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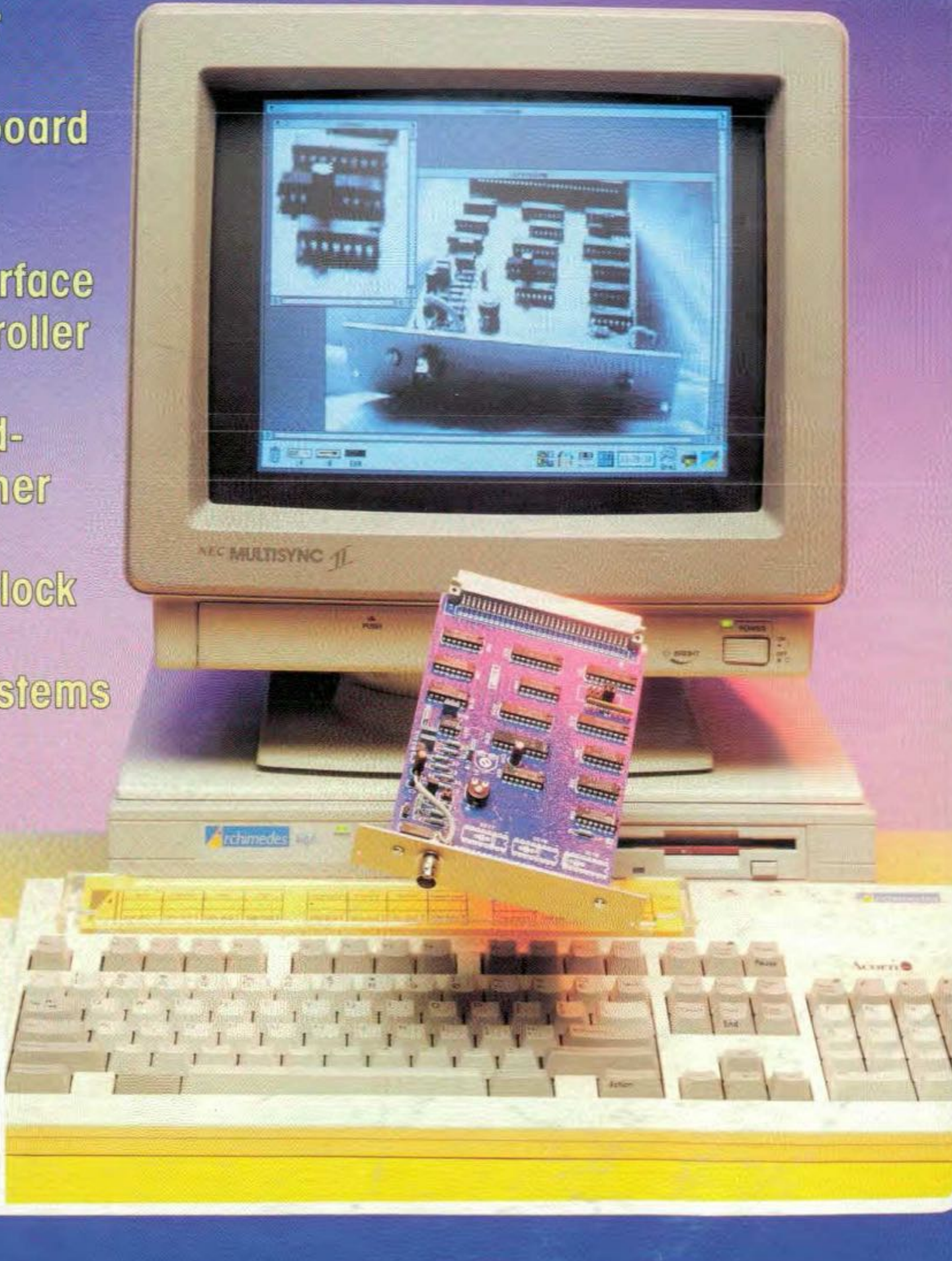

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CONTENTS

July/August 1991
Volume 17
Number 191

LEADER

AUDIO & HI-FI

COMPUTERS & MICROPROCESSORS

GENERAL INTEREST

INTERMEDIATE PROJECT

POWER SUPPLIES & BATTERY CHARGERS

RADIO, TELEVISION & COMMUNICATIONS

TEST & MEASUREMENT

MISCELLANEOUS INFORMATION

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TIMECODE INTERFACE FOR SLIDE CONTROL

PART 1: SYSTEM OUTLINE

Noticing that the projector is running out of step with the audio programme is pretty embarrassing when your friends and relatives have gathered to watch your carefully prepared slide presentation. The circuit described here ensures perfect synchronization between the slide controller and a music or voice programme recorded on tape. This is achieved by recording an accurate time code on a tape track and playing it back later, sending commands to a slide projector control.

A. Rigby

OVER the past few years we have published a number of circuits related to electronic slide control systems. Many photography enthusiasts and photographers' clubs are now using two or more projectors to bring life to otherwise rather dull slide presentations. At some stage, it will be required to add sound to the presentation, and be able to have some special effects such as fading one slide into another. These functions invariably require an electronic slide projector control, a lamp dimmer, and a system to synchronize the audio track on a tape recorder to the projector control.

The circuit described here records time signals on a tape track. This is done at fixed intervals, allowing projector control commands to be accurately timed and processed by, for instance, a computer. Similar systems are also available commercially (at a much higher cost than the circuit described here), and are generally identified as being based on timecode synchronization.

To be able to make optimum use of the circuit, you will need the following equipment: a slide projector control (Ref. 1), a multitrack recorder, slide projectors and a computer. The computer can be a PC or a microprocessor-controlled stand-alone system. Such a system, based on a Z80 microprocessor, is currently being developed and will be published in a future article.

The complete system is capable of controlling the slide projector and the timecode interface. The practical use is basically as follows. The computer is used to program a slide presentation with all the possible effects such as 'fades', 'twinkles' and lamp intensity changes. Next, the presentation is coupled to a music/voice programme on tape via the timecode interface. The time information used to control the slide projector is recorded on track 3 or 4 of the tape, and allows the user to define the exact instants when a slide control command occurs. This provides perfect synchronization between the tape and the slide projector. A change in the timing in the series only requires a different timing code to be recorded. This can be done at an accuracy of 10 ms, which is quite a luxury compared to hand-timing the pulses, which hardly allows control signals to be moved back and forth if a correction is required.

As already mentioned, timecode systems are available commercially. These systems are pretty expensive, though, and often do not include the necessary lamp control circuits, or 'faders'. The system proposed here is much cheaper, has a performance which is at least equal to commercial systems, and is suitable for 4 to 16 projectors.

The principle

The time code is recorded on tape as a serial signal with a bit rate of about 1,000 per second. The system is suitable for reel and cassette tape recorders. The logic ones and zeroes that form the digital control signal are converted into bursts of 5,000 Hz and 2,500 Hz respectively. Each byte (8 bits) requires about 10 ms. A complete digital word consists of one startbit, eight databits, one parity bit and two stop bits.

One nibble (4 bits) allows a decimal number to be stored. When 5 nibbles are used, we can put a time code on tape that sets a control action which is to occur 99 minutes and 59.9 seconds later (or, slightly unusually, 9999,9 seconds). This means that the timecode has sufficient capacity for use with long-play reel recorder tapes.

Since 5 nibbles correspond to 2½ bytes, one nibble remains for a an integrity check on the data recorded on tape. One complete timecode, including the checksum, takes about 30 ms.

Since the timecode and the music programme are recorded on the same tape, the two are inseparable. This means that the synchronization is not upset by tape stretch and other irregularities during recording or playback.

When the timecode is read back from the tape, the resolution can be increased by hav-

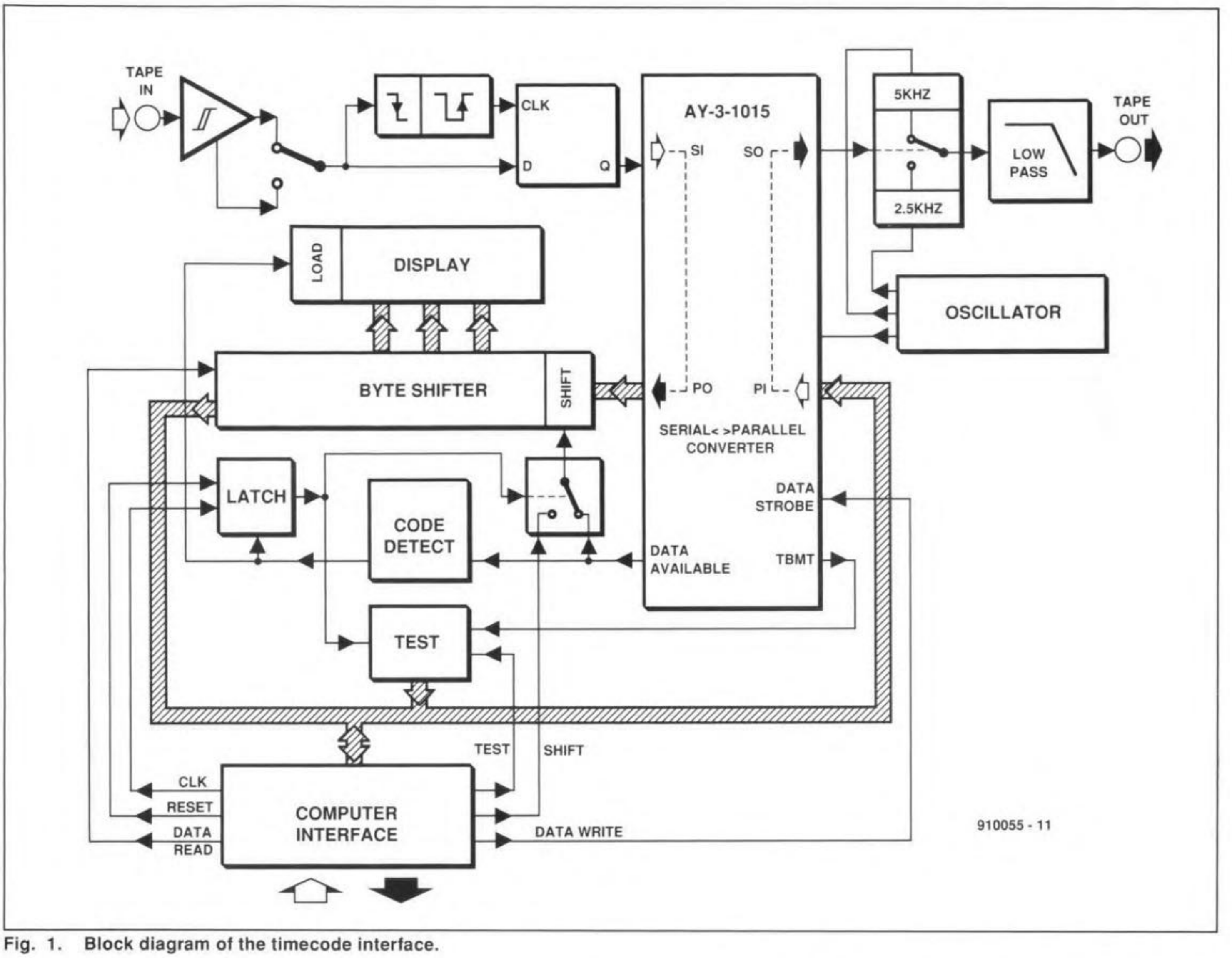


Fig. 1. Block diagram of the timecode interface.

ing the computer calculate times in between recorded time codes. Note, however, that this implies that the computer clock must be capable of working on its own, without copying any incorrectly decoded time information. When the timer is used in manual mode, the higher resolution intervals are not applicable, since we have enough trouble as it is detecting codes in 0.1-s steps and responding to them with the appropriate action. For manual use, the timecode interface can be equipped with a LED read-out that shows the current time. This read-out is modular and based on LED units used in the Elektor Electronics Digital Train System (EEDTS, see Ref. 2). When the tape is played back, the interface can be disconnected from the computer and used as a digital tape counter.

The timecode interface is perfect for use with the projector control system described in Ref. 1. We have no reservations about calling the resulting slide presentations professional and timed to perfection.

Those of you who have already looked at the photograph of the prototype may wonder why it has four line signal sockets, where only two are expected for a two-way recorder connection (one input and one output). The two extra sockets allow a new data format to be generated that contains all the information about a certain slide presentation. This enables a presentation with a sound programme to be started at any point in the slide sequence. More importantly, however, the extra format makes the use of floppy discs optional while still ensuring that the information about the sequence remains coupled to the sound programme. During the development of the slide presentation, time codes are generated on a PC and sent to a stand-alone controller. Next, the new data format is recorded on another tape track. By virtue of the information on this track, the actual presentation can then be run without a PC.

A look at the hardware

The hardware for the timecode interface is designed to allow a minimum amount of software to control both the timecode system and the (optional) read-out. In principle, it is possible to record and retrieve the serial code direct to and from the magnetic medium. This is usually done with the aid of a serial-to-parallel converter. Such a system, however, requires continuous read and write operations on the tape, which can be problematic if a reliable RS232 connection is not available on the computer.

Here, the hardware is capable of gathering all bytes that form a code, and storing them until the next code is available. If necessary, the computer can call up a certain code. Note, however, that the code can be read out only once to prevent the system reading incorrect codes. The data can be read by the computer at high speed in parallel form. Likewise, the writing of data to the timecode interface, and from there to the tape, is a simple process that requires little time.

The block diagram in Fig. 1 illustrates the operation of the system. The most important part is the bidirectional serial-to-parallel converter. Data is recorded on the tape and played back as a serial signal. In the circuit, however, all information is processed as parallel data.

The format converter is capable of transmitting and receiving independently. The clock oscillator determines the speed of the serial signal, which, incidentally, may be set differently for transmission and reception.

Transmit operation

The parallel data applied to the unit by the computer is converted into a serial datastream that consists of logic ones and zeroes. Next, these digital levels are converted into tone bursts of 2,500 Hz (logic 0) and 5,000 Hz (logic 1). The clock frequencies used for this conversion are derived from the converter clock. Before the bursts are sent to the tape recorder, their level is adapted, and the bandwidth is limited.

Receive operation

The data retrieved from the tape is amplified and subsequently digitized by a Schmitt-trigger. A frequency detector recognizes the two burst frequencies, and converts them into logic 1s and 0s which are applied to the serial-to-parallel converter. When the data is valid, the 'data available' (DAV) signal is actuated, and the data appears on the parallel outputs of the converter.

Data processing

A time code consists of three bytes which are held together as a unit by a byte shifter and a code detector. When the converter detects the start of a new dataword, the previously loaded word is shifted one location in the byte shifter. In this way, the system can hold up to four bytes at a time. The 'oldest' byte is lost when the next word appears.

To enable the system to recognize a complete code in the datastream, the codes are separated by short pauses. This results in the DAV signal being active longer during a pause than in between bytes that form a code. This is detected by the 'code detect' block, which also serves to feed the received code to the display. When the codes are not used, the display will simply show them one by one as they are retrieved from the tape.

Computer action

The synchronization function of the circuit requires that the time information can be read, recognized and processed. This is achieved via an interface that allows the computer to detect the presence of a timecode. The code detector output is latched in the computer interface with the aid of the CLK (clock) line. A buffer, which also serves to read other signals, allows the computer to test for the presence of a code. To prevent new databytes being loaded, the shift input is also switched to the computer interface when a code is present.

The computer interface allows the code to be read and processed on a byte-by-byte basis. When the read operation is finished, the latch requires a reset signal before it can accept the next code.

Timing of the datastream

It will be clear that the bytes that make up the time code must be sent in quick succession to enable the system to detect them as a coherent block. We must take into account however the code detection time as well as the time required to convert a byte to serial format and record it on the tape. Since the parallel-to-serial converter can not handle further data just after receiving a byte, and has only room for two bytes, there is a requirement for the system to signal that the next databyte can be offered. This is achieved by using the TBMT (Transmitter Buffer eMpTy) signal supplied by the converter. A new databyte can be applied as long as TMBT is active, indicating that the

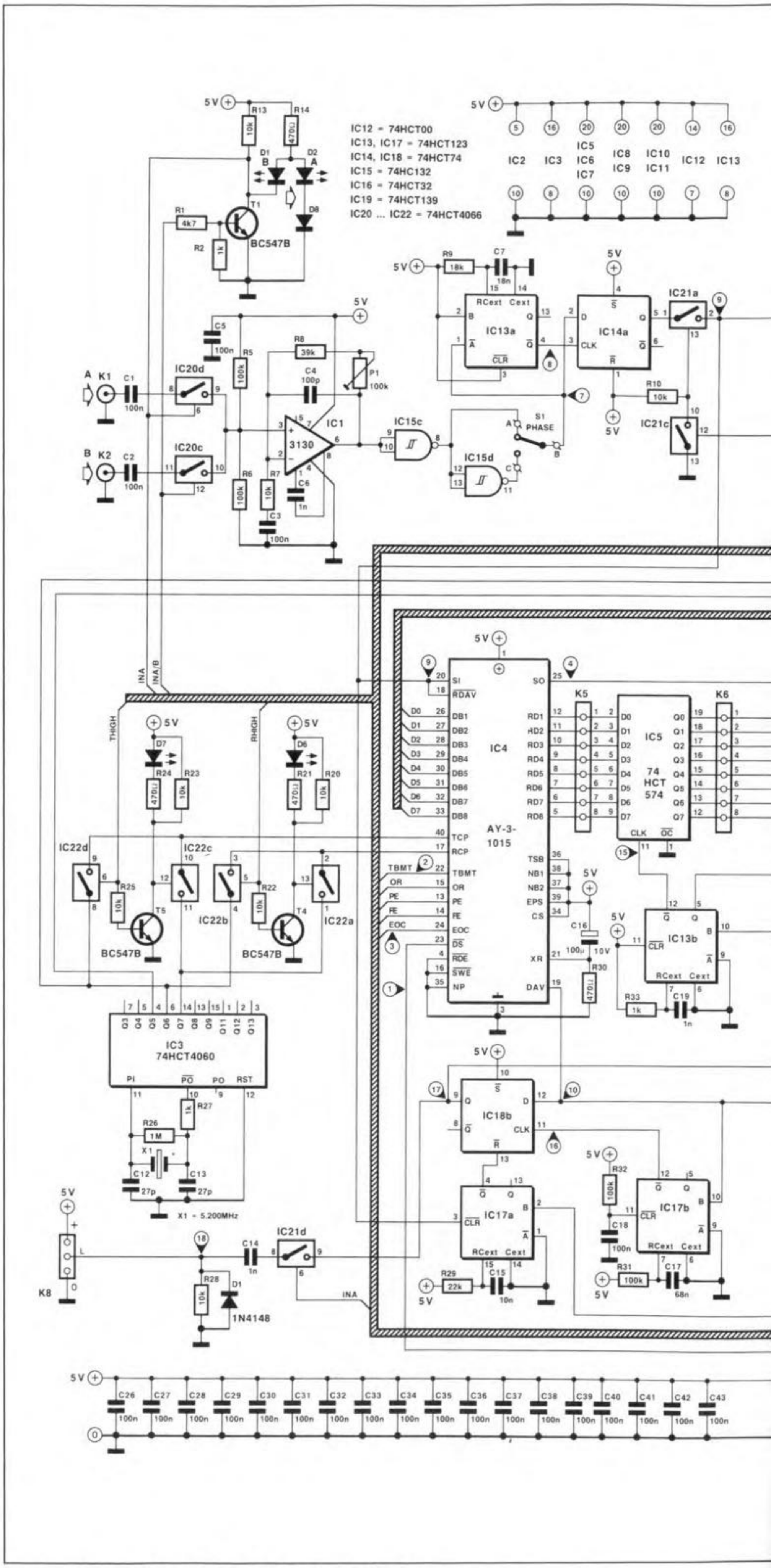
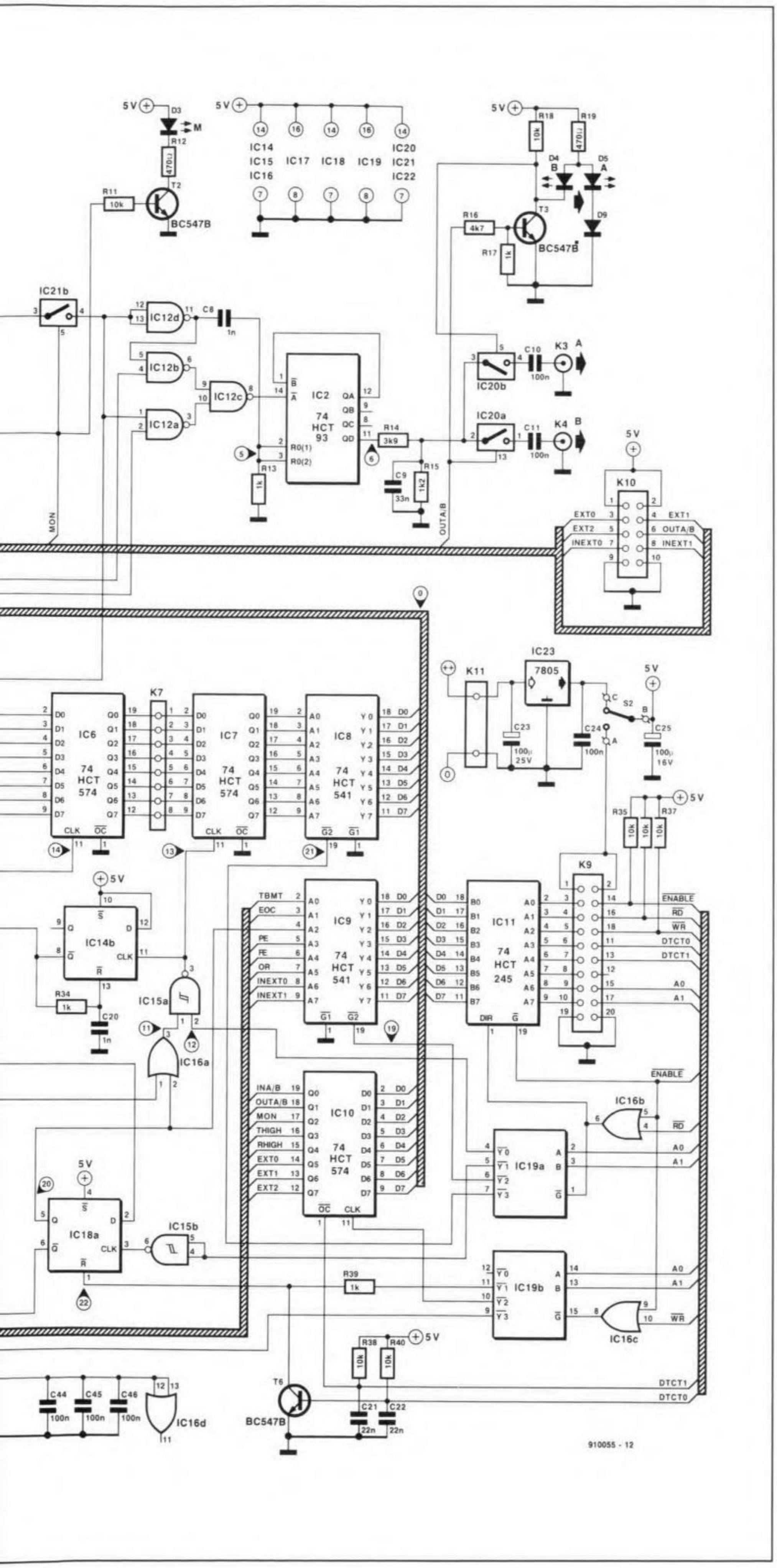


Fig. 2. Circuit diagram of the timecode interface.



transmit buffer is empty after sending a byte to the internal shift register.

The write speed of the system is ensured by sending the bytes that form a code at the time the buffer is empty. Due care should be taken, however, to leave sufficient time between codes to enable them to be detected as coherent blocks during reception.

The above system works on the assumption that the TBMT output of the converter is continuously monitored. Another possibility is to send the next byte just before the end of the previous one, under interrupt control. This allows the system to handle other tasks in the mean time, without being fully 'tied up' with the interface.

The interface is based on two possible speeds, 10 ms/byte and 5 ms/byte. These speeds allow interrupt cycles to be used of 20 ms and 10 ms respectively (two bytes can be sent during an interrupt). To make sure that the code can also be read back under interrupt control, a minimum pause of one interrupt period is required.

Computer interface

The interface between the timecode controller and the computer is relatively simple, and consists of a few ICs only. The PC and the timecode interface communicate via the universal I/O interface for IBM PCs (Ref. 3). As already mentioned, we have in the pipeline a stand-alone Z80-based control card designed to assume the function of the PC. This card also has an interface for the slide controller, and offers PC control and manual control as options.

Circuit description

The practical realization of the above functions is shown in the circuit diagram in Fig. 2. The heart of the circuit is formed by the parallel-to-series format converter, a UART (universal asynchronous receiver/transmitter) Type AY3-1015D, IC4. This IC is capable of converting data from serial to parallel and parallel to serial. These operations are independent and may run at different speeds.

First, the parallel-to-series conversion is described, i.e., the writing of data to tape. The timing diagrams in Fig. 3 through 6 illustrate how the conversion works. The numbers that identify the signals in the timing diagrams correspond to those found at various points in the circuit diagram.

Parallel-to-series conversion

Figure 3 illustrates how a parallel code is converted into a serial signal that is recorded on to tape. The signal direction is basically via IC11 and a pulse at the $\overline{DS}$ (data strobe) input of IC1 (signal 1). The tape signal is shown as signal 6. First, the code is converted from parallel into serial format. The serial output signal, 4, available at the SO (serial output) pin of IC4, is fed to IC12.

A clock oscillator based on a 4060, IC3, determines the bit rate of the serial signal. The electronic switches in IC22 select between two clock speeds, which may be set in-

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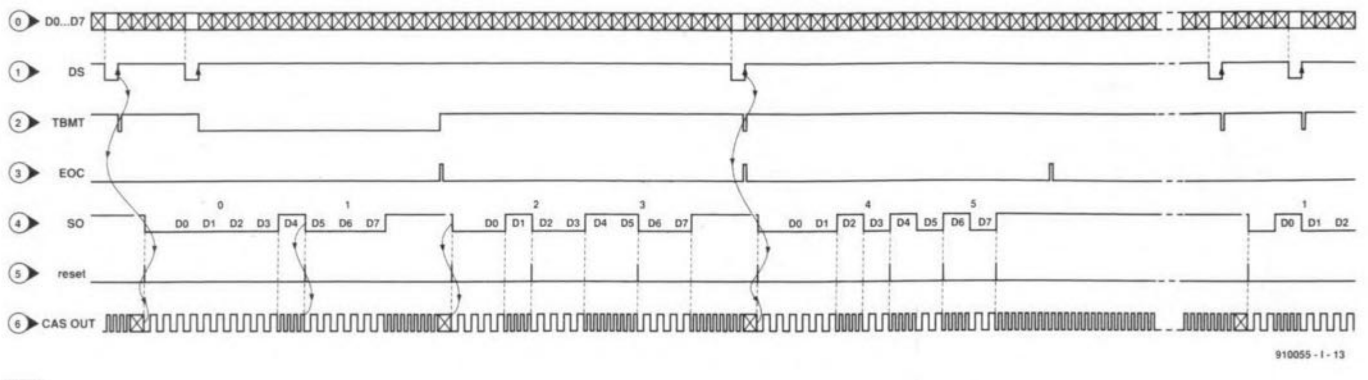
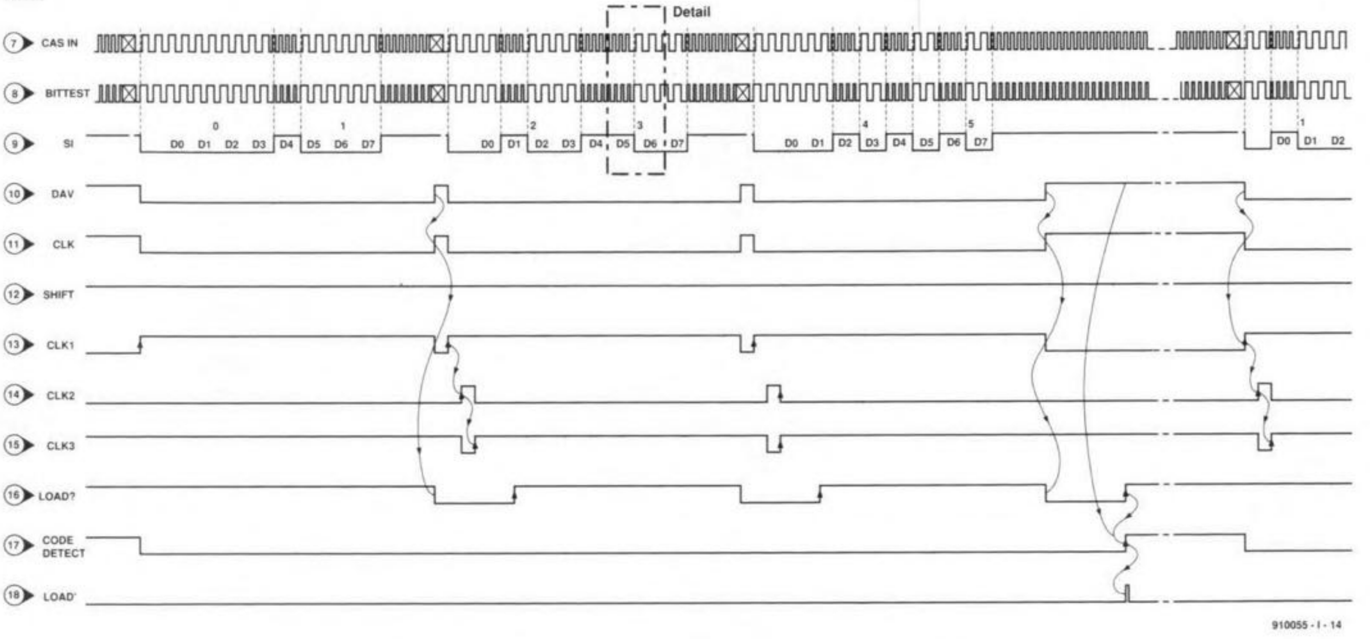
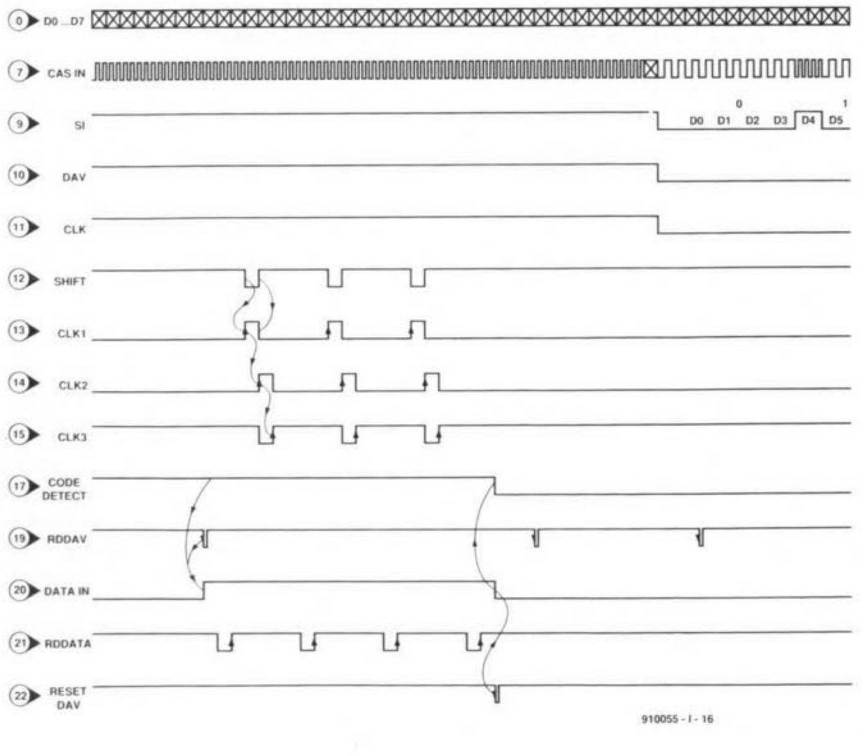

0 D0...D7
1 DS
2 TBMT
3 EOC
4 SO
5 reset
6 CAS OUT
D0 D1 D2 D3 D4 D5 D6 D7
910055 - I - 13

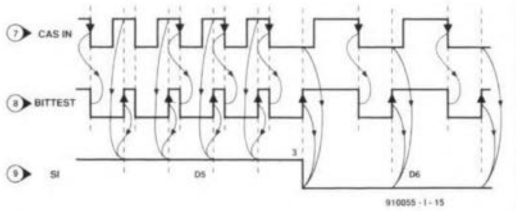
4


Detail
7 CAS IN
8 BITTEST
9 SI
10 DAV
11 CLK
12 SHIFT
13 CLK1
14 CLK2
15 CLK3
16 LOAD?
17 CODE DETECT
18 LOAD'
D0 D1 D2 D3 D4 D5 D6 D7
910055 - I - 14

5


0 D0...D7
7 CAS IN
9 SI
10 DAV
11 CLK
12 SHIFT
13 CLK1
14 CLK2
15 CLK3
17 CODE DETECT
19 RDDAV
20 DATA IN
21 RDDATA
22 RESET DAV
D0 D1 D2 D3 D4 D5
910055 - I - 16

6


7 CAS IN
8 BITTEST
9 SI
D5
D6
910055 - I - 15

dependently for transmission and reception. The clock oscillator also determines which frequencies are fed to gates IC12a and IC12b. IC12 forms a frequency selector controlled by the level of the SO output of IC4. IC2 divides the output signal of IC12c by eight. Assuming that the lower bit rate is used, this results in four periods for a logic 1, and two periods for a logic 0, corresponding to frequencies of about 5 kHz and 2.5 kHz respectively. At the higher bit rate, the number of periods is halved (but the frequencies remain the same).

You may wonder why we have gone to all this trouble when the outputs of the 4060 already supply the required burst frequencies. The reason is that the signals at the divider outputs are not synchronous with the UART output signal (remember, the UART derives the timing of SO from its clock signal). If the bursts are not generated synchroously with the SO signal, frequency changes could occur in one period, resulting in signal peaks, tape saturation and other unwanted effects that cause trouble when the data is read back from the tape. In the present circuit, the synchronism is actually achieved by C8 and R13, which reset IC2 (signal 5) on every logic 0 (which occurs at the start of a serial word). This ensures that every dataword starts with a well-defined 'low' period.

Components R14, R15 and C9 form a level conversion circuit as well as a low-pass filter. The output signal is limited to about 1 V_{pp}. Electronic switches IC20a and IC20betermineo to which output the recording signal is fed.

Function	A1	A2	$\overline{RD}$	$\overline{WR}$	I/O address
SHIFT	0	0	0	1	BASE + 0
RRDDAV	0	1	0	1	BASE + 1
TEST	1	0	0	1	BASE + 2
RDDATA	1	1	0	1	BASE + 3
---	0	0	1	0	BASE + 0
RESETDAV	0	1	1	0	BASE + 1
WRTAPE	1	0	1	0	BASE + 2
WRDATA	1	1	1	0	BASE + 3

Table 1. Address assignment in the timecode interface.

Serial-to-parallel conversion

At the tape input of the interface, switches IC20d and IC20c determine which signal is fed to amplifier IC1. The gain of IC1 is made adjustable with preset P1 to allow the sensitivity of the circuit to be matched to the playback level of the tape recorder used. IC1 is set to amplify the sinusoidal input signals with respect to half the supply voltage. Next, the signal is converted into a pulse train from which the logic 1s and 0s can be extracted. This is achieved in a reliable manner by making use of a specific characteristic of HCMOS integrated circuits, in which the digital level (0 or 1) is related to half the supply voltage. This means that a gate in the 74HC132 package forms an ideal zero-crossing detector if a little hysteresis is added. Mind you: IC15 must be a HC type, not a HCT type.

Assuming that the data recovery circuit works, pin 8 of IC15 supplies a copy of the signal sent to the tape recorder (signal 6). To eliminate the 180° phase shift introduced between the input and the output of some tape recorders, switch S1 allows the digital datastream to be inverted.

As shown in the timing diagrams, signal 7 consists of two frequencies that must be converted into logic 0s and 1s (see also Fig. 4). The falling signal edges (signal 7) start a one-shot, IC13, whose output pulse width is set to about 75% of the period of the highest burst frequency. When the $\overline{Q}$ output (signal 8) returns to logic high, the level of the input signal is latched in IC14a. As illustrated in Fig. 5, a logic 1 is latched at a high frequency, and a logic low at a low frequency. The decoded signal (9) is fed to the serial input of the UART via electronic switch IC21a. The result of the serial-to-parallel conversion is available on pins 5 through 12 of IC4. The DAV output of the converter (signal 10) indicates that a new byte has been read.

The byte shifter discussed earlier is formed by IC5, IC6 and IC7. A rising edge at the CLK input of IC7 (signal 13) causes the byte to be transferred from the input to the output. At the same time, MMV (monostable multivibrator) IC14b is started. A little later, IC14b starts another MMV, IC13b. The setting of IC13b clocks IC6 (signal 14), while the resetting clocks IC5 (signal 15). This results in all bytes available via K5, K6 and K7 being shifted one position.

Disregarding the computer interface for the moment, signal 13 is the result of the DAV (data available) signal (10). At the end of the DAV signal, a new byte enters the byte shifter. DAV is reset by the start bit of the next byte received.

Besides controlling the byte shifter, signal 10 starts the code detector formed by IC17b and IC18b. If signal 10 is still at logic 1 when the $\overline{Q}$ pulse is finished (this occurs when a code is received), a logic 1 is latched in IC18b (signal 17). A start bit of the next byte in a subsequent code (signal 9) resets this information again via IC17a. The received code can be visualized by connecting 2½ 'EEDTS' address display modules to K5, K6 and K7. The code displayed remains stable until a new valid code is received.

When input B is used, the display is switched off because it would show a different data format that makes no sense to visualize.

Communication with the computer

Connector K9 may be connected to the universal I/O interface (Ref. 3) or to any other equipment that provides a similar control bus. The PC I/O interface keeps the address decoding in the timecode circuit simple. The address selection signals are available at the outputs of IC19a (read) and IC19b (write). Table 1 lists the functions of the selection lines. The RDAV signal allows us to check the status of the code detector (signal 17). When a code is ready for reading, this condition is stored in IC18a (signal 20). This bistable blocks signal 10, which prevents the code being changed in the mean time. The TEST signal (19) is used to read the information held by buffer IC9. TEST indicates that a code has been detected. If it is active, the databytes can be read or shifted with the aid of RDDATA (21) and SHIFT (12) — see Fig. 6.

The code detector is restarted by signal 22, RDAV. The $\overline{Q}$ output of IC18a resets the code detector via IC17a. The UART is written to with the aid of the WRDATA signal.

The WRTAPE signal enables input A or B to be selected via IC10, a monitor position to be switched (SO, signal 4, is fed direct to SI, signal 9), and the transmitter and the receiver to be switched to the high bit rate via THIGH and RHIGH.

The remaining inputs and outputs of IC9 and IC10 are brought together on connector K10, which is intended for options related to recorder control.

Status signalling and power supply

LEDs are used at a number of positions in the circuit to indicate the configuration selected.

A voltage regulator, IC23, is provided on the board to enable the circuit to be powered by a mains adaptor when used in stand-alone applications without a computer link (tape playback only). Components R35 to R40, C21 and C22 ensure that the interface can read tape signals recorded at the low bit rate. Switch S2 provides a selection between computer supply or adaptor supply. ❑

Continued in the September 1991 issue.

References:

1. "Computer-controlled slide fader" *Elektor Electronics*, March and April 1988
1a. "Centronics interface for slide fader" *Elektor Electronics*, October 1988.
1c. "Replacement for TCA280A" *Elektor Electronics* March 1990.
2. "The digital model train" Part 12 — address display, *Elektor Electronics*, March 1990.
3. "Universal I/O interface for IBM PCs" *Elektor Electronics*, May 1991.

INTERMEDIATE PROJECT

A series of projects for the not-so-experienced constructor. Although each article will describe in detail the operation, use, construction and, where relevant, the underlying theory of the project, constructors will, none the less, require an elementary knowledge of electronic engineering. Each project in the series will be based on inexpensive and commonly available parts.

MODERN LED CLOCK

Clocks, as most of you will be aware, can take many shapes and sizes. Here is one with a fairly unusual read-out, intended as an eye catcher on your desk.

J. Ruffell

As shown in Fig. 1, the 29 LEDs on the front panel of the clock are arranged in four groups: 12 for the hours indication, 6 for the 10-minutes indication, 10 for the minutes, and 1 for the seconds indication. The read-out works as follows: suppose it is 3.54 (a.m. or p.m.). This time is indicated as follows: in the top bar, the third LED from the left lights (3 hours); in the centre bar, the LED at the extreme right (50 minutes); and in the lower bar, the fifth LED from the left (4 minutes). The time indication is, therefore, obtained by adding the values indicated by the three bars.

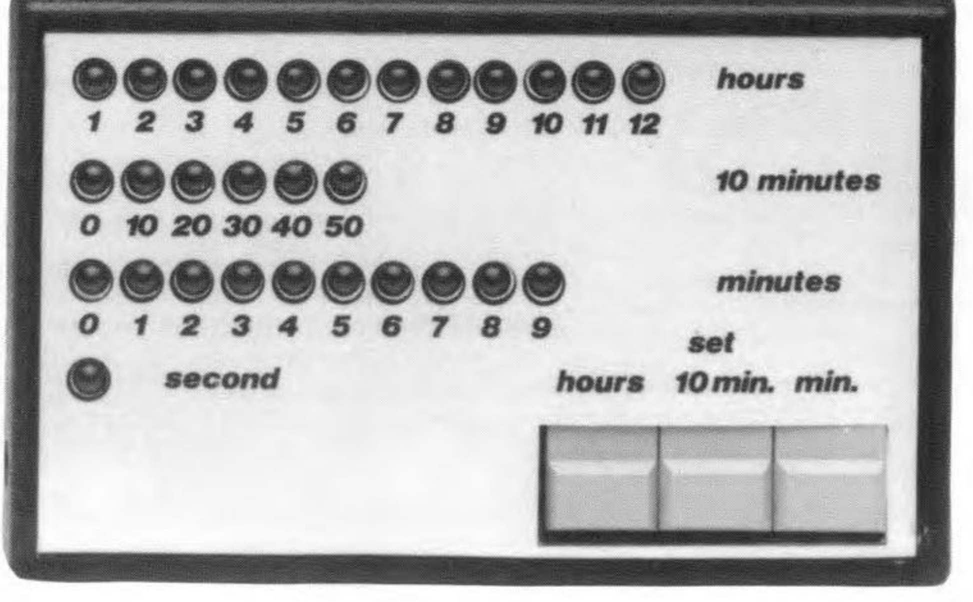
The circuit

The clock consists of three main parts: a counter, an adjustment circuit, and a read-out. These functions are easily located in the circuit diagram, Fig. 2. The mains frequency, 50 Hz, is applied to the clock input of counter IC1, which divides the clock input signal by 50. Its Q2B output supplies the seconds pulses. If the mains frequency is 60 Hz, pin 11 of IC1 should be tied to ground instead of to the positive supply line.

The second counter, IC4, is wired to divide by 60, and supplies the minutes pulses, i.e., a rectangular output signal with a period of 1 minute. Via an XOR gate, N1, the minutes pulses are fed to the clock input of a 4017 decade counter, IC3. The ten LEDs at the outputs of the counter, D1-D10, form the minutes read-out. When IC3 reaches output state 10, it supplies a high level at its carry-out (CO) pin. This pulse clocks a second 4017, IC5, via XOR gate N2. The second decade counter counts to 6 and drives the 10-minutes indicators, D11-D16.

Every time Q6 of IC6 goes high, the counter resets itself via D32. This happens when 6 periods of ten minutes, or 1 hour, have elapsed. The hours pulse is fed to a third 4017 counter, IC7, via XOR gate N3 and bistables FF1 and FF2. Since we require an indication of 12 units (12 hours), the hours pulse can not be fed direct to the 4017, which can only count to 10. The first bistable divides the hours pulses by two, so that the counter is advanced every two hours rather than every hour.

A 12-hour indication is obtained by resetting the counter when value 6 is reached (Q6-RST connection), and using the Q and $\overline{Q}$ signal of bistable FF1 to control two driver transistors that, in turn, control two groups of six LEDs connected to the outputs of IC7. This works as follows. The first clock pulse sets FF1, so that the Q output goes high, and



the $\overline{Q}$ output low. This switches on T2, so that one of the LEDs D23-D28 lights. The 0-to-1 transition at the Q output of FF1 sets the second bistable, FF2, which actuates its Q output and thus clocks IC7, while T1 is switched off (because $\overline{Q}$ is low). The two bistables toggle on the next clock pulse supplied by N3. As a result, T1 starts to conduct, so that one of the LEDs D17-D22 lights. The other group of LEDs, D23-D28, is switched off via T2. The counter, IC7, does not receive a clock pulse, and remains at the previous state until the third clock pulse occurs.

You may wonder at this stage why the second bistable, FF2, is used when the $\overline{Q}$ output of FF1 could control T1 direct. We found it a pity not to use the second bistable when it is available anyway in the 4013 IC. Its purpose here is to allow you to start the clock at 0.00 h exactly. By making sure that FF2 is set, and FF1 is reset, when the clock is switched

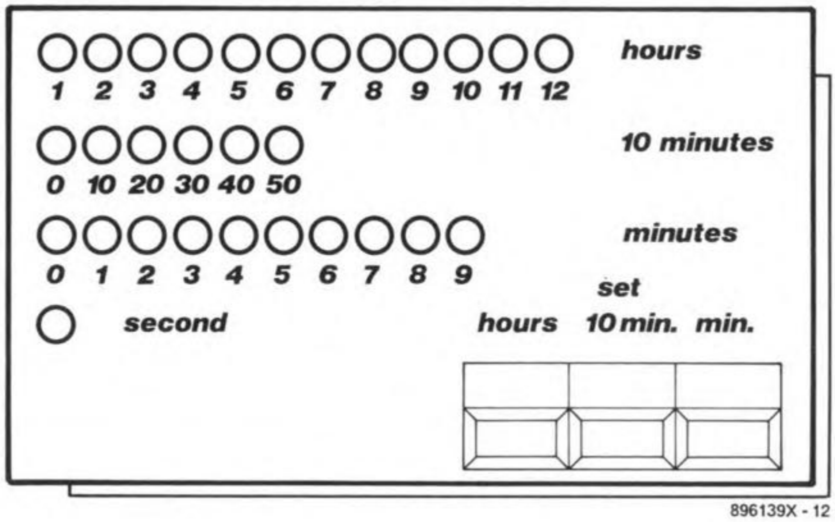


Fig. 1. Suggested front panel layout of the LED clock.

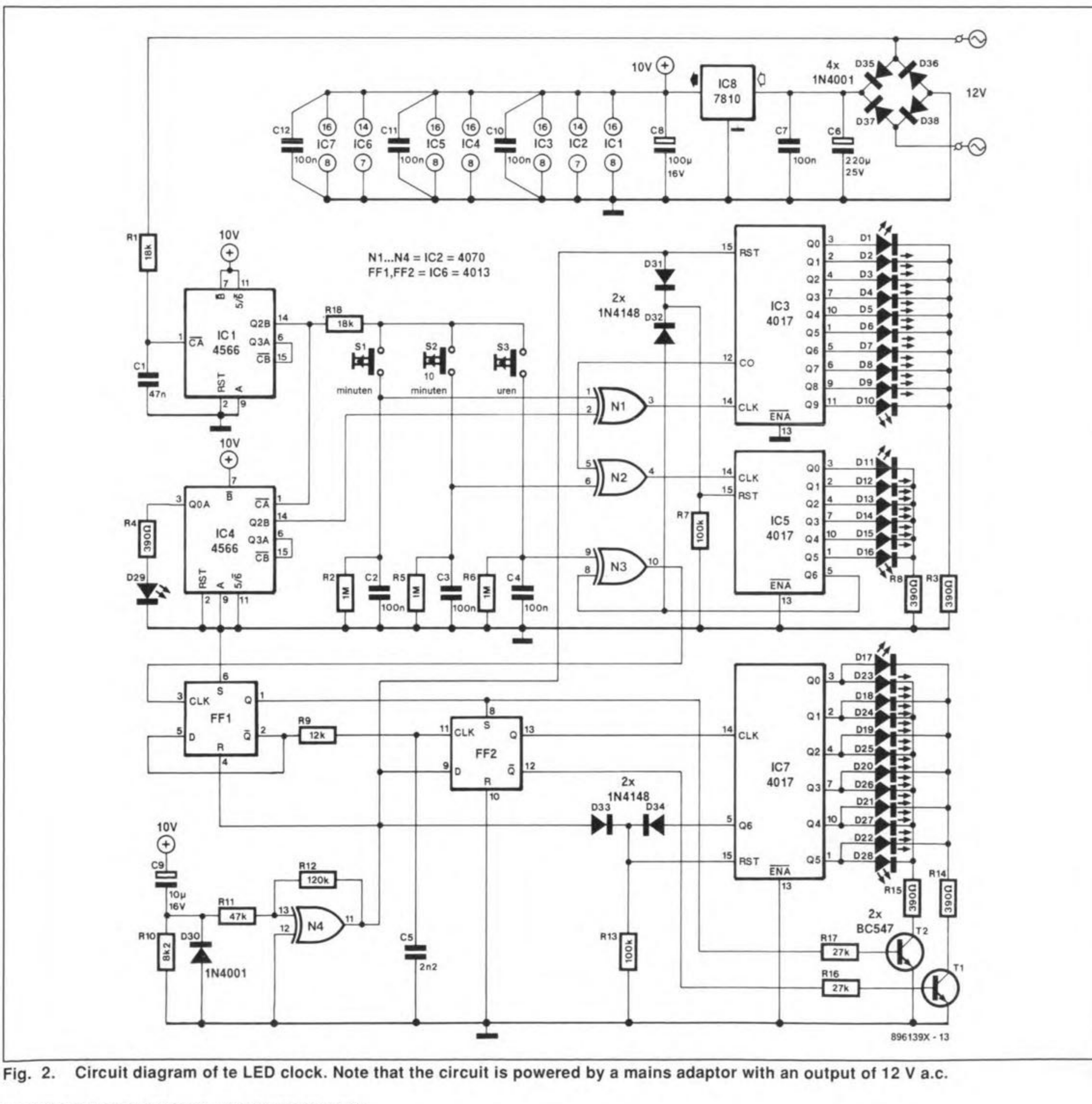


Fig. 2. Circuit diagram of te LED clock. Note that the circuit is powered by a mains adaptor with an output of 12 V a.c.

