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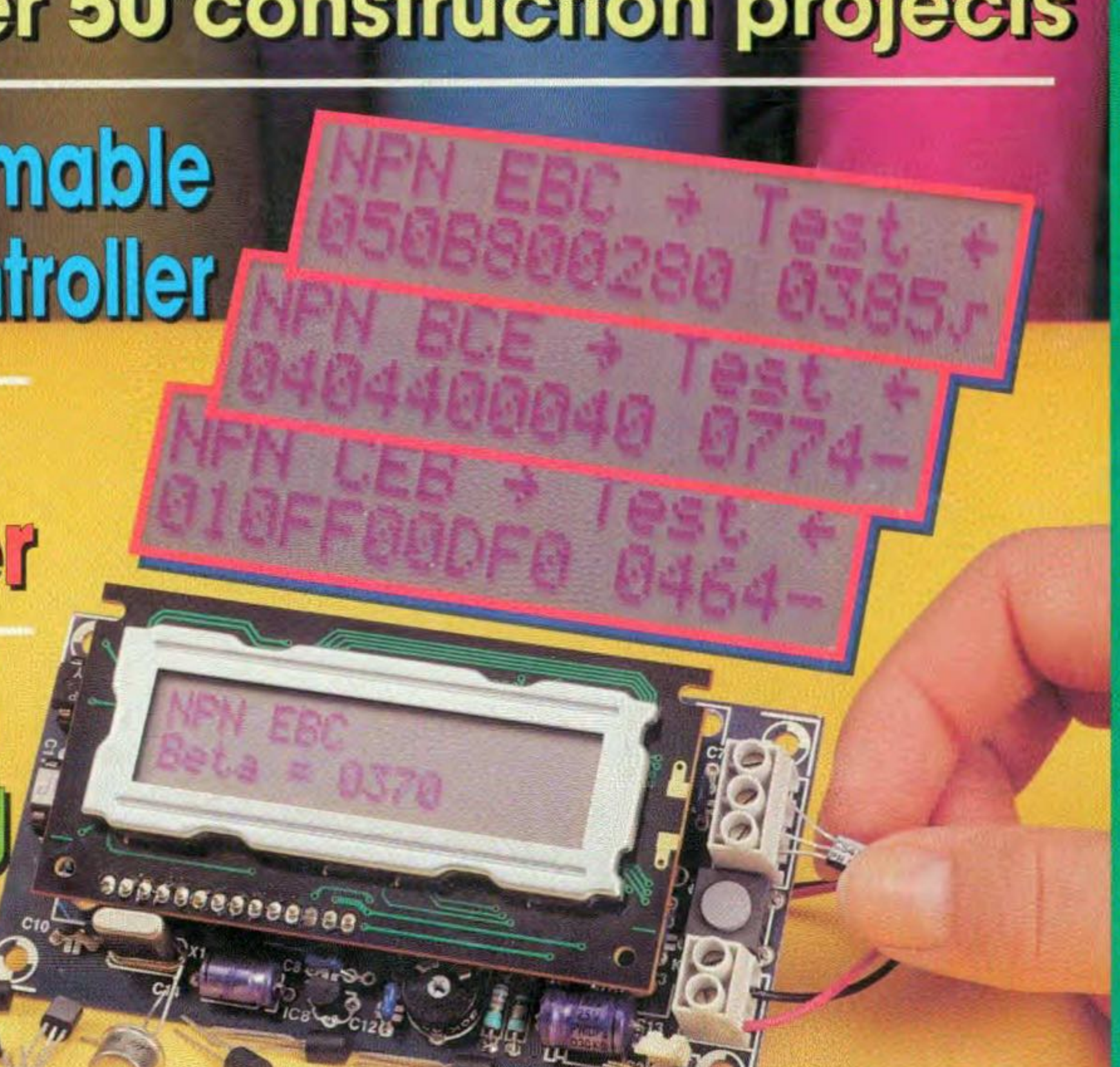

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ELEKTOR ELECTRONICS

December 1995
Volume 21
Number 239
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- Copybit inverter
- Passive VU meter
- I^{2}C interface for Centronics port
- Secam–PAL converter
- Component tester
- PLC course
- Triangular waveform generator as analogue-to-digital converter
- and others for your continued interest.

Front cover
When a transistor is to be tested, it is, of course, imperative that it is inserted correctly into the tester socket. The tester described on page 24 contains a microprocessor that determines what type of transistor is inserted (n-p-n or p-n-p), ascertains the pinout, measures the current amplification, and portrays the findings on a liquid crystal display.

To all our readers: thank you for your continued support during the past year and may peace and happiness be with you in the coming year.

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FROM THE WORLD OF ELECTRONICS

The Electronic Industries Association's International Winter Show is held every January in Las Vegas, Nevada.

AMATEUR RADIO LICENCES NEW 'M' CALL SIGN SERIES

Applicants for a full Amateur Radio Licence will receive a new M call sign from 1 April 1996. Full licencees are currently issues with a G call sign while novices, who will be unaffected by this change, are issues with call signs commencing with 2. The change needs to be made because the G series is rapidly running out of suitable combinations.

Reservations for M call signs are being accepted already, while reservations for G call signs will continue to be accepted until 31 March 1996. Further details may be obtained from the Agency's Amateur Radio Unit (Tel. 0171 215 2171).

Existing holders of G call signs are not affected by this change and will continue to use their own G call signs. Even where a licence has lapsed, the holder of the G call sign can apply for its re-issue at any time. Existing holder of G call signs will not be able to change their existing call sign to an M call sign.

APPLE AND THE INTERNET

Transparent communications to a wide range of services has been a major strength of the Macintosh™ since its inception. The Apple™ development of core networking protocols that work seamlessly together gives users tremendous flexibility on how and when to make their Internet connection. Whether to a local TCP/IP network, over a remote connection or by wireless, the Macintosh can offer consistent levels of service to the Internet and support the same wide range of tools. These capabilities make the Macintosh the ideal platform from which to exploit the Internet. At the same time, access to traditional Macintosh network services can be maintained with products like Apple Remote Access and Apple I/P Gateway.

For the Internet, MacTCP™ is software that allows the Macintosh to share files and electronic mail with other computers using the Transmission Control Protocol/Internet Protocol (TCP/IP). This protocol provides the basis for most communication on the Internet. This means that the Macintosh can easily telnet, or remote connect to, other computers using standard terminal protocols; transfer files with the File Transfer Protocol (FTP); find shared files on a remote computer with the Network File System (NFS); send mail with the Simple Mail Transfer Protocol (SMTP); and manage networks with the Simple Network Management Protocol (SNMP).

The Apple IP Gateway combines the advantages of MacTCP and Apple Remote Access in a single software application. With this package, remote Macintosh computers can access the full suite of services supported by TCP/IP from any location. Te Gateway permits any Macintosh on a network the ability to reach the Internet.

Gopher

Internet Gopher was developed at the University of Minnesota as a means for students, staff and faculty to find information on the campus networks without knowing arcane computer commands. It has spread rapidly beyond Minneapolis to become one of the most popular ways to distribute information on the Internet.

Wide Area Information Servers (WAIS)

WAIS was invented by the joint collaboration of Thinking Machines Corp. Apple Computer, KPMG Peat Marwick and Dow Jones. It is a tool that makes the contents of documents searchable over networks from a wide range of computing platforms and systems. It provides a single interface to search for information on diverse computers over the Internet.

World-Wide Web (www)

The World-Wide Web was created at the European Laboratory for Particle Physics (CERN) just outside Geneva, Switzerland, as a means to make terabytes of data, reports, scientific results and surveys available to physicists and other researchers.

The vast quantity of information on the Web makes it difficult to locate specific files and documents. CERN maintains a basic directory of information on the Web called the www Virtual Library, but it is not exhaustive.

AppleSearch

AppleSearch 1.5 takes a different approach to Internet resources than traditional Internet tools like Veronica and WebCrawler. At one level, AppleSearch can cooperate locally with Internet tools like Gopher. Another way in which AppleSearch works cooperatively on the Internet is through its own WAIS Gateway. This permits WAIS servers to be included as AppleSearch resources, as if they were locally available hard disks or CD-ROMS.

World-Wide Web and AppleSearch

Developed at the University of Texas Health Science Center, AppleWebSearch provides indexes to World-Wide Web. One application of AppleWebSearch was developed by Nick Arnett at Multimedia Computing Corp. in Campbell, California to provide information about libraries and the Internet.

More detailed information on this topic is contained in *The Macintosh and the Internet* available from Apple Computer UK Ltd, 6 Roundwood Avenue, Stockley Park, Uxbridge, United Kingdom UB11 1BB.

Some useful books are:

Michael Fraase – *The Mac Internet Tour Guide*, Chapel Hill, N.C.: Ventana Press, 1993 (with diskette of software)

Paul Gilster – *Finding it on the Internet*, N.Y.: Wiley, 1994.

Paul Gilster – The Internet Navigator, 2nd Ed., N.Y.: Wiley, 1994.

Ed Krol – *The Whole Internet User's Guide & Catalog*, 2nd Ed., Sebastopol, Calif: O'Reilly & Associates, 1994.

Editor's Note:
To get a connection to the Internet, you will need to link either your computer, or your organization's network to an Internet service provider. This can be done via a modem, an ISDN (digital telephone) connection or leased line.

If you work for a large company or academic institution, you may already have a connection to the Internet.

Different kinds of connection offer different speeds. Leased lines are fastest with speeds from 64 kbit/s to 1042 kbit/s. ISDN lines offer speeds of typically 64 kbit/s, while modems are slow (from 2400 bit/s to 32 kbit/s. It should be borne in mind, however, that your connection is only as fast as the slowest link in the chain between you and a server.

Modems and ISDN lines usually require that you pay normal telephone fees. Your service provider will also charge an annual or monthly fee covering the cost of connection and technical support. Prices start at around £12·00 per month plus VAT for modem users. Most service providers will explain how to get hold of Web browser, e-mail software and which modems to use.

Service providers in the UK are:

- British Telecom: 01345 585 110
- Demon Internet Services: 0181 349 0063
- EU-Net: 01227 475 497
  Pipex: 01225 250 120

It's worth comparing prices, and finding out what kind of technical support is offered. Some service providers are becoming overwhelmed by demand, so even a fast modem can seem slow on their networks.

Our Editorial & Administrative Office in Dorchester is not on the Internet, but Head Office (where Technical Services is located) in the Netherlands is: *e-mail: elektuur @ euronet nl.*

UNIX→PERL

UNIX is the operating system of computer scientists and technologists. It is adaptable to any need. Consequently, users have adapted it again and again to accommodate their own ideas. It now comes in 20 different versions, all as similar, yet subtly different, as English English and American English.

Trying to maintain a common set of programs on different UNIX machines can be exasperating. This is why a new computer language, Perl, has been developed by Larry Wall, a systems manager. Perl cuts across the barriers between different versions of UNIX with ease. Like many program available on the Internet it is free, but, unlike many of these, Perl is useful and it works.

WELSH COLLEGES SELECT HIGH-SPEED CABLE NETWORK

Seven higher education establishments in South Wales are to be linked by a high-speed, fibre-optic cable communications network. Centres on the University of Wales, Cardiff and Swansea, the network to be installed by CableTel South Wales will be among the first in the UK to use fibre-optic technology to link colleges over such a wide geographical area – two of the colleges are more than 50 miles apart.

The network will greatly ease the flow of communications between the colleges and cope with the rapidly increasing demand for data transmission services, such as the huge growth in the use of electronic mail.

Based on Synchronous Digital Hierarchy – SDH – technology, the new network will provide 155 Mbit/s capacity through a metropolitan and regional network, which is also linked to SuperJANET – the Joint Academic Network. Compared with the current maximum 2 Mbit/s capacity of the present system in South Wales, this is the equivalent of

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going from a number of congested single-carriageway roads to a 75-line superhighway.

Further information from Tony Morgan, Computer Centre Production Manager, University of Wales, Telephone 01222 874 875

BT HAS LAUNCHED CAMPUSWORLD

In September, BT launched CampusWorld – the world's largest on-line network providing a dedicated service for education.

By accessing the Internet through CampusWorld, educationalists at all levels will be able to find what they need quickly and easily, so saving time and money. The service is the only on-line network to provide detailed curriculum support and a range of resources put together by a large team of teachers and consultants in the UK and Europe.

It is expected that by March 1996 about 3500 UK primary and secondary schools will have subscribed to CampusWorld A key element of the service is the ability of members to network on projects. Schools from around the world, for example, can get involved in mediated debates about a wide range of subjects, often involving specialist comments from recognized experts in the field.

CampusWorld provides clear guidelines to teachers and lecturers on how to manage student-centred research on the Internet, with protection from less desirable areas. Teachers can create their own environment, defining how much of the Internet may be accessed.

CampusWorld has three main components:

- The main body of teaching resources and information put together by CampusWorld's consultants – a 'walled garden' on the Internet – which is available only to customers of the service. This is a huge interactive database containing a combination of curricular and cross-curricular services created for BT as well as a selection of the best educational services available on the main Internet.
- An Internet mailbox.
- Full access to the Internet, controlled by password.

A wide range of professional partners provide their materials through CampusWorld, including The National Trust, The Wellcome Trust, many museums, the French Embassy, the BBC, Ordnance Survey, BP, and the Police.

Projects and resources are aimed at all levels of education from five-year olds to further and higher. Examples of those currently available on the CampusWorld server are:

- Newspaper Day – with the help of up-to-the-minute world news delivered by e-mail, schools are challenged to produce a newspaper within the space of a school day.
- From page to stage – the chance to question two actors and their director about the challenge of playing Macbeth; questions can range from the difficulty of playing particular scenes and the actors' approach to their roles to the challenges for directors.
- Living in space – a cross-curricular project with accompanying resource pack, including teachers' notes and pupils' worksheets; tasks sent out by e-mail each day.
- Science-Net – teachers and students can send in a question on any medical or scientific matter and receive a personal replay from a team of professional scientists.

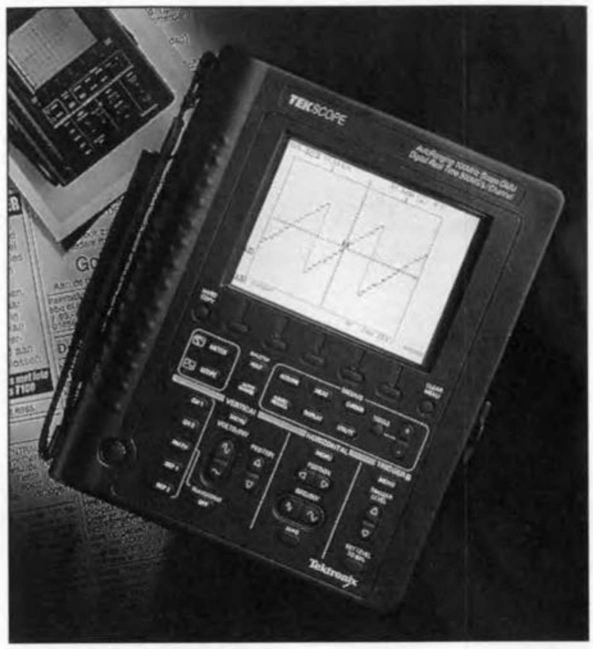
Note: BT's existing on-line curriculum support service for schools – Campus 2000 – is based on Telecom Gold e-mail technology and will be phased out over the next 18 months. The majority of its 4000 customers will migrate on to the new CampusWorld service.

+950110-I

WINNER

BIGGEST EVER International Circuit Design Competition, published in the July/August 1995 issue of Elektor Electronics.

International First Prize, a THS720 Tekscope worth approx. £1800, made available by Tektronix,



AWARDED TO

Mr. Laurent Lamesch of Lamadelaine, Luxembourg, for his superb design of a

50-MHz 16/32-CHANNEL LOGIC ANALYSER

First, a big 'Thank You' to all of you who have taken the trouble of participating in the Contest. The jury of five had a tough time marking up designs mainly for originality and practical use. Some 230 designs lodged in our editorial offices, and created huge piles on some of the jury members' desks. Fortunately, in spite of the large number of competing designs, it soon appeared that a relatively small selection was a class above the rest. And then it took surprisingly little time for the jury to elect the unanimous winner. Read all about the winning design this month. Others with no less power, originality and ingenuity will follow in our January and February 1996 issues.

Lamadelaine, 16th September 1995

Dear Ladies and Gentlemen,

I hereby endeavour to propose my contribution to the International Circuit Design Competition as mentioned in the July/August 1995 issue. The proposal concerns a 50-MHz Logic Analyser with an input word width of 16 or 32 bits, selected by the user. The circuit is connected to the printer port of a PC.
The 16-bit version of the Analyser uses 27 electronic components as described in the Competition rules, i.e., semiconductors, resistors and capacitors. This version of the circuit is fully functional.
The 32-bit version has an additional circuit which is almost identical to a section of the 16-bit version, except for a few minor differences in wiring. In principle this is an extension of the basic circuit with an additional 'channel', which is already contained in the basic circuit.
Should you find that the 32-bit version of the Analyser does not meet the Competition rules, I would ask you to take only the 16-bit version into consideration.

With kind regards,
Laurent Lamesch

On 17th October 1995 the International 1st Prize, a Tektronix THS720 TekScope, was awarded to the winner of the competition. Left to right: Mr. Pierre Kersemakers, Elektor's Editor-in-Chief/Publisher; Mr. Patrick Lesne, Marketing Manager, Tektools Marlow; Mr. Erik de Jong, Dealer Account Manager Measurement Business, Tektronix Holland; Mr. Laurent Lamesch; Mr. Ernst Krempelsauer, Chairman of the Jury and editor of Elektor's German edition.

THE Logic Analyser is connected to a PC via the parallel printer port. It may be built as a 16-bit or 32-bit version. The storage depth is 4,096 words, the sampling frequency 50 MHz (max.). Either an internal quartz oscillator or an external TTL signal may be used as a clock source.

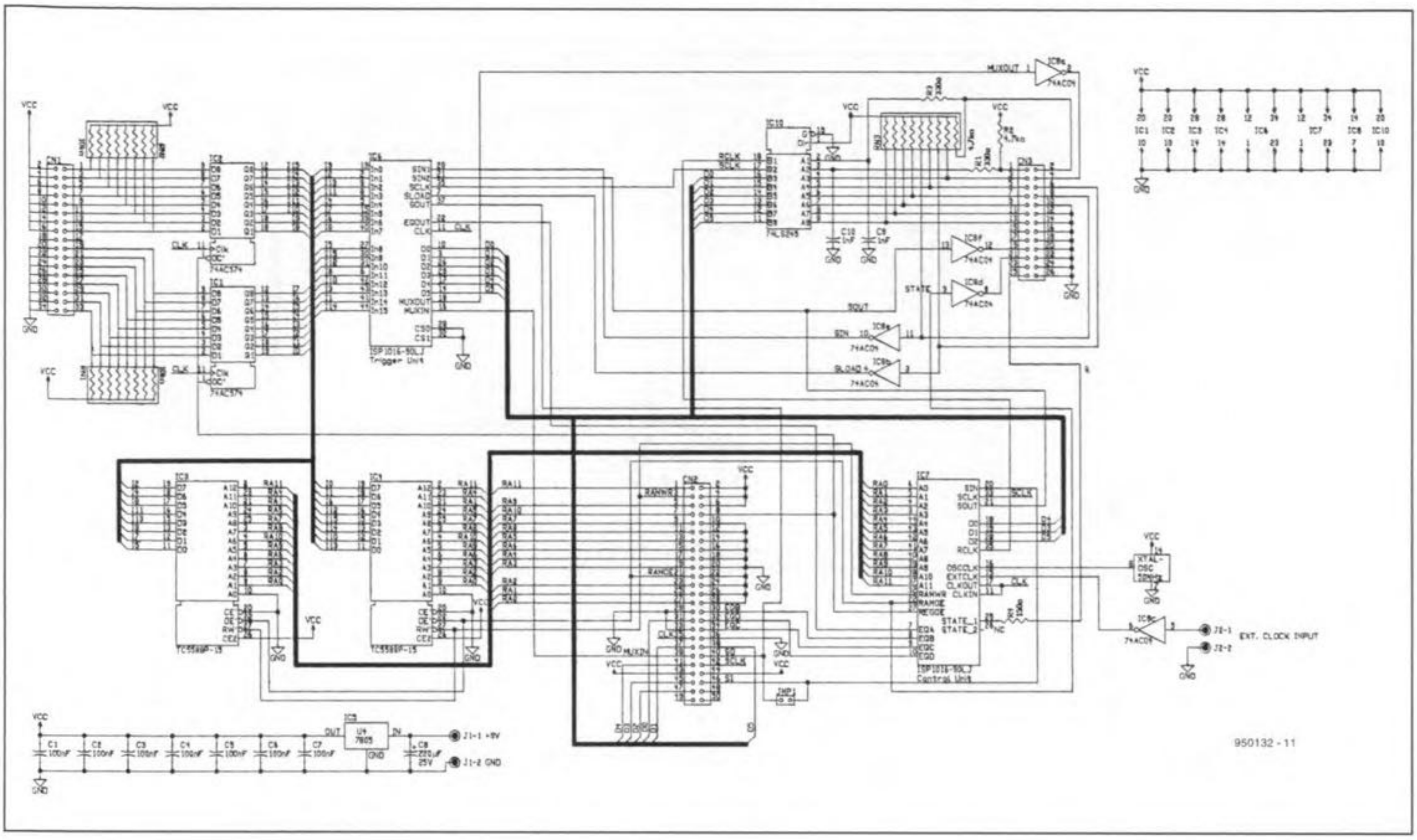


Fig. 1. Schematic of the main analyser circuit.

Internally, the reference frequency may be divided by a factor 2^0 through 2^6, and used as sampling frequency.

The analyser is triggered by a comparison between the input word and an adjustable trigger value, where, additionally, every input word bit may be masked individually. The time in which the trigger condition is satisfied to enable triggering to take place, is user adjustable. It may lie between one and 15 sampling periods.

After a successful triggering, the analyser's RAM is half filled with input data. Because the RAM is continuously being written to before the triggering, it is half filled with input values which were collected before the trigger instant, while the other half contains words collected after the triggering.

Next, the RAM is read out by the PC, and the result of the measurement is displayed on the screen.

Circuit description:

For the lower 16 channels, the circuit of the Analyser consists basically of two ISP1016-90 PLDs from Lattice, two fast SRAMs and two 8-bit input registers.

The state of the input lines is latched via input registers IC1, 2 (74AC574). Only the latched result is used by the rest of the circuit.

The trigger PLD, IC6, contains a 16-bit comparator, which compares selected bits in the input word with an adjustable value. EQOUT on IC6 is set to 1 when the comparison result is positive.

The comparison and masking bits are contained in a shift register of the trigger PLD, which is loaded with SCLK, SIN1 and SLOAD by the PC.

The analyser contains effectively one long shift register, which is distributed across all ISP1016s in the Analyser. Via SOUT, the shift register contents may be read again non-destructively by the PC, to check that it is correct.

The trigger PLD also contains a

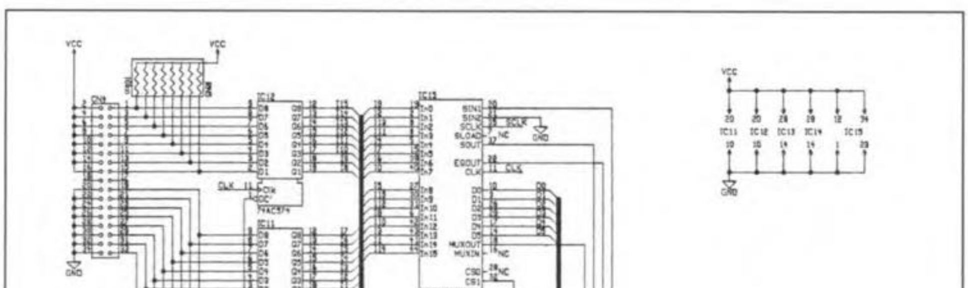


Fig. 2. Circuit diagram of the optional 32-channel extension.

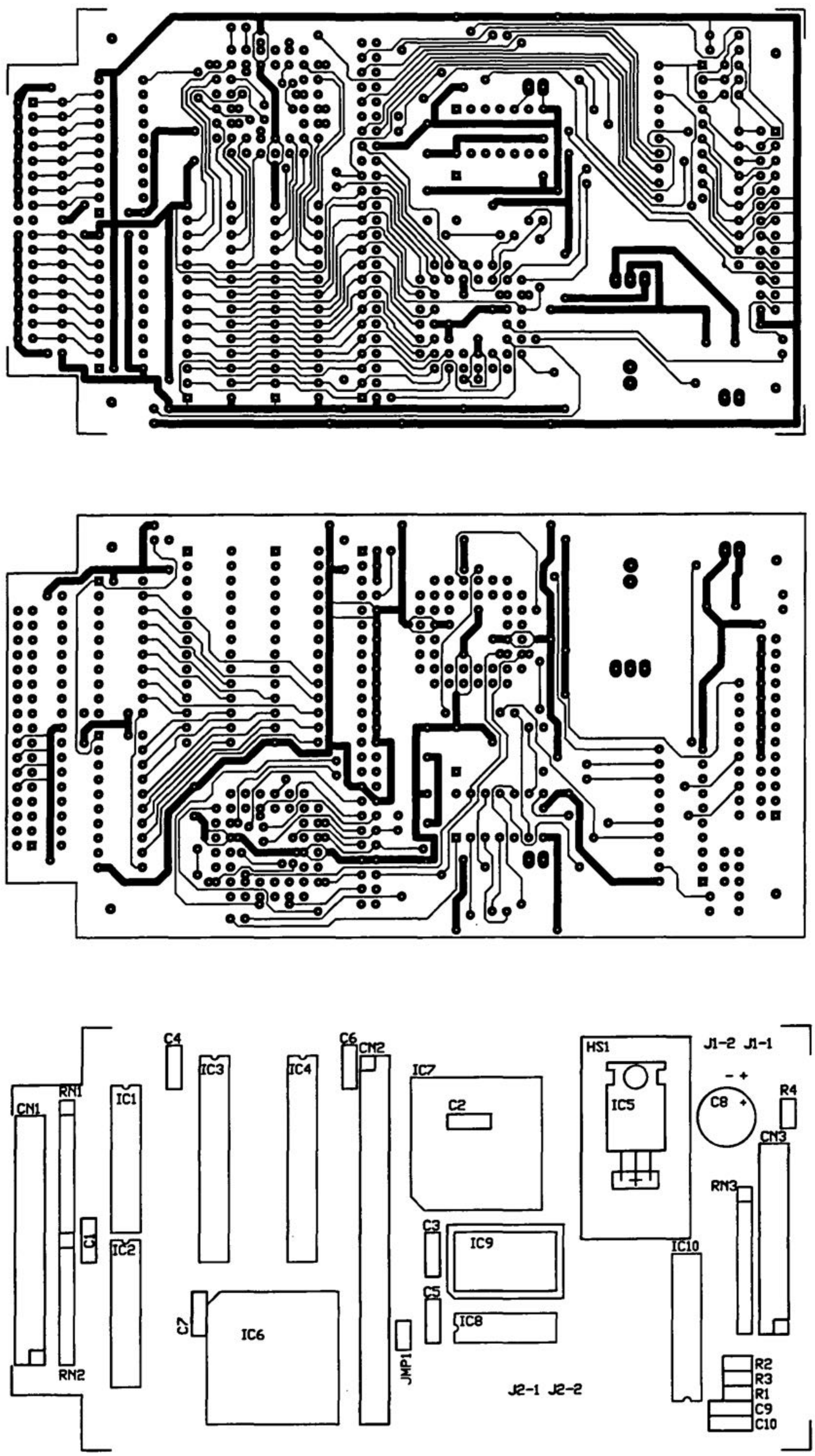


Fig. 3. Artwork (100%) of the double-sided printed circuit board (not available ready-made through the Readers Services).

multiplexer, which is used by the PC to put all databits of the SRAM sequentially on to line MXOUT as it reads out the Analyser's RAM. The multiplexer inputs are selected using lines D0 through D5.

In addition to the RAM address counter, the counter PLD, IC7, also contains the entire timing control of the Analyser, whose core is a 3-bit Finite State Machine (FSM). The PLC contains a register through which the PC is able to check the FSM. This register copies the states of inputs D0, D1 and D2 on IC7 at the rising edge of RCLK.

The 32-bit version of the Analyser has one additional trigger PLD, plus two input registers and sRAMs. Apart from a few differences in wiring, this extension is identical with a section of the basic circuit.

The circuit of the Logic Analyser contains a 5-V power supply set up around a 7805 voltage regulator. Input power may be obtained from a 9V/1A mains adaptor.

Construction

The entire circuit (16-bit version) is built on a double-sided board. The 32-bit version has an additional plug-on board, which contains channels 16 through 31. This board is plugged on to the main board. JMP1 should be fitted to select 16-bit operation. The jumper is removed to select 32-bit operation.

It should be noted that C2 is fitted at the solder side of the board. IC sockets should not be used except for the ISPs and IC10. IC10 may only be an LS type.

The connection to the PC is made via the parallel printer port of the PC. CN3, a 26-way boxheader, receives an IDC socket which is fitted on to one end of a length of 25-way flatcable. The other end of the cable is fitted with a 25-way sub-D connector. Pin 26 of the

VCC	2	1	Input Channel 15
VCC	4	3	Input Channel 14
VCC	6	5	Input Channel 13
VCC	8	7	Input Channel 12
VCC	10	9	Input Channel 11
VCC	12	11	Input Channel 10
VCC	14	13	Input Channel 9
VCC	16	15	Input Channel 8
NC	18	17	NC
GND	20	19	Input Channel 7
GND	22	21	Input Channel 6
GND	24	23	Input Channel 5
GND	26	25	Input Channel 4
GND	28	27	Input Channel 3
GND	30	29	Input Channel 2
GND	32	31	Input Channel 1
GND	34	33	Input Channel 0

Main Board

Ref:	Value:	Comment:
IC1	74AC574	DIL case
IC2	74AC574	idem
IC3	TC5588P-15	Toshiba Cache-SRAM, may be replaced by
IC4	TC5588P-15	other 15-ns SRAMS in Skinny-DIP case.
IC5	7805	Fit with TO-220 heatsink
IC6	ISP1016-90LJ	Trigger Unit: programmed with trig6.jed
IC7	ISP1016-90LJ	Control Unit: programmed with cnt11.jed
IC8	74AC04	DIL case
IC9	XOSC 50MHz	50MHz Quartz oscillator, DIL case (e.g. from Segor)
IC10	74LS245	Use LS version ONLY!
C1	100nF	all 100nF: 5mm pitch, ceramic, good RF
C2	100nF	properties
C3	100nF	
C4	100nF	
C5	100nF	
C6	100nF	
C7	100nF	
C8	220uF/25V	upright, 5mm pitch
C9	1nF	5mm pitch
C10	1nF	5mm pitch
R1	330R	
R2	4k7	
R3	330R	
R4	150R	
RN1	8x10k	Resistor array in SIL case, 1 common
RN2	8x10k	pin for all resistors
RN3	9x4k7	
CN1	34-pin boxheader, opt. 90-degree type w. eject lever	
CN2	2x25-pin SIL IC socket pin, precision contacts	
CN3	26-pin boxheader	
JMP1	2-pin pinheader	

Miscellaneous:
IC sockets, ONLY for IC6, IC7, IC10
34-pin IDC socket
26-pin IDC socket
25-pin sub-D plug IDC type
Heatsink for TO-220 (IC8), U-shape
Jumper
Solder pins
BNC socket for chassis mounting
0.5m 34-way flatcable
17 off miniature test probe
Mains adaptor socket
Mains adaptor ≥ 9V, ≥ 1A
Enclosure, e.g., Euro-Module Series 1608, height 44mm (order code EM044GA with Simons El.)

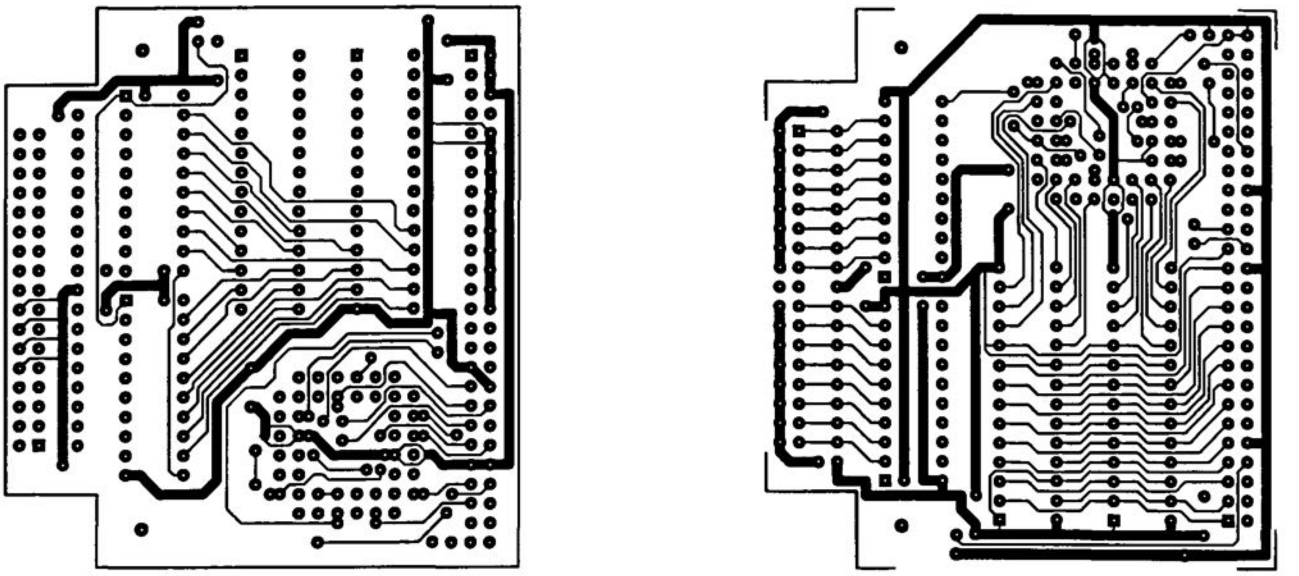
IC Programming Service

Send us two (or three) blank ispLSI or pLSI type 1016 ICs (Lattice) for programming with the files trig6.jed and cnt11.jed. Please use proper anti-static packaging, and mail to our Dorchester office. For prices and ordering codes, see page 70.
We regret that ready-programmed ICs are not available through the Readers Services.

Slave board:

Ref:	Value:	
IC11	74AC574	DIL case
IC12	74AC574	DIL case
IC13	TC5588P-15	Toshiba Cache-SRAM, may be replaced by
IC14	TC5588P-15	other 15-ns SRAMS
IC15	ISP1016-90LJ	Trigger unit: programmed with trig6.jed
C11	100nF	All 100nF: 5mm pitch, ceramic, good RF
C12	100nF	properties
C13	100nF	
C14	100nF	
RN4	8x10k	Resistor array in SIL case, 1 common
RN5	8x10k	pin for all resistors
CN4	34-pin boxheader, opt. 90-degree type w. eject lever	
CN5	2x25-pin pinheaders, fitting for CN2	

Miscellaneous:
IC sockets, ONLY for IC13, IC14
34-pin IDC socket
0.5m 34-way flatcable
17 off miniature test probe



IDC socket is not used, i.e., the 25-way cable should be aligned at the pin 1 side of the IDC socket.

At the input side, a 34-way box-header is used. When the enclosure mentioned in the parts list is used in combination with angled plugs with eject headers, the plugs should be filed before soldering them, so that they are not in the way of the pillars in the case. At the end of the 34-way flatcable, a test probe is soldered to each input line, as well as one to any of the ground lines. The pinning of the input connector is shown in a separate box.

With channels 16 to 32, the value '16' should be added to the input channel number. The external clock input, JP2-1, JP2-2, is connected to a BNC socket, while the power supply connector, JP1-1, JP1-2, is wired to a mains adaptor socket.

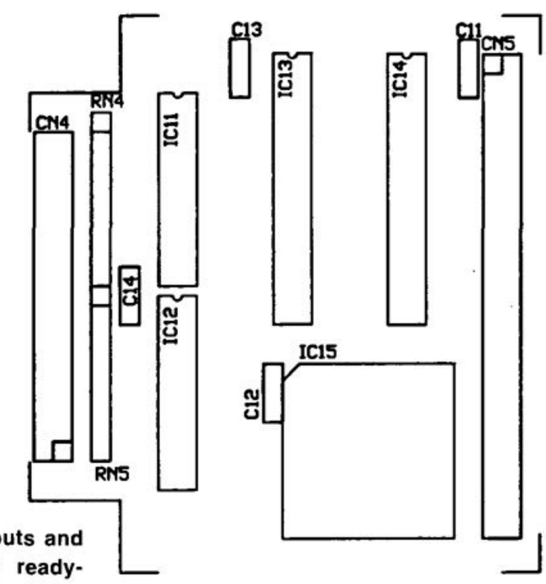


Fig. 4. Extension card copper layouts and component overlay (not available ready-made through the Readers Services).

Software:
The software consist of two parts, the Analyser control program proper and a program which redefines the VGA font. The latter is necessary to enable the signal waveforms to be displayed. A batch file, LA.BAT, handles the calling of the two programs. When problems occur with the font switching, the parameters of the switchover program may be changed, as well as those of the Analyser program. Information on how this may be achieved is supplied by these programs when they are called.

Any standard parallel Centronics interface may be used. The port address of the interface may be any value, and may be conveyed as a parameter when the Analyser program is called. By default, the address of the LPT1 port is used. The argument format is displayed when the program is called.

The video card used should be a colour VGA type. When the original character set is selected, it is also possible to employ other video cards, provided they offer an 80×25-character colour text mode. So far the software and the Analyser have been tested on a 386SX and a P5-75 computer. On an 8088 or a slow 80286, the screen build-up is probably too slow.

During use of the Analyser care should be taken not to clear the contents of the Analyser RAM before the data capturing instant. In other words, triggering should not occur before the RAM has been fully written to at least once. In the event of early triggering, a part of the RAM contains data of the previous measurement. All data occurring after the trigger instant are, however, always correct, provided the user has not cancelled the data capturing beforehand.

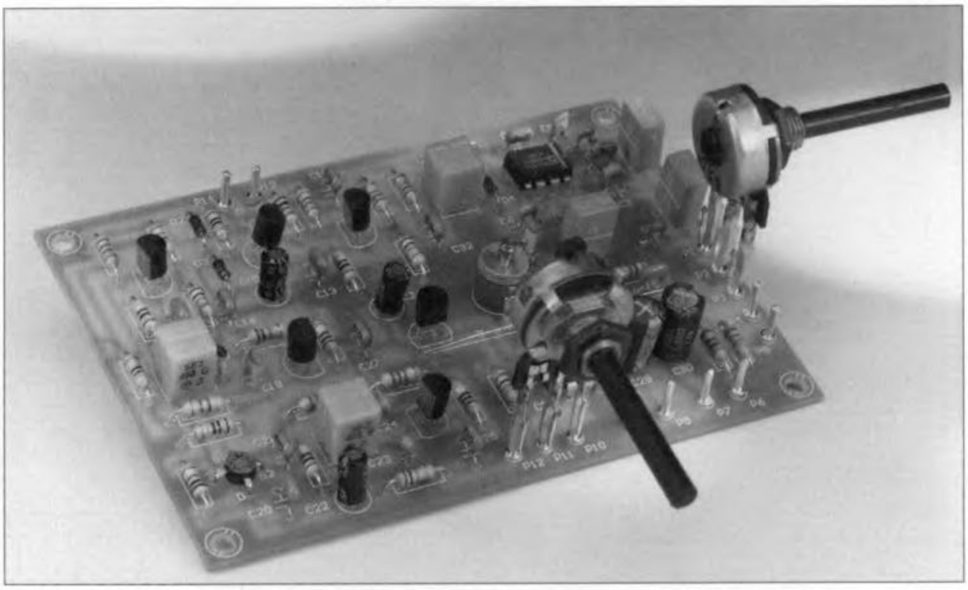
Next Month: More Contest results!
1. a 16-page supplement showing a selection of prize winning circuits from all partcipating countries;
2. A list of all winners and prizes awarded by our UK sponsors.

Can I build this?

Yes, provided you are able to make your own PCBs. The control software (on diskette) is available through our Readers Services, while a programming service is offered for the two (or three) isp1016 ICs in this project. For ordering codes and prices, see page 70. Please note that the hardware and software have not been tested by the *Elektor Electronics* design laboratory. We hope to publish a fully tested and documented version of the Logic Analyser sometime next year, complete with house-style circuit diagrams and ready-made printed-circuit boards.

FAX RECEIVER FOR VLF AND SW

A receiver circuit is described which, in its basic configuration, opens up the frequency range below the range allocated to long-wave broadcast services. This so-called VLF (very low frequency) range is particularly interesting to the radio amateur because it is used by weatherfax and other utility stations. Several stations can be received which transmit weather charts, satellite images for sea and air navigation, and miscellaneous meteorological data. The receiver is simple to modify for shortwave reception on 80, 40 or 20 metres.



By Holger Eckhardt, DF2FQ*

APART from offering a low-cost means to acquire weather information from first-hand sources, the receiver presented here is also an excellent project for those of you interested in radio facsimile reception technology in general.

Circuit description

The circuit diagram of the receiver is given in **Fig. 1**. Basically, the design is that of a super-heterodyne receiver with an intermediate frequency of 450 kHz. A five-pole low-pass filter built around L_1 and L_2 acts as a pre-selector. Having an input impedance of about 1.5 kΩ, the pre-selector enables relatively short antennas to be connected also. It is followed by a double-balanced mixer which is integrated in IC_1, together with the VFO (variable frequency oscillator). The VFO is a free-running Colpitts type with diode tuning. Together with the pre-selector, the VFO determines the received frequency.

Two ceramic filters are used for the IF pass-band; one ahead of the IF amplifier, and one behind it. Because the filters used are actually made for pilot tone detection in AM stereo receivers, they have excellent channel selection properties. By cascading these filters, their slope steepness is doubled. As a bonus, the second filter helps to keep wideband noise generated in the IF amplifier away from the BFO (beat frequency oscillator).

The IF amplifier built around transistors T_2 and T_3 features automatic gain control (AGC). The IF signal is amplified once more by T_5, and then rectified by diodes D_2 and D_3. The control voltage amplifier, T_2, is driven in proportion with the IF signal level, and pulls the emitter of T_1 to the positive supply line. This causes a reduction of the collector current in T_1, and, consequently, reduced gain. The control range of the AGC is about 70 dB, which means that the audio output signal varies by only 6 dB when the signal level at the antenna input changes between about 5 µV and 20 mV.

Because the current which flows through T_2 is a function of the received signal strength, it can be indicated with the aid of a moving-coil meter connected to the S meter terminals on the board. If no S meter is used, the corresponding terminals should be interconnected. If this is not done, the AGC does not work. The maximum S meter current is about 2.5 mA.

Dual gate MOSFET T_4 acts as a demodulator in the receiver. Gate 1 is driven by the IF signal, and gate 2, by the BFO signal generated by T_6. The BFO frequency is determined by a 455 kHz ceramic filter which is used as resonator here. Because the resonating frequency of the filter is a little too high, it is brought down to the required value with the aid of two capacitors, C_{23} and C_{24}. Because both the BFO frequency and the VFO frequency are above the IF frequency, the upper sideband is selected.

The familiar LM386 (IC_2) acts as the audio amplifier in the receiver. It is capable of supplying an output power of about 0.5 W into an 8-Ω loudspeaker. The entire receiver, with the exception of the audio output amplifier, is supplied by a 78L08 fixed voltage regulator. The supply voltage of the mixer/VFO IC is stepped down to its appropriate value by a zener diode, D_4.

Construction

The printed circuit board artwork for the fax receiver is shown in **Fig. 2**. Since this board is, unfortunately, not available ready-made through the Readers Services, you have to make it yourself, have it made, or (probably easiest of all) obtain it via the author.

It is recommended to start the construction by fitting the low-profile parts (resistors, DG MOSFET, etc.).

* This article was translated from the German, and originally appeared in *CQ-DL*, April 1995. We thank the author and the publishers of *CQ-DL* for their kind permission to reproduce this article. Sections on SW conversion and PC interfacing added by the author at the request of *Elektor Electronics*.

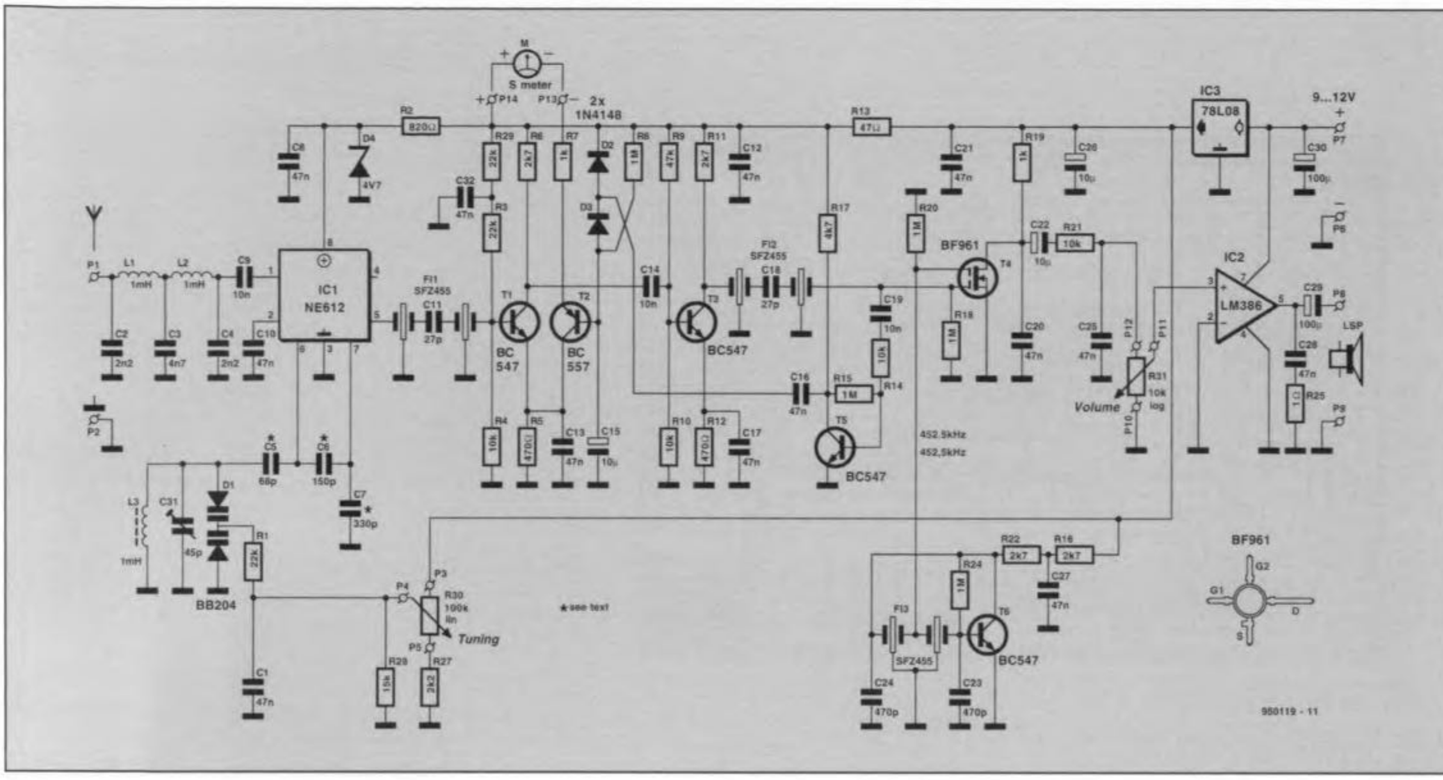


Fig. 1. Circuit diagram of the VLF weatherfax receiver.

then the capacitors and transistors, and, finally, the larger parts such as the ceramic filters and the trimmer capacitors. Observe the orientation of the ceramic filters: the notch in the case is indicated by a dash on the component overlay. Type SFZ450C filters are used in the IF amplifiers, while the BFO uses an SFZ455F.

The dual-gate MOSFET has one long terminal, which is the drain ('+' side). The terminal with a single vane or two vanes on the terminal, near the transistor body, is the source ('ground' side). These two terminals determine the position of the transistor on the board. It should be noted that the side with the type print on it is not fixed between manufacturers of the BF961, and thus can not be used as an orientation for the pinout of the device.

The inductors in the input circuit and the oscillator are fixed, ready-made, types which look like ½-watt resistors and have colour bands which indicate their inductance in microhenry. A 1-mH inductor, for example, has the following colour code: brown, black, red. The use of ready-made inductors makes the receiver almost 'alignment-free'.

Many capacitors have a coding system which indicates the value in picofarads. First comes the value, then the number of zeroes. For example, a value of 47 nF is printed as '473'. Similarly, '103' means 10 nF (10,000 pF). For good temperature stability of the receiver, make sure the VFO capacitors have the indicated TC values.

The solder pins are pushed into their holes with a little pressure from a pair of radio pliers. Next, they are soldered at the copper side of the board. Being soldered and secured fairly tightly in their holes, the terminals will not easily fall out when wires are soldered to them.

MAIN TECHNICAL DATA

Frequency range:	**75 to 150 kHz**
Sensitivity:	**1 µV for 12 dB S/(S+N)**
IF selection:	**2.5 kHz at –6 dB, 4.5 kHz at –40 dB**
Image rejection:	**–50 dB**
Supply voltage:	**9.5-14.5 V**
Current consumption:	**15 mA, max. 90 mA at max. AF level**

Setting up the receiver

Start by connecting the 12-V supply voltage to the board. The current consumption should be about 15 mA. The output pin of the voltage regulator should supply a voltage of 8 V. Next, connect the loudspeaker. A soft hum should be heard if you touch pin 3 of the LM386 with your finger. The hum should also be heard, a little louder this time, if you touch the gate 1 terminal of the MOSFET. Now connect an antenna, preferably, a few metres of wire. Depending on the presence of nearby computers, TV sets or neon lighting, you will probably hear some QRM (noise). If you are lucky, you will hear a VLF broadcast station straight away.

The only adjustment required is that of the VFO trimmer, C_{31}. Set it to about half-way travel, and then turn the tuning pot, R_{30}, through its full range. At some point you will hear the characteristic ticking noise of the DCF77 transmitter at Mainflingen in Germany. The 'clock' ticks sound like short, noisy, high-pitched notes which occur in a seconds rhythm. The exact frequency of DCF77 is 77.5 kHz. Now adjust the trimmer until DCF77 is at the start of the band. At the upper side of the band you will then (probably) be able to receive the DeutschlandFunk transmitter at 153 kHz. If the tuning range is con-

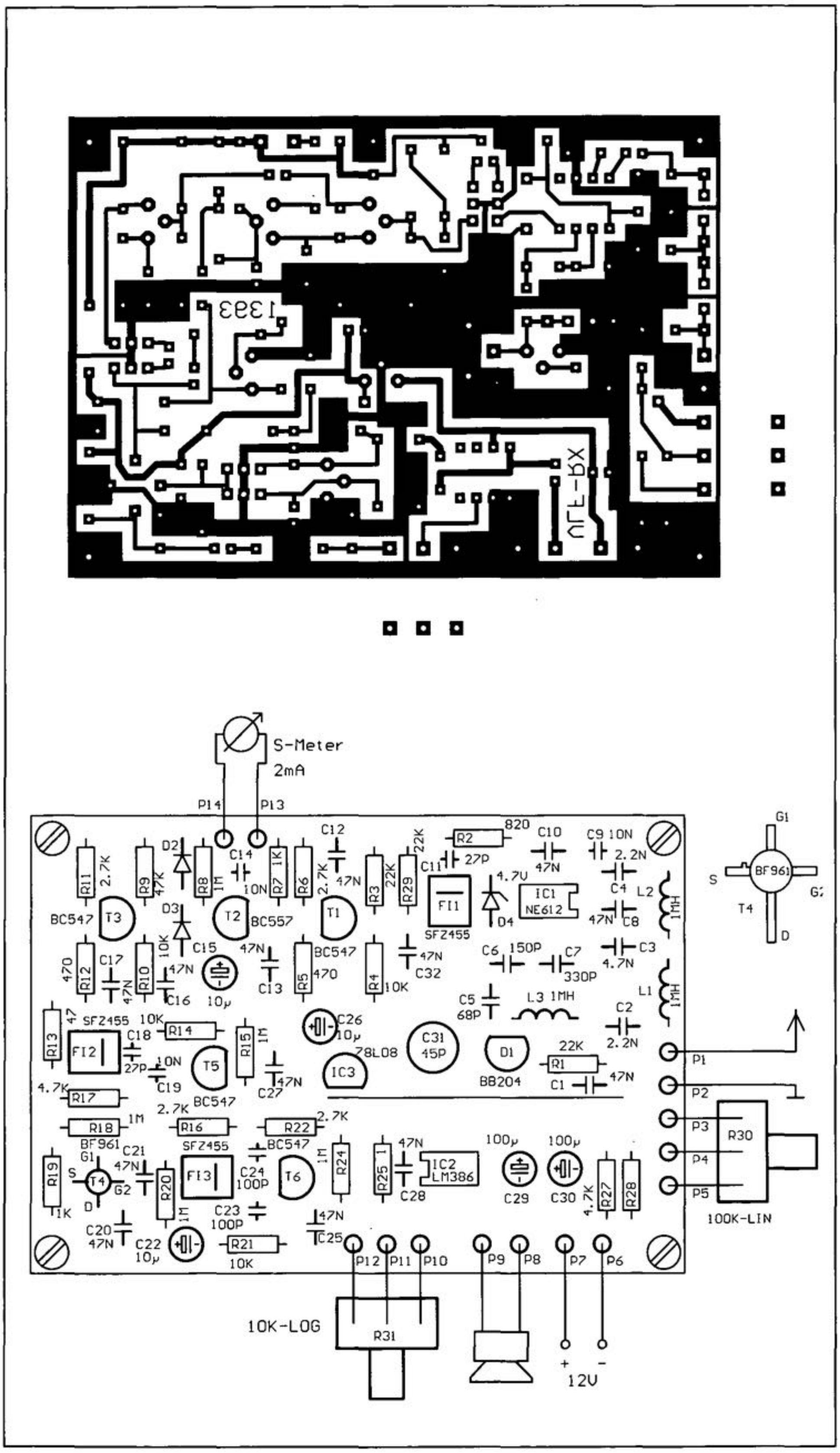


Fig. 2. PCB artwork (board not available ready-made through the Readers Services).

COMPONENTS LIST

Resistors:
R1;R3;R29 = 22kΩ
R2 = 820Ω
R4;R10;R14;R21 = 10kΩ
R5;R12 = 470Ω
R6;R11;R16;R22 = 2KΩ7
R7;R19 = 1kΩ
R8;R15;R18;R20;R24 = 1MΩ
R9 = 47kΩ
R13 = 47Ω
R25 = 1Ω
R27 = 2kΩ2 (see text)
R28 = 15kΩ (see text)
R30 = 100kΩ lin. potentiometer
R31 = 10kΩ log. potentiometer

Capacitors:
C1;C8;C10;C12;C13;C16;C17;C20;C21;
C25;C27;C28;C32 = 47nF 5mm
C2;C4 = 2nF2 5mm
C3 = 4nF7 5mm
C5 = 68pF/-330 5mm
C6 = 150pF/NP0 5mm
C7 = 330pF/NP0 5mm
C11;C18; = 27pF 2.5mm
C9;C14;C19; = 10nF 5mm
C15;C22;C26 = 10µF 2.5mm
C23;C24 = 470pF 2.5mm
C29;C30 = 100µF 2.5mm
C31 = 45pF trimmer

Inductors:
L1;L2;L3 = 1mH 5mm

Semiconductors:
D1 = BB204B
D2;D3 = 1N4148
D4 = ZF4.7
T1;T3;T5;T6 = BC547
T2 = BC557
T4 = BF961
IC1 = NE612
IC2 = LM386
IC3 = 78L08

Miscellaneous:
FI1;FI2 = SFZ450C
FI3 = SFZ455F

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siderably larger or smaller, that may be corrected by increasing or decreasing the value of resistor R_{27}. Those of you having a frequency meter may measure the VFO frequency at pin 7 of IC_1. The range should be about 525 to 600 kHz when R_{30} is turned across its range. Note that a low-capacitance probe is required for this measurement.

The BFO frequency should be about 452 kHz, and may be measured at the gate-2 terminal of the MOSFET. If it is on the high side (received signals sound shrill), C_{23} and C_{24} may be increased a little to 560 pF. If the sound is dull, or if the wrong sideband is received, these capacitors should take a smaller value.

