ELEKTOR ELECTRONICS

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JANUARY 1997
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Focus on DATASHEETS ON CD-ROM



MAGNETIC-FIELD METER

SOFTWARE COMPETITION: WINNING ENTRIES

BATTERY-OPERATED PREAMP

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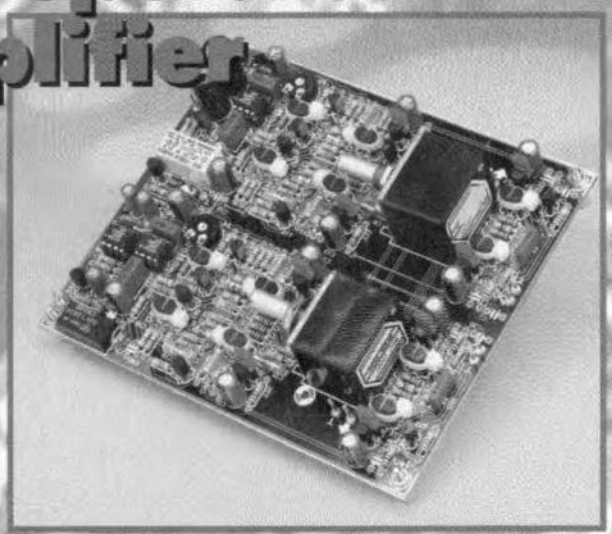
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ELECTRONICS NOW AND TOMORROW

In a short series of articles, starting this month, we will endeavour to present a broad overview of the direction electronics may be going during the last few years of this century. When reading the articles, it should be borne in mind that many 'promising developments' have failed to make it over the past ten years or so. You only have to think of the videophone (or picturephone), the digital audio tape (DAT) system, the digital compact cassette (DCC), the Series 2000 video recorder, the Betamax video recorder, and the mini disc system. On the other hand, the thermionic valve (or electron tube) and radio are making a comeback, while the compact disc (CD) has been a great success, although its popularity is also waning now.

Information technology

According to many technologists, Information Technology (a combination of computers and telecommunications) is, or will be, more significant than any previous technological revolution. IT pervades all sectors of the economy: for instance, it can improve the performance of a tractor on a farm; it can improve the design, manufacture and marketing of a car; it can provide a medical diagnosis as well as administration in health care.

During the past 20 years, the global network of computers, telephones and televisions has increased its information-carrying capacity a million times over. It is interesting to reflect that in 1940, Thomas Watson, then chairman of IBM, predicted a world market for maybe five computers, while a year earlier, the influential *New York Times* stated that "television will never be a serious competitor for radio because people must sit and keep their eyes glued on the screen; the average American family has no time for this."

Computing power doubles every 18 months or so, in line with Moore's Law. Today's $2,000 laptop is many times more powerful than a $10m mainframe computer in the mid-1970s. Then, there were only about 50,000 computers in the whole world; now there are an estimated 140 million. The USA has the largest computer density per head of population (35 per 100), followed by Australia (27/100), Canada (25/100) and Britain (20/100). Another factor is the staggering decline in the price of computer-processing power, which has fallen by an average of around 30 per cent per year in real terms over the past 20 years. Computer power is now estimated to cost a hundredth of one per cent what it did in the early 1970s. If cars had developed at the same pace as microprocessors, a new car would now cost typically $5 and do 250,000 miles to the gallon (just over 90,000 km per litre)

In 1843 Samuel Morse (1791–1872) launched the era of instant communication. when the American Congress authorized a telegraph line, first conceived by him in 1837, between Washington and Baltimore (at a cost of $30,000). From then on, things moved fast as governments and business concerns saw the tremendous advantages of the system. Within a few years, there was a telegraph line between London and Washington and by the late 1850s, many trading nations were in telegraphic contact with one another. The longest telegraph cable (10,000 km) was laid between London and Calcutta by the early 1860s.

In 1960, a transatlantic telephone cable could carry only 138 conversations simultaneously. Now, in 1996, a fibre-optic cable can carry 1.5 million conversations at the same time. Another aspect of IT is that it reduces communications and transactions costs, helping markets to work more efficiently. A three-minute telephone call between New York and London now costs about $2; in 1930 it would have cost more than a hundred times as much in today's prices. Pundits reckon that in 10 years' time transatlantic video-phone call will cost only a few cents an hour.

A contemporary of Morse, Charles Babbage (1791–1871), professor of mathematics at Cambridge, spent most of his life in developing a calculating machine that could produce and print mathematical tables without error. His 'difference engine', completed in 1833, was used to compile tables of logarithms from 1 to 108,000. His 'analytical engine' was to be capable of executing any sequence of arithmetic instructions. Many of the basic principles of modern electronic computers owe their origins to this machine.

No medium has ever grown as fast as the Internet. It already has an estimated 50 million users worldwide, with the number doubling each year.

IT may prove environmentally friendly by reducing pollution and congestion as people tend to telework and teleshop, which will make many car journeys unnecessary. It should be recalled, however, that when the car was first introduced, it was seen as an environmentally friendly alternative to the horse-drawn carriage which at the end of the last century was causing severe traffic jams in London and New York.

IT makes work more mobile in other ways, too. In some services, sophisticated telecommunications have replaced physical contact with customers. Computers that can recognize speech have replaced telephone operators. ATMs (automatic teller machines) have superseded bank tellers. Firms can shift jobs such as computer programming or processing insurance claims to lower-wage countries on the other side of the globe. Nevertheless, in countries where IT is strong, the USA, Japan and the UK, since 1980 total employment has risen by 24%, 17% and 9% respectively, whereas in the European Union where IT is not nearly as strong, employment has risen by only 2% (although it should be borne in mind that in the USA and the UK labour mobility, as well the ability to

A Book for your Letter

The work of Marconi in proving that radio waves do not necessarily travel in straight lines, which resulted in today's world-wide radio communications networks, engendered a fiery interest in many people to become radio amateurs. These people were the forerunners of what are now called 'experimentalist' and home constructor'. This army of amateur constructors grew enormously with the advent of radio broadcasting in the 1920s. It is hard to imagine today, but then there was a widespread feeling that it was extravagant and almost decadent to buy a ready-made radio receiver. This feeling was taken advantage of by various manufacturers who started to market kits of parts. These kits proved to be enormously popular; for example, Cossor Radio (now part of Raytheon) in the period 1927–1936 sold more than 750,000 kits of their popular radio receivers.

After the Second World War, home construction really took off since finished electronic products were either not available or too dear, but vast quantities of electronic parts, surplus to the armed forces' requirements, flooded the market.

Home electronic construction reached a peak during the 1970s and then started to tail off. This was partly due to the fact that manufacturers had begun to realize that there was a vast consumer electronics market waiting to be satisfied. Other reasons were changes in the social life of most people in the western world, resulting from a better standard of living.

However, there are, no doubt, other reasons why home electronic construction is declining although the interest in, and use of, electronics is growing. If you feel that you can point to some of these reasons, write to Elektor Electronics (Publishing), P O Box 1414, Dorchester DT2 8YH, England, outlining them in no more than 250 words. The five letters that in our opinion most clearly set out additional reasons will be published in this magazine and their writers will receive a free book from our library.

accommodate change, is also much greater than in Europe).

Telephones

In some East European countries it takes many years to get a telephone line, which costs many hundreds of dollars and on top of that a bribe of a few hundred dollars.

In western Europe and in the English-speaking part of the rest of the world, the GSM mobile cellular communications business is the fastest-growing sector in the whole of the telecommunications market. Since a relatively slow start following the opening of the first GSM network in Europe in mid-1992, the subscriber base expanded very rapidly during 1994 and 1995.

It is expected that by early 1997 the total installed digital network base will exceed that of all analogue technologies. The user base at the end of 1997 is expected to be two and a half times the size it was at the end of 1995, and is projected to continue increasing to reach almost 58 million by the end of the year 2000.

During 1995, GSM mobile services finally became universally available in most western European countries, and competitor GSM services, operated by an independent supplier, will also be available in those countries early this year. Only in Switzerland will there be continued dependence on the PTT and users will probably have to wait another two years before they can enjoy a competitive alternative.

In addition, DCS-1800 services are being extended, although much more slowly. It is likely that DCS-1800 licenses will be awarded to existing GSM operators in some countries such as Sweden, the Netherlands and Italy (they already have in the UK), allowing them to use extra spectrum in congested urban areas.

The European Commission deserves much of the credit for the liberalization of the digital mobile cellular market. Although some countries, the UK, Sweden and Denmark, have taken a liberal view of mobile cellular, it has taken intense and continuing pressure by the EC to persuade other governments to free up this market

There are few suppliers of digital cellular network infrastructure products: Ericsson, Motorola and Nokia dominate the market, with Ericsson the clear leader with more than 50 per cent of the infrastructure business.

The first of a new class of global mobile telephone is likely to come on to the market in about eighteen months' time as manufacturers start producing the new multi-mode handset that can roam cellular frequency bands around the world. These dual-mode handsets operate on 900 MHz and 1800 MHz.

Computers

In essence, a computer exists merely to bring software to life – and this task can also be fulfilled by a network such as the Internet. Although the network computer announced in mid-1996 by the American company Oracle is not new – rather, it is a development of a technology designed in Britain in the 1980s. Nevertheless, the NC appears to have a bright future. Basically, it shifts the emphasis from the desktop to the network. And, if you come to think of it, the move from desktop to network is not a matter of hardware at all, but of software. Software is really a strange, intangible commodity that consists of bits – binary digits or 1s and 0s if you like. These bits are by themselves inactive, just like our genetic code, and only come to life when they are placed in the right receptacle. Whether that receptacle is a network or a computer does not matter at all.

Currently, one of the striking things when you go to a computer hypermarket or a computer show is that you hardly see a 'normal' computer: they have become multimedia stations, fitted with modems (28,800 or 36,600 bauds), and telephone, answering machine, fax, television, and more, built in. Forget clocks of 100 or 150 MHz; these new machines quiver with 200 MHz or even 300 MHz clocks. It may be called Multimedia, but in reality it is Information Technology entering the office or home.

Music & video recording

It may be a little too early to say whether the Digital Video Disc (or, as some say, the Digital Versatile Disc) or DVD will mean the end of the road for the CD, CD-ROM and the VCR, but there is no doubt that the new disc is the most important piece of consumer electronics since the appearance of the video cassette almost 25 years ago. It is highly unlikely to be a commercial failure like so many developments in the past 10–15 years: Sony's Mini disc and Betamax; Philips' DAT (digital audio tape) and DCC (digital compact cassette); and the videophone. Time will tell.

Pundits have no doubts: they reckon that over the next 5–10 years the new technology will almost certainly replace, if not wholly then certainly mostly, the video cassette, the audio CD and the CD-ROM. Certainly, by the time the first DVDs are hitting the market later this year or early next year, depending on where you are, the CD will be 15 years old: they are no longer modern. Columbia/Tri-Star Home Video in Hollywood is planning to release150 movies in DVD format within the next year, 50 of them to be available with the launch of the DVD player in the USA early this year.

It may be that although the DVD will do well in computer and video applications, where the extra capacity is more than welcome, music lover will decide that having more than 25 times as much music on a disc may not be what they want.

What is interesting, of course, and this may even decide music lovers that it is worthwhile, is that both Sharp and Toshiba have publicly stated recently that they will have a marketable, rewritable digital video disc system in about two years's time.

The semiconductor 780 nm (infra-red) laser used in in current DVD equipment has a power output of around 5 mW. At these levels, the current density within the cavity of the laser is 2000 A. Sharp Laboratories say that a rewritable system will require a semiconductor laser with seven times this output. Work is, therefore, underway in their laboratories to produce red lasers with current densities of 1000 A at 35 mW. Other lasers under development include blue and ultra-violet (635–650 nm). These will eventually be used for disc systems with up to 8 Gbit of storage capacity.

The next generation, high-definition digital video that will become standard in the early part of the next century will need an enhanced disc with better capacity. A medium that can store 15 Gbyte a side, or three times the capacity of present DVDs will be needed.

The increase in capacity will call for a dramatically increased data storage density. This can only be achieved by decreasing the wavelength of the laser beam that reads and writes data on the disc. Therefore, researchers at Toshiba's R&D Centre have succeeded in achieving a wavelength of 417 nm, more than enough to meet the high-density demands of high-definition video. The laser is a blue-purple emitter operating at 20 V with a threshold current of 5 A.

Away from the DVD, sheet music can be created on a home computer and printed out or published on the World Wide Web. Sunhawk Corporation of Seattle has developed Solero, a Windows-based software that not only lets users create their own sheet music with their computer, but also scan in existing printed-sheet music (using any standard computer scanner) so that it can be edited on-screen and played back via the computer or made available on the World Wide Web.

Electronic publishing

What effect will the Internet have on a printed magazine such as ours? In time, no doubt many publications will be distributed mainly electronically. Already, may scientific journals are electronic, while the paper ones are increasingly kept for their archival value only. Paper and distribution, which account for a large slice of the cost of a typical paper publication, will vanish in cyberspace. Indeed, the Internet gives many opportunities: global reach, speed, interactivity, the ability to combine text, sound and moving images.

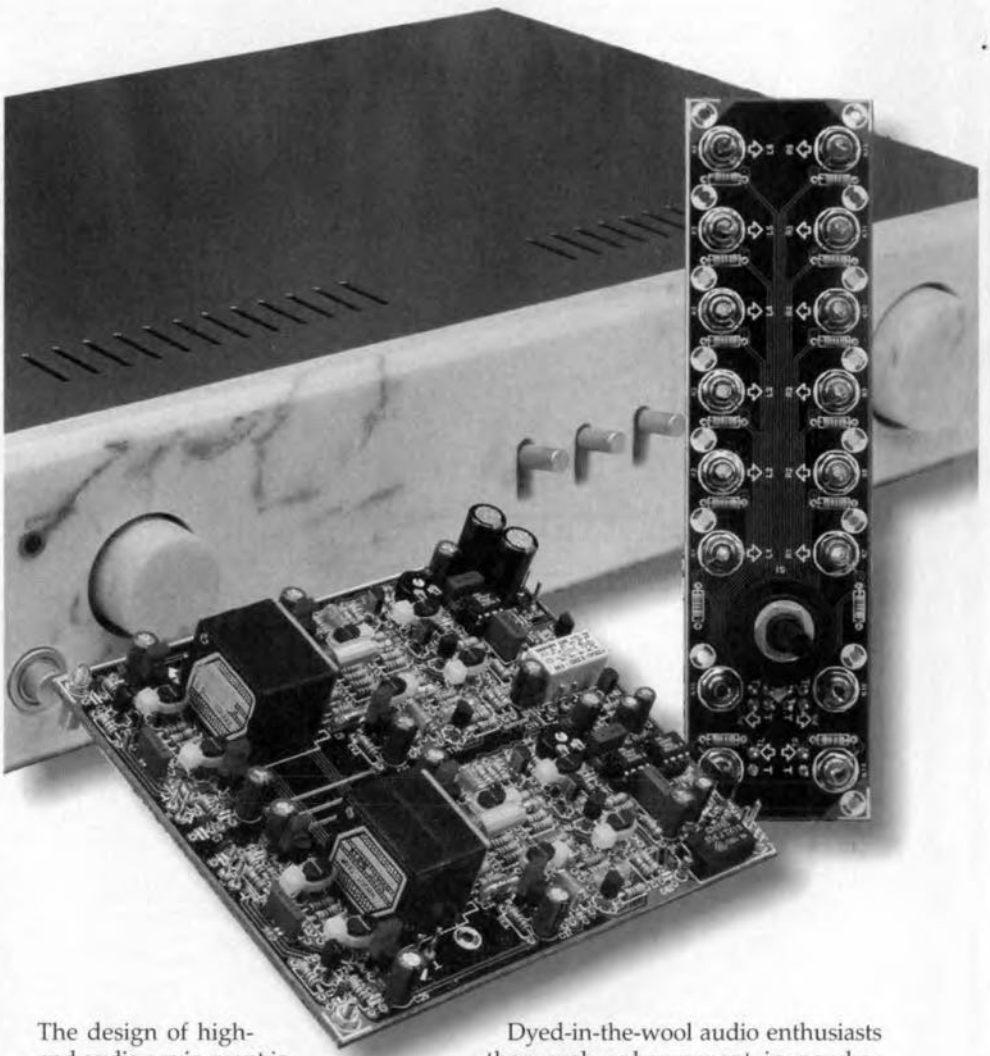
To say that electronic publishing has a bright future is not to say that paper publishing has none. No doubt, most paper publications will find ways of coexisting with the Internet. It has been done before: radio, far from being destroyed by television as gloomy surveys suggested 40–50 years ago, is more profitable than ever, but not as profitable as it would have been without television.

[975003]

Sources: ***BBC Music Magazine; Byte; Der Spiegel; Internet Advisor; L'Express; MacWorld; New Scientist; The Economist; The Times; Time.***

battery-operated pre-amplifier - part 1

a unit for purists



This preamplifier is intended for those audio enthusiasts who are interested in only the best. Its discrete design produces distortion figures that are measured in tenthousandths of a per cent (the remainder of its specification looks very good, too!). Moreover, bearing in mind that in certain areas the mains supply voltage is not as pure as it should be, the preamplifier is powered by rechargeable NiMH batteries. In this first of a two-part article, the preamplifier proper will be described. The second part, to be published next month, will deal with the specially designed battery charger.

Design by T. Giesberts

The design of high-end audio equip-ment is typified by the continual striving for the best possible quality. In the high-end design world, bass boost networks, equalizers and impressive displays are not contemplated. In fact, such ancillary facilities are considered undesirable. The only aspect that is of importance is the quality of the signal processing. This quality is the be all and end all as far as real audio enthusiasts are concerned: no concessions are given or asked for. Only true quality is worthy of the name hi-fi.

A difficulty arises when the specifications of an amplifier are so good that the designer is testing at the limits of his measuring equipment. Real improvements are then not possible or, in any case, cannot be measured.

Dyed-in-the-wool audio enthusiasts then seek enhancement in psycho-acoustic matters such as solid silver connecting cables, gold-plated connectors and bizarre units to treat CDs. The sense of such matters is a topic of argument among themselves and questionable to outsiders. Certainly, they cannot be measured or made audible.

A more tangible means of enhancing the performance of an amplifier is the eradication of all aspects that, outside the normal signal path, may affect the performance. One of those aspects is the mains supply. In many countries, this is far from stable, while interfering spikes and other undesirable facets are the rule rather than the exception. This justifies the assumption that it must be possible to improve the amplifier's performance by powering it not from the

mains but from a battery. This assumption has been put into practice in the present preamplifier. The mains voltage is used solely to operate the battery charger and this only when the amplifier is switched off.

THREE SECTIONS

The design of the preamplifier proper is not really spectacular. True, the fact that no integrated circuits are used in the signal path is conspicuous but nothing special. The exemplary good specifications are nothing new because they have been achieved in earlier preamplifiers. The property that differentiates the present preamplifier from its predecessors is that these specifications are allied with battery operation.

The block diagram of the preamplifier in **Figure 1** shows that it may be divided into three sections, each of which is housed on a discrete printed-circuit board.

The input selector is a passive stage which needs little comment. After all, a six-position selector is a familiar sight in many amplifiers.

The preamplifier proper consists of an input buffer, balance control, volume control, amplifier stage, and a relay that obviates annoying o/off clicks and acts as a detector of the bat-

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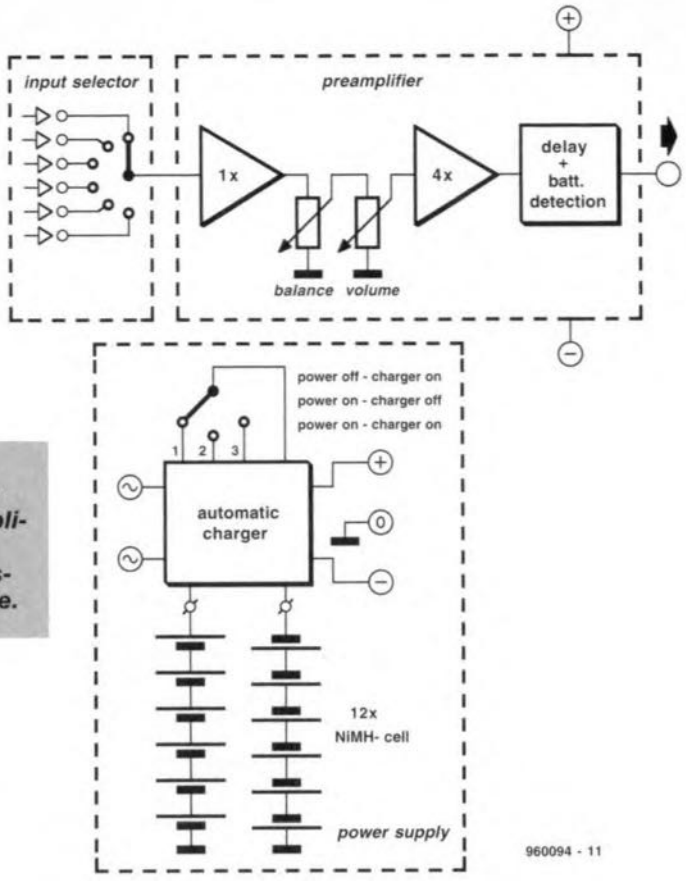


Figure 1. Block diagram of the battery-operated AF preamplifier. Only the upper two sections are discussed in this article.

Test results

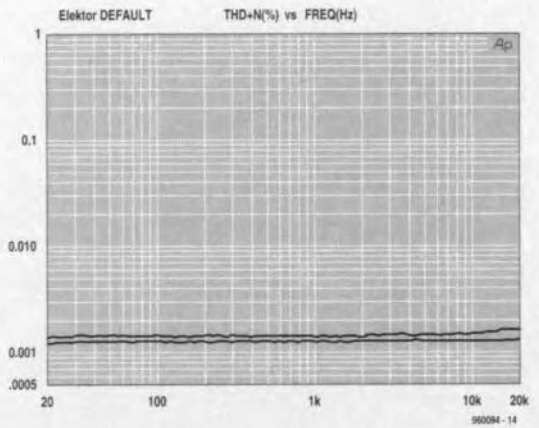
Signal-to-noise ratio	*P2 max*	*108 dBA*
(at 1 V r.m.s. output)	*P_2 min*	*106 dBA*
THD+N at 1 kHz and 1 V r.m.s. output		*0.00070%*
		(bandwidth 22 kHz)
Channel separation	*1 kHz*	*>92 dB*
	20 kHz	*>67 dB*
Crosstalk	*1 kHz*	*<–107 dB*
	20 kHz	*<–84 dB*
Input impedance		*23.6 kΩ*
Output impedance		*100 Ω*
Tape-out impedance		*500 Ω*
Sensitivity for 1 V r.m.s. output		*260 mV*
Bandwidth		*DC to 200 kHz*
Maximum input voltage		*4.5 V r.m.s.*
Maximum output voltage		*5.5 V r.m.s.*
Current drain		*21 mA*

All tests were carried out with a supply voltage of ±8 V (batteries fully charged) and the relevant inputs terminated by a 560 Ω impedance.

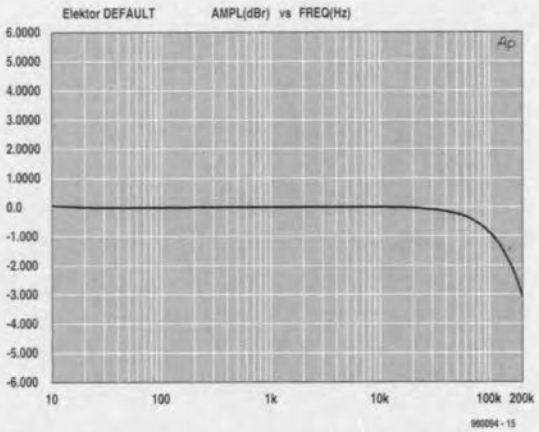
***Figure A** shows the THD+N characteristics for two dissimilar inputs. The upper curve pertains to an input of 2 V r.m.s., and the lower one to an input of 260 mV r.m.s. In both cases, the output was 1 V r.m.s. and the bandwidth was 80 kHz. It is clear that the differences between the two are very small; the respective distortion figures were 0.0014% and 0.0012%.*

***Figure B** shows the frequency response of the preamplifier. Note that this is entirely in accord with the specified bandwidth: the upper cut-off frequency is exactly 200 kHz.*

A



B



tery voltage.

The circuits are designed to operate from a symmetrical supply of ±7.2 V, which is provided by twelve NiCd batteries or twelve NiMH batteries.

The third section contains the power supply, consisting of the twelve batteries and a microprocessor-controlled charger. A three-position switch selects one of two operating positions or an emergency position.

In position 1, the power to the preamplifier is switched off and the batteries are being charged. In position 2, the charger is switched off and the preamplifier is powered by the batteries. In position 3 – an emergency position for use only when the batteries are flat – power is supplied to the preamplifier and the batteries are being charged. In practice, position 3 may never be used, since the preamplifier can operate from the batteries for up to 50 hours, while charging flat batteries takes only 2–3 hours.

When the preamplifier is not being used, the batteries are kept fully charged. When the fast charging process is over, the charger automatically goes on to trickle-charging. More about this in Part 2.

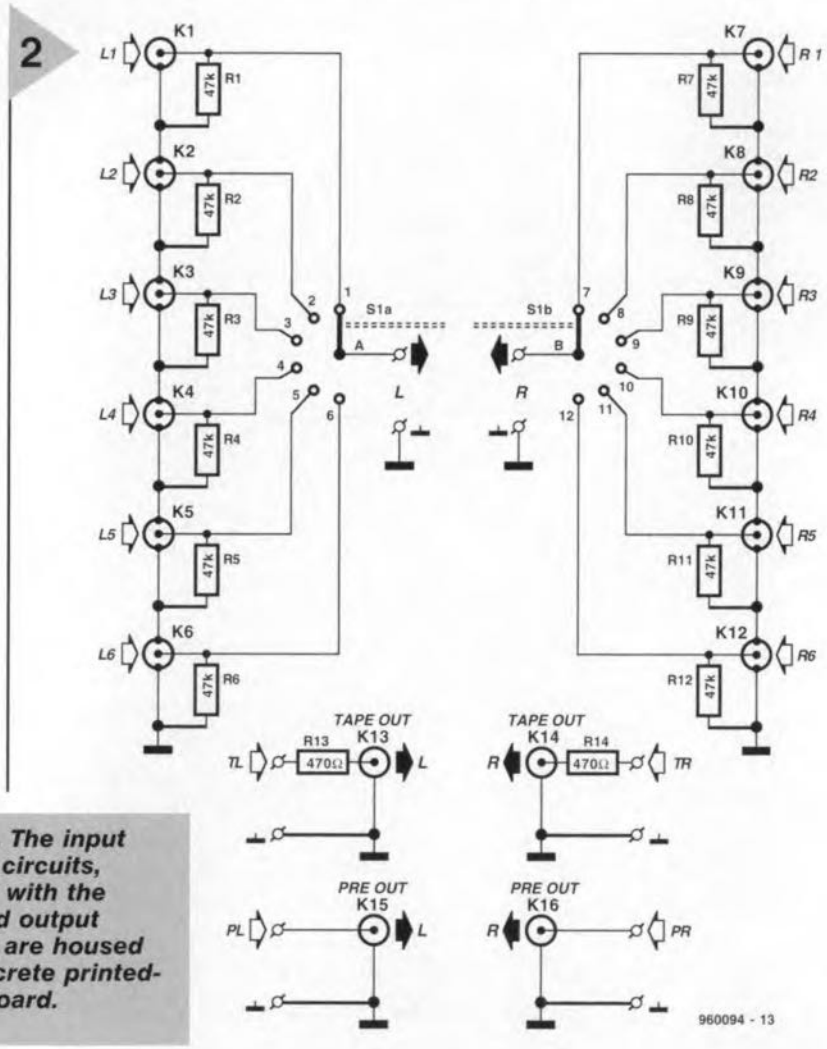


Figure 2. The input selector circuits, together with the input and output sockets, are housed on a discrete printed-circuit board.

THE CIRCUIT DIAGRAM

Although some ICs are used for special functions of the preamplifier, the signal processing circuits are all discrete designs. Moreover, virtually all components used are standard parts, so that availability of them should not cause undue difficulties.

The circuit of the input selector is shown in **Figure 2**. There is not much that needs to be said about this, because it is limited to a rotary switch, a number of resistors, and 12 input sockets. Switch S_1 provides a choice between six inputs at line levels which in practice is more than sufficient.

The input selector is housed on its own printed-circuit board together with output sockets K_{15} and K_{16}, and tape out buses K_{13} and K_{14}.

The diagram of the electronic circuits of the preamplifier is shown in **Figure 3**. This contains the complete stereo circuits: those for the right-hand channel in the top half and those for the left-hand channel in the lower half. In the following description, reference will be made to the right-hand channel only.

The input buffer is formed by stages T_1–T_7. Potentiometers P_1 and P_2 are the balance and volume controls respectively.

Stages T_8–T_{22} are amplifiers. Circuit IC_1 is a servo control for offset compensation. The combination of IC_3 and relay Re_1 provides switch-on delay (to obviate on/off clicks) and supply voltage detection.

BUFFER

Since there is a practical limitation to the number of batteries that can or should be used, a battery supply necessarily means that the supply lines are low. In the present circuit, the level is ±7.2 V. Because of this low level, amplification of the signal takes place only after the balance and volume controls. This makes it possible for input signals of a few volts to be processed.

It is clear from the foregoing that the buffer stage preceding the balance and volume controls is little more than a sophisticated emitter-follower. Cascading two emitter-followers, T_1-T_3 and T_2-T_4, renders the input and output of the buffer stage theoretically offset-free to make direct coupling possible. In practice, it is necessary for the pairs of emitter-followers to be preselected on the basis of identical amplification factor and U_{BE}, and to be thermally coupled.

The direct current operating point of the buffer, which is operating in Class A, is provided by current sources T_5 and T_6. The references for these sources are D_1 and D_2, the current through which is held constant by T_{17}. To further minimize any drift, the current sources and the diodes are thermally coupled.

High frequency interference is suppressed by a low-pass filter, R_1-C_1, at the input of the buffer stage. The output of the buffer stage is not only applied to the balance and volume controls, but is also used as the tape-out signal.

AMPLIFIER SECTION

As for other parts of the circuit, a low supply voltage and minimum current drain were important design parameters for the amplifier stages.

Obviously, the design is totally symmetrical. The input circuits are formed by two complementary differential amplifiers, T_8–T_{11}, each of which is provide with a discrete current source, T_{12} and T_{13}. In view of the required stability, transistors pairs T_8-T_9 and T_{10}-T_{11} are thermally coupled. To keep the offset low, it is desirable for the transistor pairs to be preselected on the basis of (near)identical specifications.

The outputs of the differential amplifiers drive push-pull stage T_{15}-T_{16}, which in turn actuates the output stage.

Because of the low supply voltage,

the output stage is a compound one, a kind of darlington, which produces an amplification of about ×1.7. This gain gives the other stages rather more room to operate, and ensures that the peak output voltage is all but equal to the supply voltage.

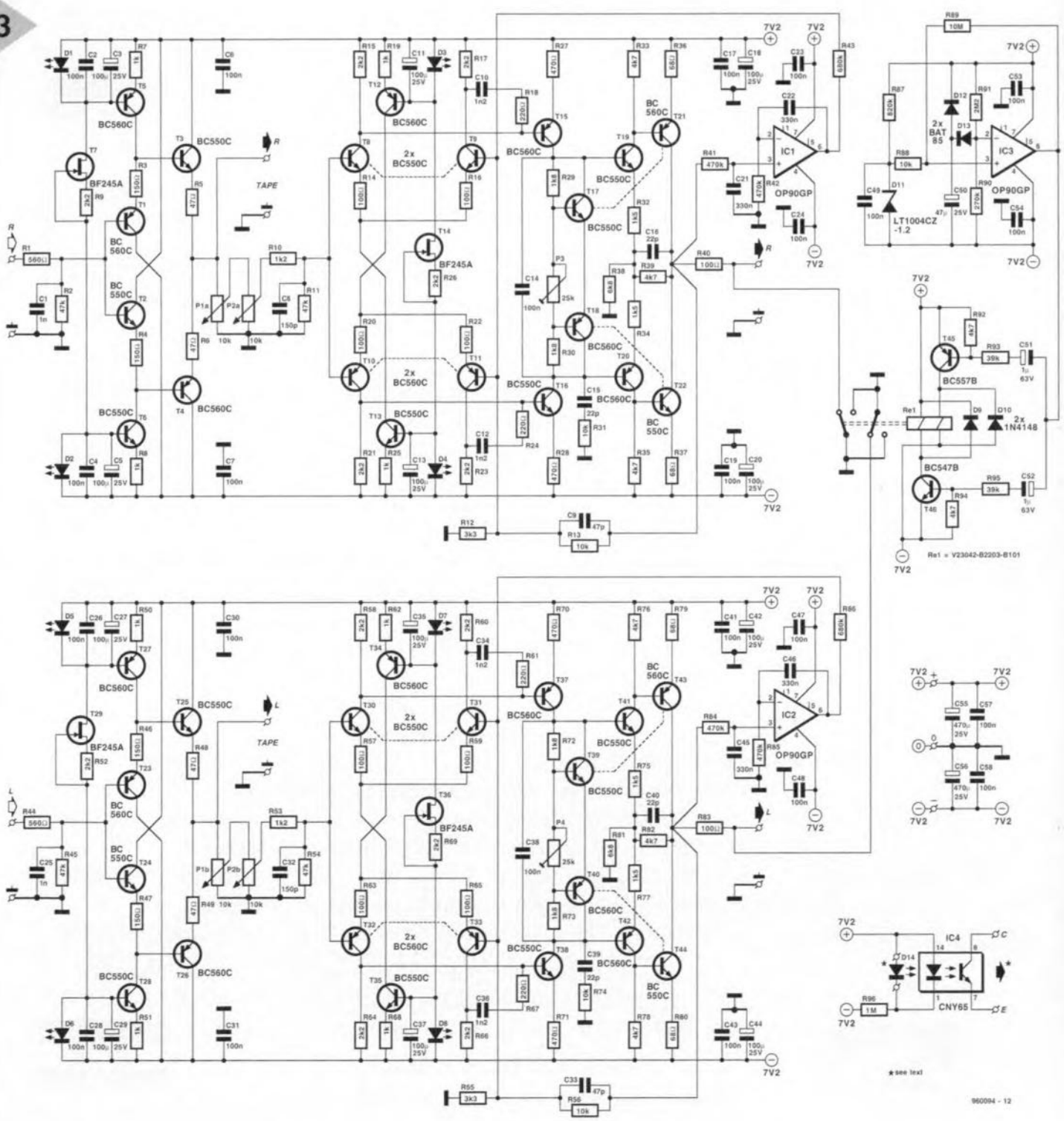
The quiescent current of the output stage is held constant by intercoupling T_{21} and T_{22} via 'zener transistor' T_{17}-T_{18}. The zener voltage, and consequently the quiescent current (about 2 mA), is set with P_3.

Combinations R_{18}-C_{10}, R_{24}-C_{12}, R_{31}-C_{15}, and capacitor C_{16}, are compensating networks. The open-loop amplification is ×1700, and the open-loop bandwidth is about 2 kHz.

Since even with matched transistors the symmetry of the amplifier will never be 100 per cent, offset compensation is provided by a servo-control, which is based around precision low-voltage micropower op amp IC_1. The low current drain of 20 μA and the low input offset of typically 0.13 mV make this op amp particularly suitable for this application.