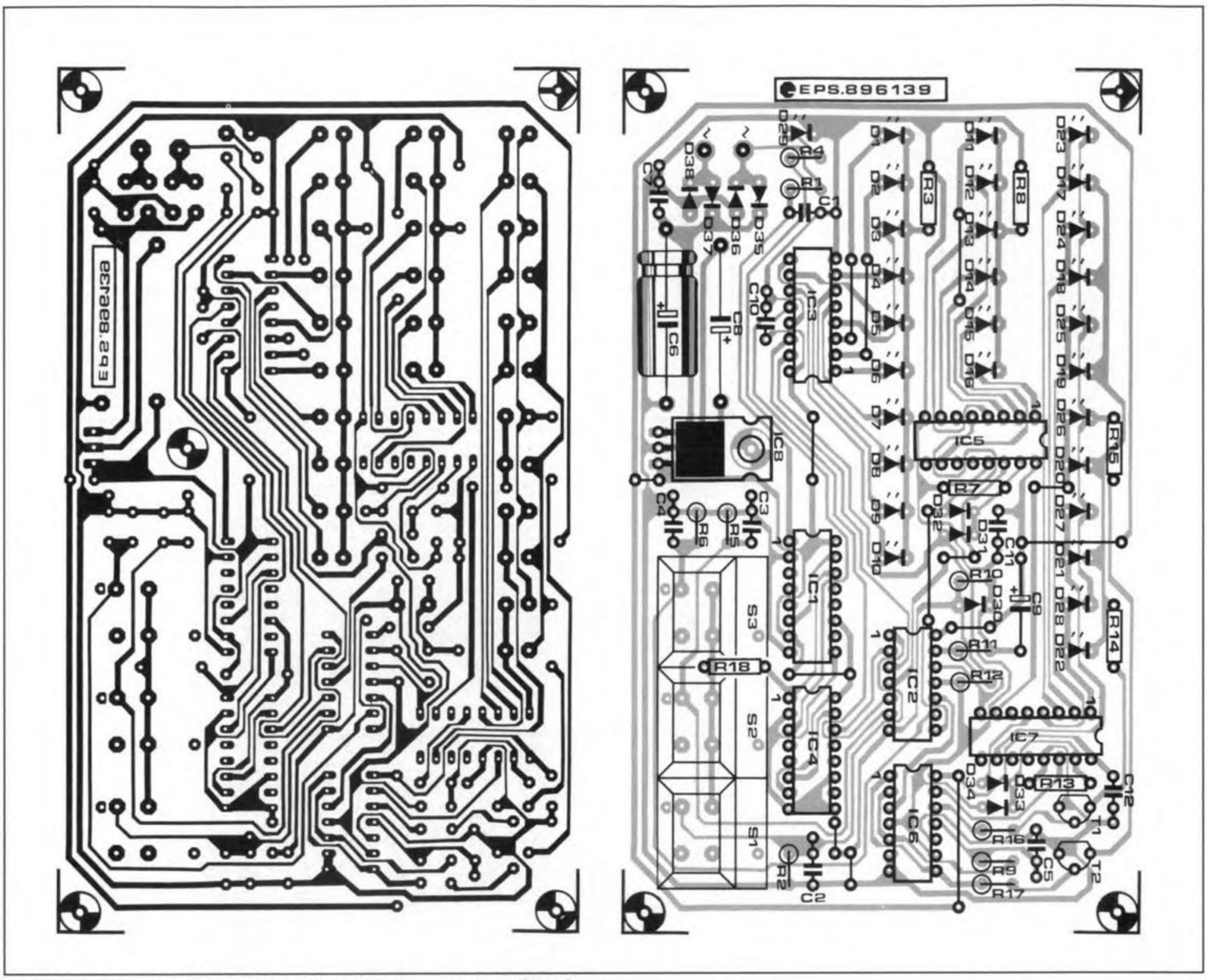


Fig. 3. Track layout (mirror image) and component mounting plan.

on, the two transistors are switched off during the first hour, allowing you to start the clock at 0.00 h exactly. Without the bistable, this would have the be done at 1.00 h, which we found less usual.

Note that although IC7 is advanced every two hours, a different LED lights every hour.

The clock is synchronized by applying the 1-Hz signal to the inputs of the minutes, 10-minutes and hours counters. This is achieved with the aid of three push-buttons, S1, S2 and S3, and three associated XOR gates, N1, N2 and N3. The push-buttons are connected to *R-C* debouncing networks to ensure reliable response of the clock setting to the actions on the keys.

Without a proper reset pulse, the decade counters, IC5 and IC7, could start at a value higher than 6 when the clock is switched on. Since in that case none of the LEDs lights, it would appear as if the clock is not functional when it is switched on. To avoid this, gate N4 supplies a well-defined reset pulse, which is also used to start the clock at 0.00 h.

The power supply is conventional, and based on a three-pin fixed voltage regulator Type 7810 (IC8). The input voltage to the board is supplied by the secondary winding of a 12-V transformer.

COMPONENTS LIST

Resistors:

2	18kΩ	R1;R18
3	1MΩ	R2;R5;R6
5	390Ω	R3;R4;R8;R14; R15
2	100kΩ	R7;R13
1	12kΩ	R9
1	8kΩ2	R10
1	47kΩ	R11
1	120kΩ	R12
2	27kΩ	R16;R17

Capacitors:

1	47nF	C1
7	100nF	C2;C3;C4;C7; C10;C11;C12
1	2nF2	C5
1	220µF 25V	C6
1	100 µF 16V	C8
1	10µF 16V	C9

Semiconductors:

29	LED	D1-D29
5	1N4001	D30;D35-D38
4	1N4148	D31-D34
2	BC547	T1;T2
2	4566	IC1;IC4
1	4070	IC2
3	4017	IC3;IC5;IC7
1	4013	IC6
1	7810	IC8

Miscellaneous:

3	Digitast push-button	S1;S2;S3

Construction

Since the clock is a relatively complex design, it is best to build it on the printed-circuit board shown in Fig. 3 rather than on prototyping board. The construction itself is straightforward once you have produced a good quality PCB from the track layout given. All LEDs and the three switches are accommodated on the PCB, so that the wiring is limited to the two a.c. supply connections.

The clock is housed in a black ABS enclosure with a front panel to the design in Fig. 1. Once you have tested and adjusted it, put it on your desk! ■

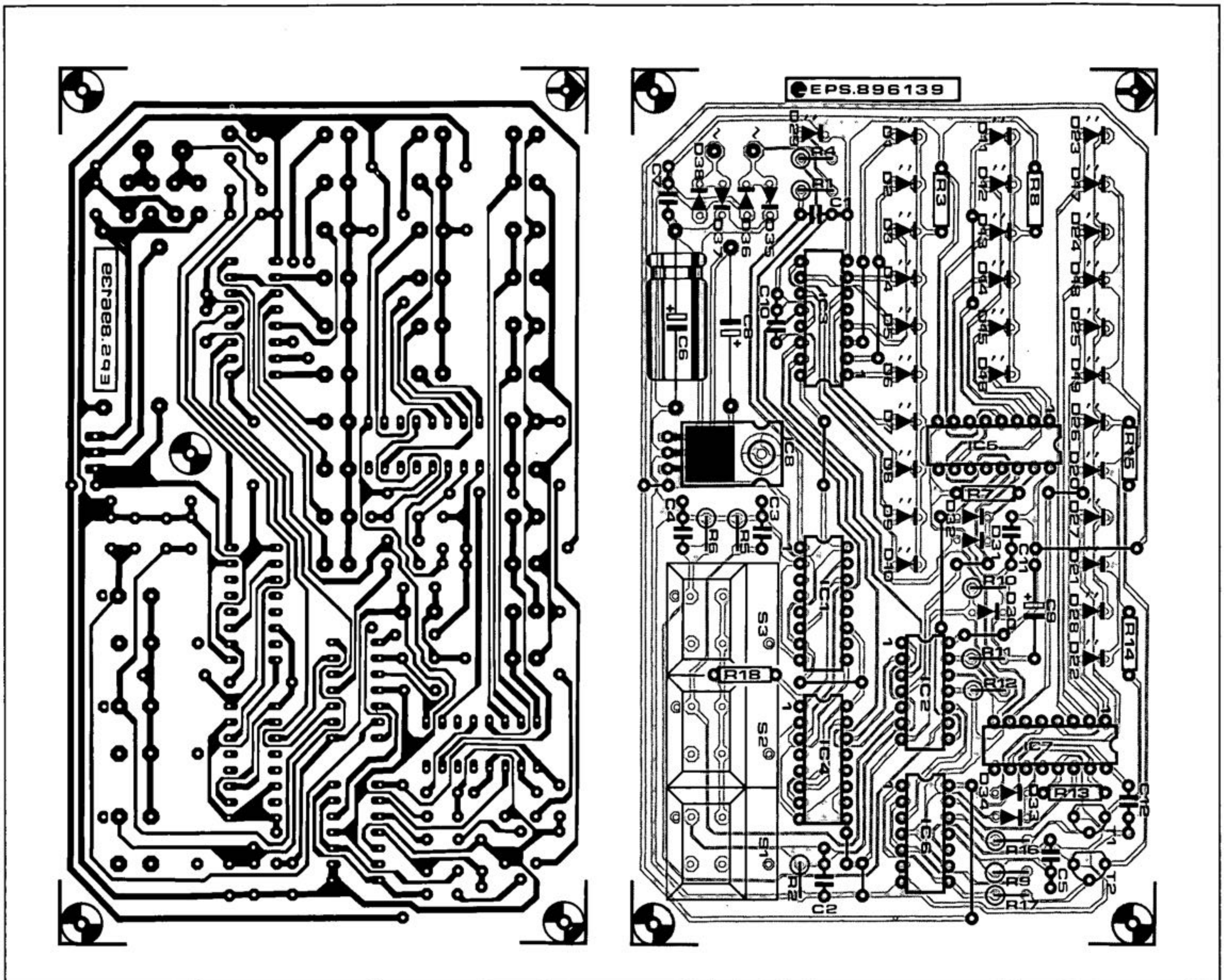
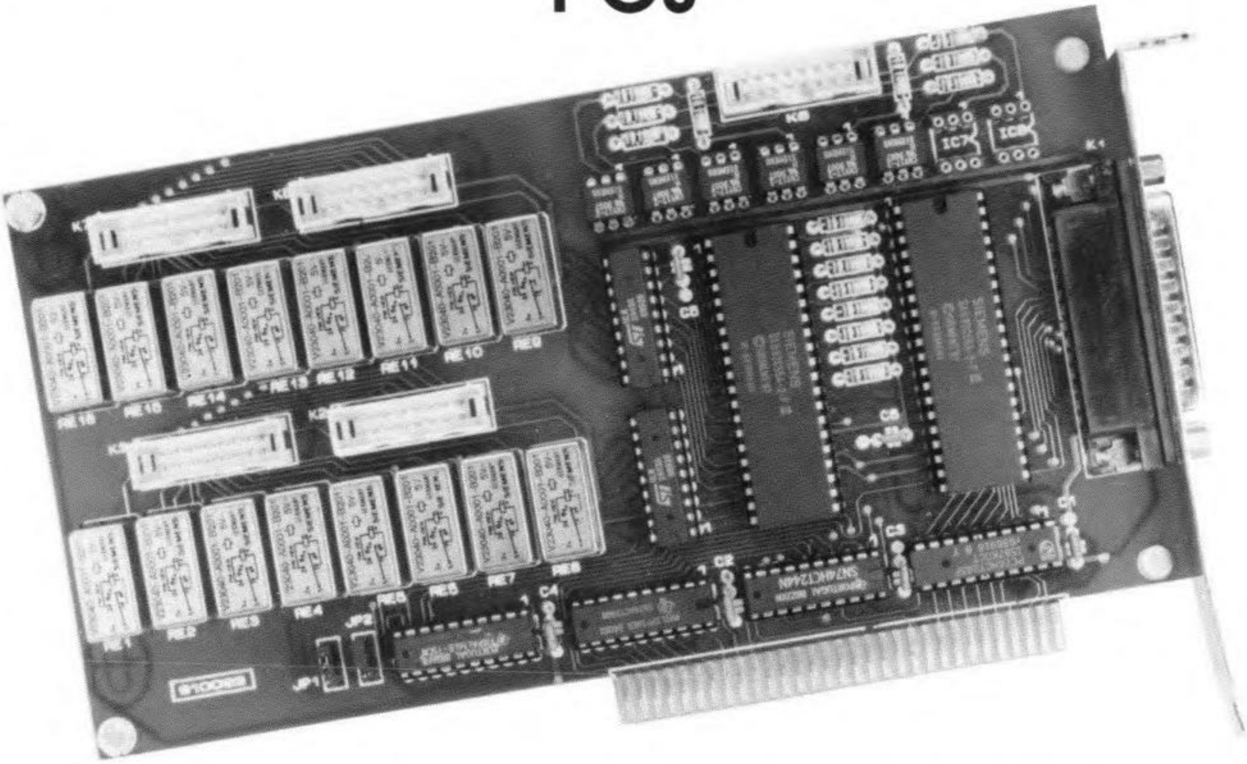


Fig. 3. Track layout (mirror image) and component mounting plan.

MULTIFUNCTION I/O CARD FOR PCs



This insertion card for IBM PCs and compatibles is the gateway to PC-based control of almost any type of equipment. Based on the familiar 8255 PPI from Intel, the card offers no fewer than 16 relay outputs, 8 electrically isolated digital inputs, and 24 programmable I/O lines.

A. Rigby

MOST industrial control systems used these days are based on PLCs (programmable logic controllers), which provide a small amount of 'intelligence' to handle automated processes at various points along a production or assembly line. Usually, the function of a PLC boils down to error detection and correction. For example, in a paper works, the sheets of paper produced by a machine will need to be packaged. This is usually done by rolling the sheets on large spools. Since the paper leaves the machine at a constant speed, and the effective diameter of the spool increases as more paper is rolled on to it, the rotational speed of a spool will need to be controlled to prevent the thin sheet of paper being torn. Such a task can, in principle, be handled by a PC equipped with the I/O card described here.

The circuit

The present I/O card is a relatively simple design because the hardware is geared fully to switching and control applications. The circuit diagram in Fig. 1 shows the general structure of the interface. The data and address signals for the I/O card are supplied by the PC via a bus extension connector. The databus is buffered by a 74HCT245 octal bidirectional driver, IC9. The address lines are buffered with unidirectional drivers, a 74HCT240 (IC10) and a 74HCT244 (IC11). Since the I/O card uses only 10 address lines, the remaining drivers in IC11 are used to buffer control signals $\overline{IOWR}$, $\overline{IORD}$, RESET and AEN.

The address buffer ICs are followed by an address decoder, which takes the form of a PAL (programmable logic array), IC12. This IC, which is available ready-programmed, performs certain combinatorial logic functions that would otherwise have required a fair number of integrated circuits. The PAL selects two address blocks in which the two PPIs (programmable peripheral interface) Type 8255 are accessed. The 8255 is used here because it is inexpensive, widely available, and simple to program.

The I/O ports of IC14 are wired direct to connector K1. The outputs of the other 8255, IC13, are connected to the on-board relays and optocouplers. Port A is connected to optocouplers IC1-IC8, while port lines PB0-PB7 and PC0-PC7 are buffered by two ULN2803 driver ICs that control the relays. The drivers ensure minimum loading of the 8255 outputs, and their built-in output diode suppresses back-e.m.f pulses when a relay coil is switched off. PPI port B switches relays Re1-

MAIN SPECIFICATIONS

- Universal I/O card for PCs and compatibles
- 16 relays with changeover contacts
- 8 optocoupler inputs for full electrical isolation
- 24 digital input/output lines
- Buffers for all PC signals
- Inexpensive and compact
- Based on PPI 8255; simple to program in BASIC or Pascal

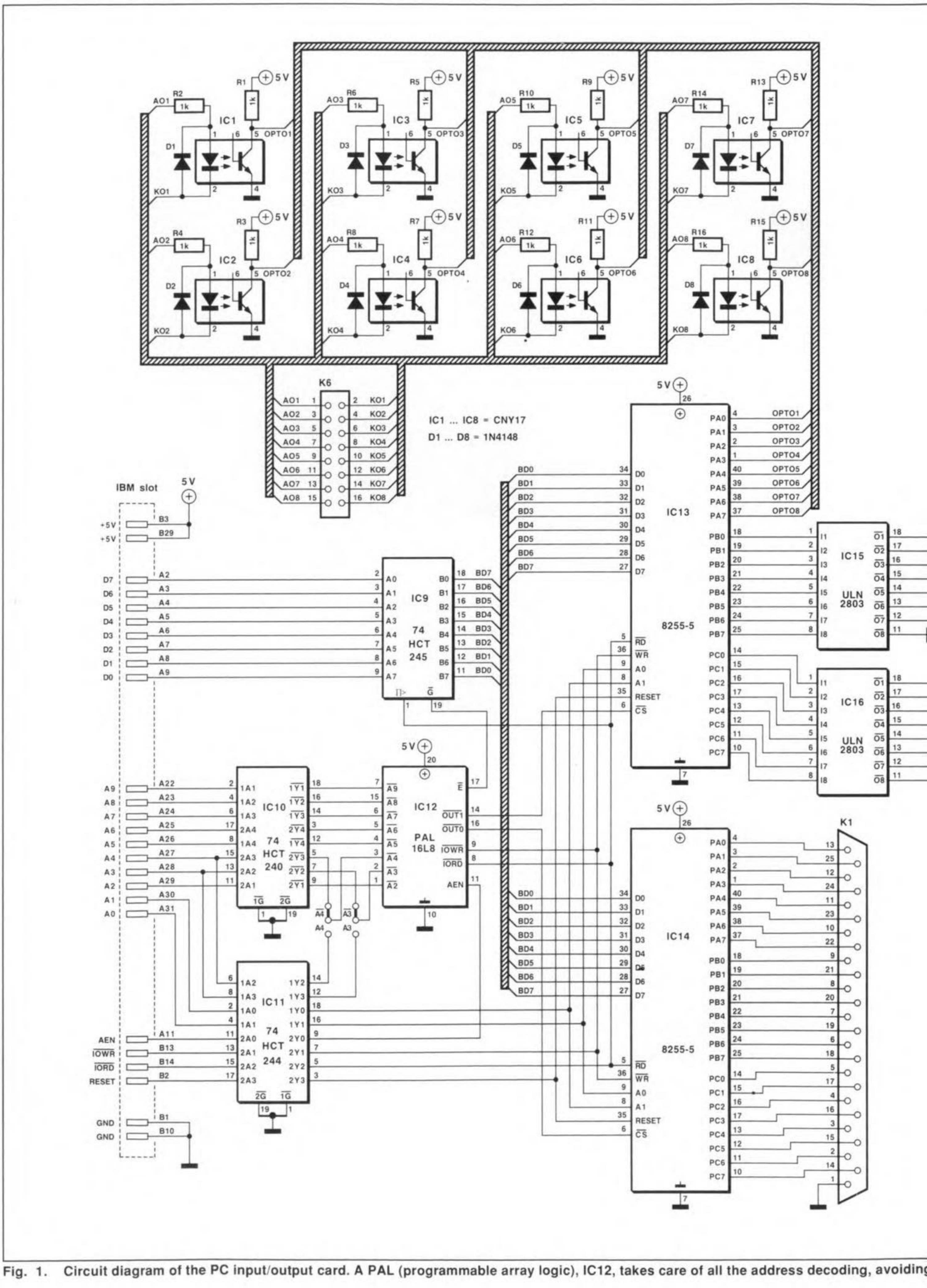
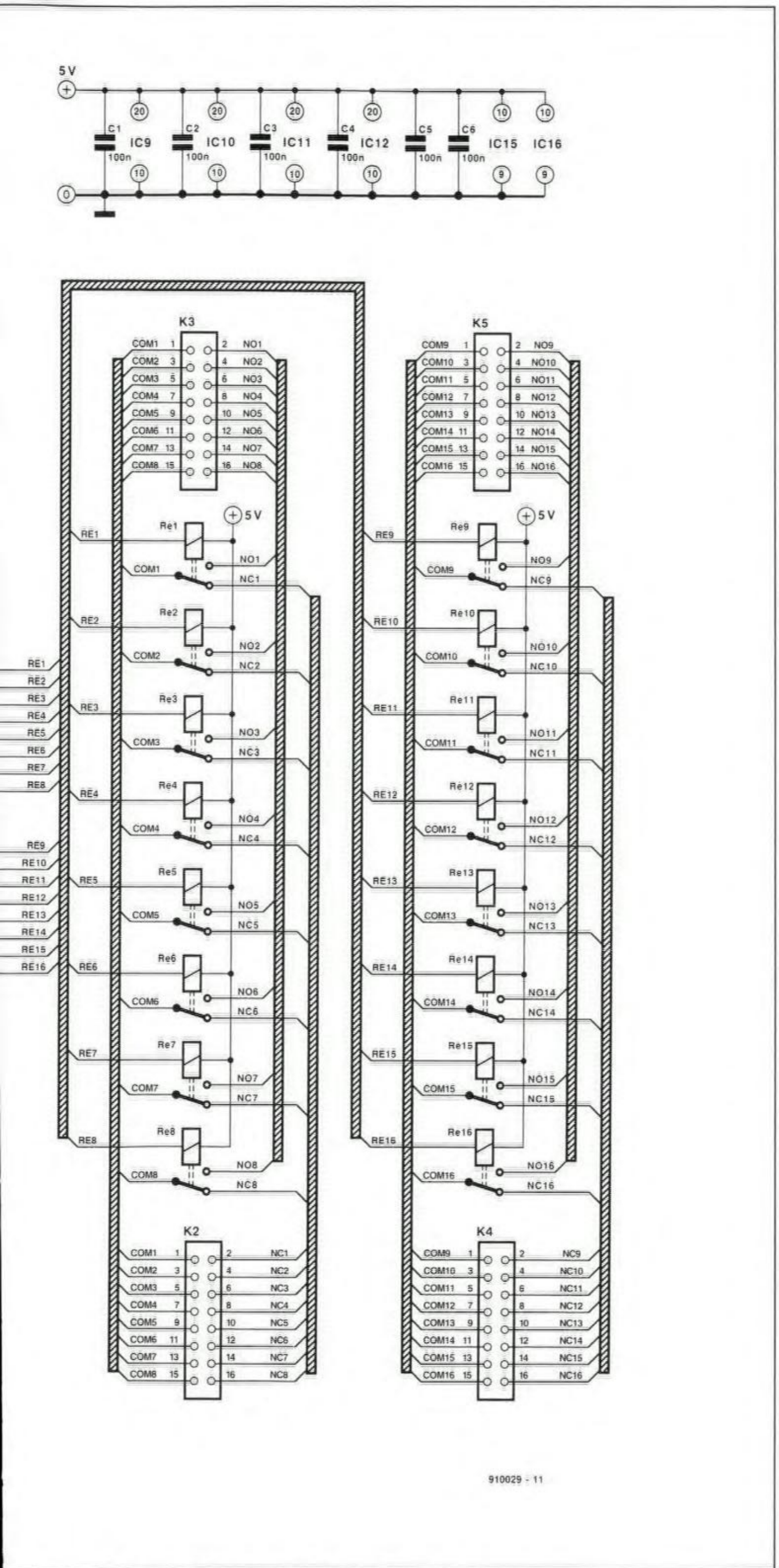


Fig. 1. Circuit diagram of the PC input/output card. A PAL (programmable array logic), IC12, takes care of all the address decoding, avoiding



complex decoder circuit based on standard logic functions.

Re8, and port C relays Re9-Re16.

Since the relays are types with a change-over contact, you have the choice between a normally open (NO) and a normally closed (NC) contact to suit your application. The relays used here are Siemens Type V23040-A0001-B201. These are quite sturdy, although they weigh only 6 g. The gold-plated, rhodium-coated, contacts are made of palladium-nickel. According to the manufacturer, the contacts are rated at a maximum current of 2 A at a voltage of 150 V d.c. or 125 V a.c. The printed-circuit board, however, forms a limiting factor here, because the copper tracks connected to the relay contacts may not carry more than 1 A. Also note that the tracks are not suitable for high voltages.

Digital input signals are measured via optocouplers that ensure electrical isolation between the PC and the peripheral equipment. Because of the inverting function of an optocoupler, a logic high input level is read as a logic 0 by the PC. The optocoupler inputs are fitted with current limiting resistors. If necessary, the value of these resistors is adapted to suit the applied voltage level, U_i. The resistors value, R, is simple to calculate from

$$R = U_i / I$$

where I lies between 5 mA and 10 mA. The LEDs in the optocouplers are fitted with parallel diodes that protect them against too high reverse voltages.

Building the card

The construction of the I/O card is simple, and merits little comment. The track layouts and component overlay of the double-sided through-plated printed circuit board are shown in Fig. 4. Ready-made boards supplied through our Readers Services are provided with gold-plated PCB bus contact fingers. All components, including the relays, are fitted on the board. The relay contacts are brought out to connectors K2, K3, K4 and K5. Input signals are applied to the card via connector K6, while the programmable I/O lines of PPI IC14 are available on connector K1.

The flatcables connected to the I/O card will have to enter the PC enclosure at a suitable location; in view of the universal character of the present I/O card, there is no other way. In some cases, the PC will have to be left open during initial tests. Later, when the card and control software have passed the test phases, a more permanent solution will have to be found to deal with the flatcables.

The only connector directly accessible at the rear of the computer is a 25-way D type that connects PPI IC14 to the real world. This connector protrudes from an aluminium fixing plate used to secure the I/O card to the metal frame at the rear of the PC.

The card must be given its appropriate address before it is fitted into a free bus extension slot. Two jumpers are used for the address setting in the I/O range between

```
 0 REM controlling multi-I/O-card for IBM-PC in BASIC
10 CLS
20 ' ...................................................... ibmio interface test
30 X=0 ' .. address 0: &H300-&H307 1: &H308-30F 2: &H310-&H317 3: &H318-31F
40 X=&H300+X*&H8
50 ' ...................................................................addresses
60 A1=X+0: B1=X+1: C1=X+2: CTRL1=X+3: ' ......................... I/O addresses
70 A2=X+4: B2=X+5: C2=X+6: CTRL2=X+7
80 OUT CTRL1,&H9B: ' ............................... A1, B1 en C1 input
90 OUT CTRL2,&H90: ' .......................... A input  B and C output
100 ' ..................................................... test of I/O ports
110 CLS
120 LOCATE 23,1:PRINT "Testing I/O"
130 LOCATE 10,1
140 FOR I=0 TO 7
150 OUT B2,2^I
160 GOSUB 240
170 NEXT I
180 FOR I=0 TO 7
190 OUT C2,2^I
200 GOSUB 240
210 NEXT I
220 PRINT HEX$(INP(A2)),INP(A1),INP(B1),INP(C1)
230 GOTO 120
240 FOR J=0 TO 100:NEXT
250 RETURN
```

910029-12

Fig. 2. **Sample test program for the I/O card.**

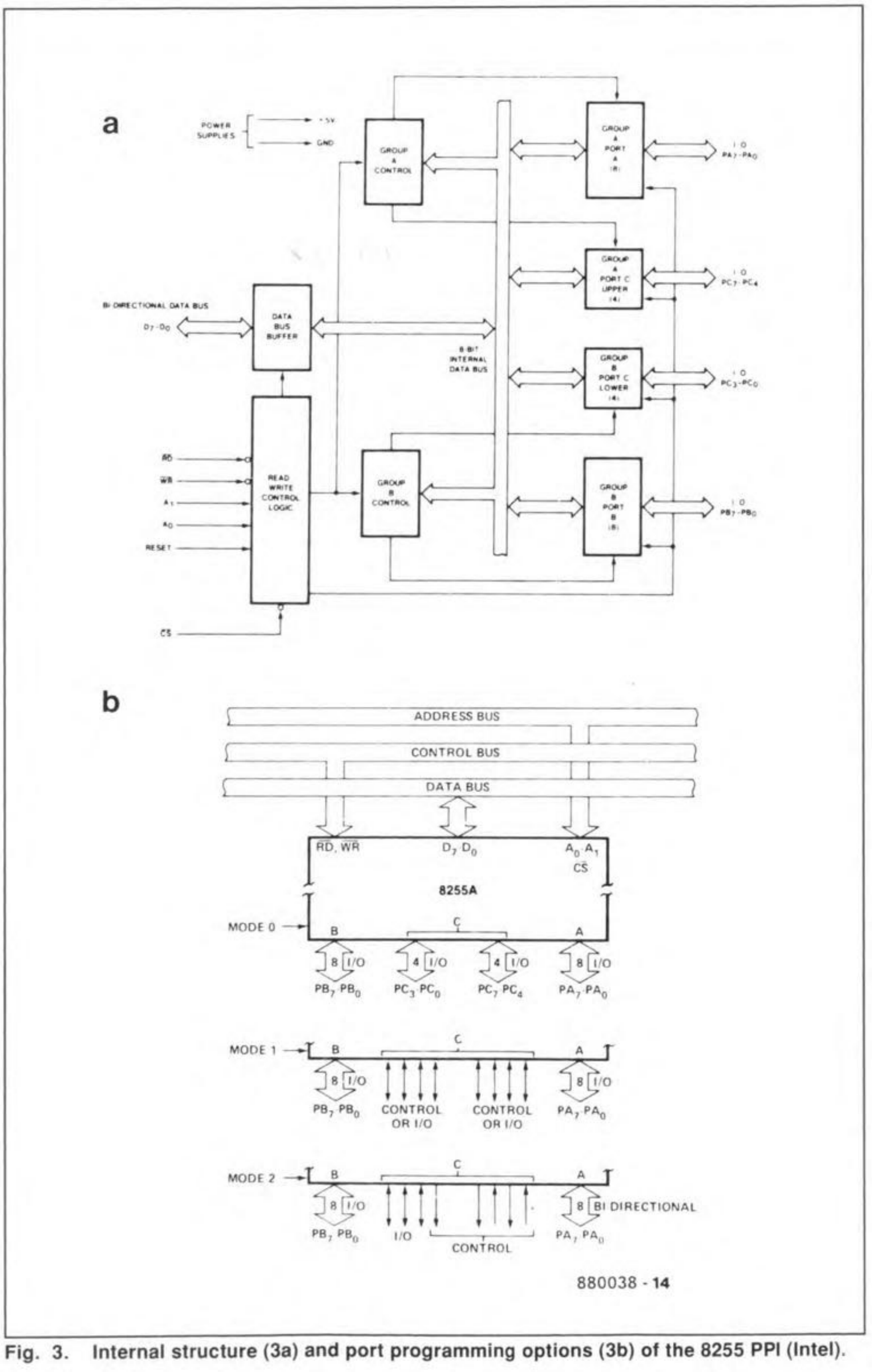


Fig. 3. **Internal structure (3a) and port programming options (3b) of the 8255 PPI (Intel).**

COMPONENTS LIST

Resistors:

16	1kΩ	R1-R16

Capacitors:

6	100nF	C1-C6

Semiconductors:

8	CNY17-2	IC1-IC8
1	74HCT245	IC9
1	74HCT240	IC10
1	74HCT244	IC11
1	PAL 16L8 (ESS 5991)	IC12
2	8255-2	IC13;IC14
2	ULN2803	IC15;IC16
8	1N4148	D1-D8

Miscellaneous:

16	PCB-mount change-over relay, 5V, e.g. Siemens V23040-A0001-B210	Re1-Re16
1	25-way male sub-D connector with angled solder pins	K1
5	26-way male box header	K2-K6
1	printed-circuit board	910029

300_H and $31F_H$, in which the card occupies a block of 8 adresses. The jumpers set the following base addresses:

300	308	310	318
$\overline{A3}$	A3	$\overline{A3}$	A3
$\overline{A4}$	$\overline{A4}$	A4	A4

In most cases, one of these base addresses will be free to accommodate the I/O card. If all four of them are available, you may even install four I/O cards.

Control software

The heart of the circuit is formed by the two 8255 PPIs, which need to be programmed depending on the control function of the I/O card. The internal structure of the 8255 is given in Fig. 3. The three 8-bit I/O ports contained in the IC are arranged into two groups of one and a half port each. This unusual division is the result of the handshake facilities offered by the PPI, which can be used in one of three basic modes:

Mode 0:	basic input/output
Mode 1:	strobed input/output
Mode 2:	bidirectional bus

The mode selection is effected by sending a control word to the 8255. As shown in Fig. 3, Port C is the odd man out because it consists of two 4-bit ports that can be used for I/O as well for handshaking and interrupt. Each of the two 'half' ports is connected to the other two, 8-bit, ports.

The special internal structure of the 8255, which is really an I/O device with two 12-bit ports, is also reflected in the control of the IC. The organization of the control word, and the function of the individual bits may be found in the datasheets of the 8255. Note that

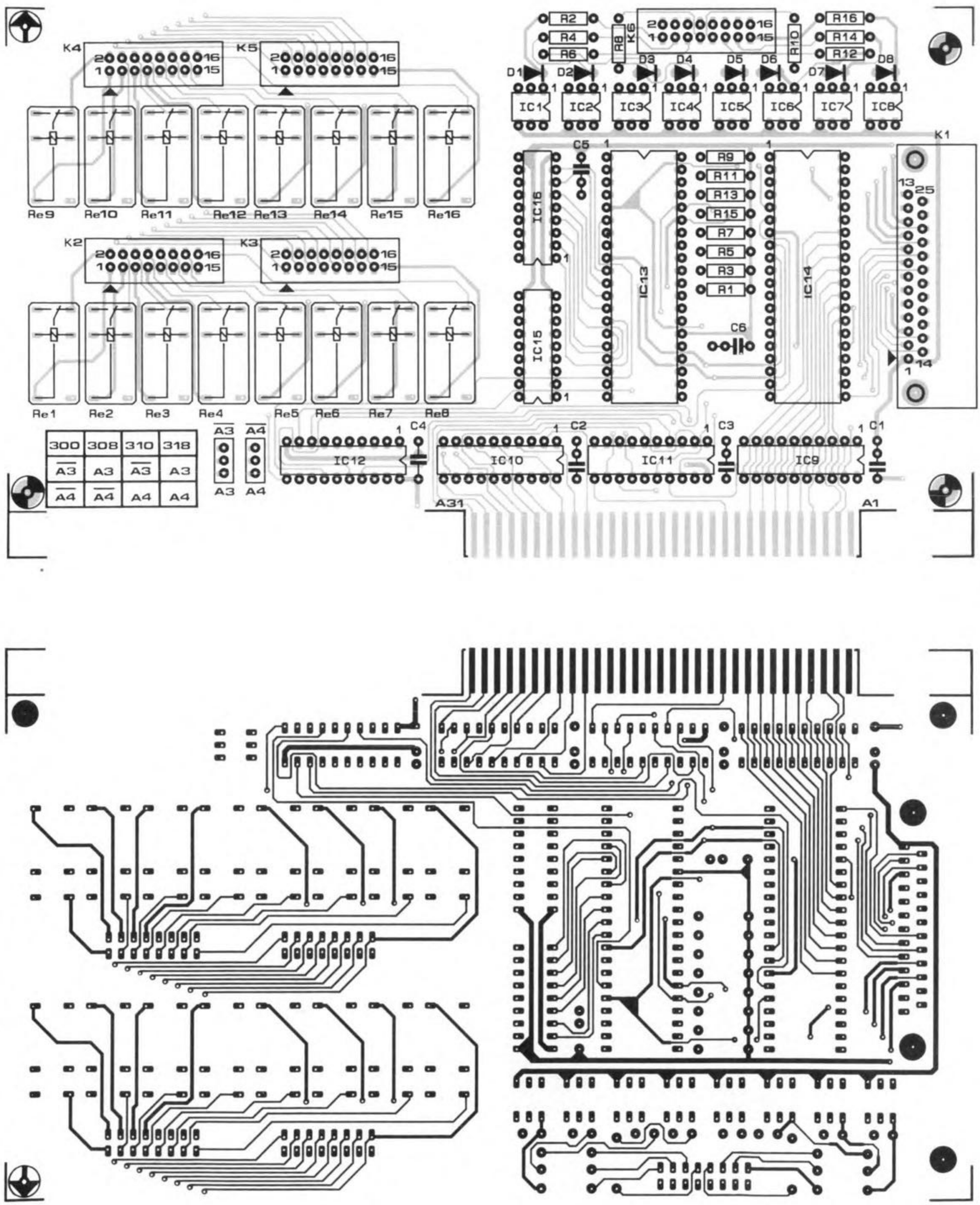


Fig. 4a. Component mounting plan and component side track layout (mirror image) of the double-sided, through-plated PCB.

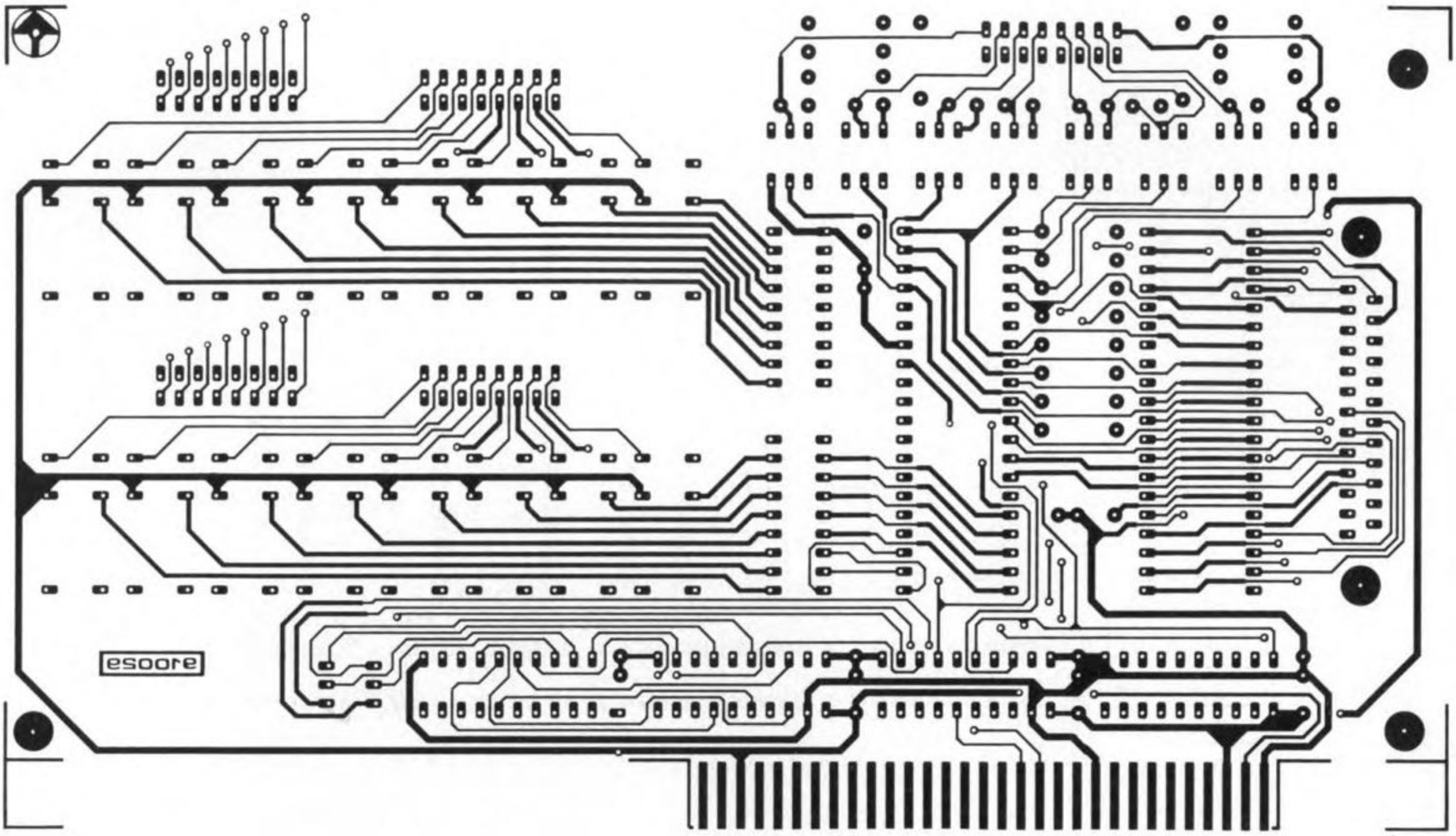
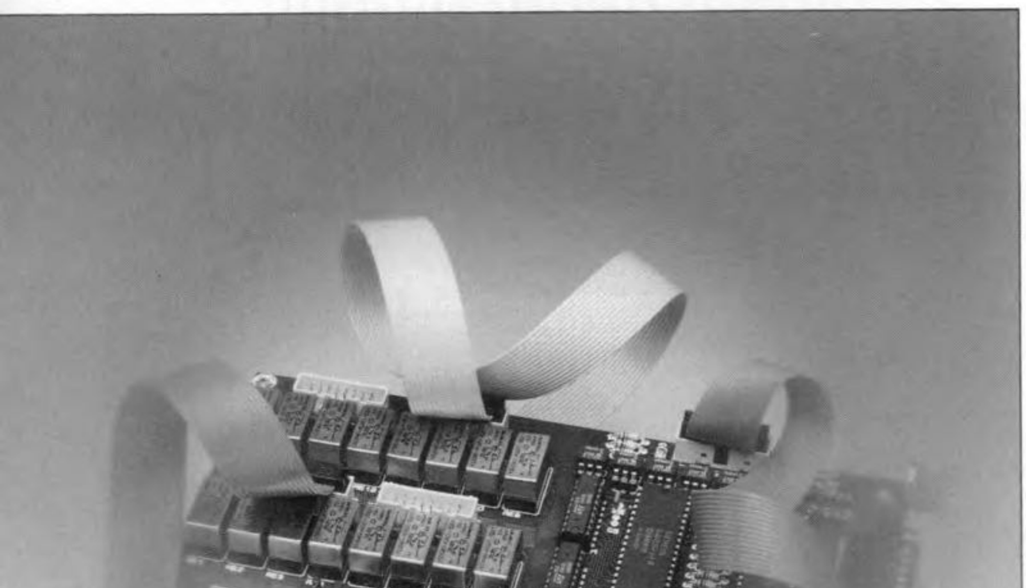


Fig. 4b. Solder side track layout (mirror image).



the port lines can not be set to input output individually — this is only possible for the entire port. Bit 7 is always '1' when selecting a mode.

The simplest setting is Mode 0, in which the processor only has to perform read or write operations on certain registers. A port programmed to function as an output can be read back at any time. The use of Mode 1 and Mode 2, and the programming of bit 7 in the control word are not covered here, since the PPI is always used in Mode 0 on this card. Further details on the 8255 can be found in the datasheets supplied by Intel, as well as in *Data sheet book 2*, an *Elektor Electronics* publication.

The PPI outputs are capable of supplying a maximum current of 1 mA at an output voltage of 1.5 V. This allows an output port line to be connected to a darlington transistor or an integrated darlington driver. The current sink capability of the output lines is about 2.5 mA.

The listing in Fig. 2 is a small BASIC program intended to help you on the way to developing your own software for the I/O card. The program shows how the PPIs are initialized, and how the relays and the optocouplers can be tested. The relays are energized in succession, and the logic levels at the optocoupler inputs are continuously read. The port lines of PPI IC14 are defined as inputs, and their logic level is shown on the screen. ■

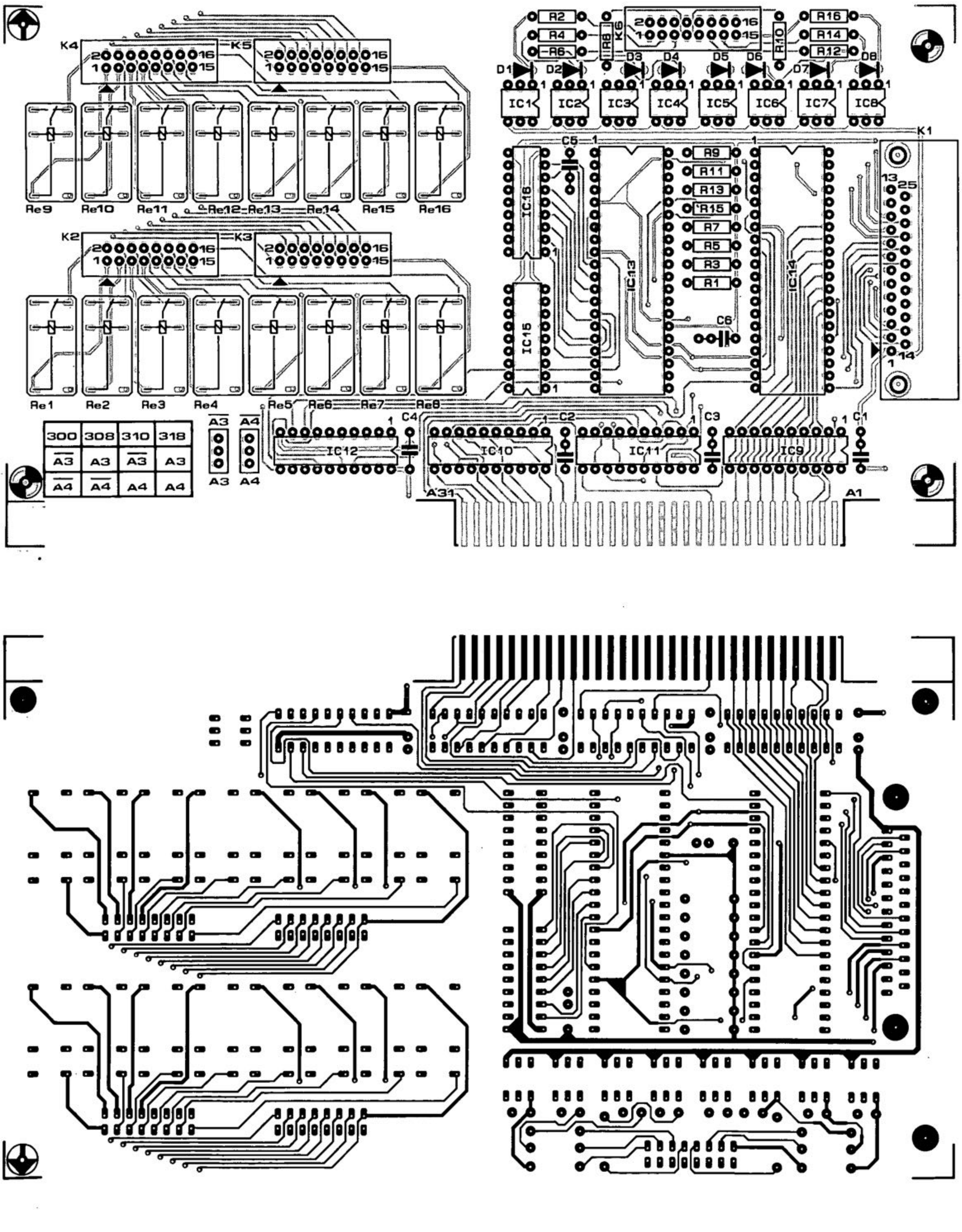
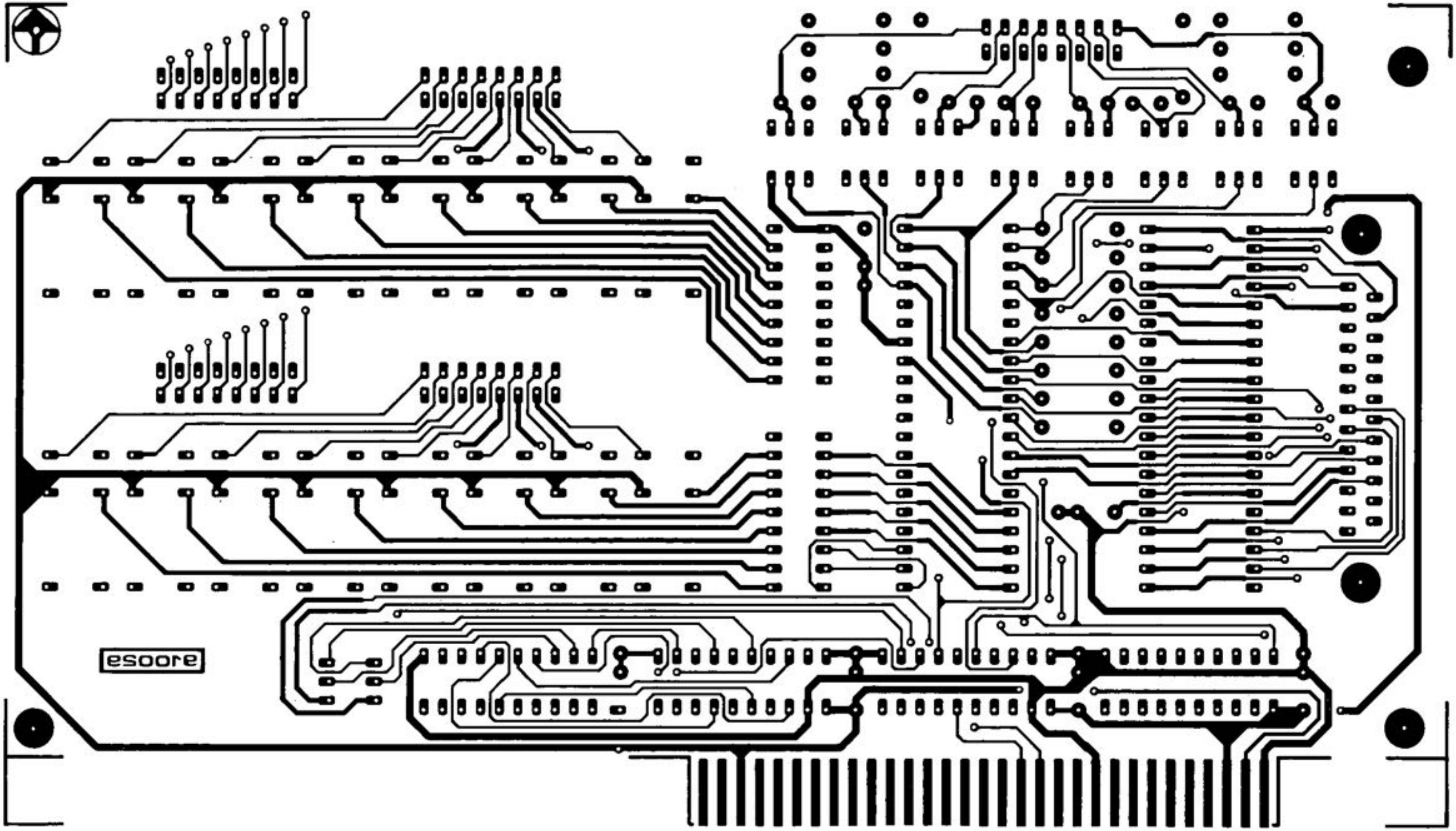


Fig. 4a. Component mounting plan and component side track layout (mirror image) of the double-sided, through-plated PCB.



BLACK-AND-WHITE VIDEO DIGITIZER

FRONT COVER PROJECT

Most of you will know that processing video images on a computer requires a video digitizer. Unfortunately, these units do not come cheap. The circuit described here is a low-cost, yet quite advanced, video digitizer with excellent performance. Designed for use with the Acorn Archimedes computer, and complete with a powerful software package, it allows video images to be captured, loaded into documents, and converted to different graphics formats for exporting to other computer systems.