Resistor R_{28} serves to linearize the tuning range. By suitable combination of R_{27} and R_{28}, the non-linear tuning characteristic of the varicap diode may be compensated such that an a certain angle of rotation of the tuning pot spindle causes a corresponding frequency change of the VFO. Because of the large tolerance on the tuning char-

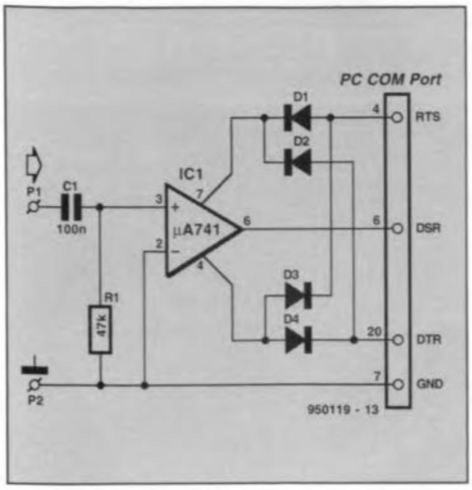


Fig. 3. Simple computer interface circuit (optional extension).

acteristics of the varicap diodes, the indicated resistor values are only intended as guidance. Some experimenting may be required here. The value of R_{27} should not be made smaller than 1 kΩ, however, since that may cause the VFO to stop oscillating. It is, of course, possible to omit R_{28} altogether. Note, however, that that results in a 'tuning dial' which is compressed towards the low side, and extracted towards the high side.

Anything else required?

After a while, you will probably get bored with just listening to the chirping noise received from fax stations in the VLF band. Well, a few tidbits are required before you are able to see the weatherfax pictures.

Starting from the far end, you first need a computer. Although it would just be possible to connect a mechanical fax machine, these 'monsters' are now obsolete, and their use is not covered here.

Software which enables facsimile images to be received on a computer is currently available from a number of sources, and for almost all of today's PCs. The author uses the program 'JVFAX' because he owns an IBM PC compatible. This program gives excellent operation, and may be copied freely ('freeware'). JVFAX was written by E. Backeshoff, DK8JV [1], and is currently found on many amateur radio bulletin boards and packet radio nodes.

Like almost any other radio fax receiving program, JVFAX requires an interface which converts the received tones into a format that can be understood by a computer. A 'high' tone produces a bright dot (picture element), a 'low' note, a dark dot. The simplest of such interfaces is probably an opamp wired to act as a comparator. The circuit shown in **Fig. 3** is found in the documentation file that comes with the JVFAX program. As you can see, it is simple to connect, and has no special parts.

The more sophisticated solution is called the FM discriminator. This circuit converts the demodulated frequencies into corresponding voltages, which are subsequently converted into digital values by an A-D converter. The FM discriminator and ADC enable a true grey scale to be reproduced with good resolution. Moreover, the ground noise typically produced by the comparator circuit is eliminated. A rela-

Band:	80m	40m	20m
C2	68pF	33pF	22pF
C3	10pF	2.7pF	0.75pF
C4	120pF	56pF	27pF
C5	68pF	100pF	68pF
C6	330pF	330pF	150pF
C7	330pF	330pF	150pF
C9	27pF	4.7pF	2.2pF
C31	45pF	15pF	15pF
C34	47pF	22pF	8.2pF
L1,L2	Neosid 501600	10.7MHz bandfilter, green	10.7MHz bandfilter, green
L3	T50/2, 55 t.	T50/6, 36 t.	T50/6, 25 t.
D1	BB204G	15pF + BB405	2 x BB405

Notes:
Capacitors C5, C6 and C7 must be NP0 types.

Internal capacitors in 10.7 MHz bandfilters used as input t.c.'s in 20-m band to be removed (crush with small screwdriver).

D1a replaced by a 15-pF NP0 capacitor, D1b is a BB405. On 20 m, both D1a and D1b are type BB405.

Table 1. Overview of component changes to enable fax reception in the three most popular shortwave bands.

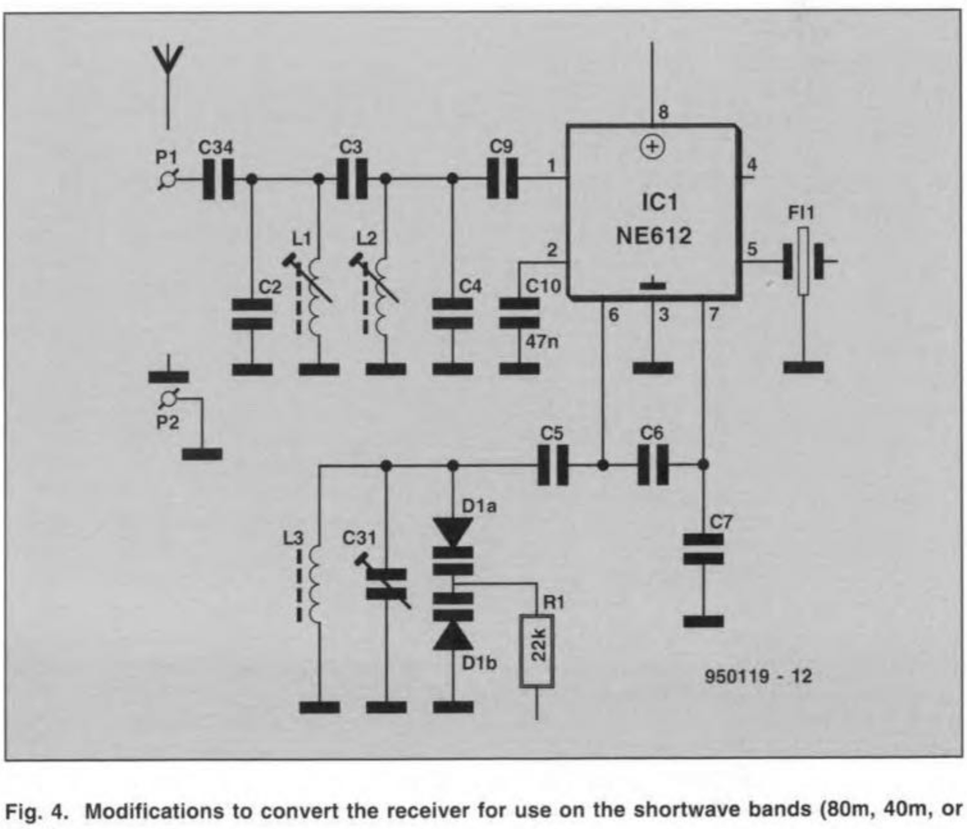


Fig. 4. Modifications to convert the receiver for use on the shortwave bands (80m, 40m, or 20m).

tively simple design of an FM discriminator for facsimile use may be found in Ref. 1.

Last but not least, there is the antenna to consider. Unfortunately QRM is very high in the VLF bands. The sources of (man-made) noise include computers, electrical wiring and equipment of all sorts, and vehicles. Fortunately, most weatherfax stations employ fairly high transmit powers, which guarantee adequate reception throughout the respective country. In many cases, it is sufficient to connect an already available shortwave antenna, or the core of the coax cable which leads to the VHF-FM or UHF-TV antenna.

Good results are obtained with antennas which are designed to capture the energy contained in the magnetic component only. A ferrite rod is such an antenna. For your first experiments, use the longest rod you can find, and wind about 150 turns of 0.2-mm dia. enamelled copper wire around it. This represents an inductance of about 2.5 mH. Connect this coil to the antenna input of the receiver, in parallel with a 500-pF tuning capacitor. Because of the resonance effect brought about by this tuned circuit, you will have to adjust it at each change of the receiver tuning. Also note that this antenna is directional.

Unfortunately, the ferrite antenna suffers from relatively low efficiency. Far better results are obtained with a loop antenna [2]. This operates on the same principle as the ferrite rod, but offers far greater antenna signals because of the larger effective area. The ferrite coil is replaced by five turns of wire around a rectangular wooden frame with a diagonal of about 1 m. More on loop antennas on VLF in the references at the end of this article.

Postscript

In Germany, the reception of certain weatherfax stations, including DCF54 at 134.2 kHz, is subject to a licence which should be obtained from the Wetterdienst in Offenbach. The broadcasts on 147.3 kHz may be received freely, however.

The receiver requires only minor modifications to enable the reception of fax transmissions in the shortwave bands. These bands, like the VLF band, contain stations which may be copied freely (i.e., without a licence). Moreover, because the receiver is also capable of SSB and CW reception, it is an ideal holidays companion. The modifications for shortwave use are summarized by the schematic in **Fig. 4** and **Table 1**. (950119)

[1] Eberhard Backeshoff, Obschwartzbach 40a, D-40822 Mettmann, Germany.

References:

1. 'Universal fax decoder, not only for weather satellites', by Berhard Thiem, *CQ-DL* 6/94 (publication in German).

2. Various articles on ferrite and loop antennas, receivers and VLF reception in *Elektor Electronics*:

- 'Small loop antennas for MW AM BCB, LF and VLF reception', by Joseph J. Carr, *Elektor Electronics* June and July/August 1994.
- 'External ferrite aerial units for short, medium and long-wave radios', by Richard Q. Marris, *Elektor Electronics* May 1993.
- 'A lower frequency receiving system', by Richard Q. Marris, *Elektor Electronics* April 1994.
- Use the *Elektor Electronics* Item Tracer to find more articles!

For further reading:

'NE602 primer', by Joseph J. Carr, *Elektor Electronics* January 1992.

SMART TRANSISTOR TESTER

Design by R. Blaschke

There are many kinds of transistor tester. Whatever kind is used, it is imperative that the transistor is inserted correctly into the test socket. The tester described in this article contains a microprocessor that determines what type of transistor is inserted (n-p-n or p-n-p), ascertains the pinout, measures the current amplification, and then portrays the findings on a liquid-crystal display – LCD.

With most transistor testers, the user has to know the pinout of the transistor to be tested, so that the device can be inserted into the tester correctly. In cases of doubt, a transistor data book has to be consulted, and this may not list the particular transistor. Some books even give wrong information.

In the design of the tester, which is suitable for use with bipolar transistors only, it was, therefore, decided to provide not only type detection (n-p-n or p-n-p) and determination of the current amplification factor, but also automatic pinout identification. Other aspects were ease of operation and clear display of the test findings. These requirements are comfortably met by the use of a microcontroller.

Brief specification

- Microcontroller driven measurements
- Suitable for bipolar transistors only
- Automatic identification of the type (n-p-n or p-n-p)
- Automatic determination of the pinout
- Tests may be cycled in single steps
- Amplification measurement up to β = 1000
- β measurement with constant base current of 10 μA
- Alphanumeric display on LCD
- Battery or mains adaptor operated
- Current drain 6–10 mA (depending on voltage regulator)
- Batter low indication
- Calibration not required

Hardware

The microcontroller chosen is the PIC16C71 which is one of the series of such devices described in the PIC programmer course published in a series of articles in this magazine in early 1994. This type of controller is eminently suitable for use in this design and requires few external components. It also contains a suitable analogue-to-digital converter (ADC) needed for the present application (a short description is given in the box on p.28). Its small size (it is housed in an 18-pin DIL case) allows it to be part of a compact design.

The display is a 2×16 LCD type.

In order to identify the type of a transistor, a standard transistor circuit is connected to the test socket as shown in **Fig. 1**. In the case of an n-p-n transistor (A), this means that

- the base is connected to the +ve supply line via a high-value resistor;
- the collector is connected to the +ve supply line via a low-value resistor;
- the emitter is linked to earth.

In the case of an p-n-p transistor (B), the +ve supply line and earth are interchanged.

To identify the type and pinout of a transistor, the microcontroller measures the base and collector currents. In the circuits in Fig. 1, these currents fall within a certain range. Since the transistor can be inserted into the test socket in a variety of ways, six possible pinouts must be tried out: CEB; CBE; ECB; BCE; EBC; and BEC.

The supply lines are switched over by 16 analogue switches contained in IC_4–IC_7 (see **Fig. 2**). Since the microcontroller does not contain 16 corresponding ports, cascaded circuits IC_2 and IC_3 form a 16-bit shift register to extend the number of ports.

The reader will note that the base current is ascertained by measurement of the voltage drop across the base resistor, whereas the collector current is assessed by measurement of the voltages at the two terminals of the collector resistor. The reason for this is the internal resistance of the analogue switches, which is of the order of 100 Ω. Compared with the value of the base resistor, this is negligible. The base current, I_B is given by

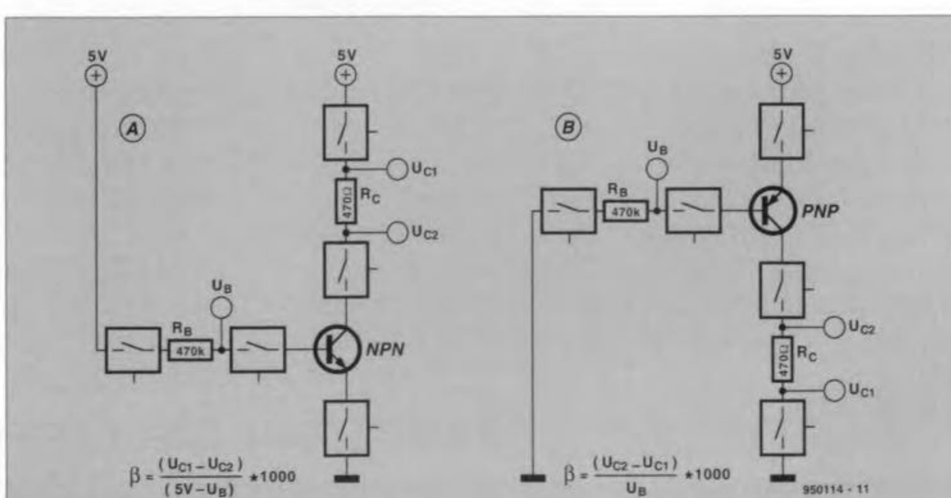


Fig. 1. Realistic values of base and emitter currents can be obtained only if a transistor is connected as shown

$I_B = (5 - U_B)/R_B$ (n-p-n)

$I_B = U_B/R_B$ (p-n-p).

Owing to the higher collector current, the consequent drop across the switch would invalidate the measurement. Therefore, the collector current, I_C, is given by

$I_C = (U_{C1} - U_{C2})/R_C$ (n-p-n)

$I_C = (U_{C2} - U_{C1})/R_C$ (p-n-p)

The current amplification factor, β, is determined by the ratio I_C/I_B, so that:

$\beta = 1000(U_{C1} - U_{C2})/(5 - U_B)$ (n-p-n)

$\beta = 1000(U_{C2} - U_{C1})/U_B$ (p-n-p)

From this, it is clear that the accuracy of the measurements is directly related to the tolerance of the resistors.

The LCD is controlled in a 4-bit mode, which saves on controller ports. Its contrast may be varied as required with preset P_1.

The tester has a 'battery low' facility. The input for this, AD_0, is also used for evaluating the status of the start switch – again, this is done to save an input to the controller. Potential divider R_{10}-R_{11} divides the input voltage by 4 so that it can be measured by the controller. When the battery voltage is in the normal range of 6–12 V, the controller is supplied with 1.5–3 V. When the supply voltage drops below about 5.6 V, that is, 1.4 V

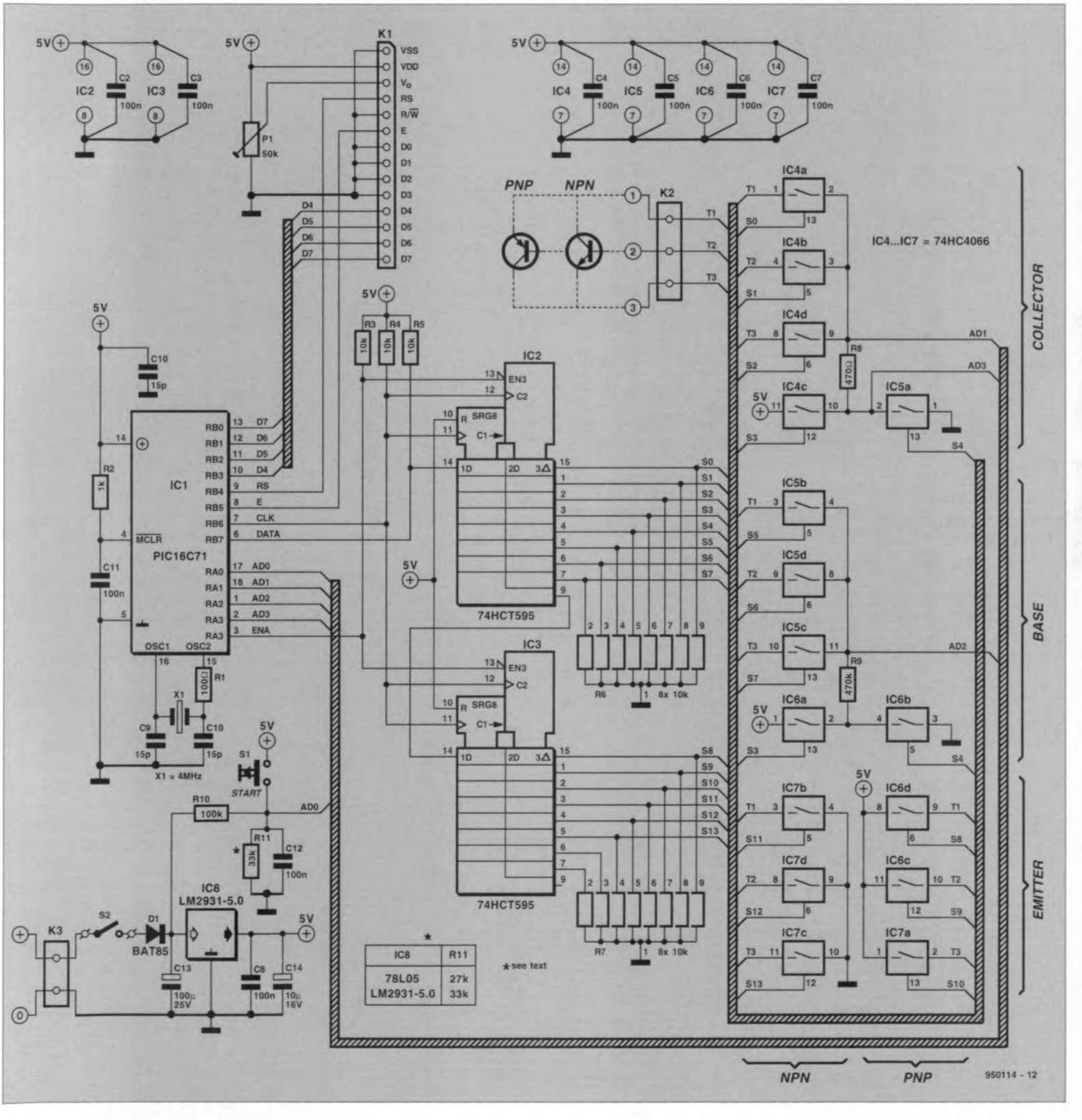


Fig. 2. Sixteen analogue switches contained in IC_4–IC_7 connect the transistor on test in six different ways. On the basis of the findings, the type of transistor, its pinout, and its current amplification factor are determined.

at AD_0 (pin 17), the tester will indicate that the battery is flat. A voltage of about 5 V at this input indicates to the controller that the start button is being pressed.

The supply voltage is obtained via a low-drop voltage regulator, which provides power for longer than, say, a 78L05 when the battery voltage becomes low. This is the reason that in the circuit diagram in Fig. 2 a small table shows two values for R_{11}, depending on which regulator is used.

Diode D_1 protects the tester against accidental polarity reversal; this is a Schottky type to keep losses to a minimum.

When instead of a battery a 9–12 V, 100 mA mains adaptor is used, IC_8 may be a 78L05 and D_1 a 1N4001.

It should be pointed out that the pull-up resistors at the inputs, and the pull-down resistors at the outputs, ensure stable operation immediately after a reset of the controller. This is because the controller ports are then arranged as input: they are high-impedance and do not present a definite level to the shift register. Until the software rearranges the ports, the resistors ensure a defined level. At the same time, a possible output of the status of the shift register is suppressed since 'input' OUTPUT ENABLE is active low.

To prevent any spurious operation of the analogue switches, resistor arrays pull their control signals to earth.

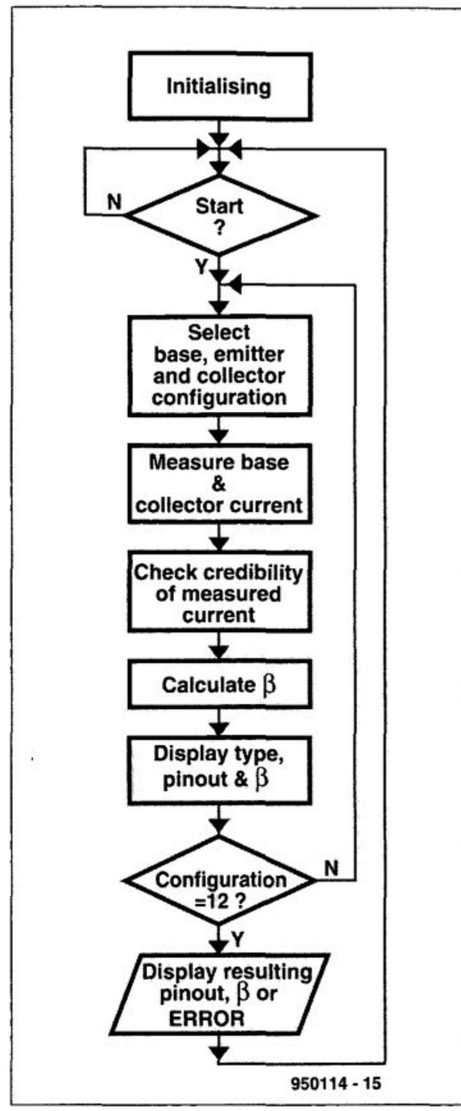


Fig. 3. Flow chart of the software. After switch-on, the test loop is traversed 12 times. After each cycle, the pinout configuration is changed.

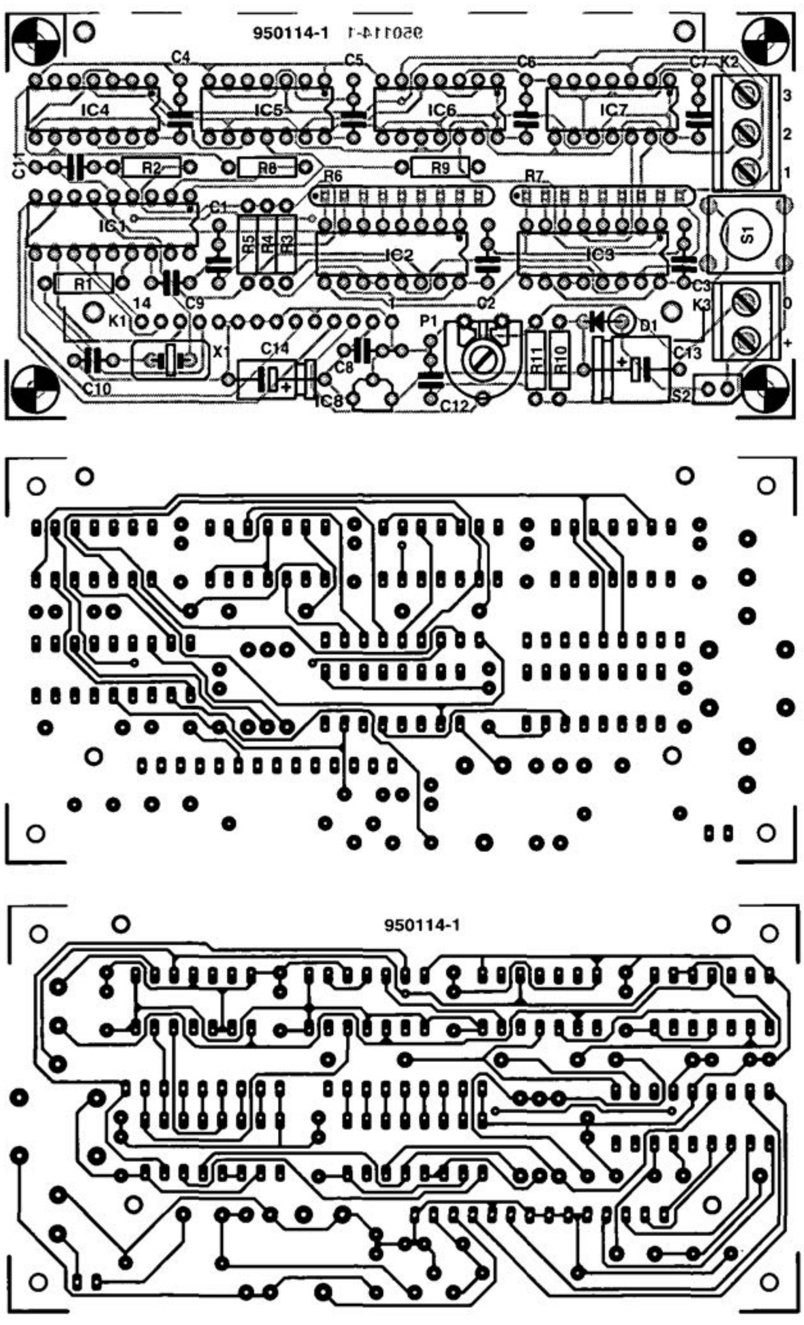


Fig. 4. The double-side, through-plated printed-circuit board for the tester (scale 1:1).

Software

The function of the software is to actuate the relevant parts of the circuit, that is, control the switching sections, determine the base and collector voltages, and arrange for the findings to be displayed. To this end, the program makes full use of the many interrupt facilities offered by the controller. Executing the necessary multiplication and division operations for computing the amplification factor is fairly tedious with a RISC processor, but entirely possible. A great help with this is the *Embedded Control Handbook* from Microchip. The 1024-word program memory is absolutely full.

Note that if during switch-on the start button is pressed, the tester is set to the single-step mode. In this mode, the test loop shown in **Fig. 3** is not automatically traversed twelve times when the start button is pressed. Instead, the start button has to be pressed for each and every successive cycle.

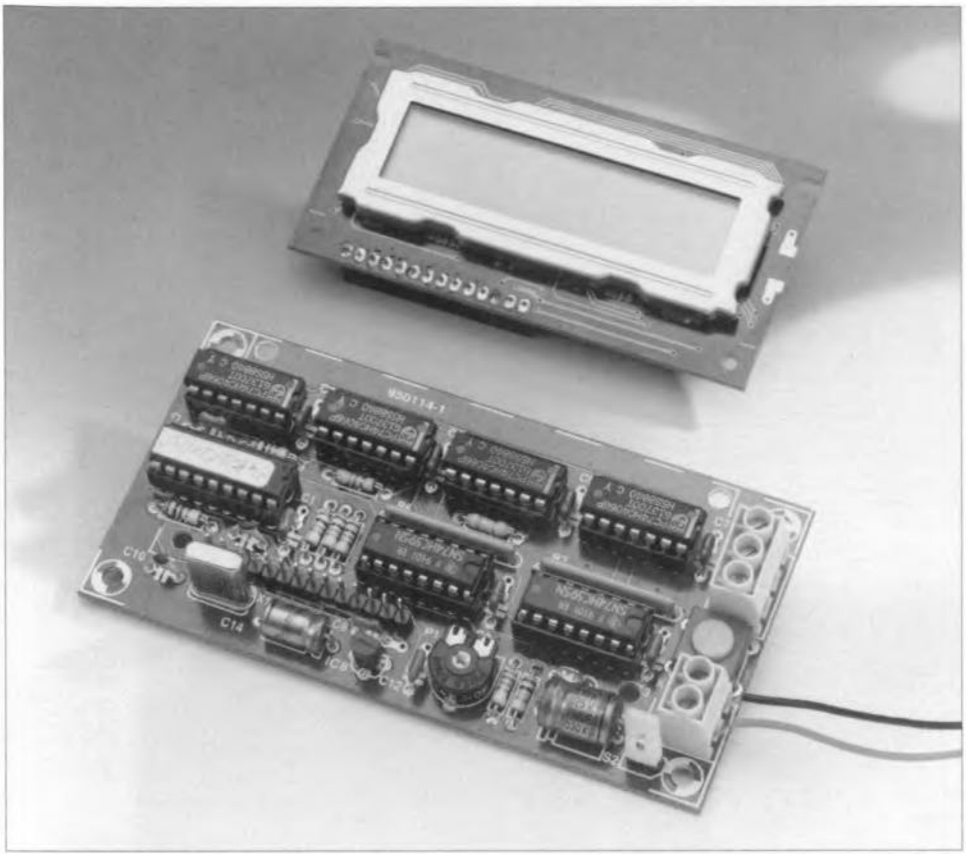


Fig. 5. The finished prototype PCB and LCD module, which is simply fitted on to the single-row terminal strip (K_1) on the board.

Fig. 6. Normal test result for an n-p-n transistor with emitter (E) at pin 1 of K_2, base (B) at pin 2 of K_2, and collector (C) at pin 3 of K_2. The current amplification factor, $\beta = 370$.

For every cycle, the display shows the type of transistor (n-p-n or p-n-p) and the pinout, as well as the results of the analogue-to-digital conversion and the amplification factor; the latter two only if the result is other than 0000. The first digit gives the voltage difference across the collector resistor, which is followed by the base voltage. For these measurements, the AD outputs are read successively 16 times and summed. In this way, the result from the ADC is extended from 8 to 12 bits, resulting in $OFFF_H$ 5 V.

Results deemed realistic by the tester are identified by a radical sign.

The single-step mode was originally intended for the development phase only, but was later thought to be useful for not-so-common transistors.

In the single-step mode, it is found that certain transistors function even when their emitter and collector terminals are interchanged, albeit with reduced amplification. This means that during testing it may found that a transistor gives two possible results; in that case, the one with the higher β is the correct one.

Construction

Because of the small number of components, building the tester on the doubled-sided, through-plated board shown in **Fig. 4** is straightforward. The only aspect that needs watching is the value of R_{11}, which must correspond to the regulator used as shown on the circuit diagram.

The LCD module is mounted on to terminal strip K_1, with the aid of a female counter part. The whole is fixed firmly in place with four screws, nuts and washers, for which holes are provided in the board. A photo of the finished board is shown in **Fig. 5**.

Testing and taking into use

When the finished board has been checked thoroughly and found all right, it may be connected to a battery or mains adaptor. Switch on (with S_2), whereupon a starting bar appears on the display. The contrast of the display can then be adjusted as required. Connect a small-signal transistor, for instance, a BC547, to K_2, and press the start button: the results will be displayed after one or two seconds (such as those shown in **Fig. 6**).

Interchange the transistor terminals at random a couple of times and it will be found that the tester, after the start button has been pressed, will every time show the correct pinout and amplification factor. Replace the BC547 by a BC557, however, and it will be found that the reading on the display, after the start button has been pressed, will change from n-p-n to p-n-p.

When everything is found in correct working order, the single-step mode should be tried. This mode is selected by holding the start button down while the tester is switched on. The display will then show the results of each and every cycle (for which the start button must be pressed every time), for example, as shown in **Fig. 8**. The HEX values represent the measured current; at their right the computed β is displayed. Note that the latest software version no longer causes the test number to be displayed.

Some practical points

With a current-amplification factor of 250, a typical base current of 10 μA results in a collector current of 2.5 mA. This shows that the tester is particularly useful for small-signal transistors, whose β values are specified for these levels of current. Of course, testing power transistors is

The PIC16C71

The PIC16C71 is an 8-bit RISC (Reduced Instruction Set Coding) device with integral EPROM (1024×14 bit) and ADC (Analogue-to-Digital Converter). It is the first member of the enhanced PIC16Cxx microcontroller family.

The high computing speed is, as in the original 16C5x series, obtained by processing single-word instructions. The word length in the new version is, however, increased from 12 to 14 bits.

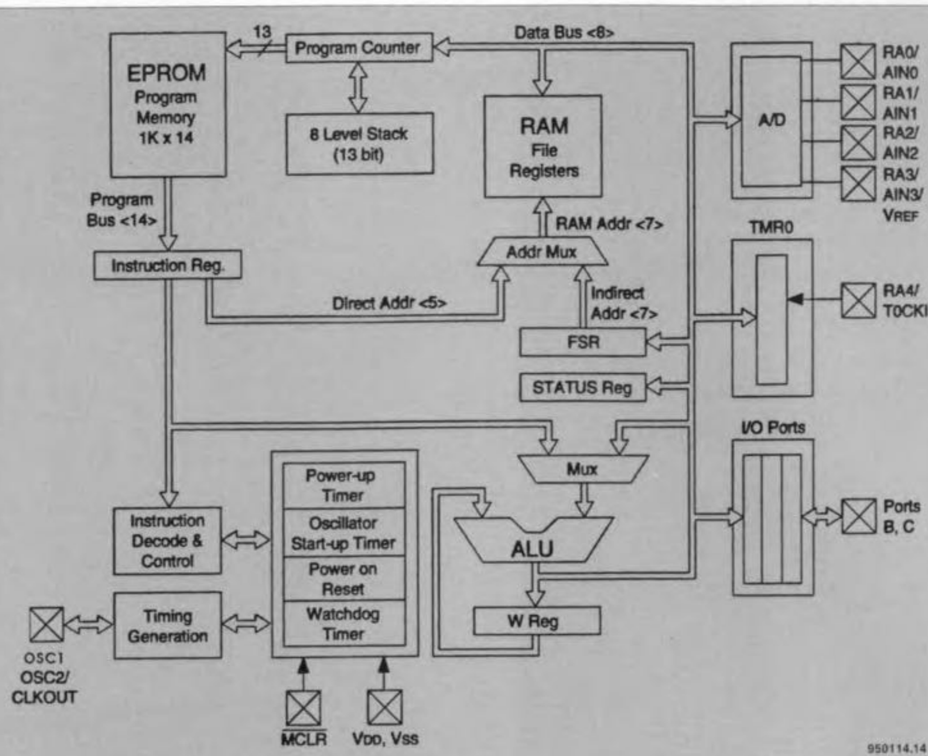
An instruction is normally executed in a single clock cycle (250 ns with a 16 MHz clock), except in case of a program branch when two cycles (500 ns) are needed. The total instruction set is a mere 35 single-word commands.

As with the 16C5x family, the clock frequency may have any value between d.c. and 16 MHz.

The peripheral equipment comprises an 8-bit timer/counter with an 8-bit prescaler (forming effectively a 16-bit timer), 13 bidirectional I/O pins, and an 8-bit ADC.

The I/O pins can provide 25 mA and sink 20 mA, so that in many cases external drivers are not required – a worthwhile saving in costs.

The ADC contains four multiplexed input channels, a sample-and-hold stage and an 8-bit resolution with ±1 LSB accuracy. The conversion time, including scanning, is typically 30 µs.



PDIP, SOIC, CERDIP Window

950114.13

also possible without any difficulty as far as pinout and type of transistor are concerned, and also to verify whether the transistor is working. However, as far as the β value is concerned, it should be borne in mind that power transistors have a rather lower β when the collector current is small than when it has its typical value of 100 mA to a few amperes, depending on the type of transistor.

Use of the tester with darlington transistors is rather limited, since the high amplification factors typical of these transistors cannot be measured when they exceed 1000.

After the board has been installed into a suitable plastic (ABS) enclosure, the connection for the transistors to be tested may be formed by a solid transistor socket connected by a short cable to K_2, or by a 3-core cable fitted at one end into K_2 and terminated at the other end into three crocodile clips for connection to the transistor on test.

Parts list

Resistors:
R_1 = 100 Ω
R_2 = 1 kΩ
R_3–R_5 = 10 kΩ
R_6, R_7 = 8×10 kΩ SIL array
R_8 = 470 Ω
R_9 = 470 kΩ
R_{10} = 100 kΩ
R_{11} = see text and Fig. 2

P_1 = 50 kΩ (47 kΩ) preset

Capacitors:
C_1–C_8, C_{11}, C_{12} = 100 nF
C_9, C_{10} = 15 pF
C_{13} = 100 µF, 25 V
C_{14} = 10 µF, 16 V

Fig. 7. This error display appears if the test results are not realistic. This may not necessarily mean a faulty transistor: it may indicate that β>1000.

Semiconductors:

D_1 = 1N4002
T_1 = BC547
T_2 = BC557

Integrated circuits:

IC_1 = PIC16C71 (with program 956502-1: see p. 70)
IC_2, IC_3 = 74HC595
IC_4–IC_7 = 74HC4066
IC_8 = LM2931-5.0 or 78L05 (see text)

Miscellaneous:

K_1 = 14-pin single-row terminal strip with associated socket
K_2 = 3-way spring-loaded terminal for PCB mounting, pitch 5 mm
K_3 = 2-way spring-loaded terminal for PCB mounting, pitch 5 mm
S_1 = single-pole push-button switch
S_2 = single-pole on/off switch
X_1 = 4 MHz crystal
PCB Order no. 950114

[950114]

Fig. 8. In the single-step mode, the result of the test performed during the previous cycle is displayed. Note radical sign after '0127'.

RF DUMMY LOAD

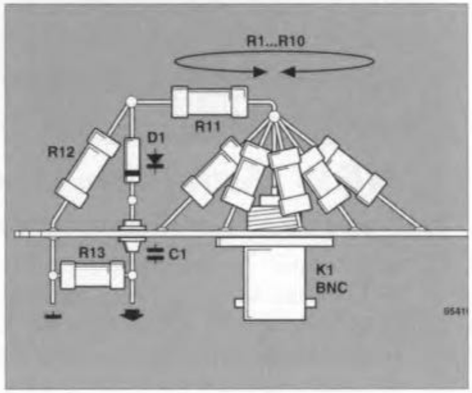
According to the radio regulations in most countries, any licensed radio amateur must have a non-radiating load to connect to his transmitter's RF output. The use of such a load is mandatory for 'off-air' adjustment of the transmitter.

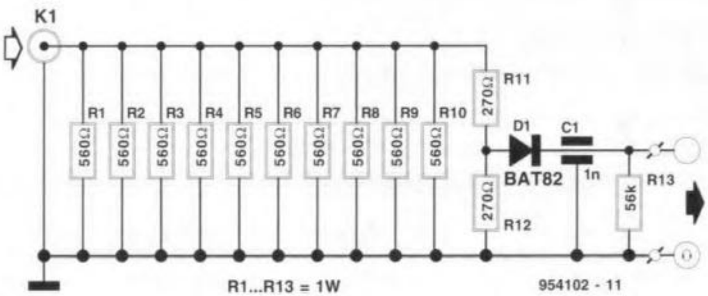
The load described here is capable of handling up to 10 watts of RF power for a couple of minutes, and is designed for the widely used 50-Ω impedance. It consists of ten parallel connected 560-Ω 1-watt resistors, R_1 through R_{10}, a voltage divider, R_{11}-R_{12}, and a rectifier, D_1-C_1. Apart from loading the transmitter output with a minimum of reflected power, the dummy load also provides a direct voltage output to which a voltmeter may be connected to measure the RF power. If the dummy load is used for power levels higher than 10 watts, simply use more, or higher-wattage, resistors to give a total of about 50 Ω. For instance, by using twenty 2-watt 1,200-Ω resistors instead of R_1-R_{10}, and 150-Ω resistors for R_{11} and R_{12}, the dummy load is turned into a 40-watt version. The diode may be almost any Schottky type. Types like the BAT85 and HSCH1001, for instance, are also suitable. Even a germanium type like the AA119 will work, but then for low powers only.

The dummy load is housed in a tin can of which the cover is used to mount the components. As illustrated, the ten 560-Ω resistors are soldered in a circle around the centre pin of the BNC socket. Their ground terminals are soldered flush to the inside of the cover. Capacitor C_1 is a feed-through type for which a small hole must be drilled in the cover. All resistors should be mounted with the shortest possible lead lengths to keep the reactive component of the dummy load as small as possible. After mounting the parts, the cover is fitted on to the tin can again, and soldered all around to seal the dummy load completely. Do not drill ventilation holes in the tin can because that will defeat the purpose of making a non-radiating load. The can may get quite hot when transmitter power is applied for a while, but that is no cause for concern.

The voltmeter read-out produced by the dummy load may be calibrated against a professional RF wattmeter (for instance a 'real' Bird Thruline). The voltages obtained at different RF power levels are noted so that a graph can be made. Depending on the reactive characteristics of the resistors used, the dummy load should exhibit a VSWR of less than 1.5 for frequencies up to 450 MHz. Resistor R_{13} may be omitted if the dummy load is always used with the same voltmeter.

Design by L. Lemmens
[954102]





FOCUS ON: SOLDERING AND SOLDERING TECHNIQUES

From the earliest days of electronics circuit construction, soldering has been used to make electrical connections. This article presents some of today's soldering techniques and tools. As will be shown, the rise of micro-electronics has been an important factor in the development of the latest soldering techniques.

By our editorial staff

SOLDER tin is a material known to everyone who is even marginally involved in electric engineering or electronics. The exact composition of the stuff is, however, far less well known, hence our initial look at this subject. Solder tin is an alloy of tin and lead. Both metals are good conductors, and have a relatively low liquefaction (melting) temperature. Other properties of these materials, such as hardness, tensile strength and elongation are positive factors in this specific application. As shown by the graphs in **Fig. 1**, both lead and tin have a fairly long melting range. Because a good solder joint requires the change from solid to liquid to occur within a relatively small temperature range, research was initiated to find a 'blend' between lead and tin which gives the best possible results. The ideal solder tin has a purely eutectic behaviour (i.e., it changes instantly from solid to liquid).

The graph shows that the melting temperature of the tin/lead alloy is always at 183 °C, irrespective of the mix. At a mix of 40% tin and 60% lead, the material is fully melted at 234 °C. So, within the temperature range from 183 °C to 234 °C, the mixture is pasty. The graph also shows that the length of the 'pasty' range is strongly dependent on the lead/tin ratio. Eutectic behaviour is achieved at a ratio of 61.9% tin and 38.1% lead. After some more research, the DIN1707 industry standard was drawn up which says that solder tin with a melting point of 183 °C should be an alloy consisting of 62.5% to 63.5% tin, and the remaining part, lead. The characteristics of a number of different tin/lead alloys are summarized in **Table 1**.

Soldering techniques

Broadly speaking, there are three different soldering methods. Apart from these, there exist a number of supplementary techniques for special applications. The oldest and best known solder technique is that using the solder iron. This is applied with manual soldering of circuits, and played an important role in the pre-circuit board days. Today, the soldering iron is used in the production of electrical and electronic equipment to solder wires and larger parts on to a board. For servicing, too, the solder iron has retained its value. Obviously, it should be noted that today's solder irons are much smaller than those of yesteryear.

Although hobbyists and other small-scale users still use the solder iron and solder pistol, soldering in the industry has gone through tremendous changes. With the arrival of printed circuit boards, automated soldering has seen rapid acceptance, while the solder iron was dumped as a production tool. Working with a solder iron is not only cumbersome, but also fairly coarse considering the size of today's SMDs (surface mount devices), which are no longer suitable for manual processing. Modern production techniques require a component placing accuracy of a few tens of micrometers, while the distance between two solder joint is a few hundreds of micrometers. Obviously such precision is impossible to achieve by hand. No wonder automated production has claimed a foremost role in the production process. Today, much electronic equipment can only be made with the aid of advanced component placement robots and soldering machines.

Automated soldering

As regards industrial soldering, there appear to be two mainstreams: wave soldering and reflow soldering. The wave technique is eminently suited to soldering so-called leaded parts, i.e., components with wires which are inserted into PCB holes. Hence, boards with leaded

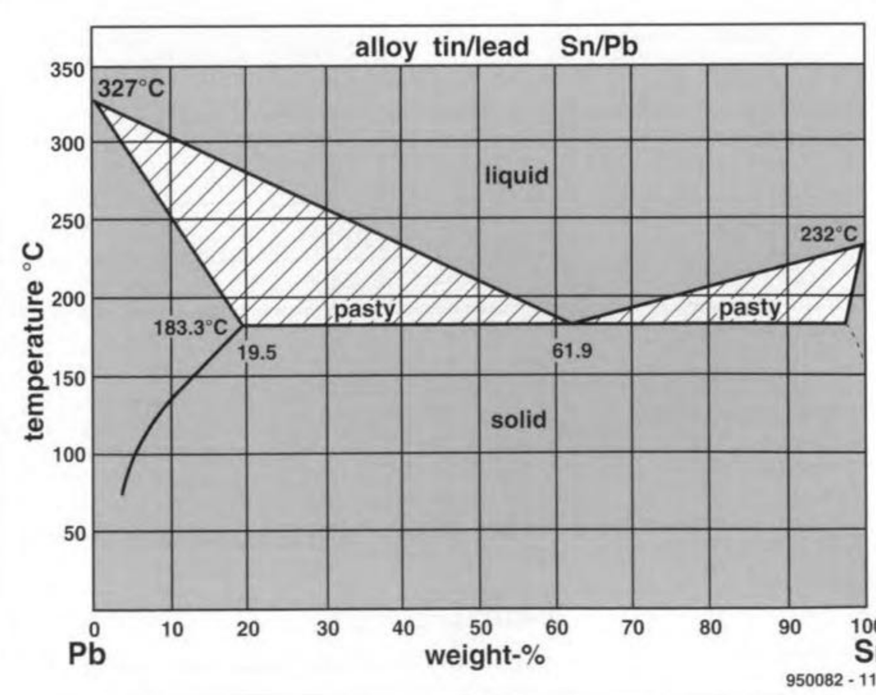


Fig. 1. Liquidus curve of different lead/tin alloys. The DIN1707 standard for solder is based on a ratio of about 63% tin and 37% lead.

Sn (rest Pb)	100%	63%	50%	40%	30%	20%
Liquefaction temp. (°C)	232	183	212	234	257	270
Solidification temp. (°C)	232	183	183	183	183	183
Melting range (°C)	0	0	29	51	74	87
Specific weight (g/cm3)	7.29	8.42	8.91	9.34	9.78	11.35
Tensile strength(kp/mm2)	1.44	5.19	4.26	4.26	4.12	1.38
Elongation (%)	55	32	43	35	26	39
Shear strength (kp/mm2)	1.98	4.31	3.97	3.44	3.19	1.39
Brinell strength (kp/mm2)	3.9	11.78	10.17	9.58	7.37	3.47
Conductivity (% of pure copper)	8.47	7.26	6.71	6.22	5.79	4.83

Table 1. The most important properties of different tin/lead alloys.

Fig. 2. When it comes to soldering, the soldering iron is the best known tool for the trade. This vintage type was introduced in the fifties, and is not really suitable anymore for soldering modern circuits. Note the burnt edges of the cardboard box onto which the iron was occasionally landed.

parts on them (and, possibly, SMDs, too) are soldered with the aid of a wave soldering machine. Reflow soldering came to the fore when SMDs started to conquer the market, and made their leaded counterparts take a back seat. The technique is, therefore, excellent for soldering SMDs. The great advantage of reflow soldering is the relatively small investment needed to get going with this technique. A reflow oven is much less expensive than a wave soldering machine. Meanwhile, the reflow technique has matured into its second generation. The infra-red heating systems of the early days are now quickly being superseded by hot air machines.

Wave soldering

Wave soldering is the technique *par excellence* for soldering printed circuit boards with leaded components. Before a printed circuit board can be used in a wave soldering machine, a thin layer of flux material is applied on it. Different techniques are available to apply the flux, such as sprayers, wave, foam and brush fluxers. Flux is a substance which greatly improves the soldering process by ensuring, among others, that oxygen is withheld from the liquid solder. This helps to prevent oxidation while the solder enters the liquid phase. Moreover, flux eliminates oxidation layers and other impurities which have a negative effect on the quality of the solder junction, and it improves the flow and adhesive force of the solder. In the industry, special machines, called fluxers, are used to apply solder flux on to boards. These fluxers automatically recognize the shape and size of the board, and adapt their spraying pattern accordingly. Clearances in the board are detected, and not sprayed. Obviously, that helps to reduce the amount of flux material used, and also the amount of contaminating residues. The PCB may have a bar code on it for the fluxer to read, enabling it to select the right fluxing program. The type of flux used, and its composition, may differ considerably under various circumstances. In fact the possibilities are so extensive that they are discussed in a separate inset in this article.

The wave soldering process may be started once the board has the flux layer and the components on it. As indicated by its name, wave soldering makes use of a bath filled with liquid solder in which waves are produced by one or more pumps fitted in the tin bath. Usually, a selection can be made between one or two waves. The use of a double tin wave produces a considerable vertical speed which causes the flux to be expelled very well, creating a good solder joint. The first tin wave heats up the solder contacts, and pre-tins them. The second wave then provides the actual solder joint. The use of a double tin wave guarantees the presence of sufficient solder, a good finish of the solder joint, and the removal of any short-circuits.

Printed circuit boards with parts on them (fitted manually or by a pick and place machine) are taken through the wave soldering machine, and so undergo a number of different treatments. An Ersa type EWS 330/350 wave soldering machine is shown in the photograph in **Fig. 4**. Inside the machine, the boards travel at a speed of about 3 m per minute. While in the machine, each board is pre-heated, soldered and cooled again. Pre-heating of the board and the components is necessary for a number of reasons: firstly, it reduces the temperature shock effect which occurs when soldering takes place; secondly, it helps solvents in the flux to evaporate; thirdly, it activates the flow agent, and fourthly, it improves the flux distribution on multi-layer cards.

The actual soldering action takes place by holding the board just above the bath of liquid solder, and then allowing the wave to pass underneath the board. As the wave touches the board, it ensures that all components are soldered relatively quickly (within about 5 s). Because the solder process is strongly dependent on the composition of the board, the machine is fine-tuned with the aid of software for the best possible results with boards that are in production at a partic-

Fig. 3. The soldering iron is still widely used for repairs on existing boards. Over the past decade, manufacturers of soldering irons have developed a wide range of accessories to enable SMDs to be soldered also (photograph courtesy Ersa).

ular moment. For that purpose, the Ersa machine offers a total of 99 user-defined solder programs.

After the wave soldering operation, the board is cooled in a controlled manner. The cooling section is an integral part of the machine. The cooling phase gives perfect crystallization of the solder, and, therefore, a perfect solder junction.

Oxidation of the solder occurs readily because the liquid solder is in direct contact with air. Without protective measures, this oxidation can cause the loss of up to 800 grams of solder per hour. Applying an oil film on to the liquid solder reduces the material loss owing to oxidation to less than 150 gram per hour.

The use of a low-oxygen atmosphere also has good effects on the results of the solder process. In many cases, the different compartments inside the wave soldering machine are fitted with N_2 injection systems. The nitrogen pumped into the compartment reduces the oxygen level considerably, and so helps to reduce the risk of massive oxidation. This, again, improves the quality of the solder joint, and reduces the amount of flux needed in the process.

The latest wave soldering machines are even capable of soldering without any flux at all. That approach is not only cheaper, but also very welcome as regards protection of the environment. A condition is, however, that the boards and the parts have been pre-tinned beforehand. Fortunately, that is not a problem because tin is already used as an etching mask during the production process of the board, while most components come with pre-tinned leads these days. In a flux-free soldering machine, the areas to be soldered on boards are cleaned with the aid of ultrasonic transducers which are fitted in the direct vicinity of the solder wave.

Fig. 4. Wave soldering is a technique applied with leaded components, but also with SMDs (photograph courtesy Ersa).

Reflow soldering

New, advanced soldering methods were urgently needed following the arrival of miniature parts and the reduced use of leaded components. Reflow soldering has made tremendous strides over the past few years, and the technique is under constant improvement. The process whereby components are fitted onto a PCB with the aid of a reflow oven (**Fig. 5**) may be divided into two phases: first, applying the solder paste, and, second, the actual reflow soldering operation. The solder paste is nearly always applied by means of silk screen printing. First, a mask (silk screen template) is placed on the board. Next, the solder paste is applied on to it with the aid of a spatula. A tiny bit of solder paste is applied to the board surface where there is a hole in the mask. The solder paste consists of small particles of solder tin, flux and a sticky compounding agent. The sticky properties of the paste are exploited with the fitting of the SMDs at their locations on the board by a pick and place machine. This machine actually pushes the parts into the small dots of solder paste. This should be done within about two hours from applying the dots. The final solder joint comes about when the board with all the parts on it enters the reflow oven. This process should take place within four or five hours. A reflow oven consists of a series of compartments in which the PCB and the parts are heated such that the solder paste dots melt and give perfect solder joints. Older generation reflow ovens use infra-red light with a wavelength between 0.7 µm and 7 µm. The disadvantage of this method is that darker parts, such as ICs, absorb a lot of precious heat. Consequently, they run very hot, while adjacent parts, especially those with bright or reflective surfaces, may not be sufficiently heated.

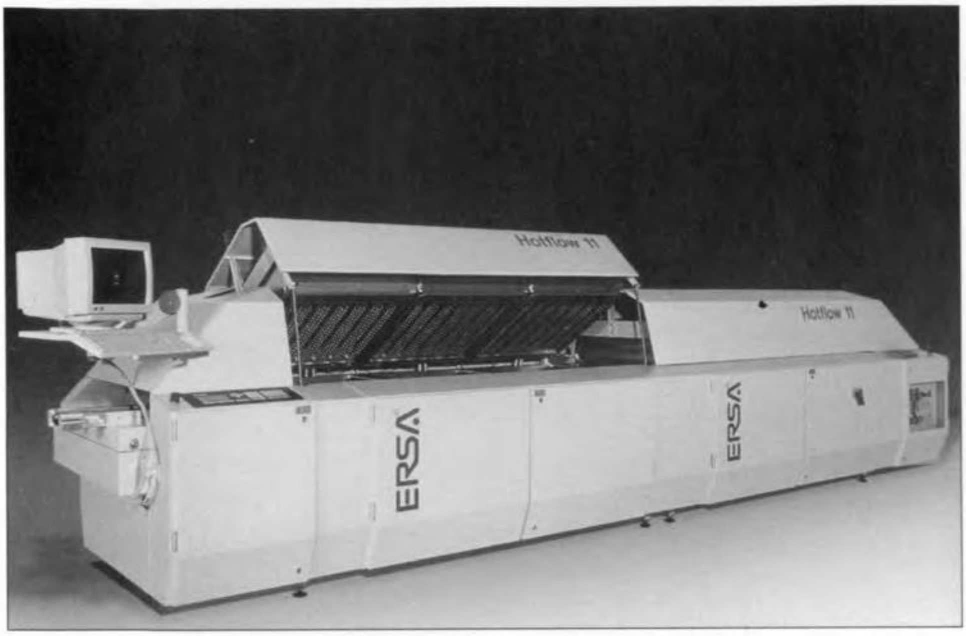


Fig. 5. Since the widespread introduction of SMDs, reflow soldering has taken the lead. These days, hot air is used rather than infrared heat to solder components (photograph courtesy Ersa).

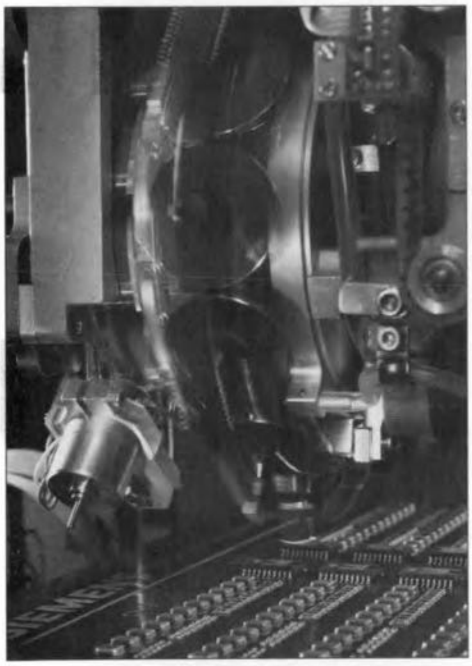


Fig. 6. Reflow soldering is inevitably linked to accurate placing of SMDs. This SIPLACE machine from Siemens does a terrific pick and place job at about 20,000 parts per hour (photograph courtesy Siemens).

In modern reflow ovens, the problem of unequal heat distribution is solved by making use of hot air. Many thousands of valves blow hot air into the compartment. Optionally, the air may be replaced by gas mixtures containing protective gases, for instance, nitrogen. Most modern reflow ovens have a number of 'zones' with different temperatures, all accurately controlled by software. In this way, the operators have the best possible control over the preheating, soldering and cooling phases. The possibilities of reflow soldering are not exhausted by far. New techniques allow ever smaller structures to package integrated circuits. Obviously, solder techniques such as reflow can only keep track of these developments with matching, i.e. extremely accurate, control.

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We thank the staff of AVT of Deurne, Belgium (suppliers of machines, tools and systems for the assembly of PCBs, wires and cables) for putting relevant background information at our disposal.

Solder flux materials

Passive flux (rosin R. flux)
This is pure resin dissolved in alcohol. This flux has low activity, and yields a small reduction of the oxidation layer. Consequently the surfaces to be soldered must have very good soldering properties. The residue is not aggressive and offers high isolation properties.