Any offset voltage present at the output is amplified and fed back via R_{43} to the base of T_9-T_{11}. The actual offset at the output of the preampli-

Figure 3. The AF preamplifier consists of a buffer and an amplifier separated by the balance and volume controls. Circuits IC_1 and IC_2 form a servo control circuit for offset compensation. The circuit based on IC_3 and Re_1 is a switch-on delay and supply voltage detector.



fier is, therefore, minimal in all circumstances.

RELAY STAGE

As mentioned before, any on/off switching clicks and other noises are suppressed through the use of a relay, Re_1. It is noteworthy that the relay contacts are not, as usual, in series with the output signal; here suppression is obtained by short-circuiting the signal to ground. This has the advantage that the relay contacts are not in the signal path during normal operation and, therefore, cannot adversely affect the signal quality. Resistor R_{40} ensures that the short-circuiting has no detrimental effects on the amplifier.

It is also worth noting that the relay is not of the usual kind, but a bistable type. Such a relay needs a pulse of only a few milliseconds to be actuated: this prevents unnecessary current drain.

The relay has two isolated windings, of which one is used to actuate the make contact, and the other to reset the relay.

Transistors T_{45} and T_{46} function as pulse-shapers. The switching pulse originates in the very brief charging current of C_{51} or C_{52}. Which of these capacitors will be charged depends on the output state of IC_3.

Comparator IC has a threefold function: (1) it provides a delay at switch-on; (2) it acts as a detector of the supply voltage, and (3) it provides rapid suppression of the output voltage when the preamplifier is switched off.

In essence, functions (2) and (3) are identical since in both the relay switches over as soon as the supply voltage drops below about 12 V. To this end, the potential at junction R_{90}-R_{91}, which is derived from the supply line, is compared with the reference voltage provided by D_{11}. This diode is a special micropower reference type that needs a current of only 10 μA. The feedback provided by R_8 and R_{89} ensures smooth operation of the comparator around the toggle voltage.

Delayed switch-on is provided by C_{50}. At switch-on, this capacitor must be charged via D_{13} before IC_3 toggles. Diode D_{13} ensures that the potential at junction R_{90}-R_{91} drops immediately the supply voltage decreases. The capacitor is discharged via diode D_{12} when the supply voltage approaches 0 V.

The value of C_{50} gives a delay time of 10–15 seconds, depending on the supply voltage. This time is inversely proportional to the supply voltage. A very long delay therefore indicates that something is amiss with one of the batteries or that the charger is faulty. The delay time may be shortened by lowering the value of C_{50} to some extent.

DISPLAY

To obtain an indication that the preamplifier is switched on, low-current diode D_{14} may be energized via R_{96}. If this is desired, the resistor should have a value of about 6.8 kΩ. It is also possible to obtain an indication via optoisolator IC_4, with which the state of the batteries can be displayed in two colours. An advantage of the optoisolator is that it draws a current of only 15 μA from the batteries. In this case, the value of R_{96} should be 1 MΩ; the LED is energized directly by the charger supply line.

The on/off indication, as well as the construction and the operation of the charger, will be further discussed in Part 2 which is intended to be published in the February issue.

[960094-1]

CONSTRUCTION GUIDELINES

Elektor Electronics (Publishing) does not provide **parts and components other than** PCBs, front panel foils and software on diskette or IC (not necessarily for all projects). Components are usually available form a number of retailers – see the adverts in the magazine.

Large and small values of components are indicated by means of one of the following prefixes :

E (exa) = 10^{18}	a (atto) = 10^{-18}
P (peta) = 10^{15}	f (femto) = 10^{-15}
T (tera) = 10^{12}	p (pico) = 10^{-12}
G (giga) = 10^{9}	n (nano) = 10^{-9}
M (mega) = 10^{6}	μ (micro) = 10^{-6}
k (kilo) = 10^{3}	m (milli) = 10^{-3}
h (hecto) = 10^{2}	c (centi) = 10^{-2}
da (deca) = 10^{1}	d (deci) = 10^{-1}

In some circuit diagrams, to avoid confusion, but contrary to IEC and BS recommandations, the value of components is given by substituting the relevant prefix for the decimal point. For example,

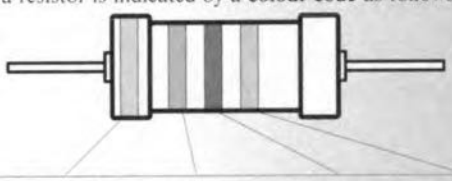
3k9 = 3.9 kΩ 4μ7 = 4.7 μF

Unless otherwise indicated, the tolerance of resistors is ±5% and their rating is ⅓–½ watt. The working voltage of capacitors is ≥ 50 V.

In **populating a PCB**, always start with the smallest passive components, that is, wire bridges, resistors and small capacitors; and then IC sockets, relays, electrolytic and other large capacitors, and connectors. Vulnerable semiconductors and ICs should be done last.

Soldering. Use a 15–30 W soldering iron with a fine tip and tin with a resin core (60/40) Insert the terminals of components in the board, bend them slightly, cut them short, and solder: wait 1–2 seconds for the tin to flow smoothly and remove the iron. Do not overheat, particularly when soldering ICs and semiconductors. Unsoldering is best done with a suction iron or special unsoldering braid.

The value of a resistor is indicated by a **colour code** as follows.



color	1st digit	2nd digit	mult. factor	tolerance
black	–	0	–	–
brown	1	1	×10^1	±1%
red	2	2	×10^2	±2%
orange	3	3	×10^3	–
yellow	4	4	×10^4	–
green	5	5	×10^5	±0.5%
blue	6	6	×10^6	–
violet	7	7	–	–
grey	8	8	–	–
white	9	9	–	–
gold	–	–	×10^{-1}	±5%
silver	–	–	×10^{-2}	±10%
none	–	–	–	±20%

Examples:
brown-red-brown-gold = 120 Ω, 5%
yellow-violet-orange-gold = 47 kΩ, 5%

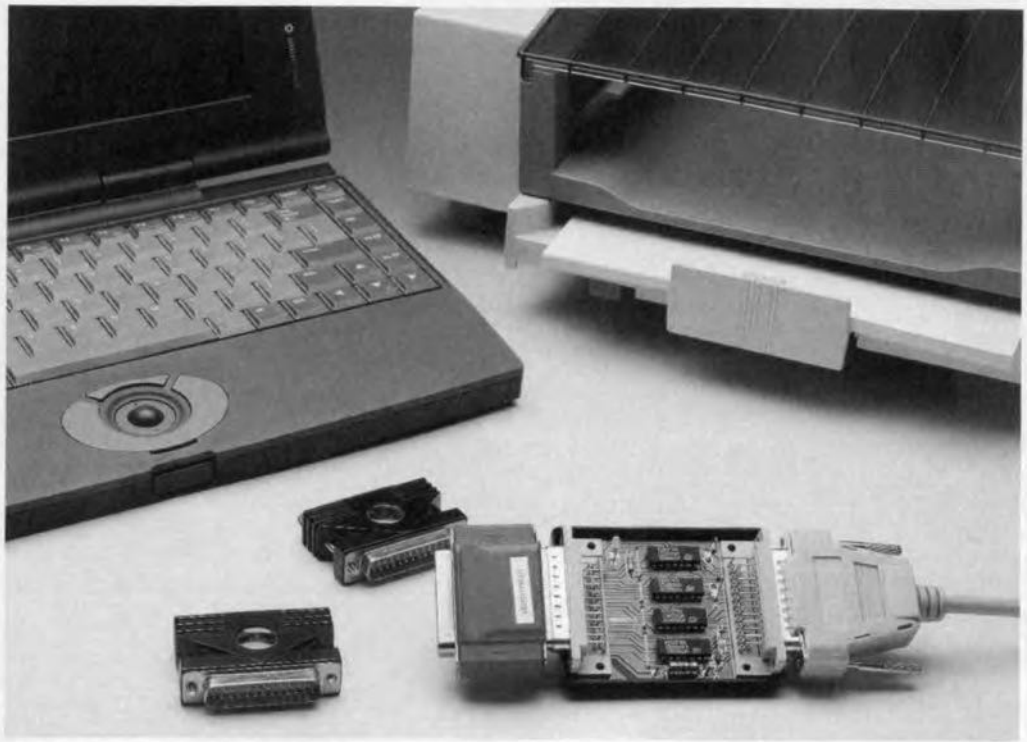
Faultfinding. If the circuit does not work, carefully compare the populated board with the published component layout and parts list. Are all the components in the correct position? Has correct polarity been observed? Have the powerlines been reversed? Are all solder joints sound? Have any wire bridges been forgotten?

If voltage levels have been given on the circuit diagram, do those measured on the board match them – note that deviations up to ±10% from the specified values are acceptable.

Possible corrections to published projects are published from time to time in this magazine. Also, the readers letters column often contains useful comments/additions to the published projects.

dongle switch

temporarily disconnects obnoxious printers



Software suppliers have adopted a number of different systems to protect their products against illegal copying. The dongle (also written as 'dongal') is a user-friendly solution which acts a kind of 'key' plugged on to the printer port connector, sitting between the PC and the printer. In some cases, a printer connected like that but otherwise switched off may cause strange effects inside the dongle. Disconnecting the printer or switching it on then appears to be the only alternative to keep the software going. The dongle switch presented here solves the same problem quickly, automatically, and in a much more elegant way.

Design by T. Will

Software protection is always a rather arbitrary matter. Arguably, a software supplier has every right to protect his product against illegal use. On the other hand, the licensed user may reasonably expect the product to function without being hindered by the copy protection. In principle, the dongle is an acceptable and (usually) trouble-free solution. Once installed on the printer port, this electronic key becomes invisible to the user. In actual fact, the main program checks the presence of the dongle at certain intervals. If the device is found, the software simply continues to operate. If the dongle is not found at the expected location, the program stops functioning, and becomes useless. An additional advantage of a dongle is that it is a portable key. If you have it in your pocket, unauthorized use of the program (though fully installed) is just not possible. Depending on the licence conditions granted to the authorised user, it is possible to install the same software on a number of different computers. The software may be run on one machine at a time, however: the one with the dongle attached!

Attractive as they may be as software protection devices, dongles may cause unexpected problems. A practical problem reported to us by many users of dongles is that the printer appears to lock up the system if it is switched off. Yes, we know it may be switched on to prevent this sort of problem, but then electrical energy is wasted by a peripheral device which is not used. The following solution was devised: switch off the printer automatically, so that the dongle 'thinks' that it is the only device connected to the printer port, while the printer is not in use. In practice, the dongle switch described in this article automatically clears all printer-related problems reported by dongle users. Long live the practical approach to electronics!

Circuit description

The circuit diagram of the dongle switch may be found in **Figure 1**. To the right in the drawing is the connector which links the circuit to the printer port on the PC. The connector for the printer is shown to the left. Each data and control line between the printer and the PC is fitted with an electronic switch, in this case, an analogue bilateral one of which four are contained in a type 4066 IC.

All switches have a common enable line which is connected to the SELECT

line on the printer. When the printer is switched off, the SELECT line is held low by the transistors in the output stage of the Centronics interface contained in the printer. If the printer is absent – in other words, nothing is connected to K1 – then the enable inputs of the switches are pulled to ground via resistor R1 and diode D1. In both cases, all electronic switches are opened, interrupting any signal traffic. Consequently, the dongle sees a high impedance at its outputs. If the printer is present and selected, the SELECT line is at a logic high level. All analogue switches are then closed, and the (active) printer is connected to the computer via the dongle.

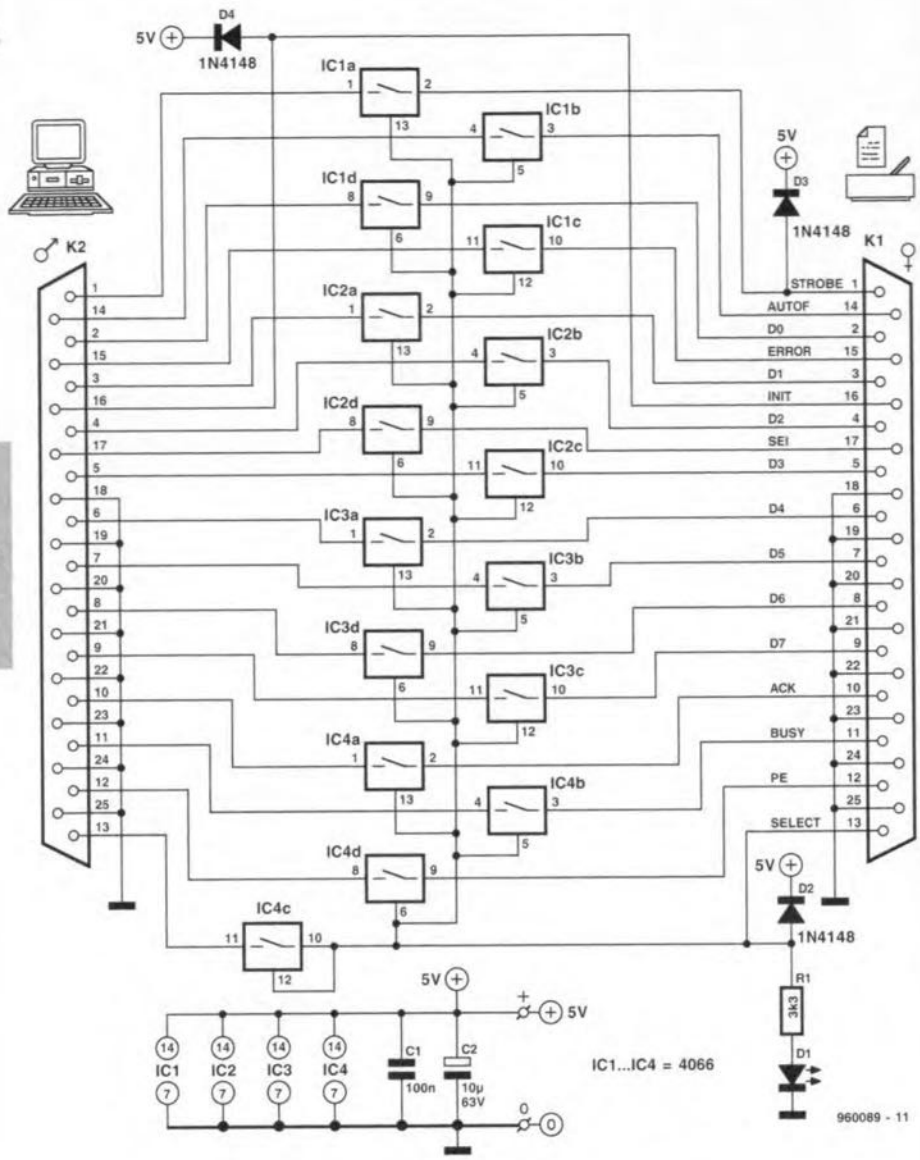


Figure 1. Circuit diagram of the dongle switch. A set of electronic switches disconnects the printer from the dongle when the printer is switched off.

All we need to complete this simple circuit is an adequate power supply. Because the complete circuit draws a mere 2 mA, supply power may be 'tapped' without running into problems. This is accomplished by diodes D2, D3 and D4 on the SELECT, STROBE and INIT line, respectively. In the rare case of 2 mA being a too high current consumption, LED D1 may be replaced by a resistor of, for example, 470-kΩ. Although this causes the current drain to drop to the micro-amps region, a visual printer status indicator is then no longer available.

If powering the circuit from the computer still causes problems, the supply voltage has to be tapped from the computer using a spare connector as applied for the combined +5/+12V supply for a floppy disk drive.

Capacitor C2 acts as a reservoir device for the supply voltage, while C1 suppresses RF noise.

PRACTICAL MATTERS

No matter how clever the design of a circuit, it is not finished without due attention being paid to 'packaging'. The track layout and component mounting plan of the printed circuit board designed for the dongle switch are shown in **Figure 2**. The finished board should fit is a compact plastic case from Conrad (order code 522848) from which the moulded ridges are removed before the board is fitted. It is not necessary to secure the board with screws because it is held in place by its connectors.

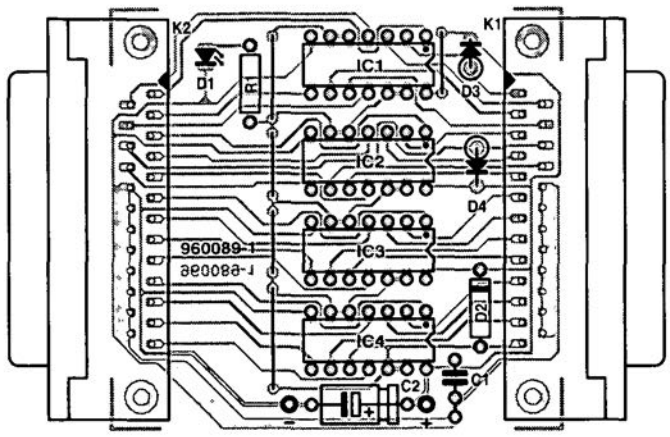
As a matter of course, the circuit is built on a single-sided circuit board (which is available ready-made through our Readers Services). Start by fitting the five wire links on the board. Next, fit diodes D1, D2, D3 and D4, and capacitor C2 (mind the polarity of this component). Proceed with resistor R1, followed by connectors K1 and K2. Note that K1 is a socket, while K2 is a plug-style connector (i.e., male). Two PCB solder pins fitted near the terminals of C2 enable an external supply voltage to be connected (only if necessary). Finally, fit the four ICs, and the board is ready for use.

Because it not certain at this stage whether it is possible to power the circuit from the PC or the printer (our own attempts at powering the dongle switch in this way were less successful), it is recommended to use a stabilized 5-V power supply in the first instance. Connect the dongle to the printer port on the PC, and then connect the printer to the dongle via the dongle switch. The photograph in **Figure 3** illustrates the order in which these components are arranged. Switch on the printer and start the PC. The protected software should run without problems. Next, switch off the printer and check that the software keeps functioning. That should be the



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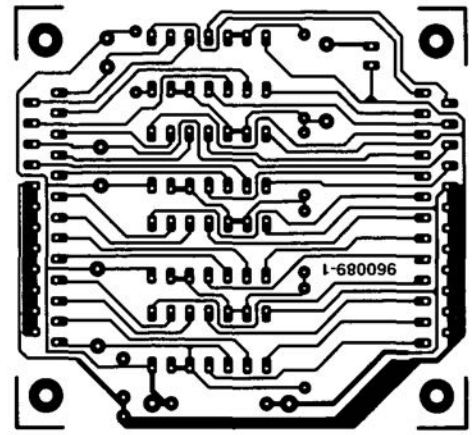
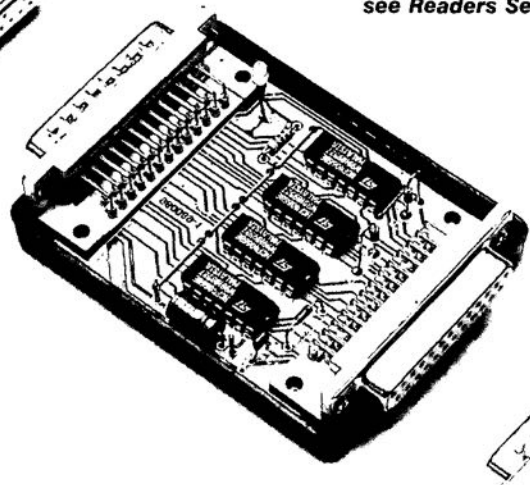


Figure 2. Copper track layout and component overlay of the PCB designed for the circuit. All components, including the two connectors, are mounted on this board (board available ready-made, see Readers Services pages).



3



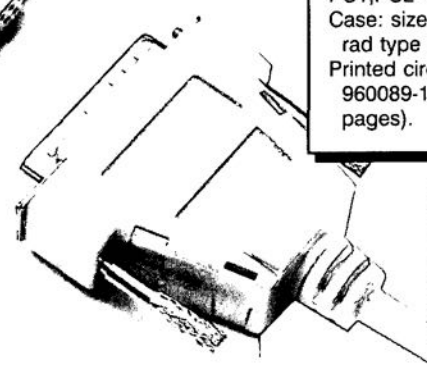


Figure 3. The dongle switch in action. Here, it sits between a dongle and a printer, preventing the printer from upsetting the operation of the dongle.

COMPONENTS LIST

Resistors:
R1 = 3kΩ3

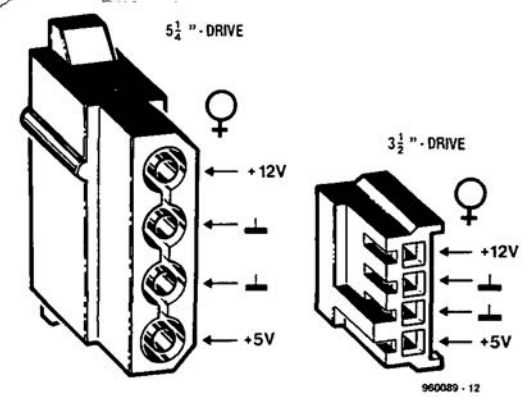
Capacitors:
C1 = 100nF
C2 = 10µF 63V

Semiconductors:
D1 = LED, 2mA, yellow
D2,D3,D4 = 1N4148
IC1-IC4 = 4066

Miscellaneous:
K1 = DB25 socket, angled, PCB mount.
K2 = DB25 plug, angled, PCB mount.
PC1,PC2 = solder pin.
Case: size 61x22x80mm e.g., Conrad type 522848.
Printed circuit board, order code 960089-1 (see Readers Services pages).

Figure 4. In case an external supply voltage is necessary after all, this drawing shows how the necessary voltage may be tapped from a floppy or hard disk drive supply connector. It should be possible to find an unused connector in almost any PC.

4



case if everything is working properly so far. Once it is certain that the circuit functions properly, the external 5-V supply may be disconnected. Use a DMM to see if a supply voltage of 5 V remains present across the ICs. If not, replace D2 by a 470-kΩ resistor, and check again. If everything works okay after switching the PC off and on again, the circuit is ready for use.

If an external power supply appears to be necessary after all, use the arrangement sketched in **Figure 4** to 'tap' power from the PC via a floppy disk or hard disk supply connector. Only two wires are required to make this connection.

(960089)


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in search of magnetic fields

magnetic-field meter



These days when electronic circuits can be found almost anywhere, there is, some people fear*, a different kind of environmental pollution. They call it electrosmog (the word does not appear in any dictionary - not even technical ones), but in this article we will call it stray magnetic fields (SMFs). Some 'experts' think that SMFs may affect the physical well-being of people. If you believe that these experts are right, the magnetic-field meter described will help you find sources of SMFs and determine their strength. These findings may help you reduce the field-strength.

Smog is a factitious word blending the sounds and combining the meanings of smoke and fog. In many other countries the word smog has been adopted to indicate the blue-grey sky that occurs on a warm, windstill summer's day when a mixture of industrial and domestic exhaust fumes accumulates in the upper atmosphere. Consequent increases in the ozone level may, in some people, cause headache, shortness of breath and a general feeling of discomfort. From this, it is clear that electrosmog is not a particularly well-chosen colloquialism to describe stray magnetic fields.

The stray magnetic fields referred to in this article are those in the low-frequency range of 200–1200 Hz. Some people claim to be affected by the SMF caused by computer monitors or high-voltage wires. There are even some who claim that the SMF caused by a bedside clock-radio affects them. So, if a colleague is habitually bad-tempered early in the morning, his alarm-clock-radio may be to blame!

The magnetic-field meter described in this article does not solve the effects people honestly believe they suffer from, but it does enable them to find possible sources of SMF.

**In spite of these fears, a number of authoritative studies, analyses and surveys carried out in several countries over the past 15 years have found absolutely no evidence of magnetic fields causing any kind of illness in human beings. The most recent analysis (October 1996), carried out by the prestigious US National Research Council investigating more than 500 studies over the past 20 years concludes that there is not a shred of evidence to link magnetic fields with illness of any sort in human beings.*

[Editor]

Design by H. Bonekamp

MEDICAL (?) ASPECTS

There are people who believe that strong magnetic fields affect their well-being. In the 1980s and early 1990s, certain organizations in a number of countries in Europe and North America engendered such fears* by publishing surveys which purported to have found a 'possible' link between magnetic fields and the 'likelihood' of people becoming ill with certain types of cancer (leukemia) and diseases of the central nervous system, such as multiple sclerosis.

Legislation in the United States and Sweden lays down that nobody must be exposed for any length of time to magnetic-field-strengths greater than 200–300 nT. Most other countries take a more lenient view, except in the field of computers: monitors must comply with the stringent MPRII and TCO standards. These stipulate the maximum magnetic field emanating from the unit.

If you feel nervous about the effects of magnetic fields, check all systems in your home that generate (electro)magnetic fields and measure such fields: the present meter is ideal for this. It has a range of 100 nT to 2.3 μT*. Measuring the magnetic flux density must be carried out at a realistic distance; for instance, that emanating from a monitor should be measured at the place where your head normally is in relation to the unit.

THE DESIGN

The principle of the present meter is shown in the block diagram in **Figure 1**. The induction coil used to detect the magnetic field is represented by an alternating-voltage source, V_1, whose average output is 1 μV. The output of the source is amplified ×101 by op amp X_1.

The op amp is linked to integrator X_2 which provides frequency-dependent amplification. For direct-voltage signals this is 1000, for high-frequency signals it is 0. The cross-over frequency is chosen so that the amplification is uniform over the range in which magnetic induction is to be measured (40 Hz – 10 kHz).

Feedback network R_4–R_6 automatically ensures that the circuit has a stable d.c. operating point at all times. This makes it possible for relatively inexpensive op amps to be used. Also, the internal attenuator ensures that the maximum d.c. amplification is ×101 ($1+R_6/R_5$). The value of R_6/R_5 also determines the lower limit of the frequency range.

The circuit diagram of the meter is shown in **Figure 2**. It consists of an input amplifier, integrator, automatic offset correction network, rectifier with d.c. suppression, display and associated drive, power supply, and a socket

Some parameters

Meter range (integral LEDs)	*100 nT – 2.3 μT*
Scale	*logarithmic*
Meter range (via DVM)	*50 nT – 2 μT*
Scale	*Linear*
Frequency range	*40 Hz – 10 kHz (±1.5 dB)*
Maximum measurement error	*5% (with stated resistor tolerances)*
Current drain	*10 mA*
Power supply	*9 V battery*

1

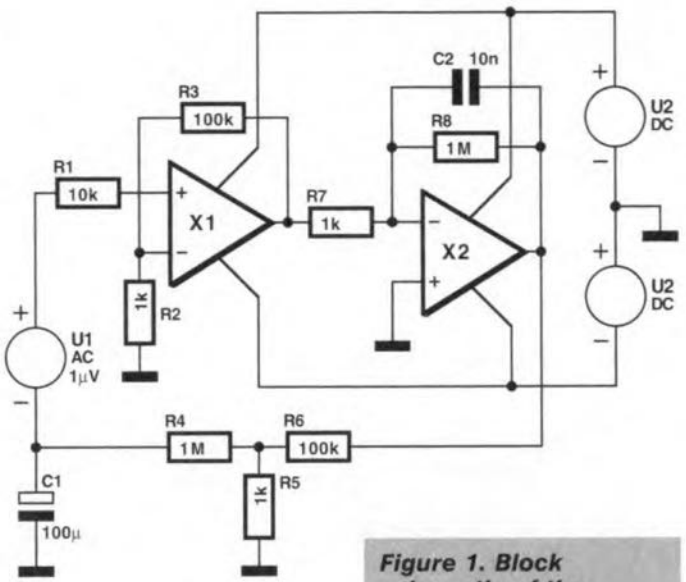


Figure 1. Block schematic of the amplifier stage that converts the detected magnetic field into a frequency-independent alternating voltage.

Some theory

Since, according to Lenin: "Practice without theory is blind, but theory without practice is sterile", here is some background theory for the magnetic-field meter.

The voltage, e_i, induced in a coil placed in a magnetic field is given by

$$e_i = -2\pi f\, N\, A\, B_{max} \cos(\omega t) \qquad [1]$$

where N is the number of turns of the coil, A is the surface area of the coil, and B_{max} is the peak magnetic flux density.

It is clear from equation [1] that the voltage is directly proportional to the frequency of the field. This means that a circuit is required whose amplification is inversely proportional to the frequency; such a circuit is, for instance, an integrator. The transfer, H_i, of an integrator based on an op amp is

$$H_i = -1/(2\pi f\, j\, R_i\, C_i) \qquad [2]$$

where $j = \sqrt{-1}$, R_i is the integrator resistance, and C_i is the integrator capacitance.

When the integrator and coil are placed in series, the quantities in equations [1] and [2] are multiplied:

$$e_i\, H_i = N\, A\, B_{max}/R_i\, C_i \sin(\omega t) \qquad [3]$$

From this it is seen that the output of the combination is independent of the field frequency.

** T, the tesla, is the SI unit of magnetic flux density or magnetic induction equal to 1 weber m^{-2}. The weber, symbol Wb, is the SI unit of magnetic flux. 1 weber = 1 volt-second = 1 joule-ampere. The tesla is named after the Croatian-American electrical engineer Nikola Tesla (1856–1943), who worked with both Edison and George Westinghouse. The weber is named after Wilhelm Eduard Weber (1804–91), professor of physics at Leipzig, who associated with Gauss in his researches on electricity and magnetism.*

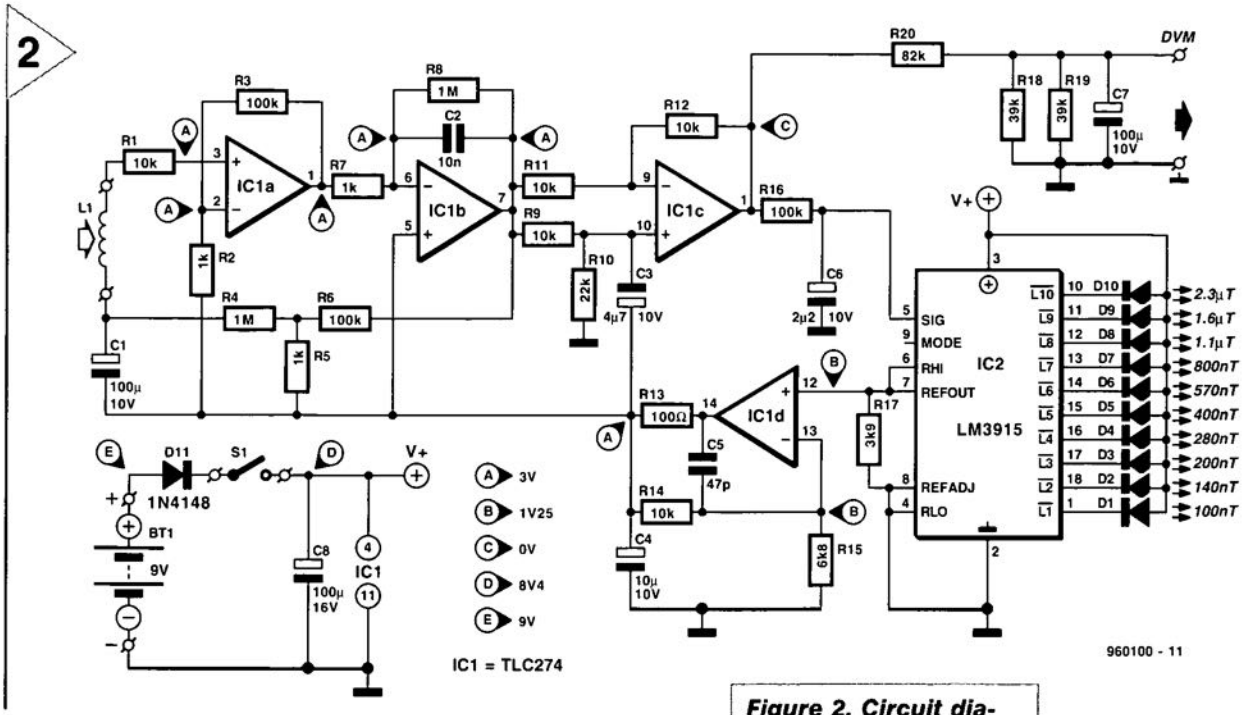


Figure 2. Circuit diagram of the magnetic-field meter, which is ideal for detecting small stray fields.

for connection to a digital voltmeter (DVM).

The input amplifier, based on IC_{1a}, ensures that the signal from the induction coil, L_1, is amplified ×101. The coil is terminated into a high impedance, so that its output is buffered by the op amp.

The integrator consists of IC_{1b}, another of the four op amps contained in IC_1.

The (active) rectifier, based on IC_{1c}, is, in fact, a differential amplifier that lessens the average voltage by the output potential of the integrator. Since the op amp is powered asymmetrically, the output is a half-wave rectified alternating voltage. This voltage is averaged by R_{16}-C_6 or, in case a DVM is used as the meter, by R_{18}–R_{20}-C_7. The form factor (2.22) is corrected by the rectifier. The level matching is purposely carried out by the rectifier since this op amp has a much larger swing than IC_{1a} or IC_{1b}.

Op amps IC_{1a} and IC_{1b} carry a pure sinusoidal signal that alternates symmetrically around a direct voltage of 3 V, whereas that of IC_{1c} alternates around 0 V. This means that this op amp can handle an amplification of ×2.2 much better than the earlier two.

The drop across C_6 is used by the display driver, IC_2, to represent the strength of the magnetic field. The driver has its own reference-voltage source. This 1.25 V source is also used to derive an auxiliary voltage for op amps IC_{1a} and IC_{1b}. The potential at node A is

$$[(R_{14}+R_{15})/R_{15}] \times 1.25 \approx 3\ \text{V}.$$

The minimum voltage at which IC_2 provide full drive is 1.2 V. Since the IC is driven by an averaged potential, the signal level required for full drive is $1.2 \times \pi = 3.77\ V_{pp}$. Because the signal amplification takes place in the recti-

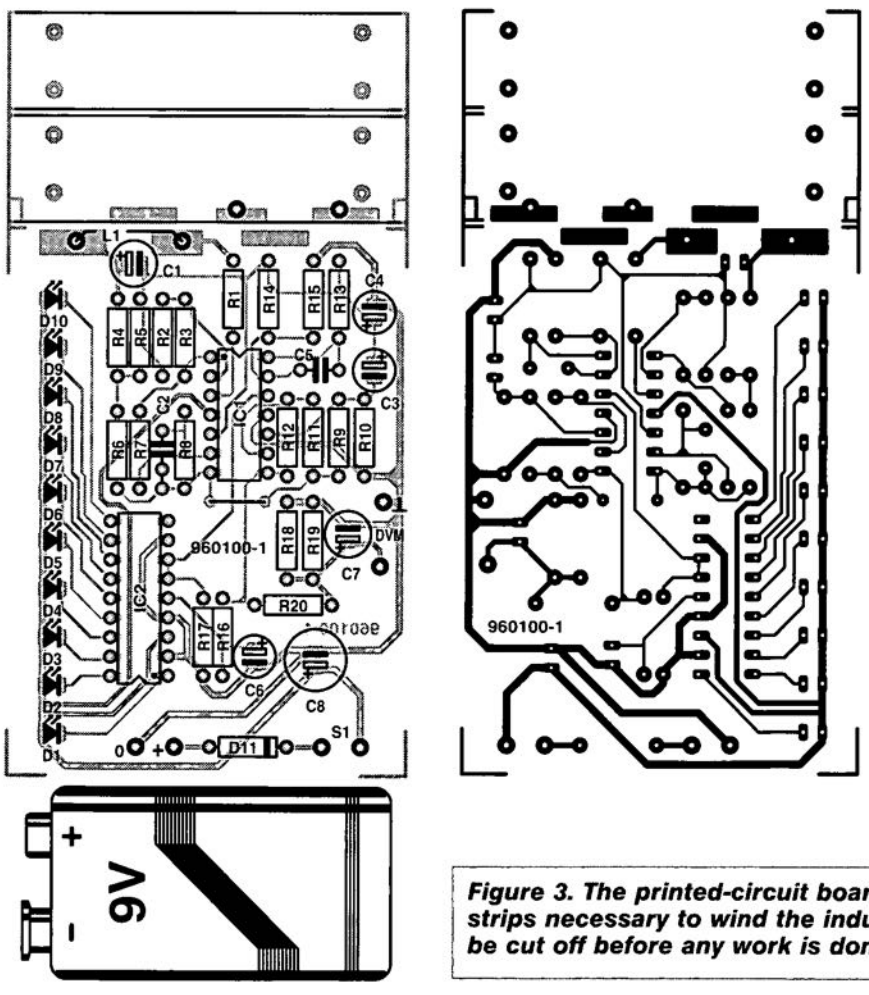


Figure 3. The printed-circuit board for the meter contains the strips necessary to wind the induction coil. These strips should be cut off before any work is done.