J. Kortink

IN recent years, the use of software and hardware tools to integrate images, sound and text on a computer has been boosted by the rise of the graphics user interface (GUI), which allows the user to have a good indication of the printed result simply by looking at the screen. This seems logical, but used to be impossible on computer systems based on text only.

The RiscOS (reduced instruction set computer operating system) implemented on Acorn's Archimedes computer is among the most advanced of GUIs, offering a host of interface options and support software.

The digitizer described here converts video signals supplied by a TV set, a camcorder, a video recorder, or a video camera with a still-picture facility, into digital data that can be processed by the Archimedes. The support software for this project offers all the routines required to edit the captured pictures until the user is satisfied with the result. Special filters have been implemented in the software that enable errors in the images to be corrected, and the contrast to be optimized.

The data formats used for the picture files enable these to be exchanged between different applications. Furthermore, the files can be converted to standardized formats such as GIF and TIFF. This allows any MS-DOS PC, Commodore Amiga, and even a UNIX workstation to use the digitized pictures.

AIM, the picture processing program developed by the Department of Applied Physics of the Technical University of Delft, Holland, is capable of importing the picture files produced by the digitizer. This means that the hardware described here is suitable for educational purposes as well as advanced studies into picture analysis, composition and processing.

The circuit

Video signals are much more difficult to convert than audio signals, mainly because the process of digitizing the analogue input levels must run at a fairly high speed, and synchronously with the video information applied to the A-D (analogue-to-digital) converter. The latter requirement can be met by

MAIN SPECIFICATIONS

- Vertical resolution: 512, 256 or 128 dots
- Horizontal resolution: 640, 320 or 160 dots
- Max. number of gray values: 256
- Occupies one podule slot
- Max. conversion time: 2.5 s
- Accepts CVBS signals
- GIF and TIFF file conversion and export
- Complete with multi-tasking software
- For all Archimedes systems: A3x0, A4x0, A5x0
- Inexpensive and simple to build

making use of the synchronization (sync) signals contained in the input signal.

Although the above functions appear pretty daunting, we have managed to keep the digitizer simple, resulting in a compact circuit built on a single Eurocard-size (10×16 cm) printed circuit board. The advantages of the digitizer over competitive designs are mainly the lower cost and the simpler construction. On the down side, it should be noted that the A-D conversion can not be run in real time, which results in slightly more time required to capture the picture. In practice, this should not be a problem since most of the previously mentioned video sources are capable of supplying a still picture for about 2.5 seconds.

The circuit diagram of the video digitizer is shown in Fig. 1a. Basically a so-called simple podule, the circuit is addressed in one of four 16-KByte address blocks reserved by the IOC. The podule operates in fast mode.

Podule ident

The jumpers around IC1 transmit the podule identification to the operating system. The function of the identification bits is given in Table 1. Bits 1, 2 and 7 are fixed; the others can be set to 0 or 1 as required by placing the appropriate jumpers. Bits 3 through 6 set the identification nibble to $E (hexadecimal), enabling the RiscOS to recognize the podule, and locate it in the memory, where it is accessed with the aid of fixed subroutines.

The podule is selected by the $\overline{PS}$ signal at pin C22 of connector K1. The selected address is then available on address lines LA2-LA15 (pins A2-A15), while the data appears on lines BD0-BD15 (pins A16-A31). Since the Archimedes works with words (of 32 bits) rather than bytes, the two lower address lines, LA0 and LA1, are not used.

As indicated by the two schematic drawings, the digitizer consists of an A-D converter (Fig. 1a) and an optional circuit (Fig. 1b) that may be used as an extra I/O port on the Archimedes.

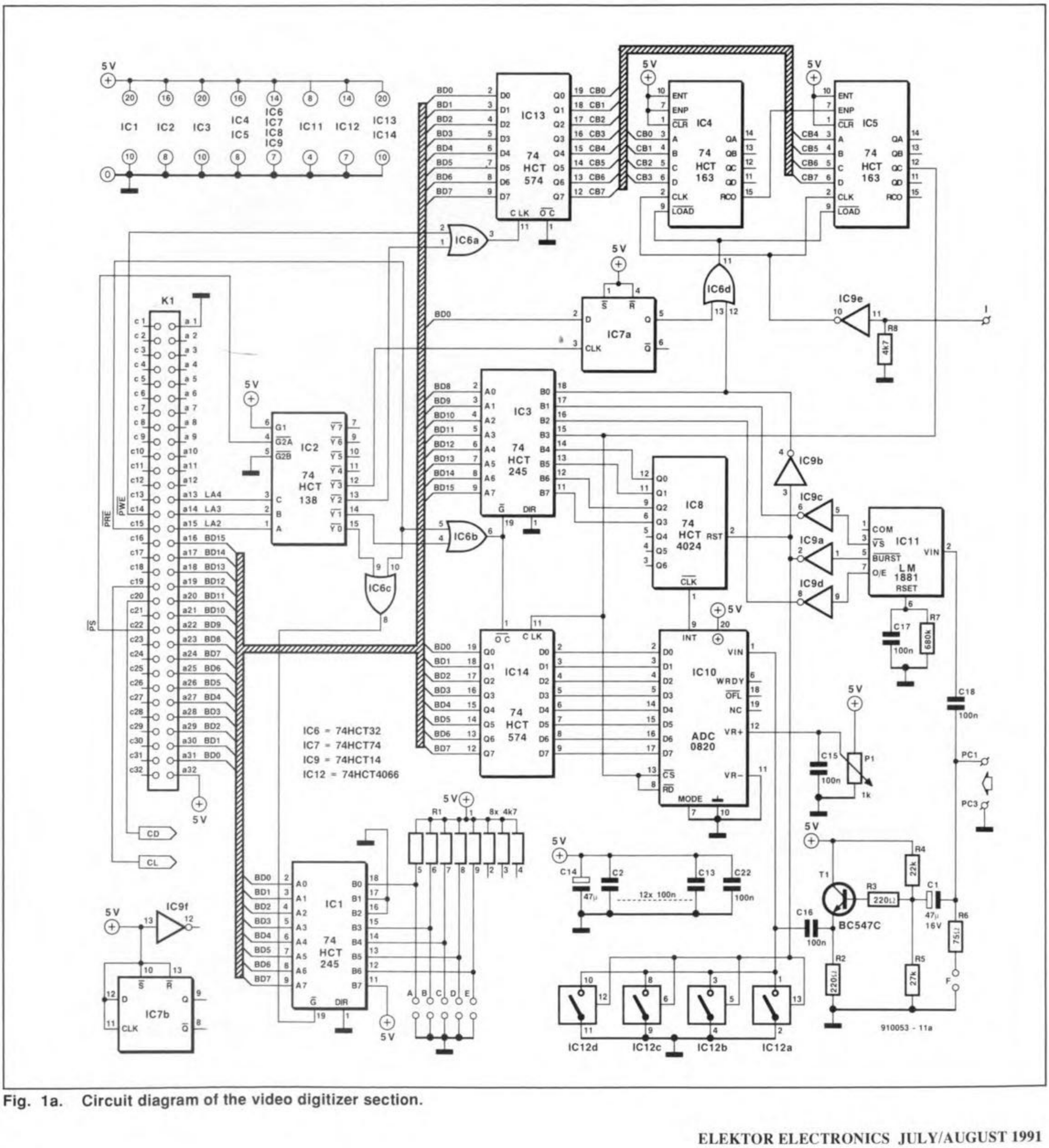


Fig. 1a. Circuit diagram of the video digitizer section.

Sync separator

As shown in Fig. 1a, the video signal applied to the digitizer follows two paths — one leads to the ADC chip (an ADC0820) via a buffer and a clamping circuit, and the other to an LM1881 via a coupling capacitor. The LM1881 is a synchronization separator that extracts the horizontal sync (HSYNC, pin 5) and the vertical sync (VSYNC, pin 3) from the composite input signal. In addition, it supplies an odd/even field indication signal on pin 7 (for interlaced video signals), and a composite synchronization signal (CSYNC, pin 1). Here, the HSYNC signal supplied by the LM1881 is used mainly by the hardware, while the VSYNC and odd/even signals are processed by the software. The latter two are fed to the computer via IC3, an octal bus buffer Type 74HCT245. IC12, a 4066 bilateral CMOS switch, restores the black level of the video signal after every HSYNC pulse. The drive to the ADC is set with a preset, P1.

Analogue to digital conversion

A black-and-white video signal can be converted from analogue to digital by taking samples of the luminance (brightness) component. This is achieved with an ADC, IC10. When the start condition occurs (pins 8 and 13 are brought low simultaneously with pin 7 held low permanently), a sample is taken of the video signal, and stored internally. After about 1.2 µs, the conversion is complete, and the digital value of the sample is available. Next, the ADC signals to the computer that the conversion is finished by actuating the INT (interrupt) line. At the same time, the digital value is stored in IC14, an 8-bit register. Next, the INT line is cleared. Since the interrupt signal is fed to a binary counter (IC8, a 74HCT4024), it is a simple matter to count the number of conversions since the last HSYNC pulse. The lower four bits supplied by the counter are read by the software via IC3, a 74HCT245. The counter is reset by the CSYNC pulse, so that its output value is nought at the start of every picture line.

A complete picture line, including the HSYNC pulse, has a length of 64 µs (PAL B, G and I systems, line frequency 15,625 Hz, raster frequency 50 Hz). Realizing that the distance between successive samples is about 0.1 µs at the maximum resolution of 640 picture elements, it will be clear that the ADC is too slow at a conversion time of 1.2 µs. Since we do not want to use the latest of (very expensive) video ADCs, we are more or less forced to run multiple sampling operations on a single picture line.

Apart from the hardware, the software and the data transmission to the computer memory are limiting factors in this respect. In practice, each picture line is sampled 64 times before it is completely digitized. This sets the time between successive samples to 6.4 µs. A disadvantage of this solution is that the picture has to be stable for at least $\frac{1}{25} \times 64 = 2.56$ s.

Since every picture line has to be sampled so often, the sampling times must be fixed accurately. This is achieved by dividing the 6.4-µs interval into sixty-four 0.1-µs slots. The sampling instant must move by exactly one slot on completion of each successive sampling operation.

After the complete picture line has been digitized, the software fetches the data from the memory, and puts the 640 samples in the right order.

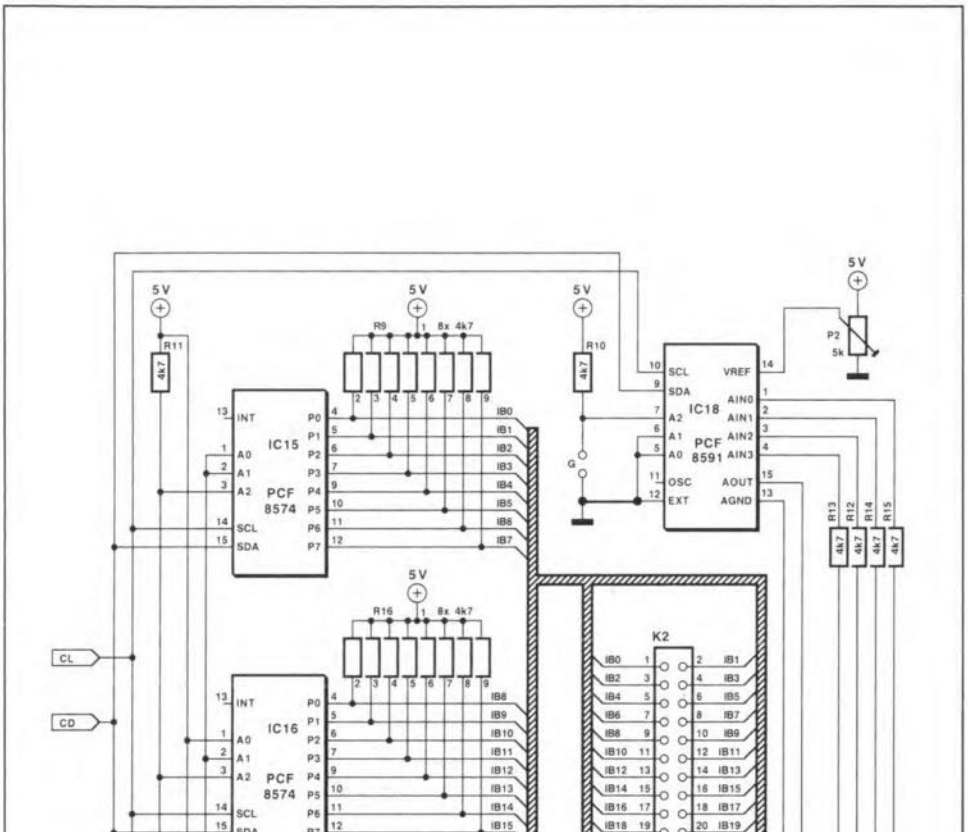


Fig. 1b. Circuit diagram of the automatic brightness extension and the 18-bit I/O port.

Counters

The exact starting instant of a sampling sequence is determined by IC4, IC5 and IC13. The first two are 74HCT163s that form an 8-bit counter clocked by the 24-MHz system clock supplied by the Archimedes motherboard. On the motherboard, this clock signal is sent to the VIDC (video processor) via a jumper, where it is 'tapped' and fed to the digitizer. This simple solution saves you the investment in a separate 24-MHz oscillator.

When the counter runs free, its outputs QA to QD supply signals with period times of 1.33 µs, 2.67 µs, 5.33 µs and 10.67 µs respectively. Of these, the 5.33-µs signal is used to control the ADC. Note that this is not the 'ideal' clock of 6.4 µs. Fortunately, we need not sample the sync signals at the start and the end of the picture line — the available 53.3 µs then cover most of the video contents of the picture line.

During the HSYNC pulse, the 8-bit counter is loaded with the content of IC13, a

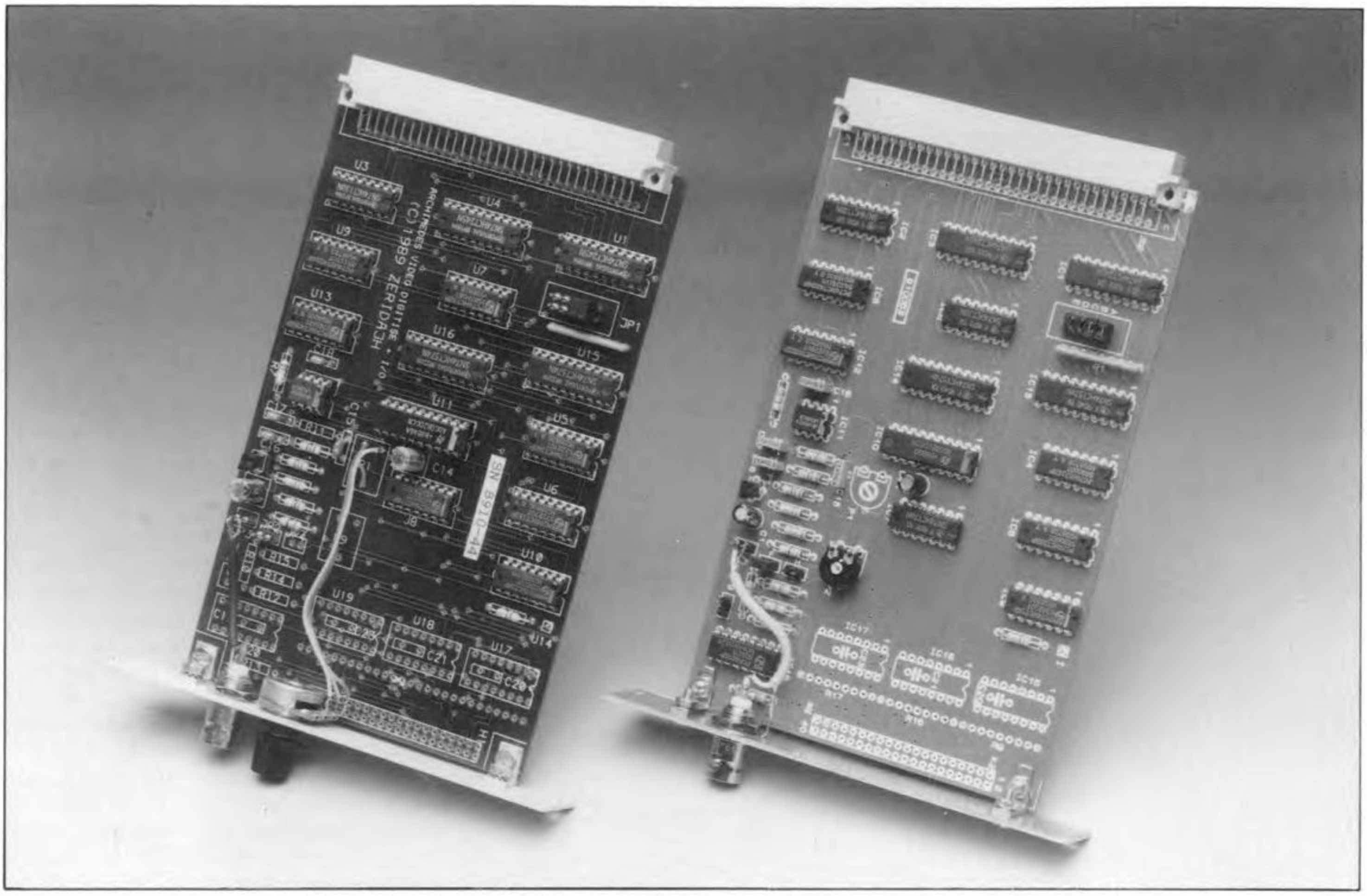


Fig. 2. Prototypes of the digitizer, with (left) and without (right) the optional extensions.

74HCT574. The value determines the time between the HSYNC pulse and the first time output QC of IC5 goes low. After that, QC will go high, toggling with 5.33-μs 'low' pauses, and enabling the ADC during the 'high' periods. After shifting the sampling starting instant 64 times, the content of the entire picture line has been sampled.

A built-in option of the circuit is that the load pulse of IC4 and IC5 can be blocked via bistable IC7a and AND gate IC6d. This allows the software to control the behaviour of the QC output of the counter via buffer IC3 and dataline BD11.

The four address selection signals are derived from the LA2, LA3 and LA4 address bits on the podule connector with the aid of a 74HCT138, IC2. This decoder is actuated by the $\overline{PS}$ signal supplied by the computer via pin 4 of the podule connector. Since IC13 is a write-only device, its selection signal is ANDed with $\overline{PWE}$ (podule write enable). Similarly, the selection signal for the read-only devices, IC1, IC3 and IC14, is ANDed with the $\overline{PRE}$ (podule read enable) signal.

As shown in the circuit diagram, the databus is 16-bits wide, and used fully to read back address 4. This allows the computer to load an 8-bit sample and the other relevant information in a single read operation.

Table 1. Podule identification word

Bit 0:	0 = podule generates IRQ
	*1 = podule does not generate IRQ
Bit 1:	*0 = podule present
	1 = podule not present
Bit 2:	0 = podule generates FIRQ
	*1 = podule does not generate FIRQ
Bit 3-6:	podule identification nibble (0 = extended PI)
Bit 7:	0 = Acorn
	*1 = other manufacturer

* Option used in this digitizer

Extra features

The circuit diagram of the (optional) extra I/O port implemented on the present podule is shown in Fig. 1b. The port consists of four ICs: three PCF8574s and one PCF8591. The PCF8574s together form an 18-bit I/O port, and the PCF8591 a single-chip ADC/DAC. All four ICs are controlled via the I^2C bus provided on the Archimedes. This bus, designed by Philips (Ref. 1) allows integrated circuits to communicate by making use of a simple three-wire connection and a communication protocol. The I/O lines are brought out to a 40-pin PCB header.

When fitted, the PCF8591 ADC/DAC is recognized by the digitizer software. The analogue output of the ADC/DAC may be connected to the reference input of the main video ADC, IC10, to implement an automatic brightness control. If this option is used, omit P1, and connect pin 12 of IC10 to pin 15 of IC18. Furthermore, the analogue ground of IC18 (pin 13) is connected to the circuit ground (pin 8 or 12). From there on, the software does all the work, and automatically presents a 'sensitivity' control option in the menu.

Construction and test

The digitizer is built on a single printed circuit board that is readily fitted into the Archimedes. This PCB is double-sided and through-plated (see Fig. 3). It occupies one podule slot. One side has a 64-way DIN (a-c row) connector, the other an aluminium fixing plate which is secured to the computer enclosure with the aid of two screws. The fixing plate offers sufficient space for the BNC connector, which is connected to PC1 and PC3, and the sensitivity potentiometer, P1.

Since the extra I/O channels are optional, the relevant ICs need not be fitted as yet. The same goes for connector K2, the three resistor arrays R9, R16 and R17, resistors R10-R15 and preset P2.

The construction of the PCB is straightforward if you follow the indications on the overlay, and the components list. The supply decoupling capacitors may be fitted at the solder side of the PCB, or, if IC sockets are used, underneath the ICs. The fixing plate is secured to the PCB with the aid of two small aluminium brackets.

The terminal marked 'I' on the digitizer board is connected to a short wire fitted with a jumper. On the Archimedes motherboard,

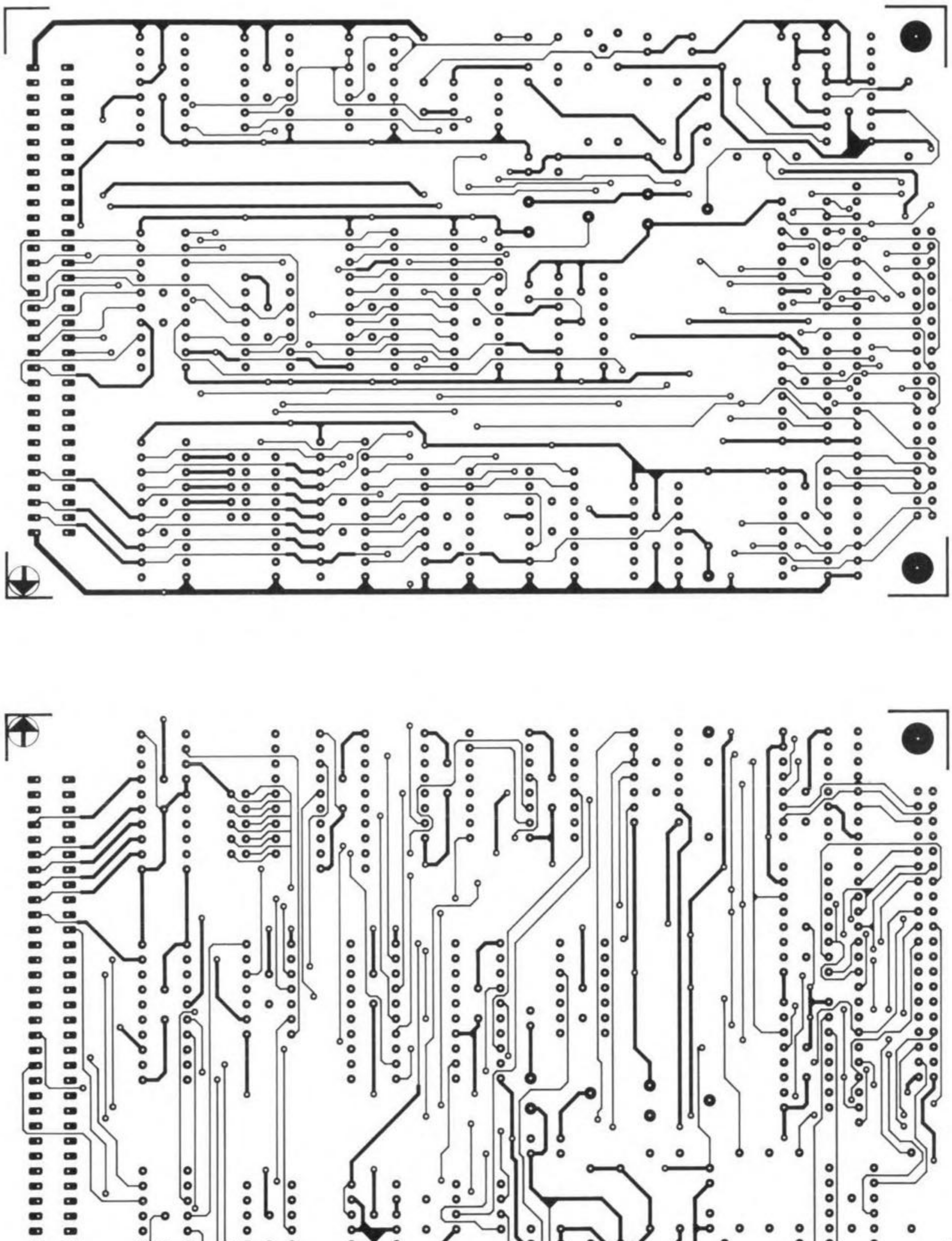


Fig. 3a. Component side (above) and solder side (below) track layout of the printed-circuit board.

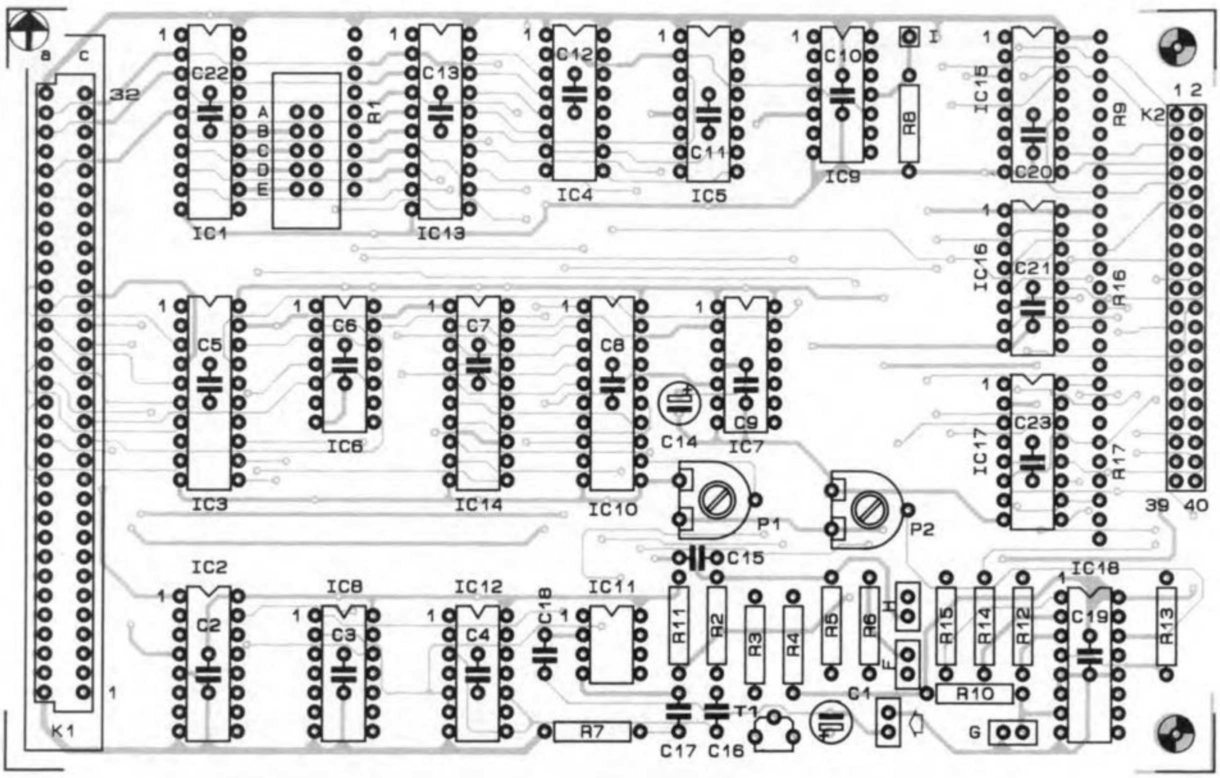


Fig. 3b. Component mounting plan.

this jumper is fitted on pins 1 and 2 of plug 3 (Model 300), or plug 4 (Model 400). The jumper already fitted is removed.

Users of a video enhancer should note that this unit works with a clock of 36 MHz on pin 2 of plug 3 or plug 4. This means that the digitizer clock lead must be connected to pin 1 only, which carries the 24-MHz clock signal.

After fitting the video digitizer in a free podule slot, and connecting the clock lead to the motherboard, set the jumpers to hexadecimal value 'E'. This is done by fitting jumpers in positions 'A' and 'B' only. Jumpers 'G' and 'H' may be used to change the base address of the ICs on the I²C bus. These jumpers are normally not fitted, enabling the I²C devices to be accessed at their default base address. Lastly, jumper 'F' is fitted only when the video source requires to be terminated in 75 Ω. This will be the case for most video equipment. When the source is not properly terminated, several errors may occur, even including a 'no video signal' prompt on the screen. If all is well so far, close the computer, and concentrate on the software.

Switch on the computer, and type 'podules' to get an overview of active podules. The video digitizer should report as 'simple podule $E'. If this is so, it is recognized by the system, and likely to be functional.

The best setting of the brightness (sensi-

COMPONENTS LIST

Resistors:

4	8-way 4kΩ7 array	R1;R9*;R16*;R17*
2	220Ω	R2;R3
1	22kΩ	R4
1	27kΩ	R5
1	75Ω	R6
1	680kΩ	R7
7	4kΩ7	R8;R10-R15
1	1kΩ potentiometer	P1*
1	5kΩ preset H	P2*

Capacitors:

2	47μF 16V radial	C1;C14
21	100nF	C2-C13;C15-C18; C19-C23*

Semiconductors:

2	74HCT245	IC1;IC3
1	74HCT138	IC2
2	74HCT163	IC4;IC5
1	74HCT32	IC6
1	74HCT74	IC7
1	74HCT4024	IC8
1	74HCT14	IC9
1	ADC0820	IC10
1	LM1881	IC11
1	74HCT4066	IC12
2	74HCT574	IC13;IC14
3	PCF8574*	IC15;IC16;IC17
1	PCF8591*	IC18

Miscellaneous:

1	64-way a-c row male bus connector (DIN)	K1
1	40-way PCB header, angled, with eject handles	K2
1	BNC socket	
1	jumper block	
9	jumper	
1	aluminium fixing plate 25×129mm	
2	angled bracket	
1	printed-circuit board	910053
1	software on disk; order code ESS 1591	

* required for optional I/O ports and automatic brightness control.

tivity) potentiometer on the digitizer must be determined empirically. The grey scale in the standard TV test chart may come in handy here, and will result in a good calibration. When the automatic brightness control is used (with the PCF8591), the adjustment is made with P2 rather than P1 (which is then not used). After adjusting P2, the software is used as a 'fine' control to set the optimum brightness.

The control software: powerful and flexible

The control software for the video digitizer is supplied on an Archimedes-format 3½-inch diskette, which contains a number of utilities that support the interface.

To begin with, we have !VideoDigi, a complex piece of multi-tasking software that arranges the digitizing of the video signals and their subsequent processing and storing in memory. It should be noted that the program !VideoDigi works only with the digitizer podule fitted in the computer. The module called !Videodigi.VideoDigi used by this application may also be used in your own programs, whence the extensive documentation file included on the diskette. In this doc file you not only find details on the operation of the program, but also a discussion of the built-in SWI modules.

The programs !AnimDigi and DigiAnim enable the digitized pictures to be used for video animations as used in, for instance, an electronic photoshow.

File standard conversion, file compression, and file exporting, are achieved with the routines !MakeGif, !MakeTiff and FulltoAIM. ■

Table 2. Podule address functions

Address 0:	read only bits 0-7: podule ident
Address 4:	read only bits 0-7: digitized video information bits 8-15: status bits of IC3 bit 8: HSYNC bit 9: VSYNC bit 10: Odd/even bit 11: 5.33-µs signal bits 12-15: sample counter
Address 8:	write only bits 0-7: start value of 8-bit counter IC13
Address 12:	write only bit 0: bistable IC7a (enable/disable free counting)

I/O components accessed via the internal I²C bus:

PCF8574-based I/O port:
IC15 = 0100 - x00*
IC16 = 0100 - x01*
IC17 = 0100 - x10*
x = 1 when jumper H is not fitted
x = 0 when jumper H is fitted

PCF8591 ADC/DAC:
IC18 = 100-1x00*
x = 1 when jumper G is not fitted
x = 0 when jumper G is fitted

The level of the LSB, *, depends on whether a read or a write operation follows: * = 1 indicates a read operation, * = 0 a write operation.

Jumpers G and H may be fitted to avoid conflicts with other hardware extensions. Jumper G must not be fitted when the automatic brightness control is used.

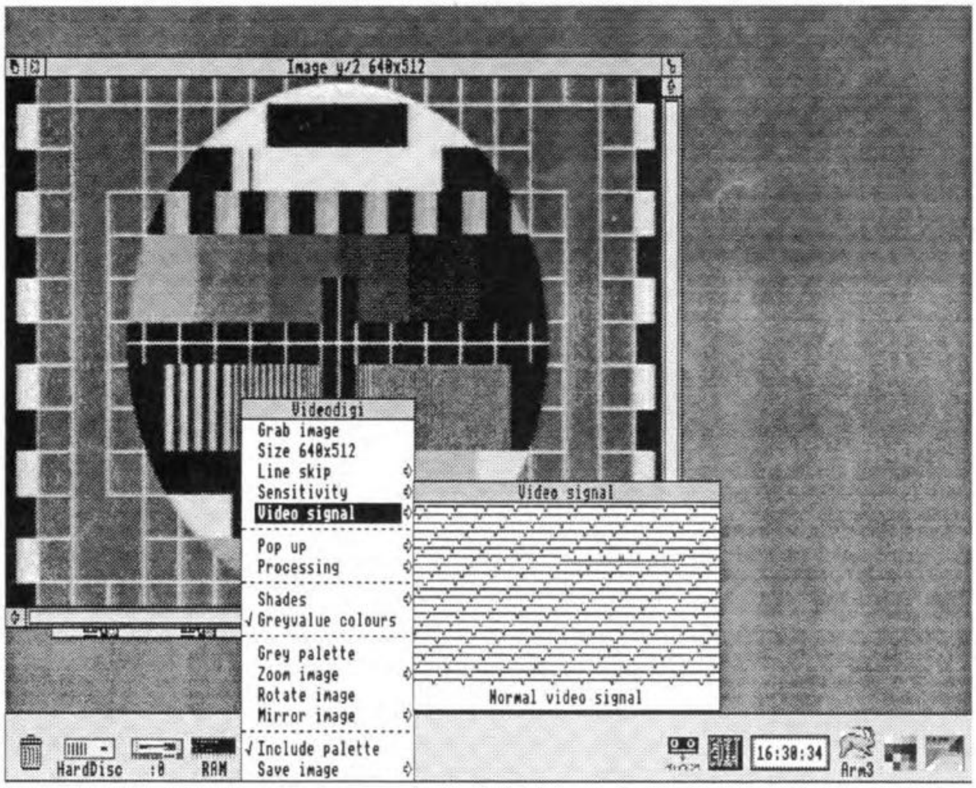


Fig. 4. The powerful RiscOS software allows the digitizer to operate in a multi-tasking environment. A number of routines are available to enhance the 'frozen' samples.

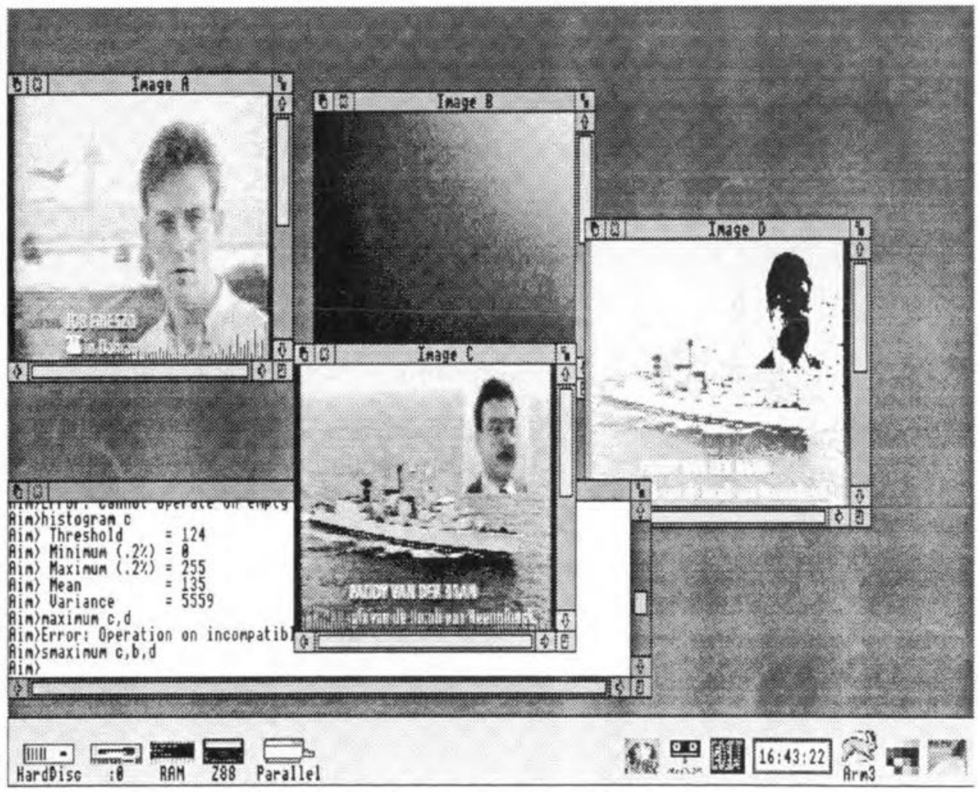


Fig. 5. Linked to !AIM, the digitizer podule and the associated software turn the Archimedes into a near-professional image processing system.

Reference:

1. Inter-IC communications", *Elektor Electronics* September 1990.

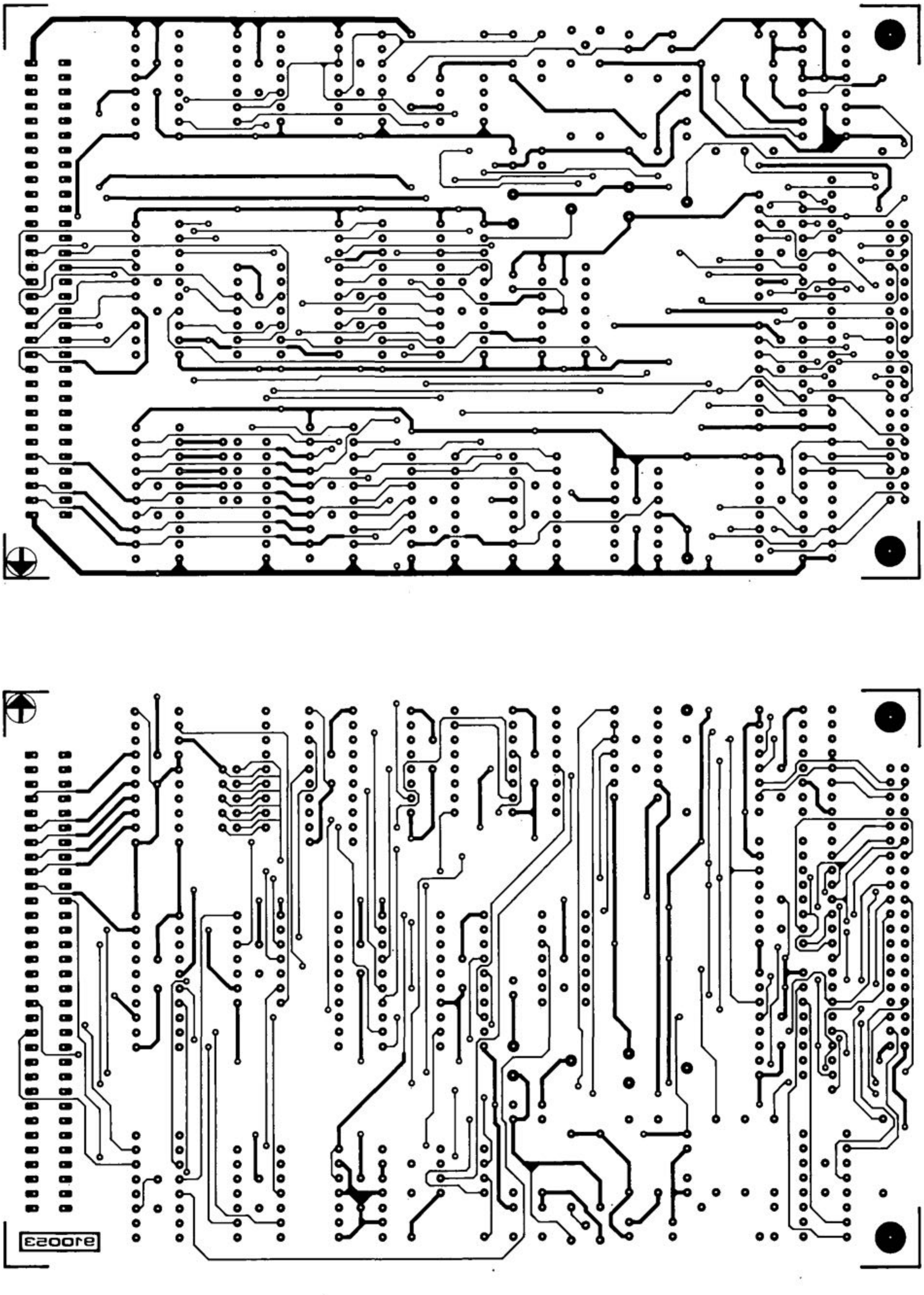


Fig. 3a. Component side (above) and solder side (below) track layout of the printed-circuit board.

WOULD YOU BE AN INVENTOR?

by C.C. Whitehead, ACGI, AMIRE

MOST of us have misconceptions about other people's jobs, particularly if those jobs, such as those of the scientist, the surgeon, the detective, the inventor, have a certain amount of (generally false) 'glamour' attached to them in the popular eye.

I am an inventor. It is not for me to say that my job is more misunderstood than most, but I often get that impression. The general public has a lot of erroneous ideas in popular circulation about inventors and inventions.

How and why did I become an inventor? The answer is simple: I was just built that way. Born with the insatiable curiosity of a monkey, I simply *had* to know how a thing worked and, having found out, worried and worried as to how it could be made to work better. That is the nature and background of practically all inventors.

You may be surprised if I say that I do not think that there is anybody in the world today who enjoys fame or fortune solely by reason of being an inventor, or who makes a good living out of it. I am writing, of course, about *real inventors* and, in order to understand what a real inventor is, one must first understand what is meant by a real invention.

A real invention is quite strictly defined by the Law and is the subject of a 'Patent Specification' in one or more of the world's Patent Offices. Unless this is so, the device, whatever it may be, has no status as an invention, and consequently the inventor or his representative can obtain no redress for 'infringement'.

Patent Law lays down without ambiguity what may or may not constitute an invention, defined legally as a 'patent'. For all practical purposes, the terms 'patent' and 'invention' are synonymous.

You may not patent a device which is obviously intended to be used for an improper (illegal) purpose.

There are peculiar restrictions relating to the patenting of devices that may be used for war purposes.

You may not patent a 'fundamental principle'. This is very important and requires some explanation. The fact is not so stated in patent law, but is inherent in its operation. Thus, if you have invented, say, a new cooking vessel, you may not describe your invention (in the patent specification) as a 'vessel for containing and cooking foodstuffs', since this would make every saucepan and casserole in the world an infringement of your patent! You would be patenting a fundamental principle—that of a hollow container.

You may not, of course, patent a device that has been 'covered' by a previous patent specification *or which has been published previously elsewhere.*

So much for the 'mustn'ts'. Now for the 'musts'.

Your invention must be novel. That is to say that your device must contain some relevant feature which has not been described elsewhere. Thus, your new cooking vessel *may* be described as 'a vessel for containing and cooking foodstuffs with an automatic self-raising cover (or lid)'. The novel part of your invention (which also absolves you from the charge of seeking to patent a fundamental principle) is the 'automatic self-raising lid'.

Your invention must be practical. You must describe exactly how your device is to be made or constructed, and how it is intended to work. It must be made clear to the examiner at the patent office that your device *can* be made and *will* work as you have described it, otherwise he may refuse to grant the patent. This is obviously necessary for two reasons. Firstly, a patent to a certain extent constitutes an official guarantee, and it is undesirable that impractical patents should be foisted upon the public. Secondly, if these rules were not enforced, the world's patent officies would soon be cluttered up with useless patents.

Patent laws were originally devised 'for the encouragement of invention and the furtherance of trade'. The idea was that an inventor would be protected, at least for a time, agains those who might steal his ideas and rob him of credit and reward for his work. This was the *intention* at the inception of Patent Law.

The real inventor then is the originator of a patent or patents. This does not necessarily mean that he has a knowledge of patent law, though most experienced inventors do require such knowledge. Modern conditions make it almost essential for him to employ a Patent Agent, a sort of cross between a lawyer and a scientist (mostly lawyer), who is competent to draft patent specifications and conduct business with the Patent Office. This relieves the inventor of a mass of essential but routine work that need not concern him in detail. Patent agents' fees may be a serious embarrassment to an amateur or 'free-lance' inventor.

No invention is ever entirely novel in its conception (before you invented your new cooking vessel, you were obviously familiar with such devices, some of which probably came very close to your own idea). The inventor then endeavours to obtain what in patent law jargon is known as 'knowledge of prior art'. This means an extensive search and reading of the literature and previously published patent specifications (the services of the Patent Agent are invaluable here) relating to the the device in which he is interested.

It may be that (so far as you are aware) the device which you have 'invented' is so far unknown and of a highly specialized nature. When you (or your patent agent) start digging into 'prior art', you will be astonished to find how many previous attempts, more or less successful, have been made to produce a similar device. That is to say, if you are new to the game. If you succeed where the others failed, it will probably be because you have the advantage of more up-to-date materials and techniques. Thus, the German Nipkow was the real inventor (in the year 1880) of our present system of television. He understood clearly the principles involved, and produced the essential device (the 'Nipkow disc'), but we had to wait for the 'electronic' techniques of the 20th century before the system as a whole could become a practical proposition. That led in its turn to the outmoding of the 'Nipkow disc'.

Having made himself familiar with 'prior art' and thereby (let us hope) assured himself that *his* invention has novel features, the inventor must make a 'model' or 'prototype' to prove that in practice the thing does really work just as he intended, and so that he can describe accurately in his patent specification exactly how it *is* made and how it *does* succeed in doing what he claims that it will do.

With the size and complication of modern devices, all of this naturally costs a lot of money. The successful birth of even a simple invention may set the inventor back £100 or so. If he is a 'free-lance' inventor, and he wishes to get credit and money for his invention, this is the point where his troubles *start*, after the successful issue of his patent!

Let us assume that he has or has acquired manufacturing facilities for his invention. If it is a commercial success, there will be imitators, almost certainly infringing his patent, some of them unknowingly perhaps, others deliberately. The onus is upon *him* to fight them in the courts. This can be a frightfully expensive business. Big business organizations have been known to infringe patents owned by smaller firms or individuals deliberately and without compunction, secure in the knowledge of their ability to ruin the patent-owner with the cost of an action for infringement, and so forcing him to abandon the action. The private or small-time inventor is always and completely at the mercy of these people. Remember, the onus lies upon *him* both to *discover* (not always easy) and to *fight* the infringement.

Consequently, we seldom hear of a successful small-time or free-lance inventor nowadays.

The inventor of today is generally the employee of a business organization. For the free-lance inventor, the risks are too great and the rewards (if collected) are too small. Yet, invention still goes on, albeit mainly in the laboratories of the big industrial organizations.

Does the employee-inventor fare any better? Let us look into this.

Though there are many successful inventors in industry, there are no 'inventors' in industry. That is to say, nobody (as far as I am aware) is employed in industry as an 'inventor'.

The extent and sophistication of modern products and production processes offer an astronomically extensive field for invention. Employees who are brought into close contact with these products and processes may frequently see the need for improvements. It may be the need and possibility of a new product or process, or a small but important change in an existing product or process. It will depend on the skill, knowledge and enterprise of an individual who may thereby become an inventor. If he does so, what will be his prospects, and what may happen to his invention?

If he is an employee, and certainly if he is an employee of an organization of any considerable size, there is a certain answer to both these questions. If he is a scientist, technician or any person holding a position that enables him to exercise judgement in his employment, he will have been required *as a condition of his employment* to sign a legally valid document binding him to assign *any* invention that he may make whilst in that employment, to his employer, and *to waive all rights to benefit from the invention or inventions*. He will be required to do all the work that is necessary (apart from the routine work of the patent agent) to secure valid 'Letters Patent', apart from his normal routine. Furthermore, when he leaves that emplyment, he may be called upon to make an assignment of 'his' patent to associate companies (usually abroad) of his former employers. This may be months, or even years, after leaving that employment, and he can claim no recompense for the trouble and inconvenience, except in some cases for out-of-pocket expenses.

It would seem that this practice started with government organizations concerned with patents in relation to armaments, where it was deemed necessary in the interest of national security to have the maximum possible hold on the inventor, after which it spread to industry in general.

Some employers do not trouble to make the employee sign the document I have mentioned. Can the employee then claim benefit from his invention. Not at all. Unless his employer is unusually generous and has made some legal provision to that end, he (the inventor) will be compelled (if he is foolish and ignorant enough to do so) to go to law to claim what he considers to be his 'rights'. He will be involved in expense which he can not afford, and will lose his case—and his reputation among employers who might have use of his services. He will lose his case because the Court will be bound to decide that (if it decides to hear the case at all) it is an established principle that employees' inventions belong to the employer.

Is there any other possible benefit to the inventor?

There is. The employer may, out of gratitude or the expectation of further inventions, give him an increase in salary, or promotion, but this is unusual. Owing to pressure over many years by organizations seeking to act in the interests of the inventor, a slight extra benefit has been gained for him. It was until a few years ago the practice of employers to have the name of the inventor omitted from the Patent Specification, so that he did not even receive the benefit (for what it might be worth) of official acknowledgment of his invention. This has been amended, and the inventor's name *must* now appear in the specification. This may sometimes improve his prospects of further employment.

There is another somewhat unsavoury practice among employers that may affect the inventor. Patent law requires that 'the name of the first and true inventor' should appear in the prologue of the patent specification. Since the specification is drawn up on behalf the employer, and the inventor is under his control as an employee, what is to prevent him putting a name other than that of *the first and true inventor* in the specification? The answer is usually that, owing to his intimate and detailed knowledge of his invention, the inventor's co-operation is necessary in developing the invention and drawing up the specification. However, if the invention is of any great importance, the employer will often include in the specification the names (as 'co-inventors') of other people who have had little or nothing to do with the invention. These are usually the names of the inventor's superiors in the firm' hierarchy, which appear on the specification in precedence to his own. When I look at a patent specification containing a list of co-inventors, I assume (unless I happen to know the people concerned) that the *last* name to appear on the list is that of the 'true and first inventor'. Of course, co-inventors do exist, and some specifications are honest in this respect.

