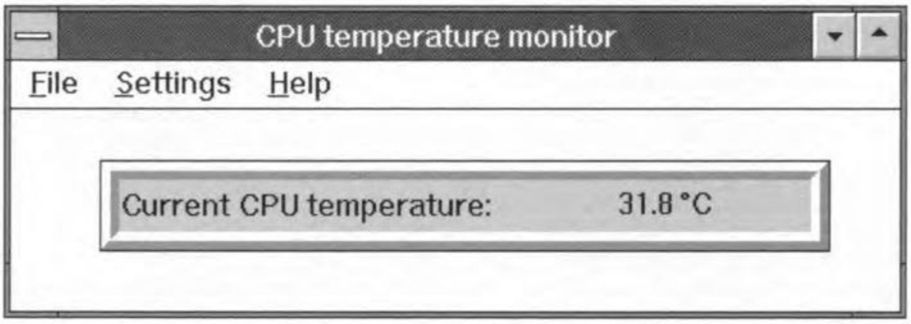
Construction and software

If the LM335 is used, you have to connect the 2.7-kΩ resistor as shown in the diagram. The LM335 or the LM35 is connected to the ADC board by means of a thin, flexible 3-wire cable. The IC terminals are best isolated using heat-shrink tubing.

What remains to be done is put the sensor in thermal contact with the CPU cooler. The simplest solution is to clamp it between the heat-sink fins, and secure it, if necessary, with a drop of instant glue. The main points to observe are mechanical stability and electrical isolation.

The Windows program for the CPU thermometer may be found on a diskette which is available through our Readers Services under order number **976011-1**. The subdirectory 'Tempmon' on the disk contains a program called TEMPMON.EXE which indicates the heat-sink temperature using the three traffic light colours, as described above. Another subdirectory on the disk, 'MAX187' contains a program called MAX187.EXE which enables the PC to display the measured temperature in °C and Kelvin. All programs have been written in Delphi V1.0. Interested readers may also find the source code files on the disk.

After installing and launching TEMPMON, all you have to do is select the right printer port and the sensor type used. Hopefully, you don't get a *red alert* straight away...



modern BIOS has a special setting for EDO RAMs which makes the reading phase faster than with normal RAMs. If everything works reliably, you can try out the effect of faster timing settings for the memory. In general, the lower the value you select, the faster the timing.

With Inkjet printers, ink in the miniature nozzles has a tendency to dry out if the printer is not used for some time. Make a habit of switching on the printer at least once a week, this will help to keep the nozzles open. Also make sure the printer head is always in the 'off' position before the printer is switched off.

Tuning Tips

hardware

If you want more speed from your computer, these are the components worth investing in:

- more memory
- a faster hard disk
- a faster video card

If you have a modern motherboard with two IDE channels, connect the hard disk to the first channel, and the CD-ROM to the second channel. This arrangement allows the hard disk to achieve its highest data throughput (particularly in combination with older CD-ROM drives). The CD-ROM drive should be set to 'master' mode (usually with the aid of a jumper) if you use it on its own IDE channel.

There's no need to panic if you no longer remember the password which some of you use at the BIOS level. Most motherboards have a jumper which allows all BIOS settings (including the password) to be cleared. If no jumper is available for this purpose, the alternative is to remove the battery for a while (for at least a couple of minutes to make sure all reservoir capacitors are discharged). Alternatively, temporarily disconnect one terminal of the battery. If that is also difficult, the last resort is to shunt the battery for a few seconds using a 10-Ω resistor.

Many modern videocards make use of an interrupt line (usually IRQ11). Since there are soundcards that want to use the same interrupt line, this should be taken into account when installing the soundcard by first checking if there are IRQ lines available which are supported by it. The System control panel provides a neat overview of the IRQ and DMA resources allocated to the hardware fitted in your computer, while also drawing your attention to possible conflicts.