Induction coil L_1

The design of the induction coil is a compromise between the surface area and the number of turns. The smaller the coil, the greater the number of turns must be. One of the drawbacks of a large number of turns is the inaccuracy arising during the winding. If the coil consists of many layers on top of each other, its surface area increases and with it the imprecision. Also, counting errors are easily made.

If it is desired to design a coil to individual preferences, it should be borne in mind that the product of the number of turns, N, and the surface area of the coil, A, must be

$$N A = 51.66 \times 10^{-3}. \qquad [4]$$

For instance, the coil discussed in the text has a surface area of 426×10^{-6} m². Substituting this quantity in equation [4] gives the number of turns:

$$N = 51.66 \times 10^{-3}/A = 51.66 \times 10^{-3}/426 \times 10^{-6} = 121.$$

So, when the dimensions of the desired coil are known, the number of turns is easily computed.

If more than 100 turns are used, trimming down to 1% accuracy is possible by adjusting the number of turns. This requires a reference signal or a calibrated meter.

fier, that is, the op amp with the largest drive range, a drop in battery voltage does not immediately affect the accuracy of the meter.

Parts list

Resistors:
R_1, R_9, R_{11}*, R_{14} = 10 kΩ
R_2*, R_5, R_7* = 1 kΩ
R_3*, R_6, R_{16} = 100 kΩ
R_4, R_8 = 1 MΩ
R_{10}, R_{12} = 22 kΩ, 1%
R_{13} = 100 Ω
R_{15} = 6.8 kΩ
R_{17} = 3.9 kΩ
R_{18}, R_{19}* = 39 kΩ
R_{20} = 82 kΩ, 1%
* = 1%

Capacitors:
C_1, C_7 = 100 µF, 10 V, radial
C_2 = 10 nF, metallized polyester film, 5%
C_3 = 4.7 µF, 10 V, radial
C_4 = 10 µF, 10 V, radial
C_5 = 47 pF
C_6 = 2.2 µF, 10 V, radial
C_8 = 100 µF, 16 V, radial

Inductors:
L_1 = see text

Semiconductors:
D_1–D_3 = LED, green, high efficiency
D_4–D_6 = LED, yellow, high efficiency
D_7–D_{10} = LED, red, high efficiency
D_{11} = 1N4148

Integrated circuits:
IC_1 = TLC274
IC_2 = LM3915

Miscellaneous:
S_1 = single-pole switch with make contact
PC_1–PC_4 = soldering pin 1.3 mm dia.
Bt_1 = battery 9 V
Enclosure as suitable
PCB Order no. 960100-1

The display driver controls ten LEDs. The diagram clearly shows which LED lights at a given field-strength. When D_{10} lights, the measured fieldstrength ≥ 2.3 µV, rather greater than the upper limit specified in MPRII (250 nT).

If the meter is linked to a DVM, this must be set to its 200 mV direct- voltage range. The measurement range is then 50 nT – 2 µT. Measuring levels below 50 nT is not possible owing to the noise floor.

CONSTRUCTION

The circuit is best built on the printed-circuit board shown in **Figure 3**, which reduces the necessary work to a minimum.

The induction coil is a DIY job. The core on to which it is wound is made from two strips cut off the PCB. These strips are formed into a 'sandwich' separated by four 1.3 mm dia. solder pins in the indicated positions. Note that the track side of both strips must face the motherboard.

The broad strip has two solder pads to which the coil terminals are soldered. The third pad merely serves to increase rigidity.

Close-wind 121 turns of 0.2 mm enamelled copper wire on to the core. If this is done carefully, the winding will consist of exactly five layers. Place the coil against the motherboard in such a way that the three copper pads at the edge of the motherboard coincide with the corresponding pads on the coil. Solder the coil to the motherboard.

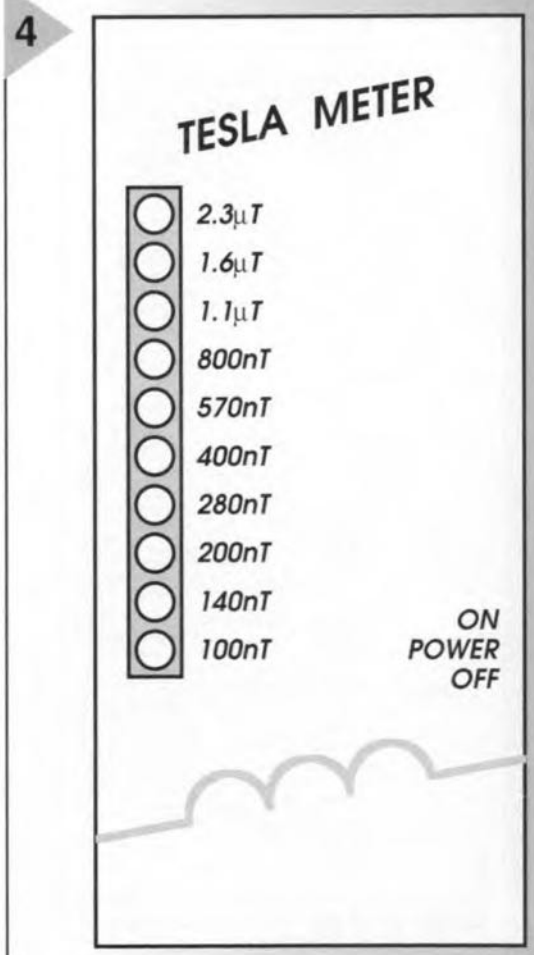
The remainder of the wiring is straightforward. First lay the wire bridge at the centre of the board. After the two solder pins have been soldered into place, solder the resistors and capacitors on to the board. Mind the polarity of the electrolytic capacitors. The ICs may be soldered directly to the board, but sockets may be used as well. The last components to be placed are the LEDs. These diodes are in three groups, each of a different colour. The green of D_1–D_3 indicates a safe level; the yellow of D_4–D_6 a dubious level; and the red of D_7–D_{10} a risky level.

After switch S_1 and the 9-V battery have been connected, the circuit is ready for use. It is best to build it into a suitable case to make a compact measuring instrument.

The meter need not be calibrated since the measurement error is negligible, provided the correct components have been used and the induction coil has been wound carefully.

[960100]

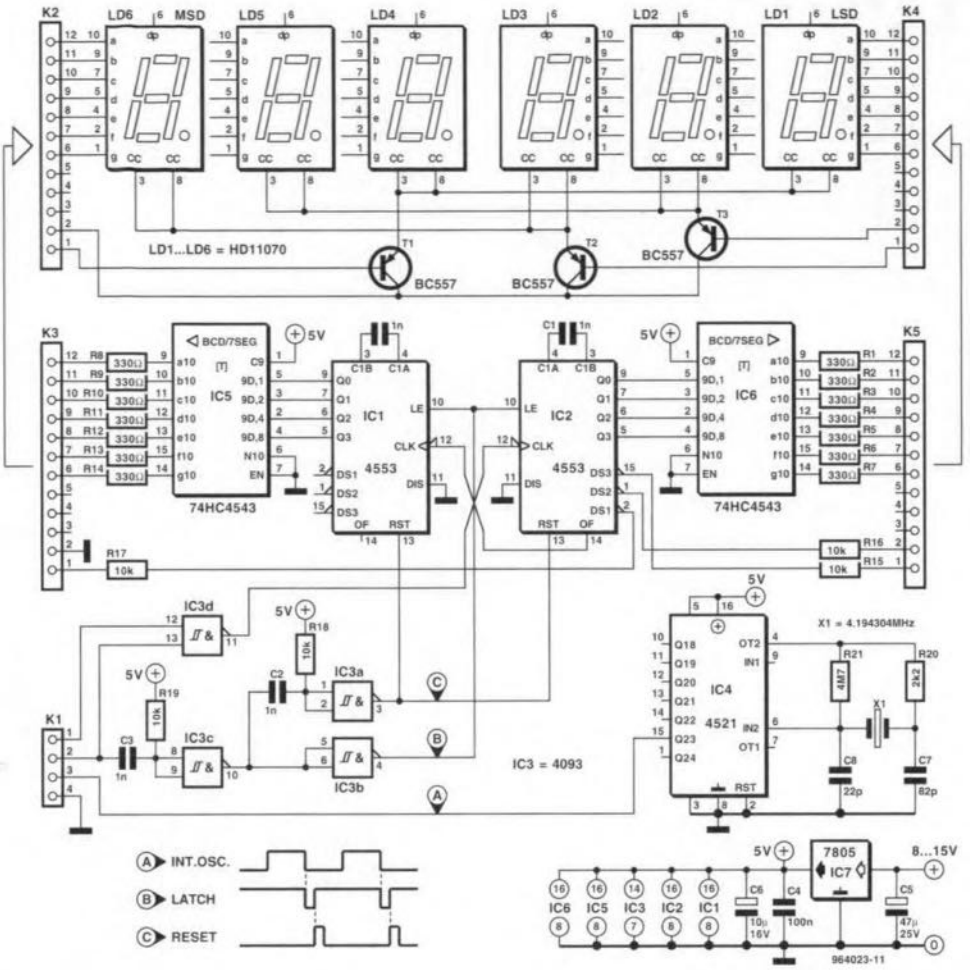
Figure 4. Proposed front panel. Since each LED indicates a certain fieldstrength, a rapid indication of the stray field is





Simple Frequency Meter

(July/August 1996)
964023



We extend our gratitude to Mr. Capel of Goes, the Netherlands, for pointing out a number of errors and omissions in the circuit diagram of the frequency meter described on page 68 of the July/August 1996 issue of Elektor Electronics.

*The main error is the missing link between pin 15 of **IC4** and pin 3 of connector K1. Also, pin 5 of IC4 has to be tied to the +5 V rail, while pin 3 should be connected to ground. Furthermore, pins 6 and 4 of IC4 have to be swapped.*

*Next, we have to look at **IC1** and **IC2**. On these two ICs, the clock and overflow lines have been exchanged. This problem is simple to solve by connecting pin 11 of IC3d to pin 12 of IC2, instead of pin 12 of IC1. Next, you connect pin 14 of IC2 to pin 12 of IC1. Pin 14 of IC1 is then left open. We also recommend adding an extra 1 nF capacitor between pins 3 and 4 of IC1, and breaking the connection between pin 4 of IC1 and pin 4 of IC2.*

*Finally, if you use common-cathode displays, connect pins 6 of **IC5** and **IC6** to ground instead of to +5 V. Else, the numbers will appear inverted on the readout.*

Realising the relative complexity of all these modifications we thought it best to reprint the complete circuit diagram of the frequency meter, hopefully without mistakes this time! Having made the modifications, Mr. Capel informs us, his circuit worked flawlessly.

Magnetic-Field Meter

960100

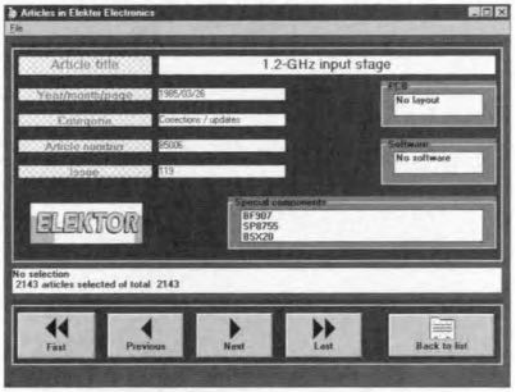
The effective length of the solder pins used to make the coil former is 7.5 mm. The nearest SWG equivalent for 0.2 mm diameter enamelled copper wire is no. 36.

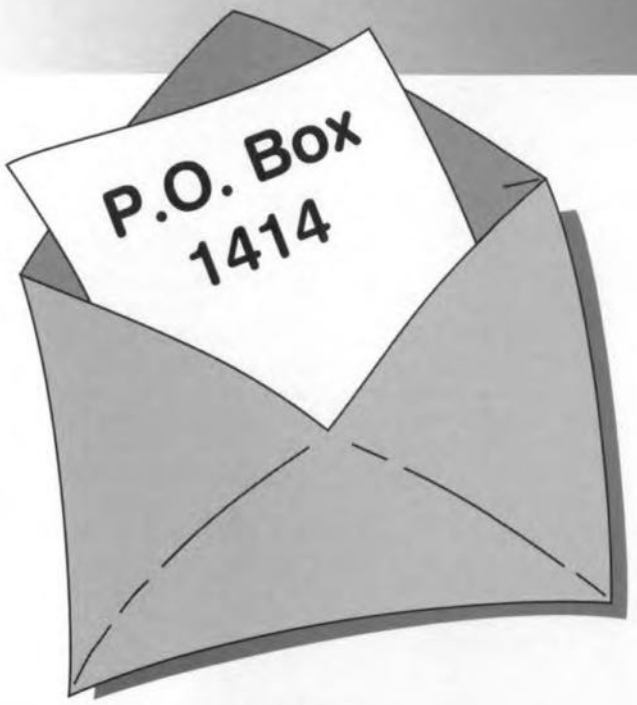
New Item Tracer

Every day, a fair number of readers contact us asking when a particular article was published. "Did you ever do a bat detector?" "Where was that article on the U24-something again?" "I want to obtain all articles covering the Centronics port, can you give me an overview?"

*You can easily answer these questions yourself if you use the latest version of our **Item Tracer**, which is now available through our Readers Services. The Item Tracer is a Windows program containing an electronic contents overview of all our articles published between 1985 and 1996. You can use search keys like (part of) title, category, PCB number, article number, software number, etc. The Item Tracer also provides useful references to all published corrections and updates.*

The normal price of the Item Tracer 1985-1996 is £11.75 (US$19), but subscribers pay only £10 (US$16). The order code is 966006-1.





underlines on cd-rom

Dear Editor—I was surprised to note on the CD-ROM with winning programs of the software competition that all hyphens in the file names have been altered into underlines.(US: underscores). I refer in particular to the programmable remote control – MiniZap – to be found in directory NL\21.

The underlining does not pose a problem as far as the EXE files and the device drivers are concerned, but when XP-ZAP.EXE (altered into XP_ZAP.EXE) is started, the program looks for ini-file XP-ZAP.EXE, which it cannot find because this is now called XP_ZAP.INI. This means that the preferred settings of the user can no longer be loaded.

lit is not clear to me why this alteration was found necessary: I have never had problems with hyphens in file name, and it occurred to me that it would be useful to other readers to write to you. Users may note that the problems can be resolved easily by renaming the file name XP_ZAP.INI to XP-ZAP.INI.

M.M.

There are several CD-ROM formats; most PCs use the ISO-9660 standard. In this standard a number of ASCII symbols cannot be used in file names and one of these is the hyphen. For the production of our CD-ROMs ISO-9660 is used and this means that during the writing of the disk all hyphens are automatically converted into underlines. It is possible to circumvent this conversion (and this is, indeed, often done nowadays), but the disk would then no longer meet the standard. As you have already correctly pointed out, the remedy is simple: copy all files to a directory on the hard disk and replace the underlines in the file names by a hyphen. All will then work 'normally' again.

remote control

(April 1989)

Dear Editor—I have been looking for the Elektor Electronics issue which contained a project for a remote control extension. This is for use to control a VCR or TV receiver from a room adjacent to the one where the equipment is located.

P.H.

This project appeared in our April 1989 issue (p. 31). Since this is obsolescent, a new design for such an extension will be published in a future issue of this magazine.

motor controller

(February 1997)

Dear Editor—Your February 1997 issue contains an article describing a 'Motor controller for R/C models'.

The data for this circuit state that the controller is suitable for operation from supply voltages of 6–10 V. My question is: can the controller be used with a 12 V supply or do I have to alter a few components?

P.K.

No problem: the controller can work from 12 V. The processor, IC_1, operates from a regulated +5 V line, irrespective of the input supply voltage. Nevertheless, we recommend an absolute limit of 15 V. What is more important, however, is the current drawn by the motor: this must not exceed 40 A to ensure that the ratings of the MOSFETs are not exceeded.

magnetic field meter

(January 1997)

Dear Editor—When I connect the 'Magnetic-field meter' to my computer and start the associated program, I get the message when using DOS: 'interface not found'; when I use Windows the program does not start at all. I have carefully checked the completed board but cannot find anything wrong.

C.S.

We have checked your board with several of our computers and have experienced no problems: all worked well. It is probable that the problem lies in the printer connection of your computer. In modern computers, a choice may be made in the BIOS between standard mode, EPP mode and ECP mode for the printer port. In many mother boards the standard setting is EPP+ECP. When in that case the ECP or the EPP+ECP mode is selected, the circuit does not work. You will therefore have to check the BIOS settings and make sure that the EPP mode for the printer port is selected.

pc sound card as af analyser

(March 1996)

Dear Editor—The 'PC soundcard as AF analyser' uses the sound card present in the computer. To what degree does the quality of this card affect the test results?

I have a simple, inexpensive soundcard and have been advised that the output of this card contains steep-skirted filters to suppress any interference causes by the PC power supply or the card itself. This is manifested by the fact that when I use a tone generator program the peak values of the high-frequency signals start dropping from about 6 kHz. Are such filters also used on a card like the Soundblaster 16?

On asking several dealers trading in such cards, I could not get the right information because the specifications supplied with the card do not include this. Cards from Terradec, I understand, are superior as regards the audio specification to SB16 cards from Creative Labs. Can you give me any advice as to which to obtain?

The second question I have is: what can be done to suppress interference and noise signals inside the computer? For instance, does whole or partial screening of the soundcard make sense?

J.W.

There are, indeed, appreciable differences in quality between the various soundcards on the market. Inexpensive soundcards often have a poor frequency response which rolls off very steeply at both sides of the band. If reliable measurements are to be carried out, the soundcard used must have a wide, linear frequency response and, if at all affordable, low distortion. We cannot advise on which to buy, but suggest that you glean the tests on soundcards that are carried out from time to time by various computer magazines.

Soundblaster cards are generally of good to very good quality and, therefore, normally a good buy. What is important when such a card is used in combination with test software is the protocol by which the card provides its drive power. Many Soundblaster-compatible cards simulate (in DOS) an old 8-bit Soundblaster card. Test software running under DOS that require 16-bit precision cannot cope with that. So, make sure that you use a genuine Soundblaster card (or an OEM product with a Vibra chip).

Screening the card is a good means of excluding external stray interference and noise. It does not reduce such interference on the supply lines, however. These can only be avoided by locating the card outside the computer and give it its own power supply.

CORRECTIONS & UPDATES

Motor Controller for R/C models
(February 1997 - 960095)

The components list printed on page 18 should be amended to read
C3,C5 = 100nF, SMD
C4 = 10nF, SMD
C6 = 47µF 10V SMD
IC2 = L4940V5

PIC Controlled Home Alarm System
(April 1997 - 970022)

All PICs in the first batch we supplied to individual readers and kit dealers contain an incorrect oscillator code word which totally disables the device. These PICs are marked by the total absence of oscillator activity. Readers experiencing problems are requested to return the faulty PIC (order code 976501-1) to us for a free replacement. Please enclose a short note stating your name and return address, and ensure proper packaging.

Magnetic-Field Meter
(960100 - January 1997)

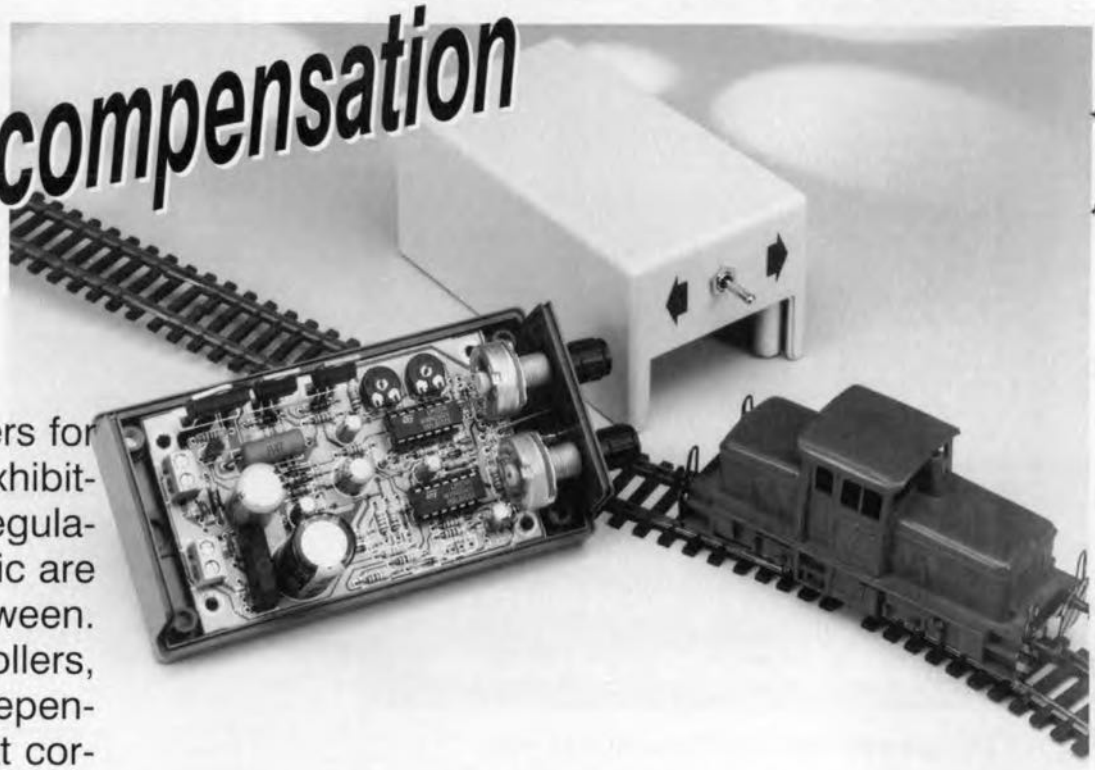
In the circuit diagram on page 28, R12 is incorrectly shown as a 10 kΩ resistor. The correct value is 22 kΩ 1%, as stated in the components list.

4-Channel Logic Analyser
(970042 - May 1997)

The program shown in Figure 3 has been tested under QBASIC 1.1 and QuickBASIC 4.5, not GW-BASIC as mentioned in the article. Because QuickBASIC is a compiler, it will produce a faster executable program than QBASIC. The highest signal speed the program can handle is mainly determined by the speed of the PC. Using a 486DX33 the maximum input signal frequency will be about 75 Hz under QBASIC 1.1, or about 20 Hz in 4-channel mode. The respective values for a Pentium 150 PC are about 250 Hz and 75 Hz. The use of QuickBASIC 4.5 will result in values which are about 6 times higher. The program will only work in a true DOS environment, i.e., not in a DOS box produced by Windows 95.
Finally, to obtain a calibrated timebase, simply apply a clock signal with a known frequency to one of the channels.

Speed regulator for model trains

with load compensation



Speed controllers for model trains exhibiting a perfect regulation characteristic are few and far between. With most controllers, speed is load-dependent. Attempts at correcting this annoying circumstance often cause loss of pull, which is, of course, undesirable. The circuit described here uses the reverse electromotive force (emf) generated by the locomotive motor as a correction signal for a pulsewidth control system. In practice, this method results in an appreciable compensation of load variations, so that the speed of the locomotive remains reasonably constant.

Design by N. de Graaf

If you want to make a model train run at a virtually constant speed, you need to find a signal that contains speed information, allowing that to be used as a reference for a control system.

Such a signal exists in the form of the reverse emf produced by the loco motor. As you probably know, a running electric motor also functions as a voltage generator. The 'reverse emf' is independent of the applied voltage and the load, and is determined by the engine speed only. By introducing the reverse emf in a control loop, it should become fairly easy to construct a regulator which keeps the speed of the model train virtually constant under all conditions, that is, independent of the weight load and the steepness of the track.

The above proposition raises the question how to measure the reverse emf, in other words, how to separate this voltage from the voltage supplied by the speed control. The answer is fairly simple: power the model train with a pulsating voltage. That allows you to carry out reverse-emf voltage measurements in the pauses between the supply voltage pulses.

EMF-CONTROLLED PULSEWIDTH

Because the complete circuit diagram of the model train speed regulator contains a couple of (essential) elements that may somewhat obscure the actual operation, the crucial ingredients have been brought together is a simplified block diagram which is presented in **Figure 1**.

Essentially, you are looking at a pulsewidth controlled motor speed regulator in which the width of the pulses is determined by the speed-dependent emf produced by the motor. If the motor speed (and, consequently, the reverse emf) is too low, the pulsewidth is increased, causing the motor speed to increase. If, on the other hand, the speed is too high, the pulses become smaller.

First, a triangular (ramp) voltage is generated, which is subsequently compared with a control voltage in a comparator (IC1d). The output of the comparator supplies a rectangular voltage. The width of the pulses is directly dependent on the level of the control voltage, which, in turn, is determined by two things: the position of the 'speed' potentiometer, P1, and the level of the emf voltage measured during the pulse pauses. Comparator IC1b compares the emf voltage with the voltage supplied by pot P1. If the emf (i.e., the motor speed) is too low, then the output signal of IC1b (i.e., the control voltage) is 'low', and vice versa. This type of control results in the

above mentioned width correction on the pulses supplied by IC1d.

Two details must not go unmentioned here. Firstly, this type of regulation system obviously requires some time to be able to respond properly; after all, the time constant of the integrator connected in series with IC1b is a (small) source of trouble. If the integration time is made too short, the system will also respond to very small speed changes, causing jerky movement of the train. If, on the other hand, the time is too long, the control system will not respond properly if the train climbs a sloping track. The upshot is that a compromise has to be found. Furthermore, the drawing in Figure 1 shows a second potentiometer. This one has nothing to do with the regulator as such, but acts as an adjustable integrator, together with the capacitor that follows it. The purpose of this integrator is to enable a fairly realistic acceleration and deceleration behaviour to be achieved for the model train.

Finally, we should mention that the numbers shown in Figure 1 correspond with those in the final circuit diagram.

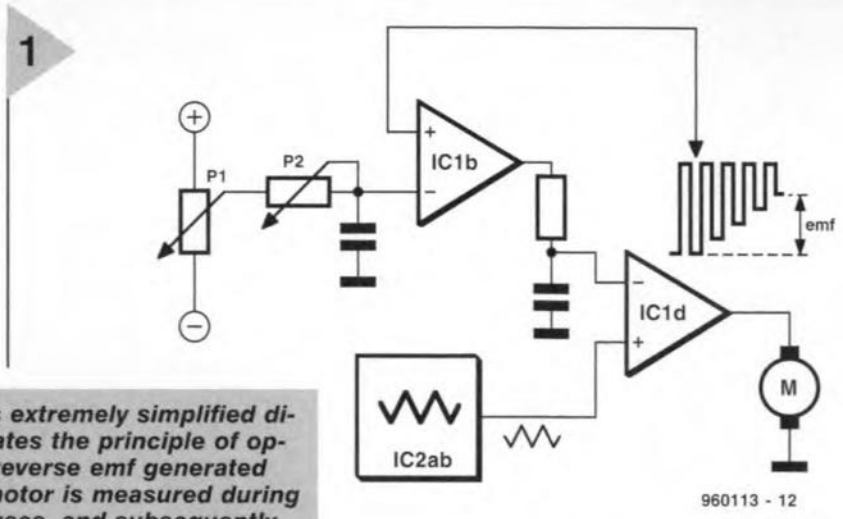


Figure 1. This extremely simplified diagram illustrates the principle of operation. The reverse emf generated by the loco motor is measured during the pulse pauses, and subsequently used as a control signal for adjusting the pulsewidth.

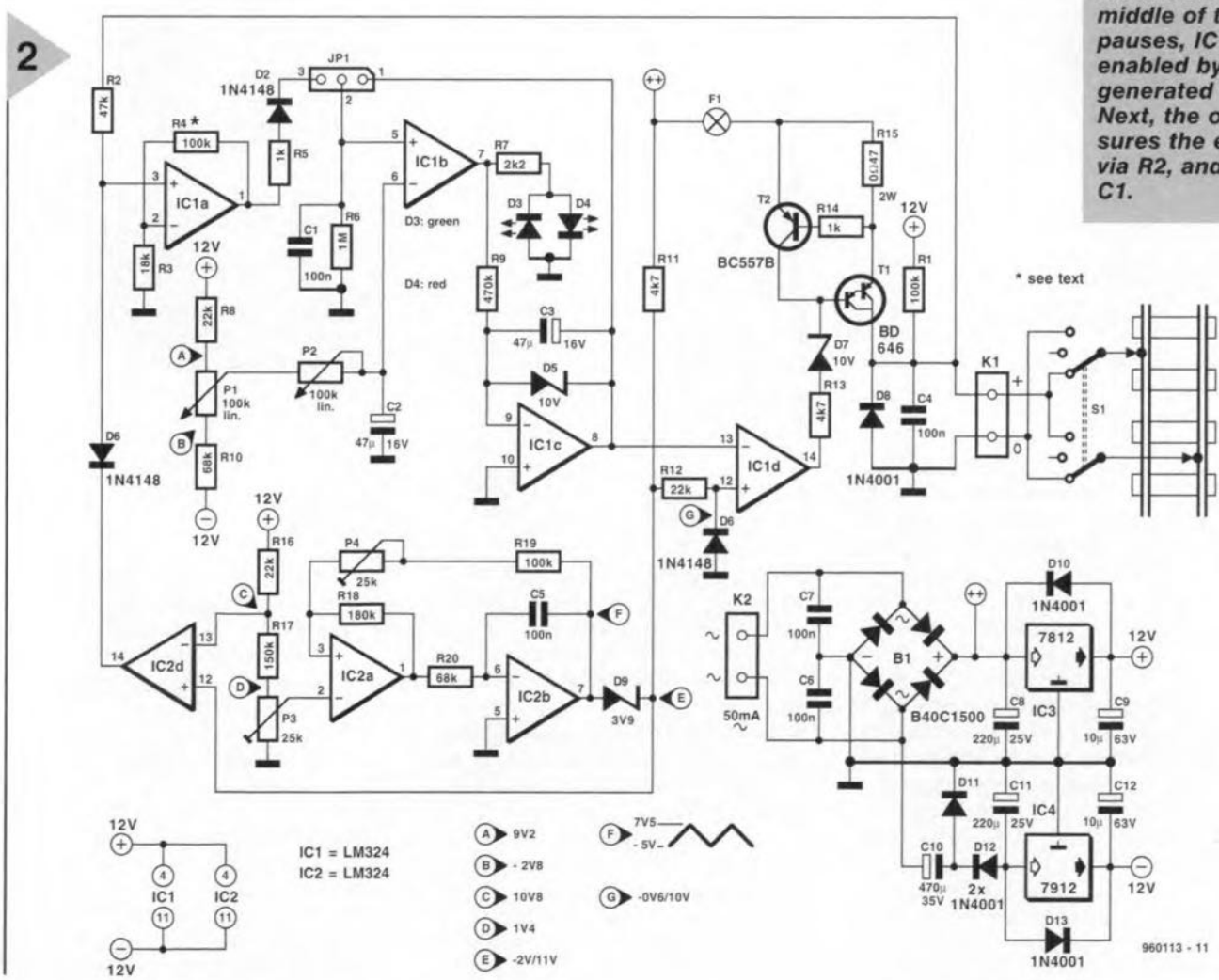
PRACTICAL REALISATION

The detailed circuit diagram of the speed regulator for model trains is shown in **Figure 2**. The general structure of the circuit as shown in Figure 1 is easily recognized in the schematic, although quite a lot has been added, of course.

The combination of Schmitt trigger IC2a and integrator IC2b functions as a triangular-wave (ramp) generator which operates at about 50 Hz. The level of the ramp voltage may be adjusted within certain limits with the aid of preset P4, while P3 allows the dc level to be shifted to a small extent. Since the settings of P3 and P4 are not particularly critical to achieve proper operation of the following part of the circuit, it is usually sufficient to set these presets to mid-travel.

As already mentioned, the ramp voltage is compared to a certain direct

Figure 2. One of the most interesting details of the circuit diagram is the practical realisation of the emf measurement. In the middle of the pulse pauses, IC1a is briefly enabled by the pulses generated by IC2d. Next, the opamp measures the emf applied via R2, and stores it in C1.



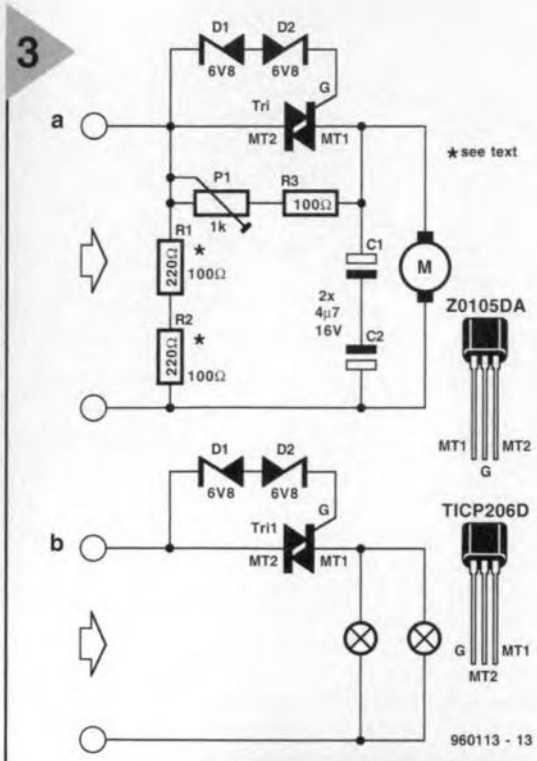


Figure 3a. Individual sensitivity control on all locos may be achieved by equipping them with this little circuit.

Figure 3b. This auxiliary circuit ensures that the train lighting has no effect on the control characteristic.

voltage (the control voltage). This comparison takes place in IC1d. The level of the control voltage is dependent on the width of the output pulses supplied by IC1d. The circuit is designed such that the pulsewidth can not exceed 90%. Via darlington transistor T1, the (inverted) pulse signal arrives at output connector K1. After the 'intervention' of toggle switch S1, the pulsating voltage is used to control the train (as regards speed, of course!)

Next, the reverse-emf measurement. The operation of this part of the circuit was not mentioned yet with the discussion of Figure 1. The starting point is, of course, the voltage available on output connector K1. As you can see from the circuit diagram, this voltage is fed back to opamp IC1a via resistor R2. As explained earlier on, the measurement of the reverse-emf is only possible and allowed to take place during the pauses of the track voltage. This is accomplished by IC2d superimposing short pulses on the peaks of the ramp voltage. These pulses coincide with the 'off' time of transistor T1, ensuring that only the reverse-emf of the loco motor is present on K1 during this short interval. During these pulses, the input of IC1a is briefly enabled via diode D1. The opamp then responds by amplifying the emf applied via R2, and storing it in capacitor C1. In this setup, diode D2 prevents the capacitor from discharging.