So much for the prognosis as far as the inventor is concerned. What about his invention? I have indicated what may ensue as far as the private inventor (who is not an employee) is concerned. Let's see how the employed inventor gets on with 'his' invention. Unless the firm that employs him has a member of the technical staff specifically assigned to this task, he will have to draw up a 'provisional specification', minutely describing his invention. In any case, he will have to assist in this task. That's where his co-operation is essential.

The work involved in drawing up the 'provisional specification' will be in addition to his other duties for his employer. If his employer is one of the less scrupulous kind, he may be put under pressure to allow somebody else's name to appear as a 'co-inventor', even thought the person in question (generally the head of the department in which the inventor is employed) may have had little or nothing to do with the invention. To be fair to employers in general, I don't think that outright substitution of the inventor's name occurs very often, but the adding of 'co-inventors' is quite a common practice—though as I have said earlier, genuine co-inventors do sometimes exist.

If the real inventor is faced with this problem, there is nothing he can do about it, other than to resign his job, and *even that doesn't get him off the hook* if the invention is of any great importance. If his erstwhile employer thinks that it is economically worthwhile, he can without much trouble or expense compel his former employee by law to complete the job. There is a somewhat Gilbertian situation here when there is a lack of trust between the parties. The real inventor may so arrange things that essential information is withheld, or even false information substituted, and then having resigned his post go abroad, so that the employer has to 'start from scratch', perhaps hampered by false information, if he wants to pursue the invention. Since it is not a *criminal* offence on the part of the inventor, and false information can be passed off as 'mistakes', there is no extradition. But it must be rare for an inventor to be prepared or able to go to such lengths, though such cases are known.

Having drawn up his 'provisional specification' (according to strict rules laid down by the Patent Office), the inventor sends it to his employer's patent agent (who might be another employee or private agent under contract) who then searches Patent Office files for any information that may be relevant to the proposed patent. The result may often be that there is a crop of 'citations', that is, former patents and extracts from such patents that may seem to cast doubt on the validity of the proposed patent. It may so happen that somebody else has already filed a specification or published an article or 'paper' in a technical journal, covering the idea, (though this is unlikely *if the inventor knows his job*), in which case the invention will have to be abandoned.

The patent agent will have been competent to deal with many of the 'citations', but some may be referred back to the inventor, who will then have to show that they are not really relevant, or, if they are relevant, he will have to modify his specification in order to 'dodge' their implications. Meanwhile, time will be passing, and somebody else (perhaps in some other part of the world) may also be working on the idea. Everything then depends on the date when the inventor finally satisfies the patent office that his invention is valid and the final specification is accepted. It may still happen that somebody else (generally abroad) has filed a similar specification in which case there will be an expensive brawl between lawyers to decide which specification was filed first, and thus ousts the other. The inventor as an employee will not be involved in this, nor in any subsequent actions for 'infringement'. But the only reward that he can expect for his work is to see his name on the final specification.

Having filed the final specification, the inventor will often be required to make 'assignments' on behalf of his employer, if the invention is at all important. There is a big 'trade' in these inventions, firms selling or 'swapping' specifications with other firms, usually associates or subsidiaries abroad. Patent Law has laid down that in such cases the 'assent' of the inventor must be obtained by signature on an 'assignment' form to carry out the transaction. Only in the case of assignments to the USA does the inventor receive a 'fee' for his signature: *one dollar*!

There has been some grumbling amongst employers about this. It not infrequently happens that the inventor has left his employment, and has to be found to make the assignment, which has to be made before a Notary Public under oath. In some other countries—notably the USA—the employer can dodge this difficulty. I sometimes wonder how many assignments have been forged. One firm I worked for chased me for assignments up to two years after I had left their employment! My relations with that firm were such that I would have dearly loved to have refused—but that is impossible under current law.

Such is the life of an inventor. As a private inventor he is at the mercy of anybody with more money. As an employee-inventor, he exists only in name, whatever the importance of his inventions. The employer is under no legal obligation to make other than *ex gratia* payments, and only if these are written into the inventor's contract of employment. Organizations claimed to be acting on behalf of inventors have struggled for years to obtain a better deal, but so far without success. Almost invariably, the inventor's only reward is the strictly private sense of achievement, which is unsubstantial.

To Karl Marx is attributed the aphorism (profoundly true) that 'nothing is understandable apart from its history'. Long ago in pre-patent days, the ease with which an inventor could be robbed of all benefit and credit for his invention(s) gave rise to the (illusory) fear that inventors, realizing the situation, would become an extinct breed. Some sort of protection seemed to be called for. Hence the Patent Laws (in the UK). Perhaps in early days these laws did give some measure of protection to the inventor, but that soon came to be illusory. Patent laws give protection only to the *owner* of the patent, who nowadays is seldom the inventor.

Taking the ethical point of view, it would seem that the private inventor is entitled to the full fruits of his invention(s). There seems to be no valid argument to the contrary. It is when the inventor is an employee that the issues become controversial. The employer points out (quite rightly) that he has facilitated his employee's invention, and is therefore entitled to at least a share of the benefit—but 99.9%? Those who are advocates for the inventor point out that the invention could not have come about but for the employee's *insight*. It is this *insight* that is the real stock-in-trade of the inventor, and is an essentially personal attribute. To which the employer replies that it is merely an exercise of initiative—for which the employee is paid.

The issue is further complicated by the fact that the employee may also be (and not infrequently is) a private inventor. The specific issue that arises here is whether in view of his contract of employment (actual or implied) he can function as a private inventor. It would seem that he can do so only in a specific case, where his employer has no interest in the invention, and *has given well attested permission* for him to proceed. If the invention is of any commercial value, such permission is not likely to be given. The employee might argue that the invention was not developed in his employers' time or with the use of any of his employers' facilities and was not in any way technically related to his employers' business.

There are two possible attitudes which the law might take in this case. It might take the view that *all* inventions of the employee, irrespective of circumstances, are the property of the employer. Or it might take the view that if the circumstances were such as the employee claims, that he was entitled to proceed, but *he would have to prove such circumstances to the satisfaction of the court*. This could be a lengthy, harrowing and expensive business. In the mean time, the employee, in view of his dispute in the matter with his employer, would have lost his employment!

Suppose now that, being unemployed, you decide to become 'self-employed' as a freelance inventor. Your best chances of success will be to make use of the experience you have obtained during the course of your employment. That would seem to be obvious. So you present your patent agent with a provisional specification (a preliminary draft) which you have drawn up. He will naturally want to know what qualifications you have in that particular line, and you tell him that in the course of your previous employment you became familiar with the subject. He will then warn you that if any of the subject matter or 'claims' in the specification bear any relation to the business of your former employer, he may involve you in (probably successful) litigation to obtain ownership of the patent.

Heads I lose, tails you win! But invention, like some other forms of occupation can be intellectually attractive and some find that reward sufficient. (910085)

LONG-PERIOD MAINS TIMERS

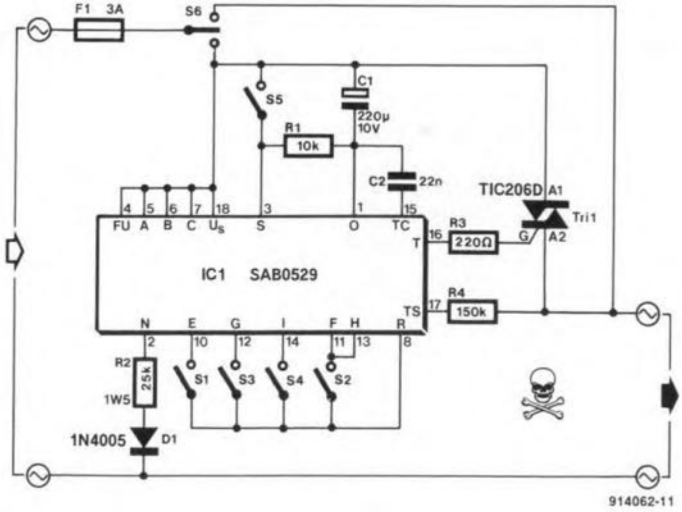
Siemens Type SAB0529 IC may be programmed for periods from 1 second to 31 hours 30 minutes. It may be used for switching staircase lights, battery chargers, and many others.

The chip is programmed via pins EI with the aid of switches S_1–S_4. When S_1 is closed, the IC is enabled for a period of 1 h; S_2: 4 h; S_3: 10 h; and S_4: 16 h. All sorts of combination are also possible: for instance, if both S_2 and S_3 are closed, and the other two switches are open, the chip is enabled for a period of 14 h.

The IC controls a 4-A triac, which can switch fairly large loads. The timer is started with S_5; in an emergency, it may be stopped prematurely with S_6.

Great care should be given to the construction, since dangerous mains voltage is present at several points in the circuit.

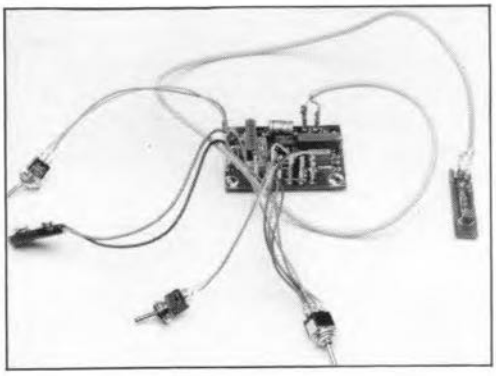
(R. Kambach 914062)

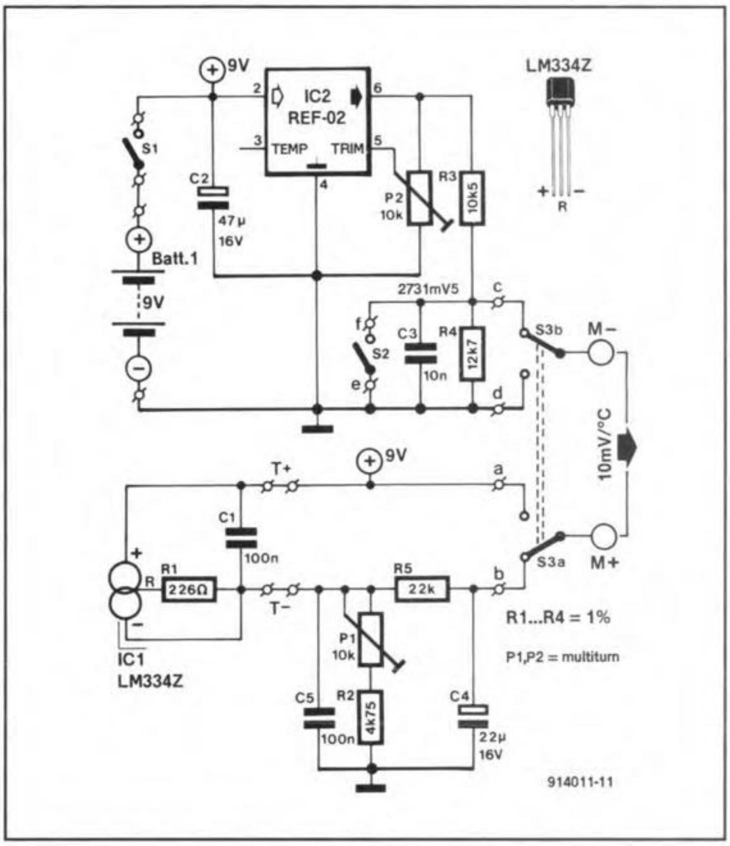


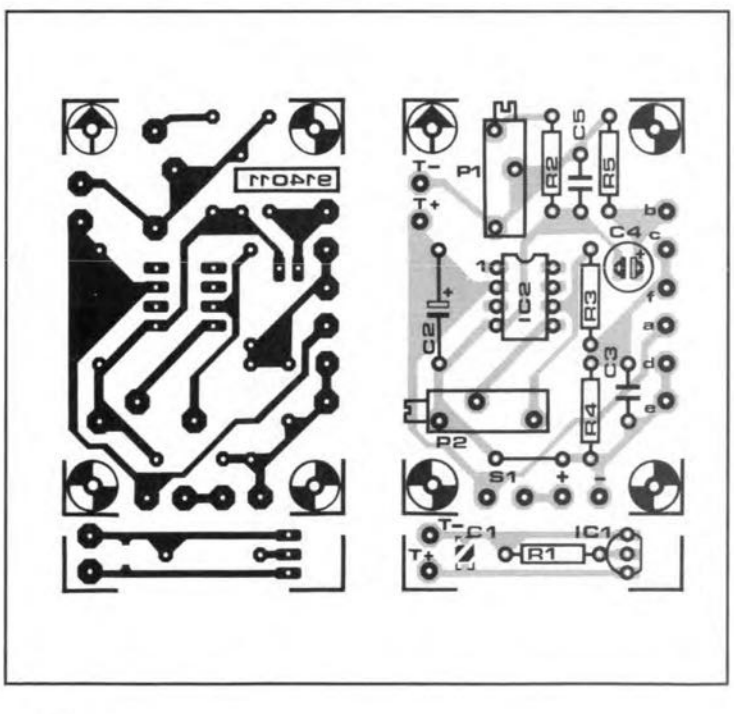
REMOTE TEMPERATURE MODULE FOR DIGITAL MULTIMETERS

NATIONAL Semiconductor's LM334Z is a temperature-dependent adjustable current source supplied in a plastic TO-92 package. In Fig. 1, a 226 Ω resistor, R_1, is used to set a current gradient of 1 μA K^{-1}.

The remote temperature sensor is formed by IC_1, R_1 and C_1. Since its output is a temperature-dependent current, a simple two-wire connection may be used between the sensor and the DVM interface. Constant current drive as applied here eliminates problems with voltage drop and expensive low-loss wiring associated with voltage drive. Also, remember that the voltage drop across a relatively long cable is temperature dependent, which calls for a fairly complex compensation circuit. By contrast, when the sensor is a constant current source, the length and the total resistance of the wire between it and the interface at the DVM side has virtually no effect on the output signal. This obviates a compensation circuit, and allows you to fit the sensor at quite some distance (up to 25 m = 80 ft) from the DVM using inexpensive wiring.







PARTS LIST

Resistors:
(1% types; E96 series)
R1 = 226 Ω
R2 = 4.75 kΩ
R3 = 10.5 kΩ
R4 = 12.7 kΩ
R5 = 22 kΩ

Capacitors:
C1 = 100 nF SMA*
C2 = 47 μF, 16 V, radial
C3 = 10 nF
C4 = 22 μF, 16 V, radial
C5 = 100 nF
* SMA = surface mount assembly

Semiconductors:
IC1 = LM334Z
IC2 = REF-02

Miscellaneous:
S1, S2 = on/off switch
S3 = DPDT switch
9-V battery with clip

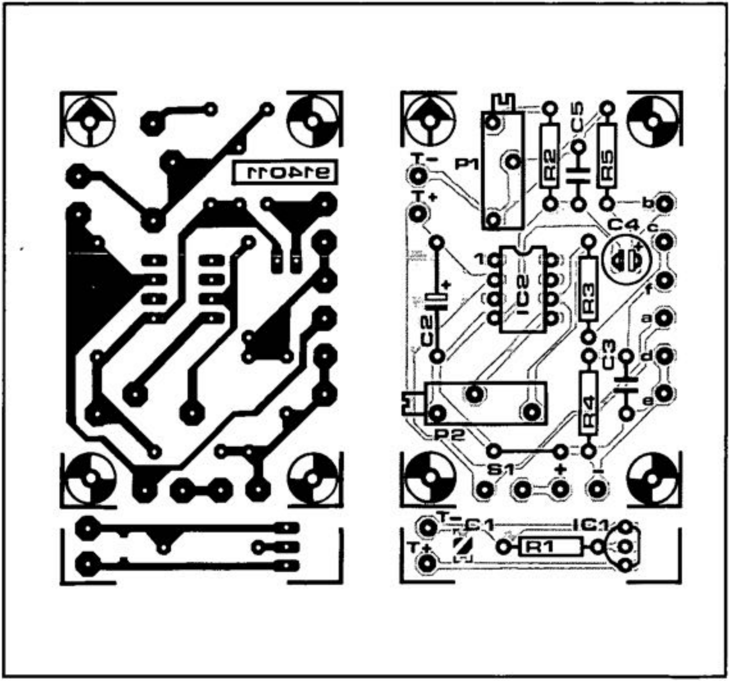
Components P_1 and R_2 convert the current supplied by the sensor into a voltage with a gradient of 10 mV K^{-1}. Capacitor C_1 suppresses high-frequency interference which may be picked up on the cable.

To prevent problems with ground levels, the current source must be powered by a separate 9-V battery as shown in the diagram. To allow temperature readings in degrees Celsius (°C), an adjustable high-stability voltage regulator Type REF-02 from Precision Monolithics Inc. is used to subtract a fixed amount of 2731.5 mV from the converter output voltage. This is achieved by 'lifting' the converter ground by 2731.5 mV (the REF-02 output voltage) when switch S_2 is opened. When S_2 is closed, the converter produces a temperature reading in kelvin.

The circuit is switched on and off by S_1. A quick battery condition check is available by switching S_{3a} to position 'a', and S_{3b} to position 'd'. Replace the battery if the DVM indicates less than 7.1 V.

Calibration of the converter is fairly simple. First, adjust multiturn preset P_2 until a voltage of 2731.5 mV is obtained across R_4 (open S_2). Next, adjust the temperature gradient (preset P_1) by comparing the DVM reading to that produced by a calibrated thermometer. Set the DVM to the 2 V range for degrees celsius readings. An indication of, say, 0.217 V (on a $3^1/_2$ digit instrument) then corresponds to a measured temperature of 21.7 °C. Properly adjusted, the temperature sensor achieves a resolution of 0.1 kelvin. Finally, the current drain is about 2 mA.

[J. Ruffell 914011]

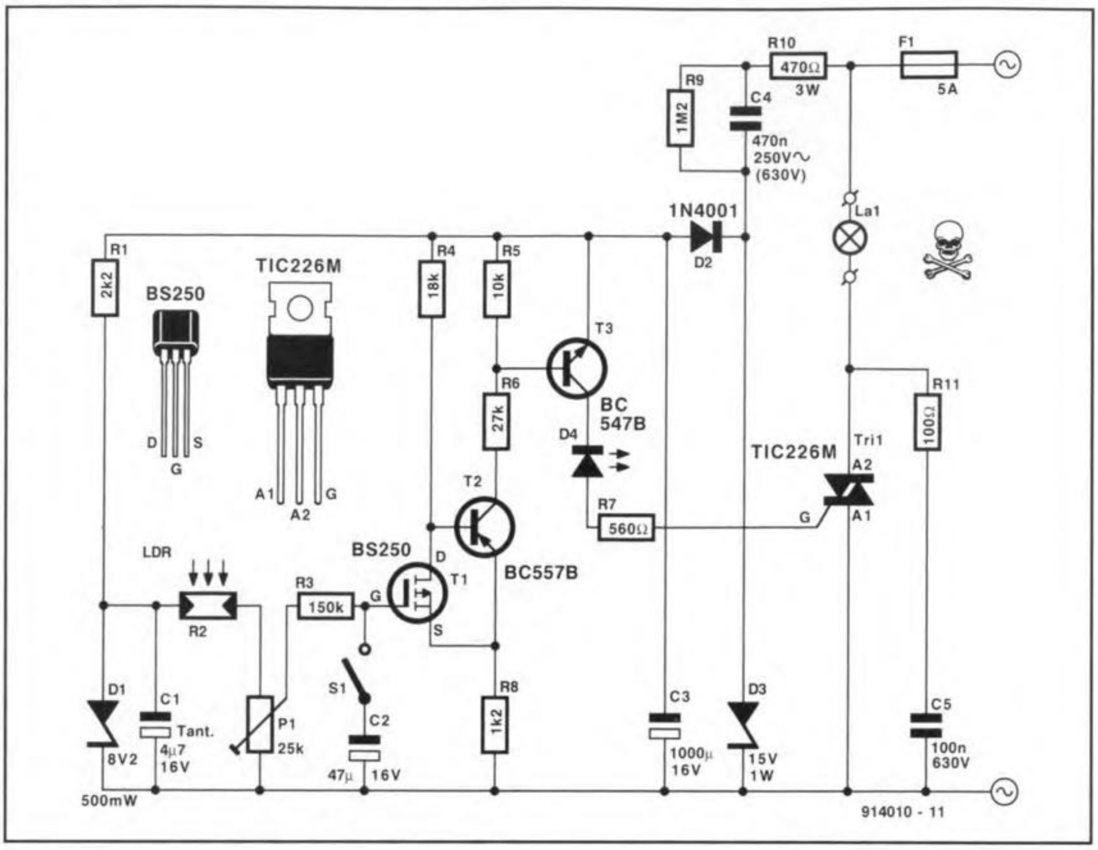


T-
T+
P1
R2
C5
R5
b
C4
c
1
IC2
R3
f
a
C2
C3
d
e
R4
P2
S1
+
-
T-
C1
IC1
T+
R1

SOLID-STATE LIGHT-SENSITIVE SWITCH

THIS electronic switch is designed to be connected direct to the mains, which obviates a low-voltage supply and so keeps the cost and space requirement to a minimum. The circuit switches a lamp on when it gets dark, and off again when it gets light. The switching is done without a relay, avoiding problems with sparks and mains pollution caused by the contacts and the coil inductance.

The switch is powered by the mains via R_{10}, C_4, D_3, D_2 and C_3. A voltage reference, D_1, supplies 8.2 V to a light measuring network, R_2-P_1. As the light intensity drops, the resistance of the LDR (light-dependent resistor), R_2, increases. Consequently, the voltage across P_1 drops, so that the gate-source voltage of FET T_1 drops also. When switch S_1 is closed, time constant R_3-C_2 causes the gate voltage of T_1 to change more slowly than the resistance of R_2. This is necessary to prevent the circuit responding to quick changes in the ambient light intensity.



Components T_1, T_2, R_4, R_5, R_6, and R_8 form a Schmitt trigger. Normally, T_1 conducts so that T_2 is off. When the gate voltage of the FET drops below a certain level, T_2 is switched on. Consequently, T_3 starts to conduct, and supplies the gate current necessary to trigger triac Tri_1. The load, lamp La_1, is then switched on. When the light intensity increases above the level set with P_1, T_1 is switched on, so that the load is switched off.

Switch S_1 is included to disable the time constant during adjustment. Resistor R_9 serves to discharge C_4 after the circuit has been disconnected from the mains.

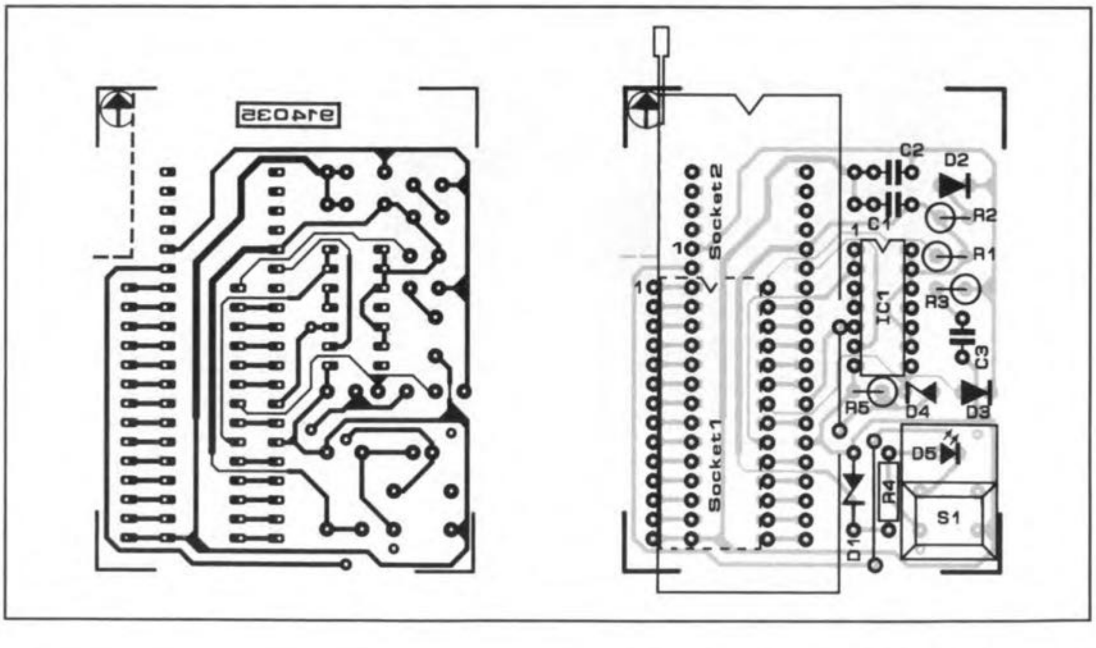
WARNING. Since the circuit carries dangerous voltages at a number of points, it is essential that proper electrical insulation is applied. Never work on the circuit when the mains is connected to it. Make sure that no part of the circuit can be touched when it is being set, adjusted or used.

(L. Rikard 914010)

1-MBIT ADAPTER FOR EPROM PROGRAMMER

THE ADAPTER allows you to program the 27C1001 EPROM which has a capacity of 1 bit organised as 128 Kbyte ×8. To be able to use the present adapter, your EPROM programmer must be capable of programming 512 Kbit EPROMs such as the 27512 or 27C512 (64 Kbyte×8). The adapter programs the 27C1001 in two steps of 64 Kbyte each, and is simply plugged into the 28-way (or 40-way) ZIF socket on your EPROM programmer. The 64 Kbyte block selection is effected manually with the aid of a switch.

The circuit of the adapter has few surprises. Socket 1 connects the adapter to the EPROM programmer, while socket 2 accepts the 27C1001. The $\overline{PGM}$ input



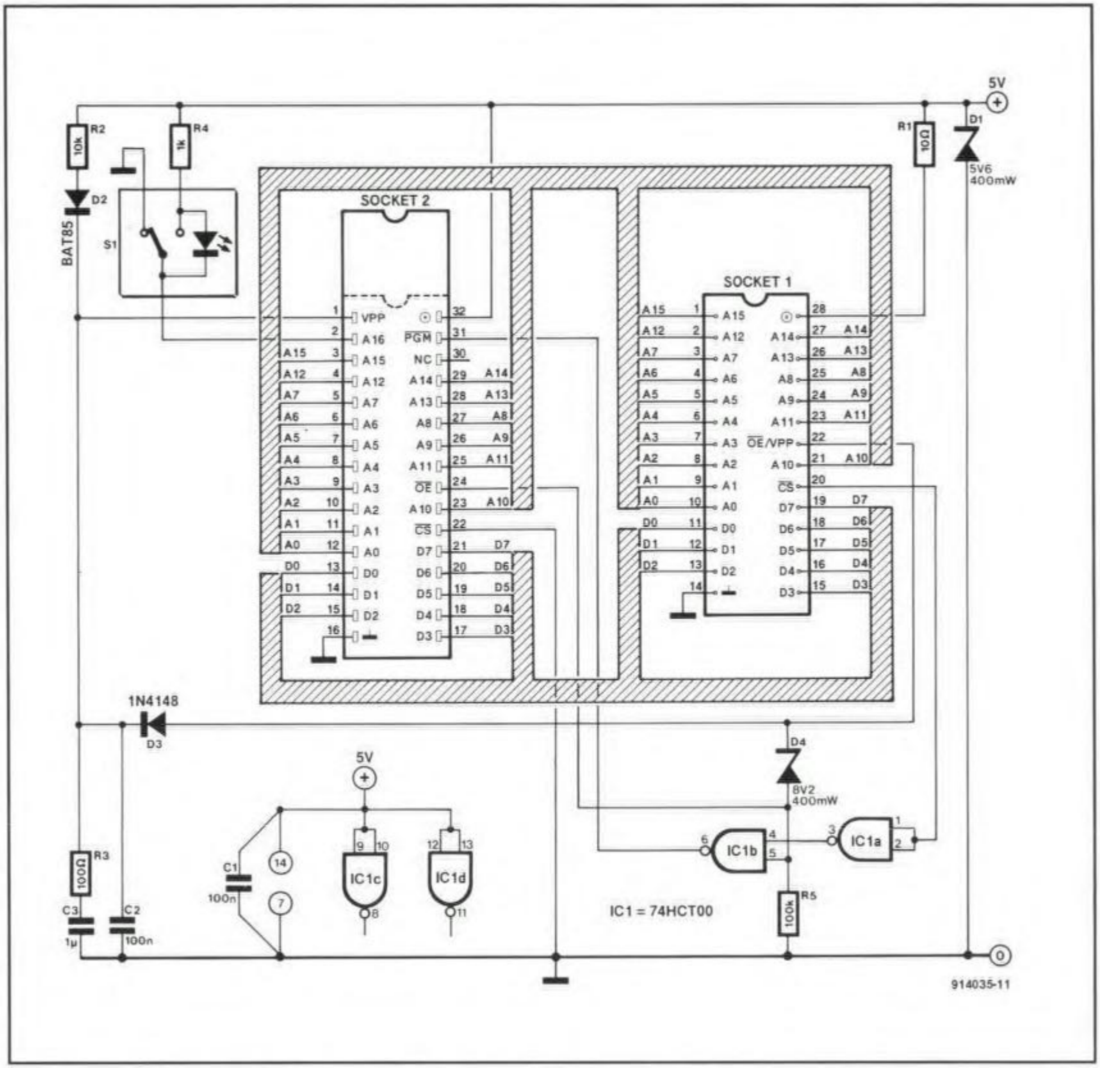
PARTS LIST

Resistors:
R1 = 10 Ω
R2 = 10 kΩ
R3 = 100 Ω
R4 = 1 kΩ
R5 = 100 kΩ

Capacitors:
C1, C2 = 100 nF
C3 = 1 µF

Semiconductors:
D1 = zener, 5.6 V, 400 mW
D2 = BAT85
D3 = 1N4148
D4 = zener, 8.2 V, 400 mW
D5 = LED, 3 mm
IC1 = 74HCT00

Miscellaneous:
S1 = self-locking push-button with integral LED, ITW Type 61-2030401
2 off 14-way strips of PCB pins (long pins at one side)
32-way or 40-way ZIF socket



of the 27C1001 is actuated (i.e., made logic low) when the programming voltage, Vpp, on socket 1 exceeds the zener voltage of D_4, and $\overline{CS}$ on socket 1 is held low by the programmer. The zener diode also enable the programming voltage, 12.5 V, to pull the $\overline{OE}$ terminal of the 27C1001 high, which allows the device to be programmed. The Vpp input of the 27C1001 is held either at +5 V (during read operations) or at about +12 V (during programming). To ensure that the 27C1001 is supplied with a sufficiently high operating voltage (nominally 5 V), a Schottky diode type BAT85 is used in position D_2. This diode is marked by a forward drop of 0.2 V only.

Switch S_1 takes the highest address input, A16, of the 27C1001 low or high to effect the selection between the lower and higher 64 Kbyte block in the device (A16 = low, and A16 = high, respectively). Diode D_5 lights when the lower block is addressed.

The construction of the adapter is apparent from the PCB layout. Start by fitting the single wire link on the board. Socket 1 is fitted at the track side of the board, and consists of two 14-pin PCB pin headers. Switch S_1 is a self-locking push-button from ITW with a built-in LED indicator. The PCB accommodates both 28-way and 40-way ZIF sockets.

(G. Rubel 914035)

1-MBIT ADAPTER FOR EPROM PROGRAMMER

THE ADAPTER allows you to program the 27C1001 EPROM which has a capacity of 1 bit organised as 128 Kbyte×8. To be able to use the present adapter, your EPROM programmer must be capable of programming 512 Kbit EPROMs such as the 27512 or 27C512 (64 Kbyte×8). The adapter programs the 27C1001 in two steps of 64 Kbyte each, and is simply plugged into the 28-way (or 40-way) ZIF socket on your EPROM programmer. The 64 Kbyte block selection is effected manually with the aid of a switch.

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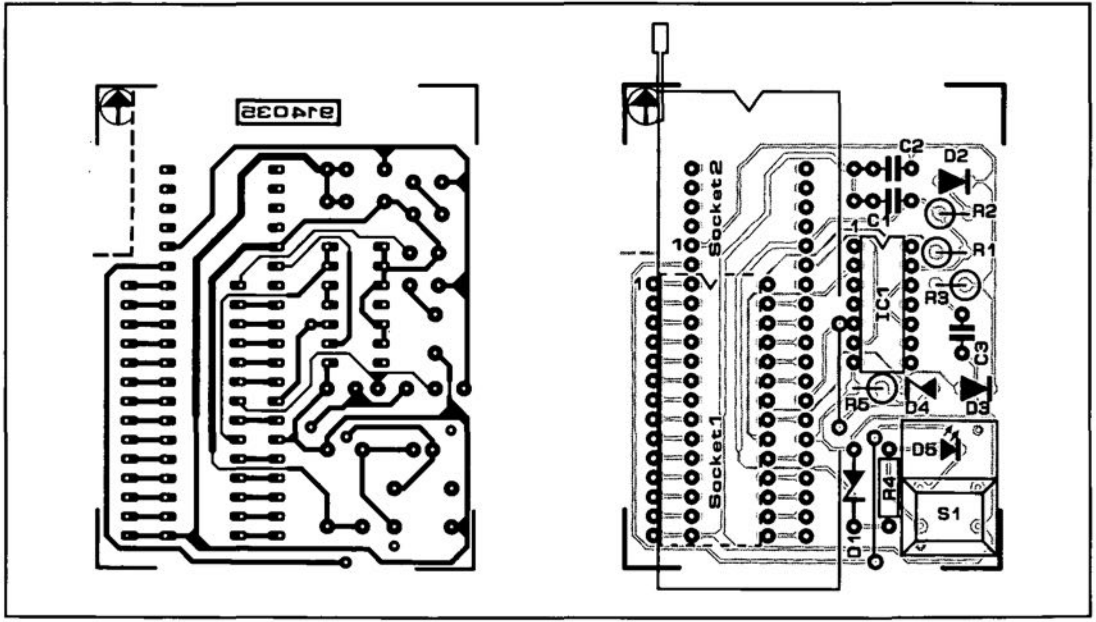
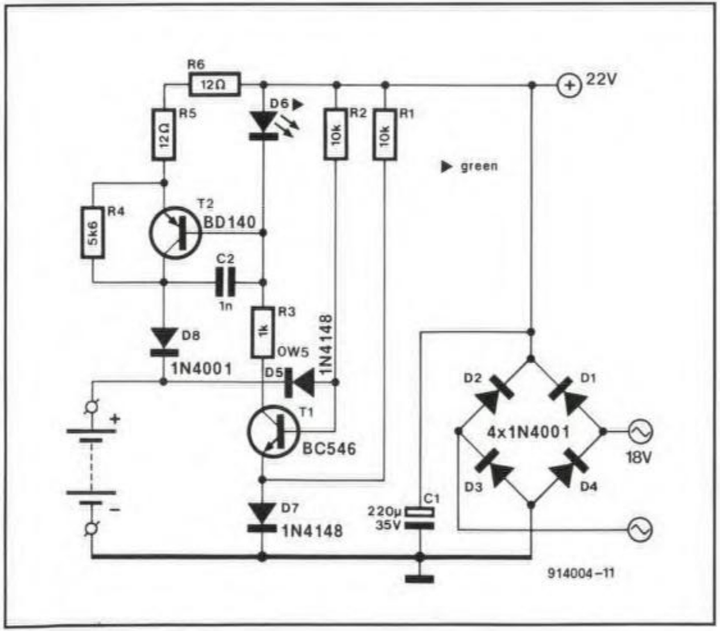




BATTERY CHARGER

THE BATTERY charger shown in the diagram may be used to charge a battery or batteries with a total nominal voltage of 12 V (that is, ten NiCd batteries or six 2-V lead-acid batteries. It is small enough to be built into a mains adapter case. Misuse is virtually impossible: batteries connected with wrong polarity, a short-circuit of the output terminals, or a mains failure have no effect on either the charger or the batteries.

Power is derived from the mains via a transformer with an 18-V secondary. The output of the transformer is rectified by diodes D_1-D_4 and smoothed by C_1, whereupon a direct voltage of 22 V is available across C_1.

Completely discharged batteries are first charged by a current of some 6 mA via R_2-D_5 and R_4-R_6-D_8. Once the battery to be charged has an e.m.f. of 0.3–0.5 V, the base-emitter voltage of T_1 becomes high enough to switch the transistor on. Charging indicator D_6 then lights and T_2 is also switched on. A charging current of some 60 mA then flows via R_5-R_6. This means that 500 mAh NiCd batteries will be charged in about twelve hours.

If the battery is connected with wrong polarity or the charging terminals are short-circuited, power transistor T_2 remains off and the charging current cannot become higher than 6–12 mA.

The current drawn by the circuit in full operation is about 80 mA.

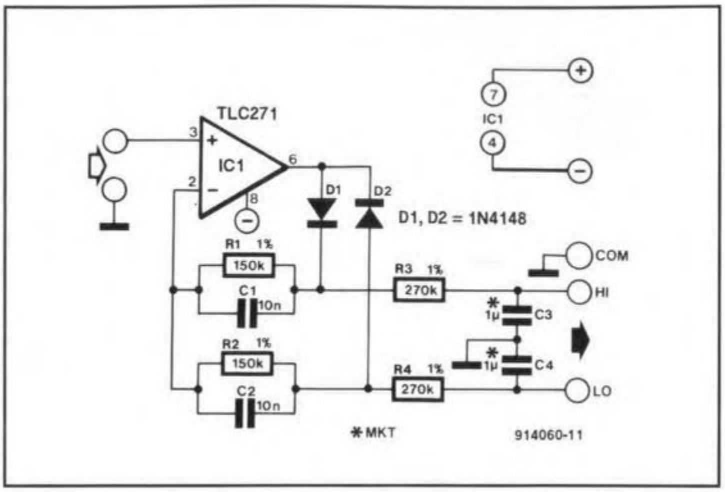
(H. Döpfner 914004)

PRECISION RECTIFIER FOR DIGITAL VOLTMETERS

THIS SIMPLE circuit, based on a single opamp in non-inverting mode, is a precision rectifier extension for digital voltmeters. The circuit can be connected to a high-impedance voltage divider without the need of an additional buffer stage that increases the cost and, more importantly, the power consumption. Another advantage of this circuit is that the accuracy is not affected by the off-set voltage of the opamp. The output of the rectifier is differential to allow ready connection to the IN-LO and IN-HI inputs of DVM ICs like the familiar 7106 and similar types.

Circuit IC_1 is a LinCMOS operational amplifier operating in the high-bias mode. The TLC271 used here achieves a good high frequency response at a low current consumption of about 1 mA. For all practical purposes, the gain of the opamp is $2R_1/R_2$, where $R_1=R_3$ and $R_2=R_4$. With the values shown, the gain is nearly equal to 1.1107, which is the r.m.s. (root-mean-square) shape factor for sinusoidal waveforms. Capacitors C_1 and C_2 are optional. They improve the response and stability of the rectifier at high frequencies.

Any d.c. component at the input, as well as the off-set voltage of IC_1, appears as a common-mode voltage across C_3 and C_4, and is therefore rejected. The low-frequency response of the rectifier is determined by the time constant R_2C_3 (or R_4C_4). With the component values shown, the 1%-accuracy bandwidth extends from 25 Hz to about 20 kHz.



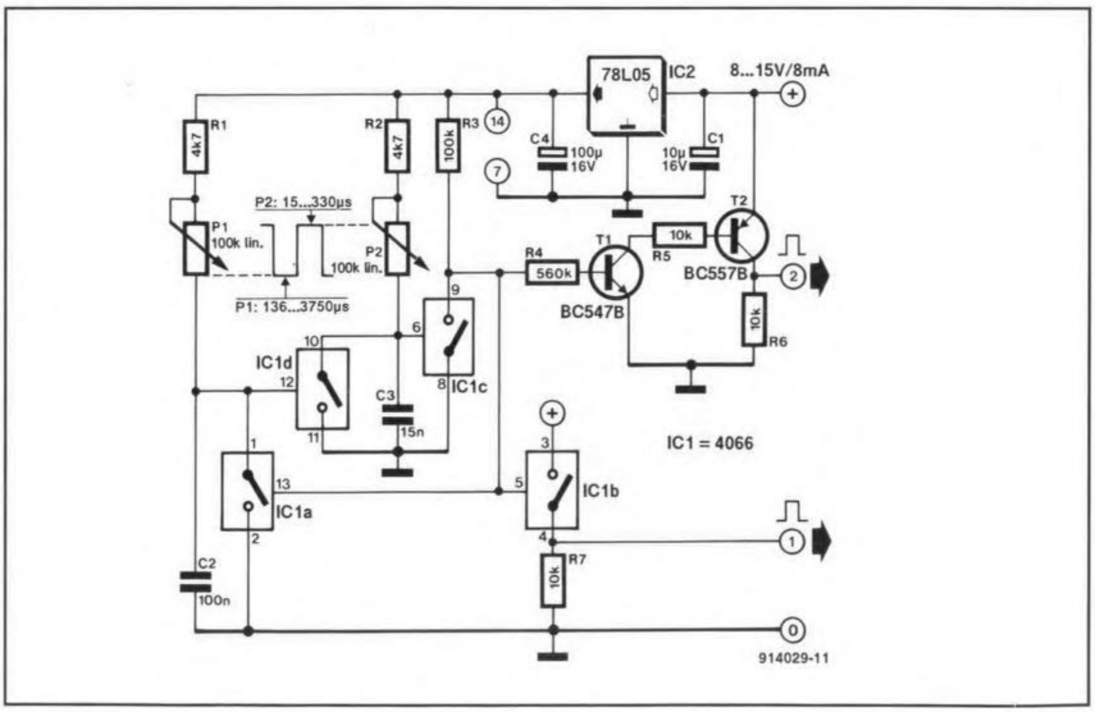
The circuit is powered by the 9-V battery used for the DVM module. The ground of the rectifier is connected to the COM terminal of the module, which is at a potential of about 2.8 V below the positive supply. The DVM should be set to a full-scale input voltage of 200 mV.

(R. Shankar 914060)

PULSE GENERATOR WITH ONE 4066

THE DIAGRAM shows how the inexpensive and widely available 4066 quad bilateral analogue switch can be used to build a pulse generator with adjustable 'high' and 'low' times of the output waveform.

Assuming that switch IC_{1a} is open, the control input of IC_{1b} is logic high, and this switch is therefore closed. This results in low levels at the control inputs of IC_{1c} and IC_{1d}. Capacitor C_2 is allowed to charge via preset P_1, and C_3 via preset P_2. When the voltage across C_2 reaches a certain level, IC_{1a} is closed so that the control input of IC_{1b} is pulled low. The outputs of the circuit, OUT1 and OUT2, are then logic high. OUT1 has a swing of 5 V, and OUT2 a swing virtually equal to the supply voltage (max. 15 V). Meanwhile, switch IC_{1c} is closed, so that C_2 is discharged. Switch IC_{1a} is opened, and C_3 is charged via P_2. When the voltage across C_3 has reached a certain level, IC_{1b}



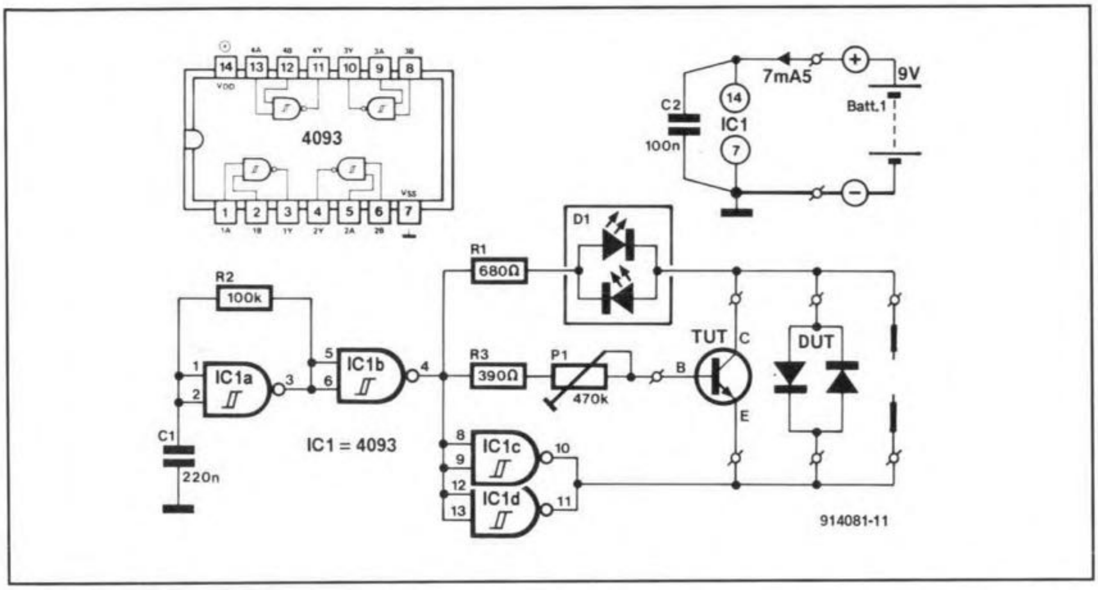
is closed, and the outputs of the circuit change to logic low.

The 'low' and 'high' times of the output waveform are adjusted with P_1 and P_2 respectively. With the given component values, the 'low' time can be set between 136 µs and 3.75 ms, and the 'high' time between 15 µs and 330 μs. Other on and off times can be created by changing C_2 and C_3.

The circuit draws a current of about 8 mA at a supply voltage of 10 V. Note that OUT1 produces a less than perfect waveform, and has a low fan-out. The other output, OUT2, is buffered and should be used for most applications.

(P. Sicherman 914029)

SEMICONDUCTOR TESTER



THE TESTER in the diagram can be used to test virtually any kind of semiconductor device, ranging from switching diodes to power transistors. In addition, it provides a rough gain indication of bipolar transistors, and, more generally, can be a useful aid in finding functional, short-circuited and internally open devices in semiconductor batches.

The tester is based on a single CMOS IC and a bi-colour LED as a visual indication. Gate IC_{1a} forms an *R-C* oscillator. The oscillator signal is buffered and made available in true and inverted form by the three remaining gates in the IC.

The bi-colour (red/green) LED indicates the direction of the current that is allowed to pass through the test probes or the device under test. Resistor R_1 functions as a current limiter.

The signals at the input and the output of gate IC_{1c} are applied to a pair of test probes, a two-terminal test socket for diodes, and a three-terminal transistor socket. The base current for the transistor under test (TUT) can be set with preset P_1. The preset may be calibrated with the aid of known, functional transistors to give an approximate gain scale.

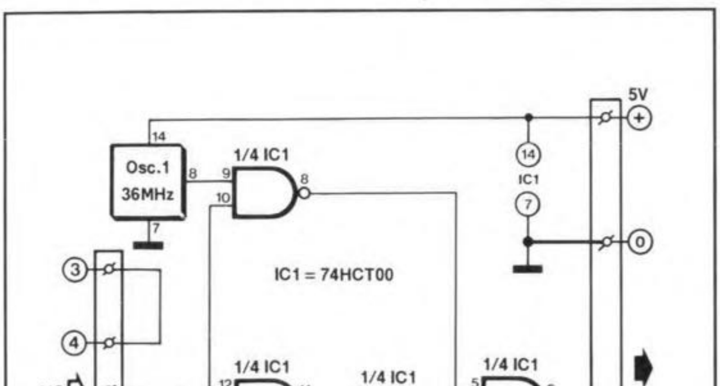
Only one LED lights when a semiconductor is functional. The LED colour then indicates the polarity (n-p-n or p-n-p, or cathode/anode). When the component is internally open, no LED lights. A semiconductor with an internal short-circuit is easily recognized by the green and red LEDs lighting simultaneously at about equal intensity. Transistors must be connected with the base, collector and emitter pins to the indicated socket terminals, so check the pinout before running the test!

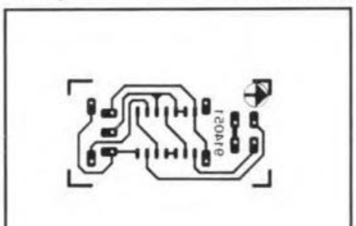
The circuit may also be used as a simple continuity tester. It draws a current of about 300 μA without a DUT or TUT connected, and about 7.5 mA with the probes short-circuited.

(Amrit Bir Tirwana 914081)

VIDEO ENHANCEMENT FOR ACORN ARCHIMEDES

THE ACORN Archimdes, well-known for its speed and good graphics facilities, has a video interface that allows programmers to design a variety of screen modes with the aid of a programmable controller. As so often, this versatility has a draw-back: since the controller uses a fixed clock of 24 MHz, the frame frequency decreases the more pixels are used in the screen image. As a result, high-resolution screen modes have a tendency to cause flicker. Fortunately, this drawback may be eliminated or nearly so by increasing the clock to 36 MHz: this has already been incorporated in the new A540 computers.





All that is necessary to increase the clock is an integrated crystal oscillator and a Type 7400 IC. To ensure that the circuit in the diagram is at all times compatible with the existing software, it may be arranged to be switched on (by software) only when the screen mode requires a higher clock.

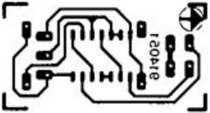
The design allows the circuit to be fitted simply to the existing connectors in the computer. The TTL oscillator and two small connectors are fitted at one side of the board (not available ready-made), while the other side houses a surface-mount version of the 74HCT00.

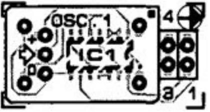
The board itself is fitted to the four pins of PL_3 in A300 computers or PL_4 in A400 computers.

The connection with the I/O line that arranges the switching between the two clock frequencies is made with a short length of circuit wire soldered to pin 3 of PL_{10} on the mother board.

The supply for the board is obtained by soldering two short lengths of circuit wire to the supply lines on the back plane (the card with the extension connectors).

(H. Stenhouse 914051)




OSC 1
IC1
4
3
1
+
0

VOLTAGE-CONTROLLED CURRENT SOURCE

THE SOURCE, based on a Type TL084 quadruple opamp, is intended to convert an input signal of 0–5 V into a current of 0–20 mA This type of circuit is used, for instance, to transfer measurands (quantities being measured) over long leads. Since the resistance of the leads is part of the current loop, it is of no consequence and can not affect the measurement.