Low or medium impact flux (RMA, resin mild flux)
This flux consists of dissolved resin with the addition of a little acid or organic salt. These added activators have a deoxidizing effect and remove oxidized layers from the surface to be soldered. The flux residue unfortunately tends to corrode the solder joint. Moreover, an oxide layer with an isolating effect appears on the solder joint. This may cause problems while testing circuits.

Highly active fluxes (RA, resin-active flux)
This type of flux contains a higher percentage of activators in the form of an acid or an organic salt. It is used mainly on surfaces which are difficult to solder. The flux residue is, unfortunately, very aggressive, and the need to remove it is determined by the application area of the relevant circuit.

Flux on water basis, or soluble in water
Fluxes on water basis are, in general, highly active. The degree of oxidation is higher than with fluxes dissolved in alcohol. Soldered objects must be thoroughly cleaned after using this flux. Flux residue may be removed with water.

Flux on water basis, with anorganic salts
This type of flux contains, for example, zinc chloride or ammonium chloride as a reduction agent. The solvent is usually based on glycerol or glycol. Some of these solvents act corrosively on the circuit board material, or cause a decrease in the isolation resistance in humid areas.

Flux on water basis with organic acid
The reduction agent in this type of flux is usually lactic acid, citric acid or melon acid. This special type of flux is applied when others are not allowed. The deoxidizing effect of these acids is limited, so that high concentrations are necessary. The advantage is that the flux residue is not harmful, obviating the need to cleanse the soldered object(s) straight away.

Solder paste
Solder paste is applied with reflow soldering. It contains solder tin as well as flux. While the flux is basically the same as the ones mentioned above, the concentration of reduction agents is usually higher.

APPLICATION NOTE

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.

High-speed battery recharger DS1633

A Dallas Semiconductor application

The DS1633 battery recharger is designed to be a complete battery charging system for standard charging or trickle-charging. It can be configured for use with 5 V or 6 V supplies and battery voltages up to 4.7 V (3.7 V for 5 V supplies). The device is flexible enough to be used with a variety of battery chemistries (lithium, NiCd, lead-acid) and cell capacities. It provides timer termination of standard charging and automatically shifts into trickle-charging. Battery voltage may be monitored and charging terminated if it exceeds a preset maximum as a safety feature. The output load line may be specified as the usual constant-current recharge with a voltage limit or it may be configured to approximate any practical load line.

All parameters, such as power supply range, charging-current load line, trickle charging rate, and timer setting, are programmed into a nonvolatile memory using the battery pin as a one-wire communication port. To ease the task of configuring the device to specific needs, Dallas Semiconductor makes available a programming kit, the DS1633K, which contains easy-to-use software and hardware for IBM PCs.

The DS1633 is able to offer this flexibility thanks to its unique architecture—see **Fig. 1**. It monitors the battery voltage and adjusts the values of the output impedance, R_{TH}, and open-circuit voltage, V_{OC}, it presents to the battery. These values can be adjusted at 32 user-definable points (breakpoints) that occur roughly every 37 mV. This allows the device to approximate a wide range of charging lines; it is not limited to constant-current or even monotonically decreasing functions.

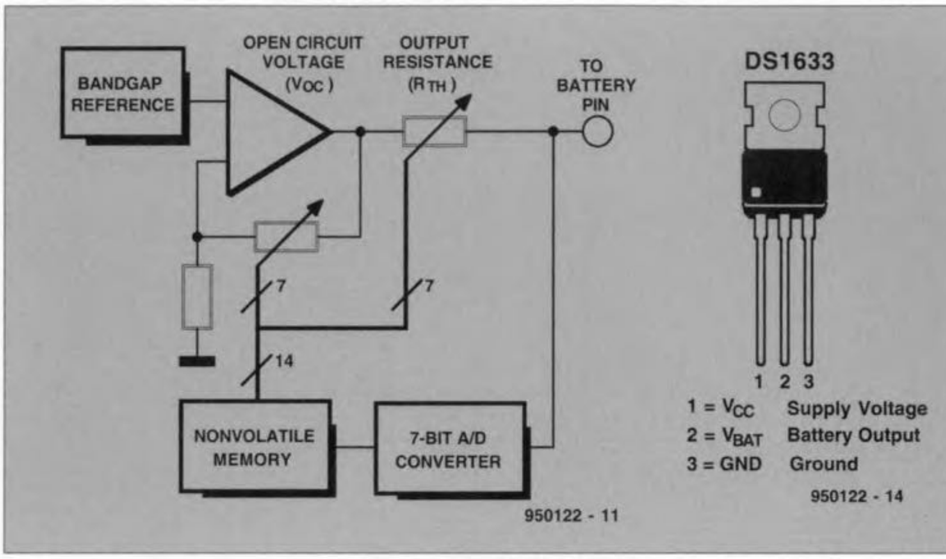

Fig. 1. Simplified block diagram and pinout of the DS1633.

Operation

Normal mode. Upon application of power, the DS1633 will perform an initialization cycle of eight seconds. During this period, it will determine if a battery is connected to the battery input by applying a voltage through the 5 kΩ output impedance and looking for a non-zero current flow out of the pin. If a battery is connected, the value of the battery voltage will be determined with a 7-bit analogue-to-digital converter (ADC). This value will be used to determine which of the 32 user-defined points should be used to set R_{TH} and V_{OC}. Generally, as the battery is being charged, its voltage will increase. When the battery reaches or exceeds each user-defined point, the values of R_{TH} and V_{OC} will be modified accordingly. The battery voltage is measured and adjustments are made every eight seconds. The battery detection is performed at one-second intervals. If the amount of time the bat-

MSB — DS 1633 MEMORY ARRAY MAP — LSB

REGISTER	CHARGE ON	PULSE WIDTH	THEVENIN RESISTANCE FIELD	OPEN CIRCUIT VOLTAGE	BREAKPOINT VOLTAGE		
0	CO_0	PW_0	PW_0	V_{OC0}	V_{BP0}		
1							
2							
3							
o							
o							
o							
30							
31	CO_{31}	PW_{31}	PW_{31}	V_{OC31}	V_{BP31}		
32	MUST FILL UNUSED BITS WITH 0'S				TIMER VALUE	TIMER STATUS	V_{TRIP}

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Table 1. Register structure of the DS1633.

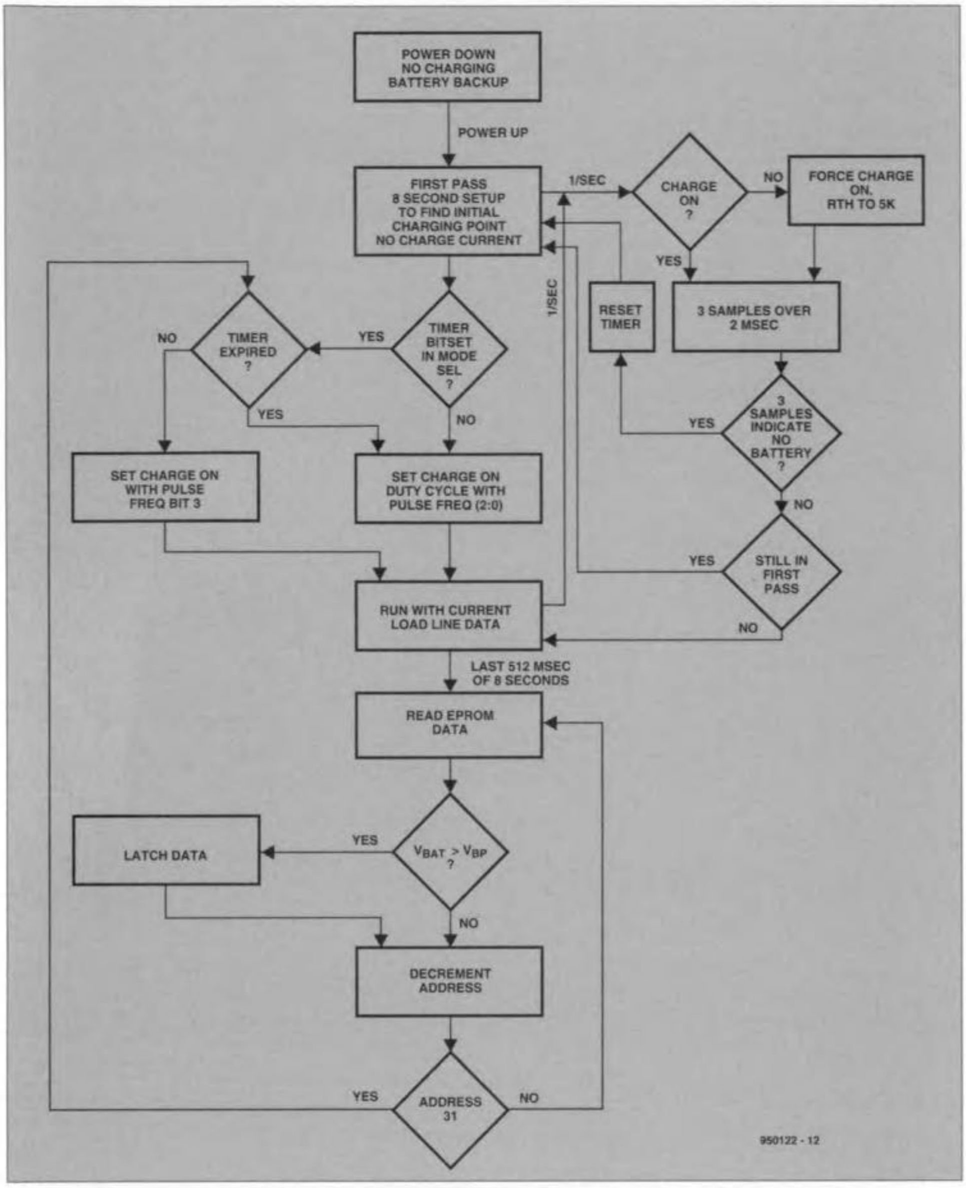


Fig. 2. Operation flow chart of the DS1633.

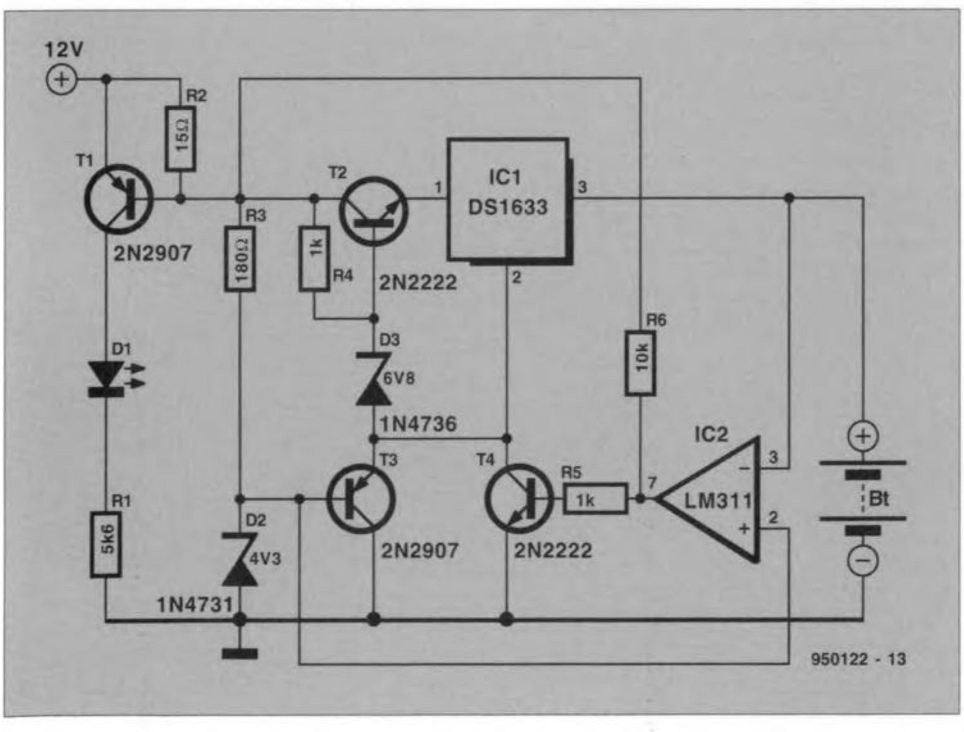


Fig. 3. Full featured battery charger based on DS1633.

tery has been charged exceeds the preset limit, the device will apply the R_{TH} and V_{OC} as before, but only for a fraction of the eight-second cycle time. This duty factor can be as low as 1/64 or as high as 1. In this way, trickle-charging can be accomplished by time averaging a short pulse over a longer period. A detailed flow diagram of normal operation is given in **Fig. 2**.

Programming mode. To configure a DS1633 for operation with a specific load line, the user must program a set of 25-bit internal registers—see **Table 1**. The first 32 of these registers (0–31) contain the information needed to locate each breakpoint and what the R_{TH} and V_{OC} are at that breakpoint, as well as the duty factor to be used after the optional timer has expired. The last register (32) contains the bits that select the system power supply level (5 V or 6 V), the timer option, and the time limit (2–32 hours in 2-hour increments).

The data for the registers is stored in nonvolatile memory and can be written only once. All 33 registers must be programmed before any can be read. Although the configuration register contains only six bits, 25 bits are required to be entered; therefore, 19 are 0s. The registers are programmed sequentially, starting at register 0. As each register is programmed, an internal pointer moves to the next register until all 33 have been programmed.

Preprogrammed versions

Type-coded DS1633x, preprogrammed versions of the DS1633 automatically provide constant-current recharging of a battery as long as the battery voltage is below the specified maximum voltage. They do so by using their V_{CC} input as a source: when V_{CC} is floated, they are dormant; when V_{CC} is reapplied, it begins charging.

Although a variety of load curves can be used to charge a battery, most do not take advantage of the fact that a battery can accept its maximum current rating for charging over its entire voltage range. The DS1633x takes advantage of this opportunity by constantly readjusting the current supplied to the battery being charged. As the voltage level of that battery rises, and the supply current drops, the DS1633x adjusts to boost the charging current back to its maximum. This feature greatly decreases the recharge time required to fully charge a lithium, NiCd, or lead-acid battery.

Typical application

For typical NiCd batteries, the 4.7 V limit on battery voltage restricts the battery to three cells. Many batteries nowadays use five cells. Moreover, with higher capacity battery packs, there are situations which require charging current higher than 100 mA.

The DS1633 has only three pins as shown in **Fig. 3**. It draws a quiescent current of only 1 mA. The value of R_2 (= R_{sense}) is selected so that when a charging current begins to be drawn from the +12 V supply, 0.7 V is dropped across it. This forward-biases transistor T_1, allowing current to flow out of the collector to drive D_1. The current through this LED is limited by series resistor R_1.

It is important to note that the voltage drop across R_2 must be accounted for in the overall charger design; the DS1633's V_{CC} limits must be observed.

Increasing output current.
While the DS1633 is capable of supplying a charging current of up to 100 mA, there are situations where a higher current is required. For example, charging an 800 mAh battery at 100 mA would take 13 hours. If the charging current could be increased to 160 mA, the battery would be fully charged in 8 hours. All versions of reprogrammed DS1633s, although providing different charging currents, come with 8-hour timer cutoff.

Since the DS1633 is essentially a voltage source with an adjustable resistor, it is capable only of sourcing current: it cannot sink current. This fact makes it possible to place any number of DS1633s in parallel, with no need for any external components.

Increasing battery voltage range.
The battery voltage limits on the DS1633 are suitable for NiCd batteries consisting of up to three cells. However, five-cell batteries are increasingly being used, so that a method of charging these batteries with a DS1633 is desirable.

Since the limit on the battery voltage is 4.7 V referred to V_{GND}, that is, the voltage at pin 2, it is possible to raise V_{GND} to keep V_{bat}, the voltage between pins 2 and 3, within limits. This method allows the DS1633 to charge batteries with any number of cells with certain constraints.

In theory, upon power up the V^+ potential at pin 1 may rise faster than V_{GND} potential at pin 2. If this were to happen, the DS1633 might be damaged or be placed in a test/programming mode, but zener diode D_3 ensures that this will never occur.

Network T_2-R_4-D_3 forms a simple pass voltage regulator that supplies the DS1633 with a V_{CC} of 6.2 V referred to V_{GND} at all times. This serves several purposes, the first of which is to allow the V^+ supply for the charger to be a convenient value, such as +12 V.

Resistor R_3 and diode D_2 provide an offset ground reference voltage that is connected to pin 2 via T_3, which is configured as an emitter follower. This will make V_{GND} about 0.7 V higher than the zener voltage of D_2.

The reference voltage is also fed to IC_2, which compares it with the battery voltage. If the battery voltage is below 4.3 V, the comparator's output will go high. This will turn on T_4, which will effectively pull V_{GND} down to with a few millivolts of the ground potential. This is good enough to make the DS1633 operate at battery voltages between 0 V and 4.3 V.

If the battery voltage is above 4.3 V, T_4 is turned off, and V_{GND} goes to the reference voltage as supplied via T_3. The change in ground reference voltage is automatic and will occur during charging if necessary.

It is the ability to dynamically shift the V_{GND} potential that makes the regulator circuit necessary. The regulator 'floats' with the V_{GND} potential and will maintain the proper V_{CC} voltage for the charger for whatever V_{GND} potential is available.

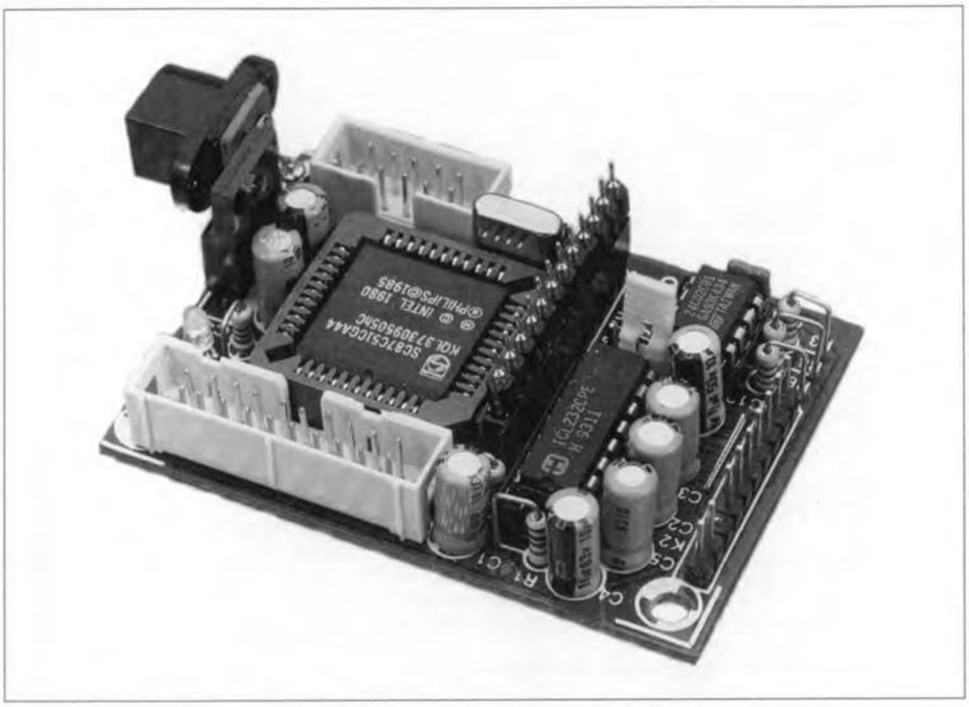
[950122]

References:
Dallas Semiconductor: *Application Note 54*

Dallas Semiconductor: *High-speed battery recharger DS1633*

'MATCHBOX' BASIC COMPUTER (PART 3, FINAL)

This concluding instalment presents the remaining features of the Matchbox BASIC computer. The large number of logic combination options and I/O features result in a powerful concept.



Software by Dr. M. Ohsmann

Arithmetic and logic operations

You can't do much with just numbers and variables. The fun doesn't start until it is possible to perform logic combinations on numbers. Fortunately, the MBC (MatchBox BASIC Computer) offers many possibilities for logic operators. The simplest and best known of these are addition and subtraction. You can do a lot with just these. Assuming that A, B, C and D are variables, then A+B is also a value which the MBC recognizes and is capable of processing. The same goes for A+B+C, A+B+C+D or A+B+C+D–1. Apart from + and –, multiplication (*) and division (/) are allowed. These operations are performed '16-bit signed'. The character '%' may be used to denote a modulo operation. For example, 'A&B' produces the remainder of the division 'A/B'. Next, there are the SHR and SHL operators, which shift values to the right or to the left respectively.

The logic operations available for bit pattern manipulation are AND, OR, XOR and NOT. These produce a new value from two values. You may write, for instance,

```
X:= A AND 1000100B ;
Y:=NOT X ;
```

Bit access
Programming 'at hardware level' often requires the testing and processing of individual bits, for instance, those corresponding to the port lines. For that application the MBC offers the '.' operator. Assuming that X and Y are values, then 'X.Y' is also a value which is '1' if bit Y of value X is '1'. If not, the expression returns '0'. For example, if you want to test if bit 3 of X is set, you write 'X.3'. Used with the ports, the dot is even allowed at more than one location, giving you ready access to individual bits.

Comparisons
A comparison represents a special way of combining two values. The MBC recognizes the following comparisons:

```
>=, <=, <>, <, >, =
```

When a comparison is performed, the two values are processed as 16-bit signed numbers. A comparison returns 0FFFFH when true, and 0 when false, and so fall in with the logic conditions discussed below. Because the result of a comparison is simply another value, it may be combined with other values. For example, the expression

```
(A>B) OR (C<D+E)
```

represents an acceptable value.

Logic conditions
Logic conditions, for instance, IF...THEN, are used to determine the program flow in the control structures offered by the MBC programming language. In the line

```
IF X THEN statement ENDIF
```

'statement' is only executed when X returns 'true', i.e., a value not equal to nought (<>0). Consequently, 'statement' is not executed when X returns 'false' ('0').

The conditions that apply to WHILE and REPEAT structures are processed in the same way. As a result, 'statement' in the line

```
IF P1.0 THEN statement ENDIF
```

is only executed of bit 0 of port P1 is at '1'.

Brackets and priority
The different types of combinations are subject to a certain order in which they are executed. This is not unlike school arithmetic, where multiplication and division go before addition and subtraction. So, when the MBC is given the expression

```
A*B+2*3+4/2
```

it starts by computing the values of A*B, 2*3 and 4/2, and then adds the three results. The priority rules that apply to all operators are given on the *Quick Reference Card* which is supplied through our Readers Services together with the MBC circuit board and diskette. The bit operator '.' has the highest priority (precedence), and the logic operators 'OR' and XOR, the lowest. Operators having the same level of precedence are processed from the left to the right. If a special order is required for the execution of such operations, you have to use brackets. Brackets may also help to improve the readability of a program. Remember, it is possible to write complex things like

```
A*B > C SHR 5 OR 101B - C SHR X
```

which may not be easy to comprehend at first glance.

RS232 (V24) interface

As already mentioned, the MBC has an RS232 (V24) interface which serves to download programs from the PC. The same interface may also be used to send or receive texts. To allow you to use the MBC with different quartz crystal frequencies or baud rates, a special command is available to determine the baud rate. To fix a baud rate of 300 bit/s at a crystal frequency of 11.0592 MHz, you simply program:

```
RS232(11059200,300)
```

For the programming mode of the MBC, it is assumed (by default) that the quartz frequency is 11.0592 MHz. Also by default, the baud rate on the PC link is 19,200 bits/s for the transfer of texts and programs.

Output using PRINT

The PRINT command is used to output texts and/or numbers, via the V24 interface, or on an LCD. For instance, you may program

```
PRINT('absolutely fab') ;
```

to print that slogan on the PC screen. Similarly,

```
PRINT(x)
```

sends the value of variable 'x' to the PC screen.

A single PRINT command may be used to output text as well as a variable or a number of values, for example:

```
PRINT('TEMPERATURE=',temp)
```

Numbers and variables, by the way, may be printed in a different formats (decimal, with decimal point, hexadecimal and so on). The MBC language also caters for outputting control characters and other special signs. For examples, see the programs on the MatchBox diskette.

Formatted output

To be able to output, for example, measurement values, it is imperative to have at one's disposal a number of purposely written routines. In that respect, the MBC offers everything you could possibly desire. Its FORMAT command allows you to define the way numbers are transmitted by the system. You may choose between decimal, hexadecimal and binary notation. Further, it is possible to specify the location of the decimal point as well as the maximum number of positions. You may also choose between signed and unsigned number representation. The general form of the FORMAT command is

```
FORMAT( options )
```

where the 'options' are:

LCD	direct all PRINT output to LCD
RS232	direct all PRINT output to RS232 interface
D	use decimal number notation
B	use binary number notation
H	use hexadecimal number notation
I	set sign at left position when negative

To indicate the length of the output field for a number, you may write

```
LENGTH=constant
```

where 'constant' is a number between 1 and 20. A range of further options is available for decimal output, including 'S' for 'signed' and 'U' for 'unsigned' interpretation of numbers. Further, you may use

```
DP=nn
```

and

```
DPSHOW=nn
```

to determine the number of positions behind the decimal point (DP) and the number of positions behind the comma which are actually shown (DPSHOW). A few examples:

```
X:=123 ;
PRINT('<',X,>"0D"0A') ;
; STATEMENT                                   OUTPUT
FORMAT (I LENGTH=10)                        ; <     123>
FORMAT (B I LENGTH=10)                      ; < 111011>
FORMAT (H I LENGTH=10)                      ; <      7B>
FORMAT (D I LENGTH=10 DP=2)                 ; <       1>
FORMAT (D I LENGTH=10 DP=2 DPSHOW=1)        ; <     1.2>
FORMAT (D I LENGTH=10 DP=2 DPSHOW=4)        ; <    1.23>
```

Character input via RS232

The function TSTC is available to test whether a character has been received from the RS232 (V24) interface. TSTC may be interrogated — a 1 means that a character is held ready in the receiver buffer. If TSTC=0, there is no character. The function GETC may be used to fetch a single character from the buffer. If you use GETC as a value, the system waits until a character is held ready in the receiver buffer, from where it may be fetched and processed as a value.

Number input via RS232

Number values may be read in hexadecimal notation using the GETHEX command. Similarly, GETDEC reads a decimal number. The line

```
X:=GETDEC
```

causes the MBC to wait for decimal input via the serial interface. The received decimal number is then stored in variable X. Incidentally, commands GETDEC, GETHEX and GETC ignore interrupts.

Arrays

Many programming languages allow the use of arrays (sometimes called fields). The MBC interpreter recognizes one-dimensional arrays only. The array index starts at 0. It is possible to declare arrays of BYTE or INTEGER variables. A few examples:

```
INTEGER X[5] ;
BYTE EEPROM Y[20] ;
```

This allows array elements X[0] through X[5] to be used as values and locations. Array Y has 21 elements, each of which is a byte stored in EEPROM. Such arrays enable complex functions in data communication to be performed. Again, for examples please refer to the course diskette.

I²C interface

Those of you who have worked with I²C devices will know that data may be read and written from/to these circuits. To enable several devices to be connected to a common bus, each device has a specific address, which is fixed by the manufacturer (although some modification is nearly always possible). The entire I²C data/command exchange protocol is integrated in the MBC interpreter, so that sending and receiving bytes to/from an I²C circuit is very easy indeed. For example, to transmit two bytes from an array called 'TX_data' to an I²C module at address 0100111xB (x=R/W bit), you simply write

```
IICWR(0100110B,2,TX_data)
```

The result is that the MBC sends the two bytes TX_data[0] and TX_data[1] to the respective I²C circuit. Likewise, to copy five bytes from an I²C device at address $0100111x_B$ into an array called RECEIVE, you program

```
IIC_RD(01001110B,5,RECEIVE)
```

The rest of the work is done by the MatchBox computer. In this way, you are able to control any I²C circuit (and there are quite a few) in a most efficient manner. The only condition is that you keep the number of bytes to be conveyed smaller than nine.

The LCD link

Those of you who followed our 8051 assembler course may remember the complexity of connecting an LCD (liquid crystal display) to the microcontroller system when you are forced to do that at the assembly programming level. Connecting up an LCD is much simpler if you use the MatchBox computer because the I²C bus is used for this purpose.

The LCD enables you to produce neatly finished, stand-alone intelligent systems offering the luxury of a text/number display.

The LCD must be initialized before you can send the first character. This is done as illustrated below:

```
LCDSET
FORMAT(LCD)
PRINT('hello matchbox')
```

The 'LCDCHR" command may be used to transmit a single character to the LCD, while 'LCDCOM' allows you to transmit bytes which serve as LCD instructions. These instructions may be found in the datasheets of the LCD.

The following program initializes the LCD, and writes an 'A' at the third cursor position (address 2) on the first line, followed by an 'x' at the sixth position.

```
LCDSET
LCDCOM(082H) ; cursor to pos. 2
LCDCHR('A') ; display the A
LCDCOM(086H) ; cursor at pos. 6
LCDCHR('x') ; display the x
```

Experienced programmers may talk directly to the LCD controller using I²C commands aimed at the PCF8574 I/O expander on the LCD board. Such direct access allows just about everything to be done with the LCD which is possible in 4-bit mode.

Subroutines

The start of a subroutine is marked by a line containing a label. The RETURN instruction is used at the end of the subroutine to get back to the main program. For example:

```
GOSUB PRINT_IT ; call subroutine
PRINT('X')
GOSUB PRINT_IT; call again
PRINT('X') ;
GOSUB PRINT_IT ; call again
STOP
;
PRINT_IT: ; start of subroutine
PRINT('*****')
RETURN ; return to main program
```

This little program causes the MBC to print

```
*****X*****X*****
```

Subroutines in general allow fairly complex assignments to be solved in a well-structured manner.

Characters and character strings

So far character strings have been used inside PRINT commands for transmission of texts. This is actually the only place where real character strings occur. Within a character string, a certain notation may be used to encode special characters such as the apostrophe. This is achieved by first writing " and then two hexadecimal numbers. In order to print it, a value may also be converted into a character. That is achieved by writing PRINT CHR(x), where x is the value of the character (32 is a space, 65 an 'A', etc.). Furthermore, it is possible to use a string as a value proper. The value is then the ASCII number of the character at the far right of the string. This allows conversion routines to be programmed quite easily. Here are a few example lines which illustrate some of the possibilities:

```
PRINT('0A=LF,0D=CR That's a new line') ;
PRINT(CHR(39),'test',CHR(39)) ; enclose word in apostrophes
X:='ABC' ; next we have X=ORD('C') ie X=67
```

Example

To close off this short course, an ingenious programming example is given which produces an LCD clock with a switching function. The clock may be set via the RS232 interface. As described in part 1 (October 1995), the LC display and the I²C clock PCF8583 are connected to the MBC. An LED is connected to pin 3.7 to visualize the operation of the switching function. The complete circuit is shown in **Fig. 1**. The program continuously reads the I²C clock. Note the elegant way in which the clock may be 'declared' using localized variables in lines 8, 9 and 10. The values are copied to the LCD. If a character is sent to the RS232 interface, that is interpreted as a prompt to set the clock. The new values are read via the RS232 interface (lines 24 to 33) and then sent to the clock module. The switching function is implemented in lines 14 through 18: each time the tens of seconds indicator is at '1', the LED at pin 3.7 is switched on. A similarly short program may be used to carry out complex timer functions. By the way, the I²C clock displays the time internally in BCD notation.

Miscellaneous matters

The CALL instruction is available to call up 8051 assembler routines which may be located in an (externally connected) EPROM. Simply write

```
CALL(x)
```

to call such a routine at address 'x', where 'x' is any value. To enable the MBC to carry on where it left off on branching to the assembler code, the routine should finish with a 'RET' instruction. Parameters may be conveyed via sections of the internal RAM, which have been declared with a special address contained within RAM or EPROM.

8051 special treats

The core of the MBC is a derivative from the generic 8051 processor. Many interesting features of this processor may be employed in the MatchBox programming language. Among these accessible features are the special function registers (SFRs), which can be addressed directly under their names. The following SFRs may be used as values: SBUF, SCON, T0 (16-bit), T1 (16-bit), IE, P0, P1, P2, P3.

The following SFRs may be used as locations, i.e., as a target for an assignment (allocation): TL0, TH0, TL1, TH1, SCON, SBUF, TCON, TMOD, PCON, IE, P0, P1, P2 and P3.

The SFRs enable you to make use of a wide range of peripheral circuits specifically designed for the 8051. For example, the timer may be re-pro-

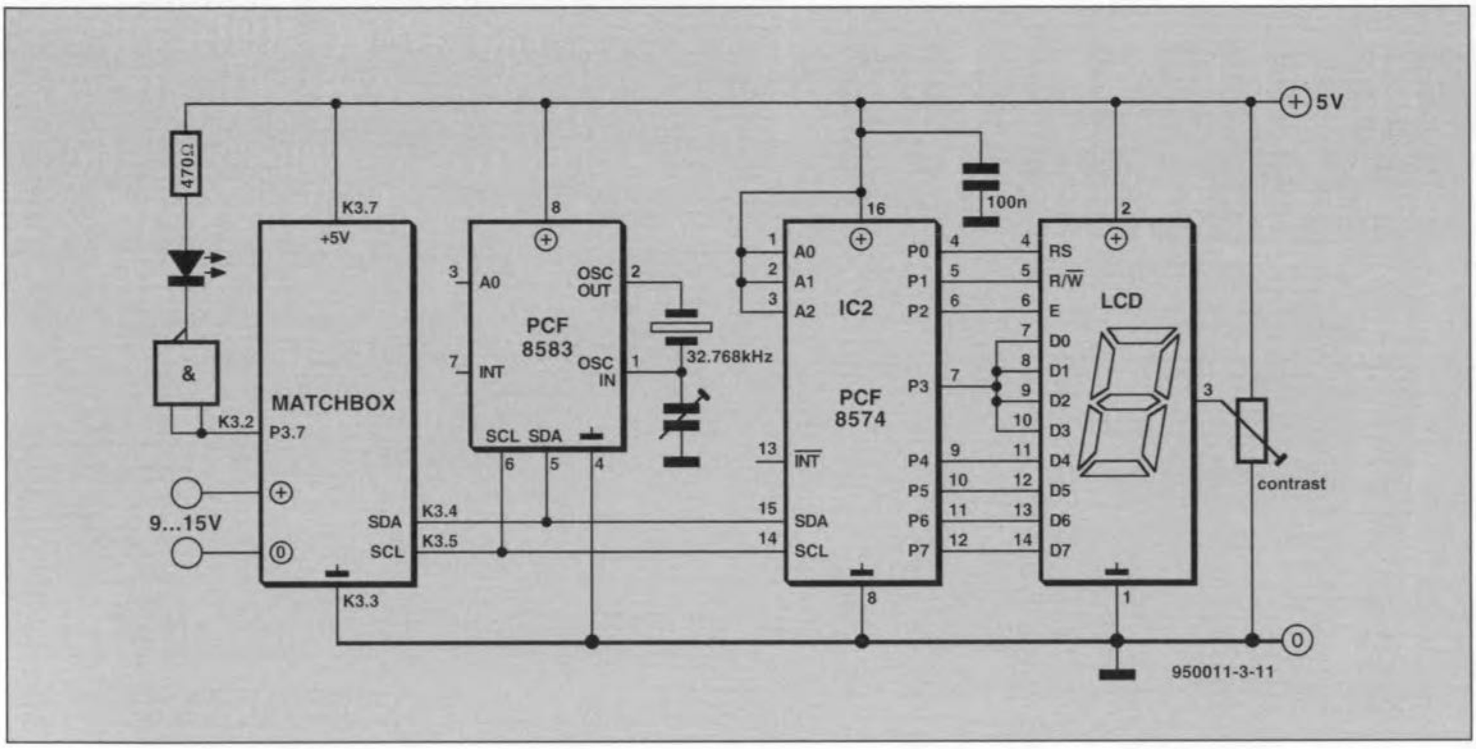


Fig. 1. Real-time clock and LCD extension for the Matchbox BASIC computer. Use this circuit in conjunction with the clock/timer program listed below.

```
0002 ; PROG4.MBL
0002 ; Subject:
0002 ; I2C real-time clock with switching function on P3.7,
       adjustable via RS232
0002 ;
0002 RESOURCE IIC-EEPROM 256 BYTES @5000H ; declare EEPROM
0002 RESOURCE 8051-IRAM  10H BYTES @70H   ; RAM needed
0002 BYTE DUMMY,inputHRS,inputMINS ; Variables for input
0002 BYTE SECS @IIC-RAM 05102H     ; fixed variables in PCF8583
0002 BYTE MINS @IIC-RAM 05103H     ; PCF8583 address 1010001x I2C
0002 BYTE HRS @IIC-RAM 05104H     ;01010001  Matchbox
0002 LCDSET                   ; initialize LCD
0003 P3.6:=0                  ; Led at P3.6 off
0008 continue:                ; Endless loop
0008     IF (SECS AND 0F0H)=10H THEN     ; When 1x seconds
0013         P3.7:=1       ;  Led at P3.7 on
0018      ELSE                ; else
001A         P3.7:=0       ; Led off
001F         ENDIF
001F     FORMAT(LCD H DP=0 DPSHOW=0 1 Z LENGTH=2)  ; output format
0027     LCDCOM(080H)      ; LCD cursor at first location
002A     PRINT(HRS,'.',MINS,'.',SECS); Output as n.nn.nn
003C     IF TSTC THEN      ; Check for receipt of RS232 char.,
003F         DUMMY:=GETC  ; if so fetch it
0043         FORMAT(RS232); Output now via RS232
004B        PRINT('"0D"0AHours:') ; Ask for hours
0057        inputHRS:=GETHEX      ; Read
005B        PRINT('"0D"0AMinutes:')      ; Ask for Minutes
0067        inputMINS:=GETHEX     ; Read
006B        PRINT('"0D"0ASeconds:')      ; Ask for seconds
0078        SECS:=GETHEX  ; Entries directly to I2C clock
007C       MINS:=inputMINS; Copy rest to I2C clock also
0082        HRS:=inputHRS
0088        PRINT('"0D"0AREADY..')       ; report READY
0093        ENDIF         ; End of clock adjustment
0093     GOTO continue    ; do again from the start
0095 END ; End of program text
```

grammed, or interrupts re-defined to requirement.

More features

The MatchBox BASIC computer has a number of other, interesting, features such as a scaling factor for output values, more FORMAT option, interrupts, timers, a SCALE operator for accurate multiplications, and much more. Because of the limited space available here, a discussion of these features is held over till the publication of future projects developed by the author for the MBC. Meanwhile, we appreciate your feedback, comment and, of course, your own applications of the MatchBox BASIC computer.

(950011-3)

ELECTRICALLY ISOLATED I²C BUS

A deadlock situation occurs if you try to use two optocouplers to isolate two devices connected on an I²C bus. Everything will be fine with the first optocoupler, which will simply convey a 'low' level (logic 0) of the relevant signal (SCL or SDA). The second optocoupler, however, has its input connected to the output of the first, and will also convey the '0', but, alas, back again to the first! This creates a loop in which the 0 will circle *ad infinitum*.

The problem can be prevented by designing an I²C interface which does not return 0's received via the optocoupler. For example, with reference to the circuit diagram, when the 0 arrives via optocoupler IC_2 (from the left to right), IC_{6d} is disabled via its input pin 11. Consequently, this 0 can not return to the I²C line again. However, when the 0 arrives from the side of T_2, IC_{6d} is not disabled, and it will be copied to the connector on the left side, via optocoupler IC1.

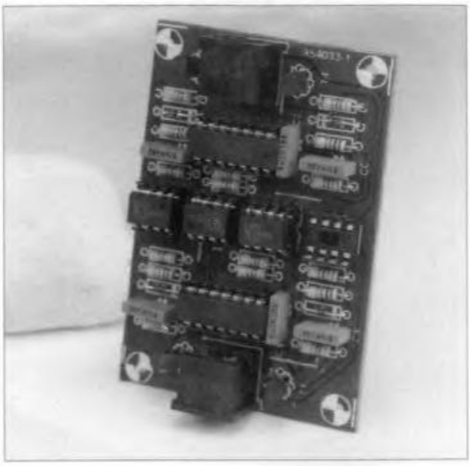
Unfortunately, there is another snag. The 0 which arrives via IC_2 is rapidly copied to the base of T_2, no problem so far. However, by the time the I²C bus should have returned to '1', T_2 needs another 2 µs or so until it is completely switched off. Next, another couple of microseconds elapse before the pull-up on the bus has lifted the relevant line to the '1' level. During the time the I²C bus should have been high, a 0 is erroneously copied from the right to the left, via IC_1. This causes oscillation, which can only be eliminated by delaying the enabling signal for the return optocoupler, IC_1. This delay is provided by network R_7-D_2-C_4. The disabling occurs immediately via D_2, but it is cleared again after the short delay introduced by R_7-C_4.

You may have to experiment a little with the delay network. Oscillation may still occur in systems with a relatively heavy load on the I²C bus. These systems will be slower than the delay introduced by R_7-C_4. The cure is to increase R_7 a little until the oscillation stops. Furthermore, you may consider replacing T_1 through T_4 with MOSFETs type BS170, which will reduce the propagation delay by 2 µs or so. The 4.7 kΩ base resistors are then replaced by wire links. If problems persist, try lowering the speed of the SCL signal. With lower-spec optocouplers such as the TIL111, TIL311 or CNY17-2, the transfer speed of the circuit will be limited to 30kHz or so. With the 6N137 fitted as suggested here, a transfer speed of well over 100 kHz may be achieved without problems.

Both bidirectional isolators require a supply voltage of 5 V at a current consumption of about 5 mA. Normally, this voltage will be present on the 6-way mini-DIN socket.

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

(K. Walraven - 954023)

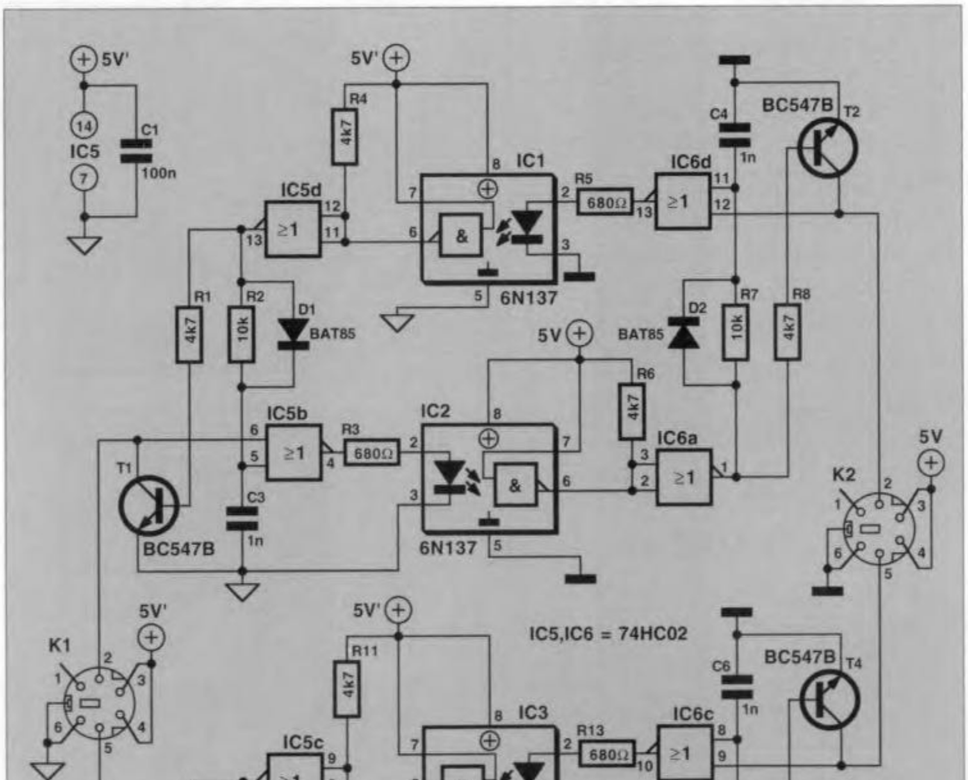


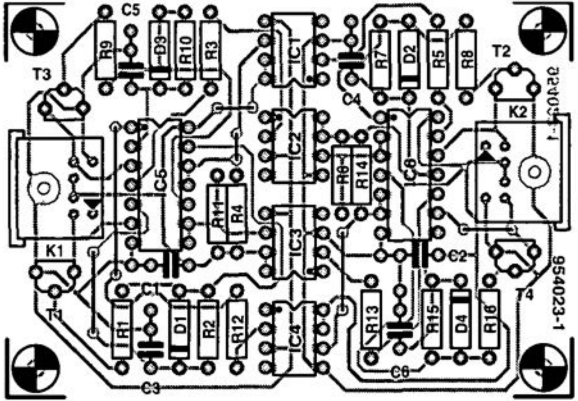
Resistors:
R_1;R_4;R_6;R_8;R_9;R_{11};R_{14};
R_{16} = 4kΩ7
R_2;R_7;R_{10};R_{15} = 10kΩ
R_3;R_5;R_{12};R_{13} = 680Ω

Capacitors:
C_1;C_2 = 100nF
C_3-C_6 = 1nF

Semiconductors:
D_1-D_4 = BAT85
T_1-T_4 = BC547B
IC_1-IC_4 = 6N137
IC_5;IC_6 = 74HC02

Miscellaneous:
K_1;K_2 = 6-way mini-DIN socket, PCB mount.




C5
R9
D3
R10
R3
IC1
R7
D2
R5
R8
T2
T3
C4
K2
IC2
IC5
IC6
R6
R14
R11
R4
IC3
C2
K1
C1
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C6
C3
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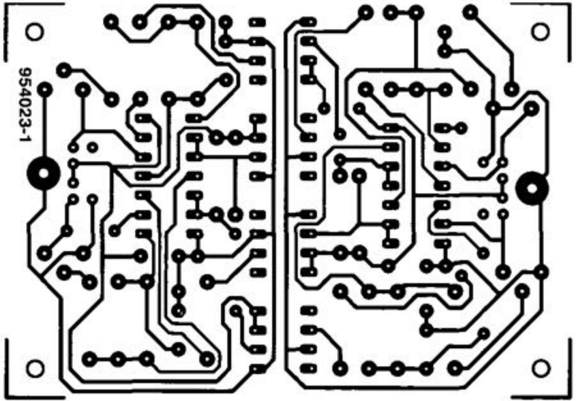
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TWO-CHANNEL RGB SWITCH

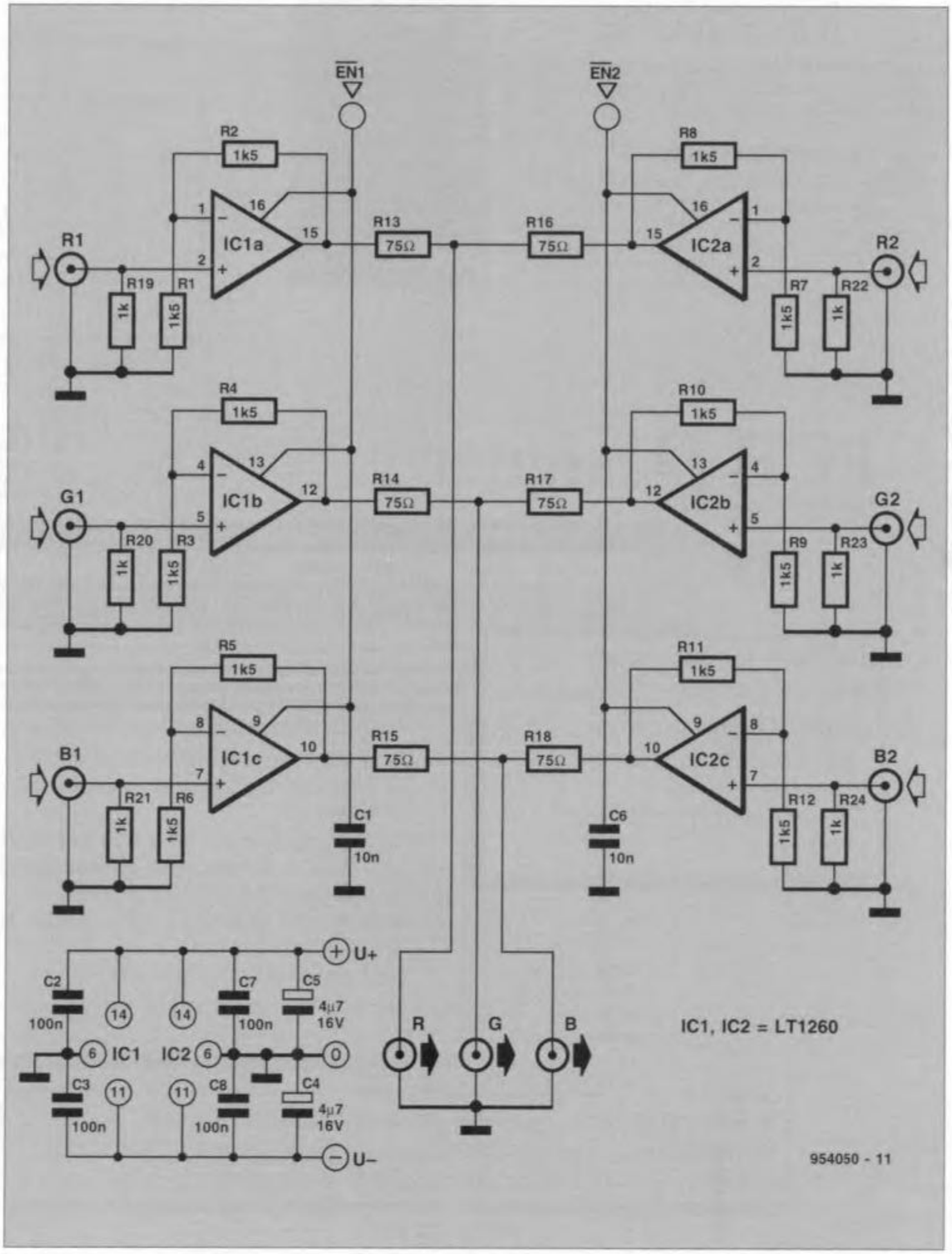
Linear Technology's LT1260 is a triple amplifier based on current feedback, and especially designed for RGB video applications. Each amplifier in the package (op amp) can be switched on and off individually. When off, the amplifiers draw zero supply current, and their outputs become high impedance. Two LT1260's are used here to create a video switch (multiplexer) and cable driver for two RGB sources. The amplifiers are very fast (max. 130 MHz) and have high-current outputs which enable capacitive loads to be driven without problems. Each amplifier draws about 5 mA when switched on.

Sync signals, if used, should be switched separately. Given their relatively low speed, that should not be a problem using conventional logic.

The V+ and V– lines may be connected to any regulated, symmetrical voltage between ±5 V and ±12V. Each amplifier has a voltage gain of ×2. The 75-Ω resistor at the output of each amplifier ensures proper matching to the coax cable. The voltage divider formed by the resistor and the cable impedance (also 75 Ω) halves the signal level again, so that each amplifier has unity gain.

The amplifiers turn on in 100 ns, and off in 40 ns, which is fast enough for video switching without serious picture disturbance. The bandwidth is at least 30 MHz. Because each op amp is capable of supplying up to 60 mA of output current, it is possible to connect more than one 75-Ω resistor (plus load of course) to an output.

(944050 - Linear Technology Application)



PHASE INVERTER FOR DIGITAL AUDIO

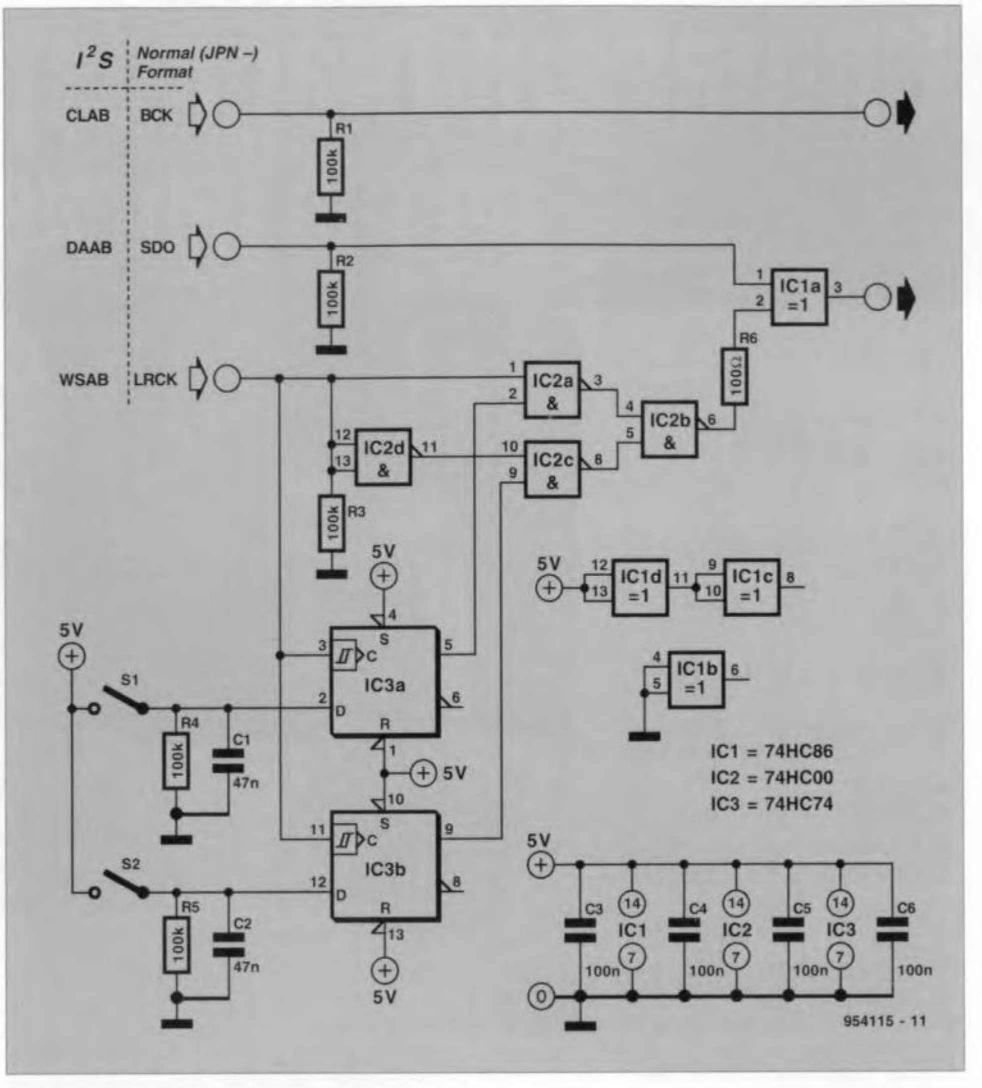
Digital audio signals normally use a two-complement code. To invert such a signal, it is sufficient to invert all data bits in the left-hand and/or right-hand channel.

The present circuit, therefore, consists merely of a switched inverter, XOR gate IC_{1a}, in the serial data stream DAAB (or SDO). Which channel must be inverted can be determined with the aid of two switches. When both switches are open, no inversion takes place. When S_1 is closed, inversion occurs when the clock signal, LRCK (or WSAB) is high; when S_2 is closed, inversion takes places when these signals are low.

The signals on the data inputs of the bistables are shifted to the outputs on the edges of the clock signals. As is seen, clock signal CLAB/BCK is passed to the output directly.

The prototype was tested successfully with the European I^2S format as well as the standard Japanese format. For these tests, a digital-to-analogue converter (DAC) was provided with I^2S signals by a Type SAA7274 chip from Philips, while another was controlled by a Type YM3623B interface chip from Yamaha. In both cases, a test signal of 0 dB/1 kHz was used.

In the first case, the inversion appeared to result in a slight reduction in distortion in both channels, whereas with the Japanese format no discernible changes occurred. When both channels were inverted, no changes were measured. All this points to the fact that inversion is a subjective matter in which everyone has to decide with his/her own ears whether there is an improvement or not.



The circuit draws a current of not greater than 1 mA.

Design by T. Giesberts
[954115]

CAPACITANCE COMPARATOR

The comparator enables an unknown capacitor to be likened to a known reference capacitor, and to indicate whether it is smaller, larger or about identical.

The circuit consists of an astable multivibrator, AMV, and a window comparator, IC_2. The AMV is formed by IC_{1a} and IC_{1b}; the time-determining capacitances are the reference capacitor, C_{ref}, and the unknown capacitor, C_x. The duty factor of the AMV is $C_x/(C_x+C_{ref})$ if the the capacitances are nearly equal.

When the oscillator voltage is averaged in integrating network R_3-C_3, a direct voltage is obtained whose mean level is determined by the duty factor and the supply voltage. When this voltage is applied to IC_2, an indication is obtained whether the duty factor is close to 0.5; in other words, how close the value of C_x is to that of C_{ref}.