Next, comparator IC1b compares the voltage across C1 (which is proportional with the reverse-emf) with the voltage supplied by the speed control pot, P1, and adjusts its output voltage until the two voltages are equal. This event is indicated by LEDs D3 and D4 lighting simultaneously. If the loco speed is too low, only D3 lights; if it is too high, only D4 lights. Next, the output voltage of IC1b is smoothed by the integrator built around IC1c, and, finally, applied to the negative input of comparator IC1d as the pulsewidth determining control signal.

FINISHING TOUCHES

The above description of the operation of the speed controller covers most of the circuit. A few details should be added, however. P2 and C2 together form the previously mentioned network which enables 'slow-motion' accelerating and braking of the model train. Jumper JP1 has been added to offer the user the choice between riding with or without emf compensation. In the first case (compensation on), JP1 is set to position 2-3, in the second case (compensation off), set it to position 2-1.

Transistor T2 acts as a short-circuit protection. When the track voltage is short-circuited for whatever reason (for example, a train derailment), the increased voltage drop across R15 will cause transistor T2 to start conducting, thereby limiting the current through T1 to about 1.5 A. Although that is still sufficient to make T1 run pretty hot, the darlington does not have to stand the maltreatment for more than a few seconds as auto-resetting polyswitch F1 will provide a total disconnect. Fortunately, most mishaps with derailments may be solved so quickly that it is not necessary for F1 to act.

Components R1 and C4 at the output of the speed regulator determine the behaviour of the circuit when there is no train on the track, or a bad contact exist between the rails and the train motor. In either case, no reverse emf would be measured, prompting the regulator to switch to 'full steam ahead'. The resistor and the capacitor, however, provide some averaging of the rail voltage, resulting in an average pulsewidth in case of a bad contact or no train on the rails.

A final detail concerns the power supply. Connector K2 accepts an **alternating voltage** between 12 V and 16 V. After rectification (B1) and smoothing (C8), this voltage is used directly for the train motor (connection marked '++'). The symmetrical 12-V supply voltage for the opamps is created with the aid of two three-terminal voltage regulators (IC3 and IC4). For the negative supply, use is made of an auxiliary circuit consisting of C10, D11 and D12. This is necessary be-

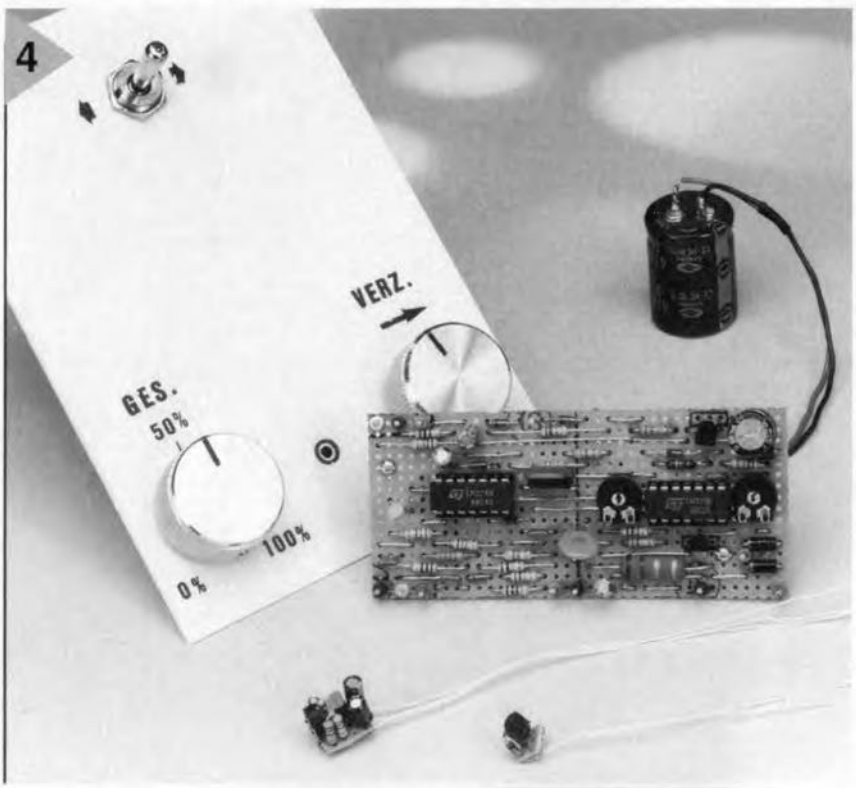


Figure 4. This prototype built up by the author is slightly different from the final version.

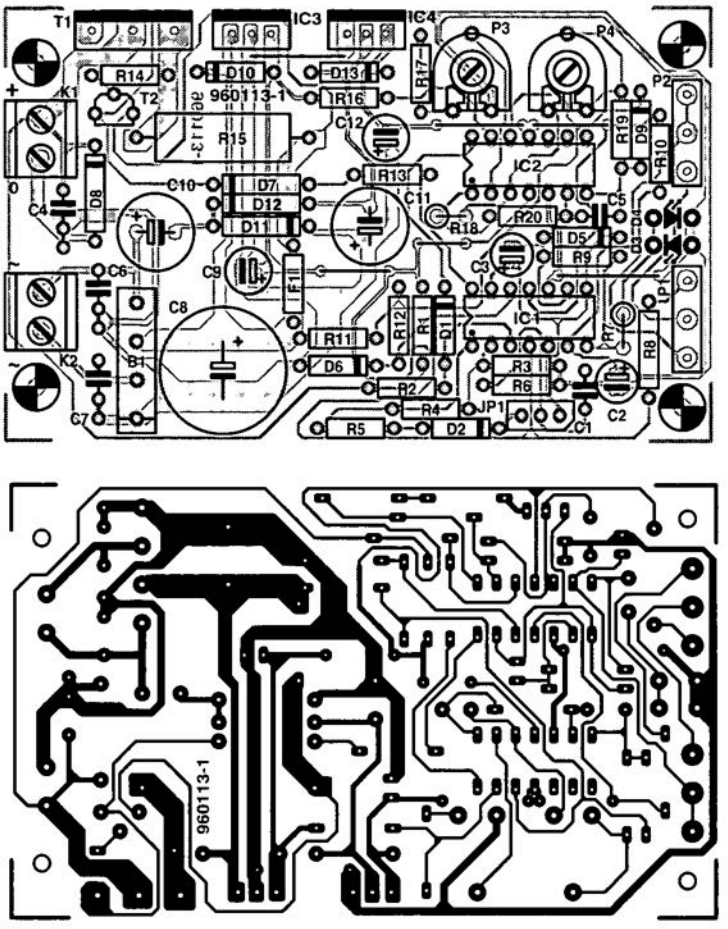


Figure 5. Track layout and component mounting plan of the PCB designed for the speed controller (board available ready made through the Readers Services).

COMPONENTS LIST

Resistors:
R1,R19 = 100kΩ
R2 = 47kΩ
R3 = 18kΩ
R4 = 100kΩ *
R5,R14 = 1kΩ
R6 = 1MΩ
R7 = 2kΩ2
R8,R12,R16 = 22kΩ
R9 = 470kΩ
R10,R20 = 68kΩ
R11,R13 = 4kΩ7
R15 = 0Ω47 2W
R17 = 150kΩ
R18 = 180kΩ
P1,P2 = 100kΩ linear
P3,P4 = 25kΩ preset

Capacitors:
C1,C5 = 100nF, pitch 5mm
C2,C3 = 47µF 16V radial
C4,C6,C7 = 100nF
C8 = 2200µF 25V radial
C9,C12 = 10µF 63V radial
C10 = 470µF 35V radial
C11 = 220µF 25V radial

Semiconductors:
B1 = B40C1500
D1,D2,D6 = 1N4148
D3 = LED green
D4 = LED red
D5,D7 = 10V zener 400mW
D8,D10-D13 = 1N4001
D9 = 3.9 V zener 400mW
T1 = BD646 (or equivalent)
T2 = BC557B
IC1,IC2 = LM324
IC3 = 7812
IC4 = 7912

Miscellaneous:
JP1 = jumper 3-pin
F1 = Polyswitch 1.1 A (Conrad/Farnell).
K1,K2 = PCB terminal block, pitch 5mm.
S1 = double-pole switch w. centre-off position, e.g. MS500C (Miyama).
Case: e.g. Bopla type E430BB (120x65x40mm).
PCB, order code 960113-1 (see Readers Services page).
Option: triac Z0105DA, 1A, 5mA gate current (SGS-Thomson, Farnell, RS Components)

*) see text

cause we want to be able to use double-phase rectification on the positive motor voltage.

ADAPTATIONS

As mentioned earlier on, the behaviour of the motor is determined to a considerable degree by the integrator's time constant. To enable he regulator to respond rapidly to changing load conditions, it is desirable to keep the value of capacitor C3 as small as possible. Unfortunately, a too small value will cause the locomotive to run erratically. In this respect, two further factors are the quality of the track and that of the locomotives. However, a good compromise may always be found by experimenting with the value of C3.

Experimenting is also the best way to establish the optimum value of the 'averaging' capacitor, C4, and for C2, too, which is part of the delay network. By the way, when operating the speed control, P1, do take into account that the pot has a small 'dead range' at the start of its travel. The loco does not receive a motor voltage until the wiper voltage is positive. This is necessary because otherwise the loco would never stop, but spend an infinitely long time decelerating. Fortunately, the small 'dead range' need not be a problem if you use a specially prepared dial for the potentiometer.

Not all locos supply the same reverse emf. If desired, the sensitivity of the circuit may be adapted with the aid of R4 (a higher value results in higher sensitivity). If several locos are controlled simultaneously, they will travel at different speeds at one and the same setting of P1. If you are bothered by this, install the circuit shown in **Figure 3a** in every locomotive. The crux of this circuit is that the track voltage is passed by the triac (Tri), while the reverse emf is blocked. Consequently, the emf on the rails is determined by preset P1 only. In this way, each loco may be individually adjusted to make it run at its maximum speed with pot P1 on the speed control set to maximum. Bipolar electrolytic capacitor C1/C2 prevents the triac from being erroneously triggered by emf surges during the pulse pauses.

Those of you wishing to perfect the system even further may want to install the circuit shown in **Figure 3b** as well. This add-on ensures that the train lighting does not load the emf, thus preventing the lights from affecting the speed of the train. An additional advantage of this triac-based lights control is that the free-running motor is no longer loaded, thereby improving the deceleration behaviour of the train.

An SGS-Thomson triac type Z0105DA may be used in the circuits of Figures 3a and 3b. The maximum current of this device is about 1 A, and the required gate current, 5 mA. Other small triacs capable of working at a trigger current of 5 mA may also be used (for instance, the Texas Instruments TICP206D).

6

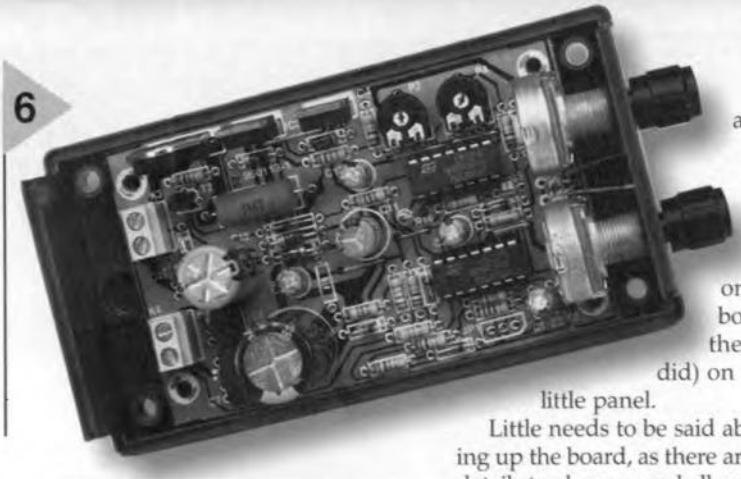


Figure 6. The potentiometers may be fitted directly on to the board. As a matter of course, the LEDs have to be fitted such that they are visible from the outside of the enclosure used to house the speed regulator.

are free to mount these controls and indicators on the board, or (as the author did) on a separate little panel.

Little needs to be said about building up the board, as there are no tricky details to observe, and all necessary information may be found in the parts list and the component overlay printed on the board.

Components IC3, IC4 and T1 develop hardly any heat during normal use and consequently do not need heat-sinks.

The finished printed circuit board is shown in **Figure 6**. Thanks to its modest size, the board, including potentiometers, fits in a Bopla type E430BB plastic case (size approx. 120 × 65 × 40 mm). The 'train direction' switch is, of course, mounted as an external component.

7

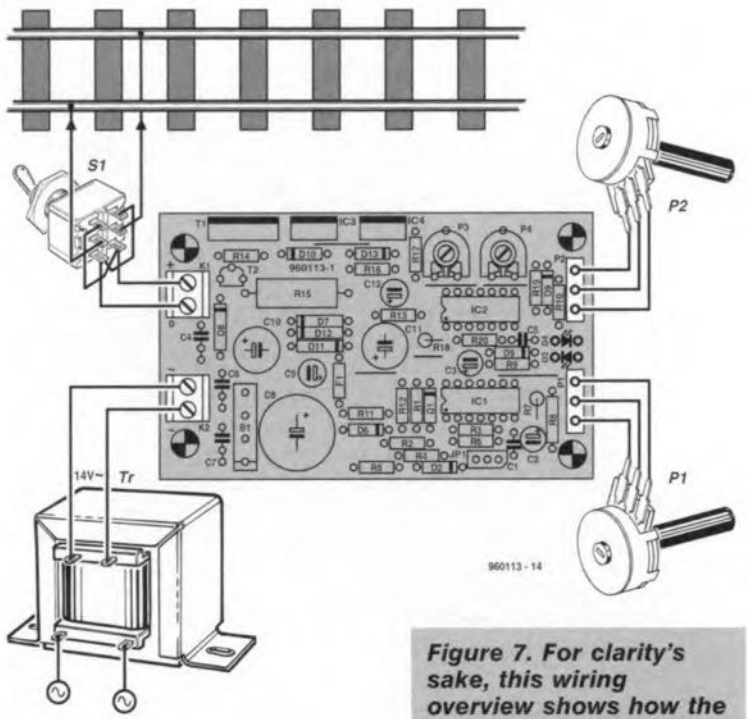


Figure 7. For clarity's sake, this wiring overview shows how the external elements are connected to the board.

Construction

The prototype of the model train speed regulator as built by the author is shown in **Figure 4**. In this version, the two potentiometers and the direction switch, S1, were fitted on a separate control panel.

Because the prototype was enhanced and fine-tuned in a number of respects, a new printed circuit board was designed for it in the *Elektor Electronics* laboratory. The final artwork is shown in **Figure 5**. The PCB has a clear layout. This board is available ready-made through our Readers Services. The input and output connector are located at one side, and the control elements P1, P2, D3 and D4, at the other. As far as we are concerned, you

Commissioning

If you forget to fit jumper JP1 in one of the previously mentioned positions, the circuit will not work at all. Once the complete board has been built up and checked, the alternating (transformer) voltage may be connected to K2. Next, it is wise to check the presence of the two regulated voltages (plus and minus 12 V).

For the sake of completeness, **Figure 7** once again indicates the connections of the external elements to the board.

As already mentioned, the adjustment of P3 and P4 is not particularly critical. In most cases, you may simply leave these presets at mid-travel. Having no oscilloscope available it is fairly difficult to check if there are pulses at pin 14 of IC2d. None the less, a reasonable adjustment may also be obtained by adjusting P3 and/or P4 until a voltage between −10 V and −11 V is measured with a DMM connected to pin 14.

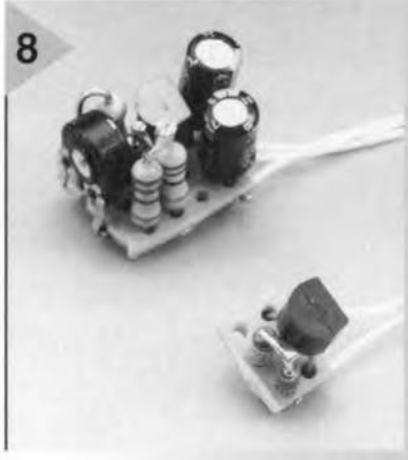
To enable you to check that the circuit works properly, a couple of measurement values are indicated in the circuit diagram. These values may be verified with the aid of a multimeter. The ramp voltage at the output of IC2b has peak levels of −5 V and +7.5 V, and an average level of 1.25 V, which is easily verified using your multimeter. Without a locomotive, the **alternating** current consumption of the circuit is about 50 mA.

Tinkering

The auxiliary circuits shown in Figures 3a and 3b have no matching PCBs because everything will depend on the available space in the locomotive(s). In most cases, space will be at a premium, so that these circuits are best built 'in the air' or on a small piece of stripboard. In any case, patience and a steady hand will be invaluable. The results of the author's efforts at building these miniature circuits are shown in **Figure 8**. (960113)

Figure 8. The auxiliary circuits of Figure 3a and 3b have to kept as small as possible because they are fitted inside the locomotive.

8



APPLICATION NOTE

electronic potentiometer Type DS1669

Parameters					
		Min.	Typ.	Max.	Unit
Operating-voltage range		4,5		8	V
Logic 1		2,4			V
Logic 0				0,8	V
Current drain			1	2	mA
Resistance tolerance				±20	%
Relative resistance linearity				±0,3	LSB
Current through resistance				1	mA
Wiper resistance				1	kΩ
–3 dB frequency limit	(10 kΩ)		1		MHz
	(50 kΩ)		200		kHz
	(100 kΩ)		100		kHz
Pulse-width (digital input)		1			µs
Pulse width (switch input)		1			ms
Auto repeat period			1		s
Repeat time			100		ms
Power-up time				10	µs
Temperature coefficient				±800	ppm/°C
Ambient temperature range		0		+70	°C

Variable resistors normally called potentiometers are used for setting sound levels, colour saturations, brightnesses, and contrasts to name but a few. If such a resistor is to be controlled remotely, it has to be an electronic type such as the Type DS1669 from Dallas Semiconductors. The resistance of this device is controlled in steps by pulses. Moreover, the position of its wiper is stored in an EEPROM until the next time its controller is switched on.

Electronically-controlled variable resistance Type DS1669 from Dallas Semiconductors is constructed as an integrated circuit in an 8-pin DIP or SMD case—see **Figure 1**. It consists of a resistance tapped at 64 positions separated in equal steps, a 64:1 multiplexer, control circuits and an EEPROM. The 64 outputs of the resistance 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 setting of the resistance is retained.

The control circuits are driven via (1) an up/down switch, (2) two down and up switches or (3) a microcontroller. In case (1), the imaginary wiper moves towards one end of the resistance; when that is reached, it reverses direction and moves towards the other end. This also happens when the circuits are controlled by pulses emanating from a microcontroller. Note that the duration of these pulses may be much shorter than those derived from the switch.

The direction of the imaginary wiper also changes when the interval between two pulses is longer than one second.

The device may also be controlled with two switches. In this case, when the imaginary wiper has reached one end of the resistance through the operation of one switch, the other switch must be operated to make the wiper reverse direction.

Whether one or two switches are used, there is an auto-repeat function which ensures that when a switch is held down permanently the imaginary wiper moves continuously from one tap on the resistance to the next.

As mentioned before, the device is available in either a DIP case—Type DS1669— or an SMD case (SO8)—Type DS1669S. Both versions may be obtained with one of three resistance values: 10 kΩ, 50 kΩ or 100 kΩ. This is identified by adding the number 10, 50 or 100, as the case may be, to the type coding.

DESCRIPTION

In Figure 1, the resistance track, *R*, is terminated into pins 4 (RL = R low) and 1 (RH = R high). As stated before, it has 64 taps that are connected to a 64:1 multiplexer, whose output is available at pin 6, RW (=R wiper). The multiplexer is linked to an EEPROM which retains the last multiplexer setting even when the supply voltage to the device is switched off.

The device is controlled via one of three inputs: (1) DC (down contact); (2) UC (up contact); and (3) D (microcontroller).

In case (1), a single (push-button) switch is used; when this is pressed the (imaginary) wiper (RW) moves towards RL.

In case (2), a single (push-button) switch is used; when this is pressed the (imaginary) wiper (RW) moves towards RH.

The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

The D input for microcontrollers is a digital input which is internally debounced.

All three inputs have an internal 100 kΩ pull-up resistor, so that all that is required is to connect switches or microcontroller as relevant.

When in case (1) the switch is pressed, the DC input is linked to the positive supply line. The DS1669 'recognizes' this situation.

So as not to reduce the life of the EEPROM by unnecessary write operations, it is written to only after power-up when the wiper position has changed and a waiting period of two seconds has elapsed. In practice, a new wiper position is written into the EEPROM when the new position differs more than 12.5 per cent or eight steps from the previous one. The EEPROM has a life of 80,000 write operations. According to the manufacturers, should some of its cells become defunct, the potentiometer function would be retained.

be complied with.

(1) The potentials at pins 1, 4 and 6 must not be lower or higher than the supply voltage.

(2) If the operating-voltage range of the DS1669 is too small, the device should be used, if possible, floating. That is, if, for instance, the device is to be used as a potential divider for a 1 V_{pp} signal which has no d.c. component, a supply voltage of at least ±3 V is required. The switches at DC and UC must then switch to –V.

The pulse from the switch(es) is debounced in the DS1669 only when the relevant switch has been closed for not shorter than 1 ms and not longer than one second. In case of the latter, the auto repeat function begins to operate at a rate of 100 ms. This means that with the function on it takes the wiper seven seconds to move from RL to RH or vice versa.

A similar situation as just described pertains when the device is controlled via pulses at pin 3, except that the minimum pulse duration is one microsecond instead of one millisecond.

1

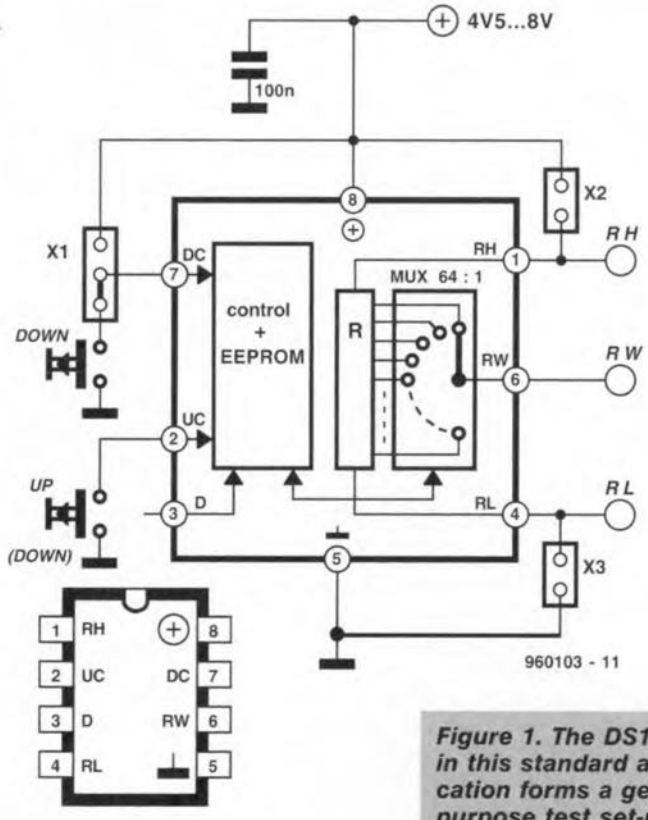


Figure 1. The DS1669 in this standard application forms a general-purpose test set-up.

APPLICATIONS

The standard application shown in Figure 1 is a general-purpose test set-up. Jumper X_1 should be set to the upper position for one-switch operation and to the lower (as shown) for two-switch operation.

Jumpers X_2 and X_3 link pins 1 and 4 to the supply lines. The potential at RW is a voltage whose level changes in 64 steps. If the device is used in a dissimilar arrangement in which the potentials at pins 1 and 4 are different, or are in the signal path, the following aspects must

A sister device for operation from a 3–8 V supply is also available under Type No. DS1869. The resistance values of this are also 10 kΩ, 50 kΩ and 100 kΩ.

[960103]

Dallas Semiconductor Corp.
Unit 26, West Midlands Freeport
Birmingham
West Midlands B26 3QD
Telephone 0121 782 2959
Fax 0121 782 2156

In passing ...

Paranormal (audio) electronics

Examples of paranormal electronics could be found in hobby magazines long before today's New Age and Esoterics hype. In 1977, the German version of Elektor Electronics was entirely devoted to this theme, which soared to immense popularity at the time thanks to a reputedly supernaturally gifted cutlery bender from Israel called Uri Geller. Soon, Mr. Geller was exposed as an illusionist, and he is currently working as a management consultant. The only phenomenon that could be called paranormal in the whole uproar was, at the most, that a renowned research establishment like the Stanford Research Institute failed to expose Uri Geller's tricks. Science critics would, of course, object that that would not be paranormal, but quite normal...

Back to electronics and the paranormal. As a matter of course, Elektor did not, at the time, engage in paranormal events, concentrating on circuits for personal experiments only, say, a high-voltage generator for discharges required for Kirlian photography, or an AF generator for the generation of low-frequency electrical fields. If and how the operation of these 'paranormal' circuits is to be interpreted is left to the user. At the time, however, nobody got the idea of applying this attitude to audio circuits. Eventually, we believed in the relation between technological progress and better sound. The ideal was an amplifier capable of amplifying an input signal faithfully, if possible without distortion or noise. At the beginning of the eighties, the aim appeared to be almost reached. The introduction of digital recording of sound, and that of the CD took us one step further: a sound could be conveyed in almost genuine form from the concert-hall microphone right up to the loudspeakers in our living rooms. Compared with the many inadequacies of the analogue record player, the CD player was virtually free of audible differences. Maybe this very circumstance helped to cause the change from irrational right up to paranormal in audio electronics. Actually, it all started with the rebirth of valve technology. Suddenly, the cold and sterile sound of digital silicon ICs could not compete with the snug warmth provided by glowing valve filaments. Even in studios, sound signals were 'preheated' with valve-based high-end distortion units before being burned on to silver discs. Although the operation and effect of distortion are explicable on the basis of known phenomena from psycho-acoustics, things did not stop there. Leafing through hi-fi magazines these days, you are bound to be confronted with phenomena which are paranormal because they can not be explained by physics. Let's see: a CD taken from the fridge sounds fresher than one from the CD rack (so why aren't there any deep-freeze CD racks yet?). A CD drive with belt drive sounds more agreeable, a digital 1:1 copy 'flatter', and the sound tip of the year is a CD drive suspended from four springs. In that case, a magnetizer is, of course, required for the CD because it gives the sound a magical quality. A similar effect, we are informed, is brought about by an internally mounted blue LED which pacifies the otherwise pretty nervous laser beam. Even if we did not mention loudspeaker cables, cinch cables and non-matching coax cables: nothing is impossible.

That Elektor Electronics is unable to keep up with all this is not caused by lack of imagination, but by the fact that this post-modern dissemination of technically embellished superstition does not fit so well in our concept.

E. Krempelsauer

p.s. the battery-operated audio preamp described in this issue is, by the way, an exception. The thing has clear advantages. Whether or not the expense for it is worthwhile, is left to the user to find out.



prize-winning programs

results of our Software for Electronics Competition 1996-97

The software competition we organized and published in last year's July/August issue has resulted in some very attractive programs which we are pleased to be able to present to our readers. In this issue we start with the winners of the five international prizes.

All software presented here is available on a CD-ROM called 'Software for Electronics 1996-97' which contains more than 80 interesting programs. Although the fact that the computer is now an important tool among electronics enthusiasts was brought home to us by the superb competition entries we received after the competition announcement, we did not expect to see such beautiful programs.

All programs with associated documentation (if any), circuit diagrams, PCB layouts and source codes (again, if supplied by the author) have been collected and transferred to a CD-ROM, so that all readers may benefit from the competition results. The five programs which were awarded international prizes are briefly described on the following pages.



International First Prize

Educational PLC Simulation V 4.8

970030-11

The 'Educational PLC Simulation' (EPLCS) program simulates the use and operation of a real PLC using just a PC. PLCs are digital electronic devices which are used as control units in automated systems. The software is useful for anyone wanting to learn about programming a PLC, and realising an actual PLC device. Unfortunately, the cost of a real PLC will be prohibitive to many schools and colleges. Moreover, a PLC should be connected to input and output devices, forcing the user to build an appropriate scale model to test the required environment. Both problems may be solved at a stroke by creating a computer program which could run on a simple PC and would simulate the operation of a PLC in a virtual environment, closely resembling the actual situation.

Program by
Panayiotis Stassinopoulos

EPLCS is here to do just that with the aid of lively screens. It is ideal for educational usage, because most educational institutes have a number of PCs, allowing lecturers to teach PLC programming without having many PLCs. In the end, real PLCs could be used to teach advanced programming techniques.

The scope of *EPLCS* is to create many different environments, in which we should compose an application using the EPLCS's PLC. The program written by the user guides the EPLCS's PLC to read the inputs from a virtual environment, process them and modify the environment as required. In this way, a comprehensive simulation of the real automation system is achieved.

Over the past few years, in the field of Industrial Automation Systems, microprocessor-based systems have replaced control units based on conventional technology. PLCs are electronic digital devices which take control of automation. 'Educational PLC Simulation V4.8' performs a simulation of an application based on PLCs, offering a good start for someone who wants to work with PLCs.

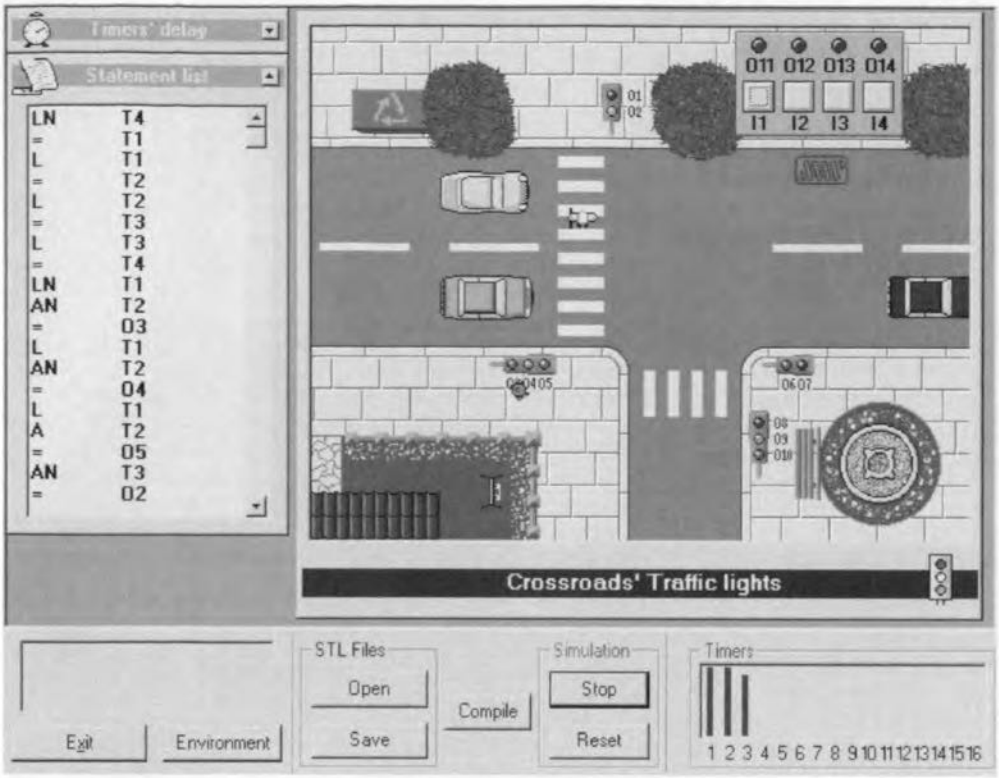
The program requirements are:
- a PC based on a 386 or later processor
- at least 4 MB RAM
- a graphics card supporting at least 256 colours (recommended resolution 800×600 in high-colour mode)
- hard disk requirements: less than 5 MB
- keyboard and mouse
- DOS 5.0 or later with Windows 3.1 or Windows 95

It is recommended to run the program under Windows 95, for many reasons. One of them is that the program has been written to comply with the GUI standards of Windows 95. The most important reason, however, is that the simulation is significantly faster and smoother than under Windows 3.1.

Whatever operating system is chosen, it is important to select 'Small fonts' (96 dpi) in the Display Settings (Control Panels).

The PLC simulated by *EPLCS* supports only digital inputs and outputs, and uses the **STL programming language**. The STL language is based on logical equations and Boolean algebra. To enable you to create the equations required to write an STL program, you should refer to the appropriate combinational or sequential logic method. All STL commands available in the program are explained in the documentation. The STL language includes an instruction set that processes addresses which contain the values of the PLC's inputs and outputs. A condensed overview of the addresses and the instruction set is given in the inset box.

The total size of the final source



code (Visual Basic and C++) was about 5,000 lines. The total size of the source files on the disk (including BMPs, icons, ...) was about 6 MB. Because of this huge size, only the most interesting source code blocks are provided on disk. They may be found in the file 'source.txt'.

An STL Program Example

We want to realise the following automation:
There are five buttons connected on PLC's addresses: I1, I2, I3, I4 and I5. When the user presses the buttons that required to satisfy the logic representation (I1+I2)·(I3+I4), the output O1 should be set and stay to logic '1' after a time delay. The output should be reset with the button connected at I5.
The appropriate STL program appears below.

STL		Comments
L	I1	RR=I1
O	I2	RR=I1+I2
=	M1	M1=I1+I2
L	I3	RR=I3
O	I4	RR=I3+I4
A	M1	RR=(I1+I2)•(I3+I4)
S	T1	If RR=1 then T1 starts to count
L	T1	RR=output of T1
S	O1	if RR=1 then set to logic '1' the O1
L	I5	RR=I5
R	O1	if RR=1 then reset to logic '0' the O1,
R	T1	and the input of T1
PE		return to the beginning and start again

The EPLCS Programming Language

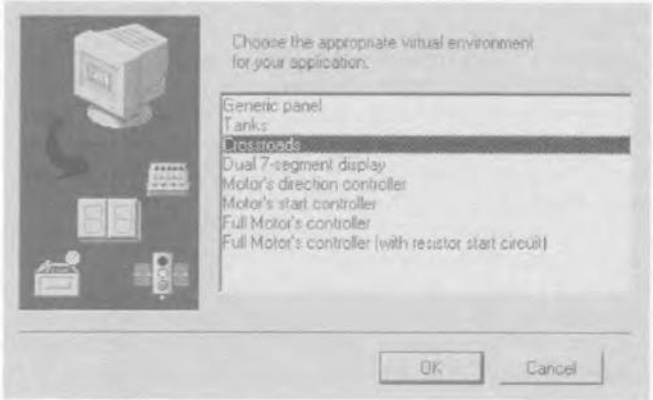
Brief overview of instruction formats. Full descriptions may be found in the documentation file.