Opamp IC_{1a} is a straightforward input amplifier. Opamp IC_{1b} adjusts the direct voltage component of the amplified input signal: the operating point may be shifted with P_2. It is, for example, possible to arrange an output current of 4 mA for an input voltage of 0 V. The output current range is then 4–20 mA

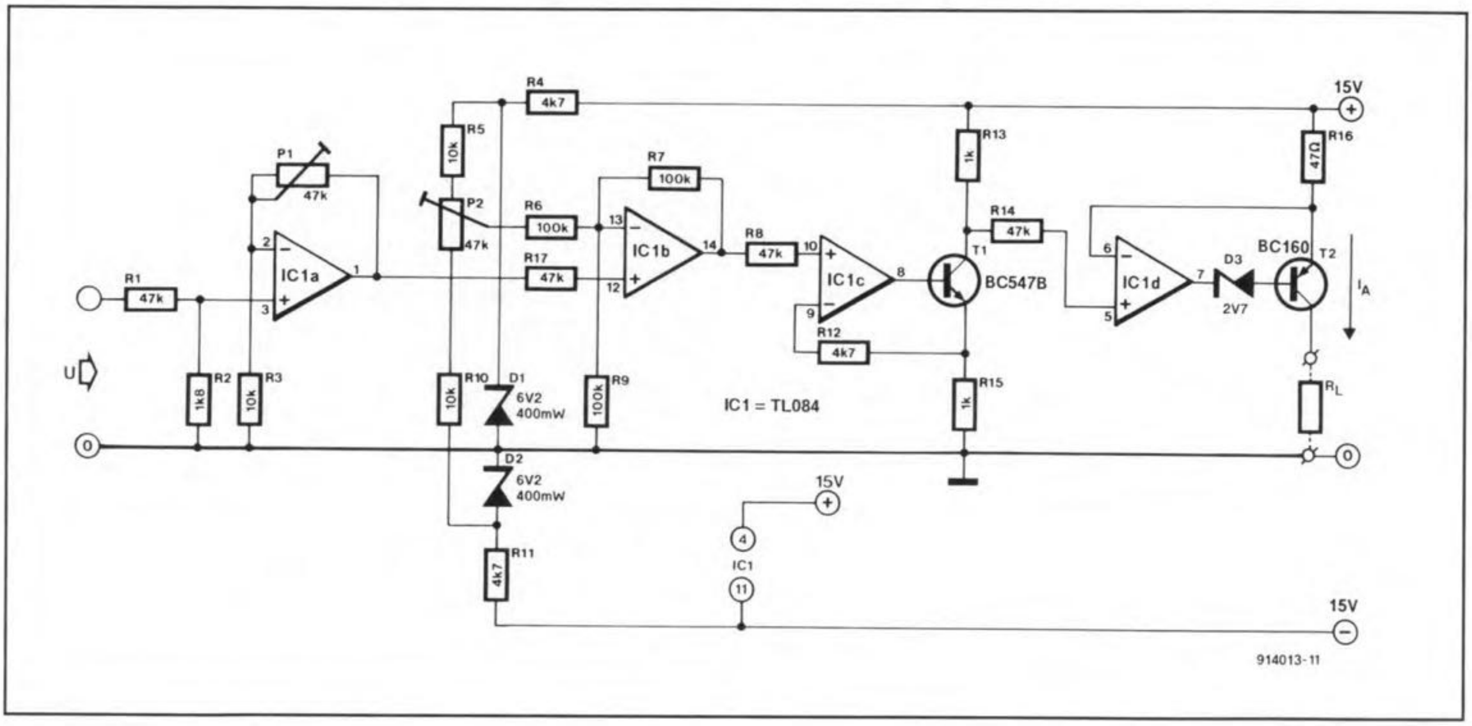
Opamp IC_{1c} and T_1 convert the output of IC_{1b} to a signal of 15 V. This makes it possible for IC_{1d} and T_2 to function as a voltage-to-current converter. The output current flows to earth via load resistance R_L.

Varying the values of R_2 and P_1 allows the amplification to be altered as required.

The circuit may also be used as a temperature-to-current converter by making the potential divider at the input consist of a fixed resistance and one with a negative temperature coefficient.

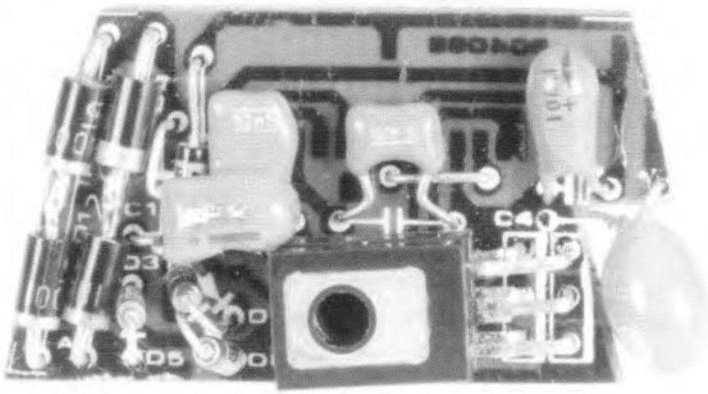
When the requirements are exacting, the two zener diodes should be temperature compensated.

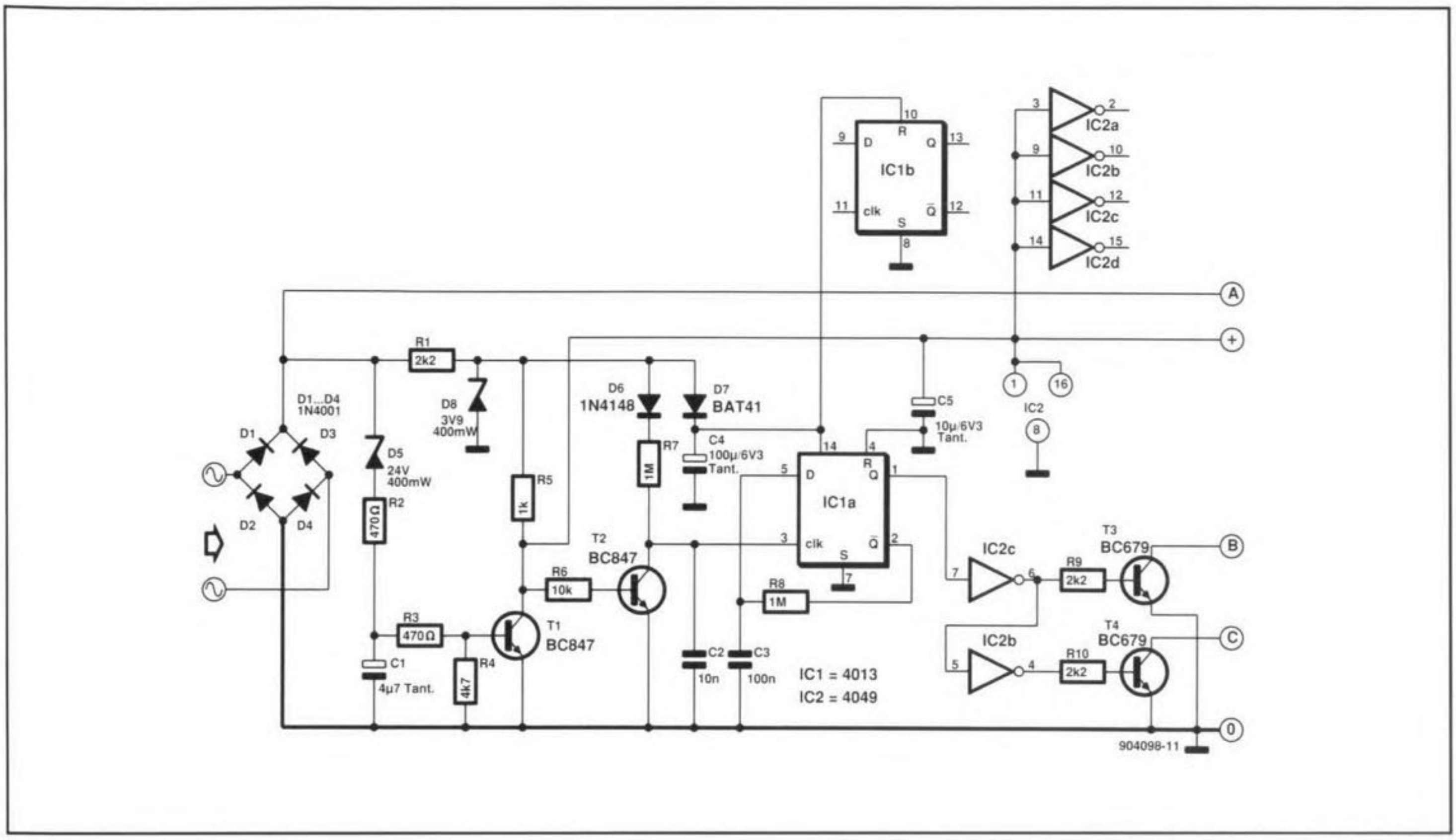
(Dr Elrich Kunz 914013)

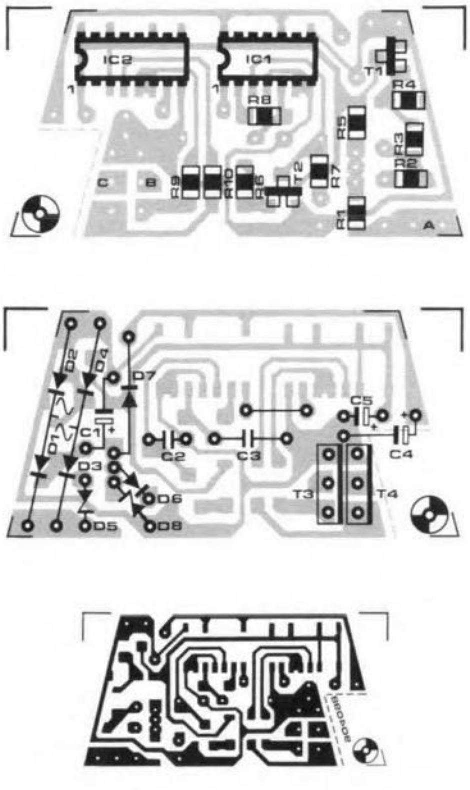


ELECTRONIC REVERSING CIRCUIT FOR MODEL TRAINS

MANY model train enthusiasts find the mechanical reversing system for trains in the H0 series from Märklin and other manufacturers primitive and unreliable. The system is based on a.c. motors and a mechanical reversing assembly operated by a small electromagnet. The motor speed is determined by the track voltage, which can lie between 4 V and about 16 V. When the knob on the speed controller is turned fully anti-clockwise, the a.c. voltage on the track is briefly increased to 24 V. Ideally, this causes the electromagnet in the loco to be actuated and overcome the counterforce of a small spring. In practice, this way of changing the direction of a model train is fraught with difficulties as the tension of the spring is a very critical factor. In not a few cases, the voltage pulse fails to actu-







PARTS LIST

Resistors (all SMAt):
R1, R9, R10 = 2.2 kΩ
R2, R3 = 470 Ω
R4 = 4.7 kΩ
R5 = 1 kΩ
R6 = 10 kΩ
R7, R8 = 1 MΩ

Capacitors:
C1 = 4.7 µF, 16 V
C2 = 10 nF, tantalum
C3 = 100 nF, ceramic
C4 = 100 µF, 6.3 V, tantalum

Semiconductors:
IC1 = 4013 (SMA)
IC2 = 4049 (SMA)
T1, T2 = BC846B (SMA)
T3, T4 = BD679
D1–D4 = 1N4001
D5 = zener, 24 V, 400 mW
D6 = 1N4148
D7 = BAT41
D8 = zener, 3.9 V, 400 mW

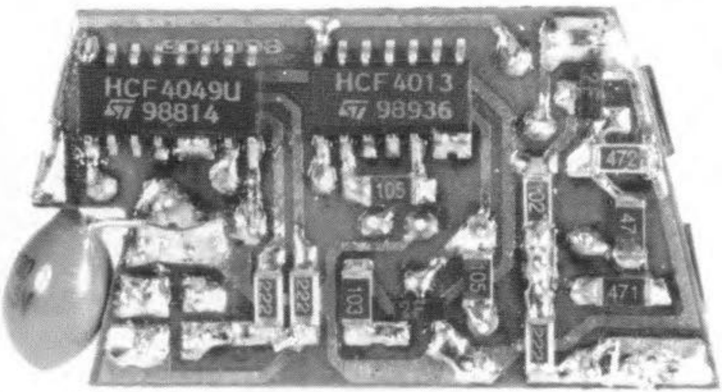
Miscellaneous:
PCB 904098
(for 5 reversing circuits)

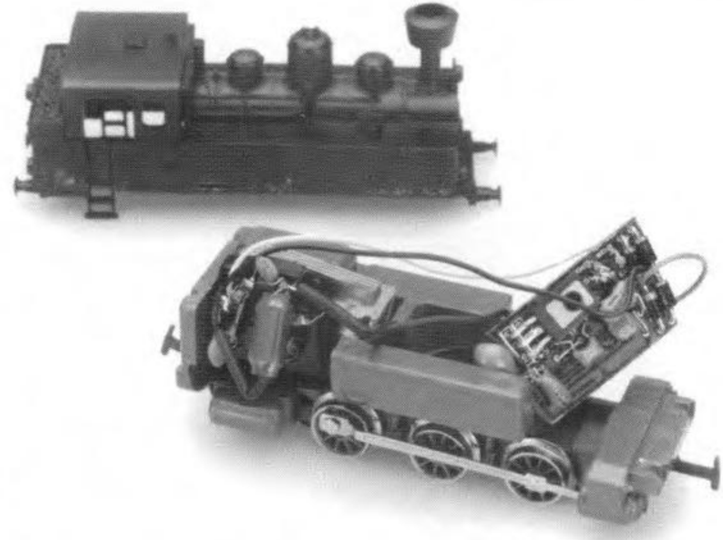
ate the reversing mechanism, and instead cause the loco to hurl itself at a turnout where it is derailed. When the spring is too loose, it may happen that a loco, running at full speed, reverses suddenly with 'disastrous' results.

Some ten years ago Märklin recognized the disadvantages of the voltage-operated reversing system, and came up with an electronic alternative in the form of a zener diode and two transistors. Unfortunately, this upgrade proved expensive and difficult to fit in existing locos, which many modellers would be loathe to give up.

In all-electronic reversing systems developed a few years ago, the direction of the loco is 'stored' in a small button cell. This is necessary to prevent the information being lost as there is no supply voltage when the loco stands still. The present circuit uses a 100 µF tantalum capacitor to keep the control circuit powered for up to 8 hours. The capacitor, in the author's opinion, is more elegant and environmentally safer than the battery. The circuit described below is based partly on SMA (surface-mount assembly) components, and is designed to be as economical as possible as regards power consumption.

When the circuit is not actuated, transistors T_1 and T_2 are off, and the inputs of IC_1, a bistable Type 4013, are effectively not connected. The last direction of the loco is stored in the bistable. When the loco runs, D_5 blocks and keeps T_1 off. The 4049 (IC_2) is supplied with about 3.5 V via R_5, so that the motor driver



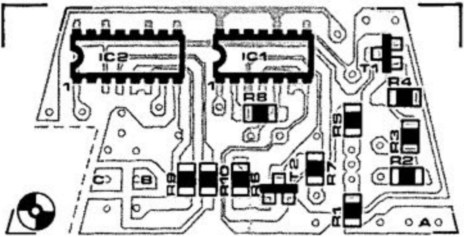


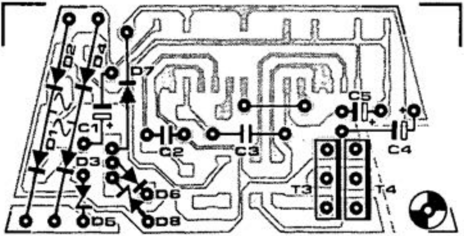
transistors, T_3 and T_4, can be controlled. Transistor T_2 conducts and supplies IC_{1a} with a clock pulse. When the track voltage rises to 24 V, T_1 is turned on and removes the supply voltage from IC_2. T_2 is switched off and supplies the bistable with another clock pulse via D_6 and R_7. The active transistor, T_3 or T_4, is changed, and the motor changes direction in a reliable manner. Since the loco motor is powered with d.c. after installing the circuit, you may avail yourself of the opportunity to isolate the loco lights from the chassis and fit diodes to couple the lighting to the direction control.

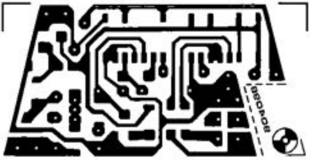
The construction of the circuit is illustrated in the photographs. The dimensions of the circuit board are such that it can take the place of the relay, which is carefully removed from the loco. No part of the circuit may touch the metal chassis.

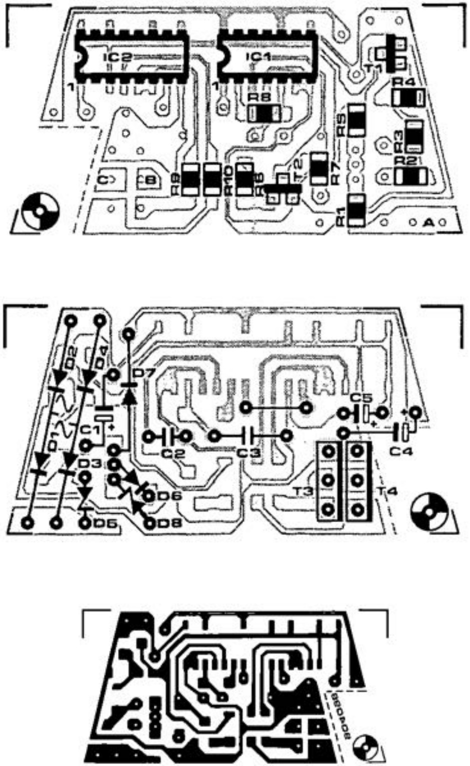
The points marked 'B' and 'C' on the PCB are connected to the field terminals of the motor, and point 'A' to the terminal previously connected to the slide contact. The slide contact and the loco chassis are connected to the bridge rectifier inputs. Finally, note that the printed-circuit board allows you to build five reversing circuits.

(C. Wolff 904098)


IC2
IC1
T1
R4
R8
R5
R3
R2
R9
R10
R6
T2
R7
R1
C
C8
A


D2
D4
D7
D1
C1
D3
C2
C3
C5
C4
T3
T4
D6
D5
D8





PARTS LIST

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C3 = 100 nF, ceramic
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Semiconductors:
IC1 = 4013 (SMA)
IC2 = 4049 (SMA)
T1, T2 = BC846B (SMA)
T3, T4 = BD679
D1–D4 = 1N4001
D5 = zener, 24 V, 400 mW
D6 = 1N4148
D7 = BAT41
D8 = zener, 3.9 V, 400 mW

Miscellaneous:
PCB 904098
(for 5 reversing circuits)

Some ten years ago Märklin recognized the disadvantages of the voltage-operated reversing system, and came up with an electronic alternative in the form of a zener diode and two transistors. Unfortunately, this upgrade proved expensive and difficult to fit in existing locos, which many modellers would be loathe to give up.

In all-electronic reversing systems developed a few years ago, the direction of the loco is 'stored' in a small button cell. This is necessary to prevent the information being lost as there is no supply voltage when the loco stands still. The present circuit uses a 100 μF tantalum capacitor to keep the control circuit powered for up to 8 hours. The capacitor, in the author's opinion, is more elegant and environmentally safer than the battery. The circuit described below is based partly on SMA (surface-mount assembly) components, and is designed to be as economical as possible as regards power consumption.

When the circuit is not actuated, transistors T_1 and T_2 are

ANGLED BUS EXTENSION FOR PCS

THIS 8-bit bus extension card for IBM PCs and compatibles allows you to connect and test insertion cards without having to open the computer. The printed-circuit board shown here is angled, and has a 62-way slot connector to accept external boards.

The pins of the bus connector are soldered straight to the copper tracks at the edge of the board.

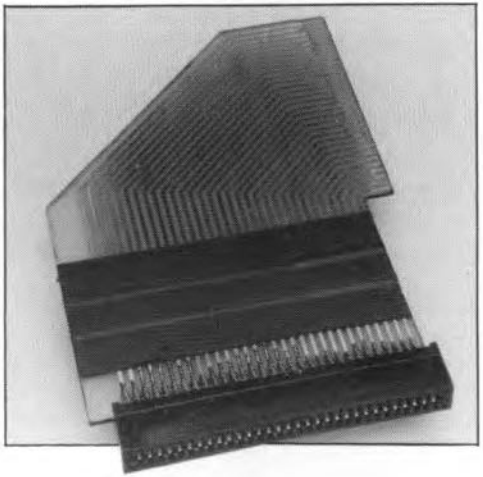
Since the tracks on the extension card pass through the metal frame at the rear of the PC, it is recommended to insulate them locally with PVC tape. Also, for mechanical stability the extension card must be secured to the frame with the aid of a support bracket.

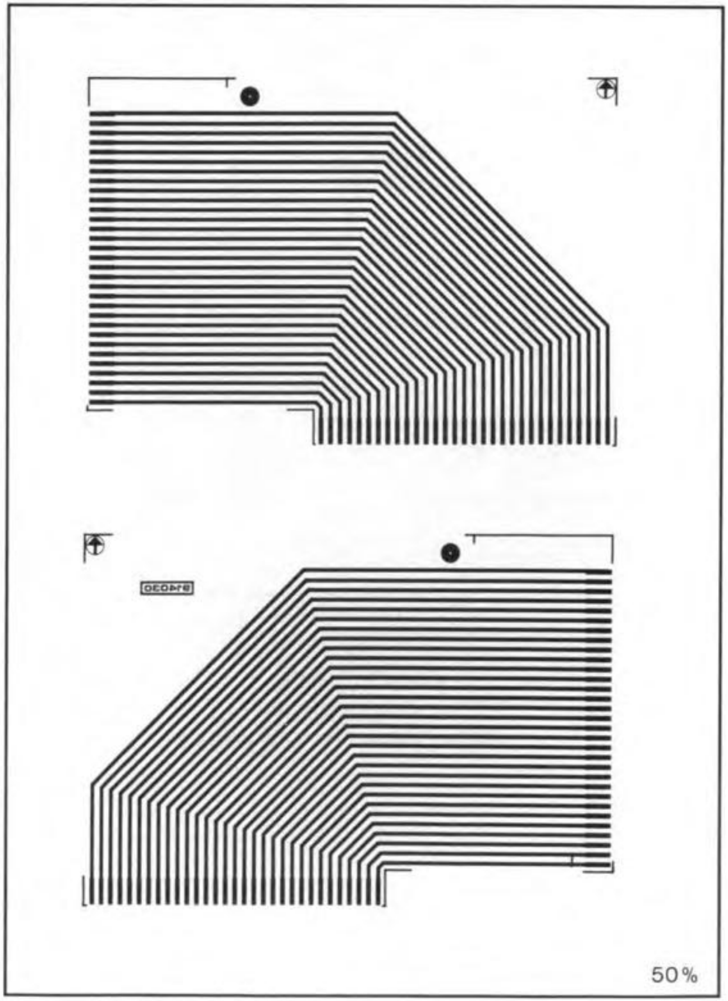
Finally, take care to fit insertion cards the right way around in the slot connector of the extension card. If necessary, put the PC on a couple of books to create room at the underside.

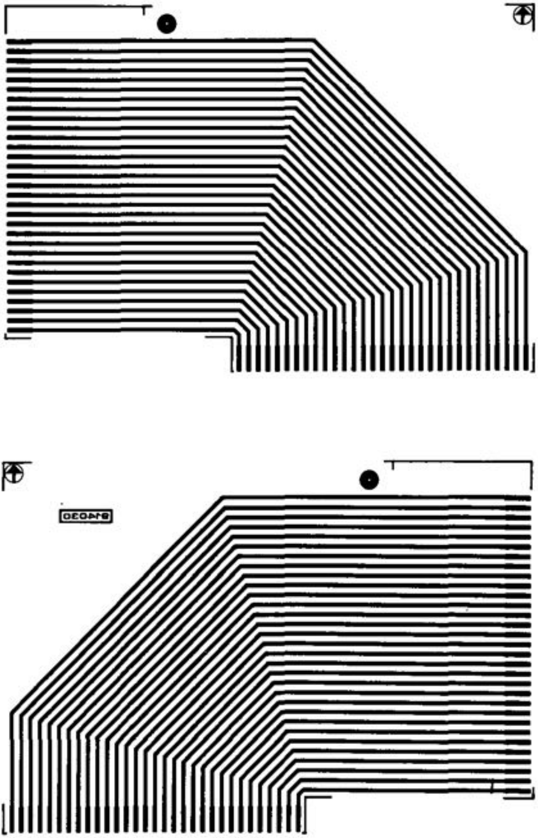
(A. Rigby 914030)

PARTS LIST

K1 = 62-way IBM bus slot connector
PCB 914030

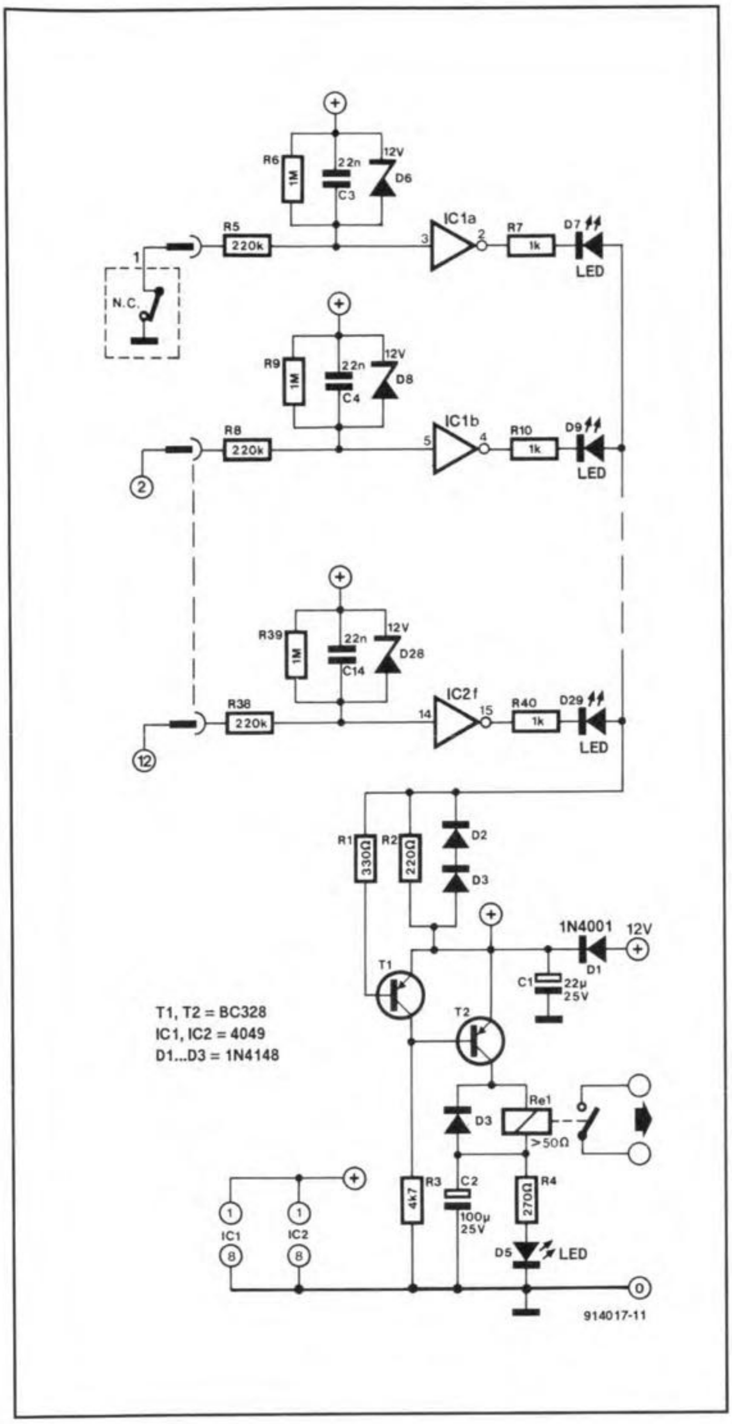






50 %

FAULT SIGNALLING CIRCUIT



THE present circuit was developed to make it possible for different sensors to be added to an existing alarm installation. These sensors may be gas or smoke detectors, door switches, infra-red detectors, and others.

In quiescent operation, the level at all inputs must be zero. When the relevant sensor is actuated, pin 3 of IC_{1a} is made high via R_5. Since this opamp inverts, its output, and thus the cathode of D_9, is at 0 V. Since the anode of D_9 is at +12 V, the diode lights to indicate an alarm condition.

Across both D_2 and D_3 a potential drop of about 1.2 V then occurs and this results in T_1 being switched on and T_2 being switched off. Relay Re_1 is then deenergized and opens the contact via which the alarm installation is controlled. Since that contact is closed in quiescent operation, a supply failure is also signalled.

When the cause of the alarm has been removed and the installation has been reset, all inputs return to zero volts, T_1 is switched off, T_2 is switched on, and the relay is re-energized. This condition is indicated by the lighting of D_5. Since D_5 and R_4 are in series with the relay coil, the load on the relay is then slightly less, so that the relay draws a smaller current. Capacitor C_2 ensures that at switch-on R_4 and D_5 are short-circuited, guaranteeing that the relay is energized.

Where the current must be kept low, the standard LEDs may be replaced by low-current types. The value of the relevant bias resistors (R_7, R_{10}, R_{40}) must then be increased to 8.2 kΩ.

Networks C_3-R_5, C_4-R_8, and C_{14}-R_{38}, form low-pass filters that prevent noise voltages actuating the alarm. That is important, because the cables between sensors and inputs may be very long.

The circuit is protected against voltage peaks by zener diodes D_6, D_8 and D_{28}. This makes it possible for the control voltage to be higher than 12 V, although regulations prohibit the use of voltages above 42 V.

Diode D_1 protects the circuit against polarity reversal.

Capacitor C_1 decouples the supply voltage.

The current drawn, dependent on the relay, is about 200 mA.

Type 4050 ICs may be used in the IC_1 and IC_2 positions, but it should be noted that these are non-inverting devices, so that part of the circuit action is then reversed.

(M. Haas 914017)

DIGITAL LED VOLTMETER

IN THIS somewhat unusual digital voltmeter, the measurand (voltage to be measured) is digitized in an analogue-to-digital (A-D) converter and then displayed in three decimal digits. The display is not the usual seven-segment type, but consists of three groups of ten LEDs. Although this type of display is a little unusual, the measured value can be read without problem after only a short familiarization period: even voltage *changes* can be readily interpreted. Note that the meter can only be used for measuring direct voltages.

The A-D converter is based on a CA3162, which can process direct voltage up to 999 mV (1 V full-scale deflection—f.s.d.). The f.s.d. is extended to 10 V with the aid of potential divider R_1-R_2-R_3. Other ranges are possible by altering the values of the resistors.

The measured value is read from three bars of LEDs: the first one of these, D_1-D_{10}, shows units; the second, D_{11}-D_{20} tens; and the third, D_{21}-D_{30}, hundreds.-

The circuit is nulled with P_1 when the input is open circuit. Zero here means that diodes D_1, D_{11}, and D_{21}, light. Diodes D_{10}, D_{20}, and D_{30}, represent the figure 9.

Next, a known voltage is applied to the input and P_2 adjusted till the LEDs read the correct value.

Some people may find it helpful to use a different colour for

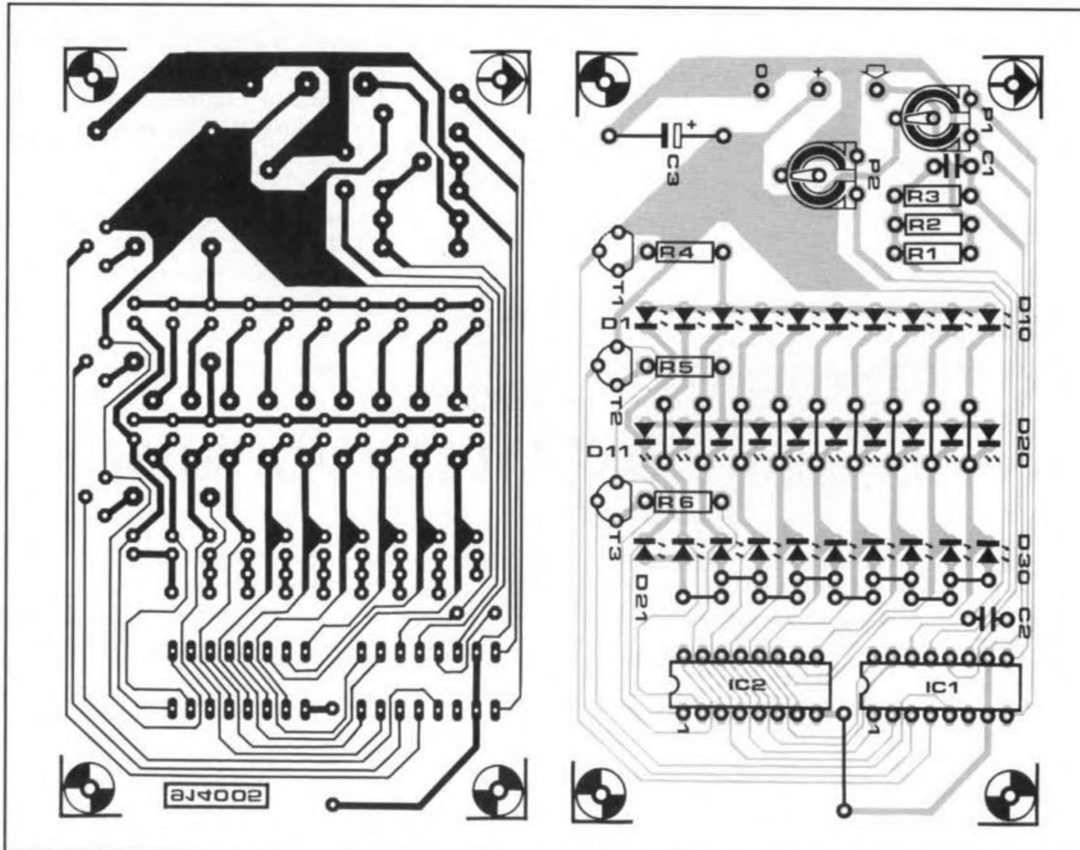
PARTS LIST

Resistors:
R1, R2 = 180 kΩ
R3 = 10 kΩ
R4, R5, R6 = 220 Ω
P1 = 50 kΩ preset
P2 = 10 kΩ preset

Capacitors:
C1 = 1 nF
C2 = 330 nF
C3 = 10 µF, 10 V

Semiconductors:
IC1 = CA3162E
IC2 = 74LS145
D1–D10 = LED, red
D11–D20 = LED, yellow
D21–D30 = LED, green

Miscellaneous:
Enclosure 70×125×48 mm



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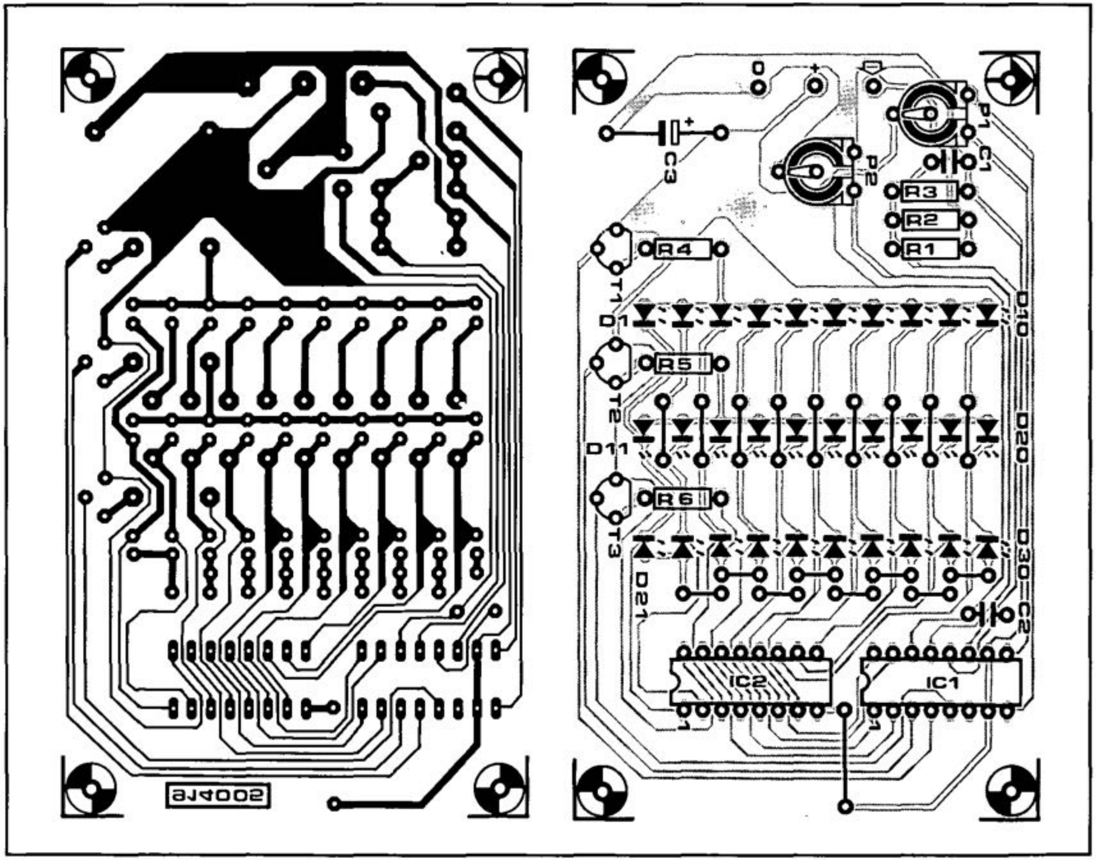
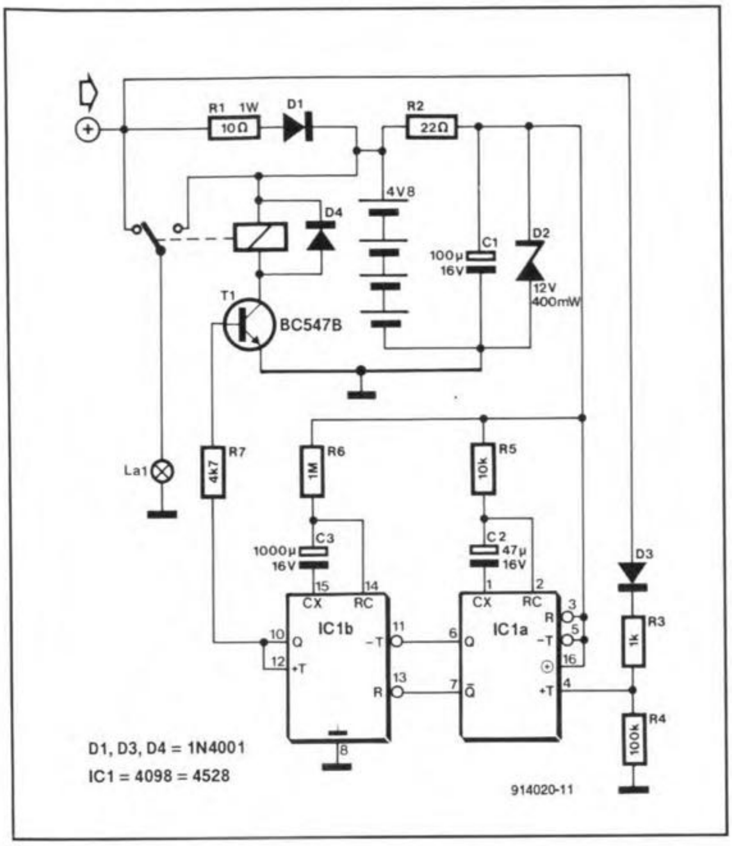




AUTOMATIC CYCLE LIGHTS

To PREVENT the dynamo-driven lights of your bicyle going out when you stop in the dark for, say, traffic lights, the simple circuit here may offer help.

The circuit uses four NiCd batteries with a capacity of between 0.25 Ah and 1.25 Ah, which are constantly charged when the dynamo is driven via R_1 and D_1. Since the battery voltage is rather less than the dynamo output, the lights are dimmed to a small extent when the cycle is stopped, but in practice that is hardly noticeable.

Monostable IC_{1a}, which has a mono time of 1 s (R_5-C_2), is used to detect whether the dynamo generates a voltage with the aid of D_3, R_3 and R_4. As long is there is a voltage, the monostable holds IC_{1b}, also a monostable, in the reset state. The relay is not energized and the lights are powered by the dynamo.

When the dynamo voltage drops, IC_{1a} is no longer triggered so that its outputs change level. This causes the reset state of IC_{1b} to be removed, whereupon its T input is actuated and remains so for two minutes, during which time the relay is energized and the cycle lights are powered by the batteries.

Strictly speaking, IC_{1b} is not essential, but it does ensure that the lights are switched and that the battery can not be discharged completely.

The relay should be a type that operates faultlessly when its supply voltage reaches 4.8 V.

It is advisable to build the circuit in a watertight, or at least waterproof, enclosure.

(U. Kunz 914020)

BOUNCE-FREE SWITCH

SWITCHES with change-over contacts with traditional debouncing circuits are not always usable or economical. Keyboard switches, for instance, seldom have change-over contacts. Furthermore, change-over switches have one extra connection, which can not always be accommodated in the construction.

The small circuit here operates with one make contact or one break contact. Which one does not matter in practice, because the Q or $\overline{Q}$ output may be chosen to invert the switch action.

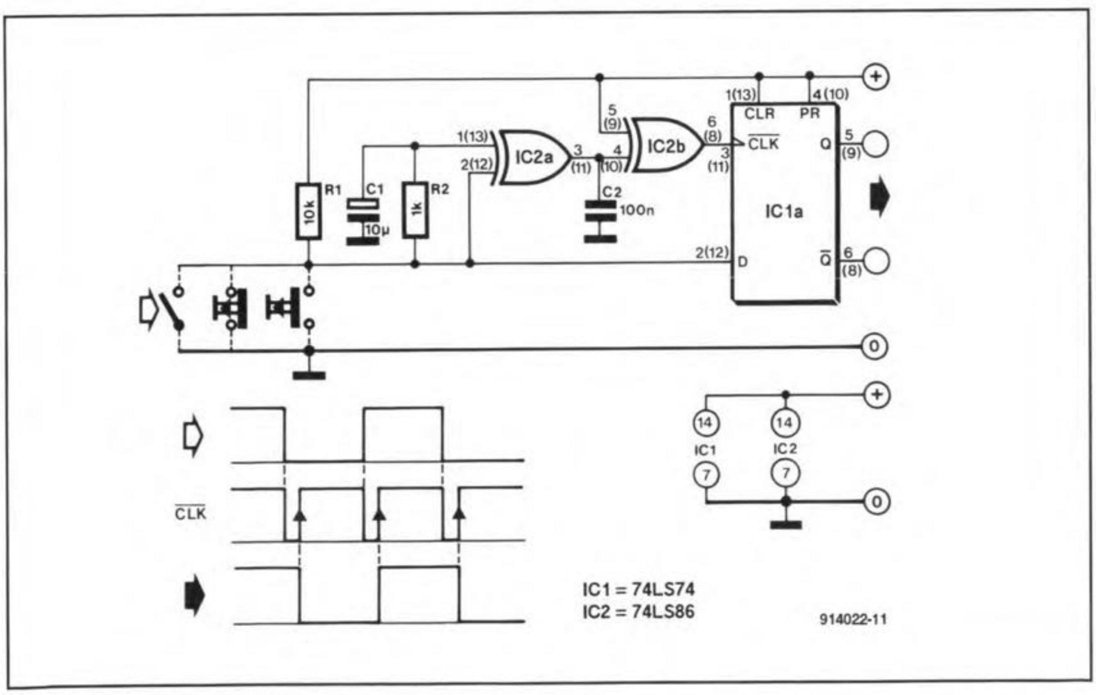
The logic level at the input of the circuit is determined by pull-up resistor R_1 and the position of S_1. The input signal goes straight to the data input of bistable (US: flip-flop) IC_{1a}, where it is clocked as soon as the contact bounce has disappeared (after 0.5–10 ms).

The clock is generated by IC_{2a}, an XOR gate. Every time its input level alters, this gate generates a pulse, whose width is determined by R_2 and C_1. That pulse is, however, not devoid of contact bounce, which is, therefore, filtered out by C_2 and the output resistance of IC_{2a}. The potential across C_2 is smoothed and inverted by IC_{2b} before the pulse is applied to the clock input of the bistable. The result of all this is that the output signal is clean, albeit delayed by a few milliseconds.

Since the bounce filter uses the output resistance of IC_{2a}, this circuit can not be replaced by just any other type. When replacing is unavoidable, the value of C_2 must be adapted to the new circumstances, or a resistor connected in series with the output of IC_{2a}.

The current drain of the circuit is 3 mA.

(S. Jeukendrup 914022).



Automatic cycle lights
(July/August 1991, p. 49)

Sir—In the construction of 'Automatic cycle lights', I have encountered three problems.

1. Triggering of IC_{1b} at input –T (pin 11) and R (pin 13). A trailing edge at –T triggers the IC if R is high. It is, however, possible that R is still low or is just changing state. A (not very elegant) solution to this is to connect the line from $\overline{Q}$ (pin 7) to R to junction R_2–D_1 (+ battery) via a 1 kΩ resistor.

2. A short pulse caused by the switching on of the battery triggered input +T of IC_{1b} (pin 4), which switched the battery off again. This was cured by connecting a 470 nF capacitor between +T and earth.

3. Triggering at +T of IC_{1b} was so sensitive that even a tiny movement of the bicycle causes the battery to be switched off. In other words, if you don't hold the bicycle absolutely still, its lights will flash on and off. The sensitivity can be made variable by replacing resistor R_4 by a 100 kΩ preset

Helge Bergmann, Hannover

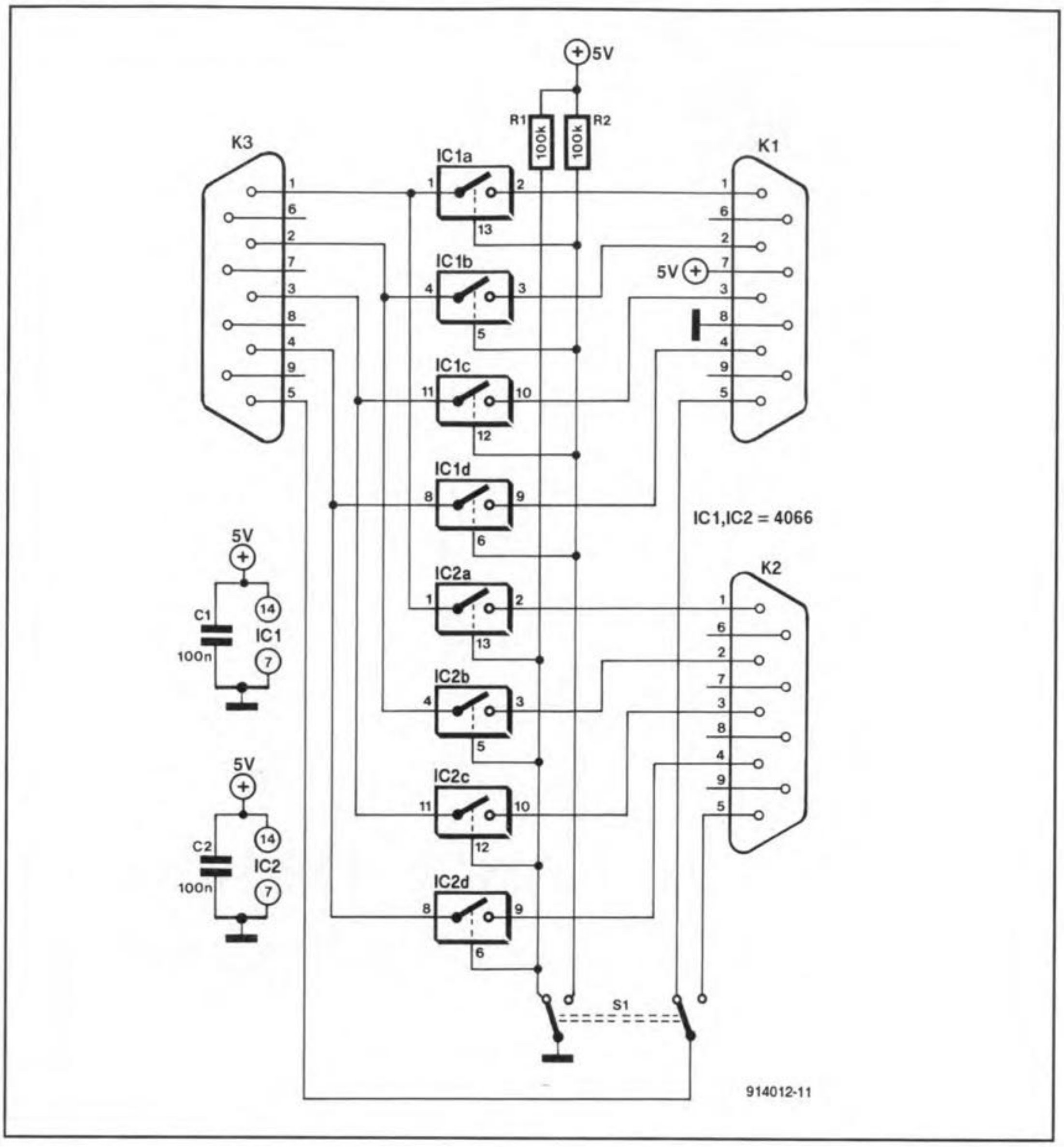
CHANGE-OVER SWITCH FOR C64 CONTROL PORT

MANY PEOPLE still use the old C64 computer to play games on, but get frequently annoyed by the constant need of changing over the joystick connectors. This is because normally only one joystick is available, while some games are controlled via port 1 and others via port 2.

The cause of the annoyance may be removed by the circuit shown here, which uses eight analogue switches packaged in two Type 4066 ICs. Switch S_1 enables pins JOY0–JOY3 to be connected to either port 1 or port 2.

The +5 V supply is derived from the C64.

(A. Rigby 914012)



WIEN BRIDGE WITH ASYMMETRICAL POWER SUPPLY

NORMALLY, a Wien bridge oscillator contains two identical capacitors and two identical (variable) resistors. That being the case, the transfer factor of the bridge in Fig. 1 is 1:3. For example, when a potential of 1 V is applied to the non-inverting input of the opamp, the output voltage of the amplifier will be 3 V.