The centre of the window is determined by potential divider R_9-R_{10}-P_1, while half the window width is set by the level at pin 9 determined by R_7 and R_8. The width of the window determines the accuracy of the measurement. Expressed as a percentage, the accuracy is $4\times R_8/(R_7+R_8)\times 100\%$.

When $C_x \approx C_{ref}$, the duty factor is 0.5 and the mean measured voltage is equal to half the supply voltage. In principle, it would therefore be sufficient to fix the voltage at pin 8 of IC_2 at half the supply voltage. However, since IC_2 is not a perfect device, it is necessary to add an offset correction, provided by P_1. This control is set up easily by connecting two identical capacitors to the test terminals.

Indication of the measurement is given by three LEDs: D_1 lights when C_x is larger than C_{ref}; D_3 when C_{ref} is larger than C_x; and C_2 when the two capacitors are equal, or nearly so.

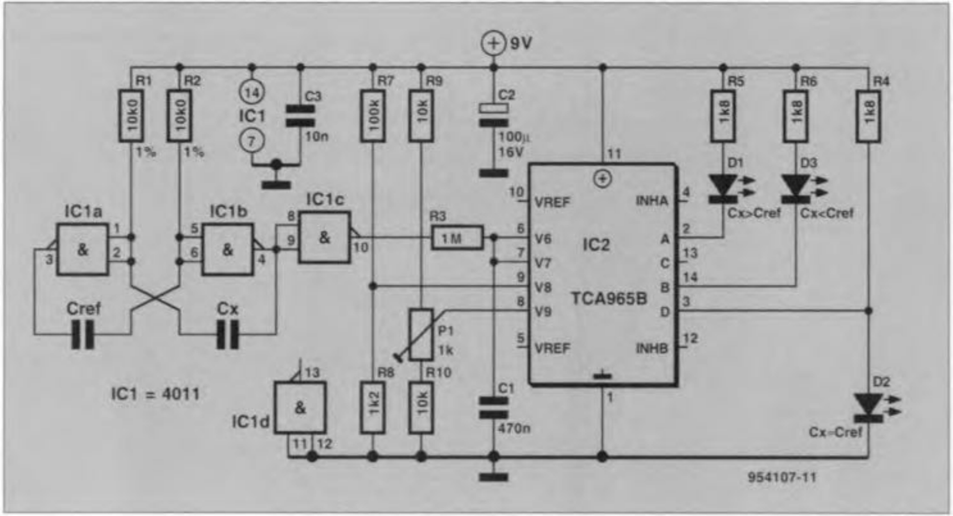
The circuit is suitable for comparing capacitors from 470 pF to 220 nF. The accuracy of the comparison is within 5% when R_8 = 1.2 kΩ and

53

within 1% when R_8 = 270 Ω.

The circuit draws a current of about 20 mA.

Design by H. Bonekamp
[954107]



HIP5600 HIGH-VOLTAGE REGULATOR

The HIP5600 from Harris Semiconductor is an adjustable 3-pin positive linear voltage regulator capable of operating up to either 400 V d.c. or 280 V r.m.s. The output voltage is adjustable from 1.2 V d.c. to within 50 V of the peak input voltage with just two external resistors. The HIP5600 is capable of sourcing 1 mA to 30 mA (with proper cooling).

From a point of safety it is extremely important to note that the IC does **not** provide electrical isolation from the mains, in other words, all parts in the regulator circuit are dangerous to touch. The circuit **must** be housed in an all-plastic enclosure. **Never** work on the circuit while it is connected to the mains.

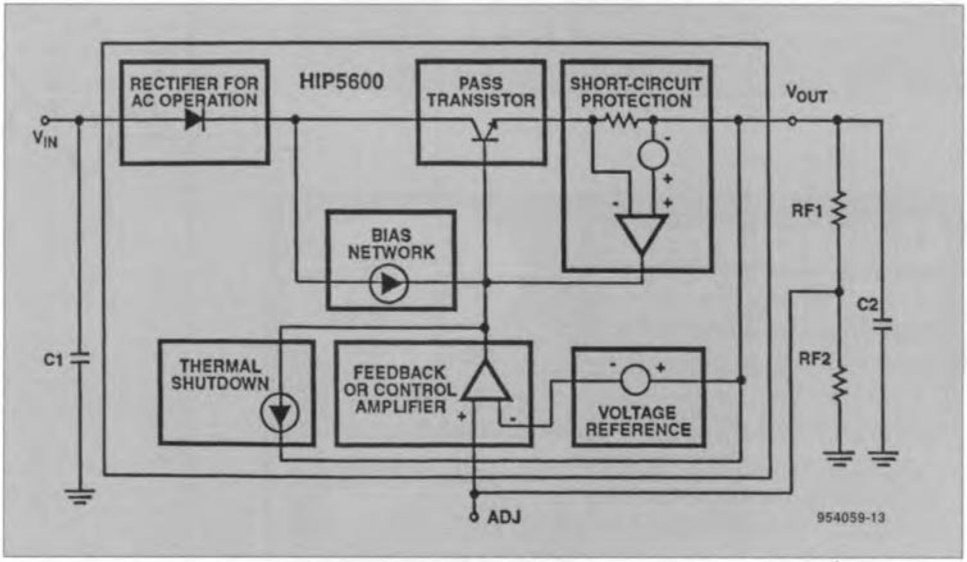
Although the input of the HIP5600 is capable of withstanding voltage surges up to 650 V, further safety is afforded by a 1-kΩ power resistor and a 250-V metal-oxide varistor (MOV) from Siemens. As shown by the block diagram, the HIP5600 has a single-phase internal rectifier. Conse-quently, output capacitor C2 is only charged during one half of the mains cycle. Its capacitance must be large enough to source the output current during the other half cycle. The HIP5600 requires a minimum load current of about 1 mA to maintain output voltage regulation.

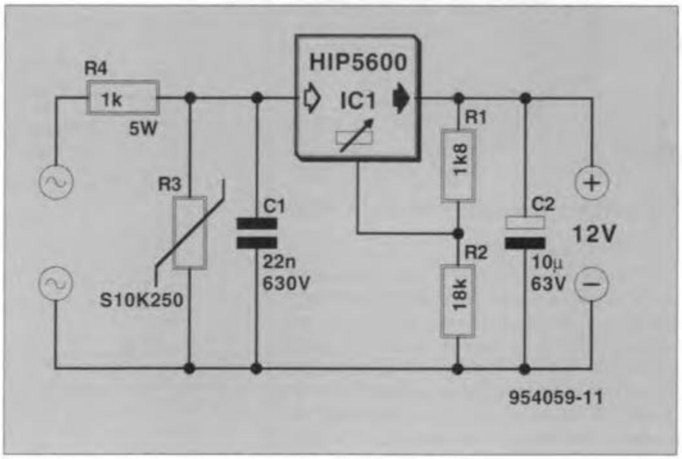
The nominal output voltage, U_{out}, is given by

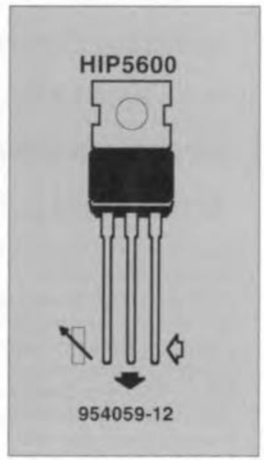
$$U_{out} = 1.18 \times (RF_1+RF_2)/RF_1 + 65\mu A \times RF_2$$

The minimum current through RF_1 and RF_2 is about 0.5 mA. Smaller values may cause erroneous operation of the voltage regulator.

Applications of the HIP5600 may be found in common regulator configurations as well as a.c.-d.c. conversion and start-up circuits for switch-mode power supplies.

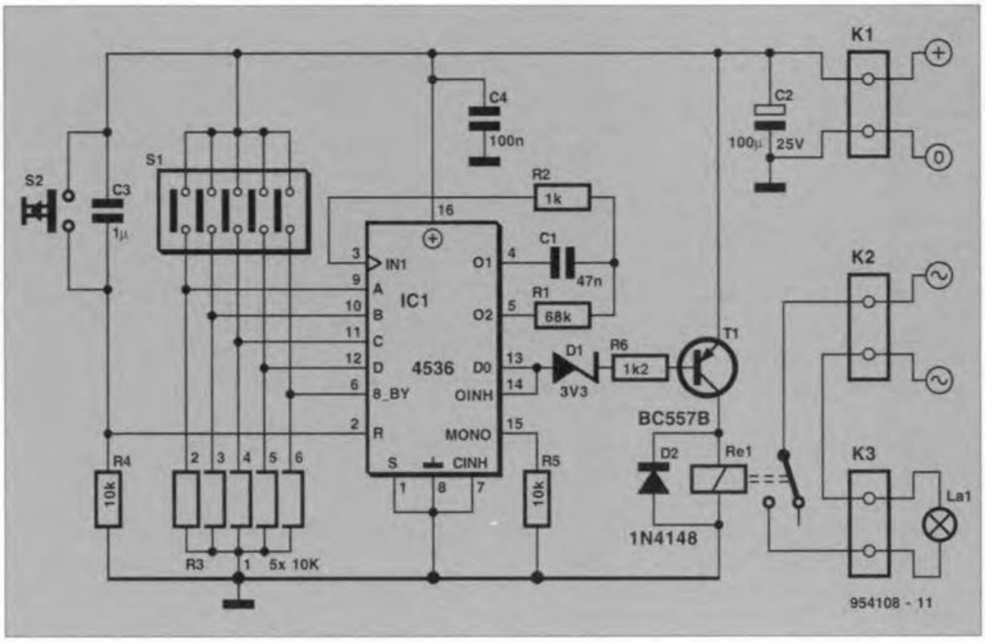






Harris Semiconductor Application [954059]

LONG-PERIOD TIMER



The timer is based on a Type 4536 from SGS-Thomson. This IC contains 24 series-connected binary scalers, which divide the frequency of the input signal by 10^{24}. The divisor can be reduced to 16 when the input is applied to pin 6 (internally, eight of the 24 binary scalers are disabled).

Inputs A, B, C and D determine which binary scaler is connected to the output. When, for instance, all five sections of switch S_1 are open, the oscillator frequency, after a reset, is divided by $2^8 = 256$. If $S_{1(1)}$ gets closed, the divisor becomes 512, and when all sections, apart from 5, are closed, the divisor is 2^{24}.

The IC contains an oscillator that operates in conjunction with an external *RC* network. With values as specified in the diagram, switching periods between 2.5 seconds and 23 hours are available (section 5 of S_1 open), or between 0.01 minute and 5.5 minutes (section 5 of S_1 closed).

When the set period has elapsed, input OINH goes high, whereupon the oscillator is disabled. After a reset pulse, generated by briefly operating S_2, a fresh cycle can be started. Diode D_1 ensures that T_1 starts to conduct only when its base is truly low.

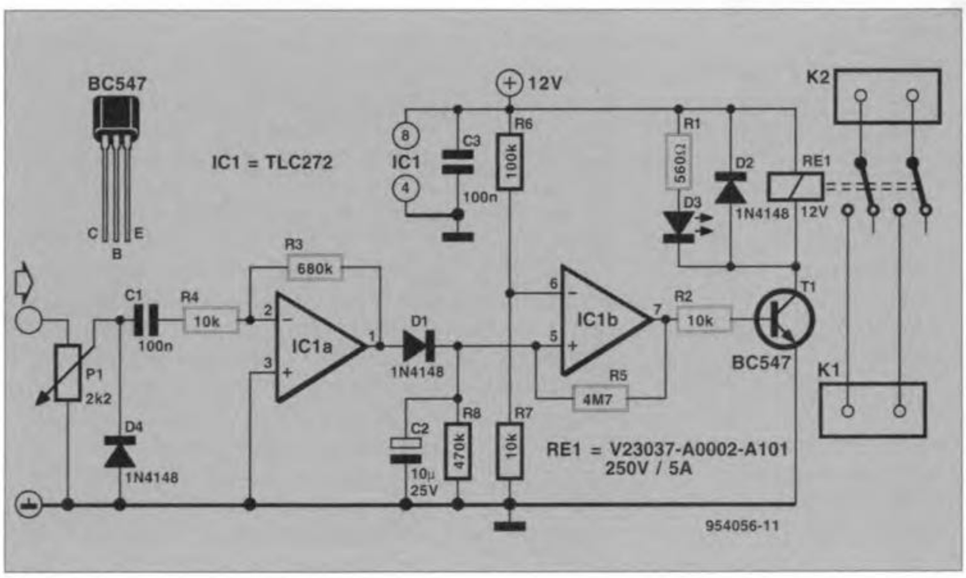
The oscillator frequency, *f*, is computed from $f = 1/3R_1C_1$.

The value of R_2 must be greater than twice that of R_1.

The supply voltage may be between 5 V and 12 V.

Design A. Rietjens [954108]

SIGNAL-ACTIVATED RECORDING



This circuit ensures that messages received by a radio or transceiver are automatically recorded on a cassette or tape recorder. It is assumed that the relevant receiver has a squelch (or 'mute') function, and that it is on stand-by on a particular frequency you wish to monitor. The cassette recorder is also switched on, and permanently switched to recording mode. When the message is over, the circuit waits for a couple of seconds, and then switches the recorder off.

Op amp IC_{1a} senses the input voltage, and charges capacitor C_2 via rectifier D_2. Preset P_1 determines the input sensitivity of the control. If the rectified voltage exceeds a predetermined level (set by R_6-R_7), the output of comparator IC_{1b} goes high. The relay is then energized via transistor T_1, and LED D_3 lights. The contacts of the relay type indicated in the circuit diagram are capable of switching the 240 V mains voltage. If the recorder has a remote on/off control input the recording function, a much smaller relay may be used. If you can not mute the receiver completely because of background noise (especially on shortwave), decrease the sensitivity of the control so that the recorder remains off. Messages on the channel will top the noise, and are then automatically recorded.

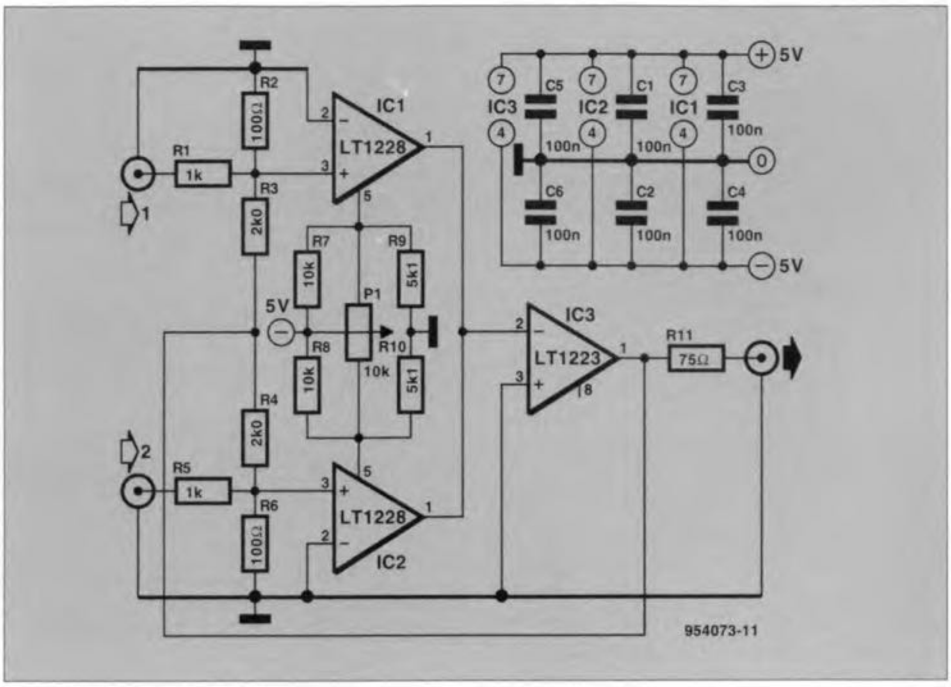
In the 'on' state, the circuit draws a current of about 60 mA. The signal rectifier, D_1-C_2, also ensures a switch-off delay of about 5 seconds. The input signal should, of course, be connected in parallel to the recording input of the cassette recorder, and have a suitable level.

(954056 - Amrit Bir Tiwana)

VIDEO FADER I

A transconductance amplifier is a device whose output current is a function of the difference voltage at the inputs multiplied by a current sent into a special control input. Probably the best known transconductance amplifier (TCA) IC is National Semiconductor's LM13700.

Here, two TCAs type LT1228 from Linear Technology are used in front of a current-feedback amplifier type LT1223 to form a simple, high quality, video fader for synchronous sources. The ratio of the currents sent into pin 5 of each LT1228 determines the ratio of the input signals at the output of the fader. The video bandwidth is a quite impressive 15 MHz. A gain of ×2 is achieved by connecting the output voltage of the LT1223 buffer to the common feedback node R_3-R_4. It should be noted that the fader inverts the video signals applied to the inputs. Because of the 75-Ω series resistor at the output, and the 75-Ω load impedance, the overall gain of the fader is –1. The choice of the third op amp is not critical — types like the LT1227 may also be used. More on current feedback op amps like the LT1227 may be found in Ref. 1. The video fader draws a current of 25–50 mA.



(954073 - Linear Technology Design Note 57)

Reference:
1. VGA distribution amplifier, *Elektor Electronics* June 1995.

PRESS-KEY ON/OFF WITH TRIAC

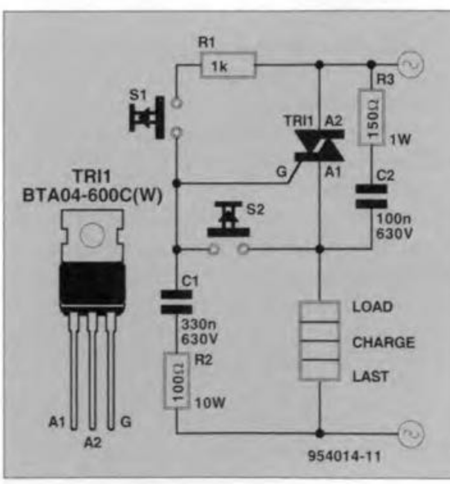
This circuit switches a mains operated load on and off under the control of two presskeys.

When the triac is off, there is no voltage drop across the load. Consequently, the gate is without voltage with respect to connection A1 of the triac. When S_1 is briefly pressed, the instantaneous mains voltage is applied to the gate. The resulting current causes the triac to be fired (triggered). Unusually, the load is not 'above' the triac, so that the mains voltage occurs across the load, while the voltage across R_1 disappears. Consequently, the gate drive disappears also. The full mains voltage appears across the load, and causes a current through R_2-C_1, which takes over the gate drive. Because the voltage lags this current, the gate drive current peaks at the zero-crossings, when the triac would normally switch off. Consequently, the triac remains on during the entire mains voltage cycle. By pressing S_2, the gate drive current is removed, and the triac switches off.

The gate current which flows through C_1 is set to 35 mA here to allow the use of triacs with a 35-mA gate current specification (suffix 'C'). Resistor R_2 then unfortunately dissipates a couple of watts. This lack of economy can be resolved by using 5-mA gate current triacs ('T' suffix). C_1 then becomes 47 nF, and the losses are considerably reduced.

R_3-C_2 is the traditional snubber network, which may be omitted if you use a so-called 'high-commutation' triac ('W' suffix). Mind you, when a bulb fails to dim properly, there is no way to ground the use of a snubber network. The same goes for dimmers, if the bulb flickers when almost fully dimmed.

The type designation for triacs from SGS-Thomson has (broadly) the following structure. Example: BTA06-600BW. The devices in the BTA series come in a TO-220 enclosure with an isolated back tab, and therefore have a slightly higher than normal thermal resistance. With 'BTB' devices, the metal part of the case is connected to the central pin. Next, '06' is the maximum continuous current in ampères. '600' indicates the maximum voltage in volts. In practice, 400-V types can be used for 240 V mains applications, but '600' types are hardly more expensive, and also give greater security. The suffix has (roughly) the following meaning as regards the gate current: A = 25 mA; B = 50 mA; C = 35 mA; D/K/S = 10 mA; T = 5 mA; W = snubberless, high commutation.



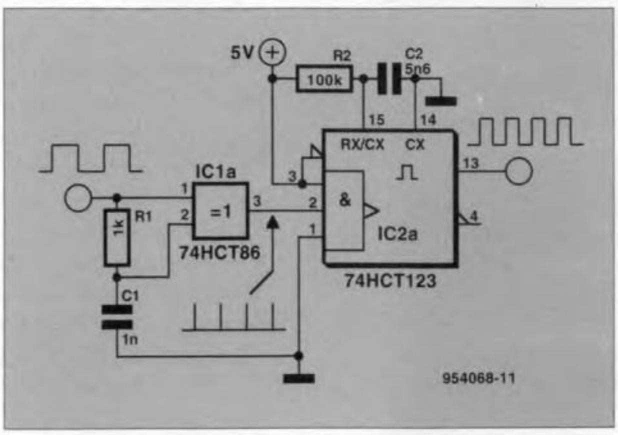
(954014 - SGS-Thomson Application)

FREQUENCY DOUBLER

A simple approach to the problem of frequency doubling a digital signal is shown here. An XOR gate, IC_{1a}, supplies a needle pulse on the leading edge and on the trailing edge of its input signal. The needle pulses trigger a monostable, IC_{2a}, whose delay time is set to a quarter of the period of the input signal. This delay time, τ, may be computed from

$$\tau = 0.45\,RC.$$

The component values shown in the circuit diagram (100 kΩ; 5.6 nF) are for a 1-kHz in, 2-kHz out frequency doubler.



Current consumption of the circuit is smaller than 1 mA.

(954068 - A. Rietjens)

S METER

The logarithmic-to-linear converter in the Type NE604 chip (IC_1) is used in the present design as an accurate S-meter for short-wave receivers. The amplifier in the chip is tuned to the i.f. of the receiver (here, 455 kHz) by L_1-C_{12}. The i.f. output of the receiver is applied to the input of IC_1, pin 16, via K_1 and C_{14}.

The output of the fieldstrength detector in IC_1 provides a current of 0–50 µA at pin 5. This current is converted into a 0–5 V potential by R_3-R_4 and this is applied to the input of buffer IC_2. The use of two series-connected 100 kΩ resistors in conjunctions with diode D_1 is deliberate: it gives an accurate voltage and it compensates temperature effects. If the specified E-96 resistors prove difficult to obtain, R_3 may be replaced by two 120 kΩ resistors in parallel, and R_4 by a 39 kΩ resistor in series with a 1 kΩ resistor (all 1%).

The useful range of the log-linear converter is at output currents of 5–40 µA. This corresponds to a voltage of 0.5–4 V at pin 6 of IC_2 (a range of 0–70 dB). The lower limit of the range is determined by the noise level and the upper limit by the saturation of the i.f. amplifier in IC_1. The effective range is sufficient for the present application: bear in mind that levels lower than S-3 are of minimal importance in short-wave communications. Remember that the values on an S-meter represent signal strengths in 6 dB steps; S-9 corresponds to 50 µV into 50 Ω.

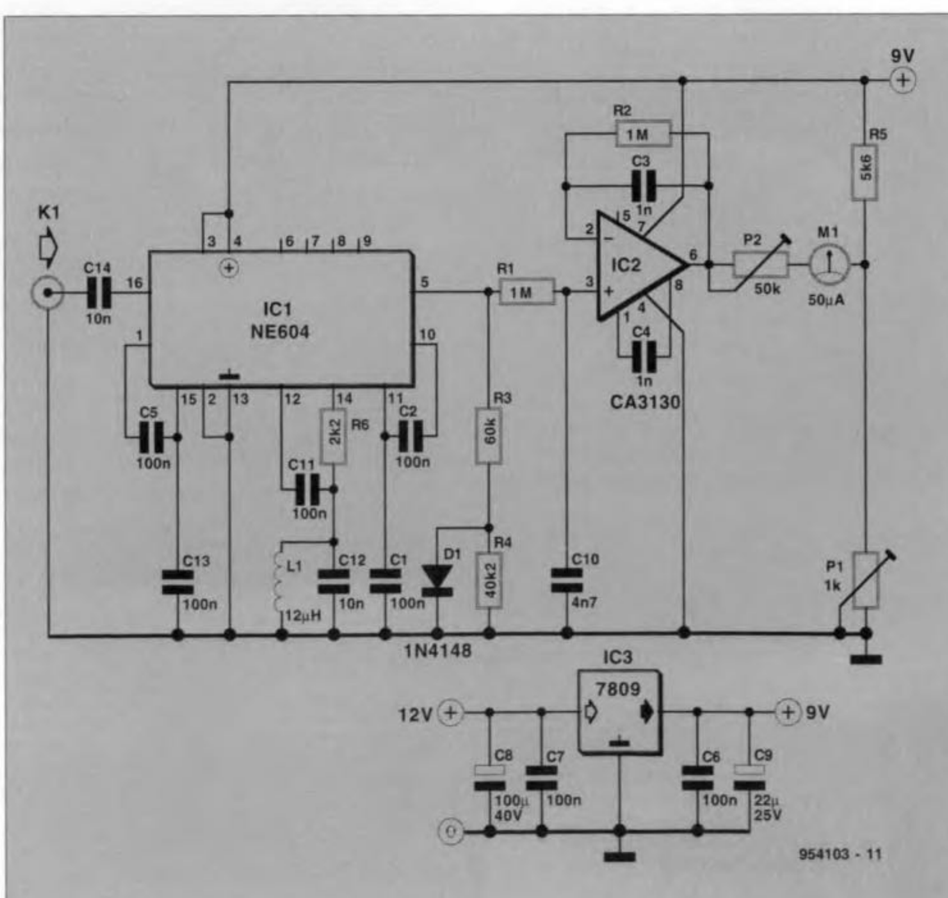
Low-pass filter R_1-C_{10} suppresses r.f. interference and noise.

Moving coil meter M_1 is connected between two presets: P_2 is adjusted so that the meter gives full-scale deflection at a voltage of 4.5 V at pin 6 of IC_2. An input signal of 50 µV at K_1 corresponds to a meter reading of S-9. The meter deflection for very low input signals (below S-3) can be set with P_1.

The power supply may be a 12-V mains adaptor but, if the meter is built into the receiver, it may well possible to take its supply from the existing power lines, since it draws a current of only about 10 mA.

Design by L. Lemmens

[954103]

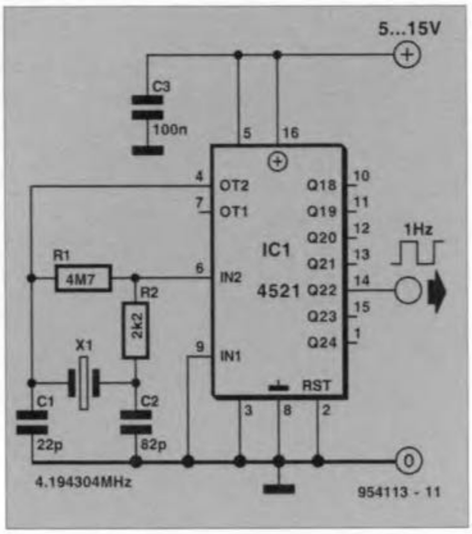


1 HZ GENERATOR

Occasionally, a very-low-frequency rectangular voltage is required. The present circuit generates a very precise 1 Hz square-wave signal (duty factor = 0.5). It operates from a supply voltage of 3.5–15 V and may be used to control CMOS as well as TTL circuits.

The generator is based on a Type 4521 chip, whose properties are comparable to those of the well-known Type 4060, but its scaling process is different.

When an input signal at a frequency of 4.19.4304 MHz is applied to the input of the IC, the signal at pin 14 has a frequency of exactly 1 Hz. (In other words, the input signal is scaled down by a factor 2^{22}). The crystal used has a standard frequency, is inexpensive and freely obtainable. The scaling circuits in the IC guarantee a duty factor of 0.5.



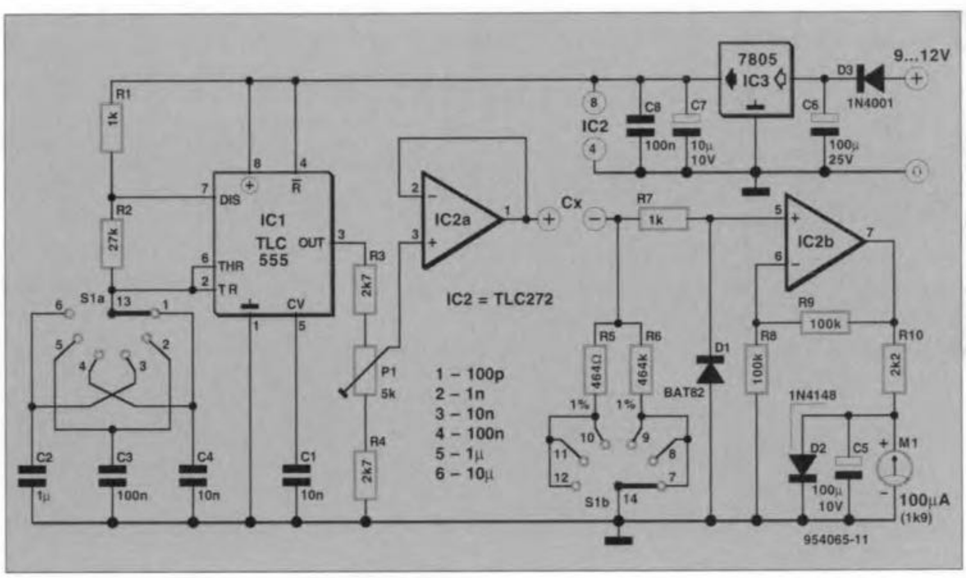
Resistors R_1 and R_2, and capacitors C_1 and C_2, form essential parts of the crystal oscillator. Their specified values guarantee correct oscillator operation.

Design by V. Himpe
[954113]

CAPACITANCE METER

Since the reactance of a capacitor is inversely proportional to the capacitance, it may be used as the basis of determining the value of an unknown capacitor.

Reactance is measured by applying the output of an oscillator to a potential divider consisting of a resistor and the unknown capacitor. The potential at the junction of these components is rectified and displayed on a moving coil meter. The meter reading increases in direct proportion to the capacitance. If the circuit is calibrated with a number of accurate reference capacitors, a simple but very useful capacitance meter ensues.



The oscillator is an astable multivibrator (AMV), IC_1. Its frequency can be increased by a factor 10 twice in succession with S_{1a}. This arrangement prevents the meter pointer sticking at 0 when the capacitance is large or very small. It is, of course, not just the value of the capacitance, but also the frequency of the oscillator, that determines the level of voltage at the input of IC_{2b}.

In positions 4, 5 and 6 of S_{1b}, the resistance of the potential divider is 1000 times greater than in positions 1, 2 and 3. This arrangement enables capacitance to be measured in six ranges, successively related by a factor 10 as shown in the table in the diagram.

Preset P_1 serves for setting up the circuit and determines the amplitude of the alternating voltage across the potential divider.

Op amp IC_{2a} functions as a buffer.

Diode D_1 short-circuits the negative half periods of the alternating voltage.

Op amp IC_{2b} provides an amplification of ×2.

Low-pass filter R_{10}-C_5 prevents the pointer from oscillating at low frequencies.

The circuit may be set up by connecting to the C_x terminals a capacitor whose value gives full-scale deflection (f.s.d.) of the meter, say, 100 nF. Set S_1 to a position that gives a meter reading of about 1/10 of f.s.d. (10 μA). If everything is all right, there is only one position of the switch where this can be done. The exact reading is obtained by adjusting P_1 as required. If the capacitor is replaced by one with a greater value (up to 1 μF), the meter reading should increase proportionally. Repeat the procedure with a capacitor of 10 nF at the C_x terminals and S_1 turned back two positions. Increasing the oscillator frequency restores the measurement balance.

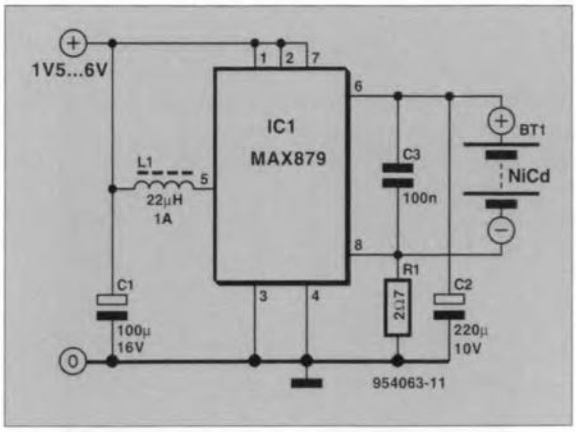
If low-tolerance capacitors are used for C_2, C_3 and C_4, the accuracy of the meter is better than 10%.

Designed by H. Bonekamp
[954065]

SOLAR POWERED NiCd BATTERY

This circuit, a d.c.-d.c. converter, is intended to charge environment-friendly batteries in and environment-friendly way. It is based on a MAX879 from Maxim Inc. and is capable of charging up to four series-connected NiCd batteries.

The MAX879 is a step-up/step-down converter with a wide input voltage range (from 1.5 V to 6.2 V), and capable of supplying up to 100 mA of charging current (sunshine allowing, of course). Here, the charging current is fixed at about 75 mA for a 14-hour charge cycle of 750-mAH 'penlight' (AA size) NiCd batteries. The output current equals U_{ref}/R_1, where U_{ref} is 0.2025 V.



By changing the value of R_1, the circuit may be modified for use with other types of battery or solar cell. However, two aspects should be taken into account. Firstly, the maximum output current equals

$$I_{out} = \frac{0.7}{0.9(U_{in} - U_{out})} \text{ [A]}$$

while the maximum current to be supplied by the solar cell equals

$$I_{max} = \frac{I_{out}\, U_{out(max)}}{0.6\, U_{in(min)}} \text{ [A]}$$

where 0.6 is a constant which expresses the minimum efficiency of the voltage converter.

(954063 - H. Bonekamp)

LED STROBOSCOPE

Normally, stroboscopes, which are intended to emit short, intensive light pulses, operate from very high voltages. The present circuit works with LEDs and operates from 15–24 V. Of course, the diodes do not give the blinding flashes one associates with stroboscopes, but for many applications they give a satisfactory output, particularly if high intensity types with reflector are used. Very suitable is the Type GL5UR3K1. A drawback of these types of LED is that they are not cheap, but sometimes they can be found in second-hand equipment.

Power for the stroboscope may be derived from a mains adaptor with an output of 15–24 V. The input is regulated by IC_3. The resulting 12 V line is sufficient to power five series-connected LEDs. The current through the diodes is limited to about 25 mA by resistor R_6.

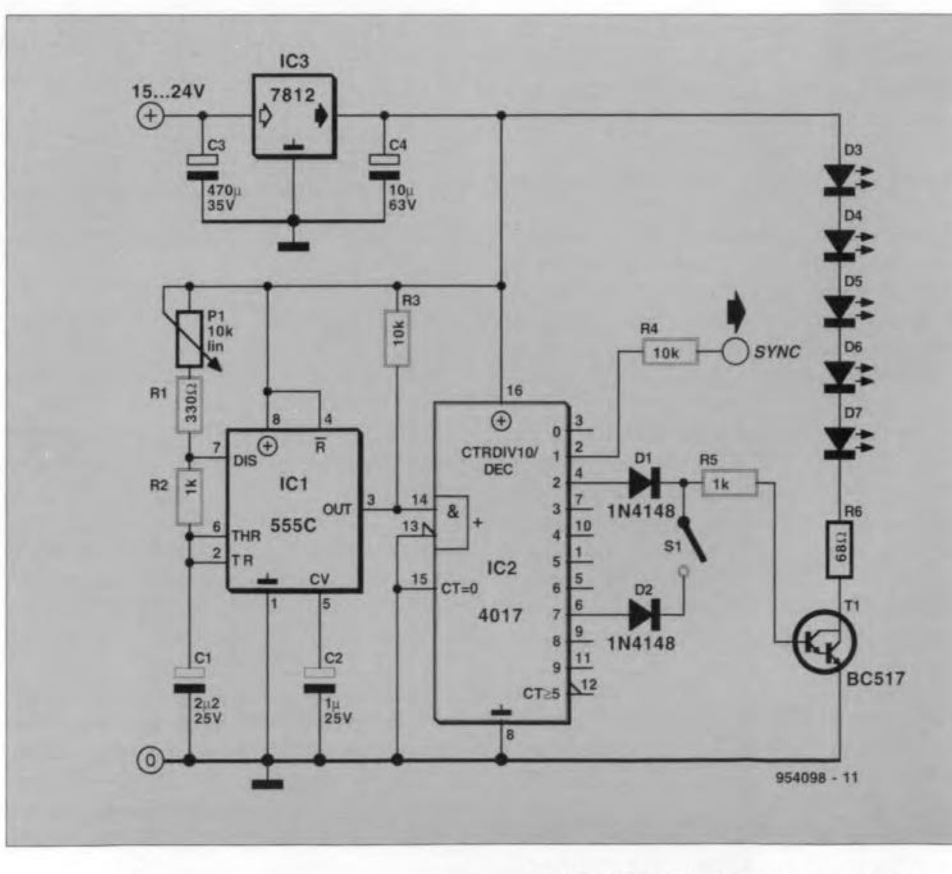
It is possible, depending on the maximum output current, for more LED chains to be used in parallel. If the output current rises above 100 mA, IC_3 should be fitted on to a suitable heat sink. It is then also necessary to replace the BC517 by a higher rating type such as the TIP130.

The switching transistor is controlled by an astable multivibrator (AMV), IC_1 and decade counter IC_2. The output signal of the AMV is set to 20–200 Hz with P_1. The signal is used as the clock for counter IC_2.

Only three outputs of IC_2 are used. That at pin 2 may be connected to an oscilloscope or frequency meter. That at pin 4 drives the switching transistor that actuates the LEDs. With S_1 closed, the output at pin 6 provides an OR function, which doubles the flashing frequency. Unfortunately, this also shifts the duty factor from 1:10 to 1:5, which for an stroboscope is not such a good value. However, the frequency doubling may, in many cases, be more than adequate compensation for this slight drawback.

Design by K. Walraven

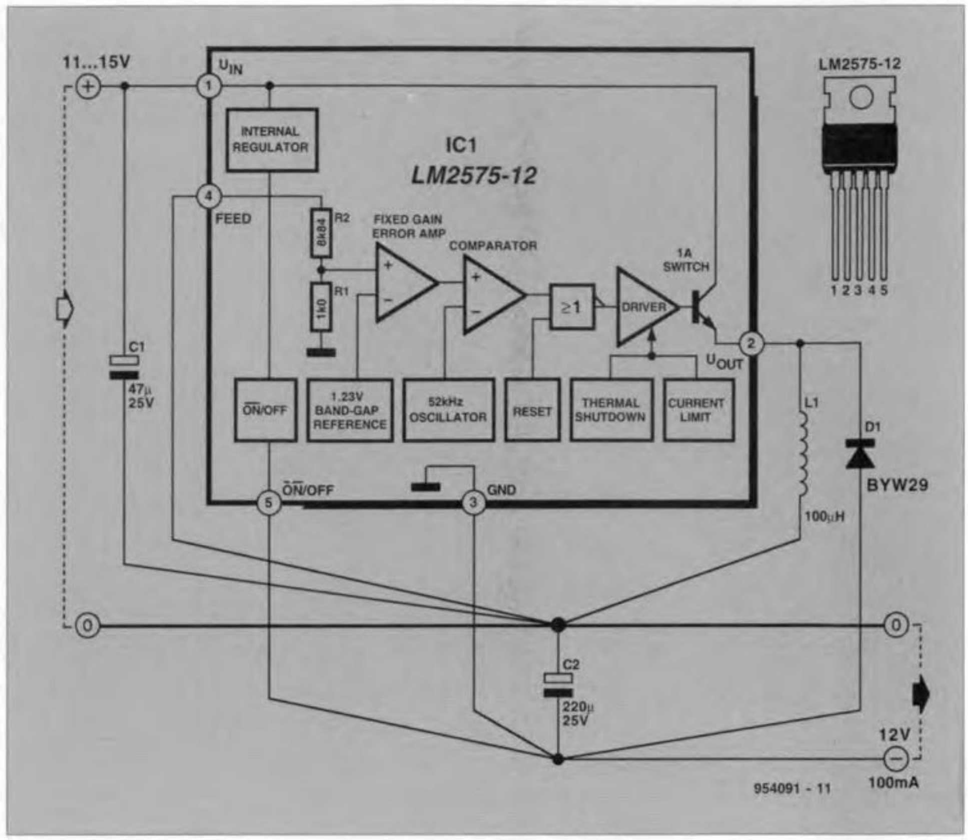
[954098]



±12 V FROM CAR BATTERY

Many audio circuits need a symmetric power supply of ±12 V. If such a circuit is to be used in a car, the –12 V line must be somehow derived from the +12 V car battery. This is done most conveniently by a switch-mode supply, in which the inversion is achieved by capacitors or inductors. When a fair power output is needed, inductors are normally used. Such supplies are often fairly complex: the present one is not nearly so. It can provide an output current of 100 mA and even up to 300 mA if a ripple greater than the nominal 50 mV is acceptable. If necessary, this larger ripple can be countered to an extent by giving C_2 a larger value.

The supply is based on a National Semiconductor chip Type LM2575, developed specially for this purpose. In the IC, a switching transistor between V_{in} and V_{out} opens and closes at a frequency of 50 kHz. This causes a series of current pulses through L_1. At each break in the current, a counter-e.m.f. is induced in the inductor which tends to maintain the current. This e.m.f. is used to charge C_2 via D_1. When the consequent potential across the capacitor exceeds –12 V, the duty factor of the switching transistor is adapted in such a way that the output voltage is stabilized.



A frequent problem with this sort of circuit is the availability of a suitable inductor. The present one must have an inductance of about 100 µH and be rated at ≥1 A. Unfortunately, commercial types are not easily found, but a good alternative, if a slightly lower efficiency is acceptable, is a choke such as the SFT12-50 from TDK. This type of inductor usually has an inductance of 50–150 µH and a rating of 1–2 A.

Diode D_1 should be a fast type rated at ≥1 A. Standard types such as the 1N4002 are too slow.

An important point to be observed is that all earth connections are taken to a common ground. The same applies to all connections to the –12 V line. Finally, the link between pin 3 of IC_1 and the –12 V line must be as short as feasible.

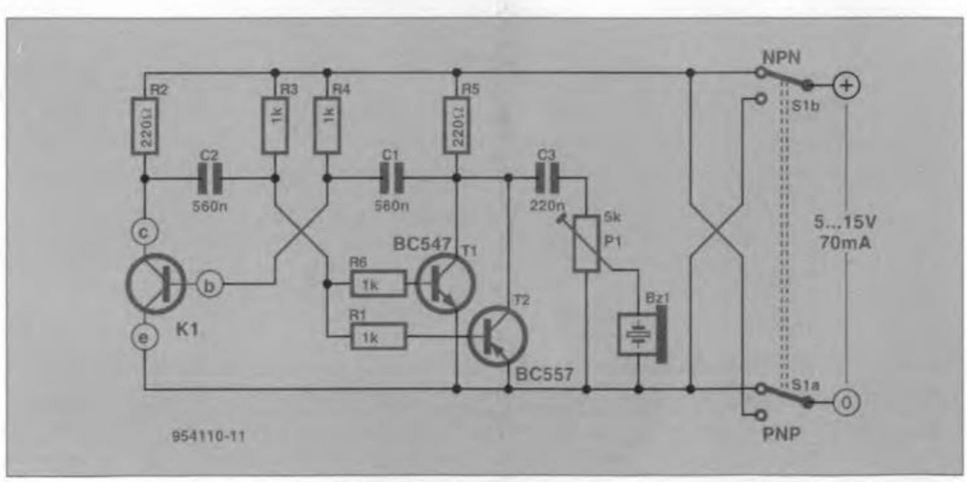
Design by K. Walraven
[954091]

SIMPLE TRANSISTOR TESTER

The tester checks whether a transistor, n-p-n as well p-n-p, works or not. If it does, the buzzer emits a squeak.

Transistors T_1 and T_2 form an astable multivibrator, AMV, which oscillates at a frequency of about 1 kHz. The transistor to be tested, T_x, is connected to the oscillator via K_1. If the oscillator works, which means that T_x works, a rectangular voltage appears across P_1, which actuates buzzer Bz_1. The volume of the emitted tone can be adjusted with the preset as required.

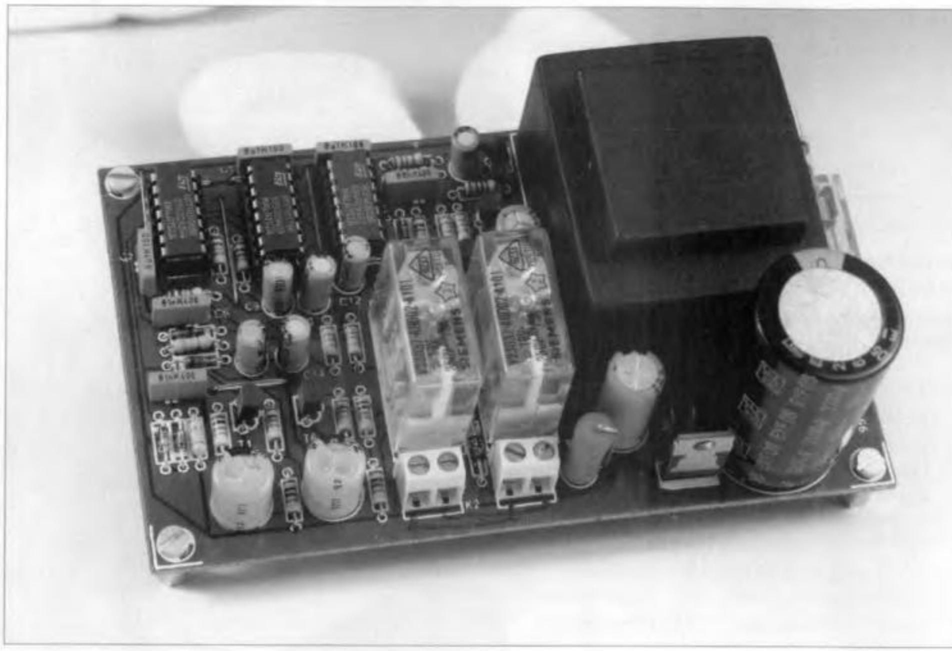
Switching from n-p-n to p-n-p transistors is effected by switch S_1, which inverts the supply voltage: T_2 then becomes part of the AMV.



Design by W. Breuherr
[954110]

TWO-WAY PC-FAX INTERFACE

This circuit imitates a small telephone exchange, allowing a PC to dial a fax machine, and vice versa, without actually making use of the public telephone network. Very useful if you want to employ your fax as a scanner (switch it to high resolution!), or as a 200-odd dpi printer. For these applications, it is assumed that you have a fax card in your PC. The software supplied with this card will then enable you to convert scanned images into the widely used TIFF format. The circuit shown here is suitable for pulse dialling only. Fortunately, that is still supported by most fax machines and PC fax cards.



Transistors T_1 and T_6 are switched on when the associated extension (PC or fax) 'lifts the receiver', i.e., opens the line contact. These transistors are normally off, keeping counter IC_4 reset. That enables gate Schmitt trigger NAND gate IC_{3d}, which generates a dialling tone of about 450 Hz, which is superimposed on to the line via capacitor C_{15}.

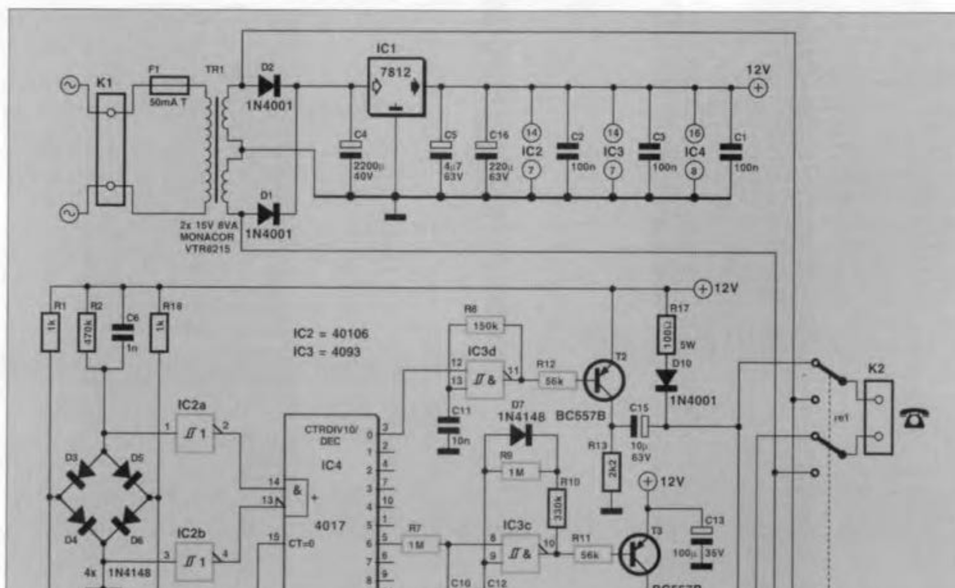
Assuming that a normal (pulse-dialling) telephone is connected, the dialling tone is audible when the receiver is lifted. Consequently, a voltage is built up across R_4 or R_{20}. Depending on the termination value of the extension, the value of these resistors may have to be changed a little for a sufficiently high voltage to build up. This voltage causes T_1 or T_6 to conduct, and thus the reset condition of IC_4 to be cleared. Nothing happens as yet, and the dialling tone remains on the line.

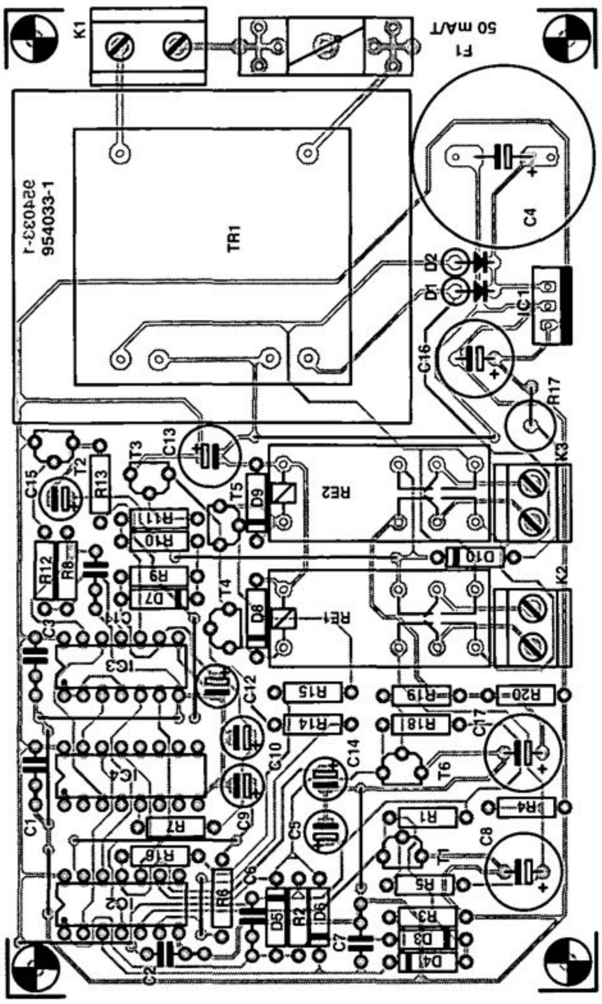
By (pulse-) dialling the number '6', T_1 (or T_6) is rapidly pulsed six times. These pulses arrive at the clock input of the counter (IC_4) via D_3 or D_5, and cause the dialling tone generator to be disabled. Gate IC_{3c}, however, is then enabled. The enable input of the counter (pin 13) is held low because the input of IC_{2b} is held high via diode D_4 or D_6.

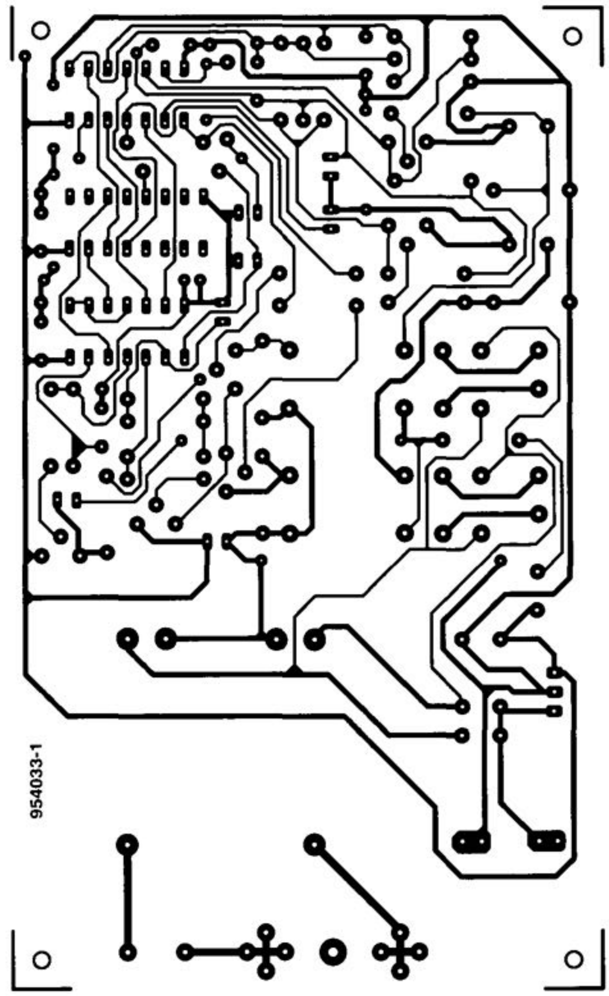
IC_{3c} pulses the ring voltage driver, T_3, at a rate of about 1 Hz. Because the other extension does not answer the call as yet, T_4 or T_5 and the associated relay, Re_1 or Re_2, are switched on and off at the same rate. This, in turn, causes the ring voltage to arrive at the called extension. The ring voltage is about 30 V here, and taken directly from the transformer's secondary. Although lower than the standardized ring voltage (normally between 40 V and 60 V), most telephones (as well as faxes and PC fax cards) will recognize it without problems. If the ring voltage is too low, try using a transformer with a higher secondary voltage (for instance, 2×18 V or 2×24 V).

When the call is answered, the relay is disabled via T_4 or T_5, so that the ring voltage disappears from the called extension, and the connection with the other extension is established. Also, the counter is disabled because its enable input is pulled high by the output of IC_{2b}.

The counter is re-enabled once the call is ended, and one of the extensions rings off. The enable signal, however, is a trailing pulse edge, which is seen as a clock pulse by the counter. Conse-







quently, this steps to output Q_7, so that the ring voltage driver is disabled, preventing the previously called extension to start ringing again. The counter is reset when the other extension goes off line also. The circuit then waits for either extension to lift the receiver again.

Construction of the interface is best carried on a printed circuit board made with the aid of the artwork shown here. This board is available ready-made through our Readers services (see p. 70). Finally, the circuit is **not** suitable or approved for connection to the public switched telephone network (PSTN).

Parts list

Resistors:

R_1;R_{18} = 1 kΩ
R_2;R_3 = 470 kΩ
R_4;R_{20} = 100 Ω
R_5;R_{19} = 10 kΩ
R_6;R_8;R_{16} = 150 kΩ
R_7;R_9 = 1 MΩ
R_{10} = 330 kΩ
R_{11};R_{12};R_{14};R_{15} = 56 kΩ
R_{13} = 2.2 kΩ
R_{17} = 100 Ω, 5 W

Capacitors:

C_1;C_2;C_3 = 100 nF
C_4 = 2200 μF 40 V radial
C_5;C_9;C_{12};C_{14} = 4.7 μF 63 V radial
C_6;C_7 = 1 nF
C_8;C_{16};C_{17} = 220 μF, 35 V radial
C_{10} = 1μF, 63 V radial
C_{11} = 10 nF
C_{13} = 100 μF, 35 V radial
C_{15} = 10 μF, 63 V radial

Semiconductors:

D_1;D_2;D_{10} = 1N4001
D_3-D_9 = 1N4148
T_1;T_6 = BC547B
T_2-T_5 = BC557B

Integrated circuits:

IC_1 = 7812
IC_2 = 40106
IC_3 = 4093
IC_4 = 4017

Miscellaneous:

K_1 = 2-way PCB terminal block, pitch 7.5 mm.
K_2;K_3 = 2-way PCB terminal block, pitch 5 mm.
Re_1;Re_2 = 12 V, 2 C-O, PCB relay, V23037-A0002-A101 (Siemens).
Tr_1 = PCB mount transformer, 2×15V, 8 VA, Monacor VTR8215.
F_1 = 50 m fuse, slow, with PCB mount fuseholder.