Addresses:

Type	Range
Input addresses (In)	I1 to I16
Output addresses (On)	O1 to O32
Auxiliary Output addresses (Mn)	M1 to M128
Timer adresses (Tn)	T1 to T16
Result register	-

Instruction Set

Function	Syntax
Read Commands:	
Load	L <address>, LN <address>
Process commands:	
OR	O <address>, ON <address>
AND	A <address>, AN <address>
XOR	X <address>, XOR <address>
Write Commands:	
write to RR	= <address>, =N <address>
set address	S <address>, R <address>
System Commands:	
Program end, return	PE



About the Winner



According to Panayiotis Stassinopoulos, the idea for developing his program was born from a necessity he stumbled on at the Control Systems' laboratory at ASETEM/SELETE where he works. Says the Winner:
"Although we had PLCs in the lab, we couldn't realize a complete automation system because we didn't have the remaining equipment to reproduce the real environment. So, I decided to create a resort for the students to give them a better understanding of complete automation. In fact, it was a great chance for me to practice my knowledge of Visual Basic. After the first successful trial, I continued adding virtual environments to the initial program. When I read about your International Electronics Software Competition, I thought it a great opportunity to upgrade the program. So, in this short period of time, I rewrote almost all of the code.
I changed the program by dramatically improving the graphics, adding animation characters and transferring the larger part of the code into a C language library in order to achieve more speed. I also changed the STL process mechanism introducing look up tables. After a hard effort (including difficult nights!), I finally finished the program just meeting the deadline."

Born in Athens in 1971, Panayiotis finished high school in 1988. He then continued studies at ASETEM/SELETE (a school of teachers in technical education) and graduated with honours in 1993. Next, he took the examinations for the NTUA (National Technical University of Athens) and passed them successfully having achieved third place. He is currently an undergraduate at the Electrical Engineering and Computer Science department of the University. At the same time, however, he has been working as a professor of Control Systems' laboratory at ASETEM/SELETE since 1993. Panayiotis spends his free time reading scientific magazines, listening to music and watching TV. He likes sports and has the sailing certificate from the Hellenic Offshore Racing Club. He is also practicing at 'para pente' and plans to participate in scuba diving courses.

International Second Prize

AF spectrum analyser

970030-1E

The program called FFT.EXE turns your PC into a spectrum analyser which employs a Soundblaster-16 card (or a 100% compatible type) to digitize analogue signals between 20 Hz and 20 kHz. The program is marked by sumptuous graphics, a well laid out user interface, and rapid response to input signal changes.

Program by H. Thomassen (Netherlands)

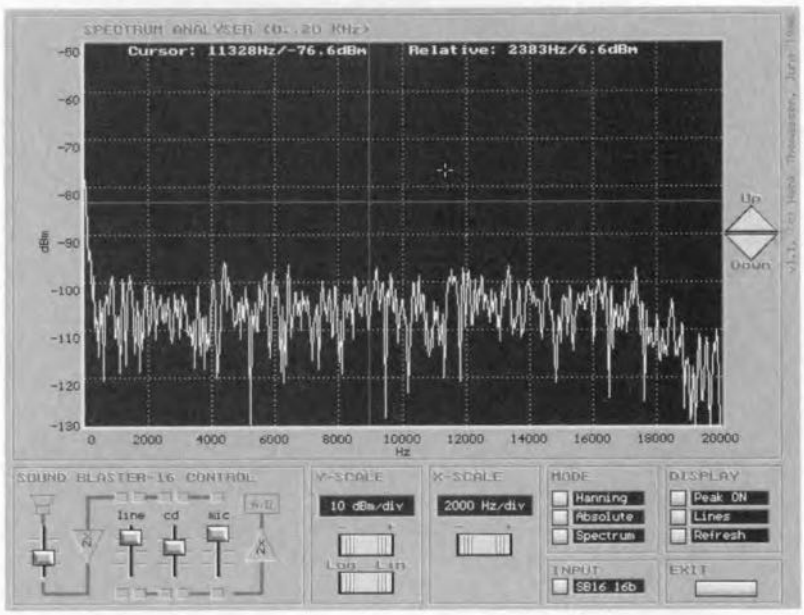
This AF spectrum analyser performs a Fast-Fourier analysis on an applied analogue input signal, and shows the frequency components present in the signal over a range from 20 Hz to 20 kHz, along with their respective levels. The minimum requirements for the program to run are a 386 processor with maths co-processor, a 16-colour VGA card, MS-DOS 6 or higher, a mouse and a 100% SB16 compatible sound card (i.e, an SB AWE32 will also work).

Options

In FFT mode, several windows may be selected for the analysis, including a Hanning window. The program is not only capable of performing an FFT analysis on the input signal, but also offers an oscilloscope function to view signals applied to the soundcard.
Further extras include an internal function generator (which supplies a simple sinewave with some noise in it, mainly to enable the analyser to be used when a Soundblaster card is not available), a calibration option for the input sensitivity, and a freeze option for the display, to enable the values of the individual measurement points to be viewed.
Also very useful is the possibility to generate a screendump (colour or black-and-white) directly from the program.

Soundblaster settings

All relevant mixer settings of the SB16 are available on the 'front panel', and may be changed using the mouse. Once launched, the program first investigates the sound card settings as presented by the 'blaster' environment (usually found in autoexec.bat). If this variable is not found, the program assumes the default settings: DMA-low = 1, DMA-high = 5, I/O address = 220. If the program does not find a standard SB16, the mixer console in the user interface is disabled. Selecting one of the inputs is accomplished by clicking (with the left mouse button) on one of the small buttons below the volume controls for line/cd/mic (the selected input is green). Because of different input sensitivities, it is not possible to select more than one input at a time. It is, however, allowed to use the left and the right channel simultaneously.
The small indicator fields above the volume controls enable you to see which inputs are connected-through to the output of the sound card.
The volume may be set by moving the slide controls (point the mouse on to the control, keep the left mouse button pressed as you move the control up or down, release when done). The range setting of the display is automatically adapted when the volume of the active channel changes. In other words, you then see a change in the signal/noise ratio.
Finally, there are separate gain blocks for inputs and outputs (×1, ×2, ×4, ×8). The gain may be changed by clicking on the left or right-hand corner of the amplifier symbols in the SB mixer section. (970004-2)



Operation

The program is fully mouse-controlled. The only operational function keys are:

F2	*create screendump with file name FFTxxxx.PCX*
alt-F2	*create screendump with file name FFTxxxx.PCX*

Most functions may be activated using the left mouse-button if the cursor is positioned on the relevant button.

Y-Scale +/−	*increase/decrease Y scale*
Y-Scale Log/Lin	*toggle Y scale between logarithmic (dBm) and linear (mW)*
X-Scale +/−	*increase/decrease X scale*
Mode (top)	*Select FFT window type*
Mode (centre)	*display absolute/real/imaginary/argument value*
Mode (bottom)	*toggle between spectrum and oscilloscope display*
Display (top)	*peak indicator on/off*
Display (centre)	*line or bar display*
Display (bottom)	*refresh on/off*
Exit	*leave program*
Up/down	*move display up or down*
Input	*toggle between 16-bit sampling/8-bit sampling/internal signal*
SB16 controls	*all essential SB16 mixer settings*

Teletext Decoder for PCs

970030-I

communication via the I²C bus

This Teletext decoder consists of uncomplicated hardware and a program called VT6. It communicates with the PC via an I²C interface. When a video signal is connected to the completed unit, the control software, VT6, allows Teletext pages to be read on the PC monitor.

By A. Aigner and W. Schaffner (Austria)

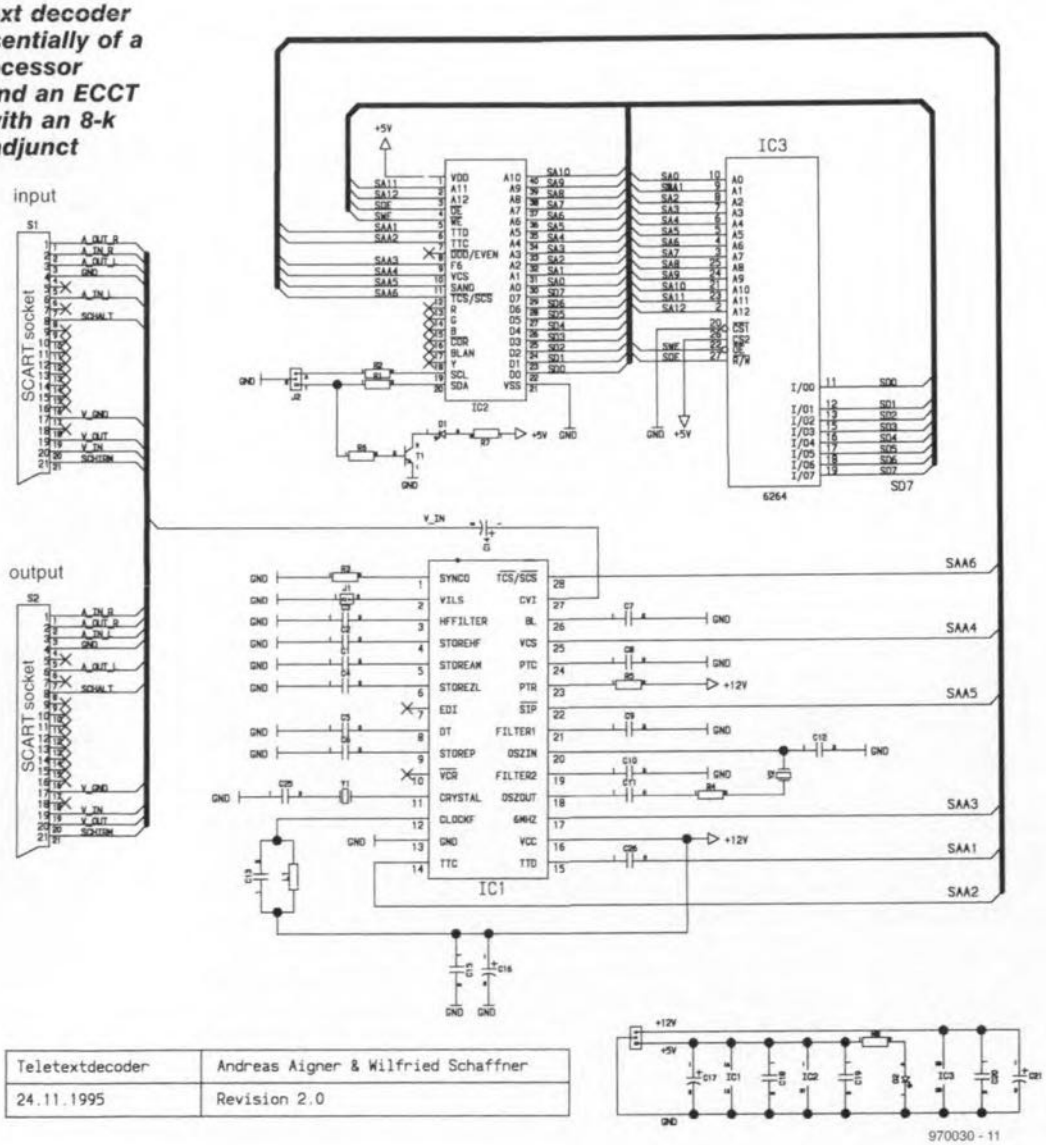
VT6 is a Turbo Pascal program for IBM PCs and compatibles which enables Teletext information to be read. As regards hardware, only the following is required: a decoder consisting of three ICs, and the I²C interface card described in *Elektor Electronics* issue 2/1992. If you want to avoid changing all addresses in the I²C Unit, the I²C interface has to be mapped at address 310h. The hardware and software are capable of reading four Teletext pages at a time (Multipage) for displaying on the monitor. The program is extremely easy to operate, presenting a menu with just three options. The **File** menu allows you to select *Reset* to initialise the hardware, or *Quit* to end the program. **AcquisitionCircuits** (single menu point *A.Window X*) switches the Teletext table X on and off. It is possible to select the table in the system: *PageControl* opens a dialogue window via which the desired page number is entered, and confirmed by pressing the return key. The software is not Windows 95 compatible, and should be run under DOS (not in a Windows DOS box).

Hardware: a must

The core of the circuit is IC2, an Enhanced Computer Controlled Teletext Circuit (ECCT) type SAA5243. Here, an 8-kByte RAM is connected to this IC. Because the ECCT is unable to process the video signal directly, a companion IC, the SAA5231, is required for this function. This building block extracts the Teletext signal from the video signal. Next, the ECCT writes the Teletext page with the desired number into the memory. Details on the circuitry surrounding these two ICs may be found in the relevant datasheets published by Philips Semiconductors.

It is not absolutely necessary to employ an insertion card to be able to read the Teletext information from the memory via the I²C bus, and transfer it to the PC. The by-pass via the Centronics port is by all means an interesting alternative, the more so because it represents a nearly 100% software solution.

Figure 1. The hardware of the Teletext decoder consists essentially of a TT video processor (SAA5231) and an ECCT (SAA5231) with an 8-k RAM as an adjunct



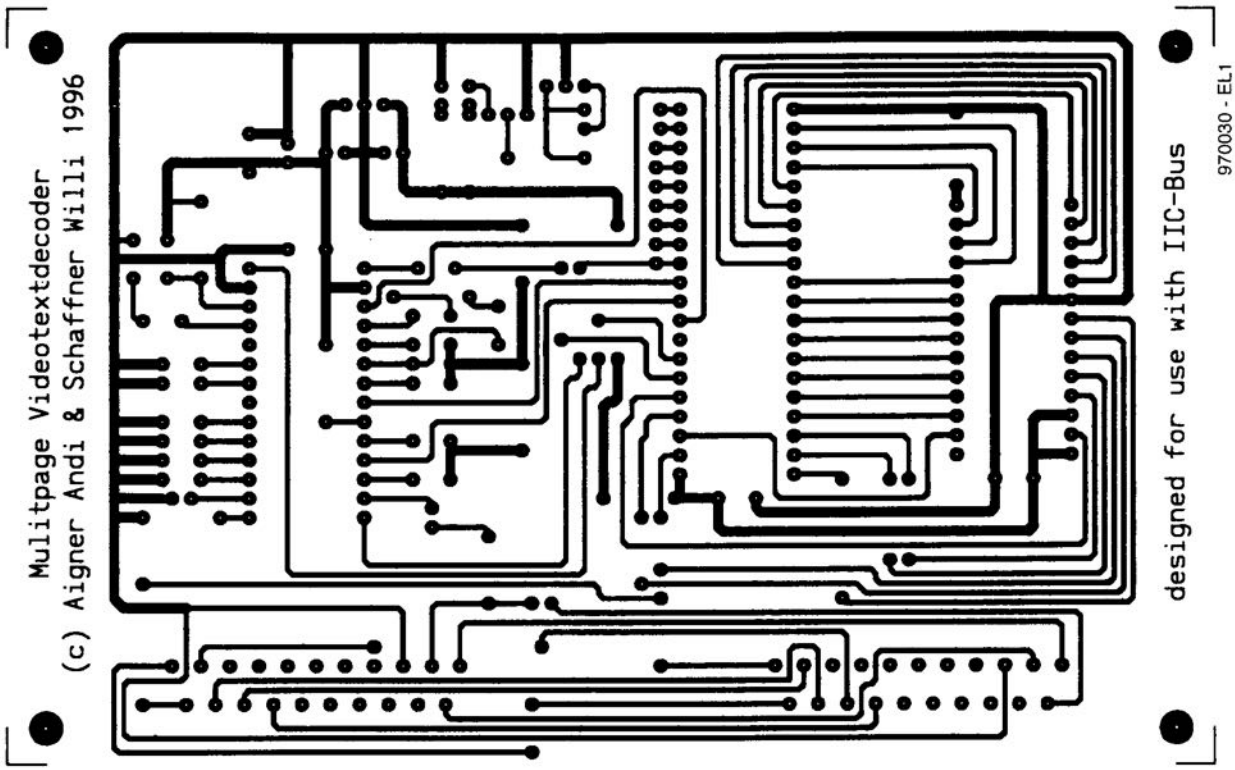


Figure 2. The printed circuit board contains two SCART connectors and a couple of pin headers which form a gateway to extensions.

COMPONENTS LIST

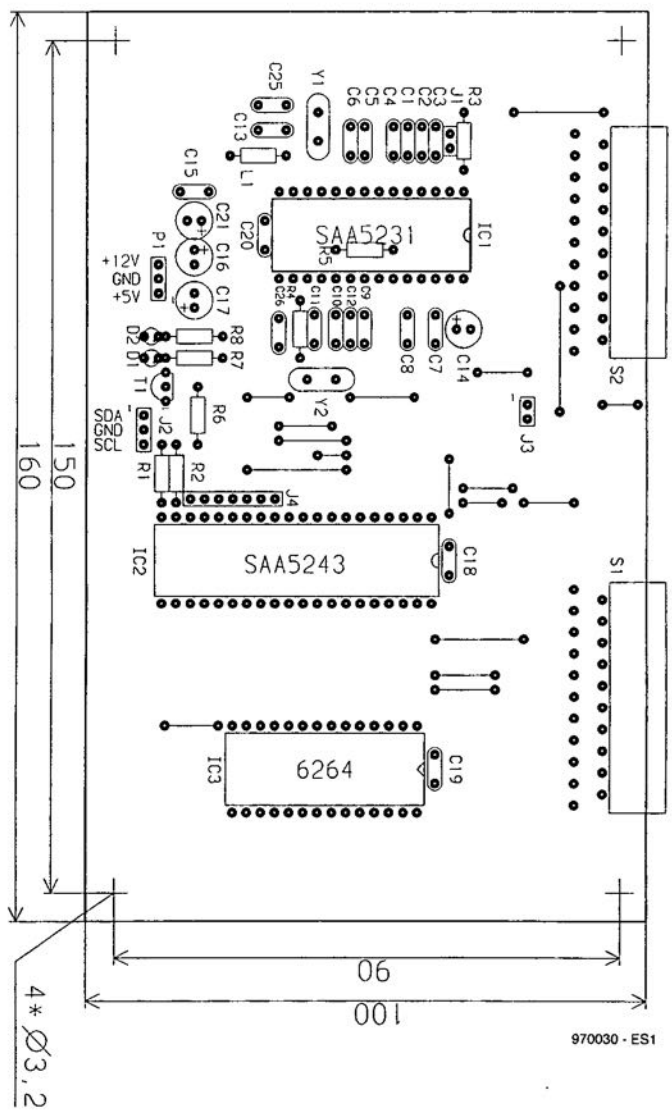
Resistors:
R1,R2 = 470Ω
R3 = 1kΩ2
R4,R7 = 330Ω
R5 = 68kΩ
R6 = 2kΩ
Capacitors:
C1 = 470pF
C2 = 1nF
C3,C25 = 15nF
C4,C15 = 22nF
C5 = 270pF
C6 = 100pF
C7 = 68nF
C8 = 220pF
C9,C10 = 47nF
C11,C12 = 18pF
C13 = 27pF
C14 = 2µF2 16V
C16 = 22µF 16V
C18,C19,C20 = 100nF
C26 = 10nF

Semiconductors:
D1 = LED, 5mm, green
D2 = LED, 5mm, red
T1 = BS170
IC1 = SAA5231
IC2 = SAA5243
IC2 = 6264-100

Miscellaneous:
J1,J2,J3 = 2-pin header
P1 = 3-pin header
L1 = 15µH choke
Y1 = 13.875MHz crystal
Y2 = 6.000MHz crystal
S1,S2 = SCART socket, PCB mount

Only a couple of gates are required so as to avoid bus conflicts. The basic procedure was described in *Elektor Electronics* issue July/August 1993. (page 42) The ECCT offers a variety of additional functions. For instance, it is possible to feed the RGB outputs and the sync to an RGB-to-PAL converter like the AD722, which allows the Teletext information to be represented in the form of a CVBS signal. A video switch like the TEA2014A then uses the blanking signal of the ECCT to switch between TV picture and Teletext. Whether or not the Teletext information has to be visible in the background is a matter of suitable software only. The ECCT has a plethora of registers whose functions are described in the datasheets. There is not much to say about the programming here, the control software being copiously documented. It may, however, be necessary to make the odd reference to an *Elektor Electronics* article covering the operation of the I²C bus. A further, possible, extension entails writing one's own data into the RAM, instead of Teletext information. That would allow text and/or graphics to be displayed on the PC screen.

(970004-3)



970030-III

Fuzzy Control Design and Simulation Toolkit

Fuzzy logic should allow people having little or no mathematical or scientific knowledge to design controllers for fairly complex systems. A software package consisting of four modules was programmed to help the user design and test his fuzzy controllers. The main module is a fuzzy control design program. The other three modules are simulators of various plants. The whole package was written for Microsoft Windows using Visual C+/C++, taking care to ensure a user-friendly environment. Dynamic Data Exchange(DDE) was employed to link any simulator program to the Fuzzy Control Design program, hence transferring the controller to the plant. Hardware implementation of the controllers designed is achieved easily because the virtual controllers may be transferred to an EPROM.

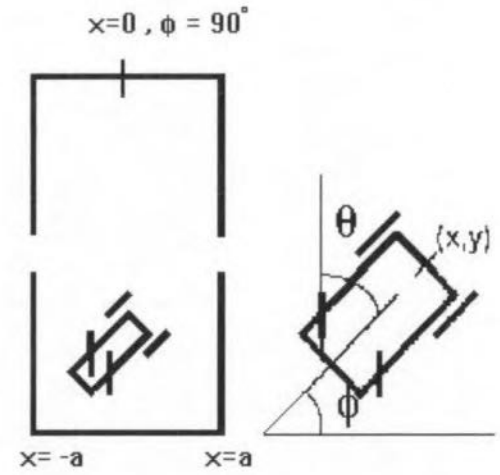
Program by Carmelo Gafa (Malta)

The main module of the package allows the user to design single-input/single-output or two-input/single-output fuzzy controllers. The main steps in designing a fuzzy controller using this program are the following:
- definition of variables
- definition of fuzzy sets
- definition of fuzzy rules
- look up table creation

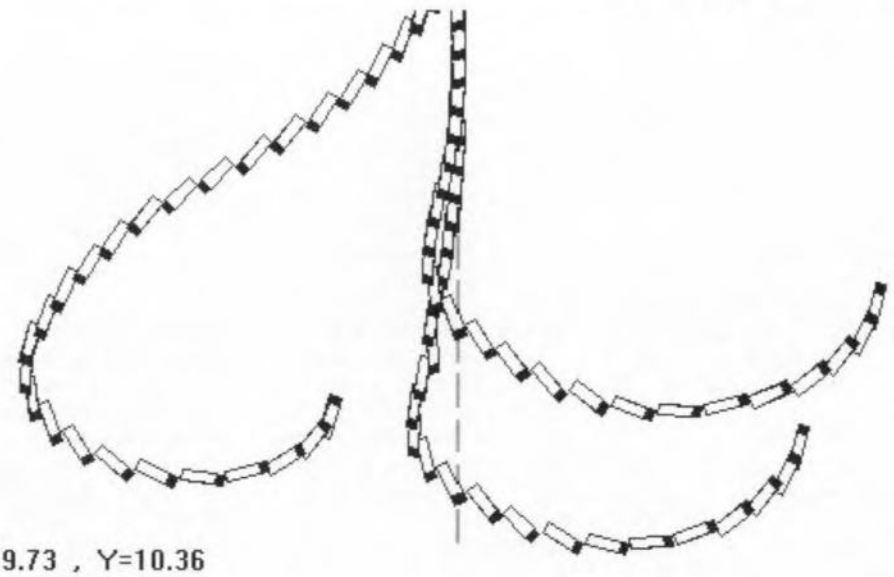
The problem that had to be tackled before facing these tasks was the quantization levels that were to be used for each applicable universe. The hardware implementation of the controller had to be considered from the very start especially when deciding this factor. The controller designed is supposed to be transferred to an EPROM, hence the size of the look up table is important.
If the input variables are converted to a digital quantity using an n bit ADC, this will imply 2^n quantization levels. For a q input fuzzy controller, the size of the EPROM needed would be $(2^n)^q$. Therefore if we were to use a 10-bit converter, for example, a 1-Mbyte EPROM would be required. The most suitable value is an 8-bit converter which will result in a 64-Kbyte EPROM, which is more reasonable. The number of quantization levels is therefore 2^8=256.

The design process

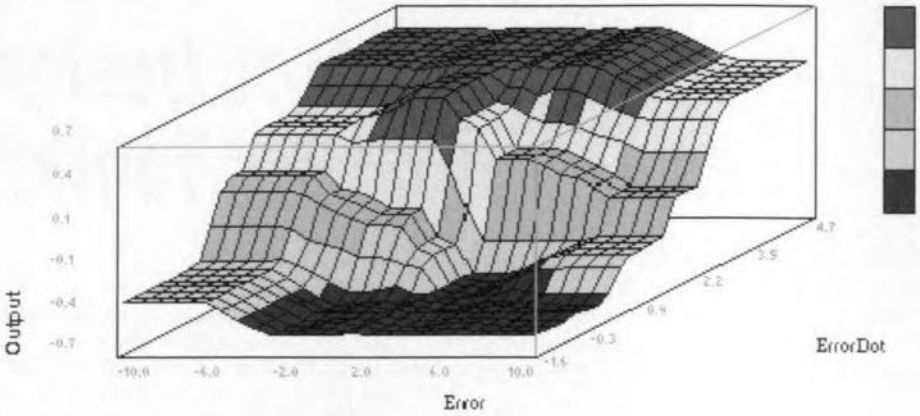
The first step is the definition of the **variables** to be used, give their name, limits, and state if they are of the input or output type. This is done using a special dialogue box.
Next, one can define the **fuzzy sets** that explain the variable. The user may select from three types of fuzzy set: triangular, Gaussian and S-Function. In addition, the user has the option to draw the fuzzy set if it does not comply with the predefined types. Editing fuzzy sets can also be carried out by adding linguistic hedges such as 'rather' or 'very', or by changing the fuzzy set name or colour. This is all very easy with the aid of a special dialogue box.
Rule entry is the next phase, again using a dialogue box. All rules may be viewed after they are entered, and a rule may be deleted and replaced if necessary.
After all the fuzzy sets and fuzzy rules have been defined, the next step is to create the **look-up** table, that is, find the output value for every possible input combination. The look-up table is displayed as a two-dimensional graph depending on the controller type. A typical control surface graph is shown in the illustration.
The program is capable of producing a binary file (having the extension .bin) of which the minimum and maximum values of the look-up table output are scaled to the range 00h to FFh. This scaled data can easily be transferred to a 64-kBit EPROM, facilitating the hardware implementation of the fuzzy control system.



Example:
Truck backing control
Backing a truck in a loading dock is a non-linear control problem. It is a good example of a process that a human can perform better than a machine. The aim of the controller is for the truck to reverse to the middle of the dock, therefore if l is the length of the dock, when y = l, x = 0 and phi=90°.
This simulation program solves two equations until the truck position coincides with a wall. The truck initial angle and length can be defined by the user using appropriate dialogue



boxes; whilst the truck initial position requires clicking on the appropriate screen location only. The control of the truck position may be imported. The drawing shows a typical trace of the truck when it is driven by the fuzzy controller.
Other examples offered by the program include an inverted pendulum control (also called cart-pole system) and general-purpose plant simulators.



International Fifth Prize

970029-I

MultiMet

a virtual DVM/scope for the PC

As indicated by its name, MultiMet is a Multifunction measurement instrument (Met for Meter). It is capable of performing an amazing number of functions. Obviously, all of this is not possible with just software: the assistance is needed of an analogue-to-digital converter interface of miniature size which is designed to plug into the PC's parallel port connector.

Technical Characteristics

Analogue voltmeter
Digital voltmeter
Oscilloscope
Data recorder
Based on LTC1286 (Linear Technology)
Resolution — *12 bits*
One differential analogue input
Power supply — *4.5 to 9 V*
Current consumption — *250 µA, 1nA in sleep mode*
Sample-and-hold internal
Max. clock speed — *200 kHz*
Max. sampling rate — *12.5 kHz*
Min. hardware requirements: 386 PC or better, VGA card, largest possible base memory size for fast acquisitions.

Software and hardware design by F. Mocq (France)

The Jury was duly impressed by the presentation of this competition entry, which is a full-blown project really, and not just software. The program requires a small converter interface which takes the form of a small plug-in device for the Centronics port. One side of the interface has a 25-pin Sub-D plug for the connection to the PC, the other, a BNC socket. The circuit diagram and the printed circuit board artwork for the interface are shown in **Figures 1 and 2** respectively. Note that the small board is double-sided, and that the artwork is printed at actual size to help you produce a perfectly working interface board.

Circuit diagram

The analogue input is protected against overvoltages by a pair of diodes. Supply wires or sockets are not required because the supply voltage is furnished by the PC's parallel port. The A-D converter used here is a low-power, 12-bit type (4,096 values). The output data is written to the PC in serial fashion, the parallel port being programmed to act as an interface. The acquisition speed depends, to a certain extent, on the speed of the PC. Tests indicated some 9,300 samples/s using a 386DX40, and 16,500 samples/s using a Pentium-100. Apparently, the converter, limited to 12.5 kHz by the manufacturer, may be used at a higher speed without running into problems. Programs requiring a graphical display are better off if a Pentium or a 486DX/100 is used. The analogue input covers 0 to 5 V in 4,095 steps. The accuracy achieved by the system is of the order of mVs. The input impedance of about 100kΩ is not likely to present problems to any sensor interface supplying an output voltage between 0 and 5 V (temperature, pressure, humidity, speed, current, light intensity, etc.). There you are: at last, a useful application for your vintage 386 computer, barred from the world of Windows 95. Considering the number of inputs/outputs which remain available on the PC's parallel interface, it is possible to envisage more extensions: several converters, outputs for driving an antenna rotor, a battery charger, or implementing an optical isolation based on the 6N139 to protect the PC, etc.

Software

Note: *it makes no sense to copy the files to the hard disk as the installation procedure* ***must*** *be run from diskette.*

The program was written in C, to be more precise: C++ version 3.0. The source file is supplied, including the Borland extensions which are required for compilation. The fact that the program is made up of modules has helped a great deal in the development, and will not fail to facilitate its maintenance.

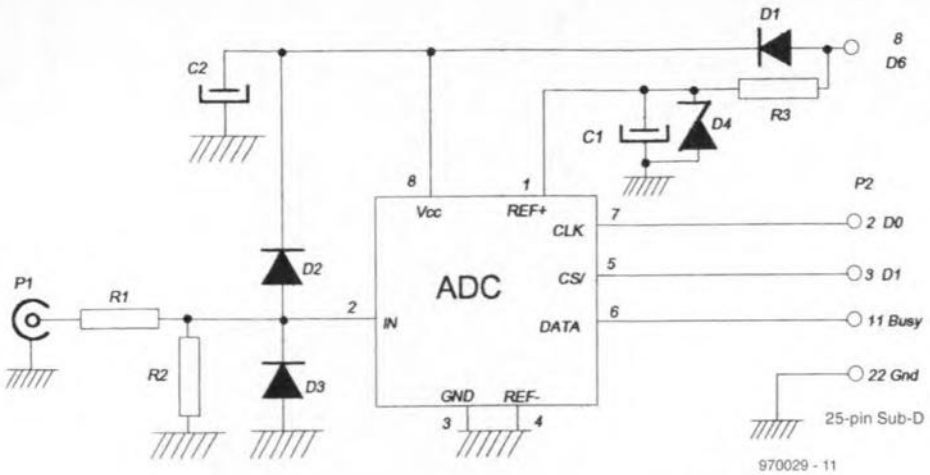
MULTI.H is the header file in which the functions used by the program are declared.

MULTI.C is the main program, written to handle the initialisations and the launching of the virtual test instruments.

MULTI_GEN.C contains the general usage functions, such as read_data( ).

VOLTMET.C is an oscilloscope aimed at signal observation, but also capable of capturing and saving screens to the hard disk (16 screens in the present versions).

FAST-OSCILLO is a variant of



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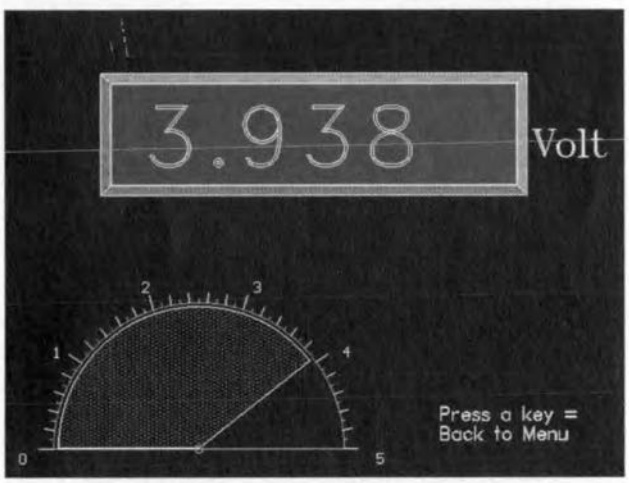
the previous module, of which it forms a part, actually. FastOscillo displays curves on the screen after having acquired the data, whence its higher acquisition speed.

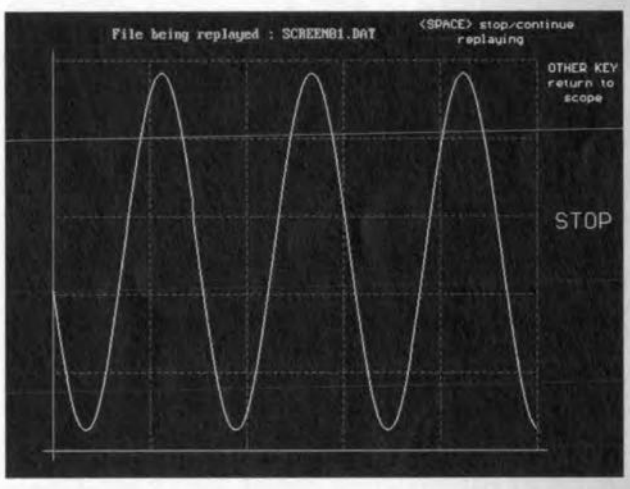
DATA_LOG.C is a logger of data on disk, offering a sampling rate of anything between 10,000 per second and 1 per 18 hours. For fast acquisitions, the size of the data file is restricted by the capacity of the conventional (base) memory (<640 kBytes); for slow acquisitions, the restricting factor is the available disk space.

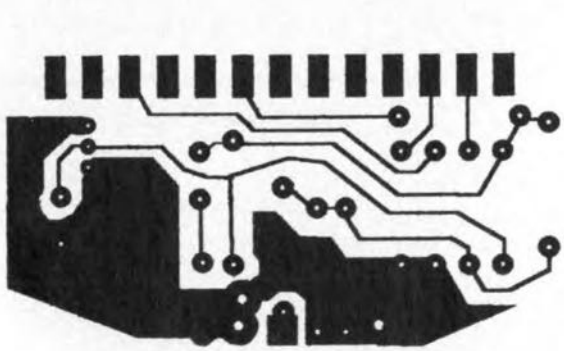
MULTI.HLP supplies information on using the program. The oscilloscope screens and the data recorded on the disk are in ASCII format, ready for importing into a spreadsheet program or table maker. The accompanying examples include classic alternating waveforms captured in oscilloscope mode, and the charging graph of a NiCd battery recorded in *data recorder* mode. These recordings have been processed using Excel and given a graphical treatment. Excel has no, problems importing ASCII files containing delimiters.

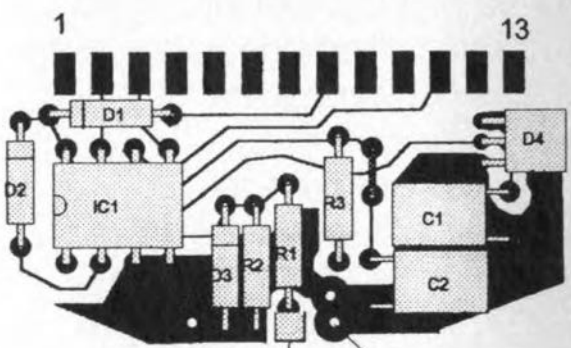
The two screendumps shown here as illustrations give only a modest impression of the numerous possibilities offered by this combination of hardware and software.