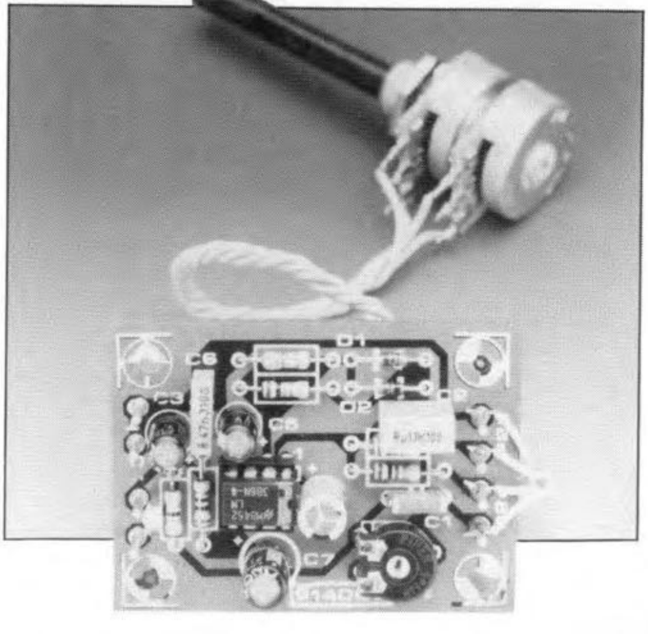
In many cases, a smaller transfer factor is required. With reference to Fig. 2,

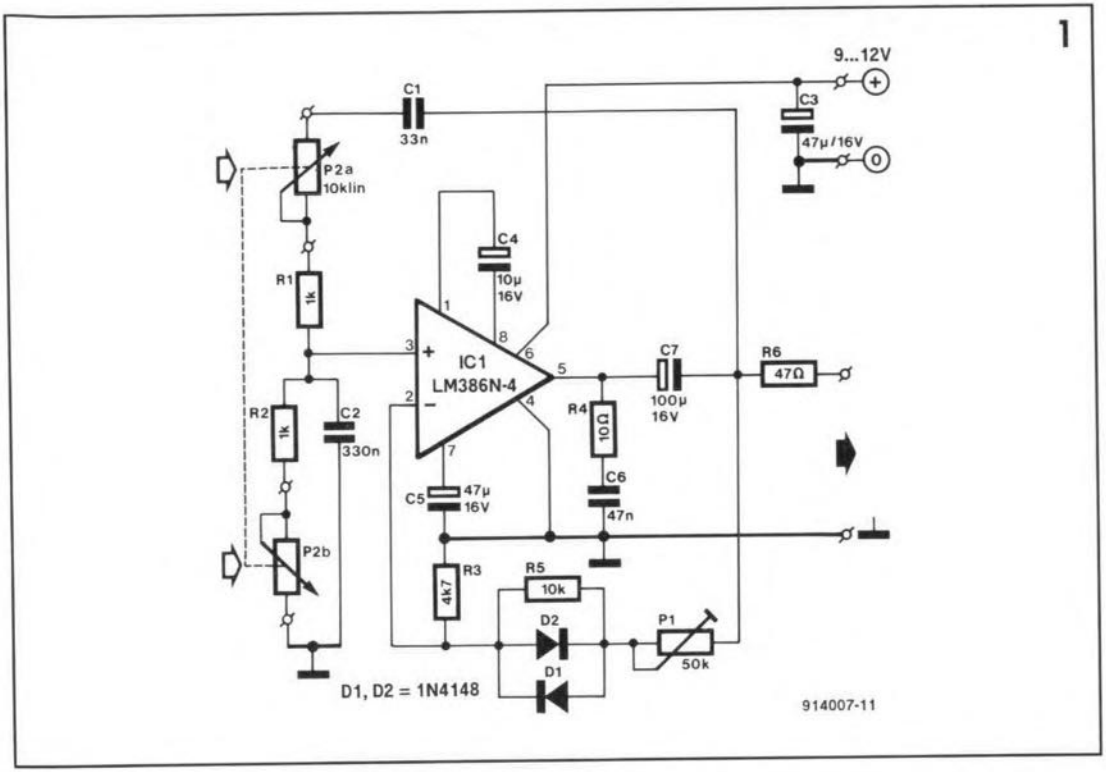
$$U_p/U_o = 1/(1+R_1/R_2+C_2/C_1)$$

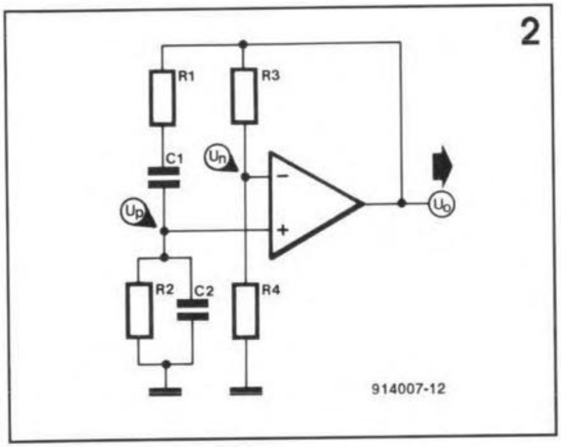
from which it follows that the factor becomes smaller if the value of R_1 or C_2 is increased.

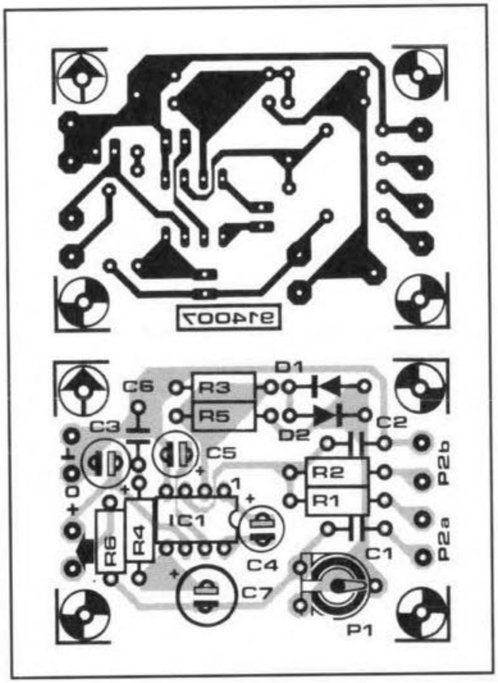
The frequency is altered when the value of both capacitors or of both resistors is changed. That makes it possible to vary the frequency by using a dual-gang potentiometer in place of the two resistors. Since the two resistances are then always identical, the ratio U_p/U_o will be 1:12 when $C_2=10C_1$. To ensure sufficient positive feedback for the oscillator to start, the amplification of the opamp must be >12. With values as shown in Fig. 1, the amplification is

$$A=1+(R_5+P_1)/R_3=13.8.$$









Stability of the output voltage is ensured in the traditional manner by two anti-parallel connected diodes in the feedback loop. Preset P_1 is adjusted so that the sinusoidal output voltage is just not clipped by the supply voltage.

The frequency of the output signal may be set between 150 Hz and 1500 Hz with P_2; higher frequencies may be obtained by altering the values of C_1 and C_2.

The supply voltage, which must be regulated, may lie between 9 V and 12 V. When the oscillator is not loaded, it draws a current of about 6 mA.

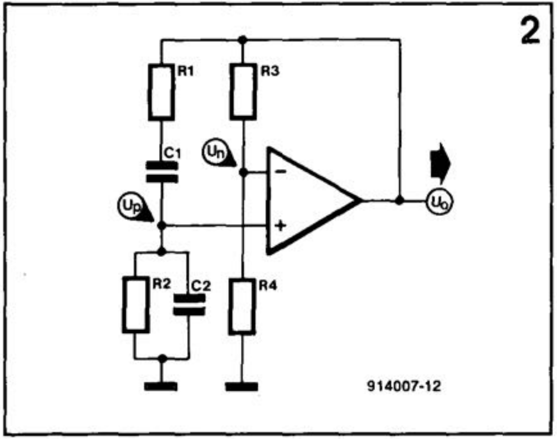
(J. Ruffell 914007)

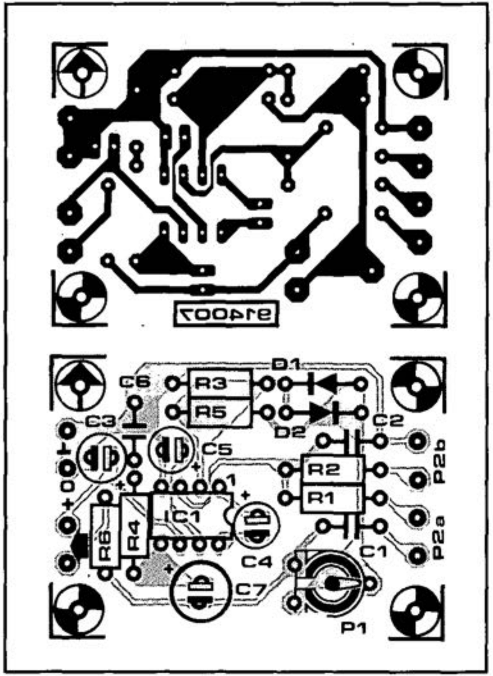
PARTS LIST

Resistors:
R1, R2 = 1 kΩ
R3 = 4.7 kΩ
R4 = 10 Ω
R5 = 10 kΩ
R6 = 47 Ω
P1 = 47 kΩ preset
P2 = 10 kΩ, dual-gang linear preset

Capacitors:
C1 = 33 nF
C2 = 330 nF
C3, C5 = 47 µF, 16 V, radial
C4 = 10 µF, 16 V, radial
C6 = 47 nF
C7 = 100 µF, 16 V, radial

Semiconductors:
D1, D2 = 1N4148
IC1 = LM386N-4





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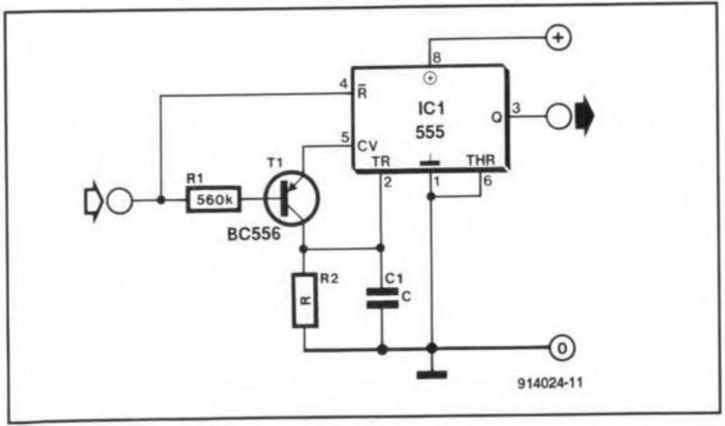
TIME DELAY WITH ONE 555



MANY electronic circuits frequently require the brief delay of a pulse. Such a delay, here between 100 μs and 100 s, is easily provided by a simple circuit based on the popular 555. That is more than adequate for most applications.

The output of the 555 can go high only if the potential at pin 2 drops below a third of the level of the supply voltage, provided that the level at pin 4 is high. In quiescent operation, the level at pin 4 is low and C_1 is charged via T_1, so that the output is low.

When the input goes high, T_1 is switched off and C_1 is discharged via R_1. In that condition, the reset state is cancelled, and after a time delay that depends on the state of discharge of C_1 the output of the 555 goes high. The time delay in seconds is calculated from $\tau = 0.69R_1C_1$, where R_1 must be greater than or equal to 10 kΩ.

(S. Bolt 914024)

SWITCH FOR CENTRAL-HEATING PUMP

THE PUMP in some central-heating systems has two or even three speeds. At the lowest speed, not much hot water is pumped around the circuit and this may result in the boiler overheating. The switch circuit proposed here prevents that happening.

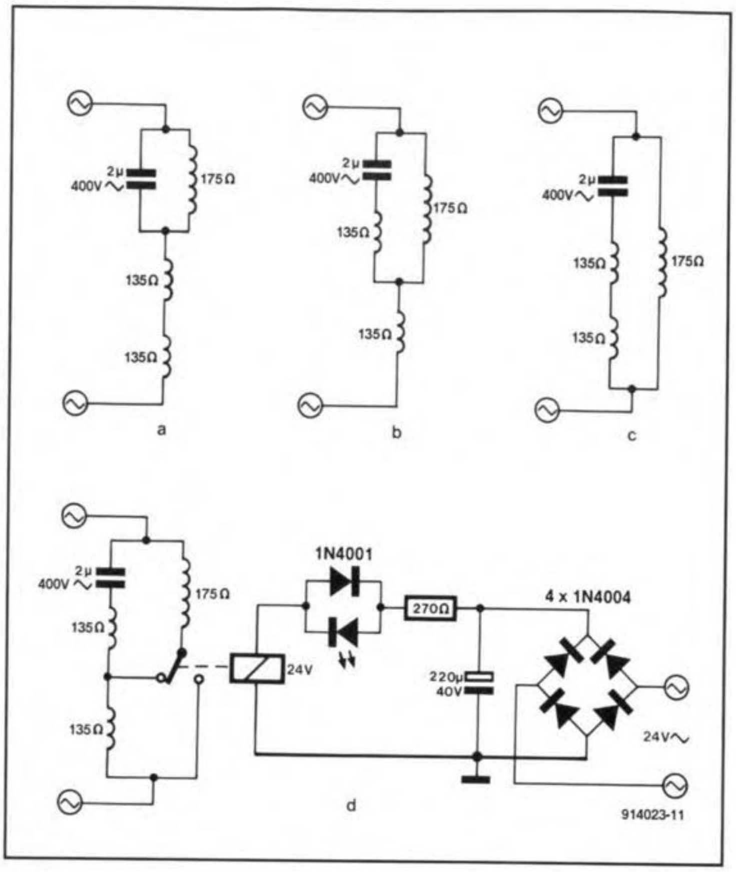
The electrics of the pump are as shown in the diagram. The main winding is normally 175 Ω and the auxiliary windings 135 Ω: these values may, however, be different in certain pumps and this should, of course, be checked. The capacitor in series with the windings provides the necessary phase shift that enables the motor of the pump to rotate. In positions *a* and *b*, the impedance is increased and this results in a weaker field so that the motor runs more slowly and the pump displaces less water.

A simple circuit enables the automatic switching between *a* and *b* or between *b* and *c*. Its 24-V input is parallel with the drive of the gas valve of the main burner. When that valve closes, the speed of the pump increases and the boiler can not overheat.

If the installation uses a 240 V drive for the gas valve, a small transformer may be used to obtain the 24 V.

On a safety note, bear in mind that the 24 V supply, which reaches the thermostats in various rooms, is insulated from the mains only by the relay. Therefore, that relay should be a heavy-duty type that provides adequate insulation

[K. Walters 914023]

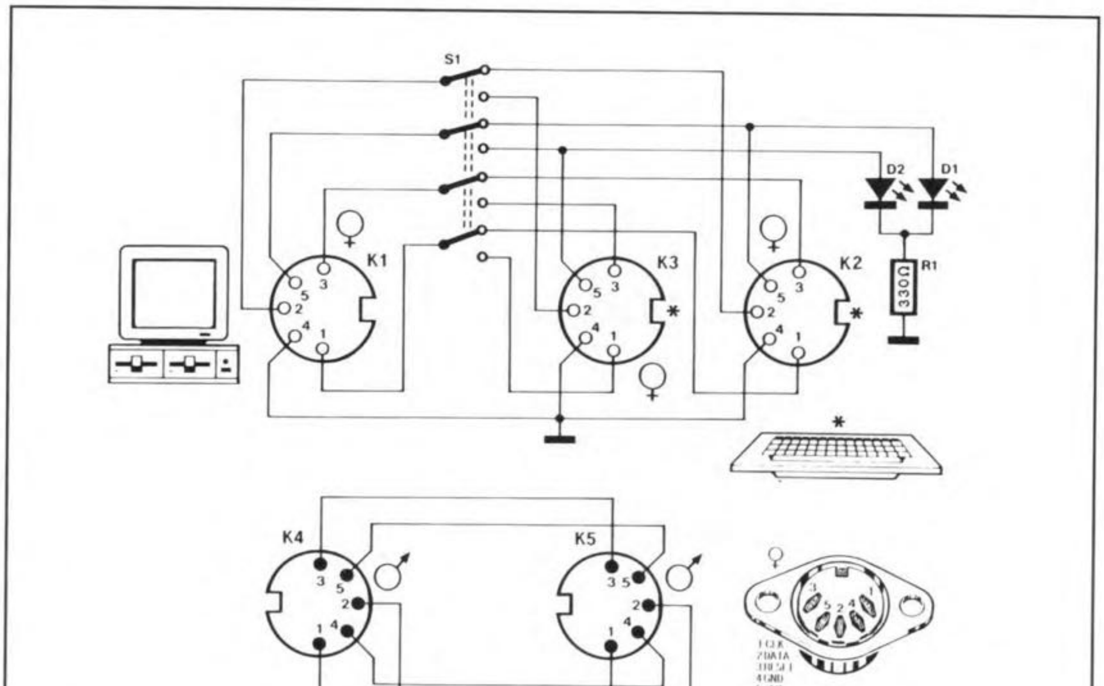


KEYBOARD CHANGE-OVER SWITCH

IF YOU have a non-qwerty keyboard and would like to use this with your computer without having to relearn where the deviating keys are, this simple circuit will help. It receives two keyboards on K_2 and K_3 respectively and connects these via switch S_1 and connector K_1 to the computer. Check the keyboard connections at your computer, because some PC compatibles have a slightly different pin layout. The connection between the circuit and the computer is via a standard 5-way DIN cable; you can, of course, make your own cable as shown at the bottom of the diagram (K_4 and K_5).

Switch S_1 is a four-pole change-over type, either rotary or toggle. Since the supply line is switched also, the additional keyboard does not increase the load. The additional LEDs that indicate which keyboard is in circuit increase the current drain by about 10 mA.

So much for the hardware; now for the software. Whatever keyboard you connect, the codes it generates do not change. Advising the computer that a different keyboard layout is used is the task of the keyboard driver. In MSDOS versions up to 3.2, this driver is called KEYB??.COM, where in place of the question marks an abbreviation for the



relevant country is given. Normally, the correct version of this program is executed in AUTOEXEC.BAT, after the change-over you have to start the program manually. From version 3.3 onwards, there is the file KEYBOARD.SYS (and in some old versions), KEYB??.SYS), and then you have no choice but to restart (alt-ctrl-del) the computer every time the keyboard has been changed with a system disk in drive A on which you have stored the relevant data in CONFIG.SYS and pass these to KEYBOARD.SYS. Alternatively, you can install the correct KEYB??.SYS.

(J. Ruffell - 914016)

PRESETTABLE SHUNT REGULATOR

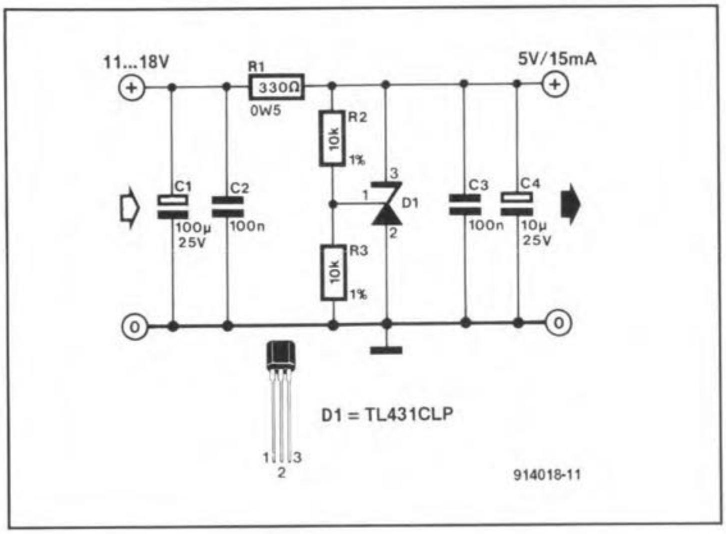
DEPENDING on its location, linear voltage regulators are arranged traditionally into two sub-groups: series and shunt (or parallel) regulators.

In practical circuits, series regulators, particularly the popular integrated types in the 78xx family, are normally used, since these give good regulation and allow a reasonable output current.

Nevertheless, good shunt regulators are also becoming available, for example, Texas Instruments' Type TL431. The commercial version of this, the TL431C, offers excellent temperature stability and very low dynamic impedance (see table). Although shunt regulators usually function in the same way as a zener diode, the TL431C offers a facility that no zener diode does: the zener voltage may be set anywhere between 2.5 V and 36 V with the aid of two fixed resistors. To function properly, the device needs a cathode current of not less than 1 mA. The voltage across the IC is then $U_{cat} = 2.5(1+R_2/R_3)$. If the values of R_2 and R_3 are not too high, the current through this reference network is negligible (<4 μA).

A possible application of the device is the compact 5 V power supply shown in the diagram.

[J. Ruffell 914018]



SOME TECHNICAL DATA

Cathode voltage, U_{cat}	2.5 V–36 V
Cathode current, I_{cat}	150 mA (1 mA min)
Power dissipation (at 25 °C)	775 mW
Dynamic impedance	0.5 Ω (typical 0.2 Ω)
Temperature coefficient	30 ppm K^{-1}

COMMUNICATION BUSES

THERE ARE nowadays so many different standards for buses and networks that it was thought useful to present an overview of the most current types. Note that each bus needs suitable software to transmit data. For instance, the well-known Ethernet network operates with Novell and Lantastic.

Ethernet and Thin-Ethernet buses are intended for use as a LAN (Local Area Network) between computers and computers or between computers and peripheral equipment like printers and plotters.

The Integrated Service Terminal (IST) bus is used in LANs for offices. It complies with the ISDN norm. It is intended for communication with telephones, view phones, computers, and alarm systems.

The Domestic Digital Bus (D^2B) bus is intended for interconnecting audio and video equipment. It is found on most up-to-date radio tuners and television receivers.

The Controller Area Network (CAN) bus is intended primarily for use in control system in a noisy environment (it is, for instance, standard in the new Mercedes-Benz S-class of cars). It needs only two wires for the distribution of power and information.

name of network	max. length in metres	kind of information	data format	type of connection
Ethernet	2500	data	serial	1 coax cable
Thin „	925	data	serial	1 coax cable
IST	300	data	serial	2 wires
D^2B	150	control	serial	3 wires
CAN	100	control	serial	2 wires
Future	systemlevel	data	parallel	
I^2S	boards	data	serial	
I^2C	boards	data/ control	serial	2 wires

The Futurebus is a new standard for parallel processing of data within a computer. Path widths vary from 32 bits to 256 bits. A number of processors can exchange data at very high clock speeds along these paths.

The Inter IC Sound (I^2S) bus is designed for the exchange over short distances only of digital audio (16-bit stereo) between ICs in a digital audio system. The data are transmitted serially.

The Inter IC (I^2C) bus is also designed for communication between ICs. It handles not only data, but also commands. In contrast to the I2S bus, the I2C bus is fairly slow and not suitable for the rapid transmission of large quantities of data.

(A.N.Other 914025)

MEASURING ELECTROLYTIC CAPACITORS

MOST capacitance meters have no facility for measuring large electrolytic capacitors. The circuit described here makes it possible for such capacitors to be measured with some degree of accuracy, in spite of the large tolerances these components normally have.

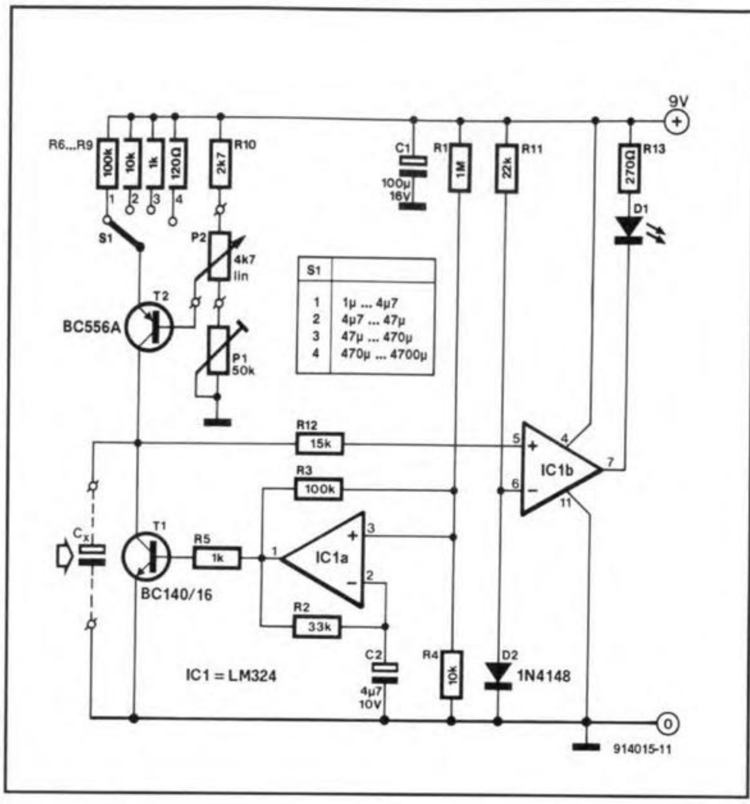
Opamp IC_{1a} is arranged as an astable. Capacitor C_2 is charged via R_2; as soon as the potential across it reaches the level of that at the non-inverting input of IC_{1a}, which is determined by voltage divider R_1-R_3-R_4, the opamp toggles and C_2 is discharged till the voltage across it reaches the new level at the + input of IC_{1a}.

The measuring circuit consists of switched resistors R_6–R_9, and S_1, R_{10}, P_1 and P_2. The capacitor on test is charged via T_2 and discharged rapidly via T_1.

Comparator IC_{1b} compares the level (0.65 V) at its non-inverting input with that at its inverting input. When the capacitor on test is connected across the input terminals, P_2 is adjusted till the LED just lights. The potentiometer must be given a scale to enable the value of the electrolytic capacitor to be read directly. The scale can be calibrated with the aid of a capacitor of known value for each range (1–4.7 µF; 4.7–47 µF; 47–470 µF; and 470–4700 µF). Basically, it is linear, but it may be necessary to make a scale for range 1 empirically.

To ensure the best possible accuracy, it is advisable to use a regulated power supply. The circuit draws a current of about 20 mA (almost all of it through the LED).

(P. Essek 914015)



HOUSE TELEPHONE

TELEPHONES are now readily and cheaply available: two identical ones and a handful of components enable a simple house telephone to be set up.

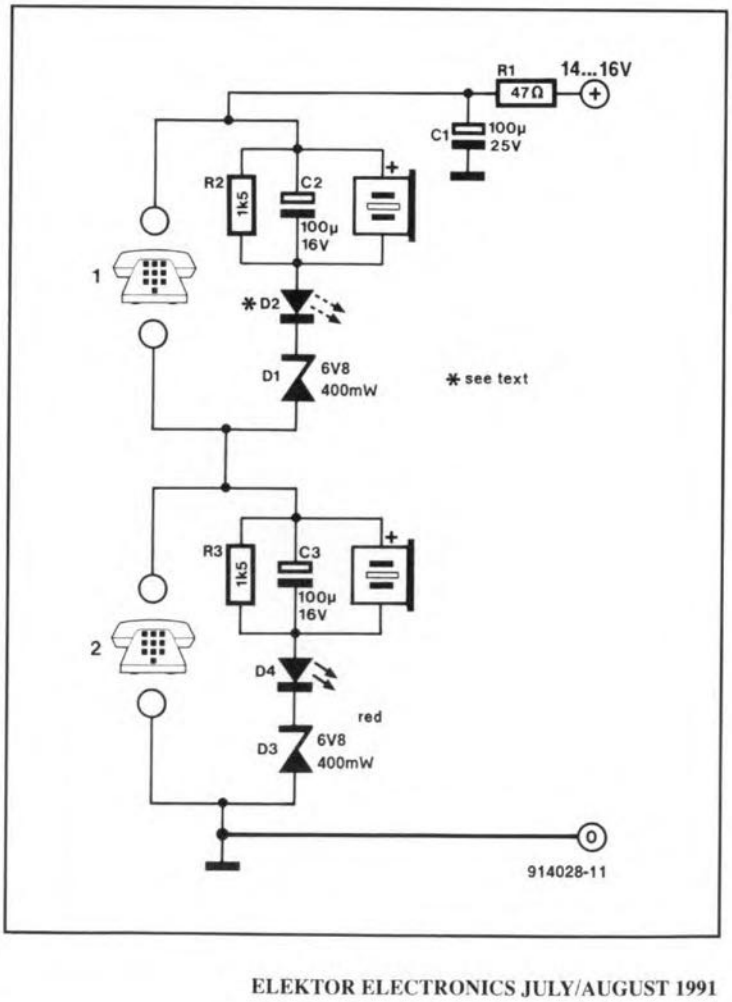
Since the two telephones are connected in series as shown in the diagram, half the supply voltage exists across either of them. Neither buzzer will sound, since the potential across zener diodes D_1 and D_3 is below their breakdown voltage.

If, say, the handset of telephone 2 is lifted, a virtual short circuit ensues across this telephone. The potential across telephone 1 then rises to almost the supply voltage. Breakdown then occurs in D_1, which causes a sharp increase in the reverse current through the diode. The buzzer will then sound and the LED light. If then the handset of telephone 1 is lifted, the supply voltage is again divided symmetrically across the two telephones, which is sufficient for carrying out a conversation.

The buzzers may be continuous-tone or intermittent-tone types to personal preference. Similarly, the LEDs may be standard or flashing types.

The power supply may be a standard 12-V mains adapter. When the supply voltage is too high, the buzzers will sound even when both handsets are lifted. If dissimilar telephones are used, one or both zener diodes need to be replaced by different types to ensure that during quiescent operation the voltage drops across the telephones are identical.

(A. Jödicke 914028)



DARKNESS-SENSITIVE SWITCH

THE CIRCUIT presented here enables the automatic switching on of outside lighting when its gets dark and, what's more, it does so for a predetermined period. A new period can be begun only when it has been light again.

The switch is a solid-state relay. From the instant that T_4 and T_5 are on, the LED in the relay lights and lamp L_1 is powered. As soon as one of the transistors switches off, the lamp will go out.

Whether T_5 is on depends on phototransistor T_3. If light falls on to this, it is switched on and removes the base current from T_5. In other words, T_5 can be on only when it is dark.

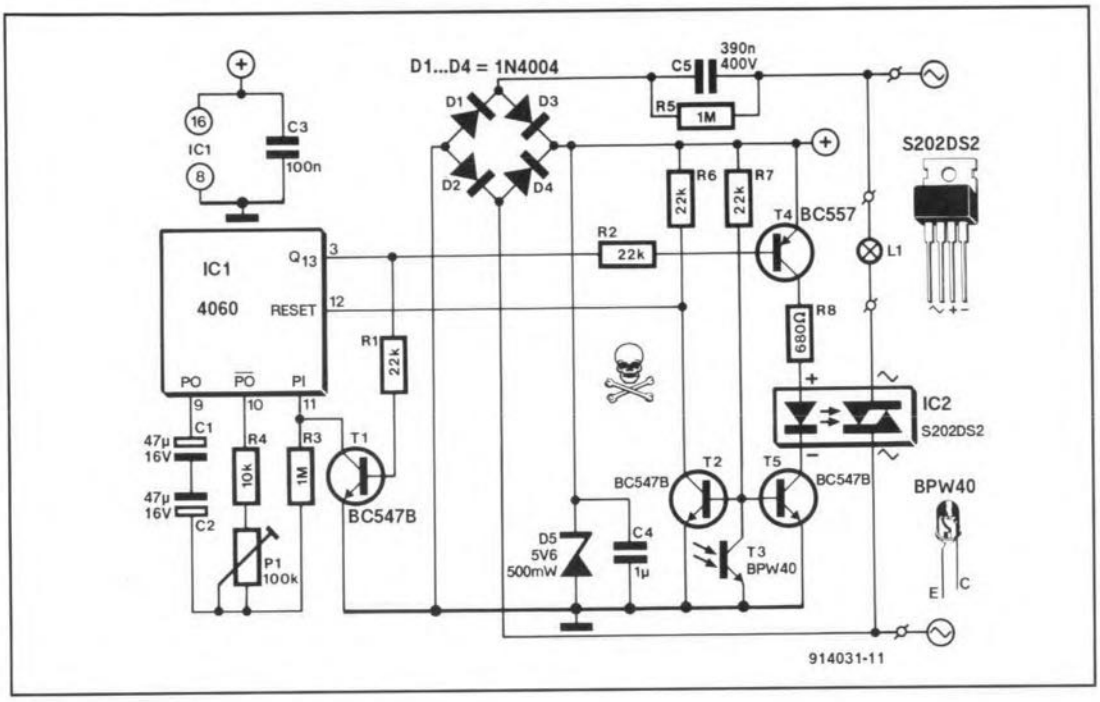
The base-emitter junction of transistor T_2 is also connected in parallel with T_3 and it, too, will therefore be off when it is light. This causes a constant reset on IC_1, all of whose counter outputs are then low.

As soon as it gets dark, base current for T_2 is provided by R_7 and the transistor switches on. The counter can then count the pulses of its internal oscillator, while the lamp remains on. When, after a short time, output Q13 goes high, transistor T_4 switches off. This causes the LED in the solid-state relay to quench and the lamp goes out. Since at the same time the oscillator is stopped via T_1, Q13 remains high. This state is maintained until it gets light again and IC_1 is reset, whereupon a new cycle can be started.

The period the lamp is on may be set to between 1 and 5 hours with P_1.

No special transformer is needed for the power supply, which may be derived direct from the mains. Diodes D_1–D_5 rectify the mains voltage and the result is smoothed by C_4. Capacitor C_5 operates as a resistance, and it should, therefore, have a working voltage rating of not less than 400 V, although 630 V is preferred.

Note that mains voltage exists at several points in the circuit: great care should be taken to insulate the switch unit adequately

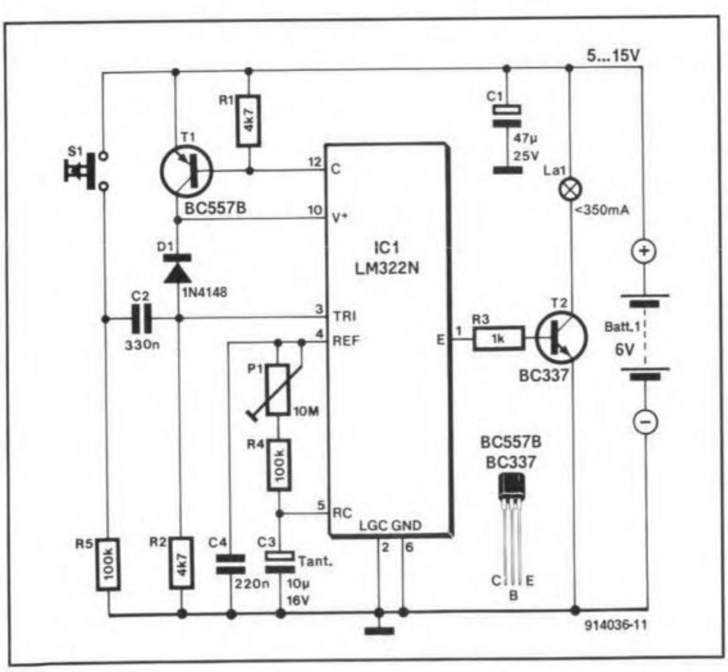


(A. Rigby 914031)

SWITCH-OFF DELAY FOR BATTERY SUPPLY

A FREQUENT annoyance with battery-operated equipment is that just after you switch it on you notice that the battery is flat. Quite probably, the last user (you?) has forgotten to switch it off. The circuit described here makes sure that this will never happen again. A touch on the button, S_1, is sufficient to let the equipment work for a predetermined period only.

An interesting feature of the circuit is that its quiescent current is 0.00 mA, because T_1 switches the timer off completely at the end of the cycle. Switching on is effected by the energy contained in the power-on pulse. When S_1 is pressed, the supply voltage is available immediately across C_2. Because of the differentiating action of R_2-C_2, the supply voltage is briefly connected to the V+ input of IC_1 via D_1. This energy is sufficient to enable the IC and start the timer, whereupon T_1 is switched on. This transistor provides energy to the IC for the remainder of the cycle. At the end of the cycle, T_1 is switched off and provides no more energy.



The on-time, t, is determined by:

$$t = (P_1+R_4)C_3 \text{ seconds.}$$

The maximum current switched by T_2 must not exceed 350 mA.

The supply voltage may lie between 5 V and 15 V.

The minimum trigger amplitude is 5 V.

The switch-off time with component values shown in the diagram is 1–100 seconds.

The current drawn by the circuit during the switching interval is about 4 mA when the supply voltage is 6 V.

(J. Ruffell 914036)

AUTOMATIC BATTERY CHARGER

THE CHARGER described switches off the charging voltage when the battery reaches its full nominal voltage and switches it on again when the battery voltage drops below a predetermined level.

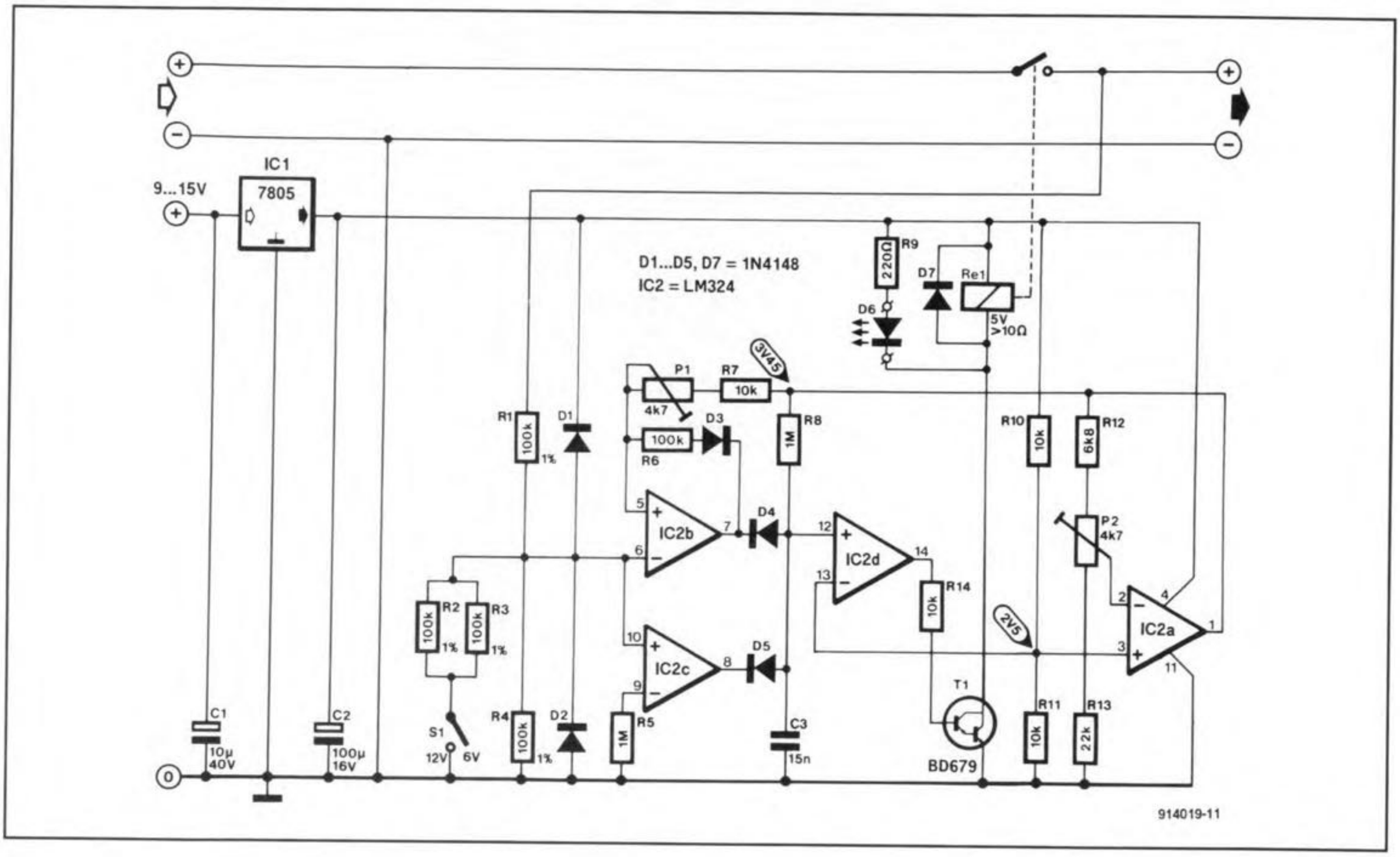
Part of the battery voltage is taken from across potential divider R_1-R_2-R_3-R_4 and compared with a reference voltage in IC_{2b}. As long as the battery voltage is 0 V, only a small voltage drop is caused across R_5 by the input current of the opamp, so that IC_{2c} toggles at 0 V. The relay therefore remains de-energized. At the same time, the output of IC_{2b} is high, but this has no effect whatsoever owing to AND gate D_4-D_5.

When a battery is connected, its small remaining voltage ensures that IC_{2c} toggles, diodes D_4 and D_5 are reverse-biased, a reference voltage is applied to the non-inverting input of IC_{2d}, and the relay is energized. The battery is then charged until its voltage has reached the nominal level. Because of potential divider R_1-R_2-R_3-R_4, there is a voltage of more than 3.45 V at the inverting input of IC_{2b}, which causes this opamp to toggle so that its output becomes low (0), the relay is de-energized, and the charging voltage is removed from the battery.

The (reference) voltage at the output of IC_{1a} is set to 3.45 V. Potential divider D_3-R_6-R_7-P_1 provides a certain hysteresis to comparator IC_{2b}. When the battery voltage drops below the level set with P_1, IC_{2b} toggles again and the charging voltage will be reapplied to the battery.

Calibration is carried out with a voltmeter connected to the output of IC_{2a}, after which P_2 should be adjusted for a reading of 3.45 V. Next, turn P_1 to full resistance. Replace the battery by a regulated, variable power supply and set its output to 6.2–6.4 V (S_1 in position 6 V) or 12.4–12.8 V (S_1 in position 12 V), that is, the voltage at which charging should commence. Adjust P_1 till the relay is energized.

(K. Walters 914019)



AUTOPOWER OFF FOR AUDIO EQUIPMENT

THIS LITTLE circuit switches off the equipment in your audio rack when this has not produced sound for some time.

The circuit is actuated by pressing S_1, which causes capacitor C_1 to be charged. Next, the output of opamp IC_{1B} goes high, and the audio equipment is powered from the mains via solid-state relay ISO_1.

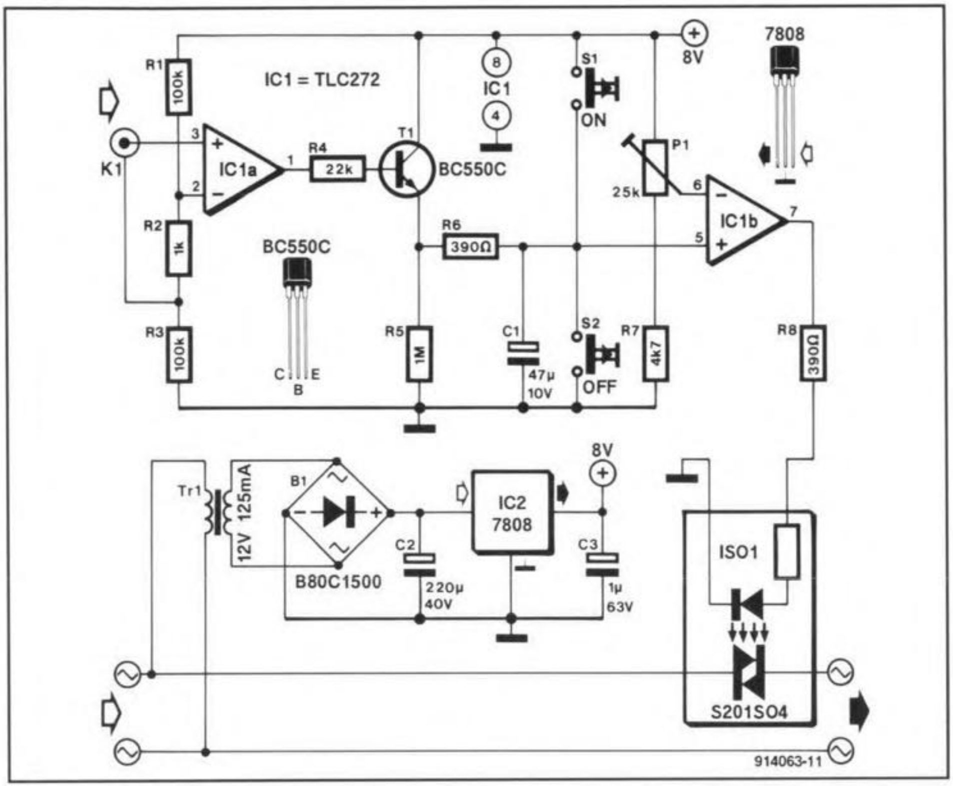
The LINE OUT signal from the audio power amplifier is fed to the input of the circuit via connector K_1. Opamp IC_{1A} is set up to function as a signal detector with a trigger threshold of about 50 mV. Note that the ground potential of the audio amplifier is raised to about +4.5 V in the auto-power off circuit by means of R_1-R_2-R_3.
When the audio signal is greater than 50 mV (i.e., 4.05 V with respect to the circuit ground), the output of IC_{1A} goes high, and transistor T_1 starts to conduct. Consequently, C_1 is charged rapidly, so that ISO_1 continues to conduct and power the equipment.

In the absence of an audio input signal, C_1 is discharged slowly via R_5 and R_6. Opamp IC_{1B} toggles, and the equipment is switched off via ISO_1 when the capacitor voltage drops below the voltage set with P_1 at the inverting input. It should be noted that the solid-state relay specified here has a maximum current rating of 1.5 A. When heavier loads are to be switched, it is recommended to use a conventional relay.

Since the relay outputs and the transformer primary are connected to the mains, great care should be taken to ensure the required electrical insulation. For reasons of safety, the circuit is best fitted in a mains adapter enclosure with a moulded mains plug. The two mains connections in the enclosure must be made with properly rated and secured screw terminal blocks. The output is connected to a mains cable with a 4- or 5-way distribution board.

The delay before the equipment is switched off will depend on the time needed to rewind a tape, change a compact disc or record, etc. To adjust the delay, connect a 100 kΩ resistor across R_5. This reduces the actual delay by a factor of about 10. Turn P_1 fully in the direction of R_7, press the START button, and wait for the desired delay (divided by 10) to elapse, whereupon P_1 must be adjusted until the output of IC_{1B} goes high. Then remove the 100 kΩ resistor, press START again and time the actual delay. If necessary, re-adjust the preset.

(T.P. Thomas 914063)



WINDSCREEN WASH-WIPE CIRCUIT

PARTS LIST

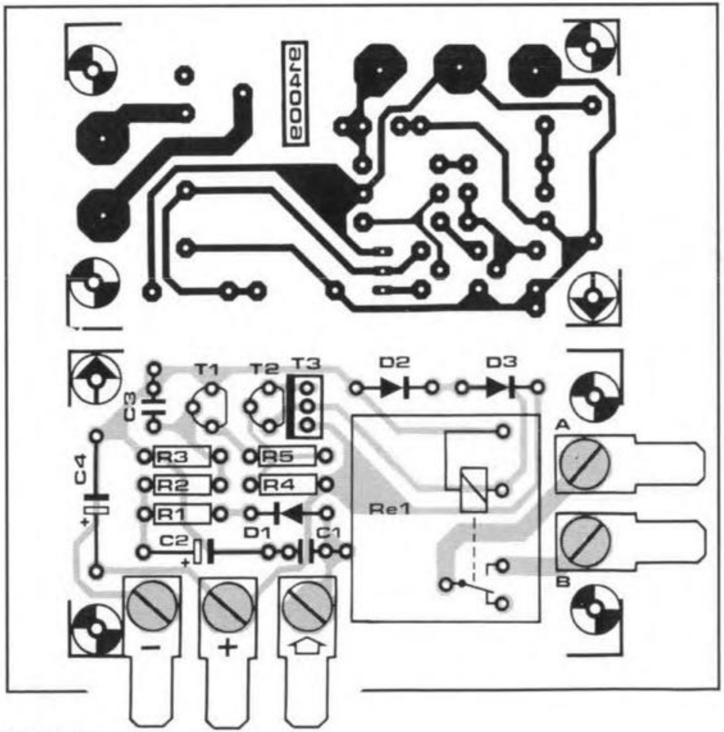
Resistors:
R1 = 220 Ω
R2 = 120 kΩ
R3 = 100 kΩ
R4 = 3.3 kΩ
R5 = 10 kΩ

Capacitors:
C1 = 100 nF
C2 = 19 µF, 63 V
C3 = 10 nF
C4 = 100 µF, 25 V

Semiconductors:
D1, D2, D3 = 1N4148
T1 = BC550C
T2 = BC560C
T3 = BD140

Miscellaneous:
Re1 = 12 V relay for PCB mounting, Z>90 Ω, contact rating >10 A

IN MANY older cars the windscreen wash pump is not coupled to the windscreen wipe function. This circuit switches on the wiper motor for a predetermined time each time the pump is actuated. The wipers start to work when the pump switch is pressed, and keep on working a while after the switch is released.

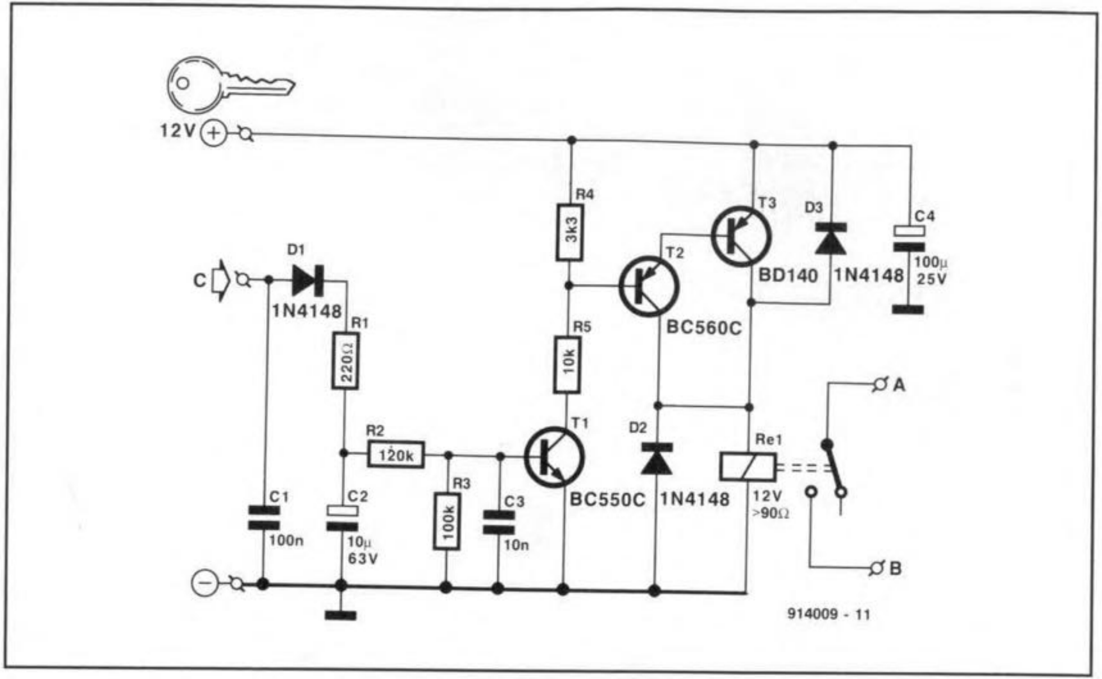


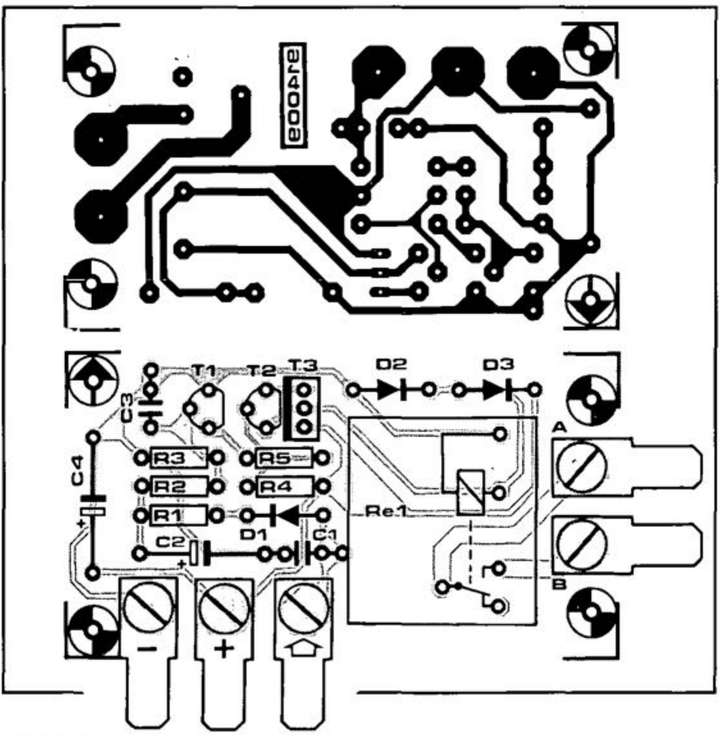
The anode of diode D_1 is normally taken to ground via the wash pump motor. When the pump is powered, C_1 charges rapidly via D_1 and R_1. Consequently, T_1, T_2 and T_3 are switched on, and relay Re_1 is energized. C_1 is charged as long as the pump motor and the wipers operate. When the pump switch is released, the washing stops, but the wiping continues for a time determined by R_2-C_2. Diode D_1 prevents C_2 being discharged via the pump motor. Diodes D_2 and D_3 protect the circuit against back e.m.f. from the relay coil.