Design by D. Paulsen
[954033

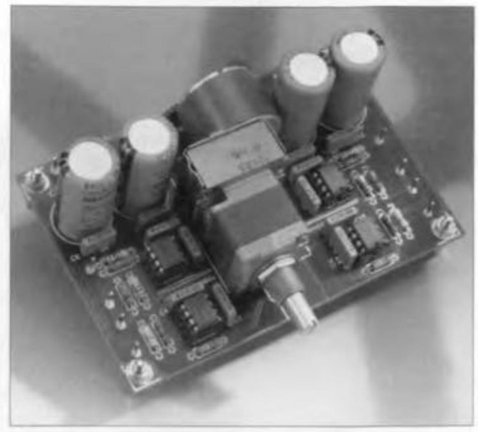
ACTIVE POTENTIOMETER

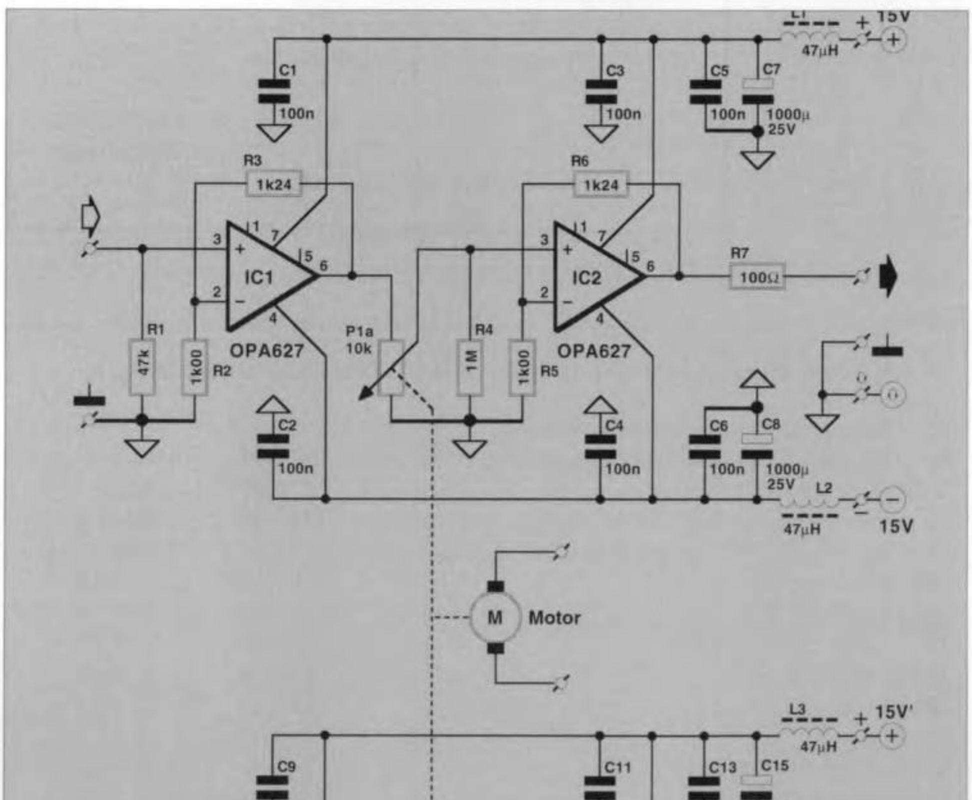
The potentiometer introduced by Panasonic a little while ago is of a quality exceeded only by the likes of the Penny & Giles potentiometer (which cost in excess of £ 100). The Panasonic devices have multilayer tracks made from conductive plastics and carbon, which are linked to the terminals by silver electrodes. The five-fold wiper is also made of silver and guarantees high accuracy (tracking within 0.8 dB) and smooth operation. In other words, this is an attractive, reasonably priced, high-quality volume control.

The potentiometer is a standard device which is preceded by an input amplifier and followed by an output buffer. It can be inserted into a line connection, so that appliances that have no volume control can be expanded to complete control amplifiers.

With the component values specified in the diagram, each op amp amplifies ×2.24 to give a total amplification per channel of ×5. This is sufficient to raise the line level of 200 mV to the standard output amplifier input level of 1 V. It is possible to alter the amplification to some extent, but it is advisable to carry any changes only to the buffer stages (IC_2 and IC_4). For example, the amplification of IC_2 is $1+R_6/R_5$. In most applications, this will do fine. With an input signal of 2 V (for instance, from a CD player), there is still a headroom of 6 dB.

If there is a need to add a selector switch at the input, R_1 and R_8 may be omitted. Bear in mind, however, that it must be possible for a bias current to flow.





The PCB allows the use of the Panasonic potentiometers and models from Alps, motor-driven as well as manually operated types. The board provides complete electrical isolation of the two channels. Moreover, signal earth and the negative supply line have been kept as far apart as feasible: they are linked only at the buffer capacitors. These arrangements prevent any effect of decoupling currents on the signal quality.

Moreover, r.f. decoupling capacitors and chokes (L_1–L_4) in the supply lines prevent any spurious products entering the signal processing circuits.

The circuit is highly suitable for being combined with the IR volume control published earlier*.

Parts list

Resistors:
R_1, R_8 = 47 kΩ
R_2, R_5, R_9, R_{12} = 1.00 kΩ, 1%
R_3, R_6, R_{10}, R_{13} = 1.24 kΩ, 1%
R_4, R_{11} = 1 MΩ
R_7, R_{14} = 100 Ω
P_1 = 10 kΩ logarithmic stereo (motor-driven) potentiometer

Capacitors:
C_1–C_6, C_9–C_{14} = 100 nF
C_7, C_8, C_{15}, C_{16} = 1000 µF, 25 V, radial

Inductors:
L_1–L_4 = 47 µH

Integrated circuits:
IC_1–IC_4 = OPA627AP

Miscellaneous:
PCB order no. 954009 (see p. 70)

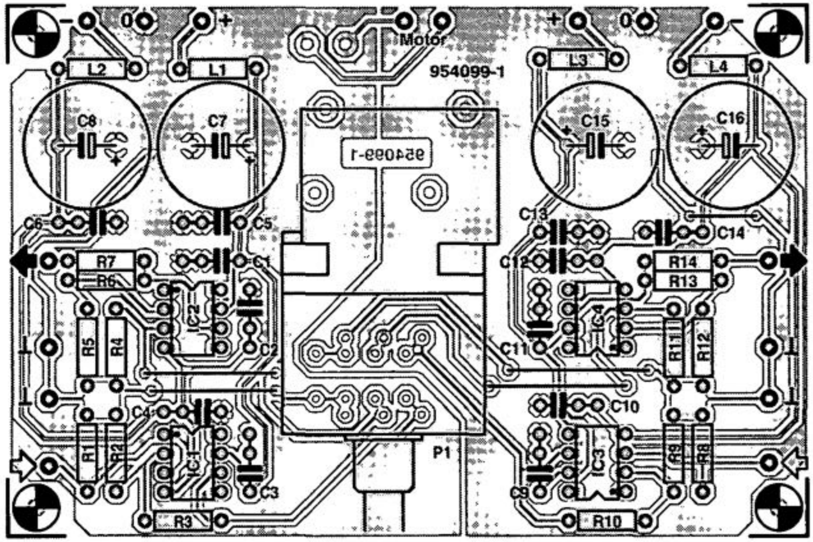
* July/August 1994

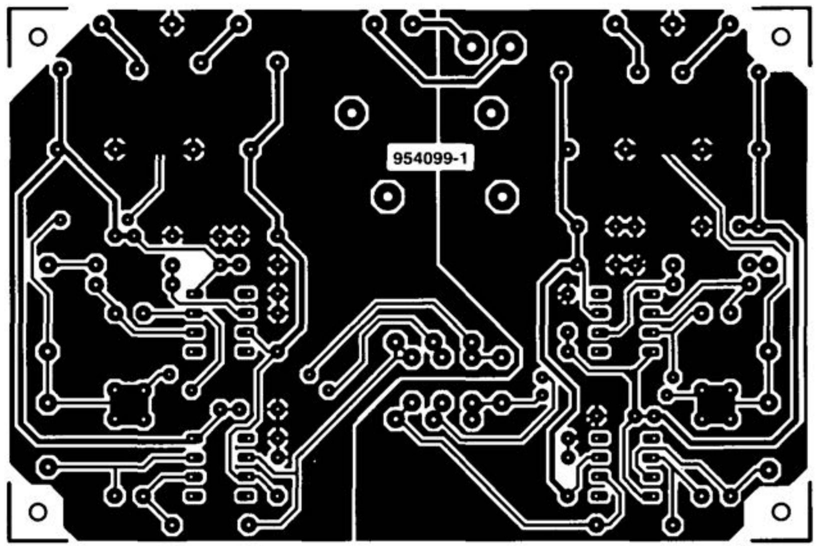
Design by T. Giesberts
[954099]

Parameters

(measured with U_{in} = 200 mV and U_B = 15 V)

Nominal output voltage	1 V r.m.s.
Maximum input voltage	4 V r.m.s.
Maximum output voltage	9 V r.m.s.
THD+N	
(bandwidth 80 kHz, 1 kHz, 1 V out)	0.0011%
(bandwidth 80 kHz, 20 kHz, 1 V out)	) 0.0012%
THD	
(2nd + 3rd harmonic, 1 kHz, 1 V out)	0.00012%
(2nd + 3rd harmonic, 20 kHz, 1 V out)	0.00054%
Signal-to-noise ratio	
P_1 at max (22 Hz – 22 kHz)>	>106 dB (108 dBA)
0.5 V out (22 Hz – 22 kHz)	>94 dB (95 dBA)
Crosstalk	
(20 Hz, 1 V out)	–140 dB
(20 kHz, 1 V out)	–115 dB
(20 Hz – 20 kHz, 0.5 V out)	–75 dB
Tracking error P_1	
(up to –60 dB)	<0.8 dB
(–60 dB to –80 dB)	<1–3 dB
Bandwidth	
(0.5 V out	2.7 MHz
(1 V out)	9 MHz
Slew rate	19 V μs^{-1}
Current drawn per channel	
(4 V in)	15.5 mA





DIFFERENTIAL PROBE

Metering circuits frequently make use of a differential input stage, which nullifies any interference generated in, for instance, the metering cable. The only drawback is that such a stage is usually quite elaborate. The present one is, however, fairly compact.

If R_1 and R_3 have the same value, the common-mode component is removed from the output signal. This signal, U_o, is computed from:

$$U_o = U_d(1+2R_1/P_1),$$

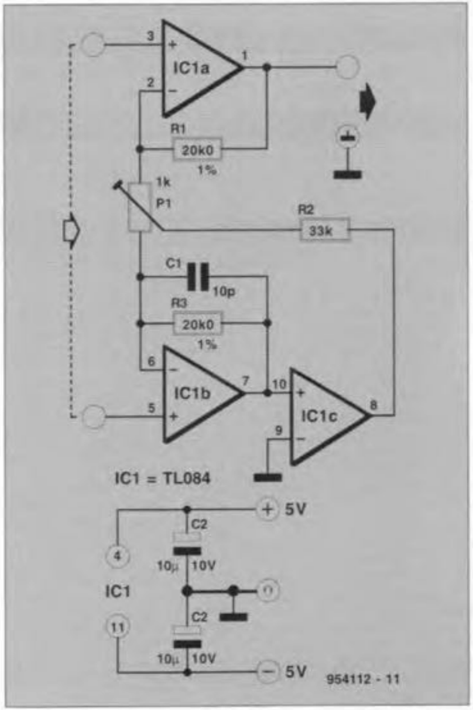
where U_d is the output voltage of the differential stage. With values as specified, the amplification is ×41. This may, of course, be altered by changing the values of one or two of the components in the equation.

Preset P_1 enables the CMRR (common mode response ratio) to be set to a maximum value. With a signal frequency of 100 Hz, a CMRR of ≥80 dB can be attained.

The bandwidth of the circuit is >50 kHz.

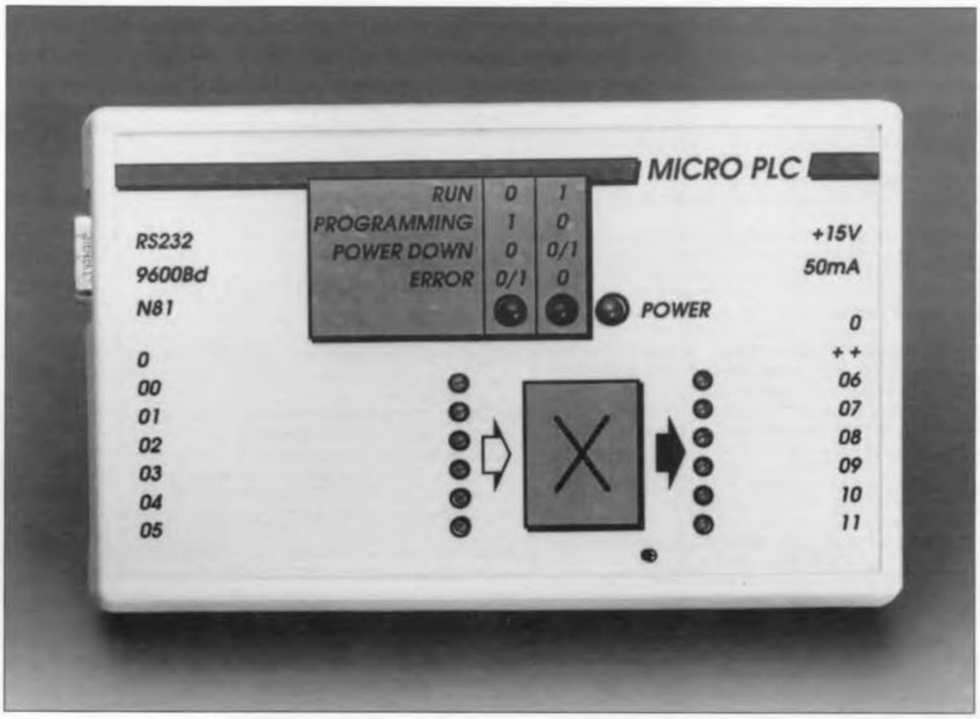
The circuit draws a current of about 6 mA.

Design by H. Bonekamp
[954112]



MICRO PLC SYSTEM
PART 1 — HARDWARE

Welcome to the first instalment in a short series describing an extremely compact control computer built around the 87C750 processor, and designed to run PLC (programmable logic controller) functions. This month we kick off with a description of the Micro PLC hardware, while the following two instalments will present a short programming course.



Design by J. Joostens

THE term Programmable Logic Controller (PLC) may not be familiar with all readers of this magazine. Still, it is hard to think of any industrial process without a major function carried out by some sort of PLC or PLC-like device. These days, all (quasi-) automatic industrial processes are monitored and controlled by such circuits. The Micro PLC presented in this article bears great similarity with products sold by Siemens, Honeywell, Eberle, Texas Instruments and Landis & Gyr. The instruction set of the Micro PLC is identical with that of the Saia PC from Landis & Gyr. However, it lacks a number of advanced functions such as executing several programs, and supporting subroutines. Unfortunately, the compact structure of the present controller did not allow these functions to be implemented. For the advanced hobbyist, however, the Micro PLC is an ingenious system which is ideal for implementing small control systems (such as window shutters or garage door openers). In companies, too, the Micro PLC may be employed to automate small projects. A traffic lights system could also be made quite easily on the basis of the Micro PLC.

Thanks to its backup battery, the Micro PLC may be programmed near a PC, and then disconnected and taken to the location where it does its job. The backup supply ensures that the program remains in the Micro PLC's memory, and can be executed at the target location.

The Micro PLC is a small controller system based on the 87C750 processor from Philips Semiconductors. Internally, this processor bears a strong resemblance to the 'generic' 8051, on which a number of publications have appeared in this magazine over the past few years. Note, however, that the actual processor supplied ready-programmed through our Readers Services is a type S87C751 from Signetics, which is downward compatible with the Philips 87C750. All memory required for the present processor, ROM as well as RAM, is contained in the processor. That is advantageous because it leaves all of the processor's I/O lines free for control functions. Also, it presents a very cost-effective approach which has a positive effect on the price/performance ratio of the Micro PLC project as a whole.

The Micro PLC communicates with an ordinary MS-DOS PC via a standard 9-wire RS-232 interface. Consequently, the software needed to develop Micro PLC application programs may be installed on any PC. Talking of PCs, the Micro PLC may also be used as an intelligent I/O card with almost any MS-DOS computer. That is possible because the Micro PLC allows a number of its output lines to be controlled via a set of very simple instructions received from the PC. This interesting option will be discussed in greater detail when we present the software which is available for this project.

Practical circuit

The circuit diagram of the Micro PLC is shown in **Fig. 1**. As could be expected, the larger part of the hardware is formed by the microcontroller. The rest of the circuit consists of a few buffers, a power supply and a voltage converter for the RS-232 interface. The circuit around the processor has relatively few parts. Apart from a reset network consisting of R_{13}, C_3 and S_1, there is just the usual crystal oscillator (C_1, C_2 and X_1). All remaining parts have to do with the supply or the communication with the outside world.

Power Supply

The power supply is a bit more extensive than usual. That is mainly because of the internal battery backup function. The supply voltage (direct or alternating), is applied via connector K_8. Diode D_{33} acts as a polarity reversal protector when a direct voltage is applied, and as a rectifier when alternating voltage is applied. Reservoir capacitor C_{10} smooths the input voltage, and suppresses any noise. The presence of a supply voltage causes LED D_{27} to emit a bright yellow light, indi-

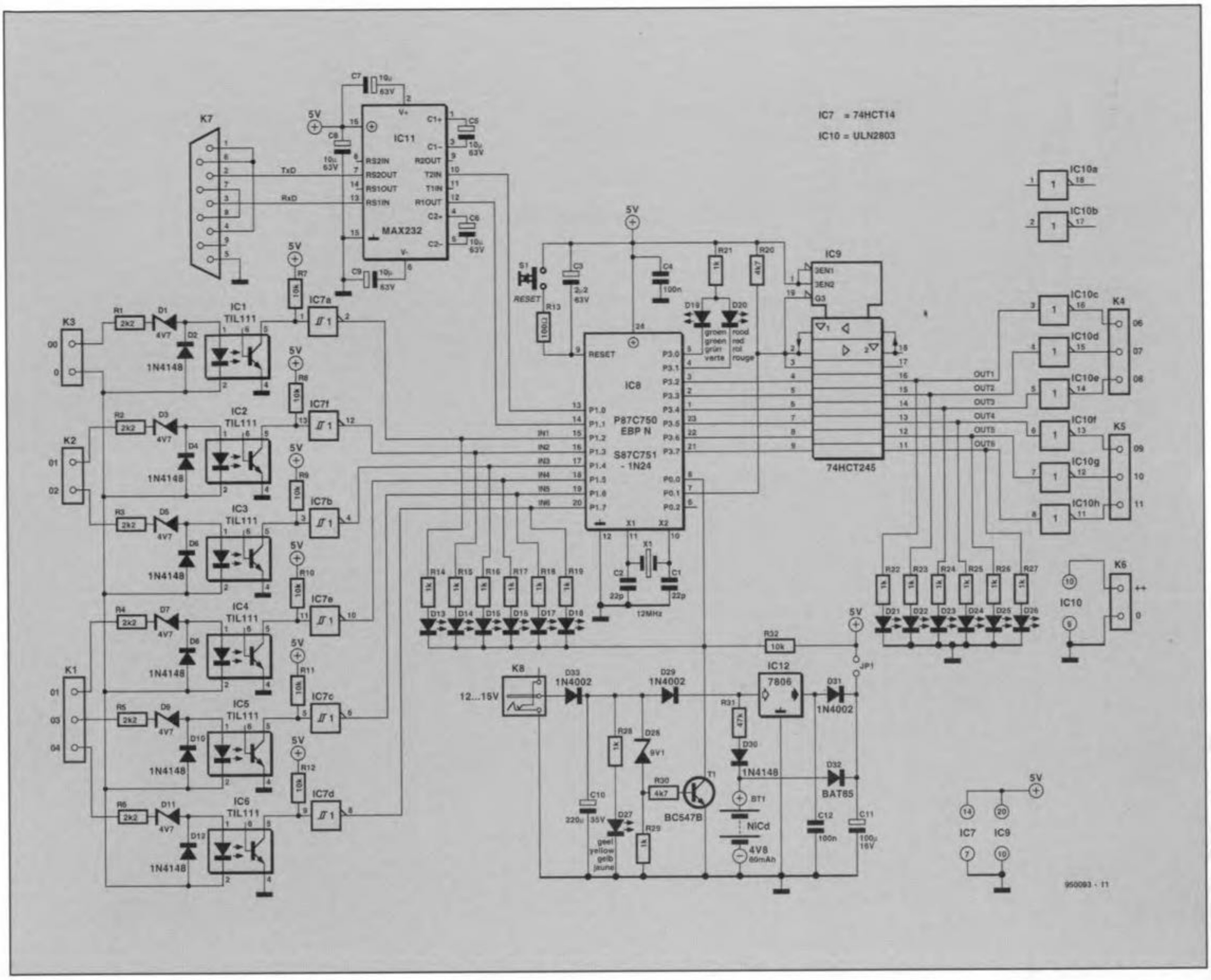


Fig. 1. Circuit diagram of the Micro PLC, an ideal companion for a vast range of control applications.

cating to the user that the circuit is switched on. When the voltage across C_{10} is just over 10 V, transistor T_1 starts to conduct. Consequently, processor line P0.0 goes low, and the cathodes of D_{13} through D_{18} are taken to ground. The effect of this is discussed further on. When the supply voltage disappears, the PLC goes into standby mode, while all its outputs are switched off via port line P0.1. When the supply voltage returns, the processor starts the control program again. As long as the supply voltage is present, the battery, Bt_1, is charged via R_{31} and D_{30} with a current of about 0.15 mA. The nominal battery voltage is 4.8 V, which is just enough to keep the processor powered. Because IC_{12} supplies a regulated supply voltage of 6 V, the voltage at the cathode of D_{31} (5.4 V) is just enough to make diode D_{32} block. Consequently, the microprocessor then receives its supply voltage via the regulator. So, if the mains voltage disappears, the battery takes

MAIN SPECIFICATIONS

Processor:	**87C750**
Clock frequency:	**12 MHz**
Supply:	**15-25 V DC** **10-18 V AC**
Current consumption:	**15 mA with LEDs off**
Instruction set:	**compatible with Saia PC**
Program memory:	**48 bytes (approx. 30 steps)**
Backup supply:	**2-3 hours**
Inputs:	**6 (15 V)**
Outputs:	**6 (500 mA/50 V)**
Aux. memories:	**6**
Timer:	**1**
Counter:	**1**
Output frequency:	**max. 3,068 Hz**
Duty factor:	**0.507**
Programming:	**via MS-DOS PC**
Communication:	**9600 baud (8 databits, no parity, 1 stop bit)**

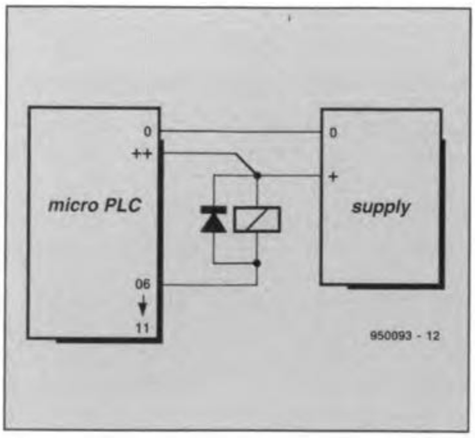


Fig. 2. A flyback diode should be fitted as shown here whenever a PLC output is used to drive an inductive load such as a relay coil.

over via diode D_{32}. The other diode, D_{31}, then prevents precious battery current from leaking away via the regulator.

Jumper JP_1 in the power supply section acts as an on/off switch. It is fitted if the Micro PLC is in continuous use. If you want to be able to switch the Micro PLC on and off frequently, you may connect a switch and two wires to the jumper pins. If you stick with the jumper, remove it if you do not use the Micro PLC for a longer period. Pulling the jumper will prevent the battery from being discharged too deeply, which should be avoided because it may permanently reduce the battery capacity.

Instruction	Mnemonic	Code	Operands	Accumulator
No operation	NOP	00	-	-
Start high	STH	01	00-17	X
Start low	STL	02	00-17	X
AND high	ANH	03	00-17	X
AND low	ANL	04	00-17	X
OR high	ORH	05	00-17	X
OR low	ORL	06	00-17	X
Exclusive OR	XOR	07	00-17	X
Complement accum.	CPA	08	-	X
Accum. to output	OUT	09	06-17	-
Set output	SEO	10	06-17	-
Reset output	REO	11	06-17	-
Complement output	CPO	12	06-17	-
Wait	DLY	13	01-250	-
Initialize counter	ICR	14	00-250	-
Increment counter	INC	15	-	-
Decrement counter	DEC	16	-	-
Compare counter	CCR	17	00-250	X
Unconditional jump	JMP	18	16-63	-
Jump if accum. = 1	JIO	19	16-63	-
Jump if accum. = 0	JIZ	20	16-63	-
Wait if high	WIH	21	00-05	-
Wait if low	WIL	22	00-05	-
Write to all outputs	WTO	23	00-63	-
Set accum.	SEA	24	-	1
Reset accum.	REA	25	-	0
Return to program mode	RPM	26	-	?
Software version	VER	27	-	-
Go to run mode		255	-	?

-: Accumulator not affected by instruction.
X: Accumulator updated by result of instruction.
?: Accumulator contents not known after execution of instruction.
1: Accumulator contents is 1 after instruction.
0: Accumulator contents is 0 after instruction.
All instructions (except JIO and JIZ) are always executed irrespective of the accumulator contents.
Instructions WIH en WIL only concern inputs, not counters, timers or auxiliary memories.
Value stated after DLY is the wait time in steps of 0.1 s (from 0.1 tot 25 s)

Table 1. Instruction set of the micro PLC.

Serial Communication

The RS232 interface is built around the familiar MAX232. This IC from Maxim Inc. enables an RS232 interface with standardized voltage input/output swings (well, nearly) to be implemented based on just a single 5-V supply rail. Capacitor C_8 serves as a buffer and decoupling device for the IC, while C_5, C_6, C_7 and C_9 are external charge pump capacitors for the on-chip DC-DC converter. The RxD, TxD and GND terminals needed for the serial communication with the PC are found on connector K_7.

The processor is also connected to two LEDs, D_{19} and D_{20}, which have the following functions:

red LED	green LED	Status
off	off	system switched off
on	off	programming mode
off	on	run mode
off	flashing	stop, mains outage
flashing	off	stop, invalid instruction

Safe inputs

To prevent earth return currents, the inputs of the Micro PLC feature electrical isolation with the aid of opto-isolators. This prevents switching currents from the outputs to flow through the input circuits. Each input also has a switching threshold created with the aid of a zener diode. Based on a nominal input voltage of about 15 V, the PLC recognizes input voltages from about 8 V as a 'high' level. As soon as the input voltage is high enough, the LED in the relevant opto-isolator lights. At a sufficiently high LED current, the phototransistor in the opto-isolator starts to conduct, and switches on the associated buffer (IC_{7a} through IC_{7f}). The buffer output signal is applied directly to one of the inputs of port P_1 on the microcontroller. The output level is also used to switch on a LED (D_{13} through D_{18}). High-efficiency (i.e., low-current) LEDs are used here because of the limited current drive capacity of the buffers. The LEDs light at full intensity at a current of only 2 mA. A LED which lights indicates a logic high level at the corresponding input.

Power Outputs

Once the microprocessor has processed the input signals, a bit pattern appears on the system outputs which has to be transmitted to the 'real world'. The six processor outputs, P3.2 through P3.7, are buffered by IC_9, a 74HCT245. The outputs of IC_9 are taken to an array of LEDs (D_{21} through

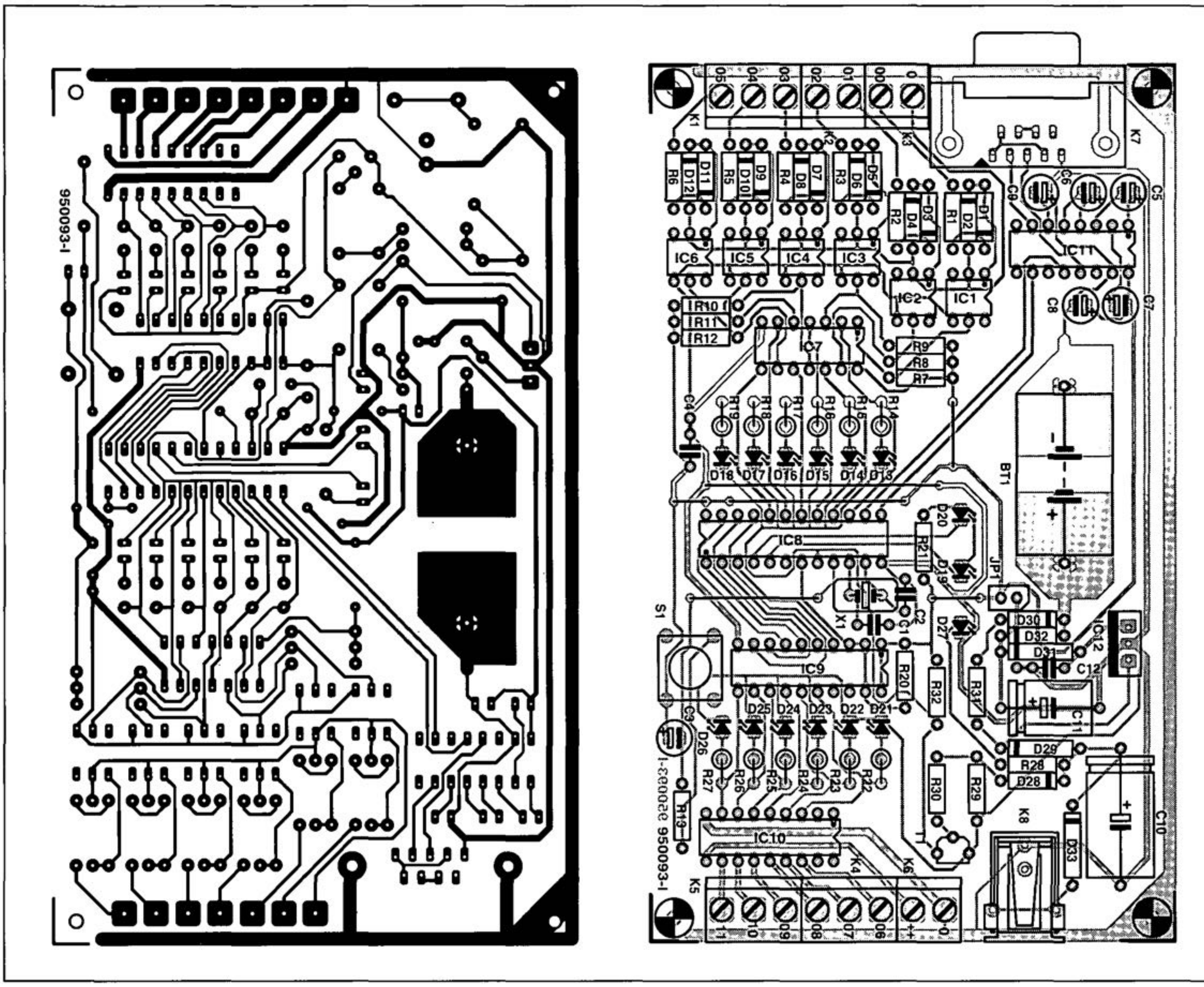


Fig. 3. Track layout and component mounting plan of the printed circuit board designed for the Micro PLC system (board available ready-made, see page 70). As with professional PLC systems, terminal blocks are used for the connections to the outside world.

COMPONENTS LIST

Resistors:
R1-R6 = 2kΩ2
R7-R12,R32 = 10kΩ
R13 = 100Ω
R14-R19,R21-R29 = 1kΩ
R20,R30 = 4kΩ7
R31 = 47kΩ

Capacitors:
C1,C2 = 22pF
C3 = 2µF2 63V radial
C4,C12 = 100nF
C5-C9 = 10µF 63V radial
C10 = 220µF 35V
C11 = 100µF 16V

Semiconductors:
D1,D3,D5,D7,D9,D11 = 4V7/400mW zener diode
D2,D4,D6,D8,D10,D12,D30 = 1N4148
D13-D18,D21-D26 = LED, yellow (3mm, 2mA)
D19 = LED, green (5mm, 2mA)
D20 = LED, red (5mm, 2mA)
D27 = LED, yellow (5mm, 2mA)
D28 = 9V1/400 mW zener diode
D29,D31,D33 = 1N4002
D32 = BAT85
T1 = BC547B
IC1-IC6 = TIL111 or CNY17
IC7 = 74HCT14
IC8 = P87C750EBPN or S87C751-1N24 (order code 956514-1)
IC9 = 74HCT245
IC10 = ULN2803
IC11 = MAX232
IC12 = 7806

Miscellaneous:
JP1 = jumper
K1,K4,K5 = 3-way PCB terminal block, raster 5 mm.
K2,K3,K6 = 2-way PCB terminal block, raster 5 mm.
K7 = 9-way sub-D socket, angled, PCB mount.
K8 = mains adaptor socket, PCB mount.
S1 = presskey, e.g., CTL3 (Multimec).
X1 = 12 MHz crystal
BT1 = NiCd-battery 4V8/60mAh (smaller or larger capacity also possible).
Enclosure 14.5x9x3 cm, e.g. PacTec.
PCB, programmed controller and disk, set order code 950093-C. Controller also available separately: order code 956514-1, see page 70.
Diskette also available separately: order code 956016-1, see page 70.

Help, it does not work!

Unfortunately it is always possible for a fault to remain hidden somewhere in the circuit. The only alternative you have in that case is to do a round of faultfinding. Use your multimeter to check that all ICs receive the required supply voltage, then check the operation of the oscillator. An oscilloscope or a frequency meter connected to pin 10 of the processor will tell you the crystal frequency instantly. A multimeter connected to this point should read about half the supply voltage. If these tests check out so far, the fault lurks almost certainly in the serial communication. Assuming that the serial cable is not connected to the PC, pin 2 of K7 should have a voltage of about –10 V, while pin 3 should read about 0 V. At the PLC end of the cable connected to the PC, these voltages should be the other way around. Measure the voltage difference between pin 3 and pin 5 at the male connector. There should be 0 V at pin 2. If not, try swapping pin 2 and pin 3.
After a reset, the Micro PLC always sends a '#' character to the computer. All data received by the system are echoed to the PC, only the ASCII value is increased by one.

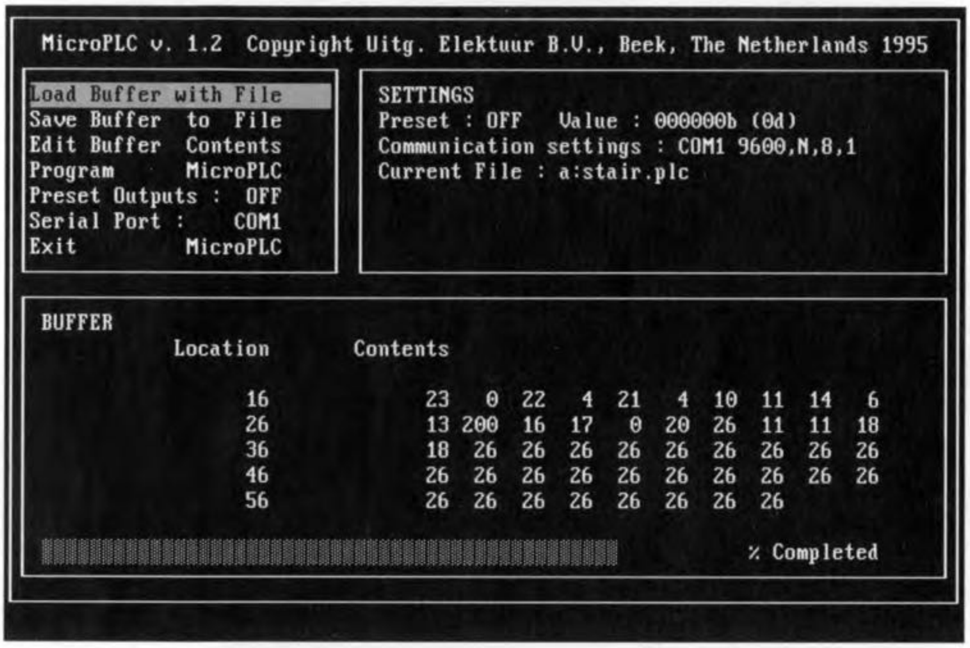


Fig. 5. This screendump produced with the 'MicroPLC' program shows how the user communicates with the Micro PLC via his/her PC.

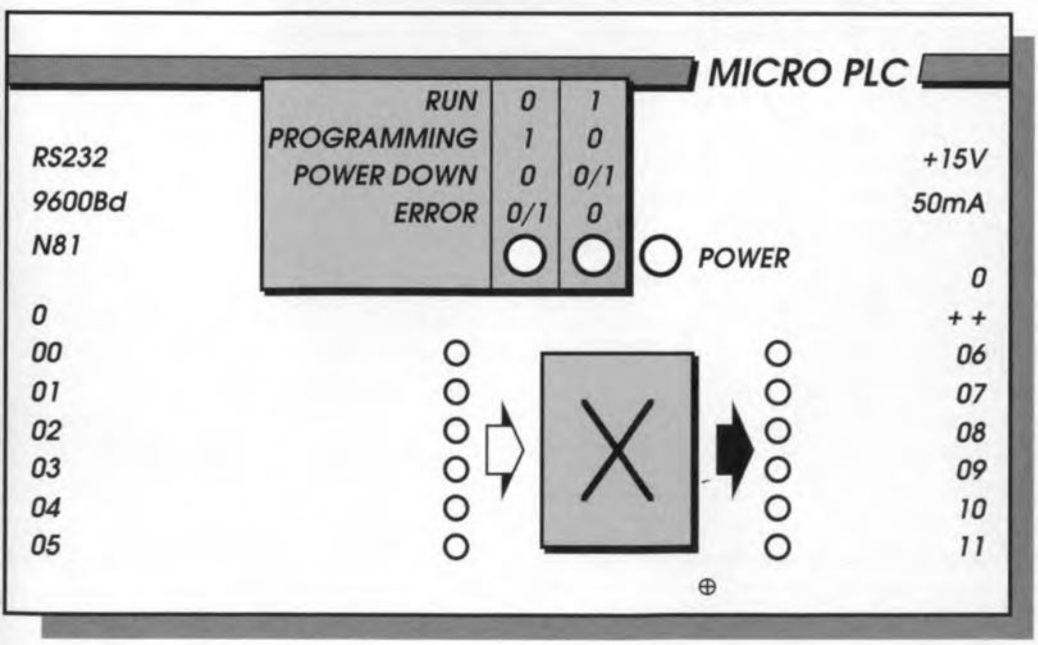


Fig. 4. Suggested cover panel layout. All relevant information is neatly arranged.

D_{26}) which serve as output status indicators ('LED on'; means high output level). Because the output current of IC_9 is too small to switch a small relay, another buffer section is added. The ULN2803 IC selected for this purpose contains buffers which are capable of switching voltages up to 50 V and currents up to 0.5 A. Unfortunately, the ULN2803 can not be loaded with six currents of 0.5 A at the same time — the total current drain on all outputs at the same time is limited to about 1 A.

In most cases, the mains adaptor which is used to power the Micro PLC system will have a current capacity of a few hundred milli-amps only. That is why the buffers have a separate supply connection. The positive and negative supply voltage connections for IC_9 are found on connector K_6. When you are certain that the total current demand remains relatively small, and can be handled by the mains adaptor, the buffers may also be powered by the existing supply. Note that the ground of the buffer supply voltage must also be connected! If the outputs are inductively loaded, for example, by a relay, each output should be fitted with its own flyback diode. The relevant connections are illustrated in **Fig. 2**.

Towards practical use

Because the Micro PLC is a system which should continue to work even under less favourable conditions, a printed circuit board was designed which fits in a sturdy enclosure. To keep the operation of the system clear and simple at all times, a front panel was designed for the enclosure.

The track layout and the component mounting plan are shown in **Fig. 3**. A cursory look at the PCB layout already indicates that the overall design is based on the typical industrial PLC. All inputs and outputs are accessible (electrically, that is) through PCB mounted screw-type terminal blocks.

Populating the board is not expected to cause undue problems. Start by fitting the six wire links, so you can't forget them later. Fit the ICs in sockets, and do not mount the battery yet. All ICs, except the processor, have the same orientation on the board. At this stage, decide whether or not you want to keep the on/off switch and the reset button accessible from the outside. Pressing the reset button causes all processor memories to be cleared, so that you have to re-program the PLC. It may, therefore, be sensible to leave the reset button inside the case, and make it accessible through a small hole. If you do not need an on/off switch, install a wire or a jumper in position JP_1.

If so required, the sensitivity of the inputs may be modified. With the component values shown, the PLC responds to input voltages of about 8 V. That level may be lowered to, for instance, 3.3 V simply by replacing the zener diodes at the inputs with wire links. If, on the other hand, higher input levels are desired, simply fit a suitably rated higher-voltage zener diode.

Ready for testing

Once all components are fitted, with the exception of the processor and the backup battery, you are ready to do a few initial tests. Connect a small 12-V mains adaptor (min. 300 mA) to the supply socket. The yellow LED (D_{27}) will light, and possibly some other LEDs also. Use a digital multimeter to check the presence of the 5.4 V voltage. If the voltage is not found, you have almost certainly forgotten jumper JP_1. Next, disconnect the mains adaptor, and fit the processor in its socket. Power up again. The red and the yellow LEDs should light. If that is the case, you may safely assume that the Micro PLC is working properly.

Now connect the Micro PLC to the PC via a standard RS232 cable, insert the disk with the control software, select the disk drive, and type

```
microplc -com1 <return>
```

If necessary, replace `-com1` by `-com2` to use the second serial port on your PC (if available).

Select the option 'load buffer with file' at the top of the screen, and then type 'loop.plc'. Next, select the option 'program microPLC', followed by 'download' and 'autostart'. Follow the instructions on the screen (reset the PLC). Downloading will then commence, and the program, a running light, will start automatically. A green and a red LED will light also, which is an indication that the Micro PLC is working properly. **Do not press the reset button**. If you do, you will have to load the program all over again. After this test, the battery may also be fitted on to the board. Almost any type of battery is suitable, as long as it supplies 4.8 V.

Install the Micro PLC in the enclosure (the PCB fits exactly in the PacTec case mentioned in the parts list). First, however, you have to drill the holes for the mains adaptor plug and the RS232 connector. The moulded PCB pillars have to be cut to size to enable the PCB to be fitted into the case. This is not difficult if you use a jig-saw or a sharp hobby knife.

The cover is drilled according to the front panel layout, for which a suggestion is shown in **Fig. 4**. The front panel lettering give the Micro PLC a close-to-professional look.

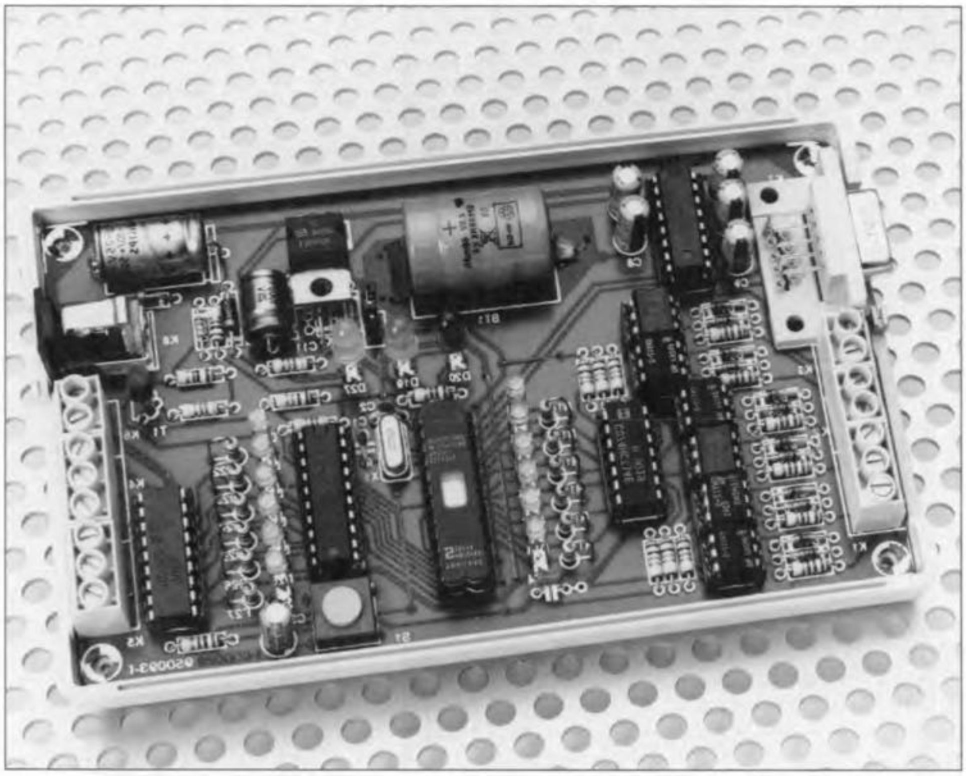


Fig. 6. Prototype of the Micro PLC. More on applications and programming in next month's second instalment.

Next month

Next month's instalment will deal with some of the programming features of the Micro PLC. To give you some idea of the possibilities for programming, we already print the complete instruction set in **Table 1**. This will enable experienced PLC programmers to make a flying start. For the rest of our readers, there is no alternative but to wait for next month's instalment.

(950093)

Fig. 7. PLCs are everywhere! A well known application is traffic lights control systems.

AMPLIFIER FOR GUITAR PRACTICE

Design by W. Teder

The amplifier described is intended as a practice unit for guitar players. Its power output is not sufficient (in most cases) for use during a (public) performance. In most other respects, it is, however, virtually identical to a standard amplifier, as evinced by its variable clipper, extensive tone control and facilities for connecting various effect units. Moreover, the facility for setting the gain and master volume controls independently offers even more interesting possibilities.

It is a fact (well, almost) that in amplifiers for musical instruments there is a fixed relationship between the power output and the control facilities provided. In other words, high-power amplifiers are richly provided with knobs, switches and sockets, whereas low-power versions (for practising) are invariably conspicuous by the sparsity of such facilities.

Many guitarists, quite rightly, are not happy with this state of affairs. In the first place, a practice amplifier should, like its bigger brother, produce a good sound. Moreover, low-power amplifiers are often used for tape recording and this requires a variety of plugs and sockets.

The present amplifier is intended to rectify this anomaly. Although compact, it provides facilities that are normally found only on higher power amplifiers. Designed for construction on a single printed-circuit board, it is fairly easy to build. Last but not least, it is designed with standard components, which makes it easy on the wallet.

Circuit description

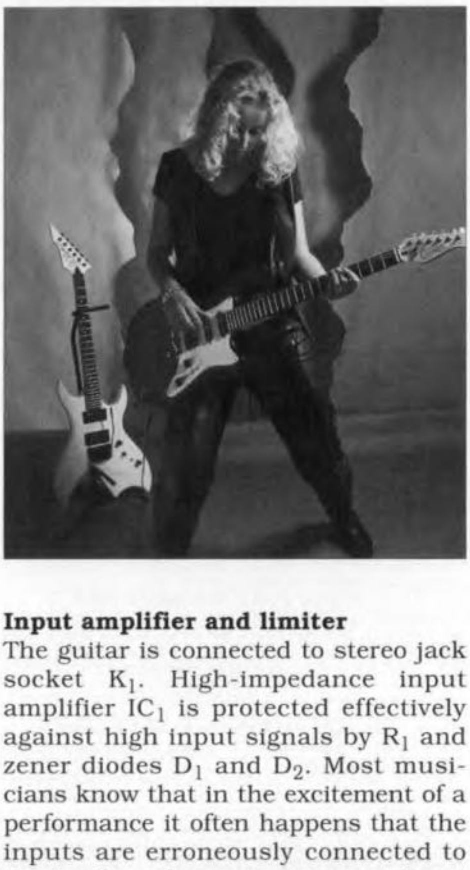
Although the circuit in **Fig. 1** looks fairly complex, it is, in fact, quite straightforward, since the 11 operational amplifiers are contained in just four integrated circuits.

Briefly, IC_1 is the input amplifier, whose gain is set with P_1. This stage is followed by clippers D_3 and D_4. Op amps IC_{2c} and IC_{2d} form an accurate overdrive indicator.

The tone control circuit is based on IC_{3c}, IC_{3d} and IC_{4a}. The amplifier stages following this circuit are part of the frequency correction network.

Circuits IC_{3a} and IC_{3b} form a noise filter, while IC_{4b} is an output buffer for the symmetric line output.

The signal finally arrives at the output amplifier, IC_5, via master volume control P_6.



Input amplifier and limiter

The guitar is connected to stereo jack socket K_1. High-impedance input amplifier IC_1 is protected effectively against high input signals by R_1 and zener diodes D_1 and D_2. Most musicians know that in the excitement of a performance it often happens that the inputs are erroneously connected to the loudspeaker outputs: most input amplifiers do not like that. The protection in the present amplifier is, therefore, no superfluous luxury.

The amplification of the input amplifier is set with P_1. The output of IC_1 drives diode limiter D_3-D_4, window comparator IC_{2c}-IC_{2d}, which forms the overdrive indicator circuit, and the first line out socket, K_2.

The gain control may be set so that D_{18} lights only at high sound peaks to give a 'clean' sound, or so that that the threshold of the diode limiter is well exceeded to give a 'distorted' sound (when D_{18} lights continuously). All kinds of effect can be obtained at settings of P_1 between these two extremes.

Capacitors C_{30} and C_{31} in the comparator circuit provide a slight lengthening of the time D_{18} lights so that even short overdrive peaks are indicated.

The lower threshold of the comparator is determined by the value of R_{47}, which may be adapted to personal requirements.

The design of the input stage assumes a signal input level of about 50 mV r.m.s.

Frequency correction

A satisfactory guitar sound cannot be obtained with tone control alone: the frequency response curve of the amplifier needs to be permanently 'corrected'. In practice, this means primarily selective amplification of high frequencies. In the present amplifier, networks R_3-C_3 (IC_1), R_{12}-C_9 (IC_{2b}), and R_{35}-C_{21} (IC_{2a}), ensure that the high frequencies are more highly amplified than low ones in the zero position of the tone controls.

Moreover, filter R_8-C_6-R_9-C_7 between the diode limiter and the correction amplifier provides maximum attenuation at about 700 Hz. This filter corresponds roughly to the loudness function on a hi-fi amplifier. Attenuation of the middle frequencies has the same effect as amplifying the low and high frequencies. In other words, the bass response is also improved, which is of benefit in a small amplifier. Readers who intend to use a 30 cm loudspeaker in a large enclosure do not need the extra 'amplification' of the bass frequencies and may replace R_9-C_7 by a 22 Ω resistor.

Since extra amplification of the high frequencies inevitably means more noise, the amplification needs to be limited at some point. This is effected, in the first instance, by networks R_{10}-C_8 (IC_{2b}) and R_{37}-C_{20} (IC_{2a}). However, the largest part of the compensation is provided by low-pass Bessel filter IC_{3a}-IC_{3b}. This filter has a beneficial, pleasant effect on the produced sound, which retains its crisp character without becoming too harsh

Some parameters

- corrected frequency response
- presettable limiter with optical indication
- noise filter
- four-fold tone control
- two sockets for effects units
- separate controls for gain and master volume
- symmetrical line output
- soft clipping

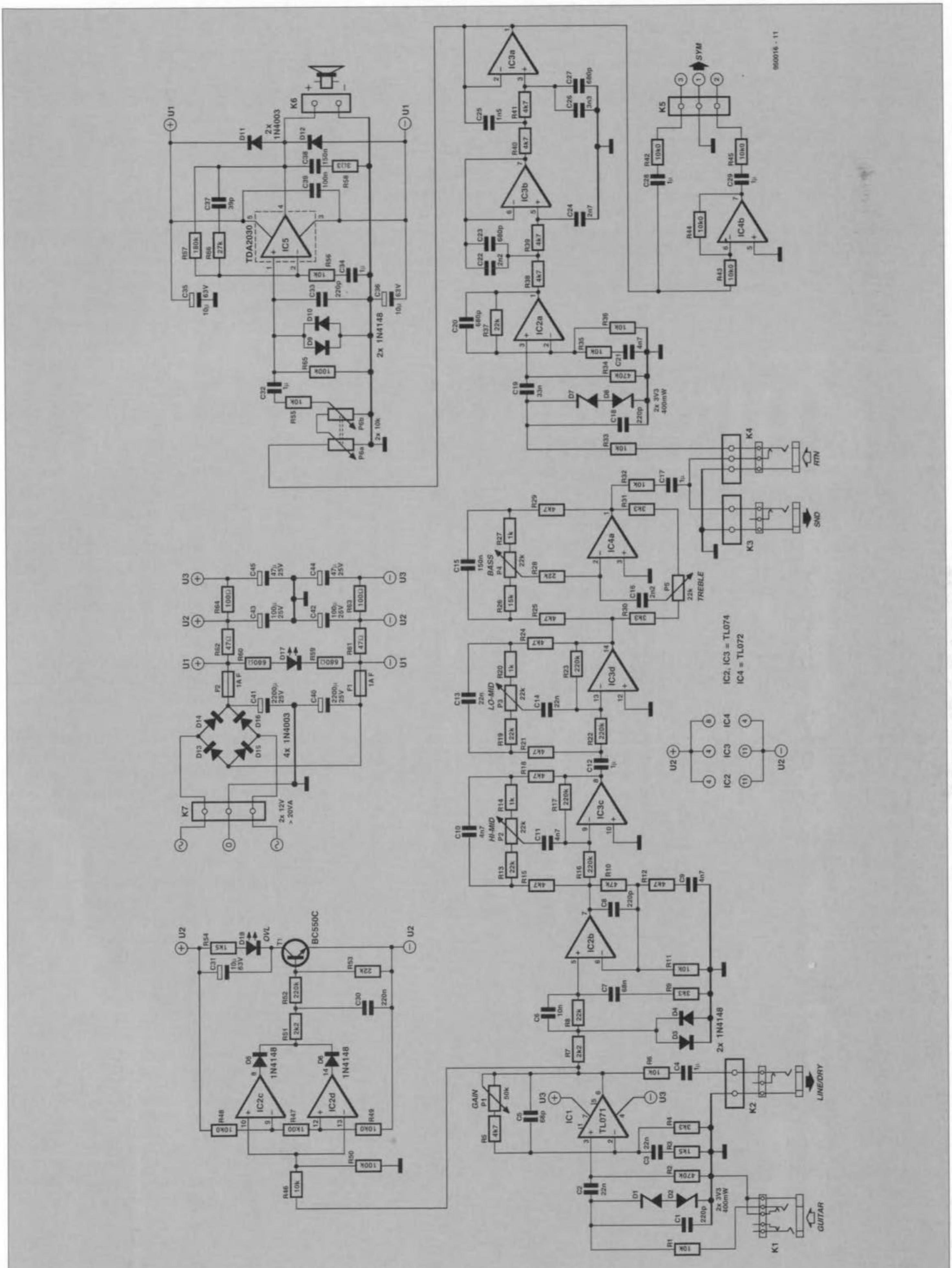


Fig. 1. The circuit of the practice amplifier has separate controls for the gain and master volume, which enables limiting effects to be used even at low sound levels.

as happens in some amplifiers.

Tone control

A somewhat unusual four-fold tone control is provided by IC_{3c}, IC_{3d} and IC_{4a}. The variable bandpass filters for the low middle (LO-MID) and high middle (HI-MID) frequencies are not symmetrical. Potentiometers P_2 and P_3 provide attenuation instead of amplification of these two frequency ranges. Although this would be absurd in a hi-fi amplifier, it is not only common, but also desirable, in an amplifier for musical instruments. In a guitar amplifier adjusted for fairly neutral operation, the level of the middle frequencies will always be appreciably lower than that of the remainder of the frequency range.

The bass control, P_4 is also asymmetrical, but the fixed bass correction provided by R_9-C_7 ensures that the bass frequencies are amplified to a satisfactory degree.

The design of the tone control makes possible a great variety of the produced sound. If greater diversity is required, experiment with the values of the resistors in series with the potentiometers, such as R_{13} and R_{14} in case of the HI-MID control.