If the motherboard offers a PS/2 connection for a mouse, it is worthwhile to actually use it (if your mouse is compatible, that is). Because a separate IRQ line, number 12, is reserved for this purpose, the two serial ports remain available for other devices (for example, a graphics tablet and a modem). If your mouse has a standard serial connection, an inexpensive PS/2 adaptor can be bought from a computer shop. Do check with the mouse supplier, however, that the mouse can be used with a PS/2 connection. Low-cost types in particular seem to be suitable either for RS232 only, or for PS/2 only.

BIOS

A new motherboard usually comes with default settings for the BIOS or SETUP utility. These are relatively slow settings which guarantee that the system starts reliably. As these settings do not enable the computer to run at the highest possible speed, each BIOS entry should be checked, with reference to the documentation supplied with the motherboard.

In particular, the settings 'CPU internal cache' and 'external cache' should read 'enabled'. If not, the system is slowed down by 10 to 30%. Fortunately, these settings are 'enabled' in most modern BIOSs.

A modern BIOS usually offers an 'autodetect' function for the hard disk. Use it, and see which optimum setting the computer suggests for your hard disk. If possible, choose 'LBA' (logical block addressing) because that will result in the highest data transfer rate.

Switch off all memory tests and test sounds, especially if you have a lot of RAM on the motherboard. This will speed up the memory scan at power-on, and kills those ticking sounds from the internal loudspeaker. Having done a full memory test once or twice you will be confident that all RAM banks are okay. Moreover, modern memory modules are very reliable; an electrical breakdown will be very rare.

A lot of useless noise can be prevented by telling the computer not to look for floppy disk drives on startup (set 'boot up floppy seek' to 'disabled'). By selecting the 'C,A' boot sequence in the BIOS you reduce the startup time by a couple of seconds.

Today's motherboards have on-board serial and parallel ports as well as an IDE controller. The BIOS allows these to be switched on and off as required, or to be redirected to another address or IRQ line. Especially with IRQ conflicts it is recommended to check the BIOS for the configuration options available for serial ports 1 and 2, and the parallel port. By the way, if you use the parallel port in ECP mode, it will also employ an IRQ line.

If you add memory on your motherboard, a 'CMOS settings invalid' or similar error message will be produced when the system is first switched on. Nothing to worry about; it is sufficient to go to the Standard CMOS Setup in the BIOS, where the new amount of memory will appear. After a simple Save and Exit Setup the computer will start without protests, and indicating the correct amount of memory.

Windows 95

Don't let Windows 95 determine the size of the swap file (virtual memory), because it is then changed all the time. If your computer has a modern hard disk with sufficient free space, we recommend setting a fixed, identical minimum and maximum size of the swap file, say, 50 to 100 MB. In this way, you help Windows 95 to avoid wasting time on a useless activity.

The same goes for the automatic hard disk cache management in Windows 95. In many cases, a lot of data is read for no purpose whatsoever, while the RAM memory is badly needed for other tasks. You can control the size manually by using Sysedit (in the Windows\System subdirectory) to add these two lines to the system.ini file, below the heading [vcache]:

```
MinFileCache=512
MaxFileCache=1024
```

These lines define a minimum and a maximum cache size of 512 and 1,024 kBbytes respectively. As a matter of course, you can use any other values which you think are appropriate.

If you have 16 Mbytes of RAM or more, go to Control Panel - System Properties - Performance - Hard disk, and change the setting 'Desktop Computer' into 'Network Server'. This change results in a marginal speed increase, and some tasks are better handled, mainly because the system reserves more buffer space.

Windows 95 runs much faster when installed on a 'clean' computer, i.e., not over an old Windows 3.1 version. However, most of you will have purchased Windows 95 as an 'upgrade'. During the installation, the computer will keep asking you about the location of the old Windows 3.1/3.11 version on the hard disk. This problem may be avoided by inserting installation disk 1 of Windows 3.1/3.11 in the floppy disk drive, and telling Windows 95 to look there. In this way, the upgrade version will install without problems. (972034-1)