Installing the circuit in a car should be easy as there are only three connecting points (apart from the supply voltage). Note, though, that the circuit is designed to work with a pump motor that has a fixed contact to ground, while its positive contact is taken to the wash switch.

The relay on the board is capable of switching 10–20 A. Its contacts are connected across the wiper switch via terminals 'A' and 'B' by means of heavy-duty wiring. The connections to the board are made via spade terminals and mating sockets as used in car electrical systems. The spade terminals are screwed direct to the board, and soldered to minimize the contact resistance. Finally, the relay may be an Omron Type G2L-113P-4S-SV or a Bosch Type 0 332 016 101. The omron type fits on the PCB, the Bosch type does not.

(L. Rikard 914009)





T1
T2
T3
D2
D3
C3
C4
R3
R5
R2
R4
R1
D1
C1
C2
Re1
A
B
−
+

TELEPHONE EXTENSION

IN MANY countries, unlike most of the UK, it is still not possible to parallel two or more telephones easily. The circuit described here may either be connected in parallel to an existing telephone or be used as a stand-alone unit, when it will energize a relay on receipt of an incoming call. The relay may be used to operate an optical or an aural indicator, or cause a trigger pulse to be generated that actuates an interface, which in turn operates a suitable telephone.

The incoming a.c. signal is applied to terminals *a* and *b* and from there fed to optocoupler IC_1 via C_1 and R_1. The negative half-waves are returned via D_1, while the positive half-waves are returned via the LED in the optocoupler. The resulting pulsating d.c. output of the phototransistor in the optocoupler is applied to inverter IC_{2a}. This (call) signal is smoothed by D_2, R_4, C_2 and R_5, and this results in a direct voltage at the input of IC_{2c} during the pulse spacing. The consequent low-level, short-duration pulses at pin 6 of IC_2 are passed to inverters IC_{2d}–IC_{2f} that serve as relay drivers, and which energize the relay (preferably a high-resistance type). Diode D_8 indicates the state of the relay. The circuit thus functions as a monos-

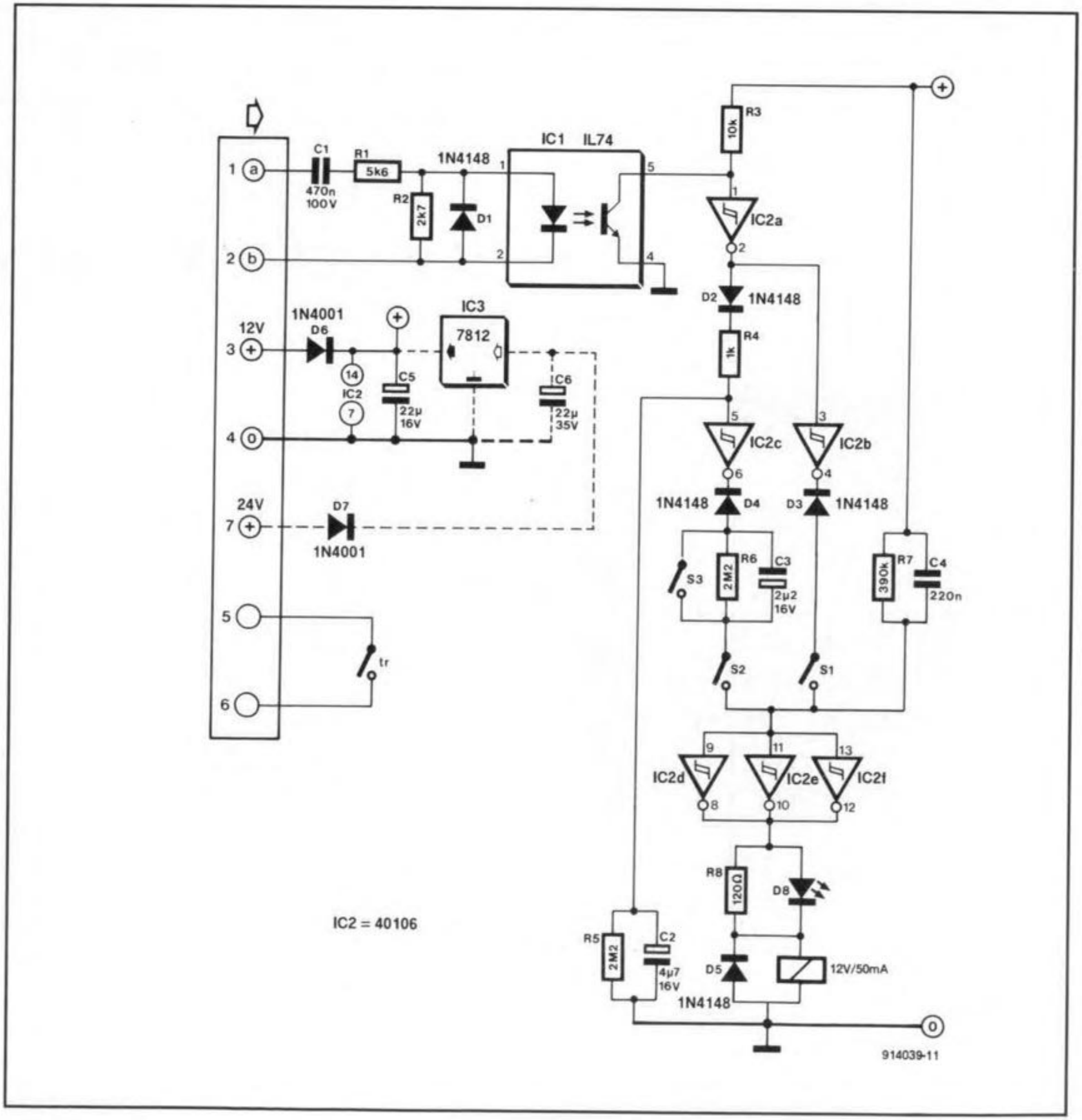


table whose time constant is formed by R_7-C_3.

When both S_2 and S_3 are closed, C_3 does not produce a pulse from the direct voltage output of IC_{2c}. The low-level potential then remains at the inputs of the relay drivers to ensure that the relay stays energized in this condition.

When S_1 is closed instead of S_2, the relay is energized during the pulse widths and de-energized during the pulse spacing. This mode of operation is best for optical call indicators.

The power supply may be a simple 12-V mains adapter. Diode D_6 protects the circuit against incorrect polarity. Higher supply voltages make a 12-V regulator (IC_3) and an additional electrolytic capacitor (C_6) necessary. The current drawn by the circuit is only a few mA.

It is advisable to check with your telecommunications authorities whether the circuit is allowed in your locality before building it.

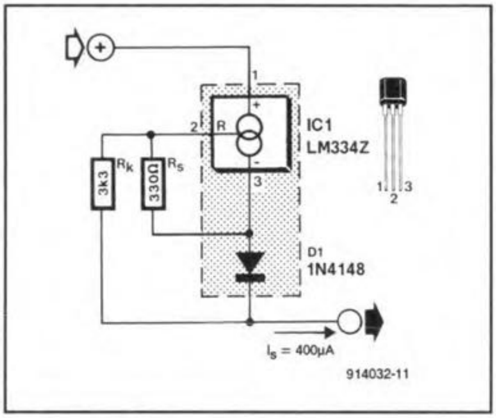
(M. Haas 914039)

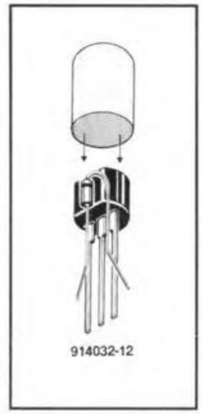
TEMPERATURE-COMPENSATED CURRENT SOURCE

NATIONAL Semiconductors' LM334Z is a three-pin presettable current source, whose output may be set to between 1 µA and 10 mA. It may be also be used floating.

In principle, just one resistor is needed for setting the current. However, the current is then strongly dependent on temperature: about +0.33% $°C^{-1}$. (This would enable the device to be used as a temperature sensor). Therefore, to obtain a stable current source, an additional resistor and a diode are needed.

For good stability, the diode must be coupled thermally to the IC (the self-heating of the source is then compensated). This is best done by squeezing the IC and the diode, separated by heat paste, into a piece of insulating sleeving shown in Fig. 2.





Although the current source may be set between 1 µA and 10 mA with the aid of R_s, it is most accurate between 10 µA and 1 mA.

The current provided by the source may calculated from

$I_s = 2/15R_s$

Resistor R_k should have a value of $10R_s$.

Set as described and with good thermal coupling between D_1 and IC_1, the prototype showed a temperature drift of not greater than 0.02% $°C^{-1}$ with $I_s < 1$ mA. The largest drift measured, 0.08% $°C^{-1}$, occurred at I_s = 5 mA. All measurements were carried out with a supply voltage of 9 V.

(J. Ruffell 914032)

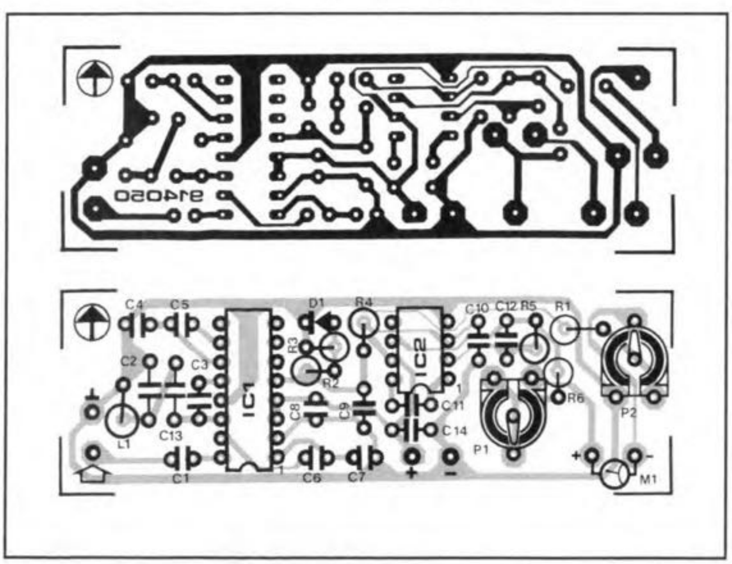
S-METER FOR SHORT-WAVE RECEIVERS

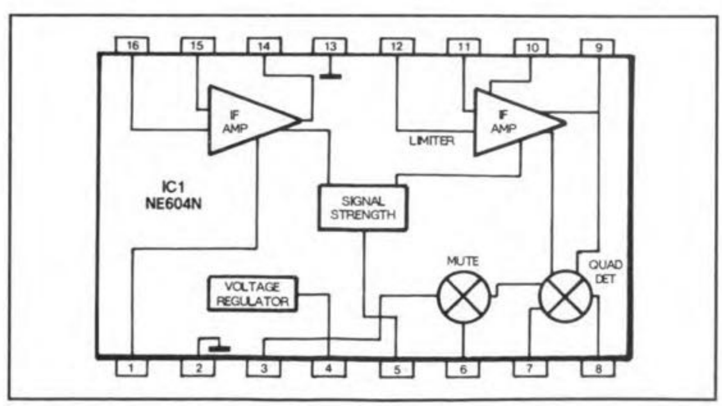
SOME radio amateurs are very keen on accurate RST reports, others (mostly the VHF/UHF fraternity) never look at the S-meter on the receiver, and are satisfied as long as they can hear the other station. This circuit is for the first group.

Traditionally, one S-point corresponds to a 6-dB increase in signal strength, while 'S9' is defined as 50 µV into 50 Ω. Unfortunately, very few receivers these days have a calibrated S-meter, hence the confusion among radio amateurs about the interpretation of the signal strength reports they exchange and write on QSL cards.

The logarithmic-to-linear converter contained in the NE604 from Valvo (Philips Components) is used here to build an accurate S- (signal strength) meter for short-wave receivers. The amplifier in the NE604 is tuned to the intermediate frequency (IF) of the receiver with the aid of L1 and C_2. Here, the circuit is dimensioned for an IF of 455_kHz, which is applied to input capacitor C_1.

The output of the field strength detector in the NE604 supplies a current of 0 to 50 µA at pin 5. This current is converted into a voltage of 0–5 V by a 100 kΩ resistance, R_2+R_3. Note that two





E96-series 1% resistors are used here, plus a diode, D_1, instead of a single 100 kΩ resistor. This is done to compensate temperature effects which would cause derating of the linear output voltage. If the specified E96 resistors can not be obtained, R_2 may be replaced by a parallel combination of two 120 kΩ 1% resistors, and R_3 by a parallel combination of a 39 kΩ 1% resistor, and a 1 kΩ 1% resistor. It should be noted that the usable range of the log-to-lin converter in the NE604 is roughly from 5 μA to about 40 μA of output current, corresponding about 70 dB, or 0.5 V to 4_V at pin 6 of IC_2. The lower level is caused by background noise of the IF amplifier in the NE604, and the upper level by limiting and saturation effects. Fortunately, the effective range of the converter is large enough for the present applications, bearing in mind that S-meter readings lower than S_3 are rare and of little meaning in the short-wave bands.

Components R_4, C_9 and C_{10} suppress ripple and noise. Opamp IC_2 is set to provide unity gain, i.e., its output voltage is 0 to 5 V. The moving-coil meter is connected between two presets. P_1 is adjusted until the meter reaches full deflection at a voltage of 4.5 V measured at pin 6 of IC_2. Next, adjust it for an indication of S_9 with an RF test signal of 50 μV applied to the receiver input.

As usual with S-meters, the meter is supplied with a compensation current that prevents any needle activity below S_3 or so. Here, this compensation current is set with preset P_2. The buffer opamp, IC_2, is not used for this purpose to keep the circuit as simple as possible. On-off push-button S_1 is optional and intended to save battery power in portable receivers.

(A. Heinrich 914050)

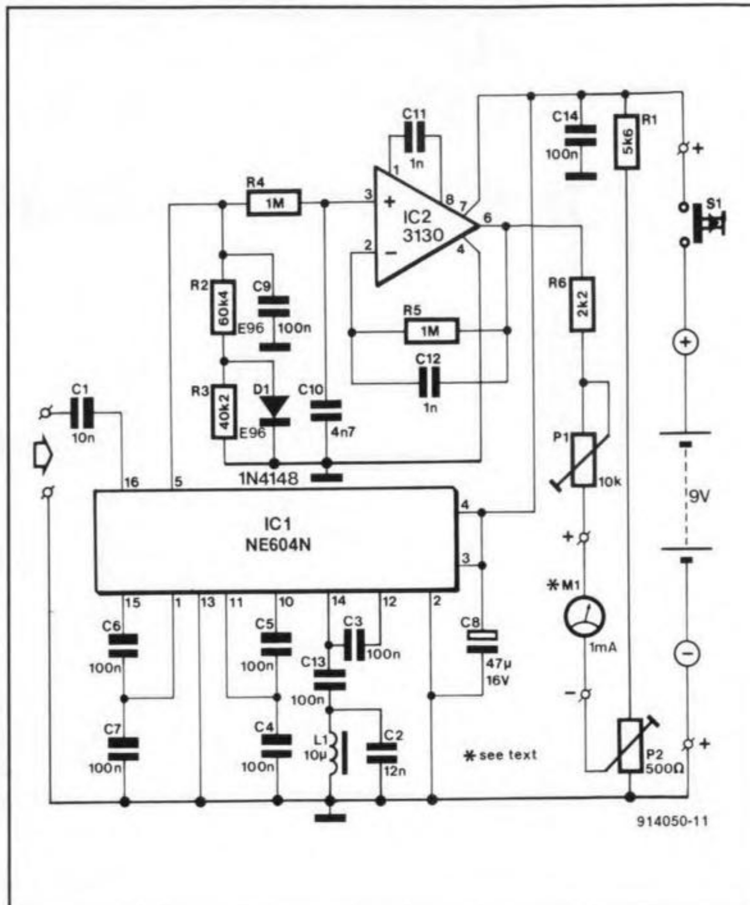
PARTS LIST

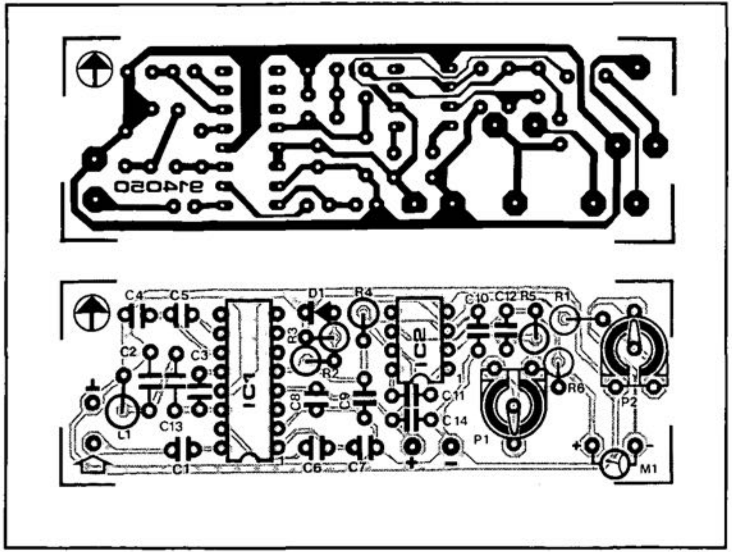
Resistors:
R1 = 5.6 kΩ
R2 = 60.4 kΩ (E96 - see text)
R3 = 40.2 kΩ (E96, see text)
R4, R5 = 1 MΩ
R6 = 2.2 kΩ
P1 = 10 kΩ preset H
P2 = 500 Ω preset H

Capacitors:
C1 = 10 nF
C2 = 12 nF
C3, C4–C7, C9, C13, C14 = =100 nF
C8 = 47 μF, 16 V, radial
C10 = 4.7 nF
C11, C12 = 1 nF

Semiconductors:
D1 = 1N4148
IC1 = NE604A
IC2 = CA3130E

Miscellaneous:
S1 = on-off push-button
L1 = 10 μH choke, axial
M1 = MC meter, 1 mA





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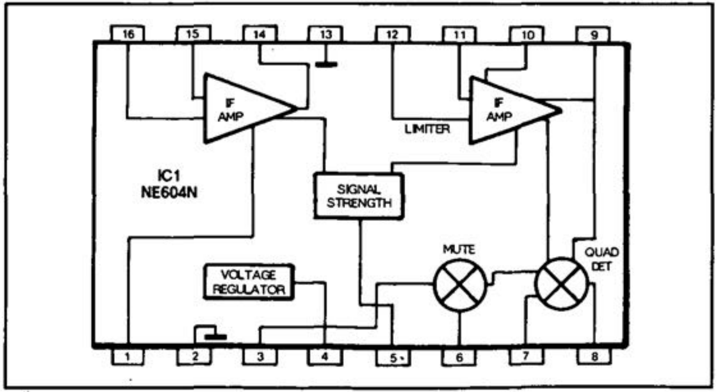
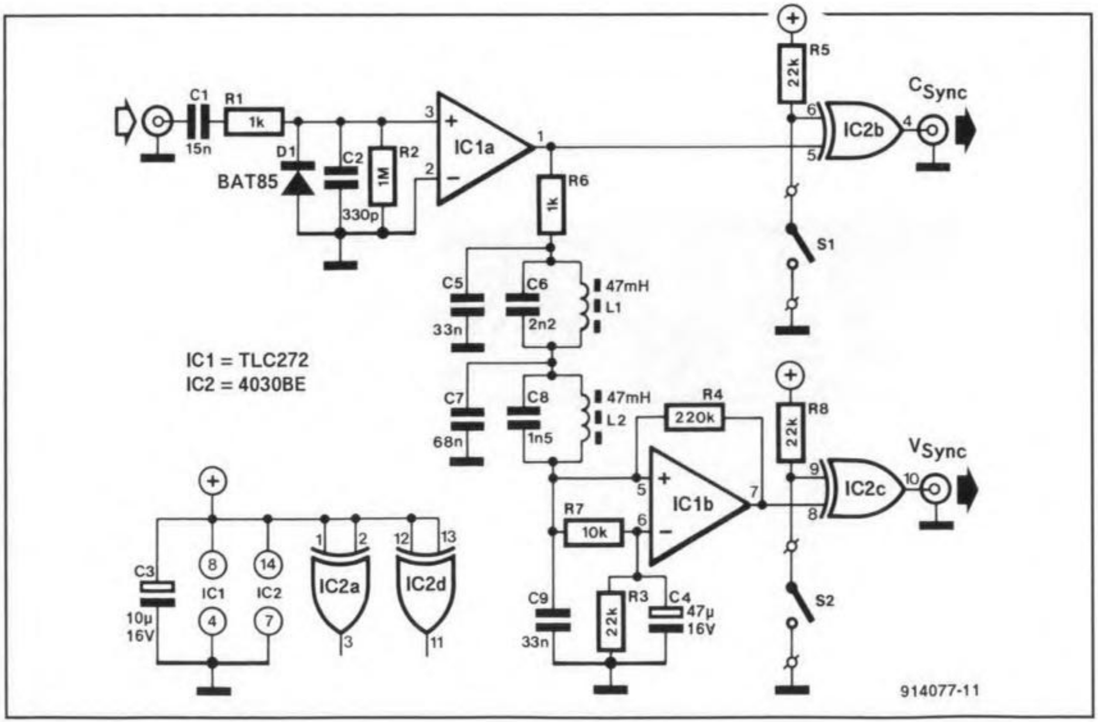


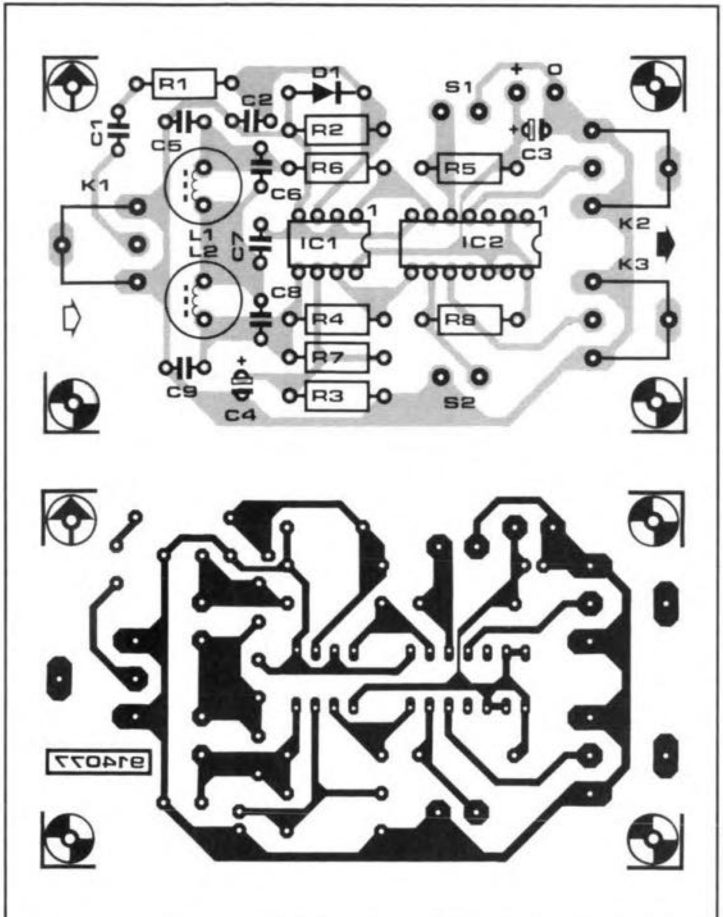
SYNCHRONIZATION SEPARATOR

This circuit forms the missing link between various video sources and, say, a multisync monitor. Based on discrete parts only, it extracts the composite synchronization (i.e., a mix of the horizonal and the vertical component) and the vertical synchronization from a composite video signal with an amplitude of about 1 V_{pp}. The output sync signals are available in true as well as inverted form to suit your monitor.

The positive composite video signal is filtered by R_1-C_2 and clamped by a Schottky diode, D_1, to extract the sync components. The CSYNC signal is fed to XOR gate N2 which functions as an inverter when S_1 is closed.

The CSYNC signal is also fed to a two-stage *L-C* filter which suppresses the line sync com-





PARTS LIST

Resistors:
R1, R6 = 1 kΩ
R2 = 1 MΩ
R3, R5, R8 = 22 kΩ
R4 = 220 kΩ
R7 = 10 kΩ

Capacitors:
C1 = 15 nF
C2 = 330 pF
C3 = 10 µF, 16 V, radial
C4 = 47 µF, 16 V, radial
C5 = 33 nF
C6 = 2.2 nF
C7 = 68 nF
C8 = 1.5 nF
C9 = 33 nF

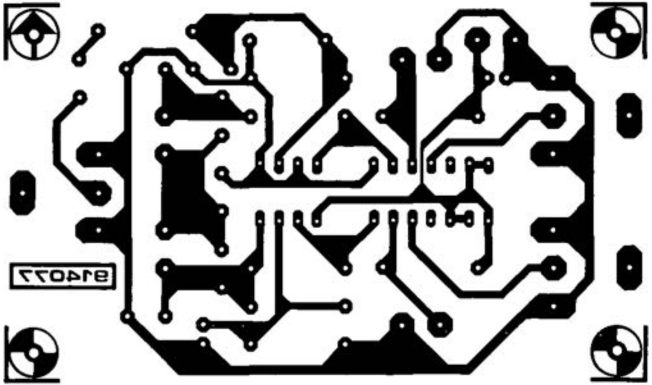
Semiconcudtocrs:
D1 = BAT85
IC1 = TLC272
IC2 = 4030BE

Miscellaneous:
L1, L2 = 47 mH choke, radial
K1, K2, K3 = phono socket for PCB mounting
S1, S2 = miniature on-off
PCB Type 914077

ponent and leaves the raster sync, VSYNC, at the inputs of opamp IC1b. Like CSYNC, VSYNC is available in true or inverted form.

The circuit draws about 200_µA at a supply voltage of 5_V. The output signals are TTL compatible.

(J. Bareford 914077)



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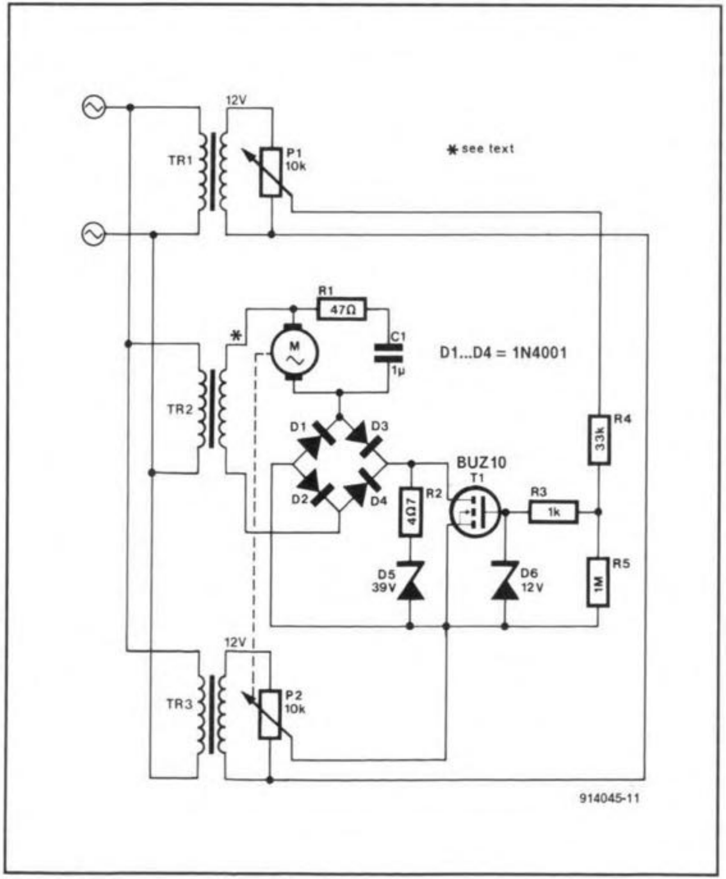
SEQUENTIAL CONTROL



Sequential controls are used where continuous remote control of mechanical installations, such as rotating antennas or valves, is required. That shown in the diagram offers a setting accuracy of 2.5%, although it has only a few components.

The control motor is in series with a bridge rectifier across the secondary of mains transformer Tr_2. The rating of the transformer must accord with that of the motor. The other two mains transformers are light-duty, 12-V types from across whose secondary a small alternating voltage may be taken by means of P_1 and P_2.

The wiper of P_1 is connected to the gate of T_1 via resistive network R_3-R_5. The wiper of P_2 is connected to the source of T_1. The source-gate junction of the transistor serves as a null-point detector. When the circuit is balanced, the potential difference between the two wipers is zero, so that T_1 is switched off. No current can flow through the motor since the current loop through the rectifier bridge is broken for each half cycle. When one of the potentiometers is adjusted, the circuit is no longer balanced and T_1 is switched on during either the positive or the negative half cycles, depending on which of the potentiometers was adjusted. Current then flows through the motor, D_4, T_1 and D_1, or through the motor, D_3, T_1 and D_2. In other words, the motor can rotate in either direction. If the motor is coupled mechanically with P_2, P_1 may be used for remote control of the motor.

The circuit as shown is intended for 12 V motors; if different motors are to be used, bear in mind that they are operated from half-wave rectified voltages, which means that the transformer must be rated at 1.52 times the motor voltage.

(G. Peltz 914045)

CORRECTIONS

Wattmeter

April 1991, p. 32-35

With reference the circuit diagram, Fig. 1, the right-hand terminal of the lower section of switch S2 should be connected to the circuit ground. This point is indicated by a dot.

In the adjustment procedure given on page 35, the references to presets P4 and P5 have been transposed. Contrary to what is stated, P4 sets the VY offset, and P5 the VX offset. The functions of the presets are shown correctly in the circuit diagram, Fig. 1.

To improve the accuracy of the instrument, connect R5 direct to the circuit ground instead of junction R6-R7. Finally, all circuit board tracks carrying mains current must be strengthened with 2.5-mm^2 cross-sectional area solid copper wire if currents higher than about 5 A are measured.

80C32/8052 Single-board computer

May 1991, p. 17-23

When a CPU type 8031 or 8052AH-BASIC is used, IC1, IC2, IC3, and IC8-IC12 must be 74HCT types. Jumper B is erroneously reffered to as Br2 in the text under "On-board EPROM programmer". Contrary to what is stated, this jumper must be fitted only when an EPROM is to be programmed — for all other use of the SBC, it must be removed. Also note that jumper B may only be fitted when the programming LED is out.

Sequential control

July/August 1991, p. 61

Motor M should be a d.c. type, not an a.c. type as shown in the circuit diagram.

Digital phase meter

June 1991, p. 32-39

In Fig. 5, the switch between input 'A' and IC1 should be identified 'S1', and that between input 'B' and IC2 'S2'. Switch S4 is an on/off type, not a push-button as shown in the diagram. Capacitors C3 and C6 are shown with the wrong polarity. The component overlay of the relevant printed-circuit board (Fig. 8) is all right.

Universal NiCd battery charger

June 1991, p. 14-19

The parts list on page 19 should be corrected to read

C7 = 2200µF 25V

When difficult to obtain, the BYW29/100 (D5) may be replaced by the BY229, which is rated at 6 A.

The text under the heading 'Calibration' should be replaced by:

4. Connect a multimeter between points G and H on the board, and adjust P4 until the measured voltage is 1 V lower than the voltage on the battery terminals.

MIDI program changer

April 1991, p. 14-17

The contents of the EPROM should be modified as follows:

address	data
OOBC	E5
00C7	80
00C8	CB
00C9	F5
00CA	7B
00CB	12
00CC	00
00CD	D2
00CE	C2
00CF	02
00D0	80
00D1	C2

Readers who have obtained the EPROM ready-programmed through the Readers Services may return it to obtain an update.

Electronic exposure timer

March 1991, p. 31-35

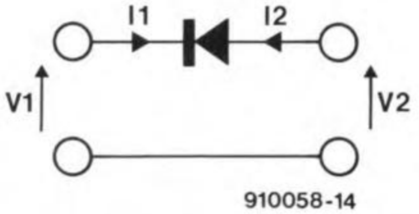
Please add to the parts list on page 32:

C16 = 33 pF

Augmented A-matrices

May 1991, p. 42-43

The drawing below was erroneously omitted in the left-hand bottom corner of page 43.



LED VU METER

ALTHOUGH there are a number of ICs on the market with which it is quite simple to construct an LED VU meter, there is still interest in building such a meter from discrete components.

The meter shown in the diagram is based on eight opamps, contained in two Type LM324 chips, that function as comparators.

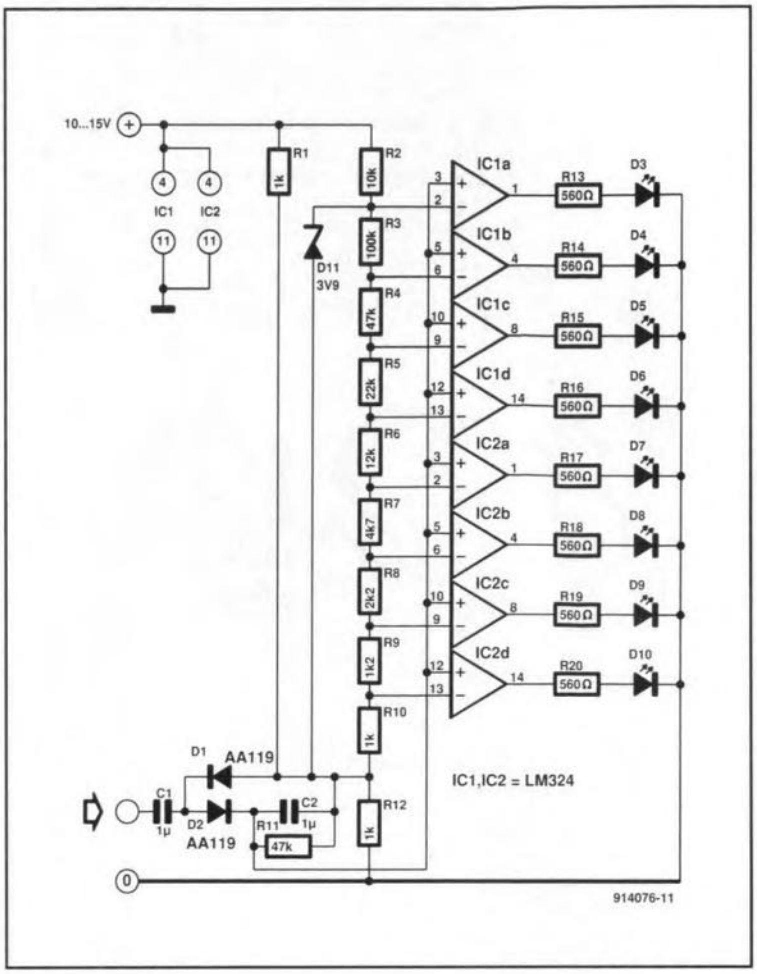
The inverting input of each of the opamps is provided with a reference voltage derived from potential divider R_3–R_{10}. The values of these resistors are chosen to give a 5 dB step between adjacent resistors. Resistors R_1 and R_{12} ensure that the reference voltages are higher than half the supply voltage.

The non-inverting input of each opamp is supplied with the rectified input signal (D_1 and D_2), which is also superimposed on to half the supply voltage.

When the voltage level at the positive input of an opamp rises above that at the inverting input, the output of that opamp goes high and the associated LED lights. The higher the input signal, the more LEDs will light. If D_3 and D_4 are red, the circuit may be used as a simple peak indicator, showing when the input signal exceeds a certain value.

The supply may be between 10 V and 15 V. The current drawn from it depends largely on the number of LEDs that light; it is not more than 160 mA at 10 V and 110 mA at 15 V.

(M. Stehouwer 914076)

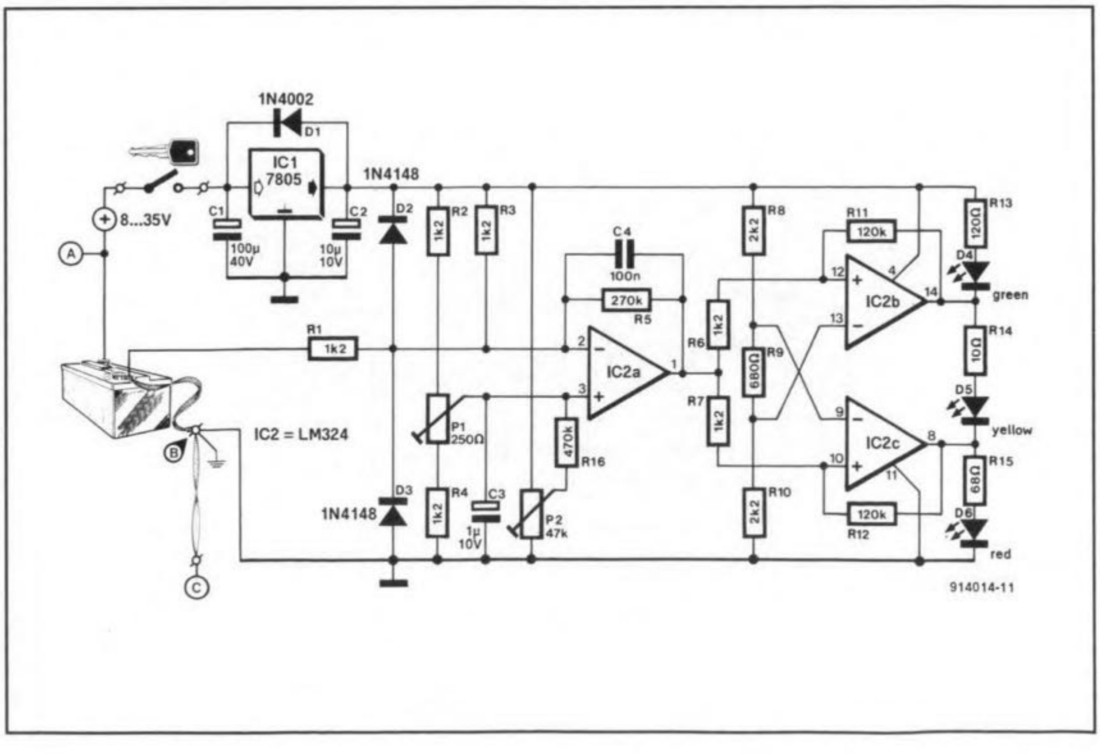


CAR BATTERY MONITOR

THE charge-discharge-idle (C-D-I)monitor described here is suitable for all vehicles with a 12-V or 24-V battery of which the negative terminal is connected to the chassis (point B in the drawing)

The current drawn from the battery is measured by monitoring the voltage drop across the heavy cable between the negative terminal of the battery, and the chassis. Usually, this cable is extended to the engine (point C). The positive terminal is usually connected to two cables, a solid one to the starter motor (point A) and a thinner one to the ignition switch.

Two LEDs fitted in the car interior indicate whether the battery is charged or discharged with a significant current, providing a reassuring check on the generator function. A third LED is provided to indicate a



kind of neutral area in which the battery is only lightly charged or discharged.

The circuit is essentially a window comparator based on opamps. The voltage drop that exists across the chassis cable of the battery is fed to resistor R_1, which forms part of a measuring bridge consisting of R_1-R_2-R_3-R_4-P_1. The small voltage unbalances the bridge, and is amplified 100 times by opamp IC_{2a} which is wired as a non-inverting amplifier. In practice, input voltages as small as +2.5 mV or −2.5 mV are detected reliably by the balanced bridge.

The output voltage of IC_{2a} controls a window comparator built around IC_{2b} and IC_{2c}. The LEDs at the opamp outputs indicate whether the battery is charged (D_4 lights), discharged (D_6 lights), or is in a 'neutral' state (D_5 lights).

The two positive feedback networks associated with IC_{2b} and IC_{2c} are decoupled at the output of IC_{2a} by R_6 and R_7 to ensure that the hysteresis of the window comparator does not affect the reference voltages supplied by R_8-R_9-R_{10}. If necessary, R_9 may be made smaller to make the 'idle' (neutral) range smaller.

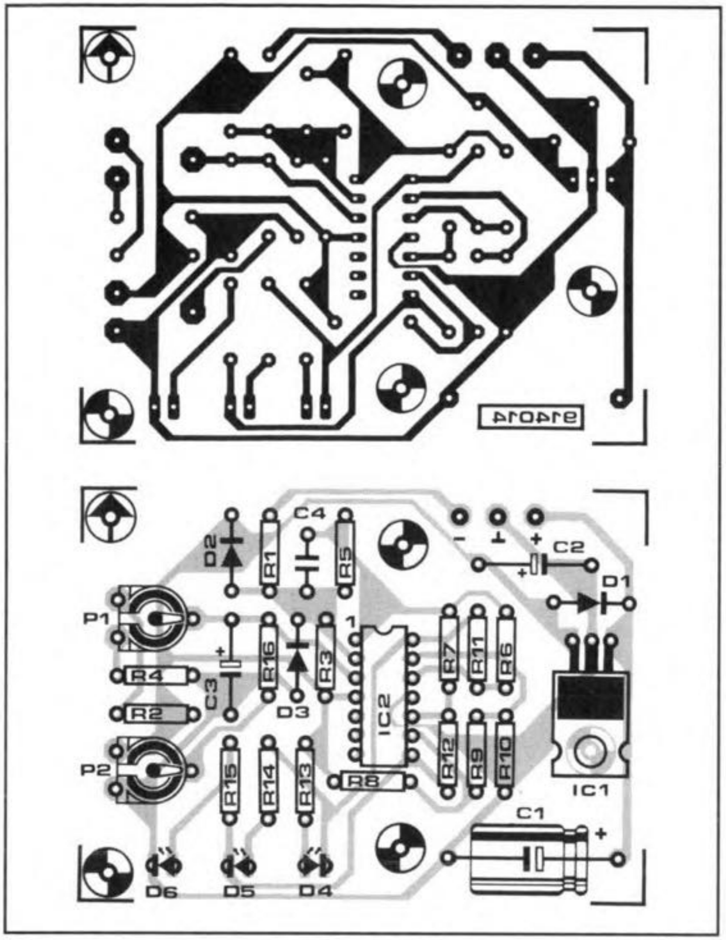
The fixed resistors in the bridge must be close tolerance types mounted such that they are in thermal contact with each other.

The circuit has an internal power supply based on the ubiquitous 7805 three-terminal voltage regulator. The regulator requires a heat-sink only when the circuit is installed in a vehicle with a battery voltage higher than 12 V.

Adjusting the circuit is straightforward. Start the engine and let it idle. Set preset P_2 to mid-travel. Next, adjust P_1 until the 'idle' LED, D_5, lights. Carefully readjust P_2 until IC_{2a} supplies an output voltage of 2.5 V. Rev up and check that the 'charge' LED, D_4, lights.

With the component values shown here, the circuit will indicate a charge or discharge current greater than about 1.5 A, which corresponds to 18 W at a battery voltage of 12 V. Suggested colours for the LEDs are green for D_4 (charge), red for D_6 (discharge) and yellow for D_5 (idle). Alternatively, the charge and discharge LEDs may be triangular types which can be fitted to point up and down respectively. The 'idle' LED is then a rectangular type fitted in between. Finally, the circuit draws about 30 mA when connected to a 12-V system.

(L. Rikard 914014)

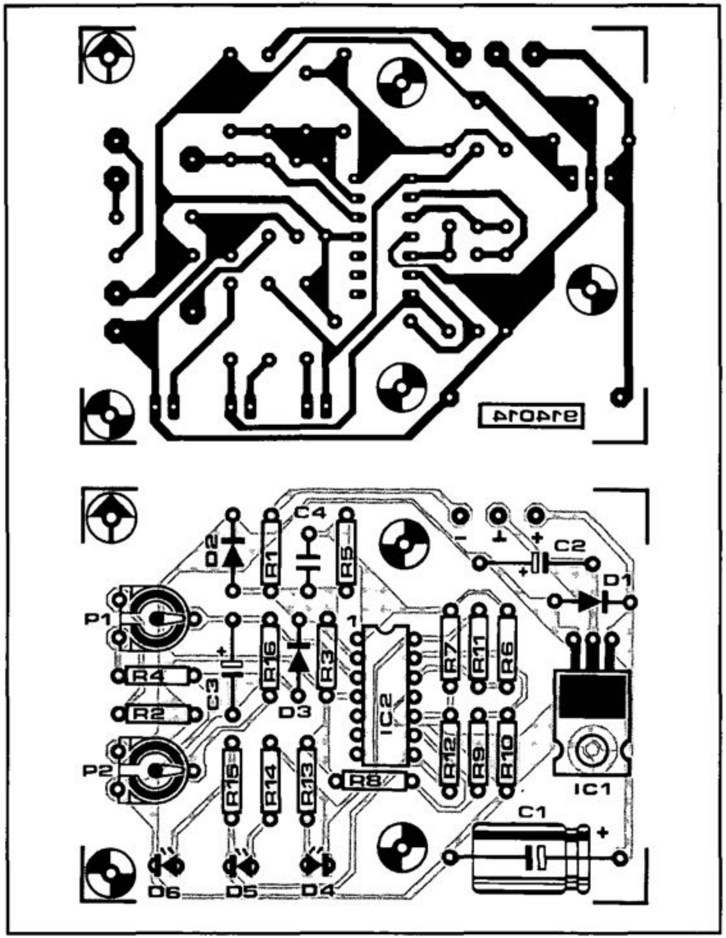


PARTS LIST

Resistors:
R1–R4, R6, R7 = 1.2 kΩ
R5 = 270 kΩ
R8, R10 = 2.2 kΩ
R9 = 680 Ω
R11, R12 = 120 kΩ
R13 = 120 Ω
R14 = 10 Ω
R15 = 68 Ω
R16 = 470 kΩ
P1 = 250 Ω preset H
P2 = 47 kΩ preset H

Capacitors:
C1 = 100 µF, 40 V
C2 = 10 µF, 10 V
C3 = 1 µF, 10 V
C4 = 100 nF

Semiconductors:
IC1 = 7805
IC2 = LM324
D1 = 1N4002
D2, D3 = 1N4148
D4 = LED, green
D5 = LED, yellow
D6 = LED, red



R_9 may be made smaller to make

PARTS LIST

Resistors:
R1–R4, R6, R7 = 1.2 kΩ
R5 = 270 kΩ
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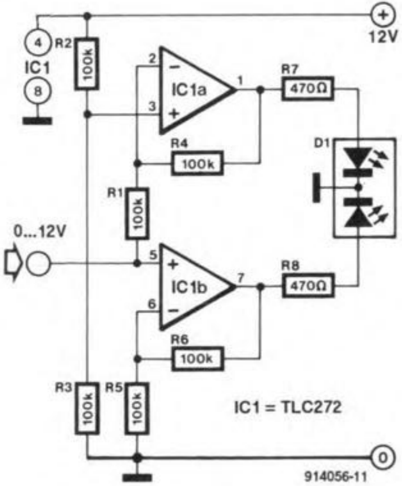
With the component values shown here, the circuit will indicate a charge or discharge current greater than about 1.5 A, which corresponds to 18 W at a battery voltage of 12 V. Suggested colours for the LEDs are green for D_4 (charge), red for D_6 (discharge) and yellow for D_5 (idle). Alternatively, the charge and discharge LEDs may be triangular types which can be fitted to point up and down respectively. The 'idle' LED is then a rectangular type fitted in between. Finally, the circuit draws about 30 mA when connected to a 12-V system.

(L. Rikard 914014)



VARIEGATED LED

WHEN the control voltage at the input of the circuit is varied from 0 V to +12 V, the LED will first light up green and then gradually, via orange and yellow, turn to red.

The two sections of the bi-colour (red and green) LED are driven separately: the green one by IC_{1a} via R_7, and the red one by IC_{1b} via R_8.

Opamp IC_{1b} has an amplification of ×2, which results in the red LED lighting from input voltages of about 0.5 V. This section lights at maximum brightness when $U_{in}>U_b/2$.

Opamp IC_{1a} is an inverting amplifier with an amplification of ×2. Moreover, its non-inverting input is at a level of $U_b/2$. When the input voltage $<U_b/2$, its output is high. When the input rises above $U_b/2$, the green section of the LED will gradually become less bright until it goes out completely when $U_{in}=U_b$.

The supply voltage should not exceed 30 V: when it is higher than 12 V, the value of resistors R_7 and R_8 should be altered accordingly.

The current drawn by the circuit depends mainly on the LED: with a 34 mcd type and a supply voltage of 12 V, it is about 35 mA.

(R. Kühn 914056)

MICROPROCESSOR SUPPLY REGULATOR

MOTOROLA's TCA5600 is a versatile supply chip for battery-operated microprocessors; its internal circuit diagram is given in Fig. 1.

Diodes D_1 and D_2 protect the circuit against reverse polarity of the supply voltage and voltage peaks respectively.

The 2.5 V reference is powered independently to enable it remaining switched on while the remainder of the circuit is on stand-by.

The d.c.–d.c. converter and presettable voltage regulator, A2, form one entity. The converter arranges for the input voltage of A2 to be of a level that ensures colrrect and stable operation of the regulator. The level depends on the level of the signals at INH1 and INH2 that control the regulator. Six modes are possible as shown in the table. Potential V_{out2} is used, for instance, as the programming voltage for an (E)EPROM and is set with the aid of resistors R_4 and R_5. Since the converter is on until the level at pin 9 reaches 33 V, it is possible, for example, prior to programming an (E)EPROM, to set the input potential to A2 to the required level in advance of the programming pulse, so that the switching from 5 V to the required level is not subject to any delays. This may also be seen from the timing diagram in Fig. 2.