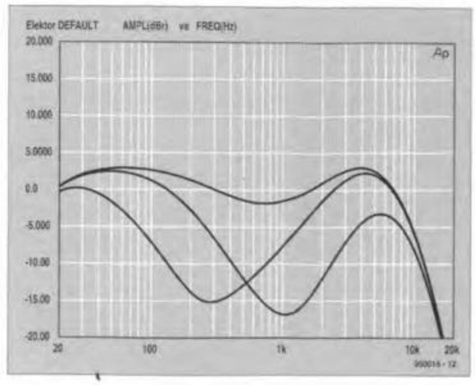


Fig. 2. Frequency response of the tone control circuit with P_2 and P_3 set to maximum and BASS and TREBELE to neutral (top curve). The curve dipping at 200 Hz results when P_2 is set to minimum, and the third curve when P_2 and P_3 are set to minimum (BASS and TREBLE retained at neutral).

The response curves of the tone control are shown in **Fig. 2** and **Fig. 4**. Figure 2 shows the response with P_2 and P_3 set to maximum and BASS and TREBLE to neutral (curve A). Curve B shows what happens when P_2 is then set to minimum, and Curve C when P_2 and P_3 are at minimum (BASS and TREBLE retained at neutral).

Figure 4 shows the response when P_2 and P_3 are set to maximum and BASS and TREBLE at maximum (upper curve) and at minimum (lower curve).

The five curves show that the difference between the extreme position is some 30 dB and this typifies the operation of the amplifier. Also, they illustrate that this sort of tone control cannot be obtained with a standard circuit.

Connectors

The tone control circuit is followed by sockets K_3 (send) and K_4 (return), to which special effect units may be connected.

The signal at K_3 is always available via R_{32}-C_{17}. When there is no plug inserted into K_4, the signal is connected to the input of IC_{2a}.

The return input is protected against spurious radio frequency signals by low-pass filter R_{33}-C_{18}, while D_7 and D_8 afford protection against high input levels.

Socket K_3 may be used as a line output: with tape recordings, this offers the advantage of the tone control having influenced the signal. However, the correction provided by filter

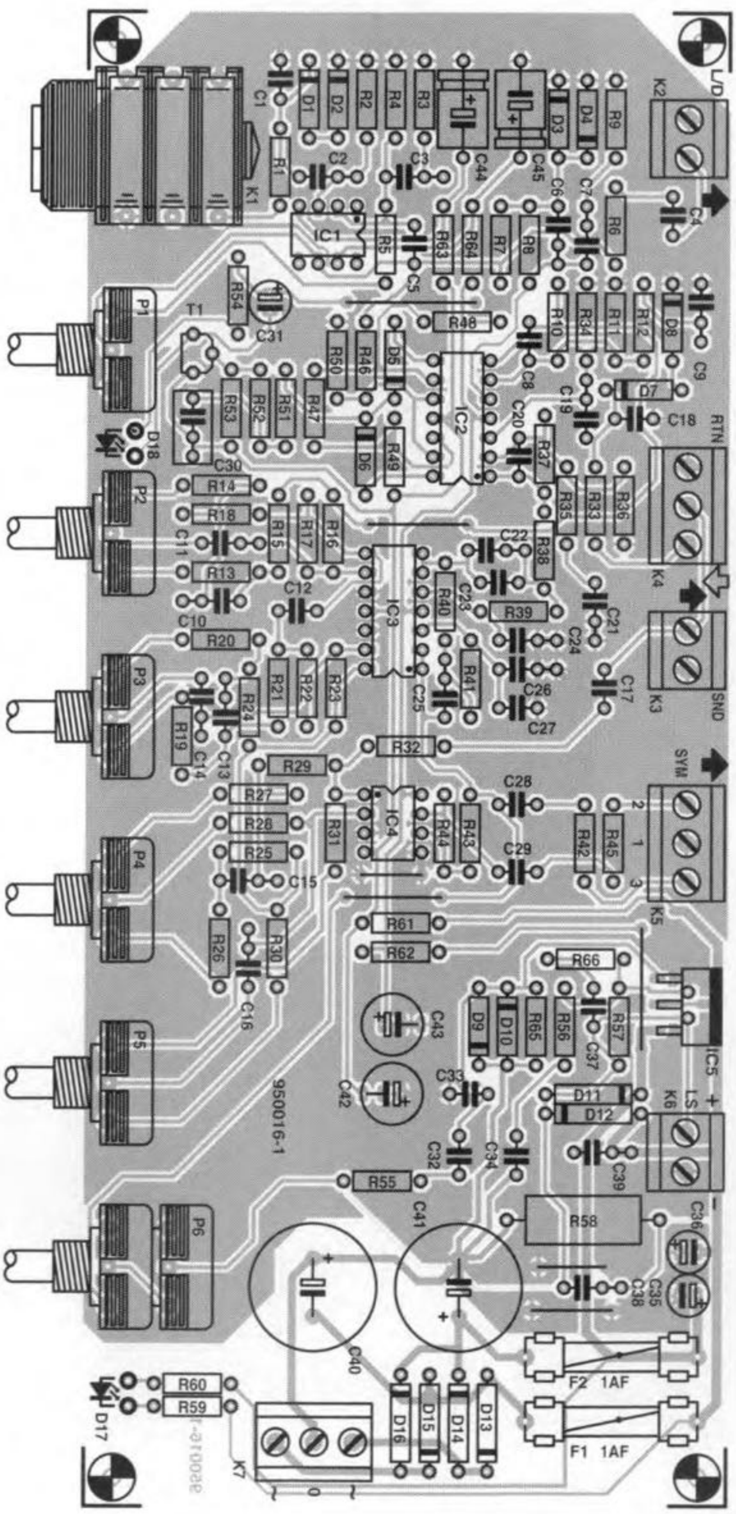


Fig. 3. Component layout of the printed-circuit board for the practice amplifier; the track side is shown on the opposite page (scale 1:1).

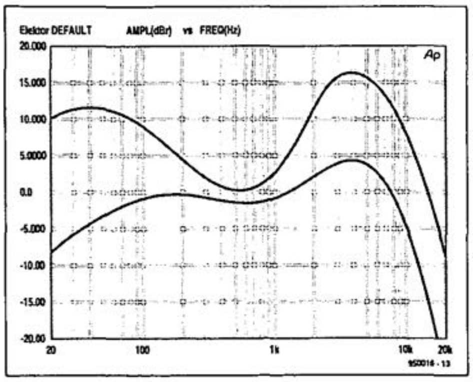


Fig. 4. Frequency response of the tone control circuit with P_2 and P_3 set to maximum and BASS and TREBLE at maximum (upper curve) and and at minimum (lower curve)

IC_{3a}-IC_{3b} is then not available. The symmetrical output at K_5, buffered by IC_{4b}, which has passed through this Bessel filter, is, therefore, immeasurably better than that at K_3.

Op amp IC_{4b} provides an average output level of 0 dBV (1 V r.m.s.), which may be used to drive a high-power amplifier.

Output amplifier

The power amplifier, which consists of IC_5, provides an undistorted output of about 10 W into 8 Ω or 15 W into 4 Ω, which is adequate for the present purposes.

The master volume control, P_6, is a stereo potentiometer arranged as a quasi-logarithmic control. Compared with a logarithmic potentiometer, this offers several advantages. For instance, the control curve is more easily reproduced since the manufacturing tolerances in linear potentiometers are much smaller than in logarithmic types. Moreover, it ensures a pleasant differential control at low volumes.

The volume control is followed by peak limiter R_{55}-D_9-D_{10}. This network provides a measure of soft clipping in the output circuit. Transistor amplifiers limit fairly abruptly when they are overdriven, which results in an unpleasant grinding noise that few people appreciate. In the present amplifier, the diode limiter begins to operate just before the transistors in the IC start to limit. This results in a rounding off of the rectangular signals that are otherwise produced by the transistors. If the soft clipping is not needed or wanted, D_9 and D_{10} may, of course, be omitted.

Power supply

The power supply has been kept as simple and economical as feasible. The only relatively expensive item is the mains transformer. Where possible, the use of a 2×12 V, 30 VA toroidal type is recommended.

The secondary voltage is rectified by D_{13}–D_{16} and smoothed by C_{40} and C_{41}. Diode D_{17} functions as the on/off indicator.

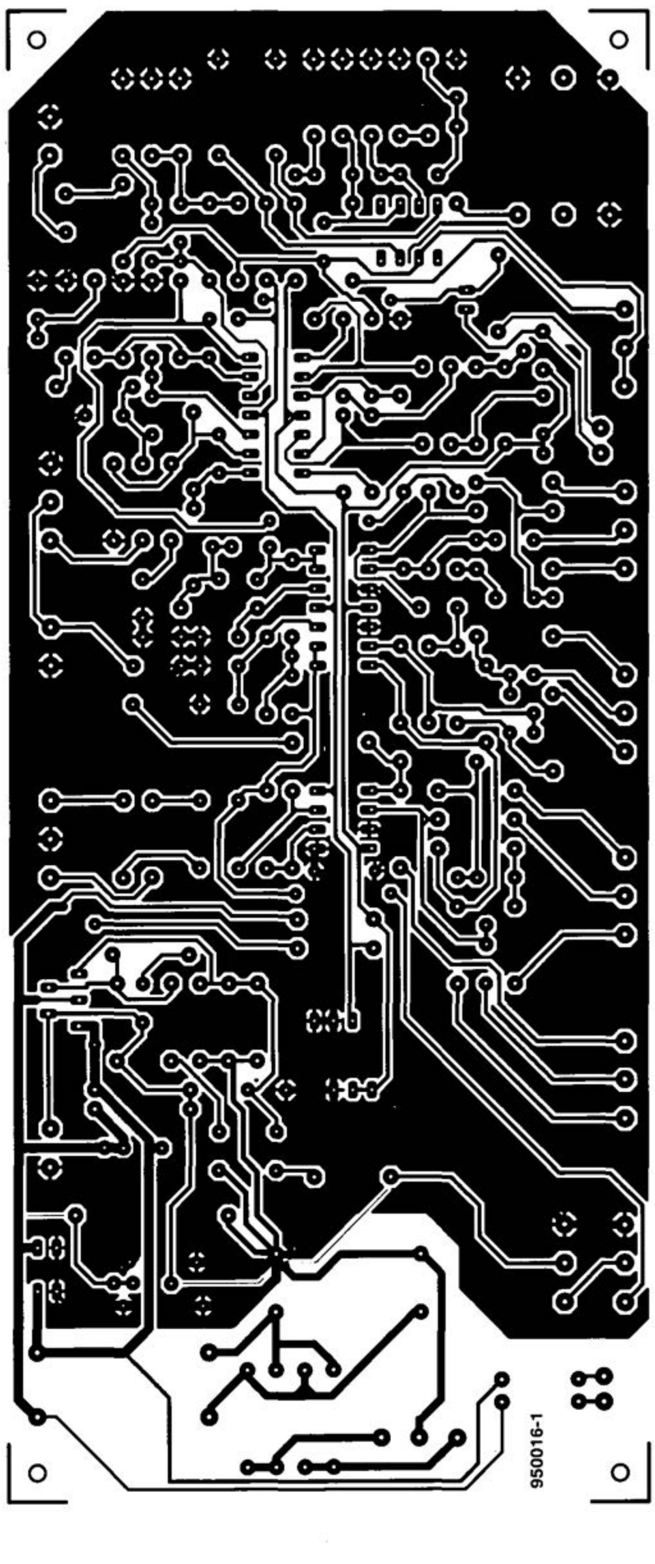
The symmetrical output voltage, U_1, is used to power the output amplifier. Output U_2 is the supply for the tone control and filter circuits, and U_3 is the supply voltage for the input amplifier.

Construction

The amplifier is intended to be built on the printed-circuit board shown in **Fig. 3**; only the mains transformer is not fitted on the board.

The design ensures that all controls, input socket K_1, overdrive indicator D_{18}, and on/off indicator D_{17}, are at the front of the board. The line out socket, effect-unit sockets, symmetrical output and loudspeaker output, are at the rear of the board.

The output amplifier is purposely situated at the rear edge of the board, to ensure sufficient space for its heat sink—see **Fig. 7**. Note that the IC must be isolated from the heat sink with the aid of an appropriate washer and heat conducting paste.



The building up of the board is pretty straightforward if Fig. 4 and the parts list are consulted regularly. **Figure 5** shows the completed (prototype) board.

Most readers will have their own ideas as to how to finish the amplifier. Not many will build the amplifier in a dedicated enclosure. The norm will probably be to fit the board at right angles to a front panel and fix it, together with a loudspeaker, into a suitable enclosure.

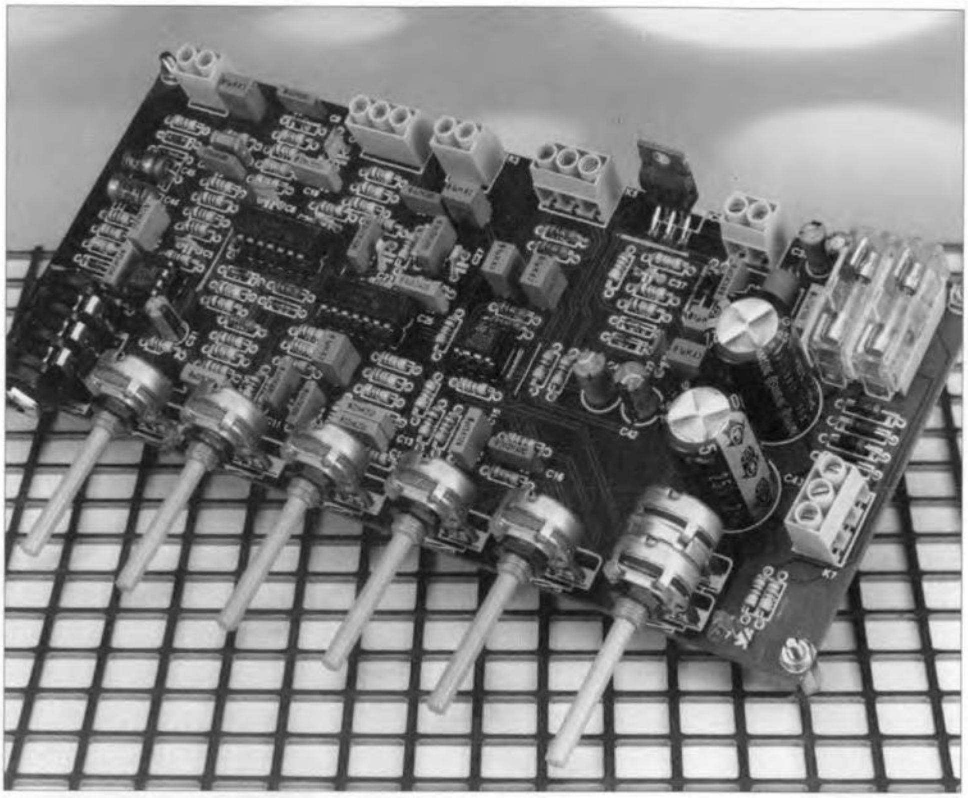


Fig. 5. The finished (prototype) board.

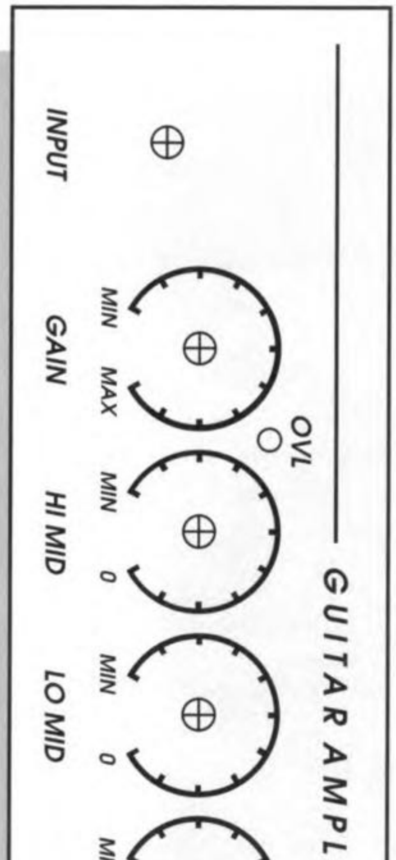


Fig. 6. Suggested front panel layout.

The shape and layout of the front panel will depend on the application. It must at any rate contain the potentiometers and the input socket, but, if much use of effects units is expected, it would seem advisable that it also carries the two sockets for these. However, it is realized that a number of purists will want as few controls on the front panel as possible.

Figure 7 shows how the prototype was finalized as a slot-in module. The layout of the front panel is given in **Fig. 6**. The board and front panel foil are available ready made—see p. 70.

Finally

In principle, the present amplifier can be used with any type of guitar loudspeaker. In view of the low power output, a standard broadband speaker is also eminently suitable. The only aspect that needs to be watched is that the rating of the loudspeaker is not lower than the amplifier power output. This means, that an 8-ohm speaker must be rated at not less than 10 W (continuous) and a 4-ohm type at 15 W (continuous). In other words, a 100 W guitar loudspeaker is entirely suitable.

Parts list

Resistors:

R_1, R_6, R_{11}, R_{32}, R_{33}, R_{35}, R_{36}, R_{46}, R_{55}, R_{56} = 10 kΩ
R_2, R_{34} = 470 kΩ
R_3, R_{54} = 1.5 kΩ
R_4, R_9, R_{30}, R_{31} = 3.3 kΩ
R_5, R_{12}, R_{15}, R_{18}, R_{21}, R_{24}, R_{25}, R_{29}, R_{38}–R_{41} = 4.7 kΩ
R_7, R_{51} = 2.2 kΩ
R_8, R_{13}, R_{19}, R_{28}, R_{37}, R_{53} = 22 kΩ
R_{10} = 47 kΩ
R_{14}, R_{20}, R_{27} = 1 kΩ
R_{16}, R_{17}, R_{22}, R_{23}, R_{52} = 220 kΩ
R_{26} = 15 kΩ
R_{42}–R_{45}, R_{48}, R_{49} = 10.0 kΩ, 1%
R_{47} = 100 kΩ, 1%
R_{50}, R_{65} = 100 kΩ
R_{57} = 180 kΩ
R_{58} = 3.3 Ω, 5 W
R_{59}, R_{60} = 680 Ω
R_{61}, R_{62} = 47 Ω
R_{63}, R_{64} = 100 Ω
R_{66} = 27 kΩ
P_1 = 50 kΩ (47 kΩ) linear, miniature
P_2–P_5 = 22 kΩ, linear, miniature
P_6 = 10 kΩ, linear, stereo, miniature

Capacitors:

C_1, C_8, C_{18}, C_{33} = 220 pF
C_2, C_3, C_{13}, C_{14} = 22 nF
C_4, C_{12}, C_{17}, C_{28}, C_{29}, C_{32}, C_{34} = 1 μF, polypropylene, pitch 5 mm
C_5 = 68 pF
C_6 = 10 nF
C_7 = 68 nF
$C_9 \neq C_{11}$, C_{21} = 4.7 nF
C_{15}, C_{38} = 150 nF
C_{16}, C_{22} = 2.2 nF
C_{19} = 33 nF
C_{20}, C_{23}, C_{27} = 680 pF
C_{24} = 2.7 nF
C_{25} = 1.5 nF
C_{26} = 3.3 nF
C_{30} = 220 nF
C_{31}, C_{35}, C_{36} = 10 μF, 63 V, radial

C_{37} = 39 pF
C_{39} = 100 nF
C_{40}, C_{41} = 2200 µF, 25 V, radial
C_{42}, C_{43} = 100 µF, 25 V, radial
C_{44}, C_{45} = 47 µF, 25 V

Semiconductors:
D_1, D_2, D_7, D_8 = zener 3.3 V, 400 mW
D_3–D_6, D_9, D_{10} = 1N4148
D_{11}–D_{16} = 1N4003
D_{17}, D_{18} = LED
T_1 = BC550C

Integrated circuits:
IC_1 = TL071
IC_2, IC_3 = TL074
IC4 = TL072
IC_5 = TDA2030

Miscellaneous:
K_1–K_4 = 6.3 mm mono audio socket for PCB mounting with switch contact
K_5 = 3-way (Cannon) socket for PCB mounting
K_6–K_8 = 3-way terminal block, pitch 5 mm
K_9–K_{11} = 2-way terminal block, pitch 5 mm
F_1, F_2 = fuse holder for PCB mounting with glass fuse, 1 A, slow
1 off heat sink for IC_5, 2.5 K W^{-1} (e.g., Fischer SK08/37.5 mm*)
1 off PCB Order no. 950016 – see p. 70
1 off front panel foil, Order no. 950016-F – see p. 70
* Dau (UK) Ltd,70–75 Barnham Road, Barnham, West Sussex PO22 0ES. Telephone (01243) 553 031. Trade only, but information as to your nearest dealer will be given by telephone.

[950016]

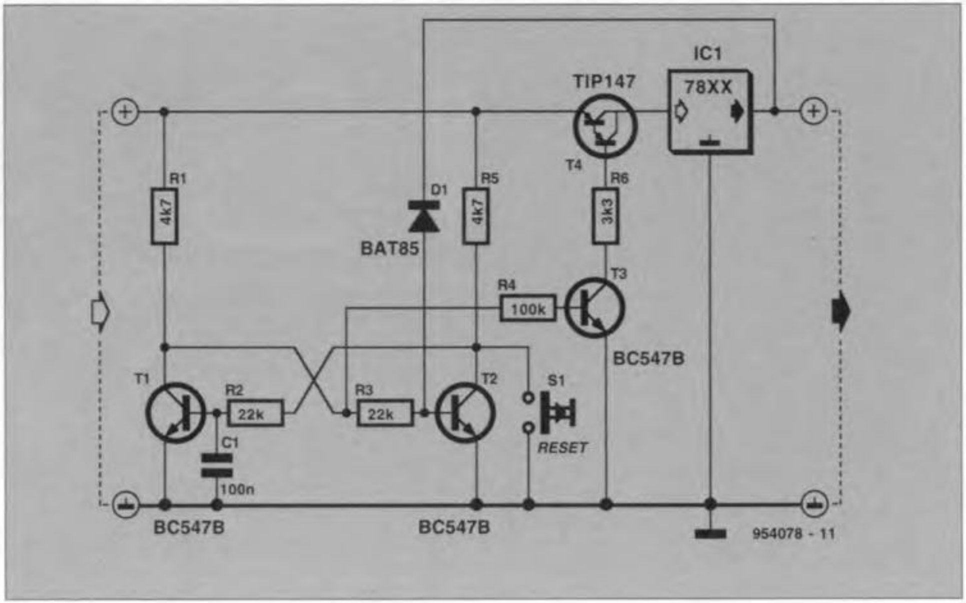
Fig. 7. The complete guitar amplifier fitted in an enclosures (top panel removed) which may be slotted into the loudspeaker box.

SHORT-CIRCUIT PROTECTION

It is not always realized that, when a short-circuit occurs in a circuit supplied via a Type 78xx regulator, this and similar types of regulator can not suddenly cut off. When a short-circuit occurs, a certain output current continues to flow. Although its level is limited, it can, nevertheless, cause damage in a few cases. This can be prevented with the present circuit, in which, when the output voltage of the regulator is too low, a bistable is actuated that instantly disconnects the input voltage from the regulator via an electronic switch.

When the supply is switched on, the bistable, consisting of T_1 and T_2, is actuated by the voltage across C_1: T_1 is off and T_2 conducts. The potential at the collector of T_1, which is thus high, is applied to the base of T_3 via R_4. Transistor T_3 is then on, which causes darlington T_4, which functions as a series switch for IC_1, to conduct. The supply voltage is thus applied to the regulator.

When a short-circuit occurs, diode D_1 causes the base voltage of T_2 to drop to not more than 0.3 V. The transistor then cuts off, whereupon the bistable changes state, which results in T_4 being disabled. This breaks the supply voltage to the regulator. This situation pertains until the short-circuit has been removed and reset switch S_1 is pressed. The bistable then changes state again, whereupon the circuit reverts to its normal operating mode.

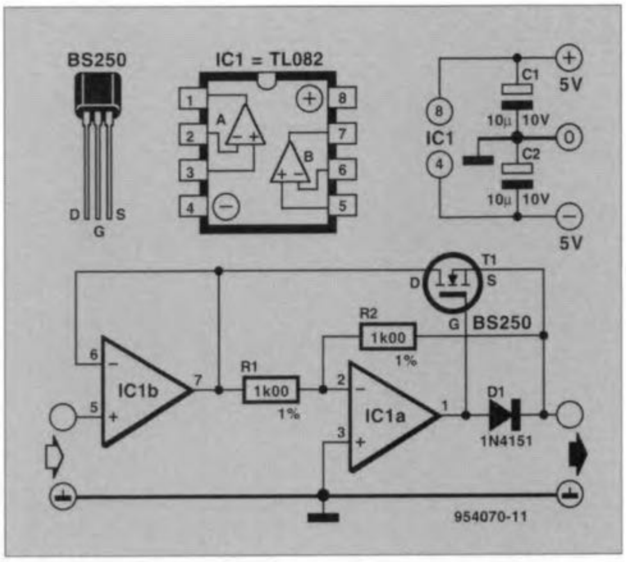


Design by H. Bonekamp
[954078]

ALTERNATIVE FULL-WAVE RECTIFIER

Here is a simple, fairly accurate and linear, full-wave rectifier for small signals (approx. 10 mV to 3 V) with a frequency between d.c. and about 1 kHz.

Diode D_1 conducts on the negative half-cycle of the input signal, so that op amp IC_{1a} provides a gain of $-1\times$ (R_1/R_2). Assuming that a symmetrical input voltage is applied, this means that the negative half-cycle appears at the output, and at the same level as the positive half wave. On the positive half-cycle, D_1 blocks, causing the op amp to soar to maximum amplification, and saturate at the smallest positive input level. FET T_1 then starts to conduct, so that the output voltage level of buffer IC_{1b} appears hardly attenuated at the output of the rectifier. The buffer, IC_{1b}, is used to increase the input impedance of the rectifier during the positive half-cycle of the input signal. Obviously, a certain minimum must be maintained as regards the impedance of the load connected to the circuit. If the load impedance is not stable and becomes too low, the drain-to-source junction resistance of T_1 becomes a degrading factor, and the linearity of the circuit is reduced significantly.



Finally, offset voltage compensation is required whenever the circuit is used to rectify input signals smaller than 300 mV. Current consumption of the circuit is about 4 mA.

(954070 - H. Bonekamp)

TRANSISTOR TESTER

The present tester is a good example of quality at a low price. It enables not only bipolar, but also field-effect, transistors to be tested for correct operation. The secret of it all lies in the fact that the transistor to be checked forms an active part of a reliable Colpitts oscillator.

The series-connected capacitors in parallel with inductance L_1 should be seen as a capacitive voltage divider which arranges the potential at the collector or drain of the transistor to be three times as high as that on the emitter or source.

To ensure that the oscillator functions correctly, the base or gate voltage must be at the correct potential required by the device. This is set with P_1, whose range is such that the potential can be positive or negative with respect to that at the emitter or source.

Depending on the type of transistor, the polarity of the supply voltage can be reversed with S_1. When this switch is in position, the tester is off.

The oscillator signal is displayed by a sensitive moving-coil meter, M_1, which is connected to the emitter or source of the transistor on test via C_3. The correct position of P_1 is that at which the meter deflection is greatest.

In an ideal case, the peak-to-peak level of the emitter voltage is about 2.25 V with a supply voltage of 9 V. When a BC547B was tested on the prototype, the output current was 90 µA, which corresponds to a voltage of 1.6 V_{pp}. When the forward voltage of D_1, 0.3 V, is taken into account, the emitter voltage is about 1.9 V, fairly close to the ideal-case value.

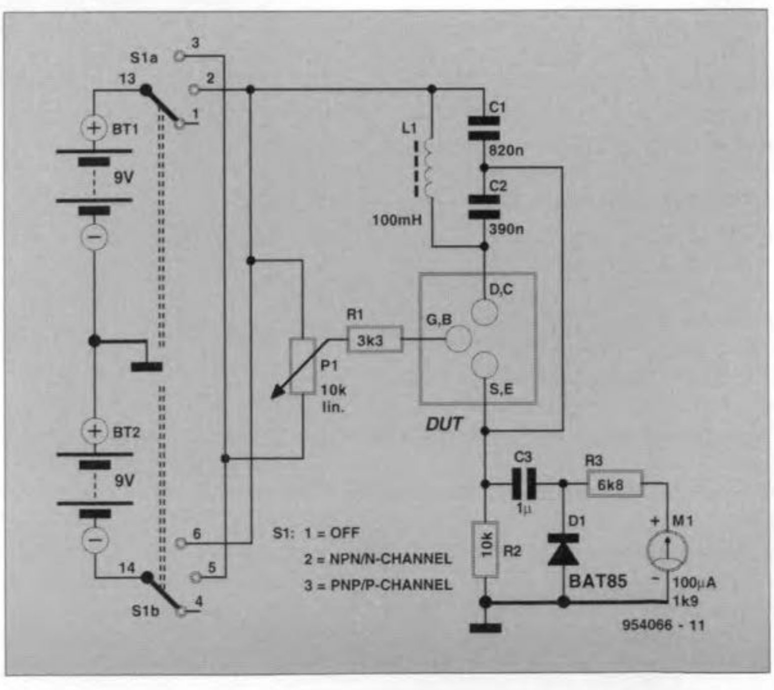
For certain transistors the meter deflection is slightly below the calculated value, which is caused by the low impedance between emitter or source and earth. This impedance depends on the components used and also affects the gain of the transistor in question.

The prototype tester was used in practical checks of Types BC547A/B, BC557B, BSX20, BF245, BS170, BS250, BD139 and 2N3055.

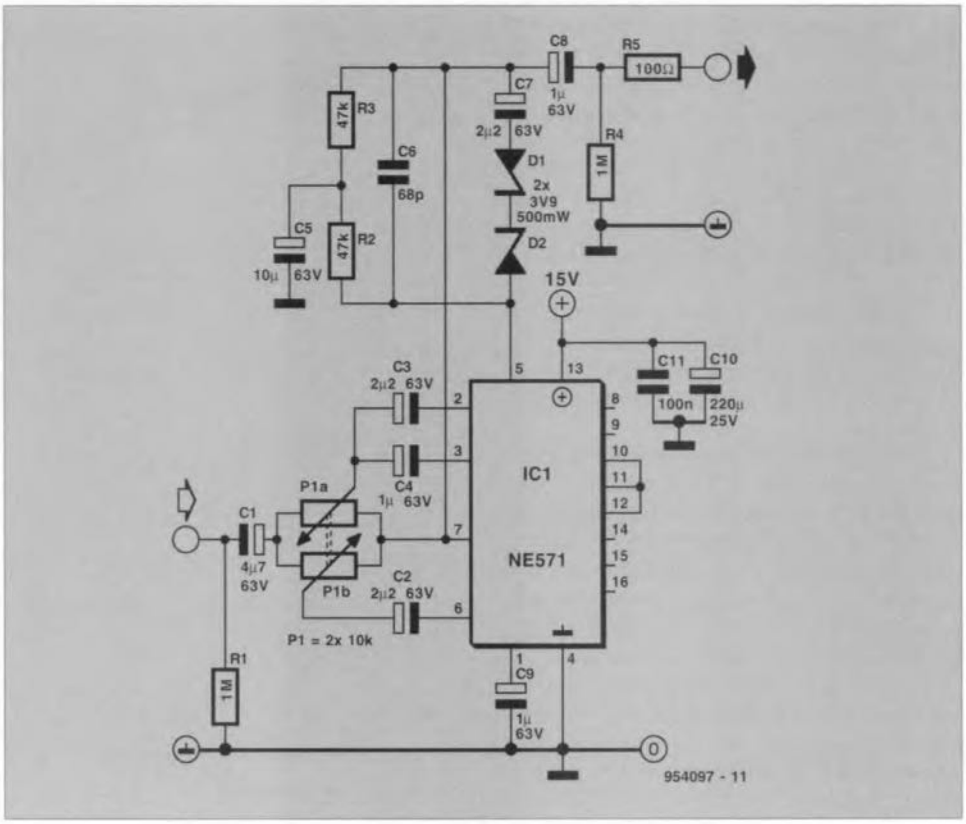
The tester draws a current of about 3 mA.

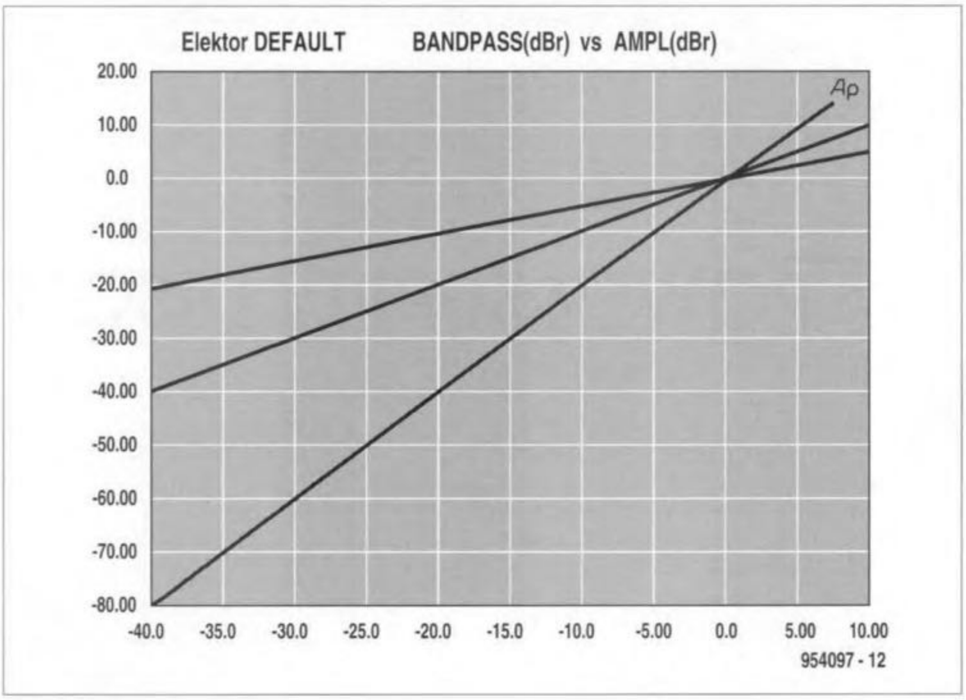
Design by G. Schellhorn

[954066]



VARIABLE AF COMPANDER





The compander is continuously variably from 2:1 compression to 1:2 expansion. This requires a linear stereo potentiometer or, for stereo applications, a dual stereo potentiometer (or two coupled stereo potentiometers).

The NE571 contains two identical circuits, which is very convenient for building a compact stereo compander. Each of these circuits consists of a rectifier which controls a gain cell and an op amp. The junction of the three sections is at a potential of 1.8 V set by a bandgap reference. With suitable feedback, the IC can operate from supplies of 6–18 V. The present circuit operates with 15 V. The feedback is needed only for the d.c. setting of the op amp, whence this is decoupled by C_5. The feedback is determined by the gain cell and P_1.

In expansion mode, the input signal is applied to the rectifier: the gain cell then functions as input. In compression mode, the processing is reversed. The mode is set by P_{1a}.

The inverting input of the op amp is connected to the input or the output by P_{1b} via an internal 20 kΩ resistor. Thus, the gain cell and this resistor change places when P_1 is varied from one extreme to the other. Because of this, the terminals of the two potentiometers are interconnected crossways, so that the wipers, from an electronic point of view, turn in opposite directions. When the wipers are at the centre of their travel, the gain cell has no effect and the transfer ratio is 1:1.

A slight drawback of the circuit is that the input impedance is relatively low (about 2.5 kΩ). This makes the inclusion of an additional buffer at the input advisable. The output is capable of providing a current of up to 20 mA.

The signal across the gain cell should not exceed 2 V_{rms}, otherwise the cell goes into saturation. The likelihood of this happening is particularly great when large dynamic signals are being compressed: the amplification is then ×10. Clipping by the gain cell is prevented by anti-series network D_1-D_2-C_7. This network causes a slight increase in the distortion with output signals >6 dBm. Lowering the value of C_9 would give a more rapid correction of the overdrive, but this would further increase the distortion at low frequencies.

The gain cell operates with a signal reference of 0 dBm (775 mV). At this signal level, the output signal is equal to the input signal, both with compression and expansion. This is well illustrated by the characteristics in the second diagram, which pertain to the extreme and centre positions of the potentiometers. There is a small difference between the positions for extreme compression and expansion owing to the impedance of the potentiometers. The transfer is then not exactly linear. Also, the reference point shifts by a few decibels; slightly more with expansion and slightly less with compression. This phenomenon is particularly noticeable at low levels. It can be countered to a large extent by the addition of a 1 MΩ potentiometer between pin 2 and earth.

The bandwidth of the circuit ranges from 13 Hz to about 25 kHz (with 0 dBm input and a 1:1 setting), but this will vary to some extent in the compression and expansion modes.

C_6 suppresses any tendency of the circuit to oscillate.

The circuit draws a current of about 4 mA.

Design by T. Giesberts
[954097]

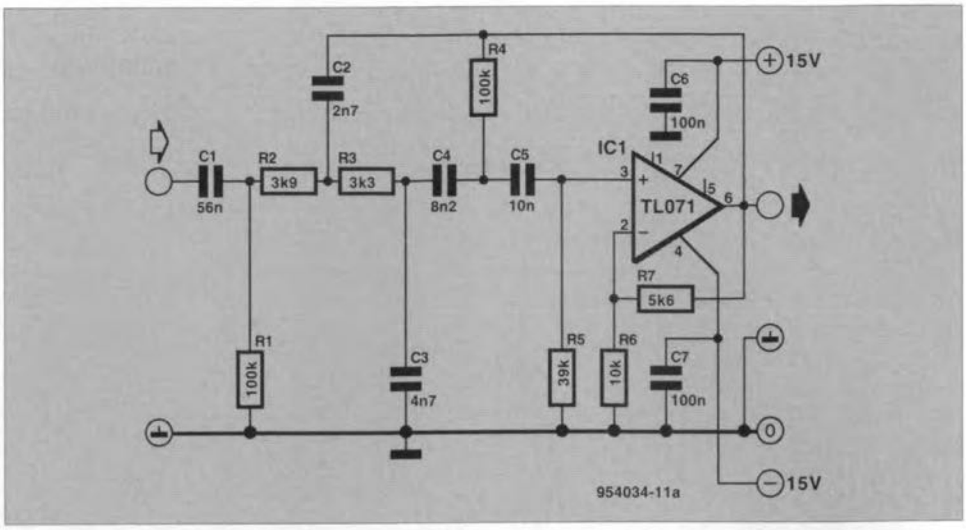
A-WEIGHTED FILTER

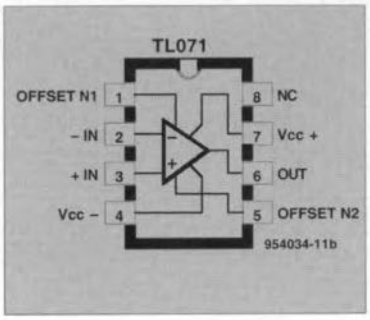
A-weighted filters are often used in sound measurements and in signal-to-noise measurements in audio engineering. In these types of measurement, standards such as DIN, IEC, CCIR, and IHF are used. Such filters correct the range to be measured in accordance with the response of the human ear. The sensitivity of the average human ear is greatest at about 3 kHz; below and above this frequency, it drops rapidly. The response of an A-weighted filter peaks at around 3 kHz and has unity gain at 1 kHz.

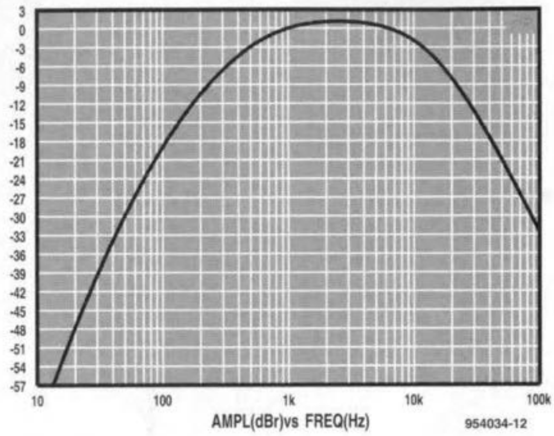
The present filter uses as few components as was found feasible and these are E12 types. The consequent deviation of the response from the ideal is <±1 dB. It is advisable to use good-quality, 10% (or, if possible, 5%) capacitors (check their value with a good-quality capacitance meter).

The op amp may be a Type TL071, but a TLC2201 is better (for battery operated equipment with $U_{B(max)}$ = ±8 V). The filter draws a current of about 2 mA.

Design by T. Giesberts
[954034]



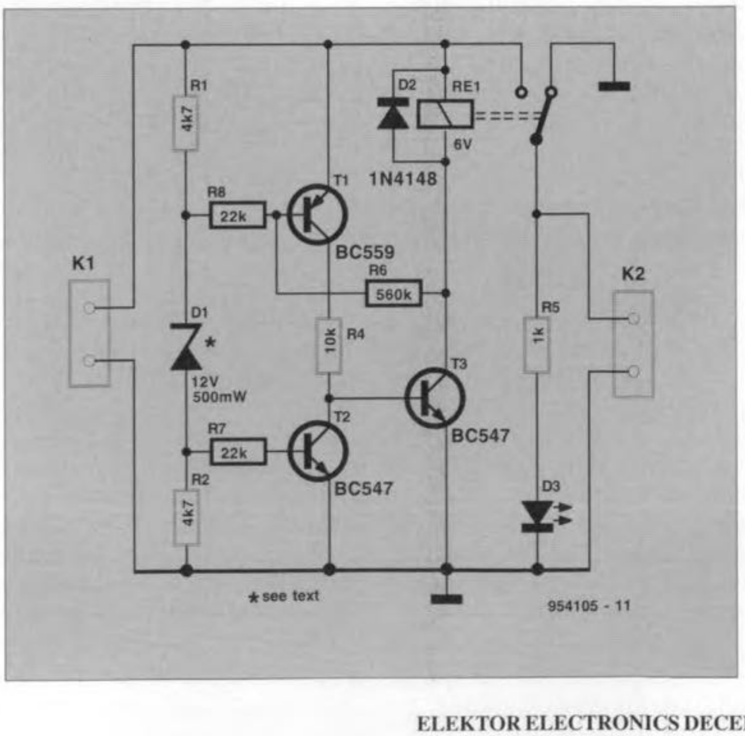




POWER SUPPLY DISCRIMINATOR

Occasionally, problems occur when a power supply does not maintain its output voltage owing to a change in load as when an amplifier is switched on or off, or when batteries are being charged. Amplifiers and oscillators are often adversely affected by such variations, while voltage regulators may exceed their dissipation. It is clearly better to have either the correct supply voltage or none. This is precisely what the present circuit arranges: it switches a power supply to an equipment on or off depending on the output voltage of the supply.

Two Schmitt triggers monitor the upper and lower limits of the input voltage. Transistor T_3 conducts when T_1 is on, whereupon the relay is energized, and cuts off when T_2 conducts, whereupon the relay is deenergized. In the first case, the supply voltage is equal, or nearly so, to the zener voltage of D_1. In the second case, the



zener voltage is increased by about 1.2 V – the drop across R_1 and R_2. Transistor T_2 starts to conduct when the potential across R_2 reaches about 0.6 V: the drop across R_1 is much the same. The feedback provided by R_6 provides a degree of hysteresis.

The switching thresholds can be varied to some extent, depending on D_1, by altering the values of R_1 and R_2. With the values specified in the diagram, the window lies between 5 V and 12 V. To obtain a window of 2–5 V, the resistors must be reduced to 2.2 kΩ; to 1 kΩ for a window of 0–2 V; they must be increased to 10 kΩ for a window of 12–20 V.

Note that the operating voltage of the relay must match the supply voltage.

Design by L. Lemmens
[954105]

POINTS CONTROL

The circuit is intended for controlling a bistable relay. Since this type of relay is frequently encountered in the points of model railways, the description is geared to this.

The control pulse to bistable relays must not be long since it may then cause overheating (and possible destruction) of the solenoid. On the other hand, it must not be short, because reliable change-over action is then not guaranteed. In short, precise timing of the relay is imperative.

Input C may be controlled by a switch which selects either 0 V (logic low = 0) or 12 V (logic high = 1). When C is low, T_1 is cut off, so that its collector becomes positive. This does not affect IC_{1a}, because the input of this stage is also positive (via R_4). The positive output pulse of T_1 is used, however, to enable T_4 via network R_1-C_1 and Schmitt trigger IC_{1b}. Transistor T_4 in turn enables T_5, a heavy-duty transistor, which energizes solenoid Re_2 of the bistable relay. The duration of the pulse is determined by time constant R_1-C_1, which, with values as specified, is 0.2 s. This is normally sufficient for a reliable switching action, but it may be lenghtened or shortened by making R_1 and R_4 larger or smaller respectively.

When input C is high, the collector of T_1 becomes negative, whereupon the solenoid of Re_1 is energized via IC_{1a}, T_2 and T_3.

Diode D_1 ensures a slightly lower voltage at the emitter of T_4, which guarantees that this transistor cuts off when the output of IC_1 is high.

Resistors R_7 and R_9 ensure that any (tiny) leakage currents of T_2 and T_4 do not adversely affect the operation of the circuit.

Resistor R_{10} limits the base current of T_5; note that the value of this resistor, if required, may be reduced to about 200 Ω.

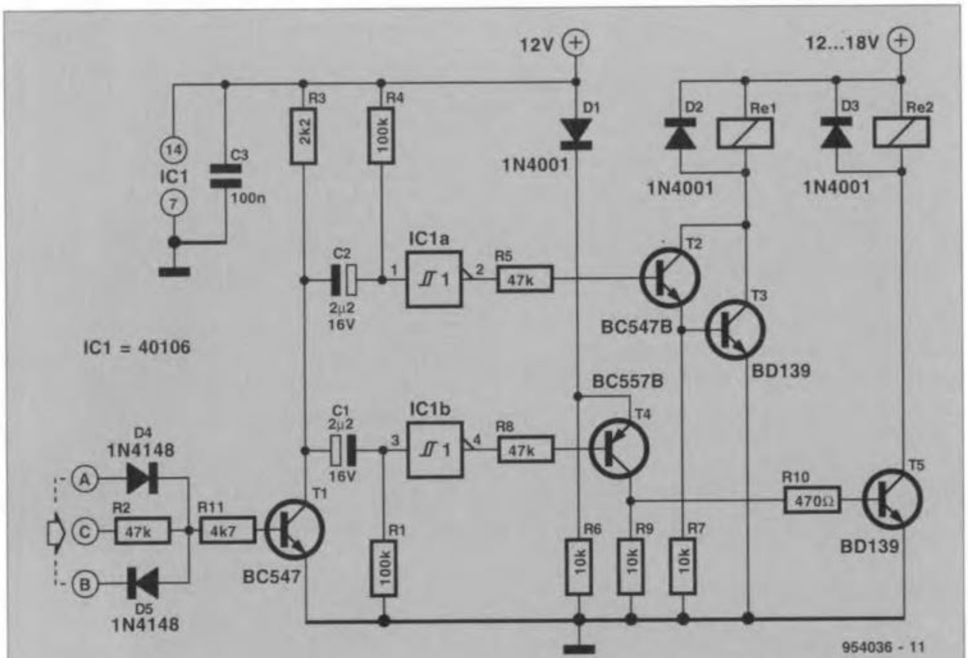
Transistors T_3 and T_5 may also be Type BD135 or, if the points draw a largish current, Type BD241.

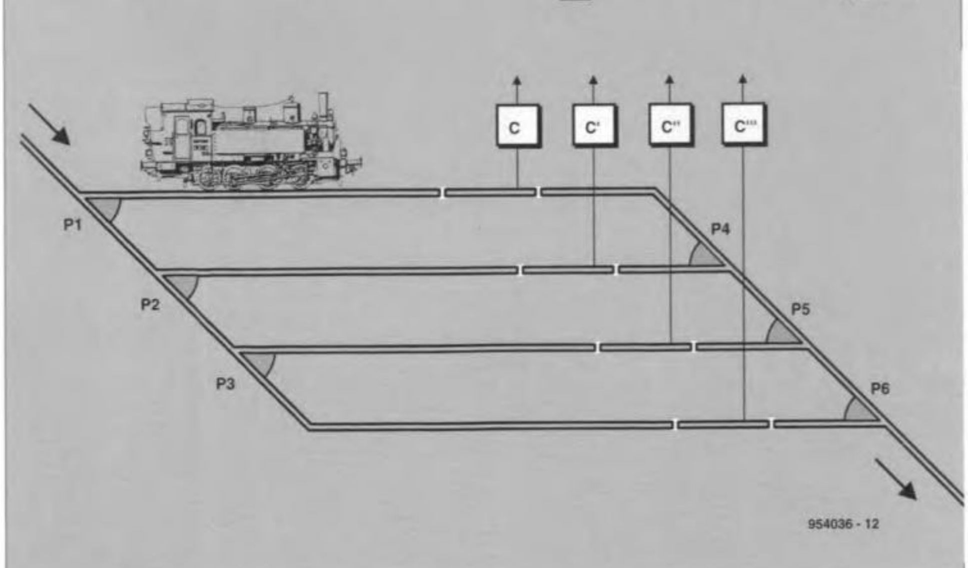
Since the circuit draws a current of only a few mA, power for it may be taken from that for the points. If this is done, an *RC* network should be included in the supply line to suppress switching surges since these can affect the operation of the circuit.

In the prototype, input C is not connected to a switch, but to a special sub-circuit which signals when the track of a station is occupied. In this way, a following train will automatically select the first available free track. When the first train leaves the station, the points are reset and the station can be entered again.

When the supply is switched on, the points are in a random position. However, since D_4 and D_5 have been added, connecting A briefly (via a push button switch) to 12 V, and B to earth, ensures that the points are in the position dictated by input C.

Design by H. Schmoll
[954036]





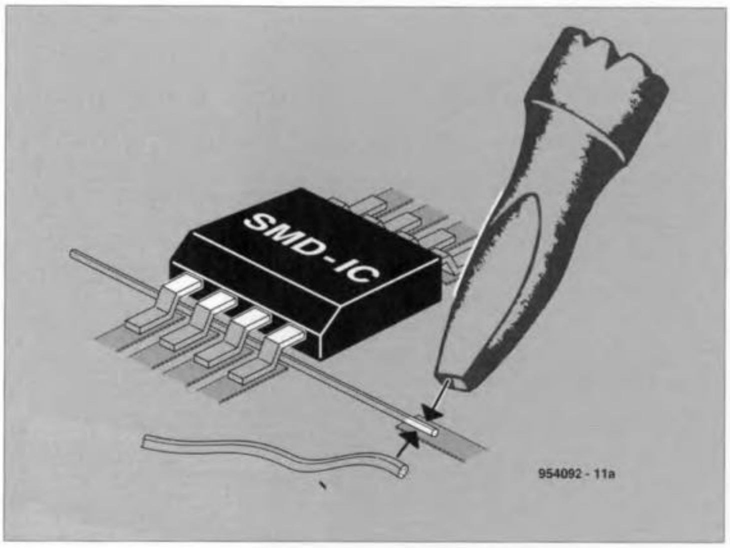
DESOLDERING SMDs

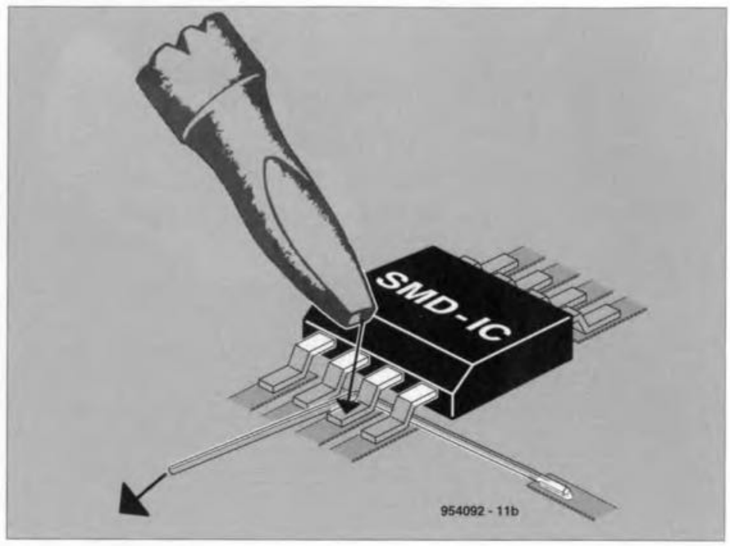
Soldering surface mount devices (SMDs) on to a board is tricky, but desoldering them is even more so. Conventional methods often result in irreparable damage to the component.

Standard ICs can be removed by cutting off all pins one by one and removing the remnants on the board with a desoldering gun. The IC is then no longer usable, but the (more expensive) board is. This method can not be used with SMDs since there are no pins to speak of.

The only way is to desolder each pin in turn and bend it upwards: not easy if the component is to be saved. There is, however, a trick for doing this which consists of inserting a length of enamelled copper wire of 0.2–0.3 mm dia. behind the row of pins and soldering one end to a pad further on the board. Pull the wire taut at right angles to the SMD as close as possible to the board surface. Heat the pins one by one, whereupon the taut wire will pass under each of the pins in turn, which is then lifted slightly, so that it comes away from the board. Take care with the last pin, however, because the wire is then no longer held by other pins, so that this last pin may easily be bent or broken. A little practice will make the desoldering of SMDs almost easier than soldering them.

Design by L. Lemmens
[954092]





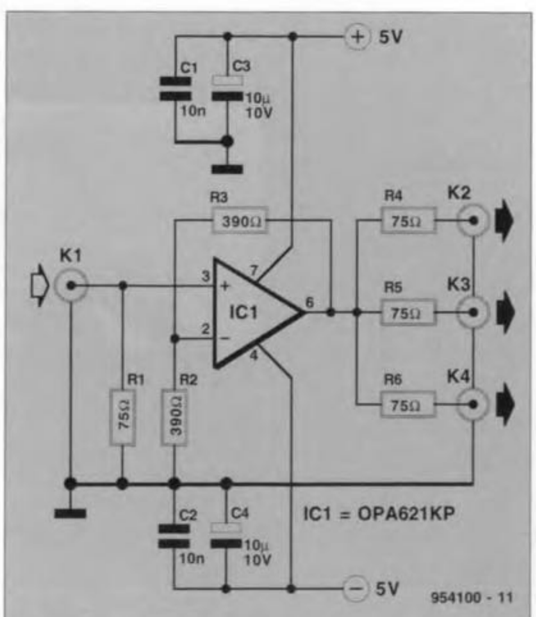
VIDEO DISTRIBUTION AMPLIFIER

The wideband distribution amplifier is based on a single Type OPA621. This op amp is typified by a very short settling time, a high slew rate, a low differential gain-phase error and a large output current (150 mA). Its symmetrical input stage is a voltage amplifier with feedback, which makes it usable in a variety of differing applications where speed and precision are needed. The low noise and distortion, the large bandwidth and the high linearity make it particularly suitable for use in r.f. and video applications.

Since the passive divider at the output, R_4-R_5-R_6, attenuates the signal by 6 dB when each output is terminated into 75 Ω, the op amp is arranged to amplify ×2 (R_2, R_3). The input impedance is determined by R_1.

The amplifier requires a symmetrical power supply of ±5 V.

As always in the construction of r.f. circuits, a number of precautions must be observed:



- use a common earth plane;
- place decoupling capacitors C_1 and C_2 as close as possible to the relevant pins of the op amp;
- keep all connections in the feedback loop (R_2, R_3) as short as possible;
- solder IC_1 directly on to the board; IC sockets have too high parasitic capacitance and self inductance for r.f. applications;
- keep connections to all passive components short; it is best to use surface-mount devices (SMDs).

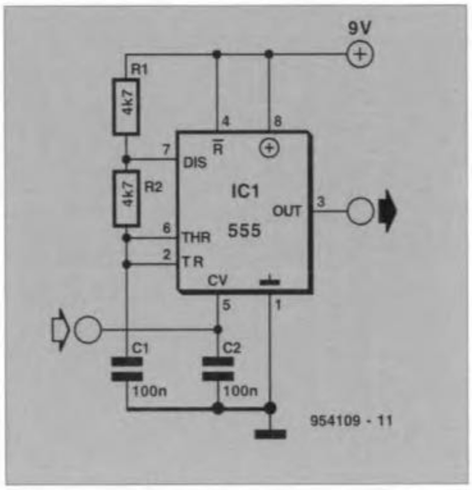
A correctly built amplifier must have a bandwidth of at least 200 MHz. The input and output impedances are standard 75 Ω. The input voltage must not exceed 3 V_{pp}.

The circuit draws a current of not more than 100 mA.