(970004-5)

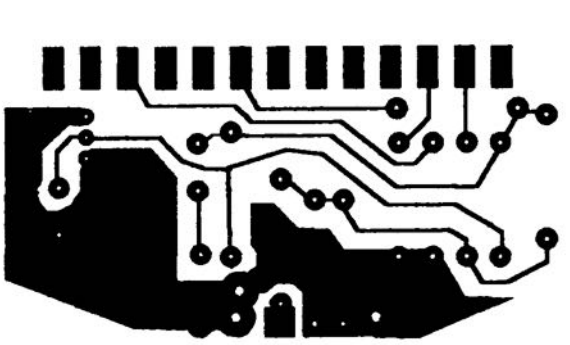


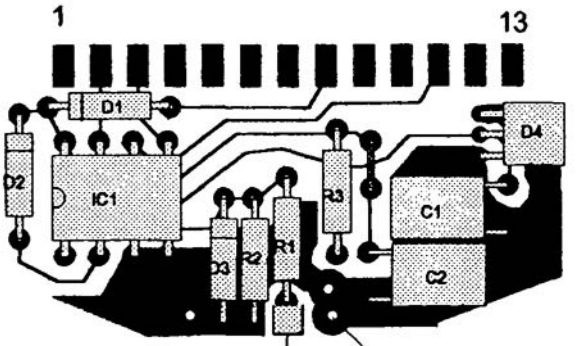






970029 - 12




1
13
D1
D2
IC1
D3
C2
R1
R3
C1
C2
D4
measurement signal input
to ground BNC and pin 22 of Sub-D 25

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focus on: datasheets on CD-ROM



shiny discs replace printed books

Now that the CD-ROM drive has achieved the status of Indispensable Peripheral on any modern computer, an increasing number of electronic component manufacturers advocate the use of CD-ROMs instead of paper to disseminate datasheets covering the specifications of their components. A few months ago, we decided it was time to start investigating this trend, and locate those famous datasheets on CD-ROM.

By our editorial staff

The indisputable advantage of a CD-ROM is it ability to hold vast amounts of data. Today, the limit is about 650 MByte for a single disc, but that is likely to become 'gigabytes' shortly if one is to believe the predictions and press releases published about the DVD (Digital Video Disc). The choice in favour of the shiny disc is obvious once you realise that a graphic representation of a printed page requires a few hundred kilobytes. A further advantage of the CD-ROM is that it is hardly subject to wear and tear, provided, of course, you give the disc its minimum care. No dog-ears, either, as with books and brochures that are frequently perused.

Low production cost as compared with the traditional book is, of course, another argument to which great importance is attached by the component manufacturers.

After about one hundred exploratory contacts of many kinds with manufacturers of all manner of electronic component we present our crop of CD-ROMs, arranged in a fairly random order.

SGS-THOMSON MICROELECTRONICS DATAONDISC DECEMBER 1995



This CD-ROM comes with an installation booklet.

Runs under PC Windows. No mention is made of installation under Windows 95, although the installation via Winsetup does not appear to present problems to Windows 95.

Extensive installation options: everything on hard disk, mixed, or

nothing on the hard disk (at the cost of much slower access). Documentation for WorldView.

Of all CD-ROMs discussed here, this one comes closest to the classic datasheet book.

A vast amount of information giving access to almost 2,800 documents that may be consulted, or about 17,000 pages of text, tables and graphs.

This is not the first DATAonDISC produced by SGS-Thomson.

Once DATAonDISC is installed, the program may be launched by a simple click on the relevant icon. Next, you see the browser, WorldView, loading, producing a screen which closely resembles that of Adobe Acrobat Reader. The main window then appears, offering the following options:



- ➢ company profile
- ➢ contents
- ➢ alphanumerical index
- ➢ tips and tricks

Probably the simplest way to get going with the CD-ROM is to select the contents, and proceed from there.

It is possible to define a number of bookmarks if you want to be able to return rapidly to a certain location. The program also allows you to send an e-mail message: very useful and well done. Internet address:
http://www.sgs.com

Siemens Technical Product Information Edition 7

Judging from the version number, Siemens is probably the first manufacturer to have put its component datasheets on CD-ROM. In any case, they have used the shortest update intervals!

The installation is totally trouble-free.

Under Windows you have a window called 'Tebis for Windows', which presents two icons, 'Wintebis' and 'Addresses'.

Possibility to search components on the basis of their electrical characteristics.



A number of components are shown with a telephone symbol which indicates that there is no corresponding file yet on the CD-ROM. It should be noted that it is not possible to open a second datasheet file. This point is made because that limitation of the program may cause you to assume that certain components are listed but do not give access to any of the datasheet files on the CD-ROM. Nothing is farther from the truth.

The datasheet files are available in English or German. It is possible to leaf through the documents and rotate pages 90 degrees. The overall quality is pretty high.

The menu proposes:

- ➢ Datasheet files of memory components (DRAM, DRAM modules, synchronous DRAM, multibank DRAM, CMOS SRAM, non-volatile memories), integrated circuits for industry, cars and communications, all kinds of memories, microcontrollers, a wide range of semiconductors (SIPMOS and others), opto-components (LEDs, displays, detectors, IR transmitters, opto-isolators, and others). In fact, the entire range of Siemens products is available.
- ➢ Address book in the form of a database file.

The CD-ROM also has a subdirectory containing the semiconductor devices used by Siemens, in WKS format, as well as an alphabetical list of available data in .XLS format (for Excel). A list is available containing all components mentioned in the documents on CD-ROM. The quality of the reproductions is very good, and the printing quality, excellent.

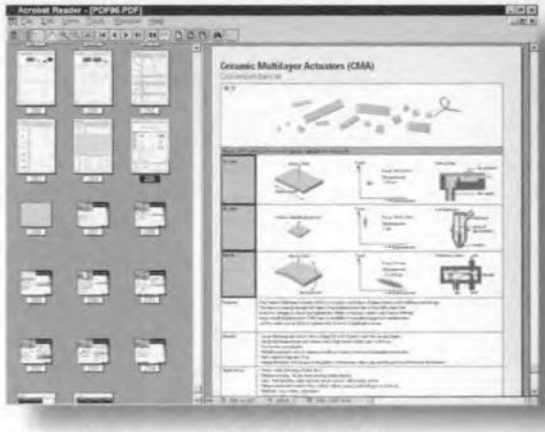
Summarizing: polished and re-polished, 7th edition. Easy to use. Internet address:
http://www.siemens.com.

Philips Passive Component

The note says that the CD-ROM contains 3,021 pages of datasheets, 10 datasheet books, 64 pages of applications, a 120-page condensed-information catalogue, and 385 datasheet files.

As indicated by the title, this disc contains information on passive parts only, manufactured by Philips Components. Realizing that these parts represent just 10% of the documentation, it's obvious that there is much more in store. This CD-ROM also employs Adobe Acrobat Reader (2.1). Once you have the program up and running, access to it is logically structured. Essentially, you have the choice between:

- going to the main menu, where you find the categories: Your Partner, Addresses, Operating Guide, Product Selection, Index series, Help and



- ➢ a copyright notice. Once in the main menu, you will notice the familiar Acrobat look which makes the document easily accessible. There, you find datasheets about:
- ➢ capacitors, resistors, thermistors, (NTC and PTC) and varistor (ZnO), comb filters, delay lines, quartz crystals and oscillators. The way in which the information is accessed closely resembles leafing through the pages of a book. There is even a kind of on-line user manual between pages 287 and 294. Everything in colour! A CD-ROM covering the active components produced by Philips is expected to become available by the second quarter of this year. Internet address:
http://www.semiconductors.philips.com.

Microchip 1996 Technical Library

This documentation is intended to run under Acrobat 2.1 (which means that files may be printed). Runs under PC Windows and Macintosh OS.

The content of this CD-ROM is highly diversified, including:

- ➢ a product selection guide;
- ➢ datasheet files and programming specifications for the PIC16/17 family;
- ➢ application files for other Microchip products;
- ➢ serial and parallel EEPROM datasheet files, and those of the EPROMs;



➢ physical characteristics of Microchip products;
➢ hardware and software development tools;
➢ application notes;
➢ an address overview.

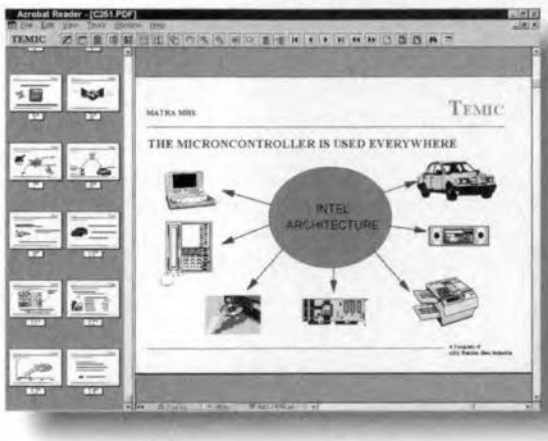
A total of nearly 200 files in all.

Summarizing: extremely useful and well done, directly readable from CD-ROM, so no installation and no hard disk space taken. Internet address: *http://www.mchip.com/microchip.*

TEMIC SEMICONDUCTORS TECHNICAL LIBRARY DECEMBER 1995

Documentation files for Acrobat Reader 2.0, with added utilities on the Acrobat toolbar, says the text. Attention, the text also says not to use Acrobat 2.1. As you probably know, Acrobat allows files to be printed at high quality.

Runs under PC Windows and



Unix.

Requires a Setup but is easily removed later.

As evidenced by this product, it is difficult to avoid typos ('MICRON-CONTROLLER').

Launched by activating an icon.

Nearly 1,000 pdf files representing more than 7,000 pages make it a little difficult to find what you are looking for, but who will grumble at such a massive amount of information.

The CD-ROM is completed by some 50 application notes and a wealth of additional information.

The menu:
➢ product selection guide;
➢ datasheet files and application notes for various components from Telefunken Semiconductors, Siliconix, Matra MHa and Dialog Semiconductor.
➢ address overview.

Summarizing: well-produced and runs very well. Internet address: *http://www.temic.de.*

ANALOG DEVICES DESIGNER'S CD REFERENCE MANUAL 1996

The installation is simple, you run Setup and that's it. The program also installs Acrobat Reader (pay attention if you have this program installed already, don't use the Analog Devices version in that case; it is better to install version 2.1 of the Reader). Once the program is installed, it may be launched by double-clicking on the icon marked 'Analog Devices CD Reference'. There is a mini guide for the installation and use of the CD-ROM. The use of Acrobat Reader seems to have become a standard when it comes to publishing datasheets of electronic components on CD-ROM.

The main menu which appears after launching the program offers four buttons which allow one of the following functions to be selected:

➢ Product Selection
allows you to choose a component for a given application. Activating this button opens a window showing three other buttons: Category Search, Selection Trees, Detailed Short Form, and the Main Menu to return to.

➢ Databook
This contains all the products available on the CD-ROM. This function may be used once you know the exact type number of a component. Typing the right number immediately takes you to the relevant datasheet file. A search system (Databook Search) enables you to enter the type number of a component. Pressing ▼ opens the list of all known components. There are also a number of additional, useful, functions including Data Sheet and Price.

➢ Cross Reference
Finding a 'Competitive Part Number' offers three options: Prefix, Part Number and Suffix

➢ Sales Information

Summarizing: cheerfully presented, easy to use and very useful. Internet address: *http://www.analog.com.*



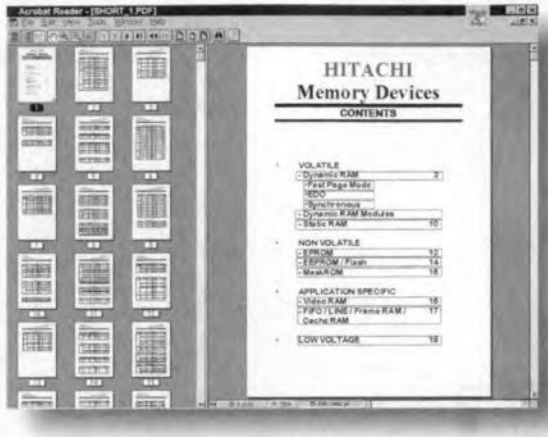
HITACHI ELECTRONIC COMPONENTS DATABOOK EDITION 4.0 MARCH 1996

Documentation intended for Acrobat Reader 2.0 (which means that files may be printed).

Runs under PC Windows and Macintosh OS.

Installs Acrobat Reader, just like a number of other datasheet CD-ROMs.

This is the electronic version of the databook covering the H8 family of



electronic products.

The CD-ROM presents 309 files of the .pdf type, corresponding to a total of more than 1,200 pages for you to peruse.

On the CD-ROM menu are:
➢ Microcontrollers: families H8/300L, H8/300H, H8/500, H8S, SH7000, SH7600, SH7700, H8, LCD controllers, datasheet files and applications, development utilities.
➢ Datasheet files covering memories, including volatile memories (dynamic RAM, Fast Page Mode, EDO, Synchronous, dynamic RAM modules, static RAM), non-volatile RAM (EPROM, EEPROM, masked ROM), special applications (video RAM, FIFO, cache RAM), low-power devices.
➢ Semiconductors: all about their enclosures and their handling.
➢ Distributor addresses.
➢ Datasheet files on components, microprocessors, memories.
➢ Physical characteristics of enclosures.
➢ Hardware tools and development software.
➢ C compiler for the H8 and SH microcontroller families.
➢ Application notes.
➢ Address overviews.

Summarizing: indispensible information for users and fans of the H8 family. Internet address: *http://www.hitachi.com.*

NEC 78K/0 FAMILY

If certain CD-ROMs may not be



obtained directly from the relevant manufacturer, there may be other ways to get at the desired information. Do not hesitate to consult professional magazines which occasionally publish interesting offers for documentation on CD-ROM.

This particular CD-ROM was put at our disposal by Fortec Electronic AG, although it originates from NEC. The program installs a preliminary version of Toolbook, and Acrobat Reader, modified and extended by programmers at NEC. The installation allows you to include or skip Acrobat Reader. Considering the widespread use of the Reader software (and the fact that it is free), few of you will have to install it from the NEC CD-ROM.

Nicely presented, in colour, with a preliminary version of TechView. This CD-ROM is dedicated a single family of integrated circuits called 78K/0 by NEC. The family has no fewer than 80 members. The CD-ROM presents some interesting functions such as the definition of the required ROM and RAM sizes, which is translated into an automatic selection of processors complying with these characteristics. The higher the number of requirements you set, the lower the number of components found. Those of you requiring additional information on the processors in this family will be pleased to find the respective user manuals, covering several hundreds of pages.

Summarizing: a pleasure to use, reads like a book, a compliment to NEC. Internet address: *http://www.nec.com*.

Lattice Semiconductor Corporation

ISP™ Synario Starter Software & ISP Encyclopedia

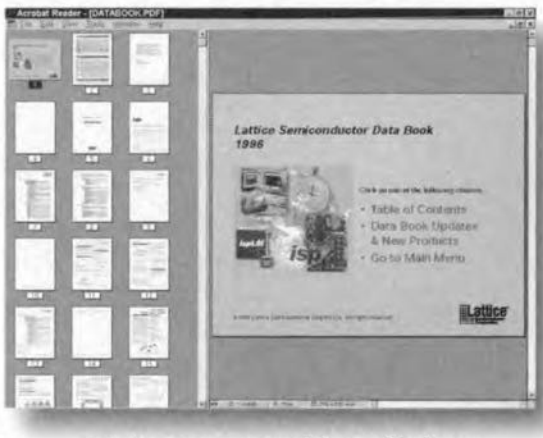
As abundantly clear from the title, this CD-ROM is dedicated to the ispLSI (isp = *in-site programmable*) products from Lattice Semiconductor.

Here, too, use is made of the Acrobat Reader software to visualize the files. The CD-ROM is divided into two sections, each containing several sub-sections again. The ISP Encyclopedia is devoted to, well, everything relating to ISP, offering

- a main menu (3 pages)
- datasheet file collections (Data Book) 1996 (998 pages)
- the ISP manual (147 pages)
- the Lattice Semiconductor application collection (501 pages)
- cost estimating (13 pages, with Excel files)
- Product Selection Guide (9 pages)

Note that all of these pages are accessible without any kind of installation on the hard disk, provided you have Acrobat Reader up and running.

The second section, ISP Synario Starter Software is really outside the scope of this article because it is 'only' a companion to the evaluation version of Synario (Entry and Functional Simulation Starter Software), a powerful bit of software supporting the ispLSI2032 and 1016 devices as well as all GALs produced by Lattice. None the less, this software is of great interest to everyone working with these devices. It actually comprises Project navigator, Schematic capture, the functionality of ABEL-HDL Entry and Compiler, Functional Simulator and other modules. Gasp! And let's not forget the extensive documentation for this software. The lot occupies 20-odd Megabytes.



National Semiconductor

National Semiconductor Technical Literature Database

The set we received from National Semiconductor comprises two CD-ROMs:

1) Datasheets and Physical Dimensions, and
2) Application Notes.

The set is dated July 1996. Updated editions are rarely produced. These CD-ROMs are easy to use because they do not have to be installed. That is, provided you have Acrobat Reader, since that is the browser software chosen by NatSem to view the files.

The program is launched by activating the file called 'Welcome1'. The first page offers three options:

- Table of Contents
- Alphanumeric Document List
- Help

Selecting the first option opens a library of thousands of pages. The first level alone has a staggering 219 pages. Clicking on one of the indicators takes you to the next level which again provides access to a specific component whose documentation may comprise several tens of pages, as for example, in the section on Microcontrollers and Microprocessors. Fortunately, Acrobat Reader has a 'Back' function (CTRL–) to go back to the previous page or previous level. Similarly, CTRL3 helps you move to the next page.

What's on the menu? Well, just about anything from BiCMOS logic to Wireless communication. You will, for instance, come across the CMOS device family, including the 4000 series, FACT, HC, HCT, VHC and many other devices, memories and microcontrollers, not forgetting ECL and TTL devices. This list is far from exhaustive. What about the Applications CD-ROM, you say. It, too, allows you to spend a long time in front of your PC screen. The structure is tree-like as with other CD-ROMs, the information narrowing as you use more selection criteria. There are 41 markers, each giving access to one or more pages. We leave you the pleasure of discovering… Internet address: *http://www.national.com*.

1996 IC Master CD-ROM Plus

IC MASTER is probably the general-purpose source *par excellence* of information on integrated circuits. This reference work will be familiar to many, if not all, readers working in the elec-



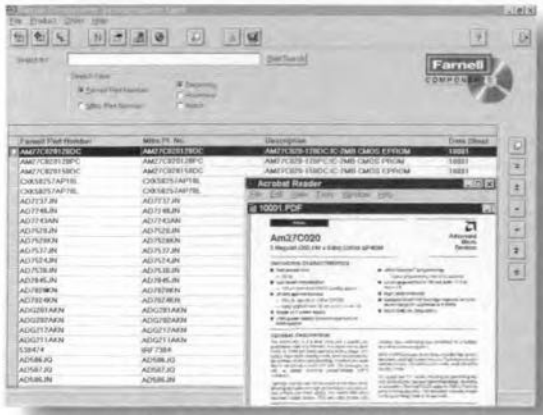


tronics industry. The CD-ROM is different from the others discussed here in that it comes with a fairly thick manual. This addition is clearly reflected in the price. Finding components on the CD-ROM seems to require some practicing and getting used to, but is quickly learned.

Those of you interested in this product should note the existence of the web site *http://icmaster.com*. The site is divided into a Guest and a Subscriber section, the latter being accessible only if you have the product serial number of your IC MASTER book or CD-ROM.

Our search for datasheets on CD-ROM also covered component distributors who include product specifications with their (digital) catalogues. This is the case with, for example, Farnell, who supply an affordable CD-ROM containing over 30,000 pages of datasheets. Great stuff for those long winter evenings...

SEMICONDUCTOR DATA FROM OVER 50 MAJOR MANUFACTURERS



Farnell issued a CD-ROM dated June 1996 of which the main contributor is Harris Semiconductors.

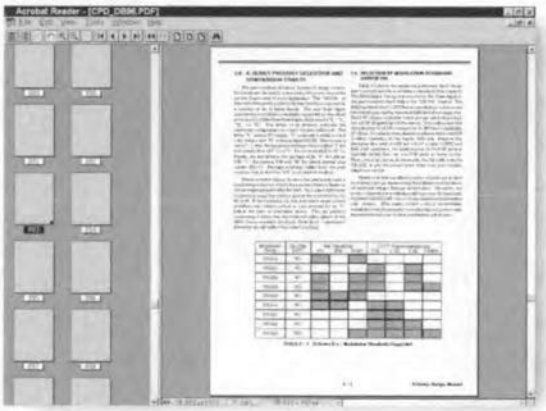
The information on the CD-ROM is easily accessible. After the installation, be sure to employ the VBDB300.dll file, as without it you will be unable to start the program.

Once up and running, you will see a list of alphabetically sorted components, along with Farnell reference numbers, the manufacturer and a short description. A few clicks are sufficient to take you to the datasheets of the relevant component. Sets an example. Internet address: *http://www.farnell.co.uk*.

Although they do not, strictly speaking, belong in the class of datasheets reference works, some CD-ROMs are still of interest to the advanced electronics hobbyist.

SILICON SYSTEMS 1996 VOLUME 1

Documentation for Acrobat 2.0. Runs



under PC Windows.

Closely resembles the classic datasheet collection on paper. Some documents are, however, not available in electronic form.

A solid amount of information: over 1,200 pages to peruse.

Contents:

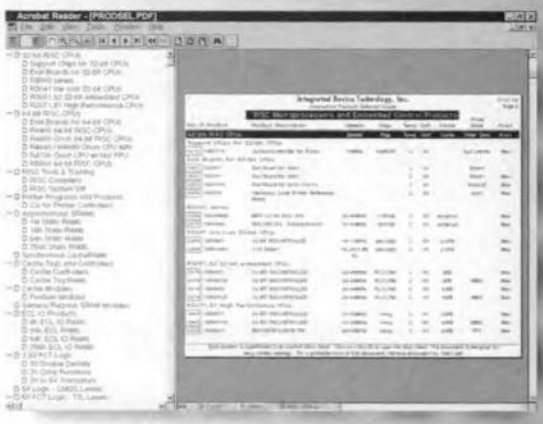
- component datasheets
- physical characteristics
- hardware and software development tools
- application notes
- manuals
- address overview

Summarizing: a classic approach. Internet address: *http://www.ssi1.com*.

INTEGRATED DEVICE TECHNOLOGY INC, MARCH 1996

Although this CD-ROM runs under Acrobat Reader V2.1, it is also possible to access the information using a Web browser, the files being stored in html format.

Three NUMINDEX files (and not PRODNOS as stated in the user manual) sorted by product number, with



description and reference to a file containing the datasheet.

DOCINDEX: provides the title and the reference number of all documents available on the CD-ROM, as well as FaxBack numbers, databooks sorted by subject.

PRODSEL: selection guide covering all products, each one having its own datasheet file.

Summarizing: astoundingly easy to use. Internet address: *http://wwww.idt.com*.

MOTOROLA CSIC

Web Site Tour Kit CSIC Family of Microcontrollers 68HC05 and 68HC08

Although this documentation is presented in the form of pdf (Adobe Acrobat) files, it is also accessible with the aid of a Web browser. Install Adobe Reader 2.1 and QuickTime 4 Windows 2.04.

Runs on PCs, Macs and Unix systems.

This CD-ROM presents a (fairly limited) series of application notes. Summarizing: this is a kind of Web site on CD-ROM, presenting a solid amount of information on the Development Tools.

The CD-ROM also presents a number of software development tools including MMDS05, M68HC705JICS and M68HC705KICS. Internet address: *http://www.motorola.com*.

CONCLUSION: A LONG QUEST

In our opinion, the initiative to use plastic data carriers instead of massive amounts of paper to print databooks can only be encouraged in this day and age of environmental protection.

(970002)

the small workshop

requirements and other considerations



Anyone interested or engaged in constructing electronic circuits, be he/she an amateur enthusiast, an experimentalist or a professional operating a small business, is faced with the question of what equipement is really necessary to carry out the work properly. Since many of these people have only a limited budget, a correct investment is of great importance. This short article is intended as an aid to making the correct choice. It includes a simple computer program to decipher the codes used for resistors, capacitors and inductors.

by L. Lemmens

Setting up a small/home workshop needs careful consideration. In this article, an attempt is made to indicate how such a workshop should be equipped: what is essential and what can wait a while. When, in due course, more, or more serious, work is to be undertaken, other equipment and facilities can be added to the basics outlined here.

The working surface should preferably be a well fitted bench or, at the very least, a sturdy table that does not move easily. If this is not so, there is the risk that at an unfortunate and unexpected instant tools and equipment start shifting about. If they fall of the working surface, irreparable damage may be caused.

Since much soldering will be undertaken on the workbench, it should be covered, at least partially, with a heat-resistant material such as formica. Also, if many repairs are to be carried out, it is strongly advisable to cover part of the bench with a strong rubber mat to protect the equipment being repaired. The mat should be anti-static and be resistant to brief contacts with a hot soldering iron.

Of course, electric power supplies of various kinds are an absolute must. Since much equipment is mains-operated, there should be a fair number (at least four, preferably 12) of mains outlets in easy reach of the workbench (NOT at floor level). It is important that these outlets be protected by an earth leakage switch. Trailing multiple sockets to BS1363 may be used, but these must contain an earth leakage switch and a com-

mon on/off switch for all outlets.

Use cables that are as short as feasible. Some of these, for instance that of a standard lamp or the soldering station, should be fastened to the workbench. These measures prevent the workbench becoming a chaotic collection of cables.

A GOOD STORAGE SYSTEM IS IMPORTANT

With time and a greater workload, the amount of components and other material grows inexorably. It is vital that a good storage system to house cables, test leads, small tool, components and other parts is available. The workbench should not be allowed to become a storage area. Small tools, components and other small parts are best kept in a suitable storage cabinet (see, for instance, the RS Components catalogue): there are many different kinds of these available from relevant retailers or mail-order firms. Give a thought to transparent drawers: these are very handy, indeed, since they show at a glance what they contain.

A small, shallow container on the workbench is indispensable for storing screws, nuts and washers, and other small parts taken from an equipment being tested or repaired.

Test and mains leads are best kept on a dedicated rack as shown in **Figure 2**. Such a rack can, of course, be made by the average handyman.

Other tools are best kept in a dedicated toolbox.

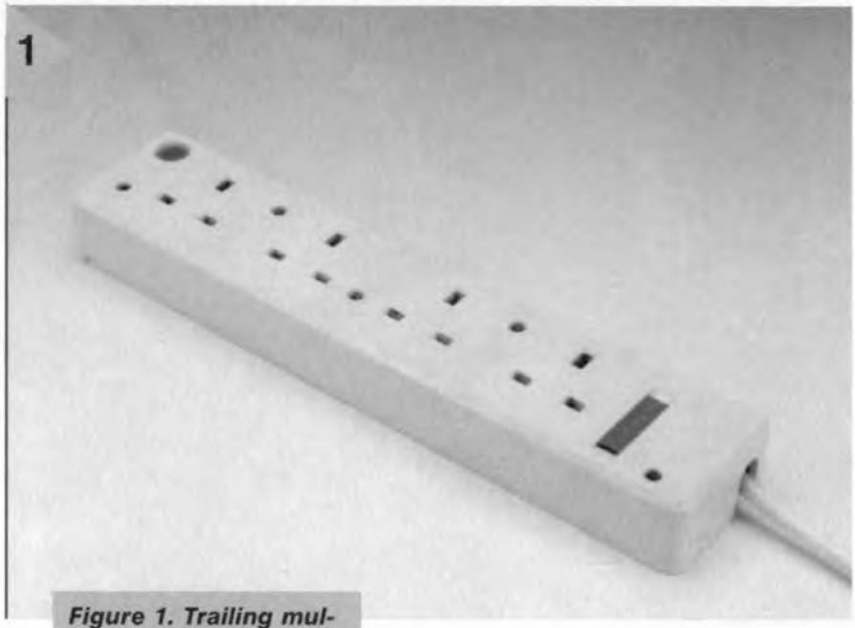


Figure 1. Trailing multiple socket; this should be fitted with a manual on/off switch and an earth leakage switch.

SOLDERING EQUIPMENT

Soldering or, more correctly, soft soldering, is a reasonably straightforward process used in electronics construction to bond components together, forming one or more electrical connections. Soldering provides:

✗ mechanical support, holding the components of an assembly together;

✗ electrical support, forming the required electrical connections of a circuit.

Most components in an assembly use the mechanical support of soldered joints alone to give adequate fixing into the assembly. A few isolated components, notably larger, heavier ones, may require additional mechanical support, such as straps, nuts and bolts, and so on.

On the other hand, all components may use solder as electrical support to form requisite electrical connections. No other method has yet been devised to take the place of solder in all assemblies to the same level of performance.

In electronic assembly, by far the most typical of soldered joints is in printed-circuit assembly, when component leads are soldered to the copper track of the board. In a typical joint, the component lead projects through a plated-through hole in the board and is bonded to the copper track with solder. In a good joint, solder is drawn inside the hole during the soldering operation. The solder between the copper track and the component lead is called the fillet.

Wetting is the process in soldering when the solder comes into direct metallic contact with the metals to be soldered together into a joint forming a specific alloy of solder and metal at the junction. In turn, this implies that the joint's metallic surfaces be so clean that metallic contact can be made.

In a small workshop, all soldering is done by hand for which a good sol-

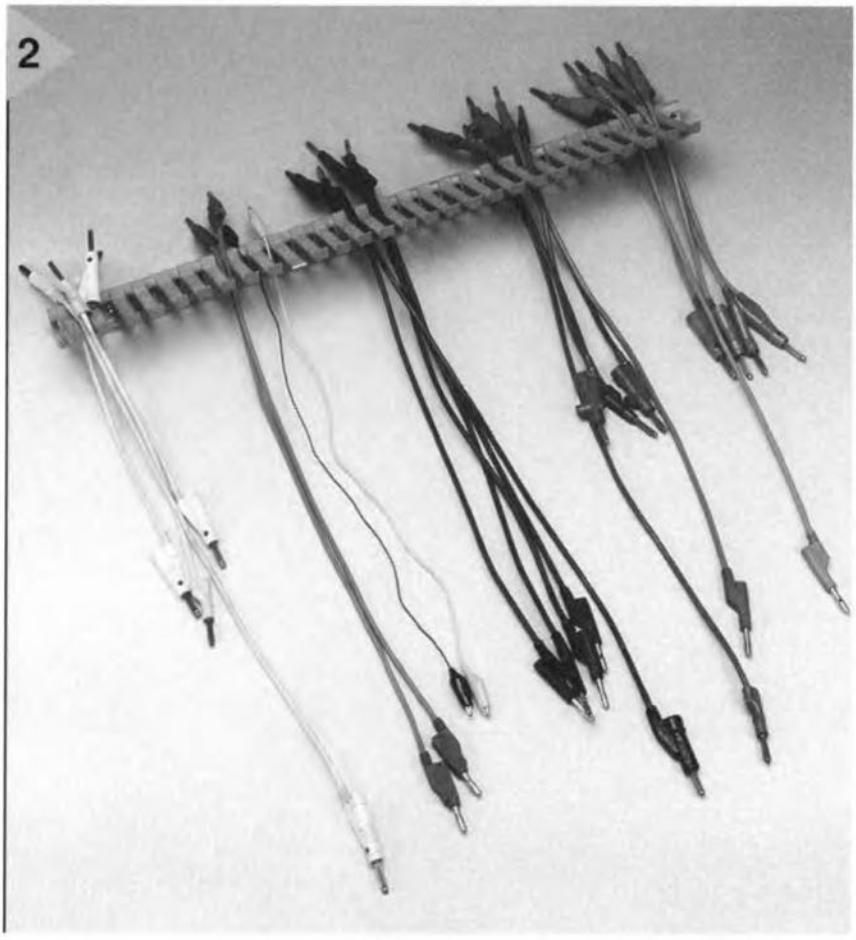


Figure 2. A cable rack may be constructed simply from a strip of wood or man-made fibre.

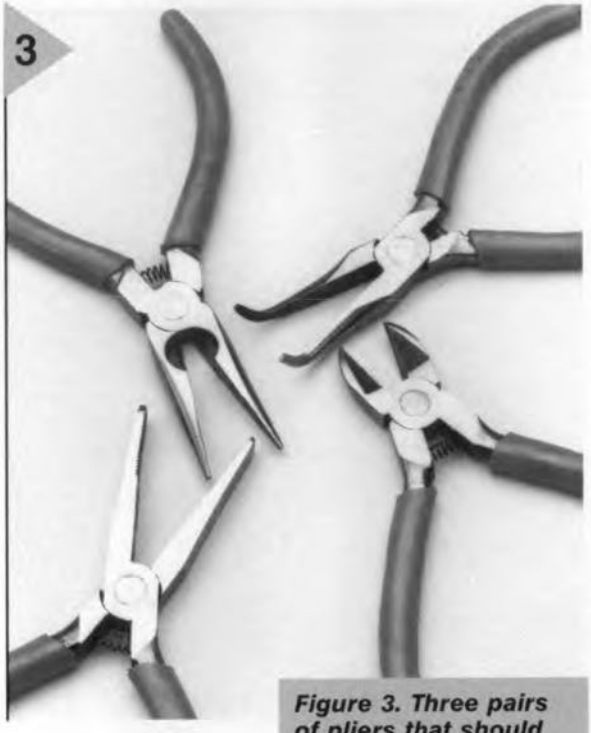


Figure 3. Three pairs of pliers that should be found in the basic toolbox of every electronics technician/engineer.

dering iron is vital. It is best to use a 30 W one with temperature control.

Since safety is of paramount importance, a reliable parking stand for holding a hot soldering iron is a must (see **Figure 5**). For good workmanship, it is necessary to keep the tip of the soldering iron clean. After doing some soldering work, remove all tin and solder flux from the tip with a small, damp sponge.

Most solders used in electronic assembly are alloys of tin and lead. One of the most useful properties of a tin/lead alloy used as a solder is the range of low melting temperatures. Over a central range of alloy proportions there is no particular melting-point, merely a range over which the alloy is neither molten nor solid – a pasty or plastic state. However, at on particular alloy proportion (62% tin, 38% lead), the alloy melts at a single temperature (183 °C), which is also the lowest melting temperature of any tin/lead alloy.

To ensure good soldering joints at all times, always use good-quality cored solder to BS441 (DIN8516). Recommended is a 60% tin, 40% lead alloy with five cores of non-corrosive flux, which is especially suitable for high-quality work requiring a low melting temperature.

Mechanical strength is an important criterion when making soldered joints. Obviously, the joint should be strong – strong enough to withstand all the possible stresses which it may experience: tensile, shear and compressive.

A few important types of joint associated with electronic assemblies are through-hole joints and surface-mounted joints.

Through-hole joints rely on the fact that a wire lead is inserted through a hole in the board then soldered to bond to a metal track.

Where joint strength in through-hole joints is quite large – far larger, in fact than the strength of the circuit materials surrounding the joint – the type of joint formed when soldering surface-mounted components limits the joint strength appreciably.

Occasionally, in rework or repair stages of an assembly's life, desoldering of components is required. It is a tricky, time-consuming operation requiring some extra tools.

First, the solder must be reheated to be molten, then it must be removed prior to component dismounting. Molten solder can be removed with implements that suck the solder away from a joint. Solder suckers can be separate tools, or form part of the soldering iron, comprising an air-bulb or plunger pump mechanism. Alternatively, woven copper wire can be made into a braid, called solder wick, impregnated with flux, which has the effect of drawing the molten solder up the braid, away from the joint.