Design by H. Bonekamp
[954100]

SIMPLE VCO

The Type 555 chip must be one of the most popular ICs used in electronics. Here it is used as a VCO (voltage controlled oscillator). The circuit depends on the fact that a control voltage on the CV input can vary the internal divisor. The consequent shift of the threshold causes an alteration of the change-over points, which result in a change in the oscillator frequency. In the present circuit, the frequency changes linearly with the control voltage within ±12.5% of the central frequency. With component values as specified in the diagram, the central frequency (pin 5 open) is about 1 kHz. If a larger frequency shift is required, capacitor C_2 must be charged and discharged via a current source (otherwise, its charging and discharge characteristics do not remain linear). According to manufacturers' data, the control voltage may be between 1.7 V and 9 V.



The circuit draws a current of about 3 mA.

From an idea by E. Chicken
[954109]

PICK-UP INPUT BECOMES LINE INPUT

Many audio amplifiers are still fitted with one or two inputs for a dynamic pick-up. Since record players are used less and less frequently, these inputs remain unused in many cases. At the same time, many audio systems lack a good line input.

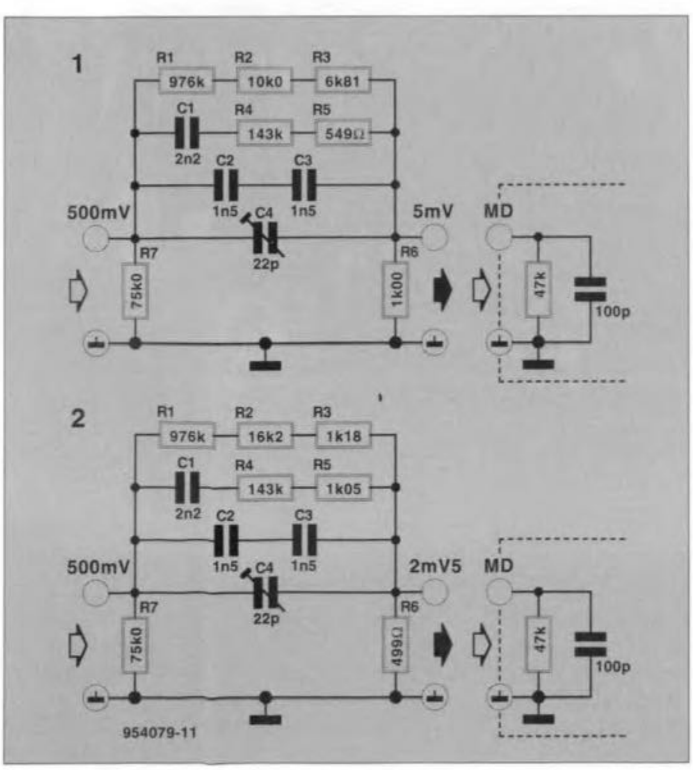
The present circuit enables the (largely) unused dynamic input to be used as a line input. A simple passive network arranges the required level matching.

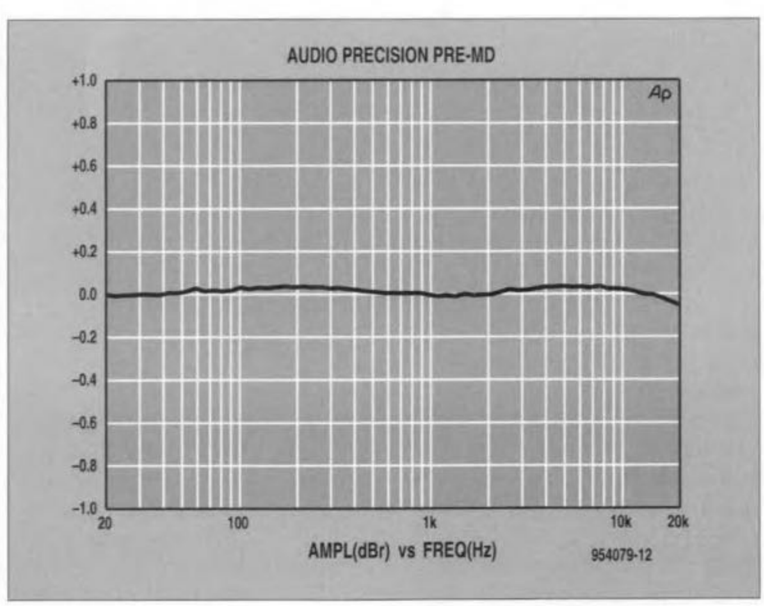
The diagram shows two versions of the circuit: version 1 provides higher amplification than version 2. Which version is to be used depends on the sensitivity of the dynamic input, which is normally 5 mV or 2.5 mV at 1 kHz. Both versions have a line input sensitivity of 500 mV.

The design is based on highly accurate components: the resistors have a tolerance of 0.1%, while the capacitors must be manually selected with the aid of an accurate capacitance meter. The resulting circuit is much more accurate than the usual RIAA correction network in the amplifier. It is, therefore, highly suitable for testing a preamplifier for compliance with the RIAA correction.

Nevertheless, standard 1% components may be used; the resulting frequency characteristic is shown in the second diagram. The theoretical deviation of circuit 1 from the ideal curve –0.05 dB at 20 kHz and that of circuit 2 at the same frequency is –0.012 dB.

Design by T. Giesberts
[954079]





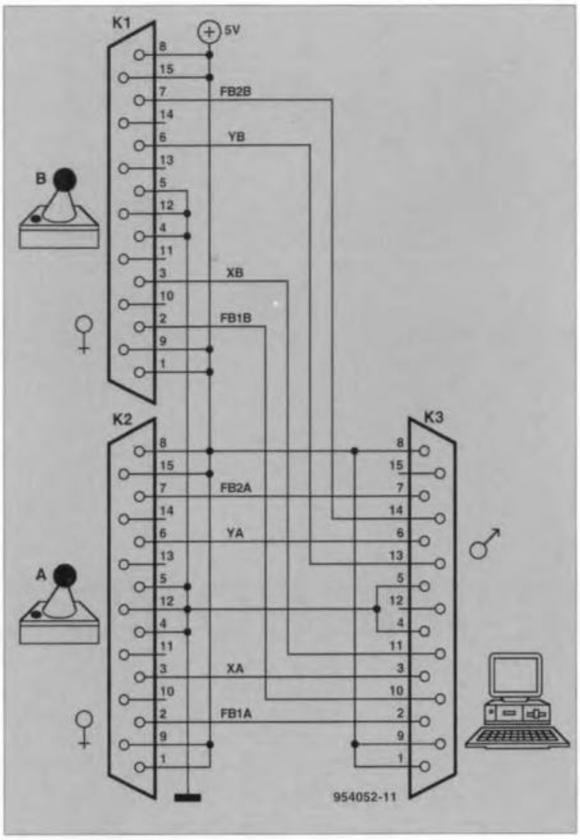
TWO JOYSTICKS ON ONE GAME PORT

Computer games remain popular. However, since many games require more than one player, it is a pity that many computers have only one joystick input. This is particularly galling when it is realized that the specifications for most multi-I/O-cards state that the game port of these cards is suitable for two joysticks. Nevertheless, the electronics for the second joystick is not fitted on many of these cards.

Fortunately, the 15-way game port of most sound cards offers better facilities. Not only is it suitable for accepting two joysticks, it also provides a real MIDI input.

Since working with a single 15-way connection is not practical for two discrete joysticks, the diagram shows how the game port of a sound card can be provided with two joystick inputs and an input and output for MIDI signals.

It should also be noted that dual joysticks are commercially available that can be used with the single 15-way port. However, this is not always convenient if the two players are sitting some distance away from the monitor. It is normally for more convenient if both players have their individual joystick.

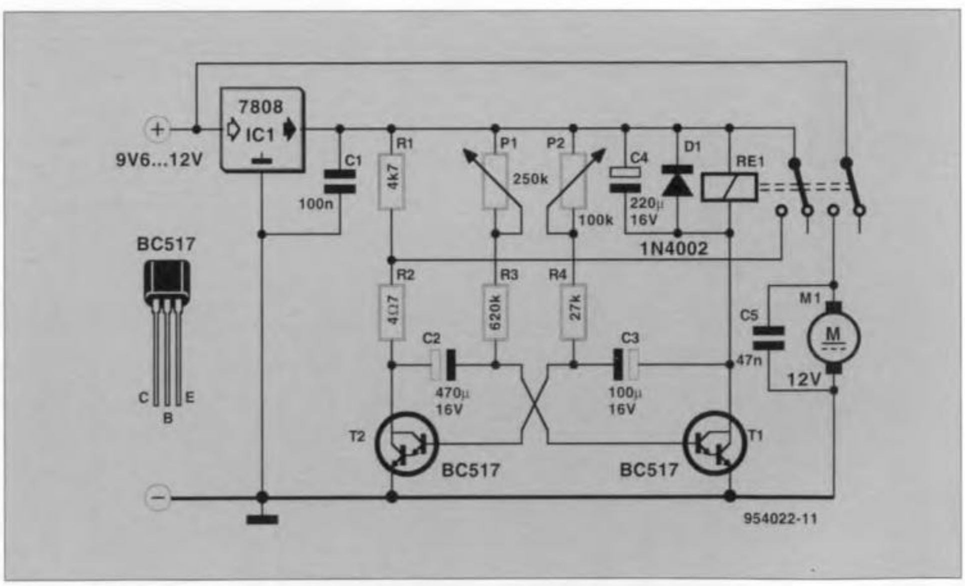


Design by L. Lemmens
[954052]

SOLAR DRYER

Drying the washing in sunlight has a number of advantages compared with using a tumble dryer: it saves a lot of energy ; the ultraviolet radiation kills most bacteria still present in the washing; the clothes and other items get a thorough airing; and the clothes are far less crumpled.

Unfortunately, standard washing lines or racks expose only one side of the washing to the sun. The designer of the present circuit uses an old windscreen wiper motor in conjunction with a 20:1 reduction gear unit to rotate a 2-metre washing pole. The motor and pole are fixed firmly to a heavy-duty base of a garden parasol.



The circuit makes the motor rotate the pole by 180° every five minutes. It is based on a multivibrator consisting of T_1 and T_2. The time lapse between two successive motor rotations is set with P_1: with the specified component values, this will be about five minutes. The operating period of the motor is set with P_2.

When the motor is energized via one relay contact, capacitor C_2 is discharged rapidly via the other contact. This is necessary because the two time constants are quite different. Resistor R_2 protects the relay contacts by limiting the charging current of C_2. The relatively large decoupling capacitor, C_4, is necessary since a windscreen wiper motor draws a large initial current, which might upset the proper operation of the multivibrator.

The motor and control circuit are powered by a large NiCd or lead-acid battery. Regulator IC_1 is needed only if it is likely that different batteries will be used to power the dryer.

The circuit draws a quiescent current of not more than 10 mA; this increases to about 1 A when the motor is energized.

Design by W. Zeiller
[954022]

STATUS INDICATOR

Many switching functions are digitally controlled nowadays. A drawback of this is that it can no longer be seen from the position of the switch what function has been selected. The indicator remedies this by decoding the 2-bit binary control word and displaying its value by LEDs.

The relevant bits are applied to the bases of T_1 and T_2 respectively. Two bits make possible the following combinations: 00, 01, 10 and 11. The circuit arranges for each of these to be indicated by a discrete LED.

Transistors T_1 and T_4 and associated diodes form identical two-from-one stages, so called because two LEDs are controlled by one bit.

Let us take T_1, D_3, D_4 and D_5 as an example and assume that the emitter of T_1 is at ground level. When the transistor is on (logic 1 at the upper input), D_4 lights and D_3 remains out. The reason that D_3 does not light is that the voltage drop across T_1 (in the 'on' state) is only 0.3 V. Since T_1 and D_4 are really in parallel with D_3 and D_5, this voltage is insufficient to supply both D_3 and D_5.

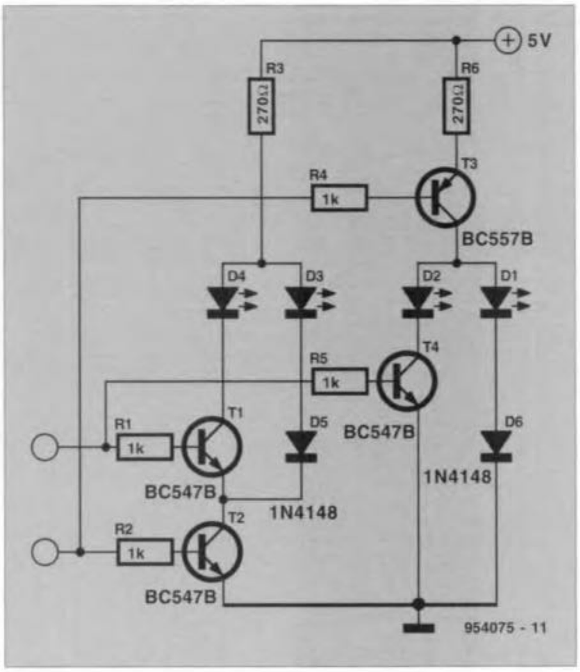
When the level at the upper input is low, T_1 is disabled and D_3 lights, while D_4 is out.

Transistors T_2 and T_3 function as an electronic change-over switch. A 1 on the lower input causes T_2 to conduct, while T_3 is off. In this case, diodes D_3 and D_4 are driven in the manner just described. When the lower input is logic low, the second two-from-one decoder, T_4, is enabled. The level at the upper input only affects D_1 and D_2; D_3 and D_4 remain off whatever.

The truth table shows the various states of the circuit.

It should be noted that the inputs must not be allowed to 'float': their levels should be 1 or 0.

The forward voltages of the LEDs should be equal: this may make using different colour diodes difficult, but some experimentation will, no doubt, resolve this.



B	A	D_1	D_2	D_3	D_4
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Design by A. Rietjens
[954075]

RESISTANCE MATCHER

The circuit in the diagram is intended primarily for the rapid selection of two identical resistors (within a few per cent). It does so more accurately and more conveniently than a good multimeter.

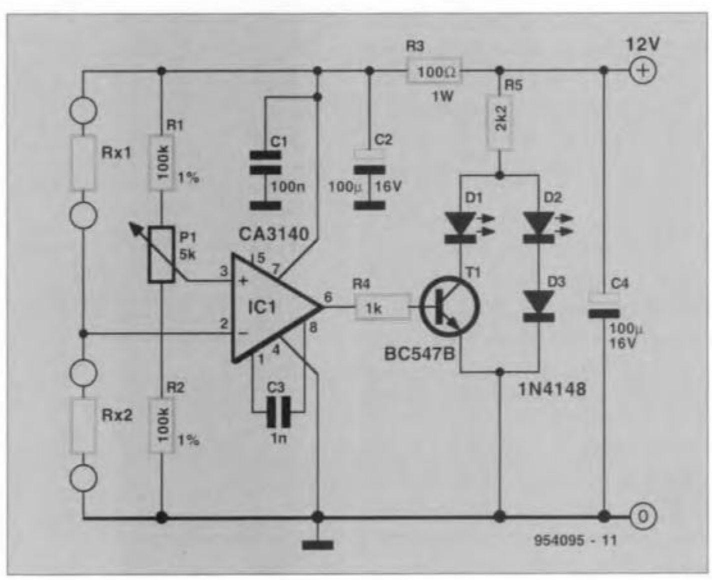
The circuit is based on the well-known bridge principle with IC_1 functioning as the bridge amplifier. The resistors to be matched, R_{X1} and R_{X2}, together with R_1, R_2 and P_1, form the measurement bridge.

The bridge is balanced by varying P_1 until a position is reached where the LEDs light alternately when P_1 is adjusted to either side of this position. Then:

$R_{X1}/R_{X2} = (R_1+aP_1)/(R_2+bP_1)$,

where a and b represent the position of P_1; the total variation of $P_1 = 1$.

If the wiper of P_1 is at one of the extreme positions, R_{X1} and R_{X2} differ by about 5%.(This can be improved to 1% by the use of a 1 kΩ potentiometer). If the wiper is at the centre of its travel, the resistors are very nearly identical. If only one LED lights, the difference between R_{X1} and R_{X2} is greater than 5% (with a 5 kΩ potentiometer).



The circuit needs a regulated 12 V power supply. When the resistors to be tested are >500 Ω, the circuit draws a current of not more than 20 mA.

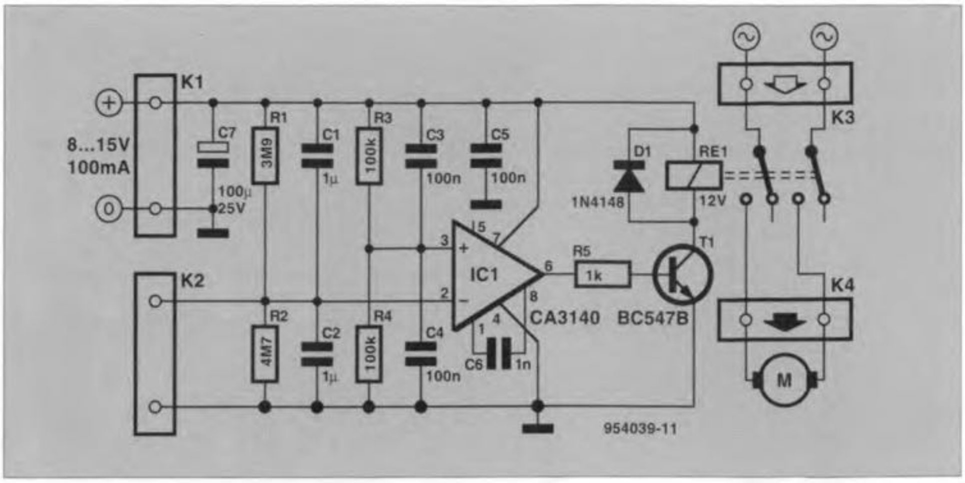
Design by A. Rietjens
[954095]

DRAINAGE PUMP SWITCH

Most drainage pumps are fitted with a level switch that provides a hysteresis of 10–15 cm. When small volumes are drained, the liquid running back in the hose will increase the hysteresis by 3–5 cm. The hysteresis can be reduced appreciably by the present circuit—see diagram.

When the level at the non-inverting input of IC_1 is higher than that at the inverting input, transistor T_1 will be switched on. The two levels are determined by potential dividers R_1-R_2 and R_3-R_4. In quiescent operation, the output of IC_1 is low.

When the sensor contacts connected to K_1 are 'short-circuited' (impedance <4.7 kΩ), T_1 is enabled. This causes the relay to be energized, whereupon the pump, M, is switched on. When the 'short circuit' ceases, the pump will continue to run because of the potential across C_1 and C_2. This prevents the sensor contact being short-circuited again by the liquid running back in the hose.



Although only a small direct current flows through the sensor contacts, they should be checked from time to time for corrosion.

The circuit may be powered by an 8–15 V supply. It draws a maximum current of 100 mA.

Design by A. Rietjens
[954039]

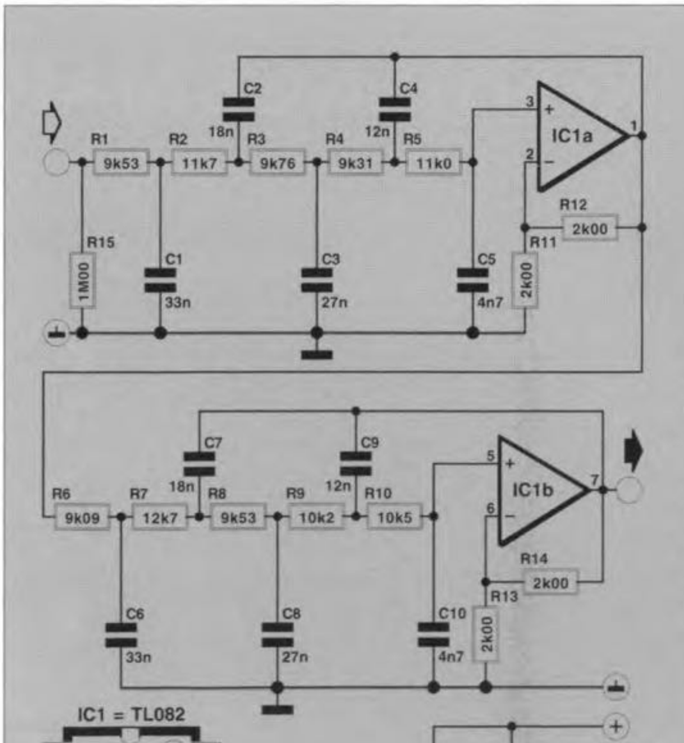
10TH-ORDER BUTTERWORTH FILTER

The proposed filter consists of two series-connected 5th-order sections. The resistors used are E96 types with a tolerance of 1%. Their theoretical value is given in the table. The capacitors are E12 types with a tolerance of 10%. Values of all components specified in the diagram have been chosen to ensure that the filter response deviates no more than ±0.02 dB from the ideal response. In spite of this, tolerances of the components and op amp properties may cause a tiny ripple.

With component values as specified, the voltage amplification amounts to ×4 (12 dB). The two sections have differing properties: for instance, the right-hand section in the diagram has additional ringing of about 2.8 dB. The cut-off point of the sections is at +9 dB (because of the 12 dB gain). If the components had the exact theoretical value, the cut-off point would be at 1 kHz. If E96 values are used, the response will be rather less steep and the cut-off point will be at about 970 Hz.

If the op amp used is a Type TL082, the filter draws a current of about 4 mA.

Design by T. Giesberts
[954029]



Theoretical values:

R_1 = 9.4802 kΩ
R_2 = 11.9470 kΩ
R_3 = 9.8723 kΩ
R_4 = 9.2621 kΩ
R_5 = 10.8728 kΩ
R_6 = 8.9344 kΩ
R_7 = 12.7182 kΩ
R_8 = 9.3631 kΩ
R_9 = 10.2326 kΩ
R_{10} = 10.3907 kΩ

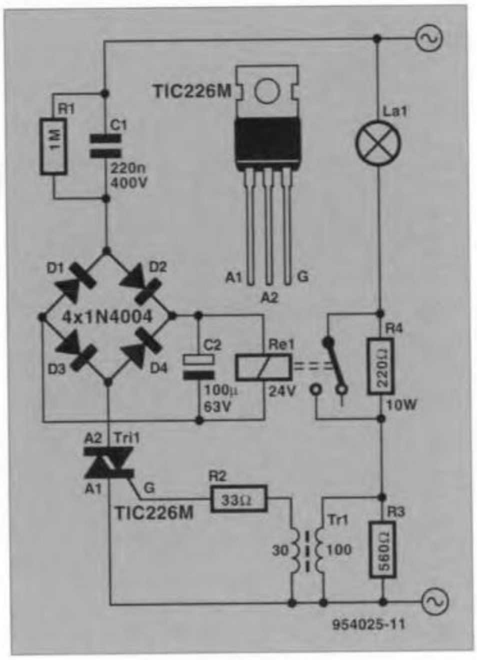
SOFT SWITCH-ON FOR LAMPS

The circuit presented is intended primarily to limit the switch-on current drawn by lamps and other mains-operated appliances. This current may be many times the normal operating level and is the reason that lamps normally give up the ghost when they are switched on.

A well-known safeguard is switching on the current in two steps: in the present circuit this is done by connecting R_4 in series with the lamp to reduce the initial current surge. After a brief period, the resistor is shorted out by relay contact Re_1.

As soon as the load draws a current, part of which flows through the primary of current transformer Tr_1, a magnetic field ensues in the transformer core. This field is resisted by a current induced in the secondary winding of the transformer, which, because of the turns ratio of 3:1, will be about a third of the primary current.

The current in the secondary winding fires triac Tri_1, which results in a potential, limited by C_1, across rectifier D_1–D_4. This potential is used to charge capacitor C_2. After about 0.5 s, the ensuing voltage across C_2 has risen to a level sufficient to actuate relay Re_1. The relay contact then shorts out R_4, so that the full mains voltage is applied to the lamp or other appliance.



The reason that a current transformer is used as sensor instead of a diode-resistor network is as follows. The triac needs a gate voltage of about 0.7 v to be switched on. If a diode-resistor network were used, the voltage drop in the load circuit would have to be at least 0.7 V, which would cause a fairly high dissipation in the network. The drop across the transformer primary is only 0.21 V, which makes quite a difference.

Although suitable transformers are available commercially, they may not be easy to obtain. It consists of a toroidal core with a primary winding of 30 turns, rated at 5 A, and a secondary winding of 100 turns, rated at 2 A (0.2–0.3 mm dia.). The self-inductance should be 10 mH.

The relay is a common or garden 24 V type.

Many different types than specified may be used for the triac. A TIC206D has a gate current range of 5–100 mA and is thus eminently suitable for smaller loads – up to 50 W. The gate current range of the TIC226 is 50–1000 mA and is thus more suited to heavier loads.

Great care should be taken in the building, testing and use of this unit since many parts carry potentially lethal mains voltage.

Design by S. Seidenberg
[954025]

VARIABLE WIEN BRIDGE OSCILLATOR

The frequency of the standard Wien bridge oscillator presented is made variable by making one of the arms a mono potentiometer. The bridge proper consists of R_1, C_1, C_2, and P_1.

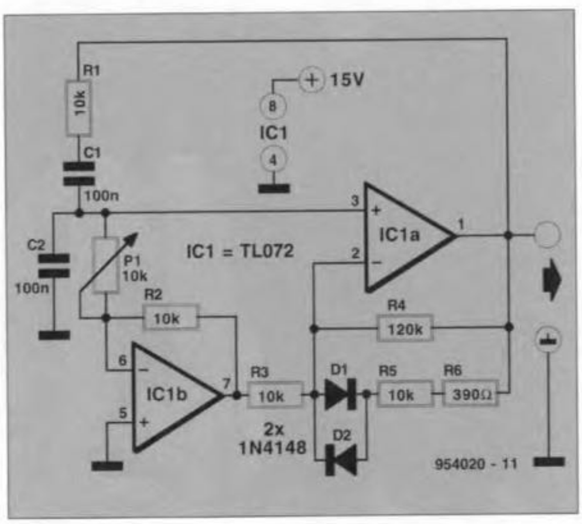
The inverting input of op amp IC_{1b} provides a virtual earth for the potentiometer. The frequency, f_0, is given by

$$f_0 = 1/2\pi\sqrt{(R_1C_1C_2P_1)}.$$

$$|H_0| = P_1/(2P_1+R_1).$$

The amplification of IC_{1b} is R_2/P_1, but since R_1 and R_2 have the same value, this could also be expressed as R_1/P_1. The amplification of IC_{1a} is unity or nearly so when D_1 and D_2 conduct. Taking all this into account, the output signal, U_0, is given by:

$$U_0 = U_0'[R_1/P_1 \times P_1/(2P_1+R_1) + 2P_1/(2P_1+R_1)]$$



or

$$U_0 = U_0'.$$

where U_0' is the potential at the non-inverting input of IC_{1a}. In other words, the loop gain is unity. Starting the oscillator requires a higher gain, however, and this is available when D_1 and D_2 are reverse-biased.

The manner of gain limiting used is simple, but has the drawback of a fairly high distortion: the level of the third harmonic in the present design is –42 dB.

With component values as specified in the diagram, the oscillator frequency can be set between 160 Hz and 1.6 kHz.

The level of the output signal is about 400 mV r.m.s.

Design by H. Bonekamp
[954020]

SINGLE-CHIP 50 W AF AMPLIFIER

The chip on which the amplifier is based, a Type LM3876, is a member of the Overture family from National Semiconductor. All members of this family are pin-compatible and mutually interchangeable. They are typified by an internal protection (called SPIKE). In practice, the difference between them is the power output. The series was described on the basis of the LM3886 in an earlier issue*.

The PCB has been designed so that it can accommodate the LM3876 (50 W) as well as the LM3886 (150 W). Because of this, pin 5 of the IC on the board is connected to the positive supply line. This connection is not needed for the LM3876, since its pin 5 is not (internally) connected (NC).

The IC is located at the side of the board to facilitate fitting it to a heat sink as shown in the photograph.

An important aspect for optimum performance is the decoupling of the unregulated supply lines by C_7–C_{10}. All earth connections go to a single terminal on the board.

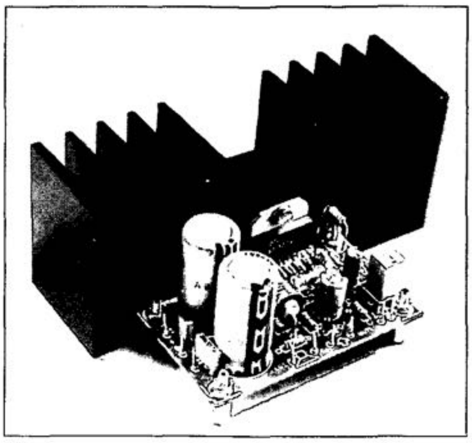
Air-cored inductor L_1 consists of 13 turns of 1 mm dia. enamelled copper wire with an inner diameter of 10 mm. The completed inductor is pushed over R_7 and its terminals soldered to those of the resistor.

All electrolytic capacitors must be mounted upright.

The amplifier can be muted with a single-pole switch connected to the MUTE input (pin 8). This function is enabled when the switch is open. If muting is not required, solder a wire bridge across the mute terminals on the board.

Boucherot network R_6-C_6 is not normally required in this application, but provision has been made for it for use in other applications.

According to the manufacturers, both chips are optimalized for a load of 8 Ω. The output power is lower when a 4 Ω load is used or when the supply voltage is reduced. When a 4 Ω load is used, the SPIKE protection becomes active when the supply voltage is about 27 V, resulting a in a reduction of the power output to 10 W. This means that it is not advisable to use loudspeaker with an impedance <8 Ω.



Parts list

R_1, R_3 = 1 kΩ
R_3, R_4, R_5 = 18 kΩ
R_6 = see text
R_7 = 10 Ω, 5 W
R_8, R_9 = 22 kΩ

Capacitors:
C_1 = 2.2 μF, polypropylene, pitch 5 mm
C_2 = 220 pF, 160 V, polyester
C_3 = 22 μF, 40 V, radial
C_4 = 47 pF, 160 V, polyester
C_5 = 100 μF, 40 V, radial
C_6 = see text
C_7, C_8 = 100 nF
C_9, C_{10} = 1000 μF, 40 V, radial

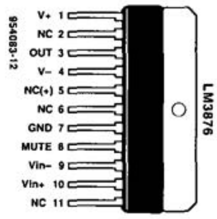
Inductors:
L_1 = 0.7 μH – see text

Integrated circuits:
IC_1 = LM3876T

Miscellaneous:
Heat sink for IC_1 <1.5 K W^{-1}, e.g. SK71/50 (Dau 01243 553 031)
Single-pole switch – see text
PCB not available ready made

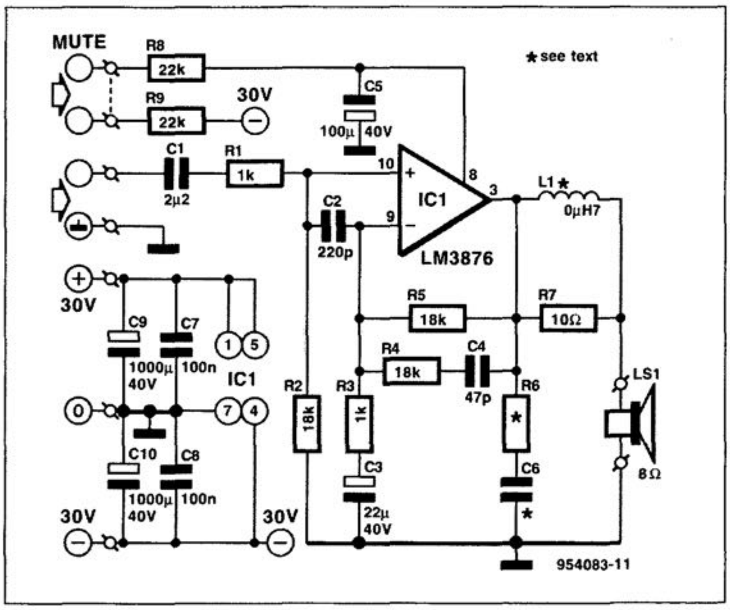
Design by T. Giesberts
[954083]

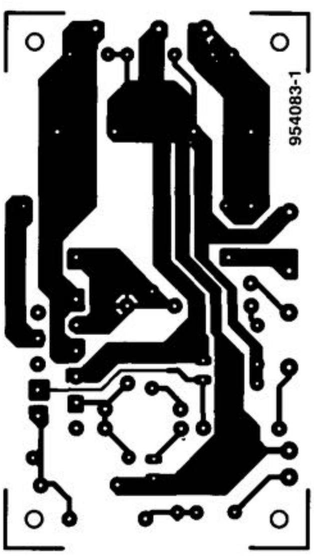
*May 1995.

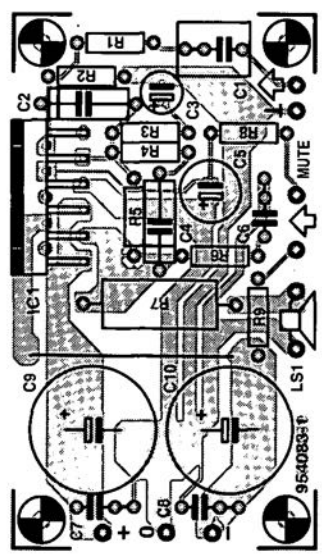


Main parameters

Input sensitivity	1 V r.m.s.
Output power	43 W into 8 Ω (THD+N = 0.1%)
Damping factor (8 Ω)	350 at 1 kHz; 220 at 20 kHz
Slew rate	11 V μs^{-1}
Power bandwidth	8.5 Hz – 117 kHz
Signal-to-noise ratio	>95 dB (linear 22 Hz – 22 kHz) >98 dBA







RESOLUTION ENHANCER

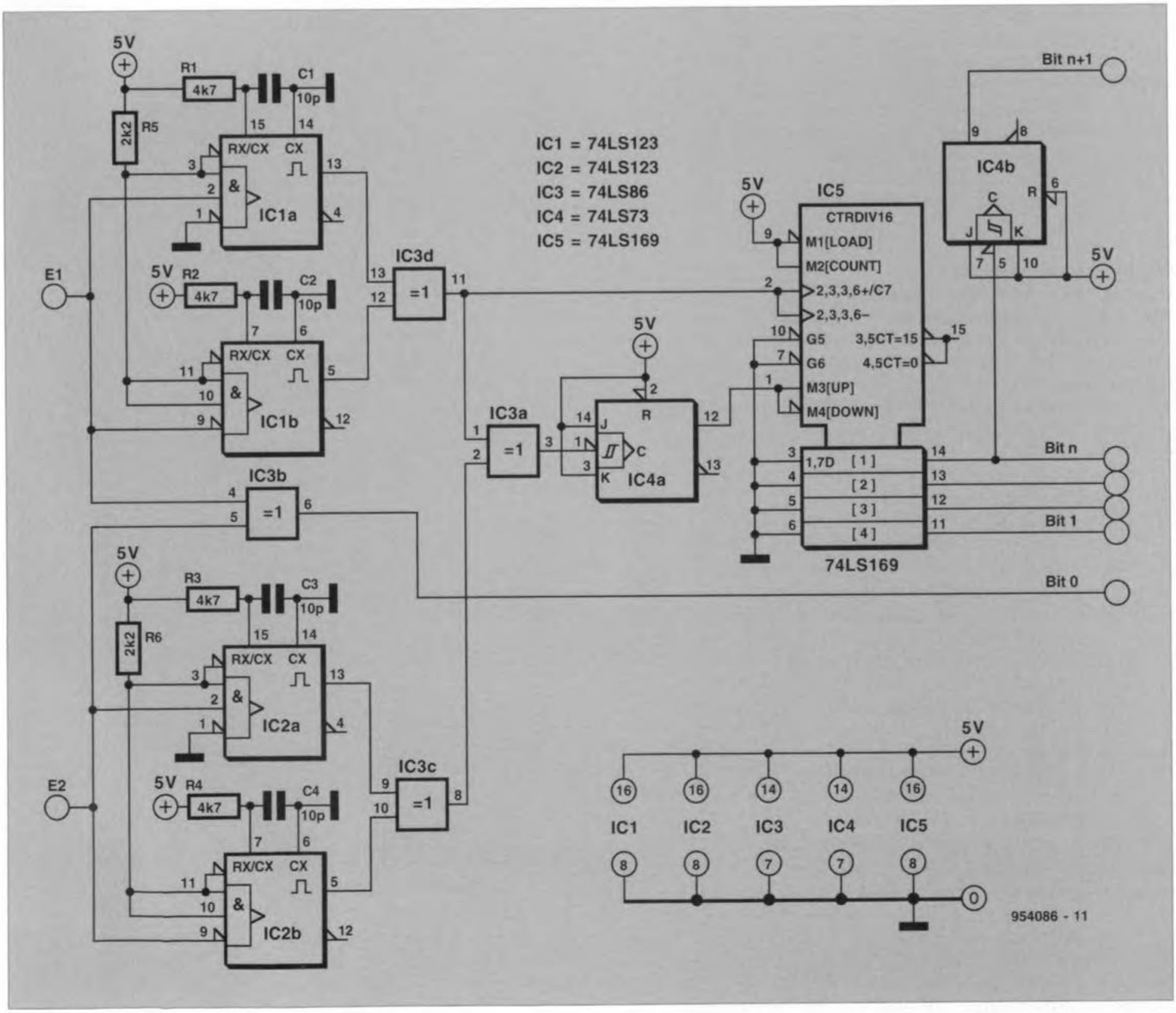
In the control of electromechanical systems such as a robot arm, positioning is often carried out with a pulse disk and two sensors. One sensor provides data on how many steps have been taken, whereas the other provides information as to the direction in which these steps were taken. The present circuit enables the resolution of the pulse generator to be doubled to give an even more accurate position.

The signals from the sensors are designed E_1 (number of steps) and E_2 (direction). Monostables (MMVs) IC_{1a} and IC_{1b} generate a new, short pulse on the edge of every pulse input via E_1. XOR gate IC_{3a} combines these pulses to a new signal at double the frequency. The new signal is used as the clock for up/down counter IC_5.

The signals from the direction sensor are processed in a similar manner. After the signals have been combined by XOR gate IC_{3c}, they are stored in bistable IC_{4a}. The Q output of this bistable signals to the counter whether it should count up or down.

The output of the counter is provided with an additional bit by bistable IC_{4b} and a 0 bit by IC_{3b}. The latter bit is a combination of the inputs at E_1 and E_2. Since the phase relationship between these signals varies, it may happen that bit 0 is inverted. This can be remedied by rotating the pulse disk slightly and resetting the counter.

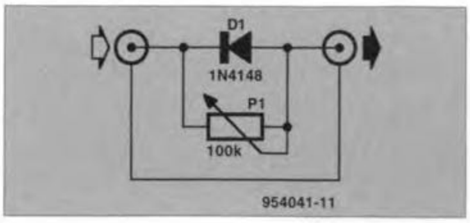
Design by H.G. Verstegen
[954086]



Correction: the power supply pin number for IC_4 in the circuit diagram are wrong: they should be 4 and 11, and not 14 and 7.

VIDEO FADER II

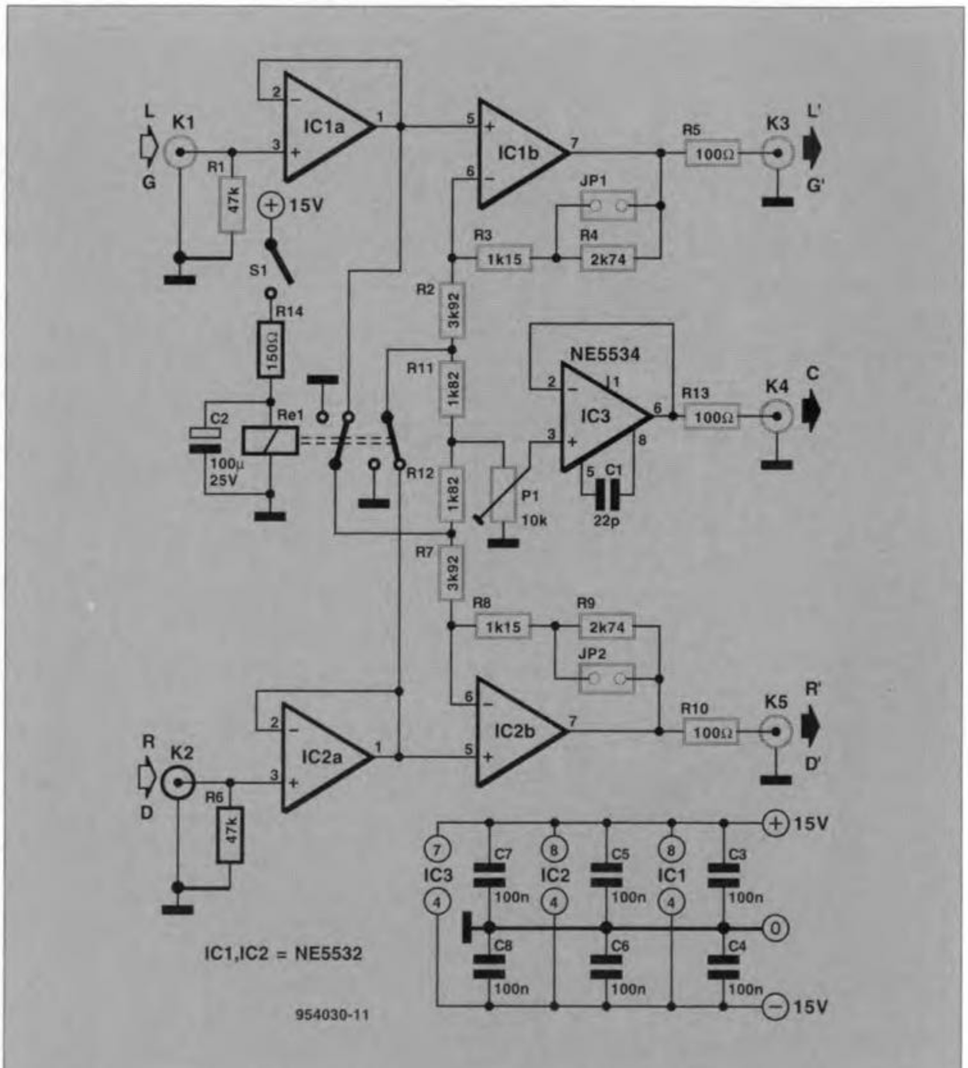
The video fader enables the image of a video film to be darkened or brightened. The input video signal is passed to the output via P_1, which is preferably a slide type. The signal is attenuated by the resistance of P_1 and the input impedance of the monitor, but the synchronization pulses are passed unattenuated by D_1. This ensures a stable image irrespective of the position of P_1.



Design by R.H. Voogd
[954041]

3-CHANNEL STEREO SOUND

The accelerating sales of Dolby Surround Sound equipment shows that spatial sound is very much appreciated by music audiences. During the development of a surround decoder, it was thought sensible to use a third sound channel, the centre channel, with standard stereo recording. To prevent the sound of this channel drowning out the other two, its mono signal is formed from part of the sound of the two stereo channels. In the present circuit, this is done by op amps IC_{1b} and IC_{2b}. Op amps IC_{1a} and IC_{1b} serve as buffers and ensure that the difference signals are as independent of the sources used as possible. If the source is nearly perfect, which is the case when its output impedance ≤50 Ω, the buffers may be omitted.



The differential amplifiers reduce the signal level in the new channels, L' and R', to a small extent. In the present setup, it is necessary for the amplifier and loudspeaker used with the centre channel to be comparable to those of the other two channels.

The relay enables the sound of standard stereo to be compared with 3-channel reproduction. The level of the centre channel is preset with P_1 when the relay is not energized (3-channel operation).

When the relay is energized, the inputs of adder R_{11}-R_{12}, and the inputs of the differential amplifiers (via R_2 and R_7) are linked to ground. The centre channel is then silent and the sound from the other two channels increases slightly – good compensation for the removal of the centre channel.

The mono information may be suppressed by 3 dB (jumpers JP_1 and JP_2 fitted) or 6 dB (jumpers not fitted). In practice, it appears that a 3 dB suppression gives an acceptable spatial effect without the centre of the sound shifting, provided P_1 has been set correctly. With 6 dB suppression, there is a strong spatial effect and the listener gets the feeling that some of the acoustic information has disappeared. This effect may be lessened to some degree by increasing the gain of IC_3.

It is clear that the present circuit is an invitation to experimentation. Optimum symmetry is maintained by the use of 1% resistors (except R_1, R_6 and R_{14}). If perfect symmetry is not required, $R_3 + R_4$ and $R_8 + R_9$ may be replaced by a stereo potentiometer. When the centre channel is not used, the circuit performs as variable spatial stereo unit.

When the relay is energized, the circuit draws asymmetric currents: 40 mA from the positive supply line and 20 mA from the negative line.

The relay in the prototype has a coil resistance of 600 Ω. If the resistance of the relay used is different, it may be necessary to adapt the value of R_{14} accordingly.

Design by T. Giesberts
[954030]

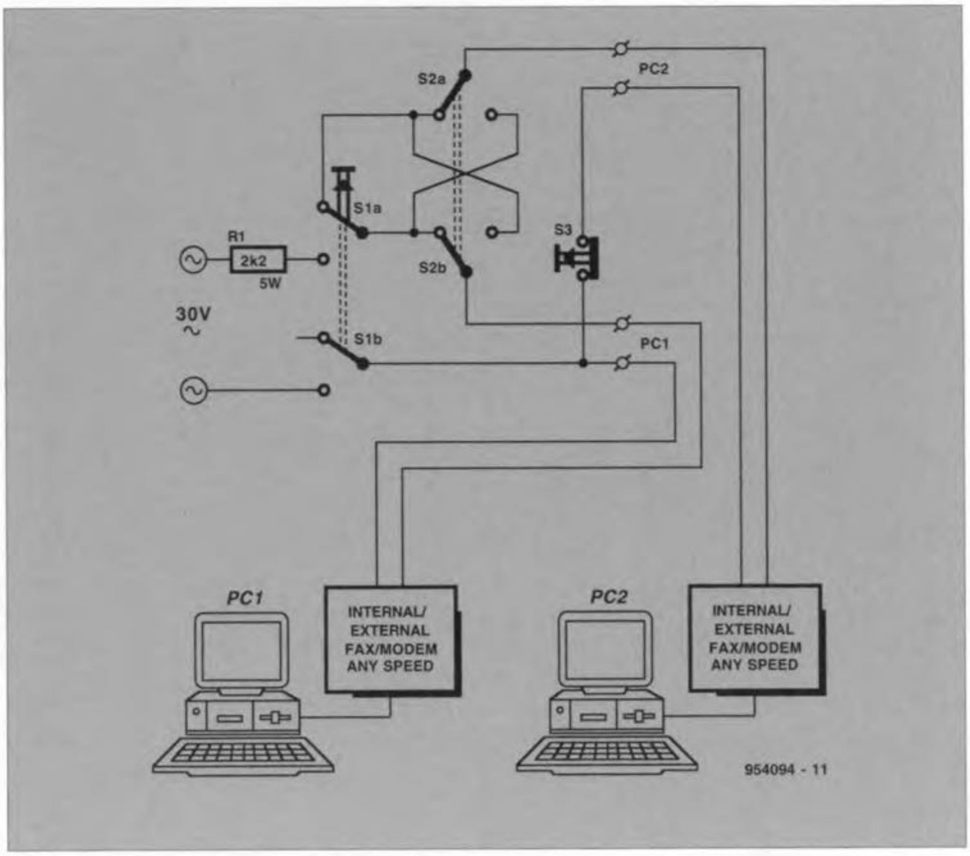
LOCAL NETWORK

Connecting two computers that contain a modem card is straightforward as shown in the diagram. The setup makes dialling a telephone number superfluous: normally, simple Hayes commands such as ATA and ATO are sufficient to effect the connection. Since the modem cards are active, that is, they impose a strong analogue signal on to the line, it is not necessary for a direct voltage to be put on to the line. All signals needed for the communication are generated by the modem cards.

Since it is not normally the intention to use the modem card for the local network only, push-button switch S_3 is provided to break the local network line.

Moreover, as it is sometimes required to start a transmission with a bell signal, push-button switch S_1 enables the brief imposition of a 30 V alternating voltage on to the line. In this mode, one of the modems needs to be called; the other must be on-line already. Which of the modems is called depends on the position of switch S_2.

Design by B. Sandeman
[954094]

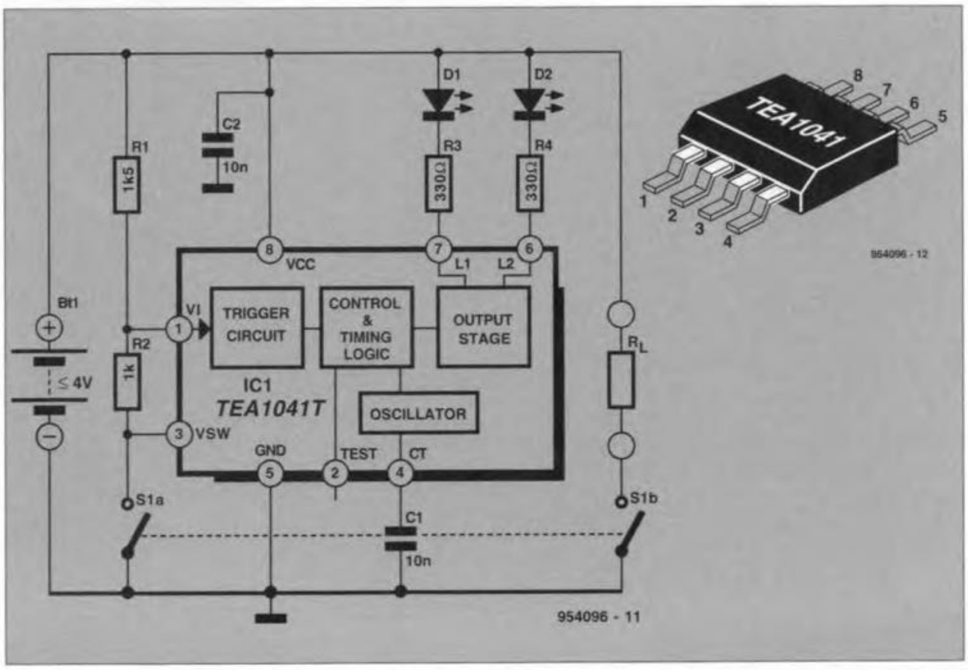


BATTERY MONITOR

The monitor, based on Philips Components' Type TEA1041T, enables a check to be kept on the power supply lines of a battery-operated appliance. Switch S_1 controls both the appliance and the monitor.

The supply voltage is applied to the input (pin 1) of IC_1 via potential divider R_1-R_2. The switching threshold at the input is 1.25 V. When the supply voltage drops below 3.1 V, the potential at pin 1 drops below the switching threshold level. This causes a timer in the chip to be actuated within about 2 s. If in that time the voltage rises above the switching threshold again, the timer is reset. If not, D_1 lights for about 2 s to indicate that the battery voltage is low. This means that the appliance should be switched off with S_1. Switching off the appliance also prevents the complete discharge of the battery via D_1.

With S_1 open, IC_1 continues to operate in the standby mode. The LEDs light alternately for about 4 s, which limits the average current drawn to about 10 μA. During the standby mode, there is no current through the potential divider.



The monitor is suitable for use with supply voltages of 1.8–4 V; the LEDs may operate from slightly higher potentials (max. 5.5 V).

Design by K. Walraven
[954096]

AF LEVEL MATCHING

The matching circuit consists of a variable passive attenuator and an amplifier with variable gain: 0–20 dB. The attenuator reduces the signal by 0, 1/4, 1/2 or 3/4. If required, the circuit may be adapted for other reduction factors.

When the upper section of DIP switches S_1 and S_2 is closed, the attenuation is 0 dB. The input impedance of the circuit, 40 kΩ, can then be changed to 30 kΩ, 20 kΩ or 10 kΩ by closing one of the other switches.

The buffer/amplifier is formed by IC_1. Potentiometers P_1 and P_2 serve to set the amplification factor. Make sure that they are both set to exactly the same value since presets have a tolerance of 20%; if they are not, the amplification in the left-hand and right-hand channels is not the same. If the circuit is used primarily as an attenuator, set both presets to their minimum value; the op amp then functions as a voltage follower.

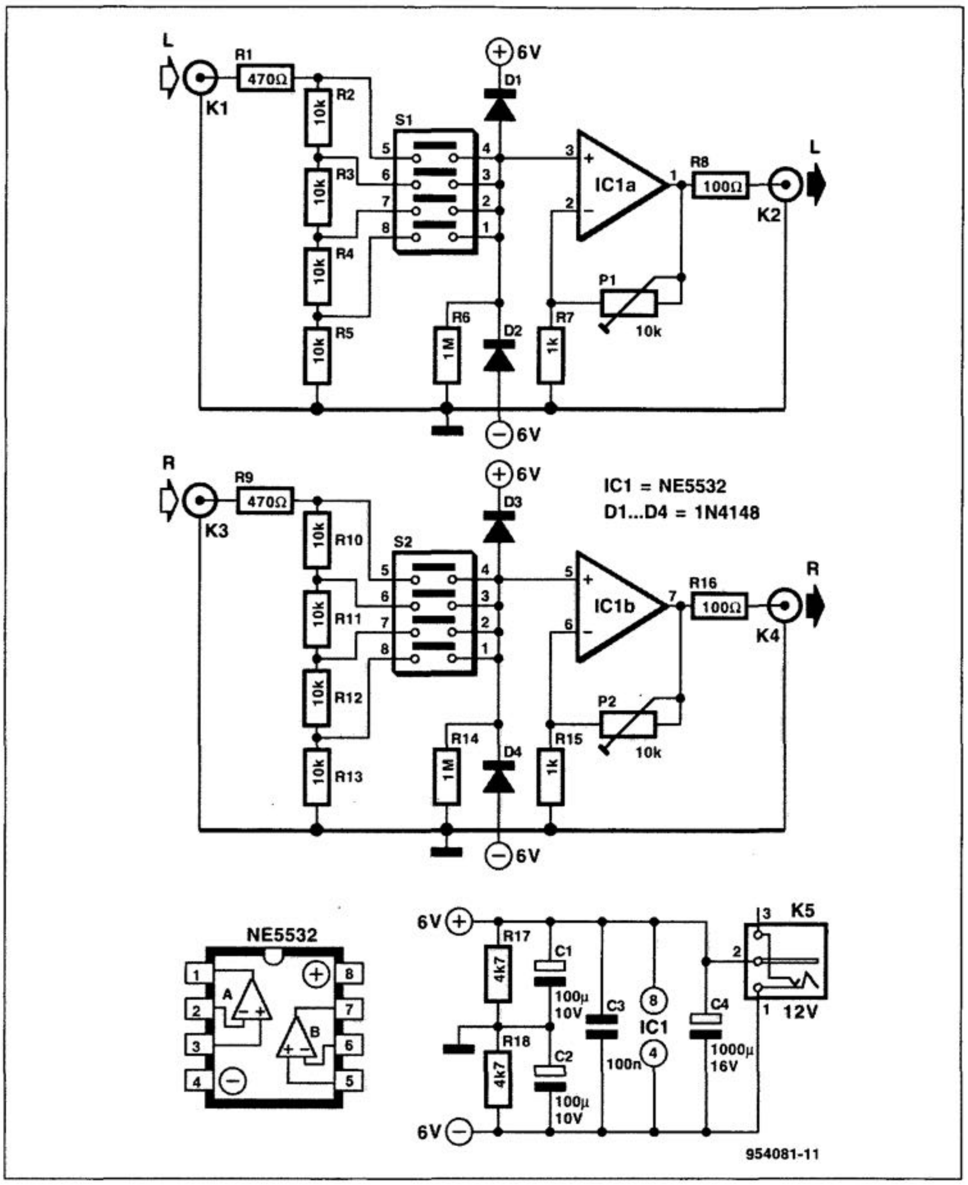
Power may be derived from a mains adaptor. Since the matching circuit should work with a symmetrical supply (when coupling capacitors may be omitted), a virtual earth is provided with the aid of R_{17}, R_{18}, C_1 and C_2. The specified values of these components apply to a load impedance of 50 kΩ. For lower load impedances, the values of the resistors must be reduced and that of the capacitors increased accordingly. The mains adaptor is decoupled by C_4.

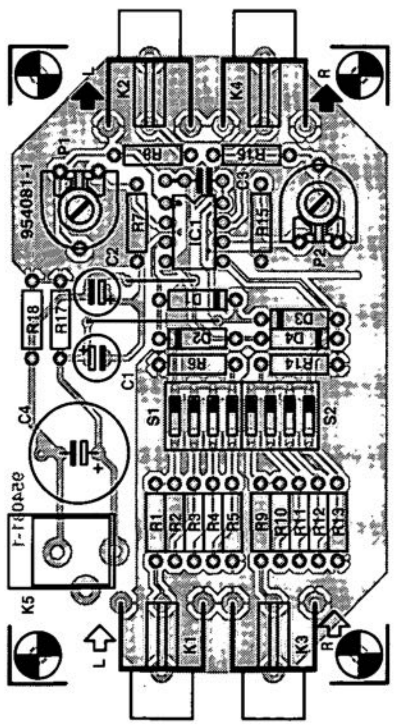
Diodes D_1–D_4 protect the inputs of IC_{1a} and IC_{1b} against too large input signals.

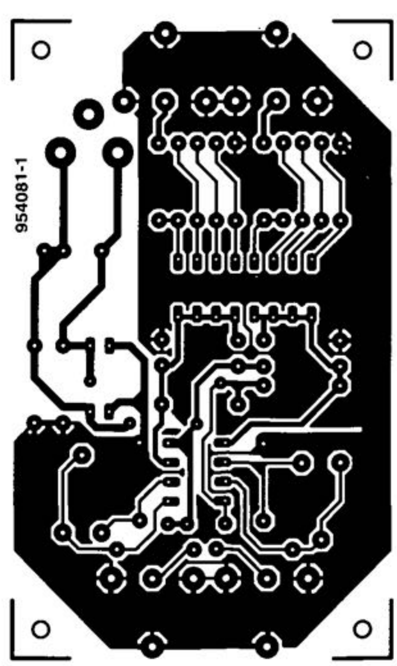
Resistors R_6 and R_{14} provide a bias current for the op amps when all switches are open.

The total harmonic distortion plus noise measured in the prototype working with a gain of 0 dB, a frequency of 1 kHz, an output voltage of 2 V, and a load of 50 kΩ was smaller than 0.0004% (at a bandwidth of 80 kHz). When the gain is raised to 20 dB and the input signal is 200 mV, the distortion rises to 0.0012%. Channel separation is >100 dB at 1 kHz and >80 dB at 20 kHz.

The circuit draws a current of not more than 10 mA.



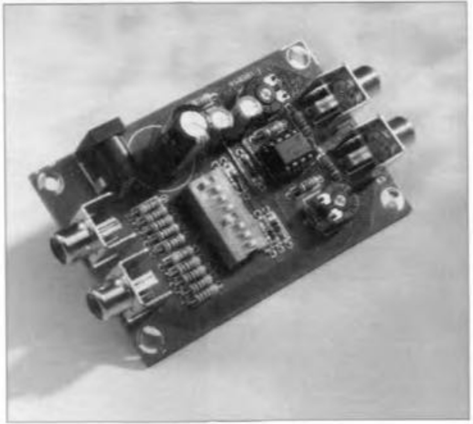




Parts list

Resistors:

R_1, R_9 = 470 Ω
R_2–R_5, R_{10}–R_{13} = 10 kΩ
R_6, R_{14} = 1 MΩ
R_7, R_{15} = 1 kΩ
R_8, R_{16} = 100 Ω



R_{17}, R_{18} = 4.7 kΩ
P_1, P_2 = 10 kΩ preset

Capacitors:
C_1, C_2 = 100 µF, 10 V, radial
C_3 = 100 nF
C_4 = 1000 µF, 16 V, radial

Semiconductors:
D_1–D_4 = 1N4148

Integrated circuits:
IC_1 = NE5532A

Miscellaneous:
K_1–K_4 = Audio socket for board mounting
K_5 = Plug for accepting mains adaptor socket
S_1, S_2 = 8-position DIP switch
PCB not available ready made

Design by T. Giesberts
[954081]

PRINTER MONITOR

With many simple computers, hard copy printing can be time consuming. In that waiting period, other work may be carried out. (Note: many other printers have a background printing facility so that the computer is available during printing).

The printer monitor proposed indicates audibly when printing has been completed. It uses the STROBE signal and earth, both of which are present on the printer cable. During quiescent periods, the STROBE line is high, resulting in capacitor C_1 being charged to +5 V via D_1 and R_1. This provides a supply for IC_1.

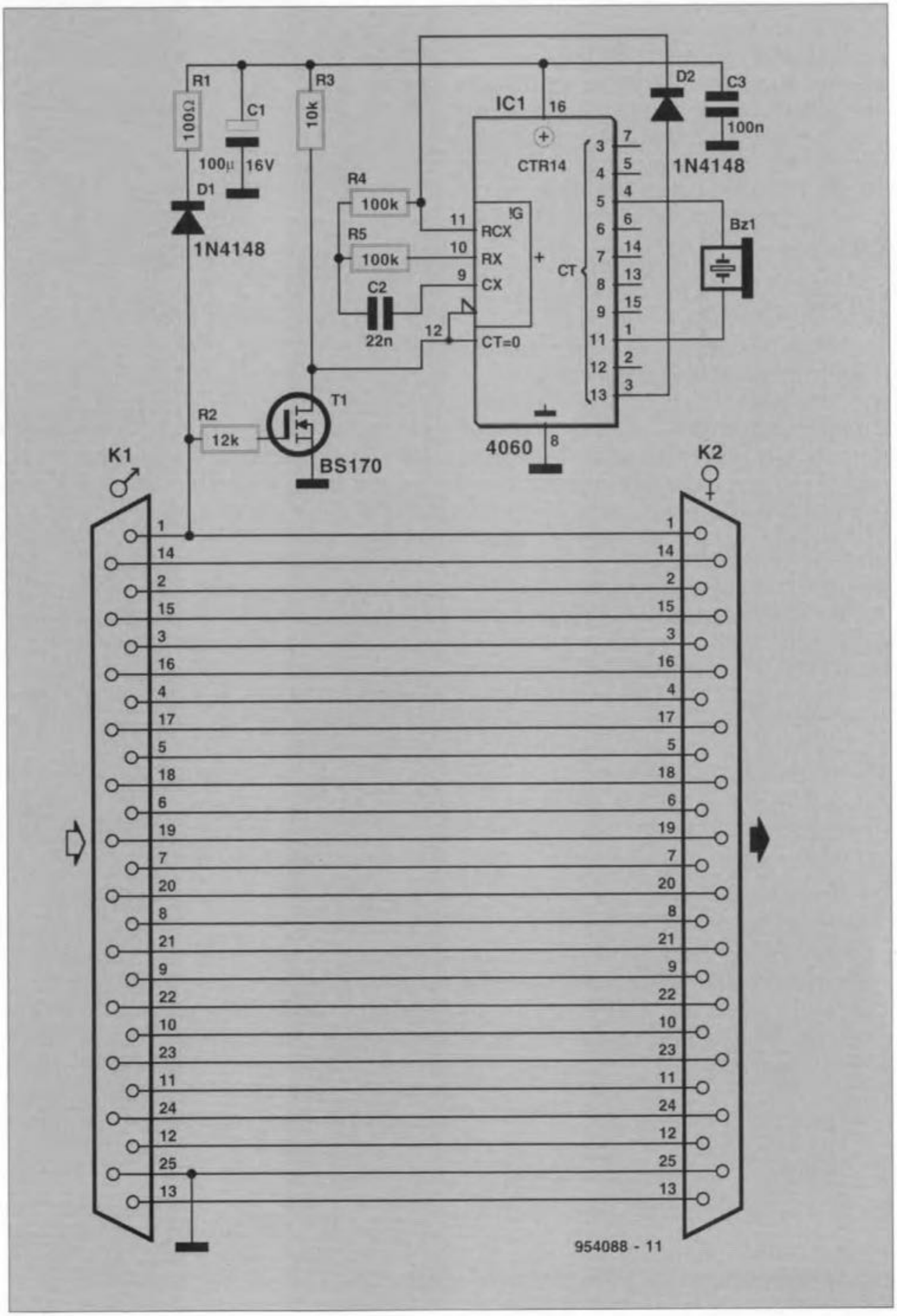
When printing has commenced, short pulses appear on the STROBE line, which ensure that the IC is reset regularly via transistor T_1.

When printing has been completed, the STROBE line is high again, so that the counter in IC_1 can complete a count cycle.

The piezo buzzer across pins 1 and 4 emits eight short beeps when pulses appear on pin 4. When pin 3 goes high, the oscillator in the IC is disabled via D_2. The circuit is then ready for the next printing instruction.

The circuit is small enough to be built in a tiny case, provided with two D25 connectors, which can be inserted into the existing printer cable.

Design by C. Galles
[954088]

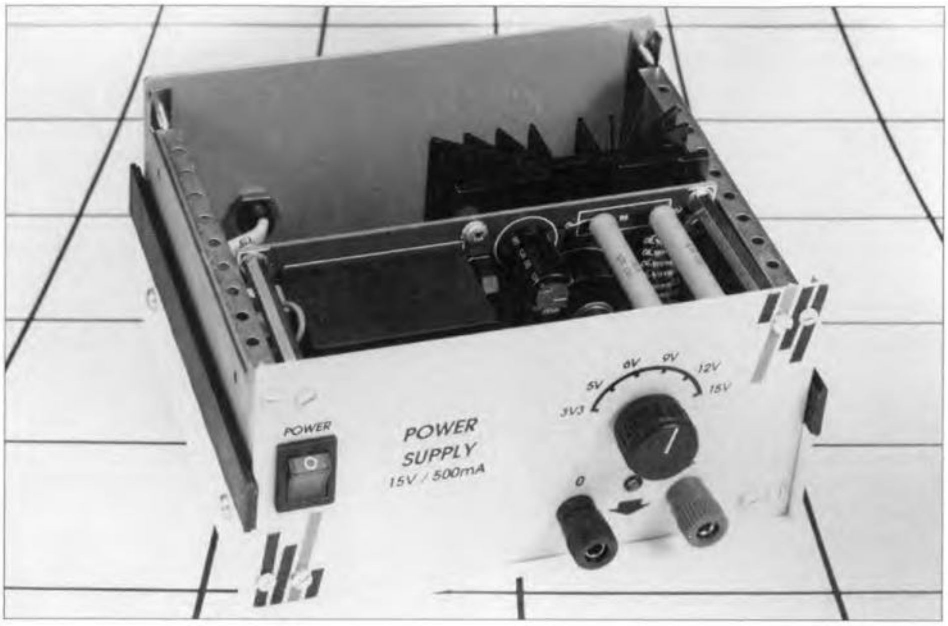


3.3–15 V POWER SUPPLY

Design by K. Walraven

A power supply is described whose output can be switched to the six most common output voltage requirements and which can provide a continuous output current of up to 500 mA. A worthwhile addition to any small workshop!

The era when a reliable power supply had to be constructed from discrete components is virtually past. Only when very specific requirements are to be met is this type of design used nowadays. Modern designs for most work in the small workshop use integrated regulator circuits of which there is an ample choice. There was a time when these ICs were not too reliable, but that is history as well. Most modern types are provided with reliable thermal and short-circuit protection, which means not only that they are near-foolproof, but also that external components can be kept to a minimum.



LM317

The reliable and proper operation of the power supply depends largely on the regulator, which in the present circuit is a Type LM317. This is one of the most popular regulators currently in wide use, which contains no fewer than 26 transistors. It is a three-pin device that can work over a voltage range of 1.25–37 V. The output voltage is set by two external resistors.

The internal current limiting circuit, in conjunction with the thermal protection and the 'safe-area' protection, ensures that the IC in normal operation is virtually indestructible. The protection circuits remain operational when the adjust terminal is left open-circuit. The device can provide a current of up to 1.5 A.

A standard application of the LM317 is shown in **Fig. 1**. Its operation depends on the propensity of the regulator to keep the difference between the output and adjust input constant at 1.25 V. In the diagram that is the potential across R_1. If this resistor is made part of a voltage divider at the output of the regulator as shown, it becomes possible to obtain a range of output voltages by varying the ratio R_1:R_2. This means that the diagram forms a complete (albeit simple) variable power supply whose output, U_0, in volts is determined by the value of R_2:

$$U_0 = 1.25(1 + R_2/R_1).$$

There are two limitations to this. In the first place, the input voltage needs to be 3 V higher than the wanted output voltage. The maximum input potential is 40 V so that U_0 can not exceed 37 V. Furthermore, the value of R_1 can not be much different from the specified one to prevent insufficient current flowing into the adjust input for the regulator to function correctly. In other words, the value of R_1 may be slightly lower, but not much higher, than 240 Ω. This means that any variation in the divider ratio must be effected by R_2.

To make the circuit in Fig. 1 into a practical unit, some additional aspects must be considered. For instance, the input voltage must be smoothed and buffered so that load peaks do not cause the input voltage to drop briefly below the regulation threshold of the LM317. Furthermore, the designer must take into account the maximum dissipation of the IC. If, for example, the input voltage is 35 V and the output potential is set at 5 V, the drop across he regulator is 30 V. The consequent dissipation is pretty high. Although the thermal protection takes care that the IC does not get damaged, there is no output voltage when it is in action and that should be prevented as much as possible.

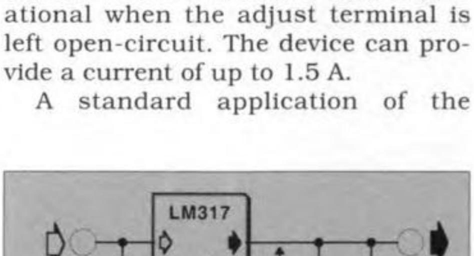


Fig. 1. Although the LM317 requires two external resistors, it can be set to any voltage between 1.25 V and 37 V.

Six output voltages

The practical circuit in which the earlier considerations have been taken into account is shown in **Fig. 2**. In this, the output voltage can be varied in six steps by adding, with switch S_{1a}, up to five resistors, R_3–R_7, to the original potential divider R_1–R_2. The reason that a switch and fixed resistors are used rather than a potentiometer is the requirement of making the supply simple and reliable. It may appear as if a potentiometer is the simplest means of varying the output, but this is not really so, for in that case some sort of output voltage indication (that is, a voltmeter) needs to be added and this would add to the cost. Moreover, a potentiometer has the drawback that it is too easily turned accidentally from its set position (for instance, by a sleeve). Imagine what would happen to an appara-

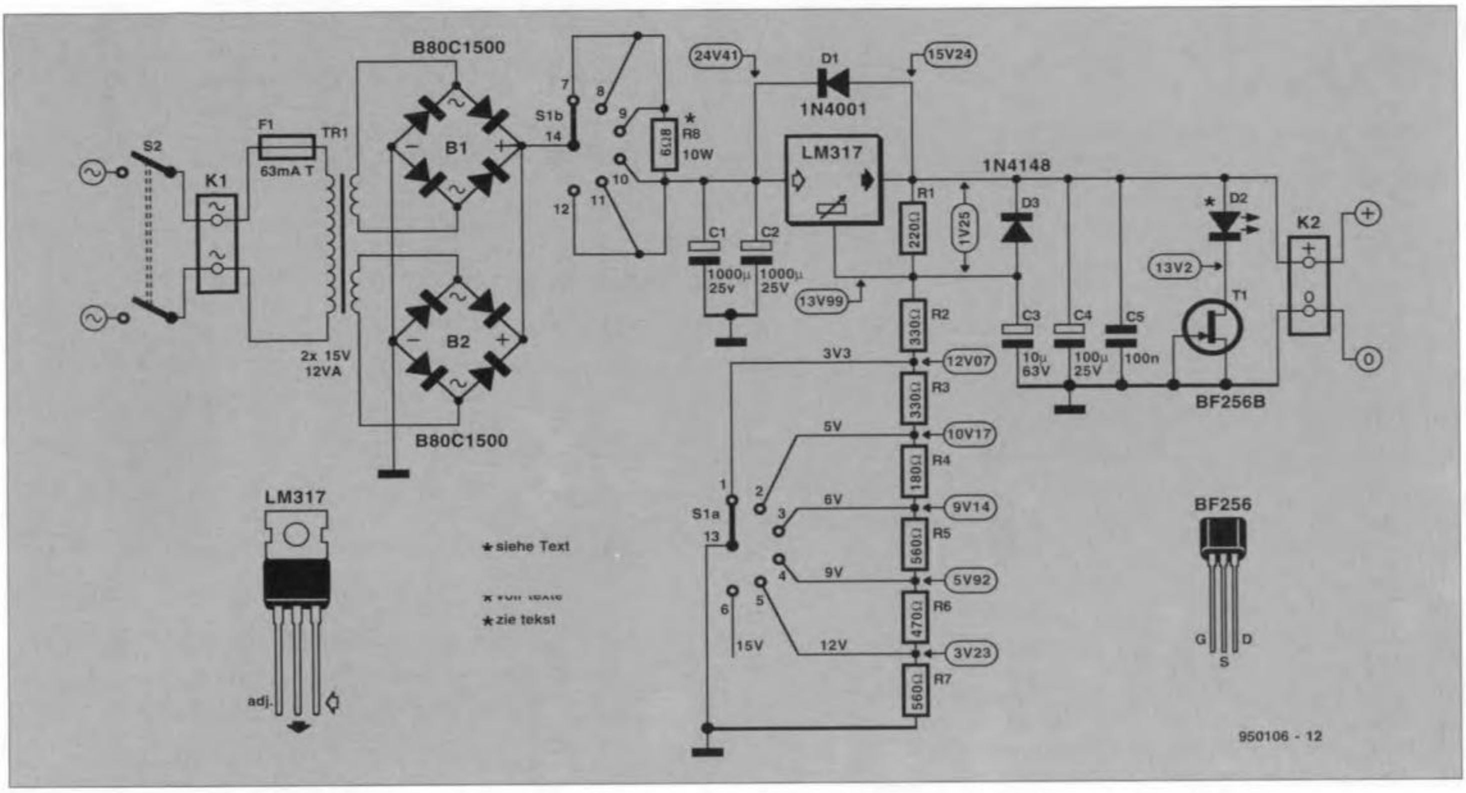


Fig. 2. In the present circuit, the potential divider of Fig. 1 has been constructed of seven discrete resistors, which are selected by a rotary switch.

tus connected to the supply if the output voltage were suddenly increased from 6 V to 15 V. This can not happen with a switch.

The six voltages can be marked around the switch on the front panel of the enclosure, so a meter or other type of indicator is not required.

It may seem advantageous for the output voltage to be continuously variable, but how often is a voltage of, say, 7 V or 10 V really required? Almost invariably, the requirement is for a 'standard' voltage: in the present circuit the values of the resistors have been chosen to give outputs of 3.3 V, 5 V, 6 V, 9 V, 12 V and 15 V. The first two are standard values for modern and conventional logic circuits respectively; 6 V and 9 V are often required for portable audio equipment; 12 V is the usual level for car electronics and r.f. circuits; and 15 V is also a frequently used supply voltage.

In the parts list, two values are given for resistors R_1–R_7; the 1% values are for those readers who want very precise levels of output voltage. The output voltages when the 5% resistors are used are 3.17 V, 5.07 V, 6.11 V, 9.33 V, 12.03 V and 15.25 V. These are probably sufficiently precise for most users.

Remainder of the circuit

The mains voltage is applied to K_1 and thence to the mains transformer via fuse F_1. The transformer is a 12 VA type with two 15 V secondary windings. Since connecting the windings in parallel is not without certain difficulties, practical considerations dictate separate bridge rectifiers to be used.

Normally, the rectifiers are followed by smoothing capacitors. In the present circuit, they are separated by switch S_{1b} and R_8. The switch connects a high-wattage resistor in series with the rectified voltage in the three low output voltage positions. This lessens the drop across, and thus the dissipation in, IC_1.

The circuit shows two smoothing capacitors: C_1 and C_2. This arrangement is due primarily because of the space on the board. Where a suitable 2200 µF, 25 V electrolytic capacitor is available, C_2 can be omitted.

Diode D_1 prevents the output voltage of the regulator exceeding the input voltage when the mains is switched off or in case of a short-circuit at the input (which is one of the situations that the regulator can not cope with.

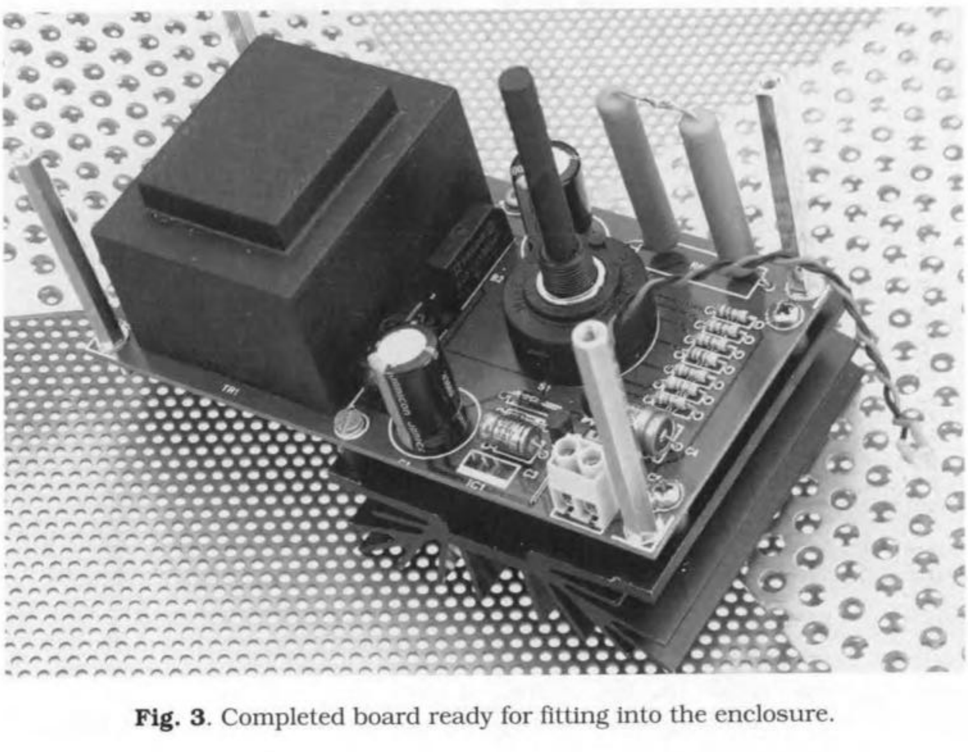


Fig. 3. Completed board ready for fitting into the enclosure.

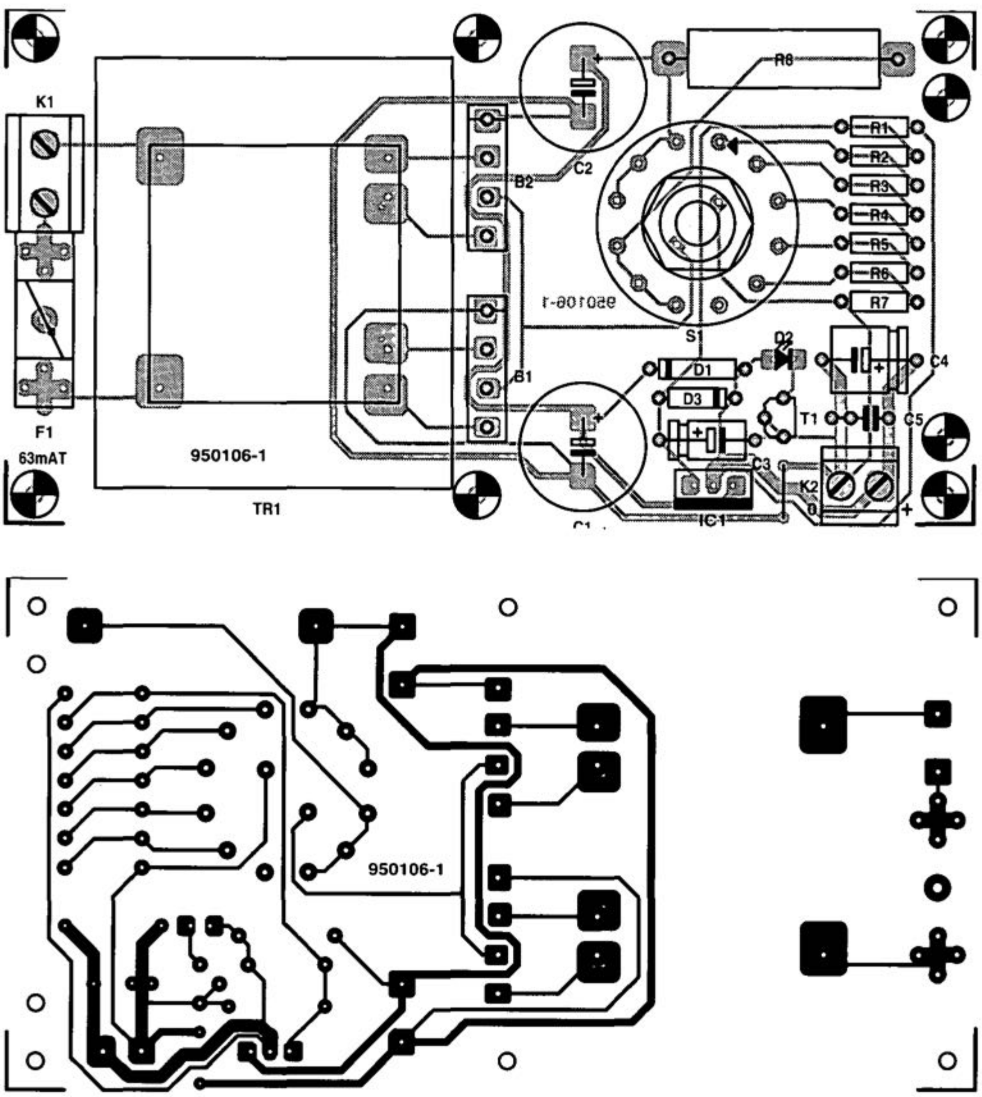


Fig. 4. The PCB has been kept compact. The regulator is fitted at the track side.

Capacitor C_3 prevents any spurious voltage peaks when S_1 is turned. Diode D_3 enables C_3 to be discharged rapidly when the switch is turned to a lower output voltage position.

Capacitors C_4 and C_5 enhance the stability of the circuit and prevent the output voltage from collapsing during pulses in the load.

Diode D_2 indicates whether or not there is a potential at the output terminals. This gives a useful check in case of a short-circuit. As long as the diode lights, all is well. To ensure a fairly even brightness, the usual series resistor is replaced by a current source, T_1, which limits the current through the diode. Only in position 3.3 V does the LED light less brightly.

Construction

The supply is best built on the printed-circuit board shown in **Fig. 3**. Before any work on this is begun, use it as a template for drilling the front panel of the enclosure. At the same time, drill the holes for the mains entry in the rear panel. While the drill is to hand, also drill the required holes for fitting the heat sink for IC_1 to the board—see **Fig. 4**.

Mount IC_1 to the heat sink, using the relevant insulating washer. Screw the heat sink to the board on short spacers and only then solder the terminals of the IC to the relevant holes in the board.

The space on the board for R_8 is rather limited for a 10 W resistor. It is, therefore, advisable to use two 3.3 Ω, 5 W or 10 W types, connected in series, and fit these as shown in Fig. 4. This arrangement ensures adequate cooling of the resistors. Do not fit the resistor(s) too close to the board.

When the board is populated (remember the wire bridge adjacent to K_2), fit it to the front panel on four 5-cm long spacers.

Test

Do not yet fit the board into the enclosure, but test it first. To this end, connect the mains cable temporarily directly to K_1 and cover all mains voltage parts and tracks with good-quality insulating tape. Switch on he mains and measure the potential across C_1 (C_2), which should be about 24 V (a few volts more or less do not matter). If the difference is more than a few volts, carefully check switch S_{1b}, the bridge rectifiers and the transformer and all connections to them.

If the voltage across C_1 (C_2) is correct, connect the multimeter to K_2 and verify that the output voltages for the six positions of S_1 are as specified. If these are very different from the stated values, measure the potential across R_1, which must be 1.25 V ±0.1 V. If this is not so, recheck the values of R_1–R_7 and make sure that diodes D_1 and D_3 are connected with correct polarity. If all these are all right, IC_1 may be the culprit, but defect LM317s are few and far between. If D_2 does not light, check that this diode is connected with correct polarity. If everything appears to be correct, bridge the drain-source junction of T_1 with a 1 kΩ resistor. If the LED lights, for some reason no current flows through the transistor, which therefore needs to be examined carefully.

The voltage levels stated on the circuit diagram apply when S_1 is in the 15 V position.

Finally, connect a small bulb or resistor to K_2 and check that the output voltages remain correct when an output current of a few hundred milliamperes flows.

Finally

When everything has been found in order, the completed board can be fitted into the enclosure—**Fig. 5** shows the wiring required, while **fig. 6** illustrates how the board is fitted in the case. Fit the mains entry cable with an appropriate strain relief, and take care that all mains-carrying parts are at least 6 mm away from the (metal) case panels. The heat sink should not be close to the mains connections, since these can get pretty hot when high output currents flow.

The front panel of the case can be finished as shown in **Fig. 7**.

Although the supply is designed for a continuous output current of up to 500 mA, the LM317 can withstand peak currents of up to 1.5 A. The prototype was tested with an output current of 600 mA, which was all right at an output voltage of up to 12 V. When the 15 V position was selected, however, the output voltage dropped to 13.9 V.

Parts list

Resistors:

R_1 = 220 Ω (215 Ω, 1%)
R_2 = 330 Ω (348 Ω, 1%)
R_3 = 330 Ω (301 Ω, 1%)

R_4 = 180 Ω (169 Ω, 1%)
R_5, R_7 = 560 Ω (511 Ω, 1%)
R_6 = 470 Ω (523 Ω, 1%)
R_8 = 6.8 Ω (2×3.3 Ω), 10 W, see text

Capacitors:
C_1, C_2 = 1000 µF, 25 V, radial
C_3 = 10 µF, 63 V
C_4 = 100 µF, 25 V
C_5 = 100 nF

Semiconductors:
D_1 = 1N4001
D2 = LED, 3 mm
D_3 = 1N4148
B_1, B_2 = bridge rectifier B80C1500
T_1 = BF256B

Integrated circuits:
IC_1 = LM317 (TO220)

Miscellaneous:
K_1 = 2-way terminal block, pitch 7.5 mm
K_2 = 2-way terminal block, pitch 5 mm
S_1 = 2-pole, 6-position rotary switch
F_1 = PCB type fuse holder with 63 mA fuse
Tr_1 = mains transformer, 2×15 V, 12 VA secondaries, e.g. Velleman Type 13/2/15 (Maplin)
Heat sink for IC_1, e.g. Fischer SK64, 75 mm, 1.7 K W^{-1} *
Insulating material for IC_1
Enclosure 80×150×132 mm
2 off banana sockets
1 off mains switch with indicator LED
1 off mains cable with strain relief
4 off 50 mm spacer
4 off 5 mm spacer
PCB Order no. 950106 (see p. 70)

* Dau (UK) Ltd,70–75 Barnham Road, Barnham, West Sussex PO22 0ES. Telephone (01243) 553 031. Trade only, but information as to your nearest dealer will be given by telephone.

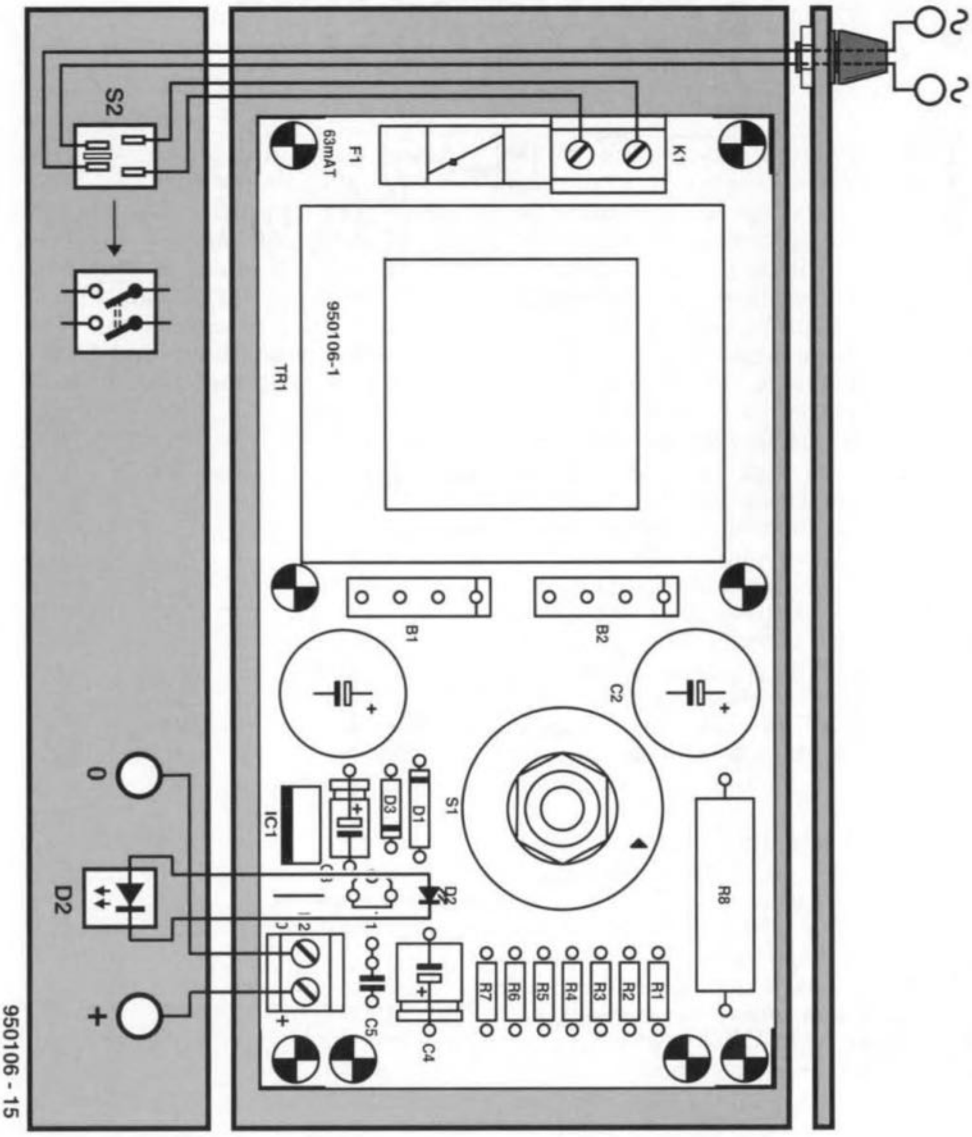


Fig. 5. Diagram for wiring up the board to external components.

[950106]

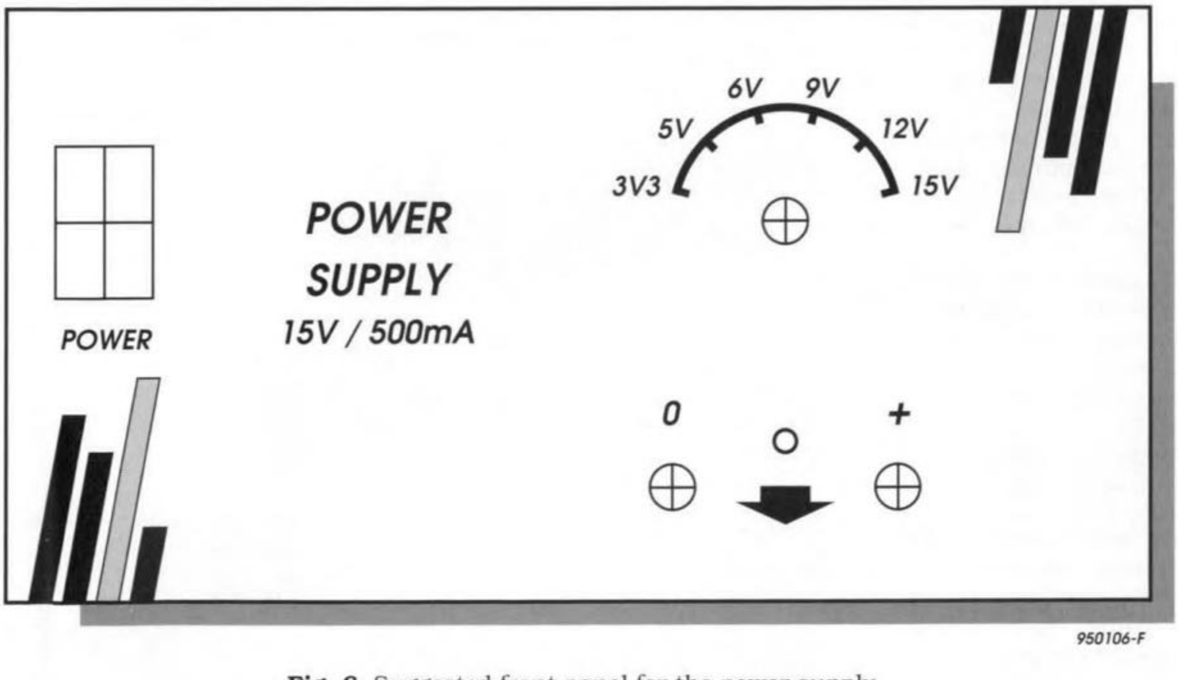
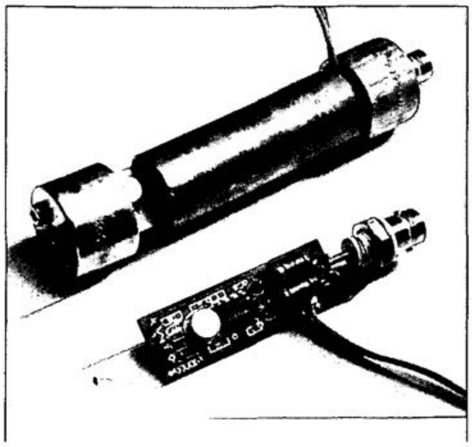


Fig. 6. Suggested front panel for the power supply.

ACTIVE PROBE



The very real advantages of an active probe over a passive one are that loading caused by large cable capacitances is prevented and that the measured value is passed to the display unit (oscilloscope, voltmeter, printer) without any interference.

The present probe can be used in many applications. Although the wideband amplifier, IC_1, can provide a fairly high output current, its input current is so high (25 μA) that the source impedance must not exceed 10 kΩ. So as to keep the measurement error small, the amplifier is therefore preceded by impedance transformer T_1. This dual transistor is connected as a source follower and is totally symmetric. The input impedance of the probe is then 10 MΩ and the input current of IC_1 does not effect the measurement (although the leakage current of T_1 does, but only to a very small extent).

Since T_1 is not integrally protected against static charges, a sort of protection is provided by D_1–D_4.

Diodes D_1 and D_2 guard the input against too high voltages. The types used have a very low capacitance and a virtually negligible reverse-bias leakage current.

Diodes D_3 and D_4 limit the input potential of the op amp to ±6 V and protect the probe against possible damage if the supply voltage is switched off (or fails) when there is still a high measurement potential at the input.

Op amp IC_1 may have an amplification of ×10 or of unity, depending on whether the value of R_6 is 1.91 kΩ or 100 Ω respectively. Capacitor C_6 must be used only in case of unity amplification.

Capacitor C_1 prevents any direct voltage at the input from affecting the setting of T_1. It may be replaced by a wire bridge, but an output offset voltage of about 25 mV, when the amplification is ×10, must then be taken into account.

Resistor R_7 matches the output impedance to the cable impedance. If the output load has no 50 Ω input, the probe can be terminated into a BNC-T connector with a 50 Ω terminating resistor.

All passive components, except C_4 and C_5, are surface-mount devices (SMDs) to guarantee a compact construction. As the photograph shows, the BNC terminal is soldered directly on to a PCB pin.

The photograph also shows the housing of the prototype, which was made of a short length of ¾ inch (18 mm) water pipe with at the ends the relevant connector case.

In the prototype, the probe pin consists of the metal part of a banana plug. The earth terminal is made from a short length of flexible circuit wire terminated into a crocodile clip.

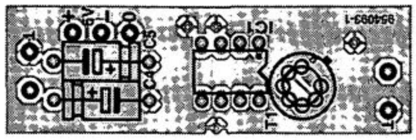
The ±5 V supply lines are connected via a small hole in the wall of the water pipe.

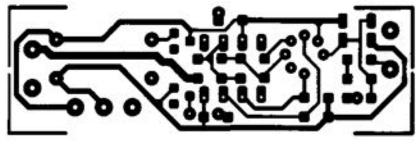
Parts list

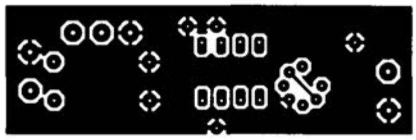
Resistors:
R_1 = 100 Ω*
R_2 = 10 MΩ*
R_3, R_4 = 2.00 kΩ, 1%*
R_5, R_6 = 100 Ω, 1%*
R_7 = 49.9 Ω, 1%*

Capacitors:
C_1 = 22 nF*
C_2, C_3 = 10 nF*
C_4, C_5 = 10 μF, 10 V
C_6 = 10 pF*

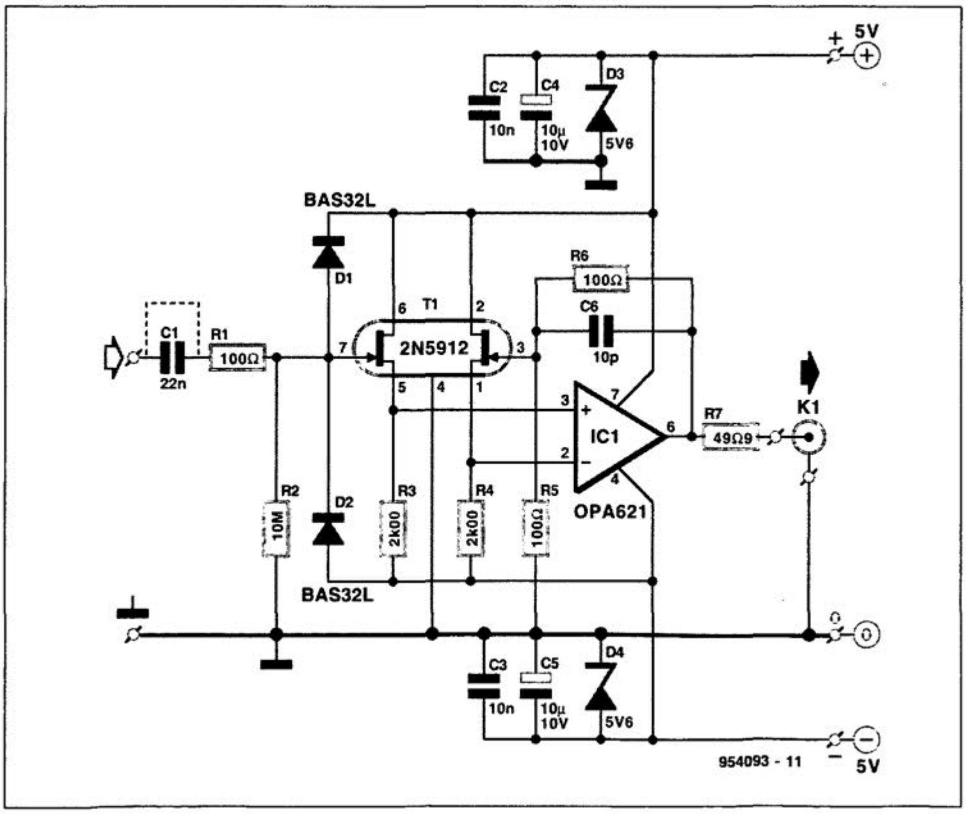
Semiconductors:
D_1, D_2 = BAS32L*







Parameters		
Amplification	1 (R_6 = 100 Ω; C_6 = 10 pF)	10 (R_6 = 1.91 kΩ; C_6 omitted)
Input impedance	10 MΩ; 5.5 pF	10 MΩ; 5.5 pf
Sensitivity	U_{in} ≤2 V r.m.s.	U_{in} ≤200 mV r.m.s.
Output impedance	50 Ω	50 Ω
Bandwidth	100 MHz (±0.1 dB) 150 MHz (±0.5 dB)	10 MHz (±1 dB)
Power supply	±5 V, <50 mA	±5 V, <50 mA



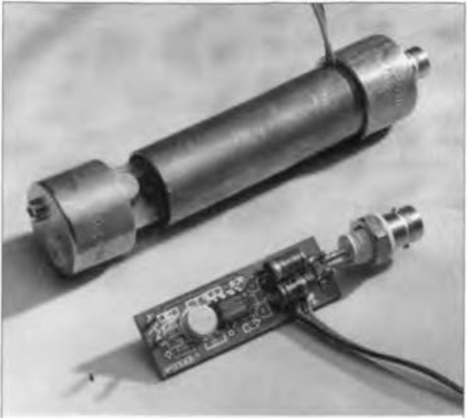
D_3, D_4 = 5.6 V zener*
T_1 = 2N5912 (Siliconix)

Integrated circuits:
IC_1 = OPA621 (Burr Brown)

Miscellaneous:
K_1 = BNC connector, 50 Ω
RG-58 cable with two BNC plugs
Banana plug (for probe pin)
Crocodile clip
PCB Order no. 954093 (see p. 70)

* SMD

Design by H. Bonekamp
[954093]



DESCALER

Water pipes can be descaled with the aid of a magnetic field or an electric filed. The present descaler uses an electric field, which is imposed on to the pipe by two thin metal plates stuck on to the pipe with insulating tape.

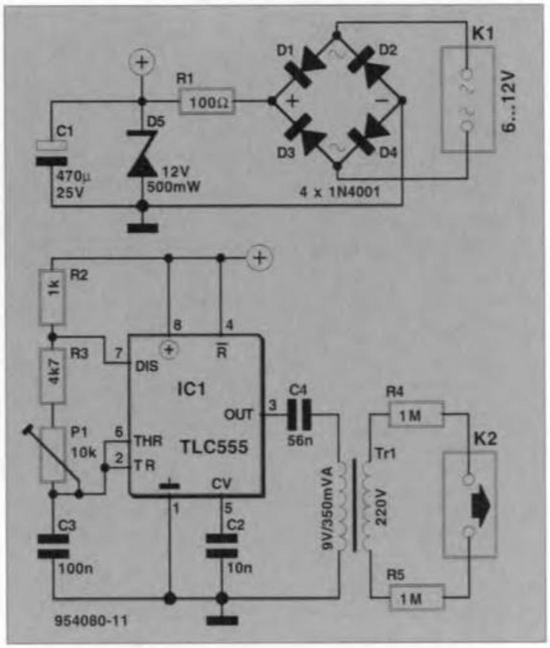
In the diagram, IC_1 is arranged as an astable multivibrator, AMV, whose frequency, with P_1 at the centre of its travel, is 700 Hz. Since a strong field is required, the output of the AMV is transformed up to about 340 V_{pp} by Tr_1. Capacitor C_4 and the primary of the transformer form a series resonant circuit. Resistors R_4 and R_5 make the output of the circuit high-impedance. Nevertheless, measures must be taken to ensure that the output can not be touched.

The circuit is connected to the plates that generate the electric field by two lengths of flexible circuit wire soldered on to the plates. The plates can be made from thin copper foil or a used tin and stuck on to the water pipe with insulating tape as shown in the photograph. Each of the strips should cover about $^1/_3$ of the circumference of the pipe. When the strips are stuck in place, wind another layer (or two) around the whole: this prevents the strips (high voltage) being touched accidentally and condensation causing a short-circuit between the strips.

After the board has been finished, it should be housed in a plastic case.

Power can be derived from a bell transformer.

The circuit is set up by connecting a (digital) multimeter to its output and adjusting P_1 for peak reading. This value may below that given in the text; this is because the multimeter loads (and thus damps) the resonant circuit.



Parts list

Resistors:
R_1 = 100 Ω
R_2 = 1 kΩ
R_3 = 4.7 kΩ
R_4, R_5 = 1 MΩ
P_1 = 10 kΩ horizontal preset

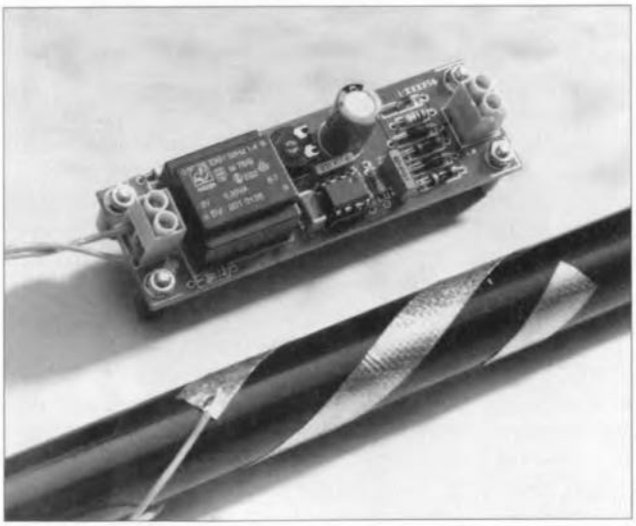
Capacitors:
C_1 = 470 µF, 25 V, radial
C_2 = 10 nF, polypropylene (MKT)
C_3 = 100 nF, polypropylene (MKT)
C_4 = 56 nF, polypropylene (MKT)

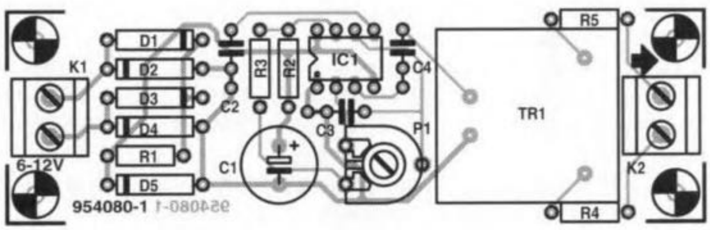
Semiconductors:
D_1–D_4 = 1N4001
D_5 = zener diode, 12 V, 500 mW

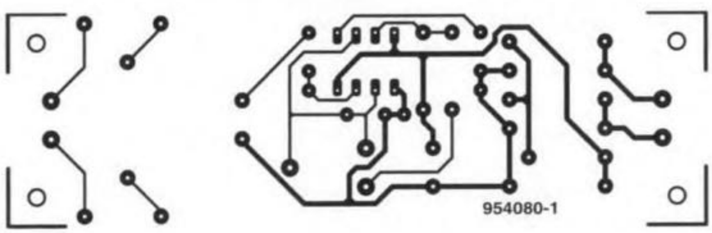
Integrated Circuits:
IC_1 = TLC555

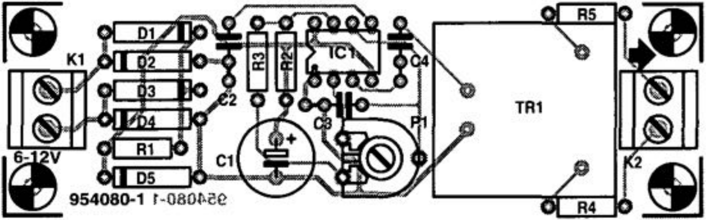
Miscellaneous:
K_1, K_2 = 2-way terminal block, pitch 5 mm
Tr_1 = mains transformer, secondary 9 V, 350 mA
PCB Order no. 954080

Design by H. Bonekamp
[954080]








K1
D1
D2
D3
D4
R1
D5
6-12V
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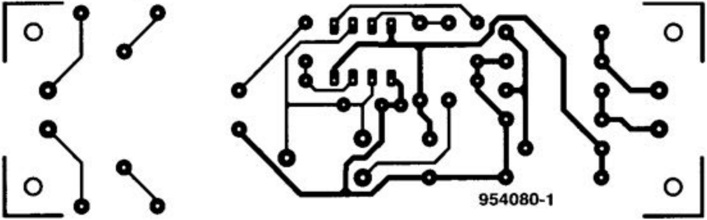
C2
R3
R2
IC1
C4
C3
C1
P1
TR1
R5
R4
K2


954080-1

LETTERS

Dear Editor—I have been told that the Information Superhighway is a political rather than a technical name. Surely this is not so?
A. Clarke, Johannesburg

It is, I'm afraid. The term was first used by Al Gore, America's vice-president, during the run-up to the 1992 presidential elections.

[Editor]

Dear Editor—Several times recently, I have come up against the name Andriesen in connection with computer technology. I have been unable to find any reference to him in a number of magazines in my local library. Can you enlighten me?
P. Engström, Uppsala

Marc Andreessen, who is in his mid-twenties, is a graduate of University of Illinois. A few years ago he developed a 'navigation system' for the Internet' World Wide Web, called Mosaic. This adds pictures, sound and video to the data to make navigating the Web much easier. Later, he and a partner, Jim Clark, set up Mosaic Communications, later renamed Netscape Communications. The first product of this company, Netscape Navigator, grabbed a very large part of the market within a very short time. The company is already reputed to be worth close to $600 million: not bad for a company barely a year old! Some pundits reckon that if the company goes on like this, it will soon dominate the Internet in the same manner as Microsoft does the PC software markets.

[Editor]

Dear Editor—A couple of months ago, I read somewhere that somebody had invented a 'clockwork radio'. At the time, I did not think much about it (I read it in the train), but later, when I wanted to find out more about it, I could not find the article back. None of my friends or colleagues seems to have heard of it and think I'm having them on. To save my face, have you heard of it?
A. Marcus, Birmingham

We think you are referring to the invention by Trevor Bayliss, which was the subject of a BBC documentary a few months ago. It is a transistor radio that operates from electricity generated by a handbrace. Already, the unit is in production in South Africa. According to some analysts, it will do more to bring information to the developing world than any other equipment in the past twenty years or so.

[Editor]

MAPLIN'S 1996 CATALOGUE OUT

Maplin's 1996 catalogue with 1200 feel-good pages contains 3500 new products, all highly innovative, cost-competitive and high-quality. The totally revised and enlarged catalogue is available from W.H. Smith and John Menzies stores at a **reduced price** (on last year's) of £2·95, or £3·45 by mail order from Maplin Electronics. Each catalogue contains money saving vouchers up to £50.

Dear Editor—I am pleased to see *Elektor Electronics* now offering an Item Tracer on floppy disk; I shall be ordering a copy straight away!

I wonder how long it will be before we 'pick up' our favourite magazine or a 'paperback' and slide it into our portable pocket-sized 'reader'. It might well be in the form of a floppy disk or CD, or perhaps it will be in the form a wafer-thin 'smart card', the like of which we currently use for public telephone credit, and so on.

Or maybe in the future, we will just make a 'transparent connection to *Elektor Electronics*' using our portable combined PDA (personal digital assistant) cellular telephone (video perhaps) and media player, download a 'preview' of this month's edition, and decide either to purchase it, or 'put it back on the shelf' so to speak!

Is it not time your magazine caught up with the information age? Several professional electronics and industrial journals already have a 'presence' on the Internet, or support a dial-up bulletin board service. A large proportion of your readers must already use e-mail, and it would surely be a simple service to provide your readers an e-mail address to write or send send data to the magazine. Many electronic component suppliers also already have bulletin boards and some allow stock check and ordering on-line (Maplin, for example).
Frank R. Fattori, Freising

Your letter is certainly thought-provoking and has, therefore, been copied to various editorial and technical staff at our Head Office in Holland. We are endeavouring to catch up with the information age, but, being part of a very large international publishing house, we cannot move as quickly as we would like (the usual problem between publishers on the one hand and technical staff on the other). Nevertheless, we (that is, the Dutch side of the business) are on the Internet (e-mail: elektuur @ euronet nl). Moreover, we have already published our own Internet Special (sorry, in Dutch only so far, although issues in other languages may follow – a German one is planned for issue before Christmas).

A CD-ROM is already being worked on (again, starting with the Dutch magazine) and will become available early in the new year. The English, French and German will follow later. In contrast to what you say, there are quite a few problems in putting back issue articles on CD-ROM, since, of course, many of these are not available in electronic form, so have to be scanned (which is still a laborious job).

[Editor]

Dear Editor—I am an old-timer in radio and radar, but am not too familiar with modern electronics and computers (although I own one). I am told that, living in retirement, I could benefit from subscribing to the World Wide Web. What is this exactly and what could it offer me? What does it cost to subscribe?
B. Fletcher, Barcelona

The World Wide Web is a realm of the Internet and allows you to visit a data bank in London one moment and in Los Angeles the next. However, for many requirements, it is a slow, tortuous business. This is because all the data have to come down a (copper) telephone line to the modem connected to your computer. The fastest modem current available operates at 28.8 kbit/s. It has been reported that, using this route, it may take 2–3 hours to download a 2–3 minute fragment of a colour film.

Other routes may soon become available, however. In many countries there are thousands of miles of cable that deliver television to domestic homes. In the UK and the USA, companies have been busy to produce cable-to-computer interfaces (a sort of modem) that deliver data to the computer at speeds of up to 4 Mbit/s, which is considerably faster than the telephone modem.

Also, in the USA, Hughes Network Systems is offering a satellite service called DirecPC, which can deliver data to subscribers at 400 kbit/s – enough to transmit a 400-page book in less than a minute. With modern compression techniques, that would easily allow real-time video.

However, much of this is for the future as far as Europe is concerned. Here, we have to continue to be happy with the good old telephone line.

[Editor]