Many printed-circuit boards are not as clean as the complexity and density of packing require. One of the main areas where high levels of cleanliness should be maintained is directly after the soldering process.

Soldering, with its requirement for fluxes to aid the process, and the resultant flux residues, is a messy business. Flux and flux residues are corrosive, so if they remain on the assembly, corrosion will occur sooner or later. Rapid malfunction of the board may then occur.

It is therefore essential for the assembly to be cleaned after soldering. Depending on the kind of assembly, and the flux used, either aqueous or solvent products may be used for cleaning. In a small workshop, these may be applied by brush, immersion or spray.

CUTTING, BENDING, AND STRIPPING

Before components can be mounted and soldered on to a printed-circuit board, their leads must be cut to size. This is normally done with a pair of small side cutters. Bending the leads as required is best done with small electrician's or radio pliers. Other tools that are useful and often essential are long-nose pliers, snipe-nose pliers, combination pliers, a wire stripper, trimming knife, standard hacksaw and blade, various sizes of scissors, a set of supadrive screwdrivers, a set of parallel screwdrivers, and a set of jewellers screwdrivers. If at all possible, buy good-quality tools: this will be rewarded by a long life and first-class workmanship.

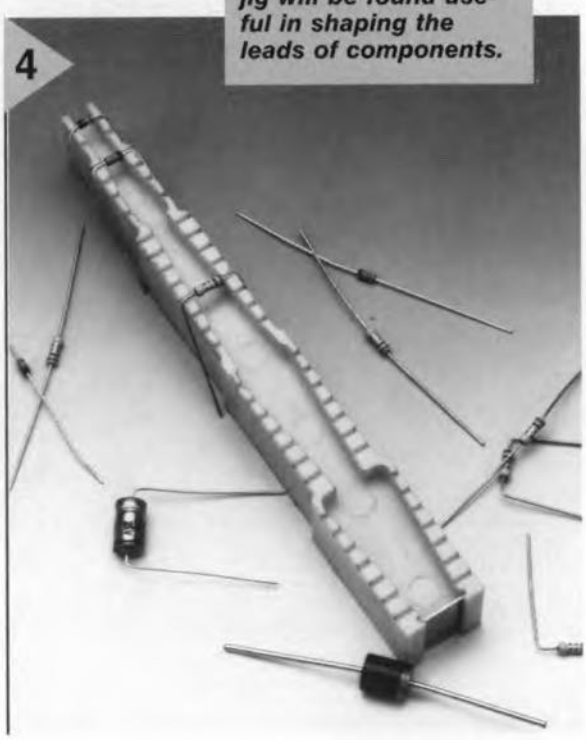
Since many manufacturers do not like every Tom, Dick and Harry to be able to open their equipment, this is often secured with torx screws, which may be of the security type or the tamperproof type. Special sets of drivers for these screws are available from most good ironmongers or mail-order firms (again, see the RS Components catalogue).

Other miscellaneous equipment that may be required comprise sets of differing length and differently terminated test leads and a rubber torch.

TEST EQUIPMENT

The testing of most electronic equipment requires a power supply, preferably of the variable output type. If the budget

Figure 4. This bending jig will be found useful in shaping the leads of components.



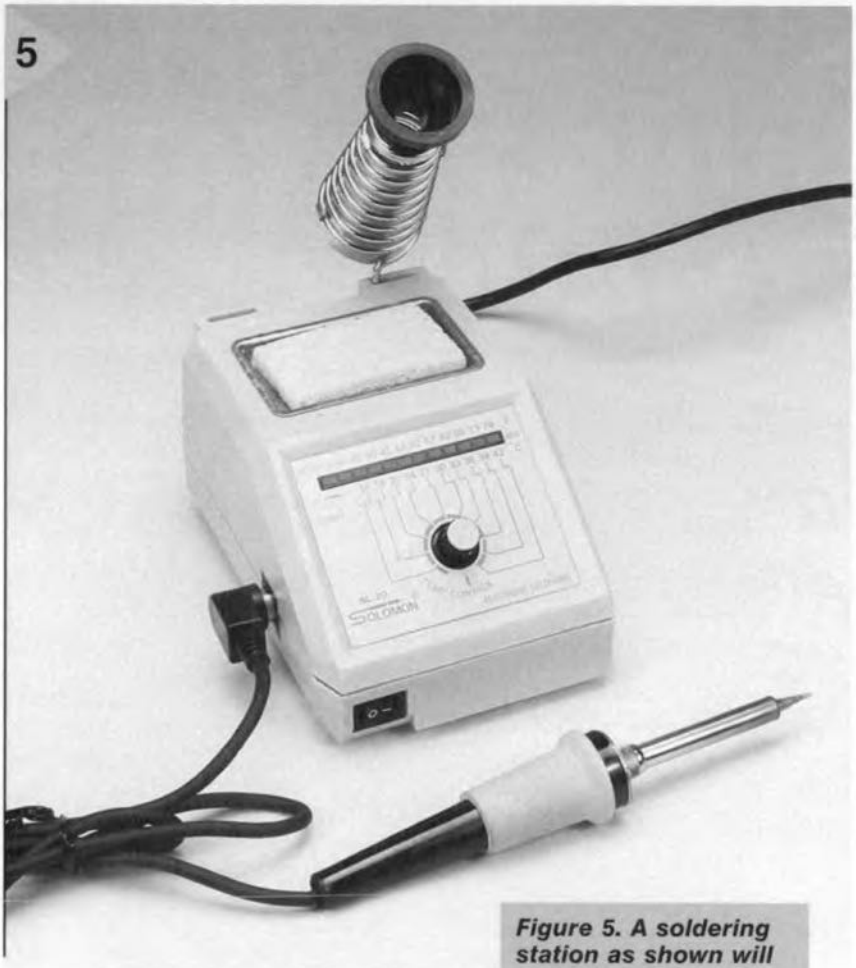


Figure 5. A soldering station as shown will give many years of trouble-free service.

does not permit this, use a good mains adaptor and a set of fixed voltage regulators like the 7805, 7809 and 7812. Most mains adaptors have such a high output resistance that they may be used for short-duration current limiting.

A (digital) multimeter is an absolute must. Bear in mind that the difference between an expensive and an economy type is often just the mechanical stability, the number of metering ranges, and the bandwidth (in alternating current and voltage measurements).

These are basic requirements. When the budget allows or the work necessitates, test equipment such as a

- Transistor checker
- Audio signal generator
- RF signal generator
- RC oscillator
- Logic analyser
- AF oscilloscope
- Dual-trace storage oscilloscope
- Accurate electronic thermometer
- Frequency meter
- Millivoltmeter
- Capacitance meter
- LCR meter
- Power meter

and others will be required, depending on the nature of the work.

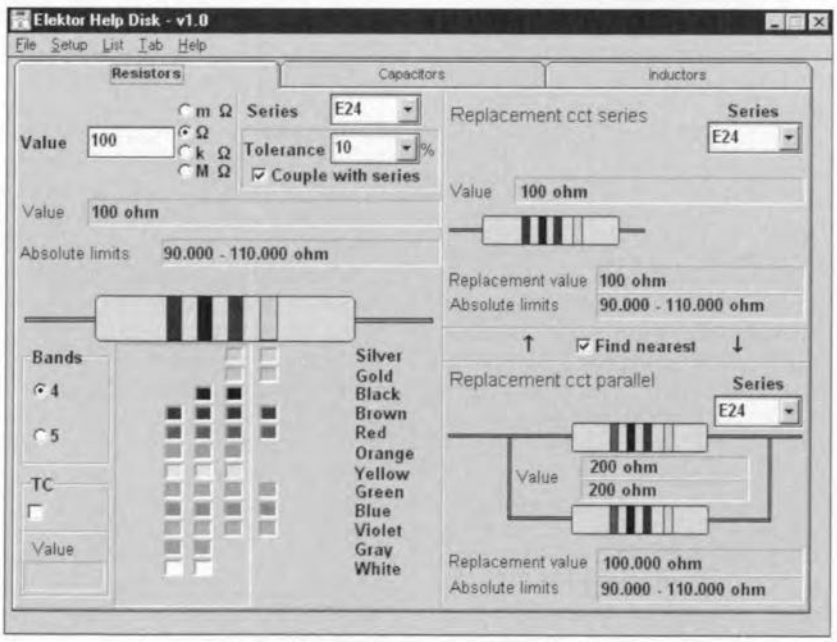


Figure 6. Screendump of the program 'Help-disc', a new product from Elektor Electronics available under Order no. 966022-1. It enables rapid decoding of resistor, capacitor and inductor colour codes.

ELEKTOR ELECTRONICS HELP-DISC

Not all electronics enthusiasts, technicians and engineers know all the colour codes for resistors, capacitors, inductors, and so on, by heart. So, they use a number of cards or a reference book to find out the value of a particular component. The new Elektor Electronics Help-disc contains a program that provides a fast and efficient way of identifying components on the basis of their colour code. Unfortunately, the disc is only available for Windows 3.1 or 95 programs (sorry all you Apple, Acorn and NT users!).

The program may also be used to compose non-standard resistor, capacitor or inductor values from a preset series, such as the E6, E12, E24, E48, E96. This is a boon when a circuit contains non-standard-value components which are therefore either not available or very expensive. The program shows on the monitor how such a component may be composed on the basis of the E24 series, in which close-tolerance components are also available.

The program also indicates within which limits the component value can vary. A screendump of the program is shown in **Figure 6**. This shows how a resistor of 490 Ω may be composed from two discrete resistors in the E24 series. Capacitors and inductors may be composed in a like manner.

No doubt, the disc will be found a useful addition to the many available data cards and reference books, particularly so since less well-known codes, such as those for the temperature coefficient or tolerance are catered for.

[970014]

monitor to guard fridge temperature

A useful aid in the kitchen



Every week the average housewife stores a fair amount of food in the refrigerator (colloq.UK: fridge). The low temperature in the fridge ensures that the food remains fresh for a couple of days at least. But what happens if the temperature in the fridge unbeknown to the family is not as low as it should be? There is then a risk of the food going off. This sort of situation may be avoided with the monitor described in this article. With the aid of three LEDs, it shows at a glance whether the inside temperature is too low, too high or right.

Design by H. Bonekamp

Keeping food fresh in a refrigerator (colloq. UK: fridge) depends on the temperature in the fridge being maintained at a correct temperature: 3–6 °C. This temperature range is selected with a variable thermostat. Some people set this thermostat once and then forget all about it until the food goes off or is retrieved half frozen.

This unfortunate situation may be avoided by the monitor described in this article. It provides a fast and efficient means of checking the temperature inside the fridge. Every time the fridge door is opened, the monitor is automatically switched on whereupon a green, yellow or red LED lights.

When the fridge door is closed, the monitor is automatically switched off again. Since the monitor in the quiescent state draws a current of only 1 μA, a single battery will power the unit for more than a year.

CIRCUIT DESCRIPTION

The circuit diagram of the monitor is shown in **Figure 1**. Although this may look more complex than expected, it is, in fact, fairly straightforward.

The temperature sensor, IC_1, provides a linear relationship of 10 mV °C^{-1} between the ambient temperature and its output voltage. Since its output is linked via R_3 to a negative potential of –0.6 V, temperatures down to 0 °C may be sensed.

The output of IC_1 is amplified ×28 by IC_2. The output of this op amp, available at pin 6, is applied to a comparator consisting of op amps C_{3a} and IC_{3b}. Offset compensation for IC_2 is provided by P_1 and R_6.

The comparator likens the output signal of IC_2 to a reference voltage that is representative of the ambient temperature. The reference is applied to pin 2 of IC_{3a}, and to pin 5 of IC_{3b}.

The reference voltage is produced by the circuit around stepped attenuator R_{12}–R_{21} and zener diode D_5. The diode is a precision type that holds its zener voltage stable over the temperature range of 0–70 °C.

Owing to the reference voltage, the circuit is relatively insensitive to the ambient temperature and to the battery voltage. The reference potential is divided by resistors R_{13}–R_{21} into nine steps of 280 mV each. It will be seen that this value corresponds to the change in voltage per °C at the output of the sensor amplified ×28. In other words, each step of the voltage divider represents 1 °C. The reference voltage of both IC_{3a} and IC_{3b} can therefore be set to a voltage corresponding to a temperature of 0, 1, 2...9 °C. The volt-

age representing the highest temperature permitted in the fridge is applied to pin 2 of IC_{3a}. When the output voltage of IC_2 exceeds this value (the fridge gets or is too warm), the output of IC_{3a} goes high, which results in D_3 (red) being actuated via R_8 and transistor T_4. The lighting of this diode indicates that action is required!

At the same time, pin 5 of IC_{3b} carries a voltage that is representative of the lowest permissible temperature in the fridge. If the temperature in the fridge drops below this value, the output of IC_{3b} goes high, whereupon D_2 (yellow) is actuated via R_9 and T_3. Again, the lighting of this diode means that the thermostat has to be reset, since too low a temperature is uneconomical and may also affect certain foodstuffs (taste!).

When the temperature is within the set range, transistors T_3 and T_4 are cut off, whereas T_5 and T_6 conduct. This results in D_4 (green) lighting to indicate that the temperature is correct.

Resistor R_7 is the common series resistor of the LEDs.

Ten-pole switches S_1 and S_2 make setting the minimum permissible temperature, t_{min}, and the maximum temperature, t_{max}, a simple matter.

1

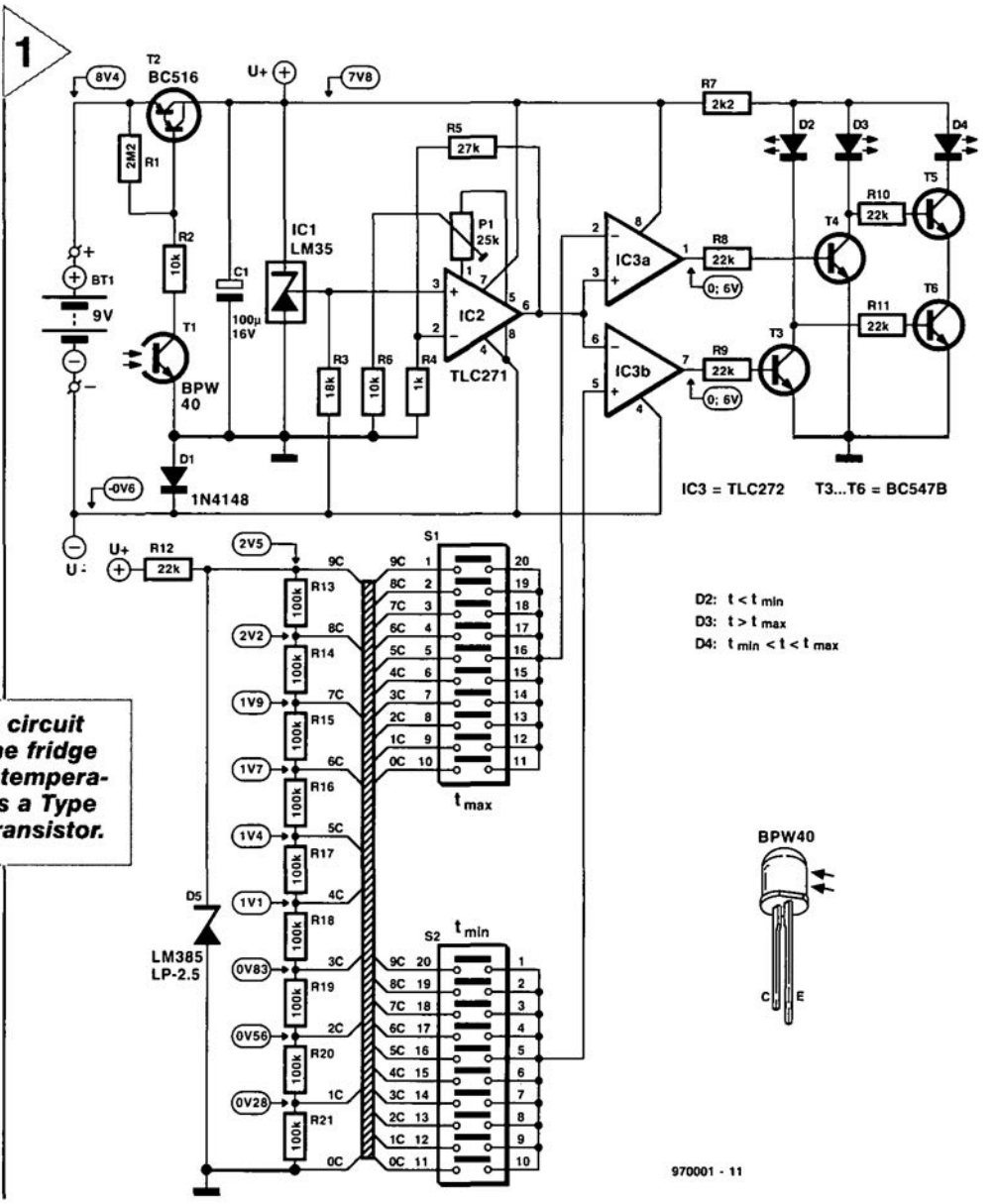


Figure 1. The circuit diagram of the fridge monitor. The temperature sensor is a Type LM35 phototransistor.

ELECTRONIC SWITCH-ON

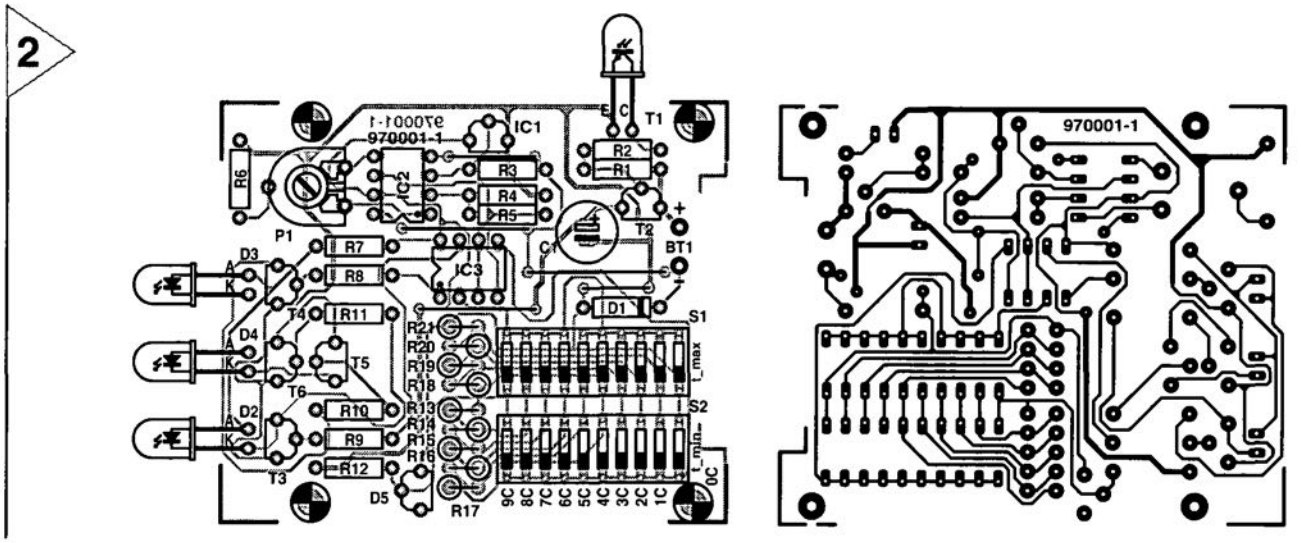
The LEDs need to light only when the door of the fridge is opened. This is arranged with an electronic on/off switch composed of phototransistor T_1 and darlington T_2. When the door is closed, the inside of the fridge is dark and T_1 is cut off. Its leakage current amounts to no more than 200 nA. The potential at the emitter and base of T_2 is then the same. This transistor is therefore also cut off and the supply to the monitor is switched off.

When the door is opened, the light inside the fridge comes on, whereupon T_1 conducts. Transistor T_2 then gets a base current and the supply to the monitor is switched on.

As mentioned before, IC_1 needs an auxiliary voltage and this is derived via

Figure 2. The printed-circuit board for the fridge monitor is available ready made.

2



Parts list

Resistors:
R_1 = 2.2 MΩ
R_2, R_6 = 10 kΩ
R_3 = 18 kΩ
R_4 = 1 kΩ
R_5 = 27 kΩ
R_7 = 2.2 kΩ
R_8–R_{12} = 22 kΩ
R_{13}–R_{21} = 100 kΩ
P_1 = 25 kΩ preset

Capacitors:
C_1 = 100 µF, 16 V, radial

Semiconductors:
D_1 = 1N4148
D_2 = LED, 3 mm, yellow, high efficiency
D_3 = LED, 3 mm, red, high efficiency
D_4 = LED, 3 mm, green, high efficiency
D_5 = LM385LP-2.5
T_1 = BPW40
T_2 = BC516
T_3–T_6 = BC547B

Integrated circuits:
IC_1 = LM35CZ
IC_2 = TLC271CP
IC_3 = TLC272CP

Miscellaneous:
S_1, S_2 = 10-pole DIP switch
Bt_1 = 9 V battery with connecting clips
Enclosure, PacTec HM-9VB [available from OK Industries (UK) Ltd, Unit 1, Barton Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants SO5 5RR. Telephone (01703) 619841; Fax (01703) 643279] or equivalent:
61 mm × 97 mm × 25 mm (w×d×h)
(2.4 × 3.8 × 1 in)
PCB Order no. 970001 (see Readers Services towards the end of this issue)

D_1. The cathode of this diode is at a potential of –0.6 V w.r.t. the earth of the monitor. The negative voltage is used as the supply voltage for IC_2 and IC_3 and at the same time makes it possible for the output of IC_1 to assume a negative value. This arrangement ensures that the monitor can operate down to 0 °C.

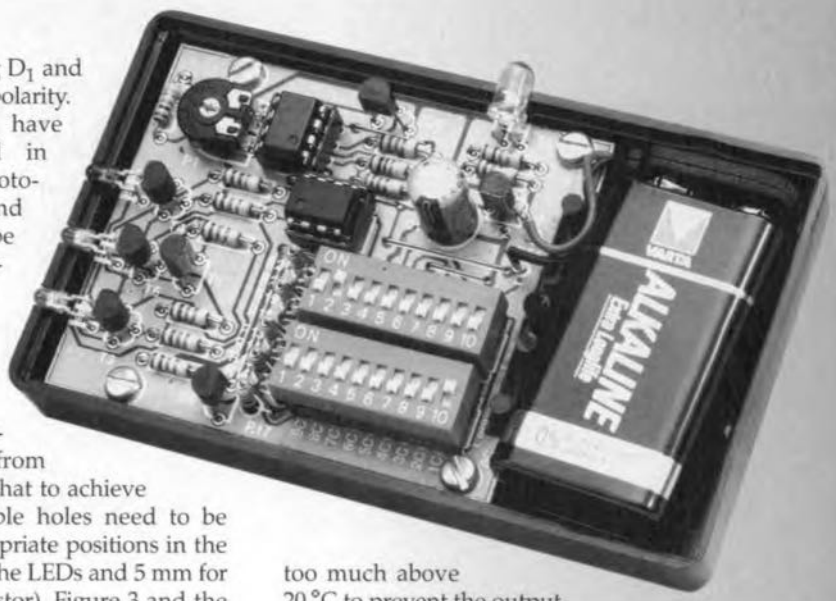
CONSTRUCTION

The monitor is best constructed on the printed-circuit board shown in **Figure 2**. The dimensions of this board enable it to be conveniently housed, together with the 9 V battery, in the case specified in the parts list.

Start by cutting out the recess near the battery terminals. Then, fit the five wire bridges, the preset potentiometer, the resistors, and the two DIP switches. Resistors R_{16}–R_{21} must be mounted upright: bend one of their terminals as required with a small pair of pliers.

When fitting D_1 and C_1, mind their polarity.

After they have been soldered in place, the phototransistor and D_2–D_4 must be bent at right angles in such a way that, when the board is fitted in the case, they protrude slightly from the case. Note that to achieve this four suitable holes need to be drilled in appropriate positions in the case (3 mm for the LEDs and 5 mm for the phototransistor). Figure 3 and the photograph of the completed prototype xshow what the final assembly looks like.



When the remaining transistors and the two ICs have been fitted, check the board thoroughly. When everything is found in order, the board can be fitted into the case, and connected to the 9 V battery. If everything is in good working order, the red LED should light. For most uses, it suffices to set P_1 to the centre of its travel, but some users may wish to calibrate the circuit to within 0.25 °C. To do this, connect a digital voltmeter (2 V d.c. range) between pin 6 of IC_2 and ground and place the entire assembly in the fridge. After about an hour, adjust P_1 to obtain a reading on the voltmeter that is equivalent in volts to 0.28 times the temperature in °C. Next, set the minimum temperature with S_2 and the maximum temperature with S_1. Close the case and place it near the light in the fridge. When next the door of the fridge is opened, one of the LEDs should light.

In the unlikely case that the monitor does not work properly, its operation may be checked with a multimeter. Connect the common lead of the meter to the emitter of T_1. Measure the voltage across C_1 when sufficient light falls on to T_1. This potential should be about 7.8 V and drop to 0 V when T_1 is covered. If this is not the case, T_1 or T_2 is faulty, but it is also possible that D_1 has been fitted with incorrect polarity.

Next, check the voltage at pin 3 of IC_2. At room temperature (about 20 °C), this should be around 200 mV. A potential equivalent to this voltage amplified ×28 should be present at pin 6 of IC_2, and pins 3 and 6 of IC_3. The ambient temperature should not be too much above 20 °C to prevent the output of IC_2 going into saturation.

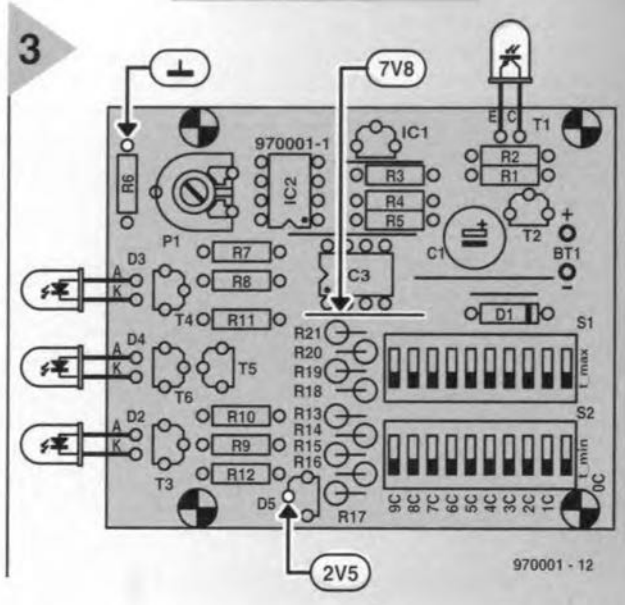
Then, check the operation of the comparators. Verify that the potential at their pin 2 can be set with S_1, and that at their pin 5 with S_2. If the voltage cannot be set, the reference source and/or the stepped attenuator do not work correctly.

Check that D_5 is connected with correct polarity. The correct potentials across the various resistors are shown in Figure 1.

Pins 1 and 7 of IC_3 should carry logic levels of 0 V and 6 V respectively. If that is so, and the monitor still does not work, one of transistors T_3–T_6 or of diodes D_2–D_4 is faulty.

[970001]

Figure 3. Drawing of the completed prototype PCB. Note that some test points have been identified.

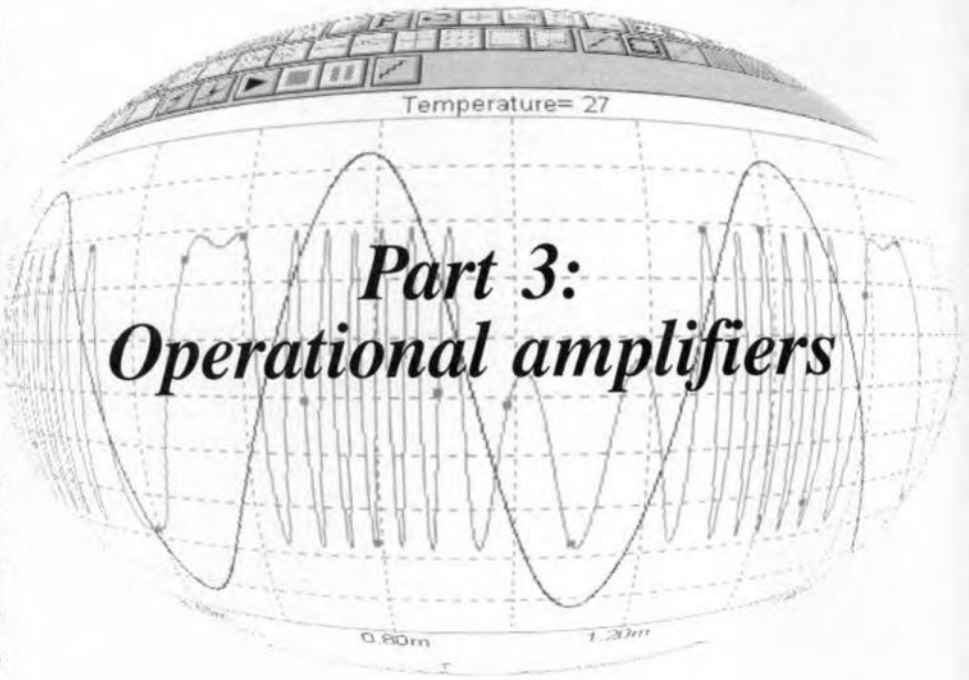


Circuit Simulation Course

ELEKTOR Electronics

HANDS-ON ELECTRONICS

a short course in circuit simulation



Part 3: Operational amplifiers

As we have seen in Part 2, the SPICE primitives, such as resistors, capacitors and voltage sources, are defined in a netlist by an appropriate code letter (R, C, V) followed by identifying numbers or letters, then by node connections and value. The exact syntax depends on the element and is more complicated for voltage sources and similar elements.

By Owen Bishop

MODELLING

A number of elements take MODEL names. In SPICE2, these are the elements with the code letters, D, NPN, PNP, NJF, PJF, NMOS and PMOS, whose identity is obvious from their codes. SPICE3 has a few more such elements including voltage and current-controlled switches and MESFETs. All of these elements need to be given model names, such as QONE, or 2N2222A, such as we used in netlists quoted last month. These names are quite arbitrary, for the convenience of the user. If several transistors are given the same model name, a single .MODEL statement in the netlist suffices to define the behaviour of all these transistors. If there are two or three different transistor types in the netlist, they are given two or three different model names and we need a .MODEL statement for each model name. The models referred to in these statements direct the computer to follow built-in sets of equations or algorithms which model the behaviour of that type of element in accordance with various parameters specified in the statement.

Neither SPICE2 nor SPICE3 has an op amp primitive. If you are using SPICE, rather than one of its commercial enhancements, you model an op amp as a sub-circuit. The simplest of these is a voltage-controlled source (**Figure 15**) which can be considered as an ideal model (ideal in the sense of being theoretical, not in the sense of being the best practical op amp for the job) because it has infinite input impedance, zero output impedance, and has a very high open-loop gain. The subcircuit to define such an op amp model is:

```
.SUBCKT OPAMP 1 2 3
E1   3 0 1 2 1E6
.ENDS OPAMP
```

The .SUBCKT line specifies the subcircuit name and lists the node numbers of the input and output terminals, as included in hexagons in **Figure 16**. Next comes the subcircuit netlist which, in this case, comprises only one component. E is the code for a voltage-controlled voltage source. The E1 line lists the node connections of the voltage source in order n+, n-, nc+, nc-, and the gain parameter. The output at n+ equals the difference between the voltages of the nc+ and nc- (control) inputs multiplied by the gain parameter. In this example, it is 1×10^6, equivalent to the open loop gain of the op amp. This is one of the simplest possible subcircuits, consisting as it does of only one element. Subcircuits may have a virtually unlimited number of elements.

In the main netlist below, which is the netlist of an inverting amplifier based on the op amp subcircuit, the name of the op amp begins with X, the code used for a subcircuit, followed by numbers or letters to differentiate between op amps if there is more than one. The subcircuit is called by its subcircuit name:

```
*INVERTING AMPLIFIER
XOA  0 2 1  OPAMP
R1   1  2  100K
R2   2  3  10K
R3   1  0  10M
V1   3   0  SIN (0 1 1K 0 0)
.END
```

You could enter this into MC5 as a netlist or as a schematic (**Figure 16**). Obtain the source E1 by Components

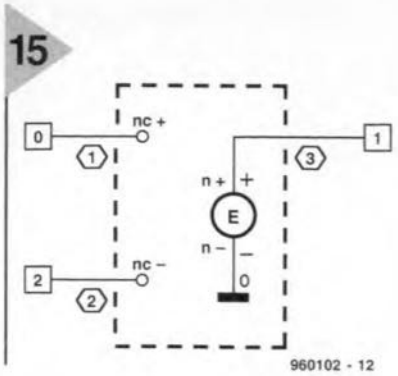


Figure 15. The numbers in the hexagons are listed in the SUBSKT line that specifies the subcircuit name.

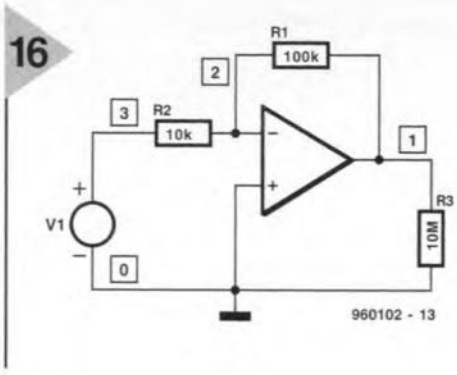


Figure 16. Circuit diagram of the inverting amplifier.

Analog Primitives Dependent Sources VofV. After placing it, enter VALUE = 1E6 in the Component window. R3 acts as a high-impedance load. When the circuit is complete, check its action by running a Transient Analysis for 5 ms and plotting both V(3) and V(1) against Time. Confirm that it acts as an inverting amplifier with closed-loop gain of 10, as illustrated in **Figure 17**. Observe the effects of varying R1 and R2, and the amplitude and frequency of V1.

Although this model behaves perfectly well with certain resistor values and input, it is not difficult to make it produce nonsensical results. Set R1 and R2 to give an open-loop gain of, say, ×100 and set the amplitude of V1 to 25 V. The output amplitude is 2500 V, which is obviously impossible. Change R3 to 2Ω and you can draw as much as 5A from its output at 10 V. At 1 MHz, the open loop gain is still ×106, whereas with a real op amp it would have dropped to around ×1 at that frequency. Some of these deficiencies can be eliminated by adding further components to the subcircuit. Add resistors to simulate input and output impedance, as well as input bias current. Add a capacitor to reduce the gain at high frequency. Add diodes to limit the output voltage swing to realistic values. The more additions, the more accurately it models a real op amp. On the other hand, the more additions, the longer the computer takes to calculate its behaviour in each cycle of the analysis.

At the other extreme, it is possible to model an op amp exactly with a netlist which includes all the components of an actual op amp circuit. It will have about 30 nodes and to include even one such detailed model in a netlist increases analysis time significantly. A compromise is reached by designing a netlist which does not follow the layout of the actual op amp circuit but, by including controlled voltage sources (not present in real op amps), behaves almost exactly like a real op amp, even though the number of elements and nodes in it are fewer than 20.

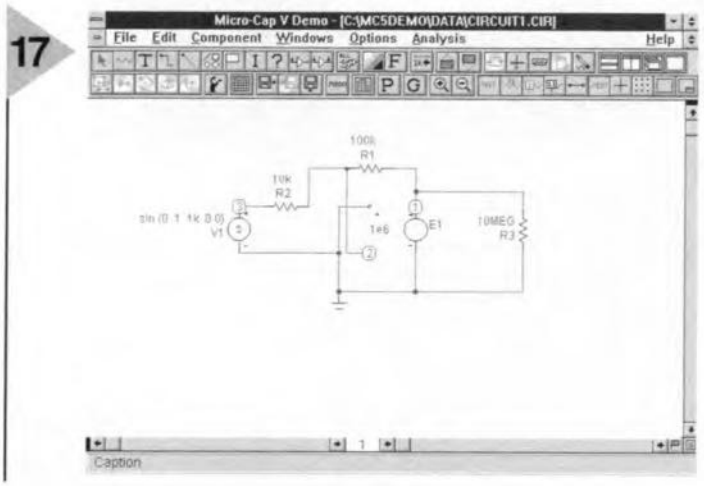
MC5 OP AMPS

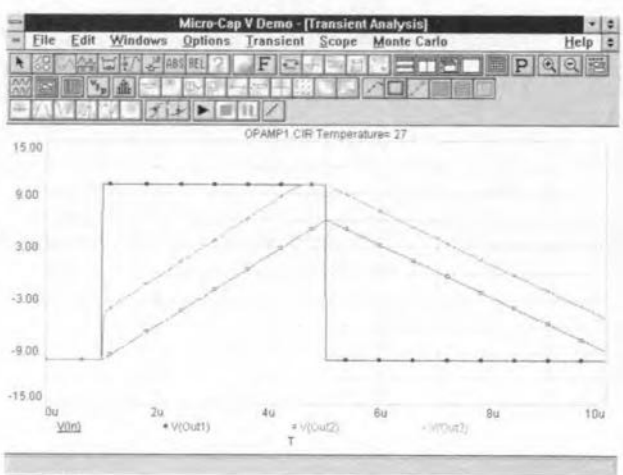
MC5 and most of the other enhancements of SPICE have their own inbuilt op amp models. There is no need to invent netlists to simulate an op amp. An op amp is called up simply by using the op amp model and defining its parameters, just as you would call up a SPICE transistor model. Examples of these are provided in the MC5 file OPAMP1.CIR, which is loaded in a new schematic window by File Open opamp1.cir. This is a demonstration of 3 different op amp models, all fed with a single pulse from a generator. The op amps are connected as voltage followers, so their outputs should theoretically follow the input exactly. Run a Transient Analysis to see what happens (**Figure 18**). The square input pulse and the square pulse from the output of op amp 01 (the ideal model) are coincident. This might be thought to be just what is expected, but note that this is a pulse of very short duration and a real op amp could not follow such rapid voltage changes because of the limitations of slew rate. The two-pole model (02, hollow square tokens on the curve) has a more realistic response but fails to reach 10V before the pulse ends. The Boyle model (03, cross tokens) has a sharp initial upsurge as the pulse begins, allowing it to reach 10 V just before the pulse ends. Here we have three models with three degrees of resemblance to a real op amp.

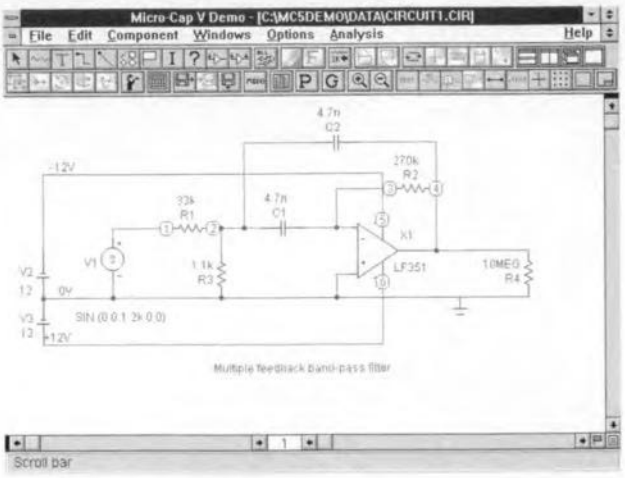
Returning to the Schematic window, look at these models in more detail by reading their model statements on the text screen (click on the bottom right corner of the Schematic window). The models are named 01, 02 and 03 respectively and they all have the same model type, OPA (meaning operational amplifier). Their parameters begin with a statement of level: 1, 2 or 3. Model 01 is level 1 and has the fewest parameters; consequently, it is

Figure 17. Schematic of the diagram in Figure 16.

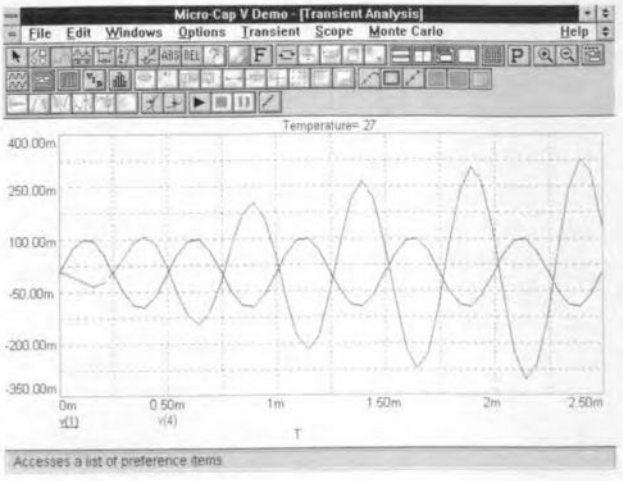
Figure 18. Transient analysis to follow the action of an op amp.







19



20

Figure 19. Active filter based on an operational amplifier.

Figure 20. Transient analysis to verify that the active filter is working correctly.

the least realistic but the fastest to run, so it is useful, but in a limited rage of situations. Its parameters specify only open loop gain, and output impedance under DC and AC conditions. Model 02 specifies the same parameters as 01 and, in addition, positive and negative slew rates, gain bandwidth and phase margin. The importance of modelling slew rate has already been noted in Fig. 18. Finally, model 03 has the same specification as the two previous models and also offset voltage, input bias current and common mode rejection ratio.

Try editing some of the parameters of these models and observe how their action is affected. Also edit the schematic to replace the pulse generator with a sine generator; vary its frequency. Finally, edit the circuit to obtain some of the standard op amp configurations, such as inverting amplifier, non-inverting amplifier, and integrator. Discover how well (or how badly) these circuits work.

Given a set of data sheets which specifies the parameters, it is possible to construct an op amp model that has the characteristics of any given manufacturer's type. MC5 has a library of models which may be used when high precision modelling is required. For example, click on Component → Analog Library → Op Amp → LF0000- → LF147- → LF347. An op amp symbol appears on the cursor which you can position as required. Click on the Select Arrow, then double click on the op amp symbol. In the Components window, check the Display box so the op amp type number is displayed on the schematic. You can optionally check the Display Pin Names box to have the names of all the op amps pins displayed on the schematic, but they often make it difficult to see the connections clearly. To examine the parameters of the .MODEL statement, click on Edit Add Model Statements bottom right of window Text Area with model statements displayed. Here we find, among other things, that the DC open loop gain of the LF347 model is ×105, its input bias current is 50 pA, and its input offset voltage is 5 mV.

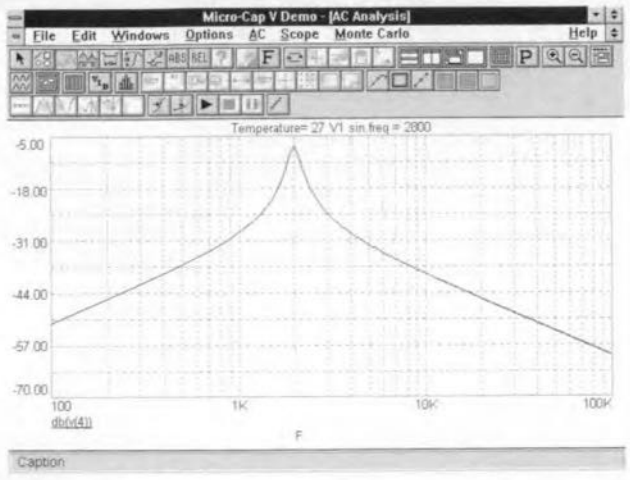
ACTIVE FILTER

Figure 19 is an active filter based on an op amp. With only one op amp in the circuit, there is no need to worry about how long the analysis will take. So we can use a level 3 model based on a particular type. We have chosen the LF351, an op amp with JFET inputs and a high slew rate (13 V/μs). The circuit operates by multiple feedback to produce a band-pass filter. The values in Fig 20 are calculated for a centre frequency f_c of 2 kHz, but using the nearest standard values instead of the exact calculated values. Using standard values for resistors and capacitors is convenient, but to what extent does this move the filter off the required f_c ? This filter can be tuned to a given fc by adjusting R3, so what value must R3 have to bring fc exactly to 2 kHz? The component values are calculated to give a filter with 250 Hz bandwidth and a gain of ×4, and we must confirm that it meets these specifications.

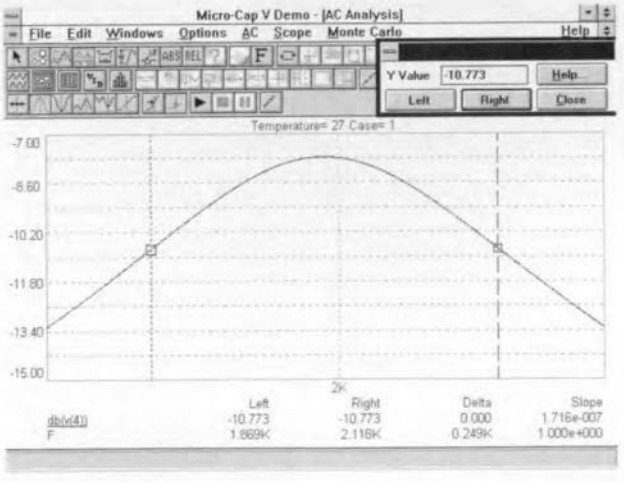
First set up the circuit; for the op amp, go to the Analog Library as described above. Note that the op amp symbol is drawn so that the (+) input is above the (-) input when the op amp 'points' toward the right. The circuit layout is clearer with the op amp turned the other way up (press the right mouse key a few times), but now

Figure 21. AC analysis of output amplitude variations with frequency.

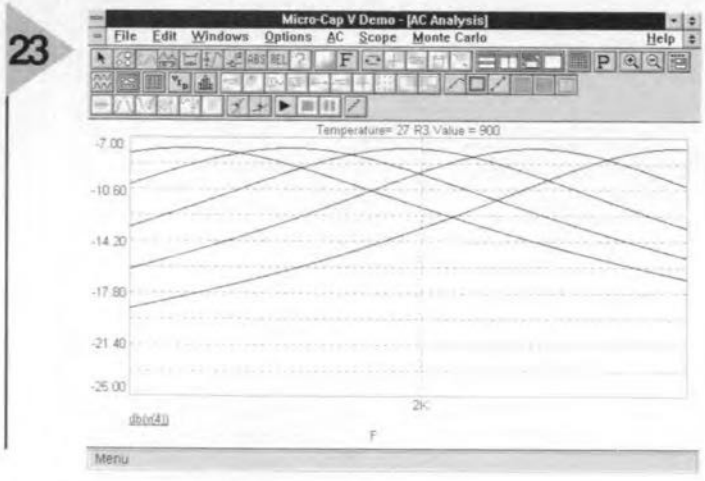
Figure 22. Placing the cursors appropriately enables the two cut-off frequencies, and thus the bandwidth, the be read.

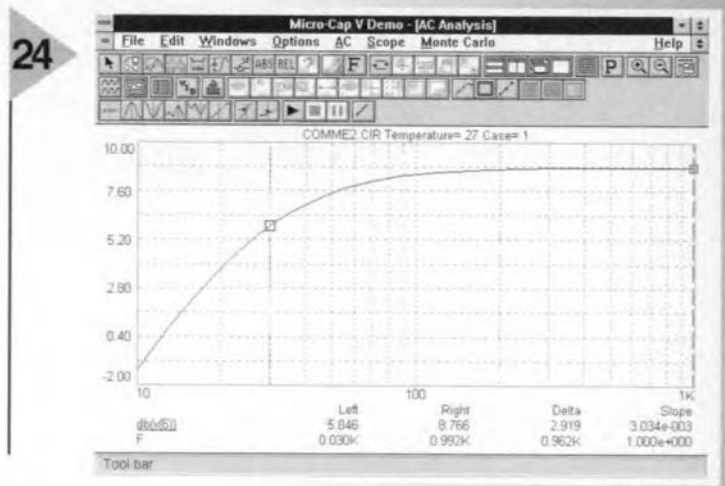


21



22





Figurer 23. Curves obtained by sweeping component values over a given range in steps of a given size.

Figure 24. Low-frequency response of an amplifierin answer to the Investigation in Part 2

we have to invert the battery connections. To remind us of this, we have labelled the power leads. Click on the text 'T' key, then click on the point where the text is to be printed. An entry panel appears; type in the text, then OK.

Check that the circuit is working properly by running a Transient Analysis. A suitable time range is 2.5 ms. Plot V(1) and V(4) against time. The result is **Figure 20**; The amplitude of V(1) is constant, but that of V(4) increases steadily. Does this trend continue or is it simply due to the capacitors gaining charge during the first few cycles? Running the analysis for 20 ms shows that the amplitude of V(4) stabilises at 346 mV after about 4 ms, a gain of ×3.45, rather lower than the design specification.

To investigate how output amplitude varies with frequency, try an AC analysis. First add 'AC 0.01 0' to the parameters of V1. Set the Frequency Range to '100k,100', the number of points to 1001. To obtain a smooth curve, under Frequency Step, select Fixed Linear. This allows 1001 points to be plotted, instead of the number being limited by the 5% Maximum change. Check the Auto Scale Ranges box. Plotting db(V(4)) against F, gives **Figure 21**. This is shown here in Cursor mode and we have clicked the 'Advance to Global High' button, and clicked the left mouse key to bring the left cursor to the peak of the response curve. This is read as 1.990 K, which is close to the required value of 2 kHz. The magnitude is –7.773 dB. To find the bandwidth, we must determine the Y-values at points 3 dB below this peak, that is, at –10.773dB. Clicking the 8th button from the left puts the cursor into the mode in which it automatically seeks a given Y-value. Click on the Left button, then the Right button (twice if necessary) to place cursors either side of the peak (**Figure 22**). Below the graph we read off the X-value of the left cursor, which is 1.869 kHz, and the value for the right cursor, which is 2.118 kHz. The bandwidth is 2118–1869 = 249 Hz, impressively close to the required 250 Hz.

STEPPING

One of the useful features of a simulator is the ability to step or sweep component values over a given range in steps of a given size. This is so much more convenient than experimenting by desoldering and resoldering, or by plugging a series of components of a range of values into a breadboard. We use the Stepping facility to tune the filter response to exactly 2 kHz, by varying R3. In AC analysis, click on the Stepping button, which brings up the Stepping window. First of all Step What; the selector button at the right displays a list of steppable components; select R3. The box below shows what parameter(s) can be stepped, in this case only its Value. In the next 3 boxes enter the From, To, and Step Value. Try 900, 1300 and 100. Click the radio buttons for Status On, Method Linear, and Type Component, then OK. This enables stepping, in which the analysis is automatically repeated for each of the 5 steps. Reduce the Frequency Range to '2.2k, 1.8k' to obtain a closer view of the response and run the analysis (**Figure 23**). The 3rd curve (from the right) is best, centred on 2 kHz; this is the curve for R3 = 1100 Ω. Note that the peak output is unchanged because tuning has no effect on gain in this circuit. It has no effect on bandwidth either. From now on, we reduce the frequency range and the stepping range to home on a value for R3 which produces exactly 2 kHz. Soon it becomes clear that the value is somewhere between 1085 Ω and 1095 Ω. If we run without stepping, with R3 = 1085 Ω and again with R3 = 1095 Ω, we obtain peaks at 2.003 kHz and 1.994 kHz respectively. Interpolating gives the best value for R3 as 1.088 kΩ.

Temperature is another quantity that can be stepped. In the Limits window, enter the temperature as 'maximum, minimum, step'. For example '0, 100, 10' means step from 0 °C to 100 °C in steps of 10 degrees. In this circuit, such a range makes virtually no difference to output. Finally, we can step component values within their normal tolerance ranges.

ANSWERS TO INVESTIGATION (2)

Last month's investigation concerned improving the low-frequency response of an amplifier. Altering C1 or C2 makes virtually no difference, but increasing C3 has a marked effect. This stabilises the emitter voltage more strongly, preventing the low frequencies being lost to ground. The best response is with C3 = 330 μF as in **Figure 24**. The plotted Frequency Range is reduced to 10 Hz–1 kHz, the region of interest. Output at Node 6 is plotted on a decibel scale. Using Cursor mode, place the right cursor as far as possible to the right, to read the maximum output level (8.766 dB). Place the left cursor on 30 Hz, the lowest frequency to be passed. The level of this is and the Delta column shows that this is 2.919 dB below the maximum, close enough to -3 dB, and using a capacitor of standard value.

INVESTIGATION (3)

The circuit of Fig 20 is set up with these values: R1 = 3.6 kΩ, R2 = 22 kΩ, R3 = 36 Ω, R4 = 10 MΩ, C1 = C2 = 1 nF. Find the centre frequency f_c, the bandwidth, and the gain at f_c.

[960102-III]

DS 1620

Sensors/Transducers

ELEKTOR ELECTRONICS

DATASHEET 01/97

Digital thermometer and thermostat

Manufacturer
Dallas Semiconductor, 4401 South Beltwood Parkway, Dallas, TX 75244-3292, U.S.A. Tel. 214-450-448, fax 214-450-0470. Internet: www.dalsemi.com.

DALLAS SEMICONDUCTOR

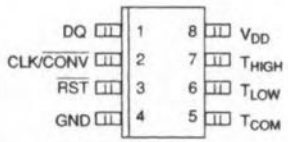
Description
The DS1620 Digital Thermometer and Thermostat provides 9-bit temperature readings which indicate the temperature of the device. With three alarm outputs, the DS1620 can also act as a thermostat. T_{HIGH} is driven high if the DS1620's temperature is greater than or equal to a user-defined temperature TH. T_{LOW} is driven high if the DS1620's temperature is less than or equal to a user-defined temperature TL. T_{COM} is driven high when the temperature exceeds TH and stays high until the temperature falls below that of TL.
User-defined temperature settings are stored in non-volatile memory, so parts can be programmed prior to insertion in a system, as well as used in standalone applications without a CPU. Temperature settings and temperature readings are all communicated to/from the DS1620 over a simple 3-wire interface.

Application
Digital thermostat, *Elektor Electronics* January 1997.

Features
- Requires no external components
- Measures temperatures from −55°C to +125°C in 0.5°C increments
- Temperature is read as a 9-bit value
- Converts temperature to digital word in 1 second
- Thermostatic settings are user-definable and non-volatile
- Data is read from/written via 3-wire serial interface (CLK, DQ, $\overline{RST}$)
- Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system
- 8-pin DIP or SOIC package

Pin description

DQ	3-wire input/output
CLK/$\overline{CONV}$	3-wire clock input and standalone convert input
$\overline{RST}$	3-wire reset input
GND	ground
T_{HIGH}	high temperature trigger
T_{LOW}	low temperature trigger
T_{COM}	high/low combination trigger
V_{DD}	power supply voltage (+5V)



DS1620S

Temperature/data relationships

Temp	Digital Output (binary)	Digital Output (hex)
+125°C	0 11111010	00FAh
+25°C	0 00110010	0032h
½°C	0 00000001	0001h
0°C	0 00000000	0000h
−½°C	1 11111111	01FFh
−25°C	1 11001110	01CEh
−55°C	1 10010010	0192h

CNY65

Opto Semiconductors

ELEKTOR ELECTRONICS

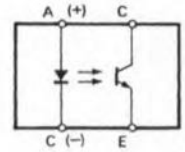
DATASHEET 01/97

Optically-coupled isolator

Manufacturer
Temic (Telefunken) Semiconductors, Theresienstr. 2, D-74072 Heilbronn, Germany.
UK sales office tel. (01344) 485757.
Internet: www.temic.de

TEMIC

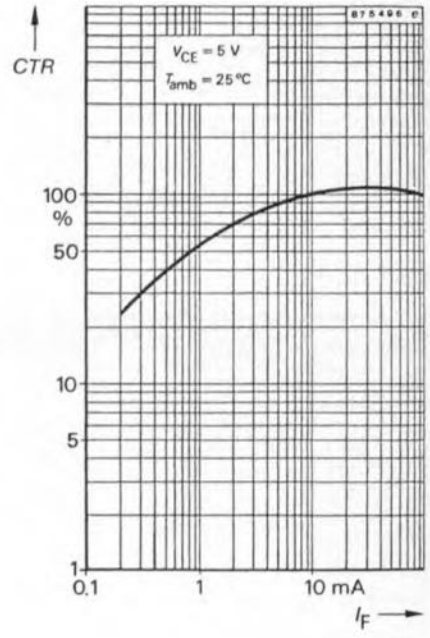
Pin connections



Applications
- In intrinsic safety circuits
- In electrical apparatus used in potentially explosive atmosphere

Application Example
Battery-operated Preamplifier, *Elektor Electronics* January 1997.

Features
- Suitable for intrinsic safety circuits according to test certificate no. Ex-81/2158 of PTB
- Nominal isolating operating voltage according to VDE 0110 B72.79: Group B 1000 VAC/1200 VDC, Group C 750 VAC/900 VDC
- Isolation material according to UL94-Flammability class
- Low temperature coefficient of CTR
- Creeping current resistance of isolation material according to VDE 0303/DIN 53480; KC ≥ 475
- Isolation test voltage 11.6 kV
- Test class 25/100/21 DIN 40045
- Very low coupling capacity (typ. 0.2pF) gives high noise immunity
- Current Transfer Ratio (CTR) = 50 to 300%



Electrical characteristics (T_{amb} = 25°C)			Min.	Typ.	Max.	Units
Emitter						
Forward voltage	I_F = 50 mA	V_F		1.25	1.6	V
Breakdown voltage	I_R = 100 µA	$V_{(BR)}$	5			V
Detector						
Collector emitter breakdown voltage	I_C = 1 mA	$V_{(BR)CEO}$	32			V
Emitter collector breakdown voltage	I_E = 100 µA	$V_{(BR)ECO}$	7			V
Collector dark current	V_{CE} = 20 V, I_F = 0, E = 0	I_{CEO}			200	nA
Coupled device						
DC isolation test voltage	t = 1 min	V_{is}	11.6			kV
Isolation resistance	V_{IO} = 1 kV, 40% rel. hum.	R_{is}		10^{12}		Ω
Collector current	V_{CE} = 5 V, I_F = 10 mA	I_C	5.0	10	30	mA
Current transfer	V_{CE} = 5 V, I_F = 10 mA	CTR	50	100	300	%
Collector saturation voltage	I_F = 10 mA, I_C = 1 mA	V_{CEsat}			0.3	V
Cut-off frequency	V_{CE} = 5 V, I_F = 10 mA, R_L = 100Ω	f_c	110			kHz
Coupling capacity	f = 1 MHz	C_k		0.3		pF

Switching characteristics			Min.	Typ.	Max.	Units
V_S= 5V, I_C= 5mA, R_L= 100Ω *						
Delay time	t_d			2.6		µs
Rise time	t_r			2.4		µs
Turn-on time	t_{on}			5.0		µs
Storage time	t_s			0.3		µs
Fall time	t_f			2.4		µs
Turn-off time	t_{off}			3.0		µs
V_S= 5V, I_F= 10mA, R_L= 1kΩ *						
Turn-on time	t_{on}			25		µs
Turn-off time	t_{off}			42.5		µs

* V_S = transistor supply voltage; I_C = transistor collector current; R_L = transistor emitter resistor

Operation — reading temperature

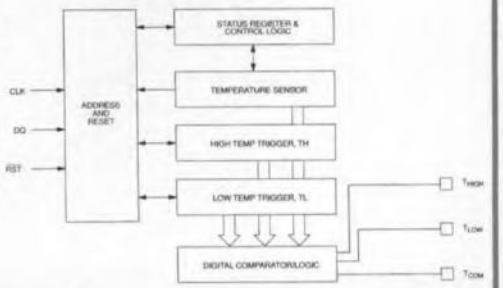
The DS1620 measures temperature through the use of an onboard, proprietary temperature measurement technique. The temperature reading is provided in a 9-bit 2's complement format. The table describes the exact relationship of output data to measured temperature. The data is transmitted serially through the 3-wire serial interface, LSB first. The DS1620 can measure temperature over the range −55°C to +125°C in 0.5°C increments. For Fahrenheit usage, a lookup table or conversion factor must be used.
Since data is transmitted over the 3-wire bus LSB first, temperature data can be written to/read from the DS1620 as either a 9-bit word (taking $\overline{RST}$ low after the 9th (MSB) bit), or as two transfers of 8-bit words with the most significant 7 bits being ignored or set to zero, as illustrated in the table. After the MSB, the DS1620 will output 0's.

Note that temperature is represented in the DS1620 in terms of a ½°C LSB, yielding the following format:

MSB	LSB
x x x x x x x 1	1 1 0 0 1 1 1 0

for T = −25°C.

Functional block diagram

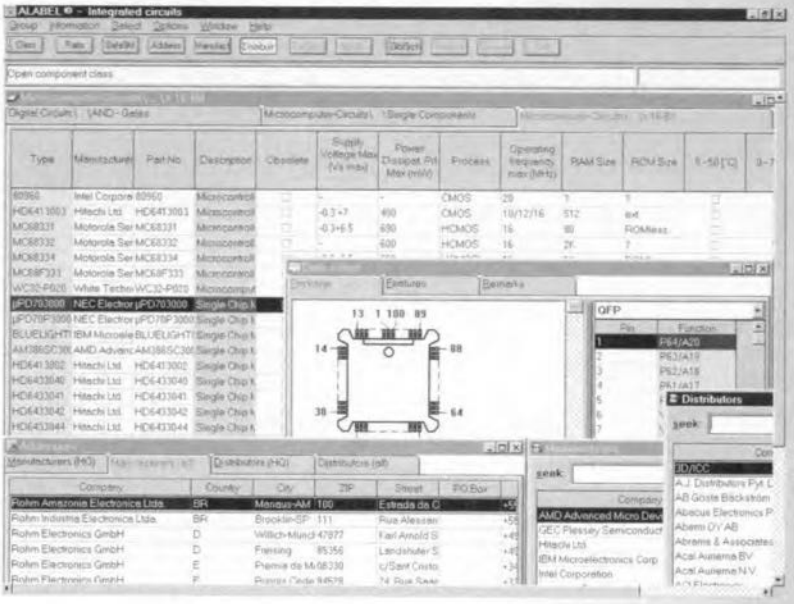


Command Set				
Instruction	**Description**	**Protocol**	**3-wire bus after issuing protocol**	**Notes**
Temperature conversion commands				
Read Temperature	Reads last converted temperature value from temperature register	AAh	<read data>	
Start Convert T	Initiates temperature conversion	EEh	idle	1
Stop Convert T	Halts temperature conversion	22h	idle	1
Thermostat commands				
Write TH	Writes high temperature limit value into TH register	01h	<write data>	2
Write TL	Writes low temperature limit into TL register	02h	<write data>	2
Read TH	Reads stored value of high temperature limit from TH register	A1h	<read data>	2
Read TL	Reads stored value of low temperature limit from TL register	A2h	<read data>	2
Write Config	Writes configuration data to configuration register	0Ch	<write data>	2
Read Config	Reads configuration data from configuration register	ACh	<read data>	2

Notes:
1. In continuous conversion mode, a Stop Convert T command will halt continuous conversion. To restart, the Start Convert T command must be issued. In one-shot mode, a Start Convert T command must be issued for every temperature reading desired.
2. Writing to the E^2 requires 10ms at room temperature. After issuing a write command, no further reads or writes should be requested for at least 10ms.

ALABEL *the electronic components bible*

Alabel stands for **All About Electronics**, and fully lives up to the expectations implied by its name. From NOVA Electronics, this CD-ROM seems poised to supersede established products like IC-FINDER and COMPFINDER-I.



Both IC-FINDER and COMPFINDER-I address only a section of the electronic components market, the former helping you to locate integrated circuits, and the latter, passive parts. Alabel does not pretend to substitute a classic datasheet book. On a single CD-ROM, Alabel presents the main characteristics of electronic components produced by the world's largest manufacturers. The CD-ROM should be invaluable to the professional engineer since it may save a lot of time spent on locating the right product, its distributor, etc. The CD-ROM contains:

- ✓ > 9.5 million individual components
- ✓ > 900 worldwide operating manufacturers
- ✓ > 2,750 manufacturer addresses
- ✓ > 7,750 distributor addresses

For every DM (Deutschmark) of the cost of the CD-ROM, you get 11,904 components, the addresses of 3.4 manufacturers and those of 7.2 distributors. We spent several hours actually making use of the information on the CD-ROM.

The database used by Alabel is divided into four groups: integrated circuits, discrete semiconductors, electromechanical parts and passive parts. The first three sub-units run under Windows 3.1 or 95, the last one, under DOS. The current version of Alabel supplies 298 manufacturers for the first group, 2,316 distributors, 46,240 basic integrated circuits. The second group offers 64 manufacturers, 625 distributors and 17,526 families. The third group comprises 107 manufacturers, 493 distributors and 33,994 families. The fourth group, finally, comprises 285 manufacturers, 1,114 distributors and 18,241 families.

Considering that you are looking at a vast amount of data held in stock by Alabel, it is not surprising to note that the minimum requirement as regards the PC is a 386SX/33, although a 486DX-50 is recommended. The minimum amount of free hard disk space is 9 Mbytes.

One of the essential aspects of this type of library, the first of this size we have seen so far, it that it is up to date. We were surprised to note, therefore, that the CD-ROM does not list the 686 processor, from IBM or Cyrix, or even the 586. This may be explained, however, by the fact that the CD-ROM we had available was dated May 1996, and that such massive amounts of data as supplied by Alabel take a bit of time to update.

A large portion of the information will be updated for the new version of Alabel which should be available by the time this magazine is out (this article was written early November 1996). Moreover, all sections will then run under the Windows operating system.

The supplier, Nova Electronics, plans to produce two updates per year, one in April, and one in November. This interval seems to be an acceptable compromise between, on the one hand, the need to update the product frequency in view of rapid changes taking place in the field of electronics, and, on the other hand, the cost of producing an update. The need to come up with updates is, however, obvious considering that the number of manufacturers contained in the database is expected to grow from just over 900 to a solid 1,500 whose total product line will comprise over 10 million electronic components.

The search engine used by Alabel has numerous entry points: component selection on the basis of type number, functional group, parameter specifications, functional description and manufacturer. It is possible to search for equivalents, define one with the aid of its enclosure, its dimensions, or its pinout. Alternatively, you may track down the distributor addresses, etc.

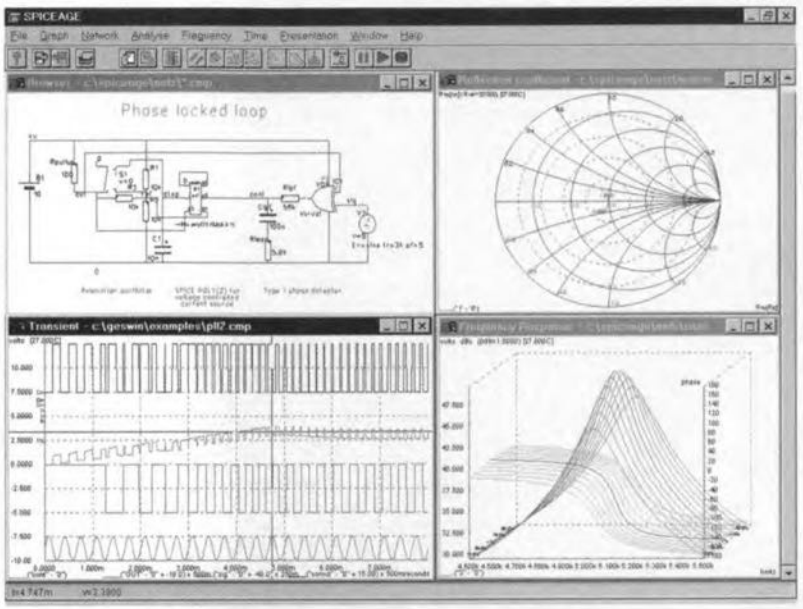
Unfortunately, there is no distributor of the Alabel CD-ROM in the United Kingdom. Interested readers may, however, obtain the product from NOVA Elektronik, Inc., 3741 Venture Dr., Suite 335, Duluth, GA 30136, USA. Tel. +1 770 232 4515, fax +1 770 497 0784.

In conclusion, Alabel represents a reference work of a power never seen before. Unfortunately, the price of this CD-ROM will be too high for the average hobbyist, but certainly not for companies, even small ones. A 20% discount is available on the cost of each CD-ROM if you take it by subscription.

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SpiceAge for Windows V5.070 released

Version 5.070 of SpiceAge, the all-European electronic circuit simulator that was first coded in 1985, is now in the second phase of its 5th major release.



New features include

- S parameter defined networks (Y parameters also)
- Smith chart presentations
- Signal convolution
- 300 dB of Fourier resolution
- Maths functions and variable names supported within components
- Statistics of Monte Carlo tolerancing available
- Compatible with Open University computerised generator-'scope
- Multiple netlist windows

In an example provided with SpiceAge, S parameters are taken from Philips semiconductor data for a BFR90 r.f. transistor. This is represented by SpiceAge's new NPORT multiport network component. The S parameters may be read directly from the data files supplied by the manufacturer or may be written alongside the NPORT component. A Smith chart is presented for the reflection coefficients of the circuit matched by the transistor.

The Smith chart presentations illustrate the plotting either of reflection coefficients from a single frequency or over a range of frequencies. Digital readouts geared to the large crosshair cursor enable the frequency and x and y co-ordinates to be traced. Smith charts are an invaluable matching tool for r.f. designers.

For further details, contact

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Email:
100550.2455@compuserve.com

(967147)

COP8 8-bit OTPs

The COPSAx OTP microcontrollers are members of the COP8TM feature family using an 8-bit single chip core architecture. These devices are fabricated in National Semiconductor's high-density EPROM process, and offered on a variety of packages, temperature ranges and voltage ranges to satisfy a wide variety of applications.



Key features include an 8-bit memory mapped architecture, a 16-bit timer/counter with two associated 16-bit registers supporting three modes (Processor Independent PWM generation, External Event counter and Input Capture capabilities), two power saving HALT/IDLE modes with a multi-sourced wakeup/interrupt capability, high current outputs, user selectable options such as WATCHDOG™, Oscillator configuration, and power-on-reset.
The program memory consists of 1024, 2048, or 4096 bytes of EPROM. The program memory is addressed by the 15 bit program counter (PC). All interrupts in the device vector to program memory location 0FF Hex. The contents of the program memory read 00 Hex in the erased state.
The data memory address space includes the on-chip RAM and data registers, the I/O registers (Configuration, Data and Pin), the control registers, the MICROWIRE/PLUS SIO shift register and the various registers, and counters associated with the timers (with the exception of the 1 DLE timer). Data memory is addressed directly by the instruction or indirectly by the B, X and SP pointers.

National Semiconductor Corp., P.O. Box 58900, Santa Clara, CA 95052-8090, U.S.A.

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