The 5-V regulator is of conventional design. A differential amplifier, A1, compares the output level via a voltage divider with the reference; the difference drives an external power transistor, T1.

Current limiting is provided by a series resistor in the emitter circuit of the output transistor.

The output of the 5-V regulatr is also applied to a Schmitt trigger that functions as an undervoltage detector. If the output drops below 5 V, the delay circuit is actuated to make the reset

TRUTH TABLE

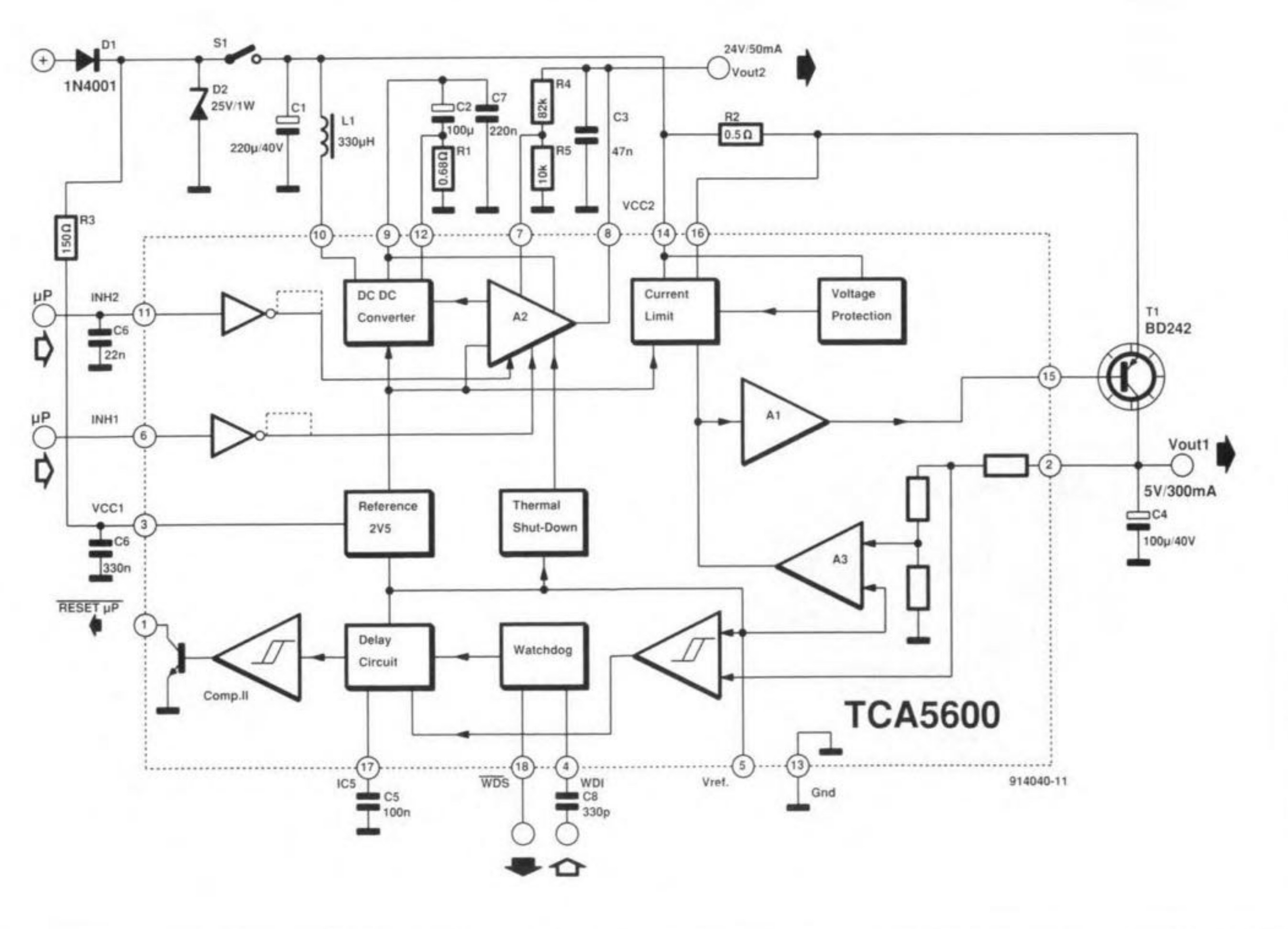
Mode	INH1	INH2	V_{out2}	d.c./d.c.
1	0	0	off	int
2	0	high Z	V_{out2}	on
3	0	1	V_{out2}	int
4	1	0	off	int
5	1	high Z	5.0 V	on
6	1	1	5.0 V	int

int: intermittent operation of the converter means that the converter operates only if $V_{CC2}<V_{out2}+2.5$ V.

on: the converter loads the storage capacitor to its full charge (V_g=33 V), allowing fast response time of the regulator V_{out2} when addressed by the control software.

off: high impedance (internal 10 kΩ resistor to ground).

1

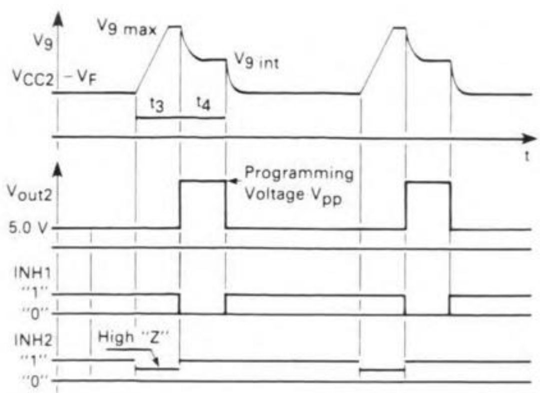


output of the IC low. This is intended to prevent spurious operation of the microprocessor at too low a supply voltage. Such operation is also monitored by the watchdog. By programming the processor to emanate regular pulses and provide these to the WDI (watchdog inhibit) pin, the watchdog can monitor whether the program is running normally. As soon as a pulse is delayed, the watchdog actuates the delay circuit, which in turn resets the processor. The watchdog function may be switched on and off via the logic level at pin 18 (WDS); if this level is low, the watchdog is enabled.

The delay circuit also provides a power-on reset, so that the processor will always start at the correct point in the program at power-on.

(L. Lemon 914040)

2



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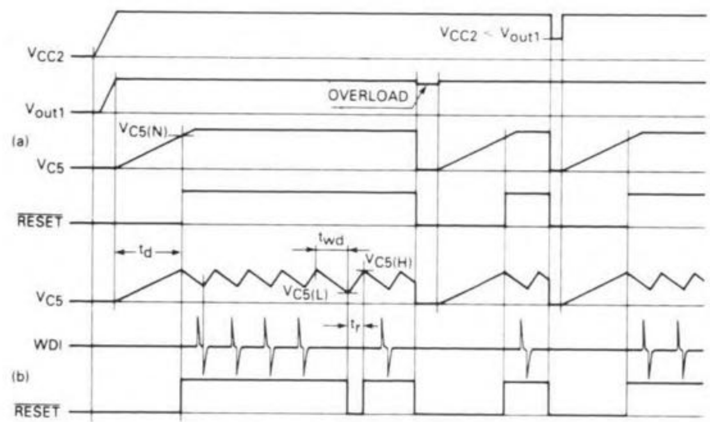
3



(a) Watchdog inhibited, $\overline{WDS}$ = "1"
(b) Watchdog operational, $\overline{WDS}$ = "0"

914040-13

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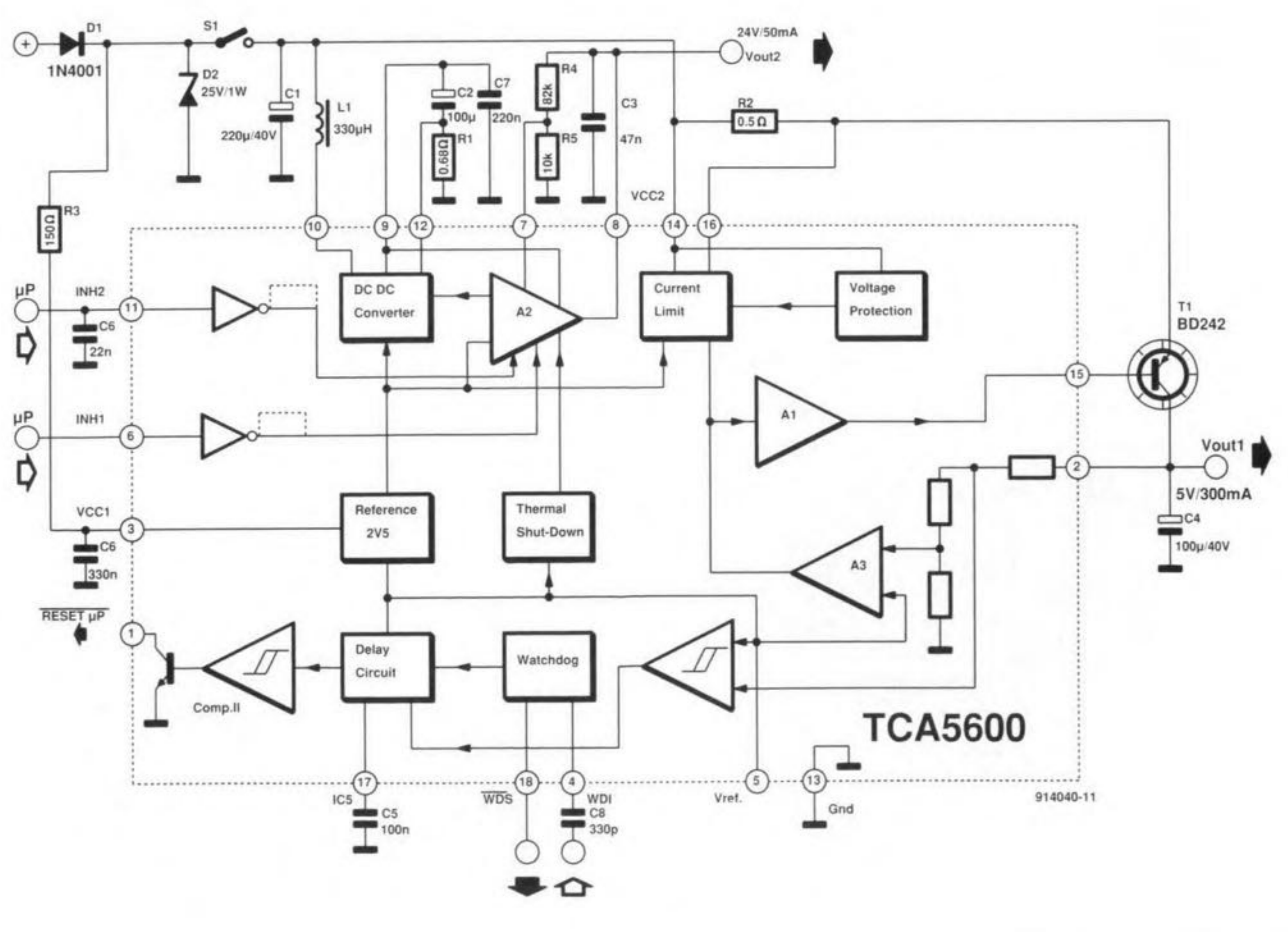

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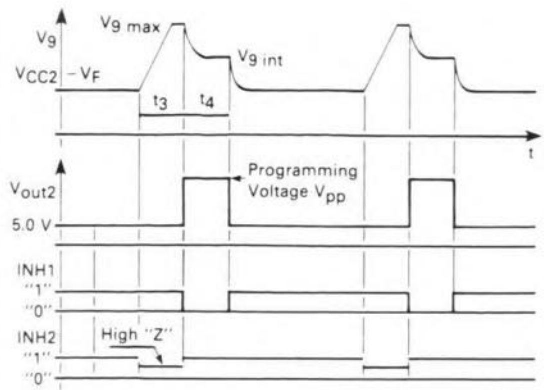
(L. Lemon 914040)

2



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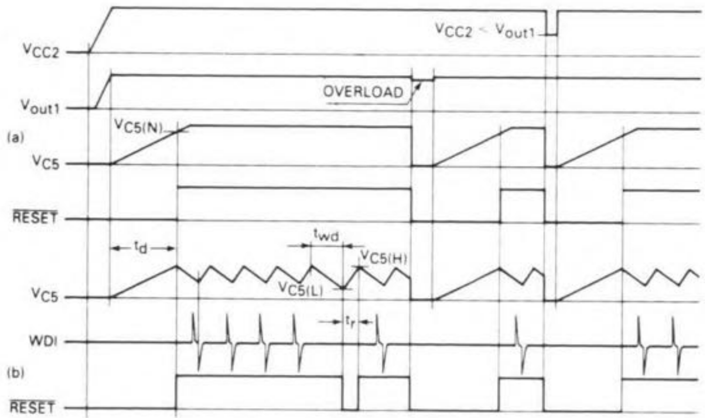

(a) Watchdog inhibited, $\overline{WDS}$ = "1"
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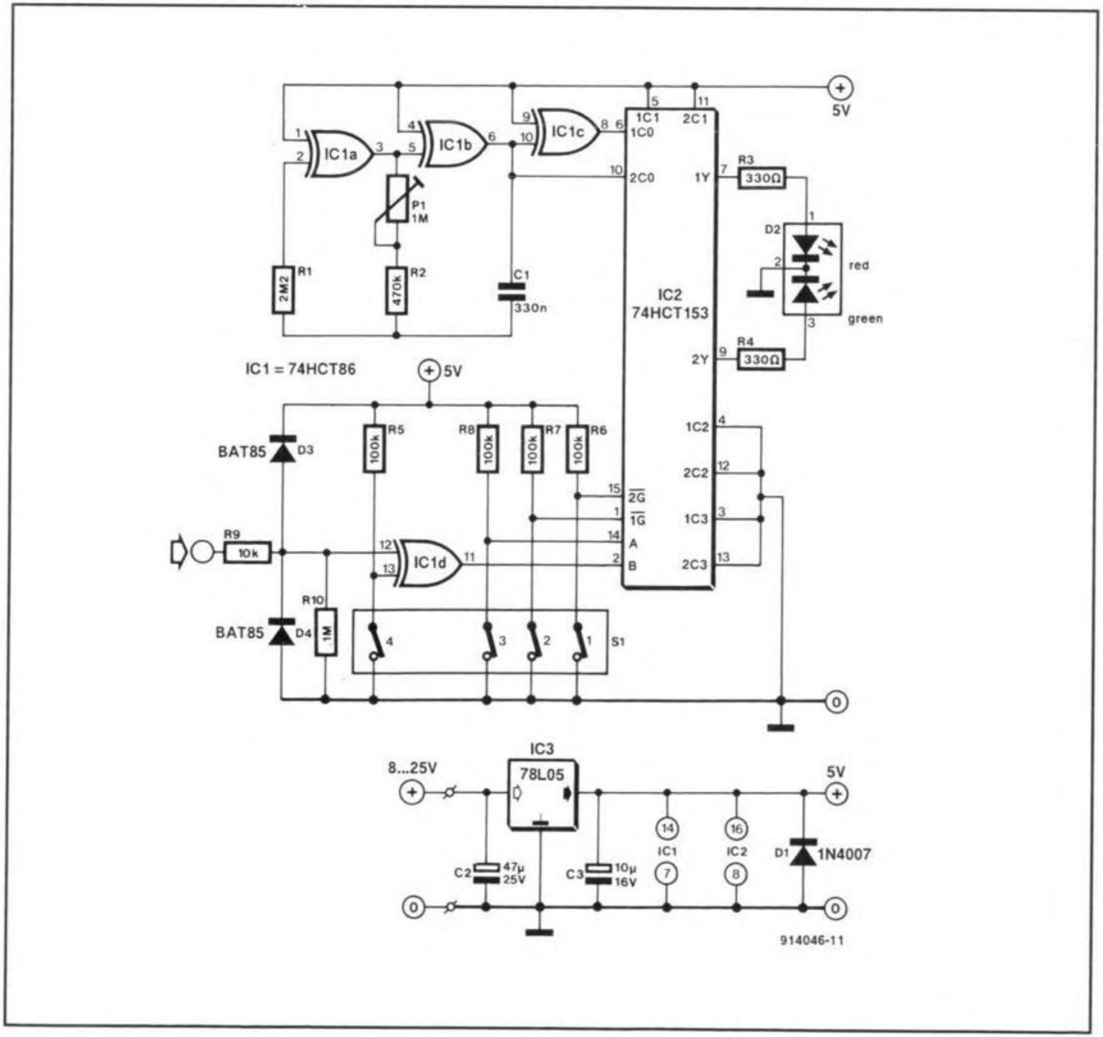
914040-13

PROGRAMMABLE LED INDICATOR



THE most popular current indicator in electronics is almost certainly the light-emitting diode (LED) which is available in a number of colours (red, green, blue, yellow, as well as dual colours) and variations (round, square, flashing). Unfortunately, these virtually indestructible devices are often abused: terminals cut too short, current too high, burnt by a soldering iron, and many others. Most of these abuses may be prevented by the circuit described here: it enables the LED indication to be adapted to the circuit you are working on (flashing or not flashing, red, gree, and so on).

The heart of the indicator is dual-colour diode D_2. The manner in which this will light when the input of the indicator is actuated depends on the settings of S_1-1–3. Switch S_1-4 enables the setting of a high or low level to which the input reacts. Components R_9, D_3 and D_4 protect the input from damage should the input voltage become too high.

An oscillator formed by IC_{1a} and IC_{1b} provides a flash frequency that is set by P_1.

Depending on the setting of switches S_1-1–3, the oscillator signal is applied in a certain manner to the dual-colour LED via multiplexer IC_2. For convenience's sake, the positions of switches S_1-1–3 and the consequent actions of the LED are summarized in Table 1 and those of S_1-4 and the status of the LED in Table 2.

The indicator needs a supply of 8–25 V. The current drawn from a supply of 25 V in normal operation is 30 mA.

(J. Ruffell 914046)

TABLE 1

S_1–1	S_1–2	S_1–3	LED action
on	on	on	flashing red/green
on	on	off	red/green
on	off	on	flashing green
on	off	off	green
off	on	on	flashing red
off	on	off	red
off	off	on	off
off	off	off	off

TABLE 2

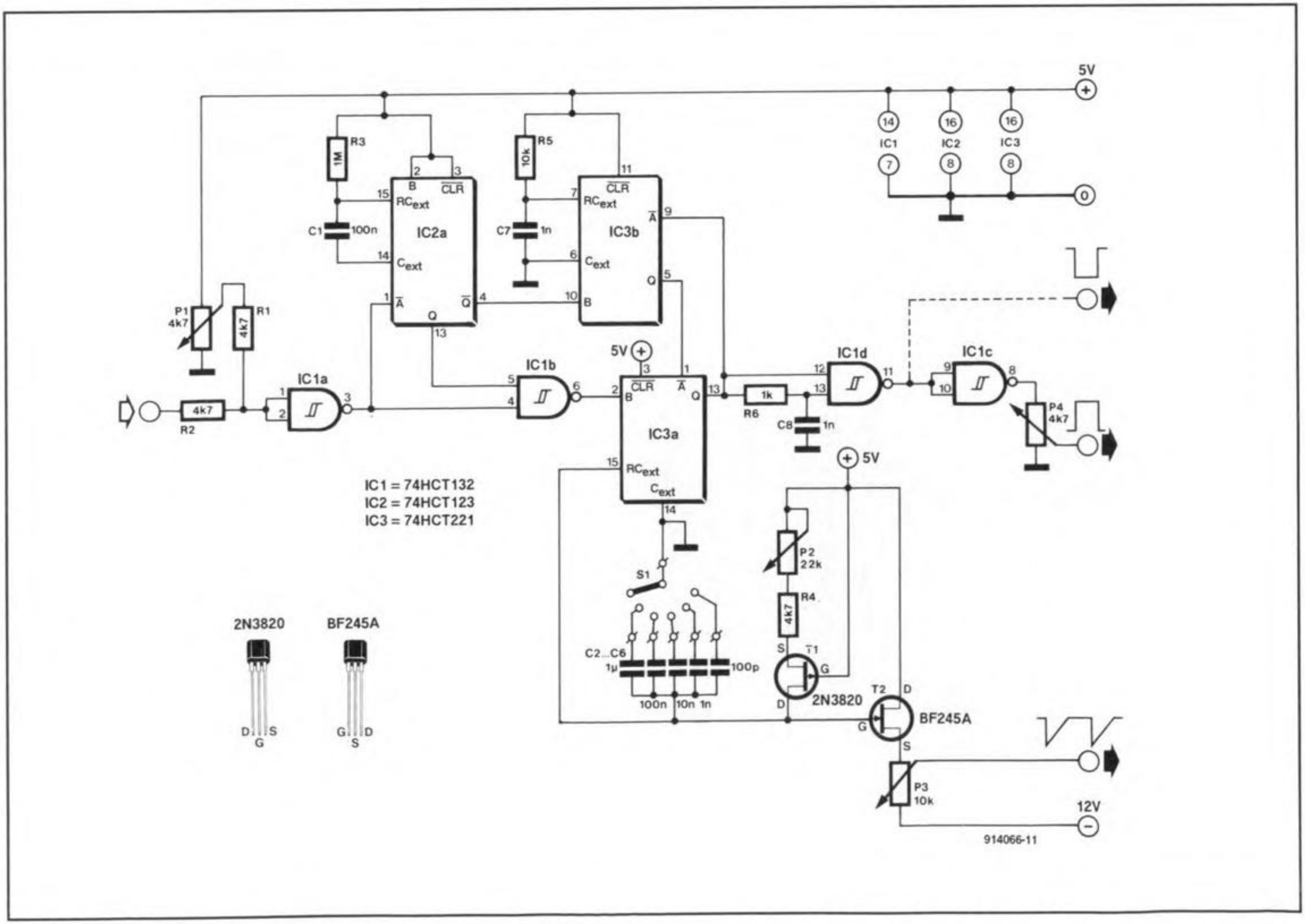
S_1–4	CTRL input	LED status
off	L	disable
off	H	enable
on	L	enable
on	H	disable

TRIGGERED SAWTOOTH GENERATOR

THE sawtooth generator shown in the diagram may be used with an oscilloscope. It is linear, retriggerable, and is enabled automatically in the absence of a trigger signal.

When a positive pulse is applied to its input B, monstable IC_{3a} generates a sawtooth, which, owing to the 'standard' *RC* network, is not linear. If, however, the resistor in that network is replaced by a current source, here T_1, R_4, P_2, linearity returns. The period of the sawtooth depends on the settings of S_1 and P_2.

The sawtooth signal is buffered by T_2 to prevent its quality being affected adversely. The voltage level at the gate of T_2 is 0–3.5 V,



that at the source is slightly lower.

The rectangular signal at the Q output of IC_{3a} is used to suppress the electron beam during the flyback.

The trigger signal is provided by Schmitt trigger IC_{1a}, which has the small drawback that the input signal must be at least 1 V r.m.s. Preset P_1 provides compensation for the d.c. level at the input. Some experimentation with the values of R_1 and R_2 is advisable since these resistors determine the operating range of P_1.

As long as trigger signals are input, IC_{3a} generates sawtooth signals. Since IC_{2a} receives the same trigger signals, it is enabled continuously. There is, however, a fundamental difference between the two circuits: the 74HCT123 is retriggerable, whereas the 74HCT221 is not; it is enabled only after the current period has been processed; all intermediate trigger pulses are ignored.

In practice, the Q output of IC_{2a} is high as long as trigger pulses are input. When these pulses cease, the Q output goes low, which results in IC_{3b} being started via the $\overline{Q}$ output. After its mono time has elapsed, IC_{3b} enables IC_{3a} and this in its turn reactuates IC_{3b}, so that, even in the absence of input trigger signals, the sawtooth generator continues to operate.

The flyback is suppressed by IC_{3a}; network R_6-C_8 provides a slight delay to ensure that the beam is suppressed at the right moment. Since these components have a fixed value, it may happen at very low frequencies that small portions of the sawtooth are not suppressed. This may be obviated by switching capacitors of different values in the C_8 position via a second wafer on S1.

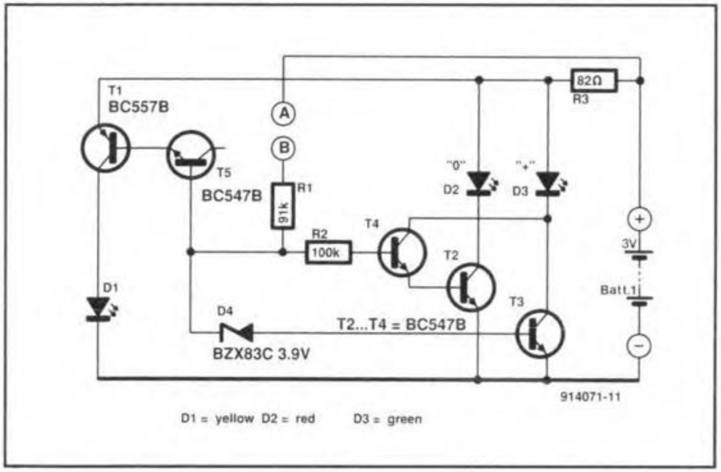
The range of the generator may be refined by adding capacitors in the time base whose ratio is 1:2:5; the capacitors in the diagram, C_2–C_6, have a ratio of 1:10. With values as shown, the period of the sawtooth in the upper position of the switch can be set between 1 μs and 6 μs; periods below 1 μs can not be obtained.

The circuit as shown draws a current of about 7.5 mA from the 5-V supply. The negative supply is not critical and may be between 5 V and 12 V.

(G.J. Knopper, 914066)

UNIVERSAL TEST PROBE

THE COMPACT test probe is made from five transistors, three LEDs, a zener diode, and three resistors. It enables rapid 'measurement' of voltage levels at digital gates, fuses, diodes, batteries, and others. Of course, it does not provide absolute values, but rather a good indication of correct operation or otherwise.



Measurements are carried out with pins A and B. If the potential difference between A (the reference pin) and B is 1.9–2.0 V, D_2 will light. If the voltage at B is ≤1.4 V higher than that at A, D_3 will light. Finally, if the potential at B is ≥11 V with respect to that at A, D_1 will light.

Transistor T_5 is used as a zener diode, which keeps the total current drawn down (since transistors 'break down' in a stable manner at a lower current than zener diodes).

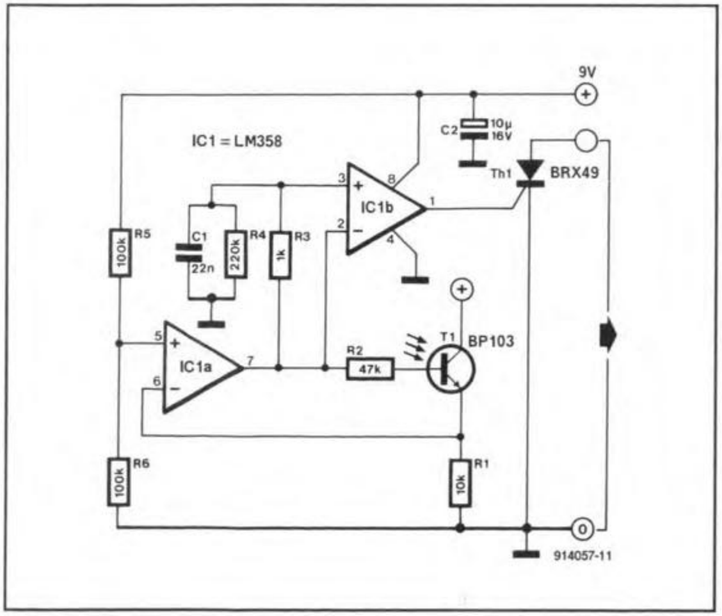
The probe allows measurement of alternating voltage.

The maximum input voltage is highly dependent on the dissipation allowed in R_1. For example, when this resistor is a 0.5 W type, the input voltage may be as high as 200 V r.m.s.

The current drawn by the circuit depends on the number of lighting LEDs: it is not more than 10 mA at a supply voltage of 3 V. In quiescent operation, the current is so low (about 5 μA) that an on/off switch is not necessary.

(T. Giffard 914071)

SLAVE FLASH TRIGGER



THE circuit in the diagram is intended for synchronous, wireless triggering of one or more slave flash units when the mother flash is triggered, so as to obtain better lighting of the photographic object.

Phototransistor T_1 is switched on upon the receipt of the light of the mother flash unit. The potential at the inverting input of comparator IC_{1a} rises, the comparator toggles and for a brief instant, determined by the value of C_1, the voltage level at the inverting input of IC_{1b} is lower than that at the non-inverting input. This causes IC_{1b} to toggle momentarily, which results in the thyristor being triggered and the flash contacts to be closed.

The circuit may be used in dark as well as in brightly lit places. The operating range depends on the mother flash and will normally be 5–15 m (15–50 ft). The sensitivity depends primarily on the base resistance of the phototransistor and this may be modified according to circumstances. Any tendency to instability may be cured by shunting R_2 with a 100 pF capacitor.

Power is supplied by a 9-V (PP3) battery.

(H. Döpfner 914057)

BINARY LOGARITHMIC LADDER NETWORK

THE network provides an attenuation between 0 dB and 78.75 dB that is presettable in 64 stepswith the aid of a 6-bit code.

Six independent, relay switched attenuator sections may be connected in series in accordance with the input code. Since the sections have identical 1 kΩ impedances, they do not affect each other and can, therefore, be interchanged without any problem. The only requirement is that the network is terminated correctly, here by R_{20}. The fairly low characteristic resistance of 1 kΩ was chosen to keep the noise generated by the attenuator low.

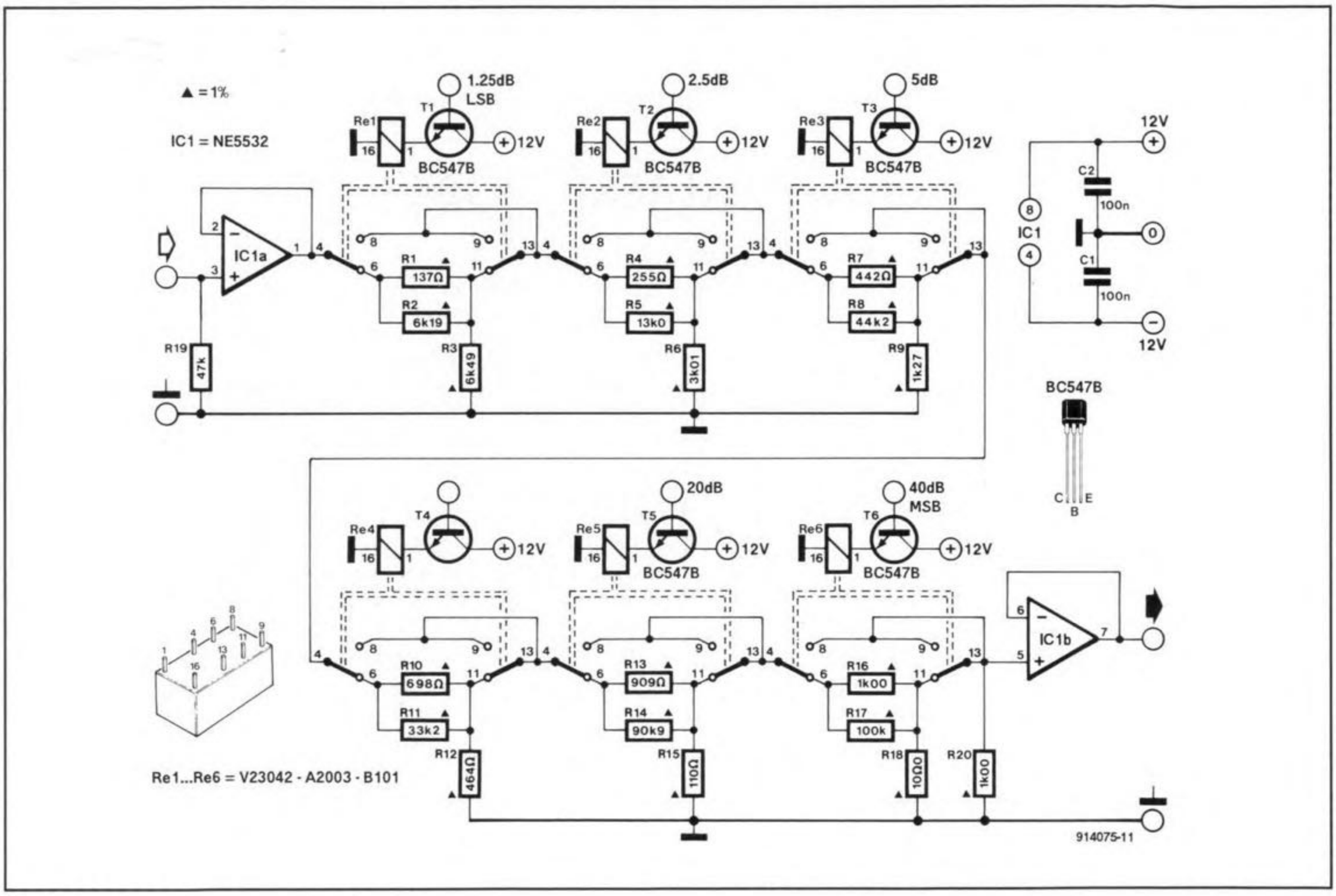
Buffering of the attenuator is effected by a Type NE5532, an IC that operates effortlessly with a 1 k input impedance.

The use of relays in the various sections ensures that there are no linearity problems with switching elements. Furthermore, relays make it possible for the control circuits and the attenuator to be electrically isolated.

The relays are driven by a transistor,so that the control inputs require relatively little energy: even a simple logic circuit (TTL or CMOS) can switch the relays in this manner.

The signal-to-noise ratio of the attenuator, with component values as shown in the diagram, is 92 dB (A-weighted even 107 dB), provided the input signal is not smaller than 1 V r.m.s. The maximum input voltage is 7 V r.m.s. Total harmonic distortion at frequencies up to 20 kHz is not greater than 0.003%. The current drawn by the circuit depends prim arily on the relays: in the prototype it was about 120 mA.

(T. Giffard 914075)



UNIVERSAL TIMER

THE timer is intended to actuate an apparatus for a predetermined period of time, for instance, an ultra-violet exposure unit or a photographic enlarger. Periods may be set between 0.1 s and 999.9 s.

The periods are set with the aid of thumb wheel switches and stored in four Type 74HCT190 counters, IC_4–IC_7. Setting is facilitated by the set times being displayed instantly on the LED display. After the start button has been pressed, the inputs of the counters are disabled and the count down starts. At the same time, relay Re_1 is energized.

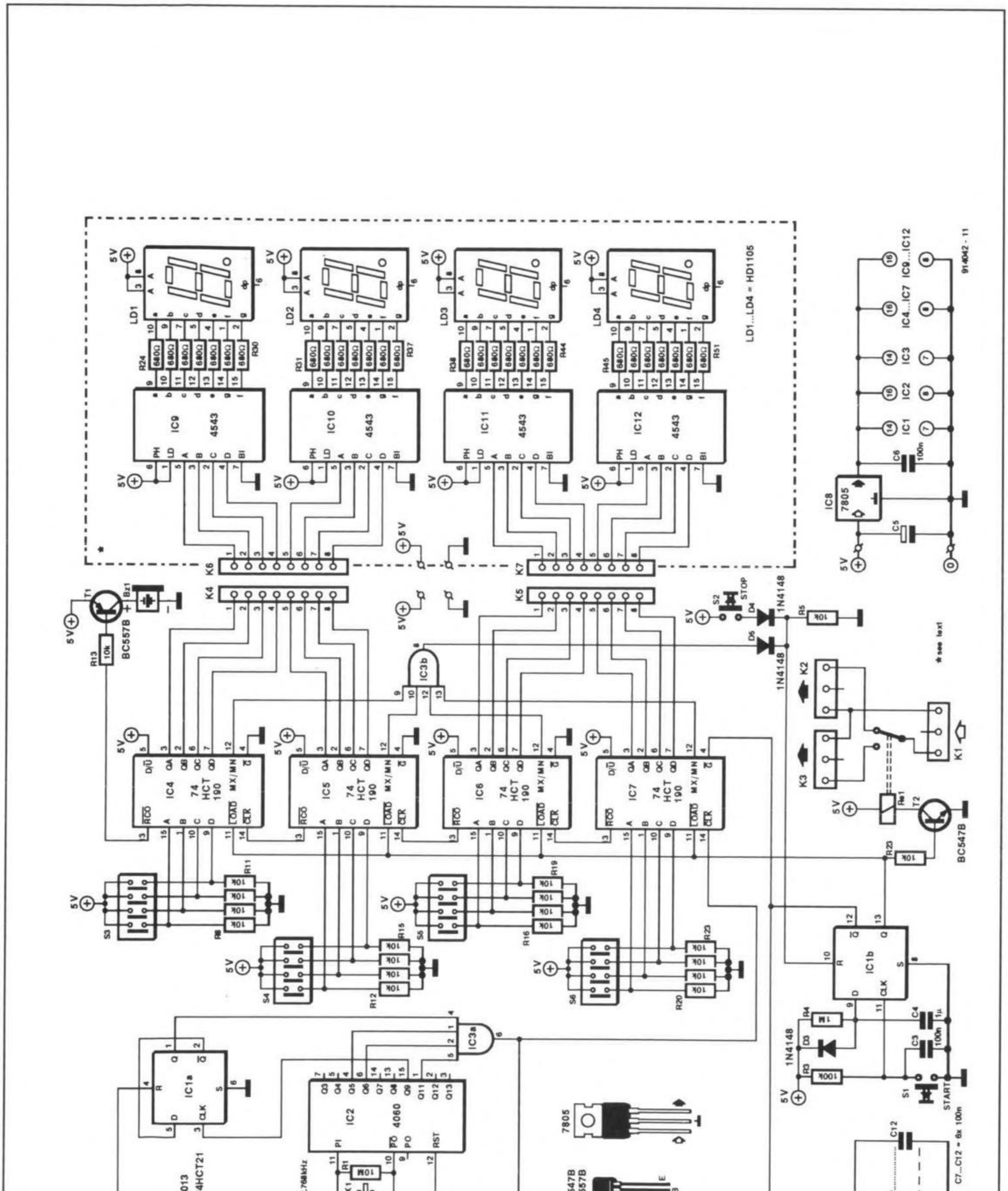
In quiescent operation, the contacts of K_2 are linked to those of K_1. Since K_1 is connected to the mains, the load connected across K_2 is supplied with mains voltage; there is no voltage supplied to the load connected across K_3. When Re_1 is energized, that is, during the switch-on period, the mains voltage is switched from K_2 to K_3. At the end of the switch-on period, a buzzer in the collector circuit of T_1 sounds. In an emergency, the switch-on period may be prematurely terminated with the aid of the stop button.

When the switch-on period is over, oscillator IC_2 is disabled and the relay is de-energized. The preset period is then shown on the LED display again.

Power for the clock may be provided by a simple 300 mA mains adapter combined with a Type 7805 regulator.

(A. Rigby 914042)

→


LD1...LD4 = HD1105
IC1 = 4013
IC3 = 74HCT21
X1 = 32.768kHz
C7...C12 = 6x 100n
* see text
914042 - 11

50 HZ BAND-STOP FILTER

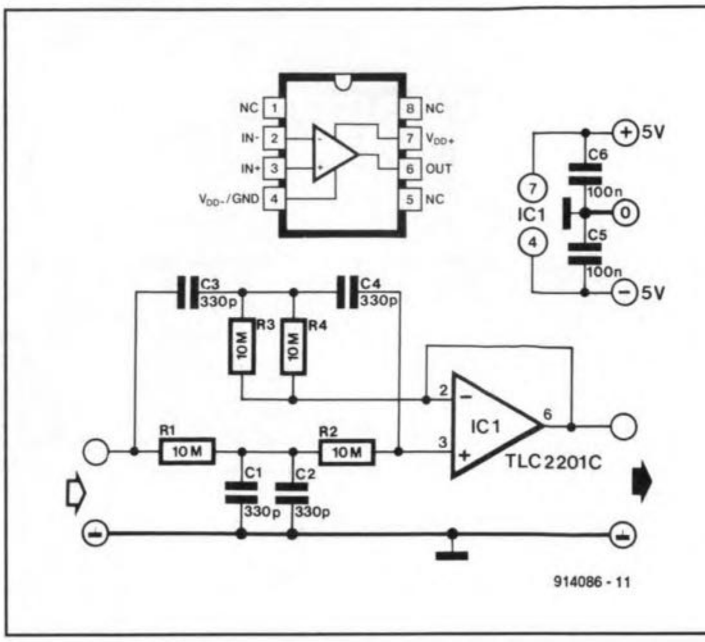
MOTOROLA's Type TLC2201 low-noise precision opamp is probably not the best-known amplifier made in LinCMOS technology, but it is certainly a very interesting and useful device. Apart from a noise figure of 18 nV √Hz^{-1}, which is low for opamps, the chip also has very good d.c. characteristics. The JFET inputs have an offset of only 100 µV, while the temperature coefficient is 0.5 µV K^{-1}. Until not so long ago, such specifications were possible only in amplifiers with bipolar inputs.

The combination of low noise, good static characteristics and a common-mode range that extends to the negative supply voltage, make the TLC2201 very suitable for applications where signal conditioning with a high source impedance is a prime requirement.

An example of this is the 50 Hz band-stop filter shown in the diagram, which provides an attenuation of some 40 dB. Because of the high input impedance, the filter can use relatively small capacitances and large resistances. Owing to its excellent d.c. properties, the circuit is also suitable as a buffer for d.c. or low-frequency signals.

The circuits requires a ±5 V supply, from which it draws about 1.5 mA.

(J. Ruffell 914086)



FIELD STRENGTH METER

THE UNIT discussed here indicates, by means of a chain of LEDs, in logarithmic ratios the strength of an electric field surrounding the unit. The input signal across the conducting discs is applied to the non-inverting input of IC_1. The amplification of IC_1, $A=R_4/P_1$. In the prototype, P_1 was set at about 210 kΩ to give an amplification of about ×50.

Opamp IC_2 functions as a rectifier: during the negative halves of the input signal, its output goes high and D_1 conducts.

PARTS LIST

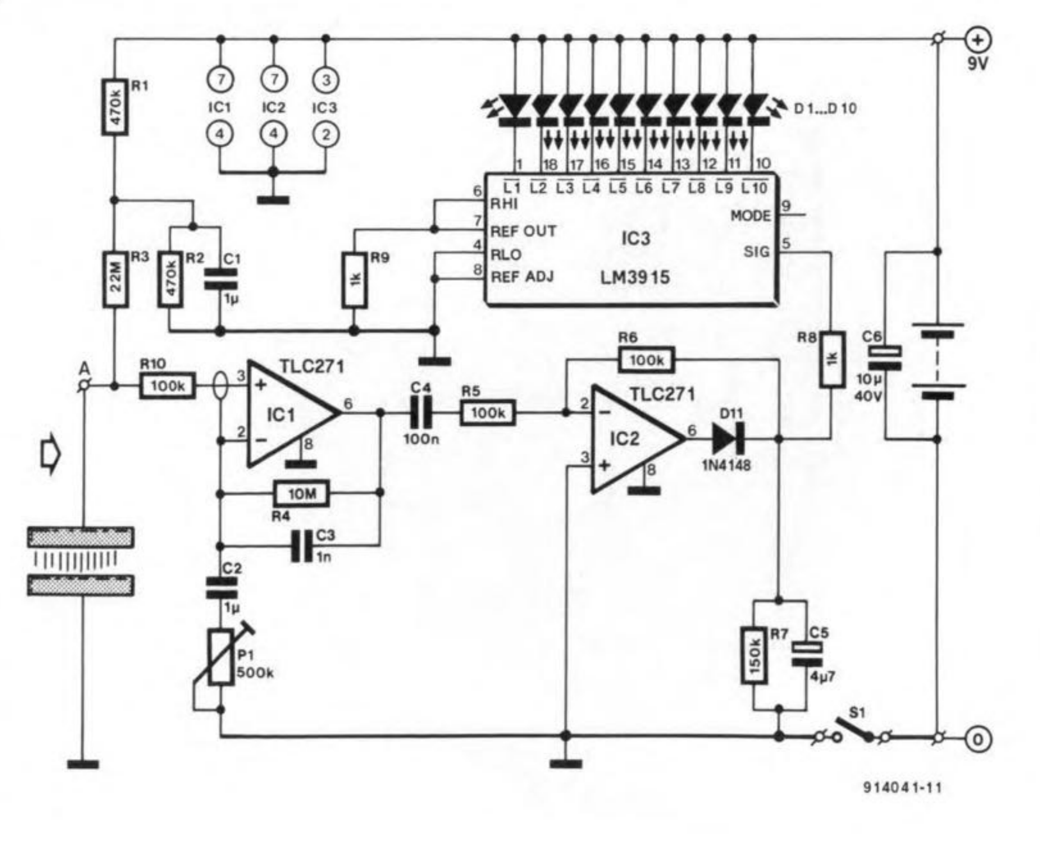
Resistors:
R1, R2 = 470 kΩ
R3 = 22 MΩ
R4 = 10 MΩ
R5, R6, R10 = 100 kΩ
R7 = 150 kΩ
R8, R9 = 1 kΩ
P1 = 470 kΩ (or 500 kΩ) multi-turn preset

Capacitors:
C1, C2 = 1 µF
C3 = 1 nF ceramic
C4 = 100 nF
C5 = 4.7 µF, 25 V, radial
C6 = 10 µF, 40 V, radial

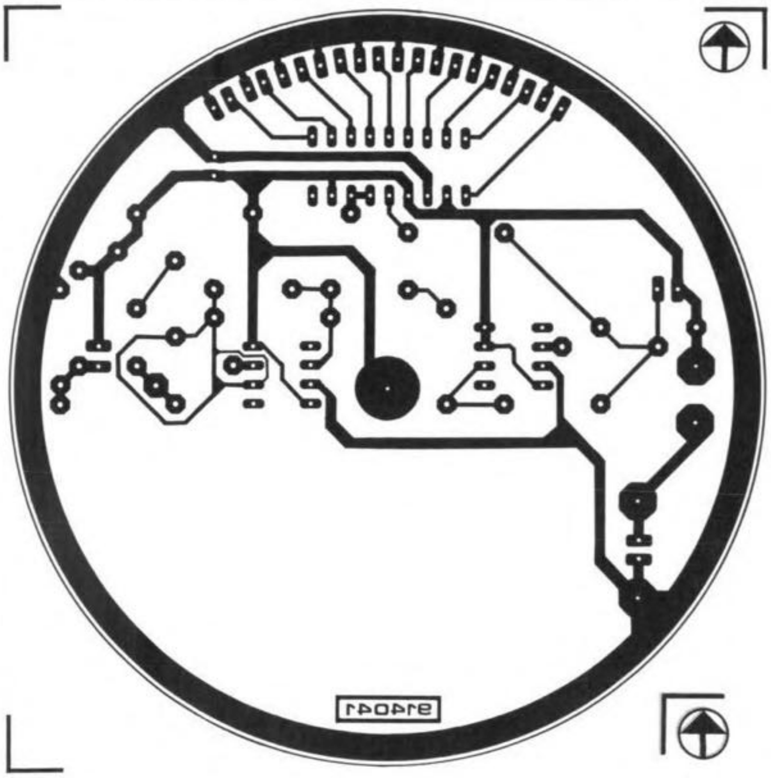
Semiconductors:
D1 = 1N4148
D2–D4 = LED, 3 mm, green
D5 = LED, 3 mm, yellow
D6–D10 = LED, 3 mm, red
IC1, IC2 = TLC271
IC3 = LM3915

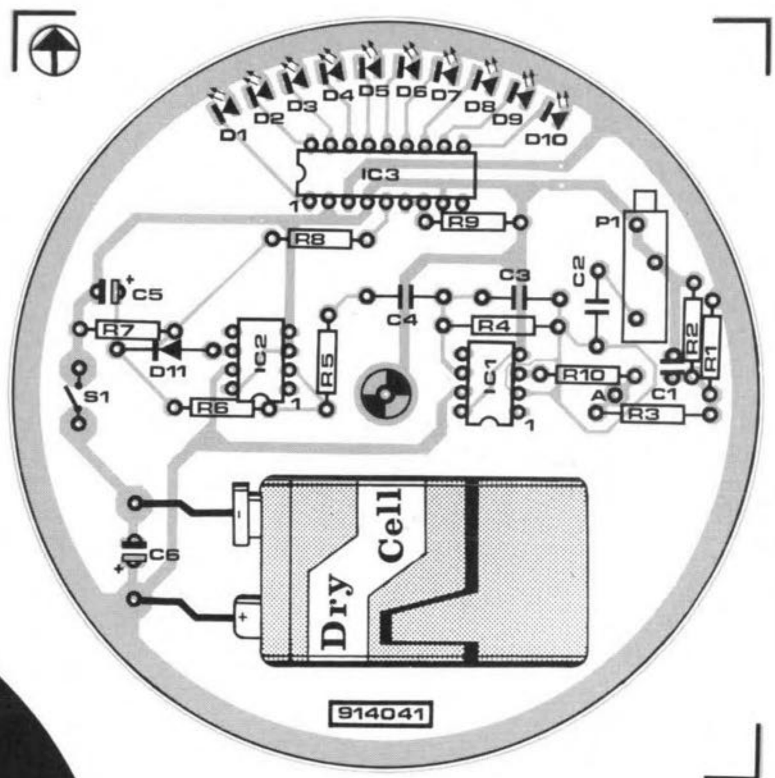
Miscellaneous:
S1 = SPST switch
9 V battery

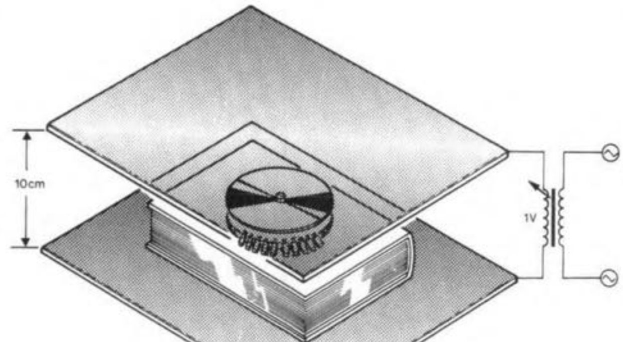
1



2




D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
IC3
R8
R9
P1
C5
C4
C3
C2
R7
D11
IC2
R5
R4
IC1
R10
R2
R1
S1
R6
A
C1
R3
C6
Dry Cell
914041


10cm
1V

During the positive halves, the signal is applied direct to the output via R_5 and R_6. Diode D_1 is then reverse biased and IC_2 does not function.

The level of the output voltage across C_5 is monitored by diode chain D_1–D_{10} via IC_3. The capacitor is discharged slowly via R_7 when the signal ceases.

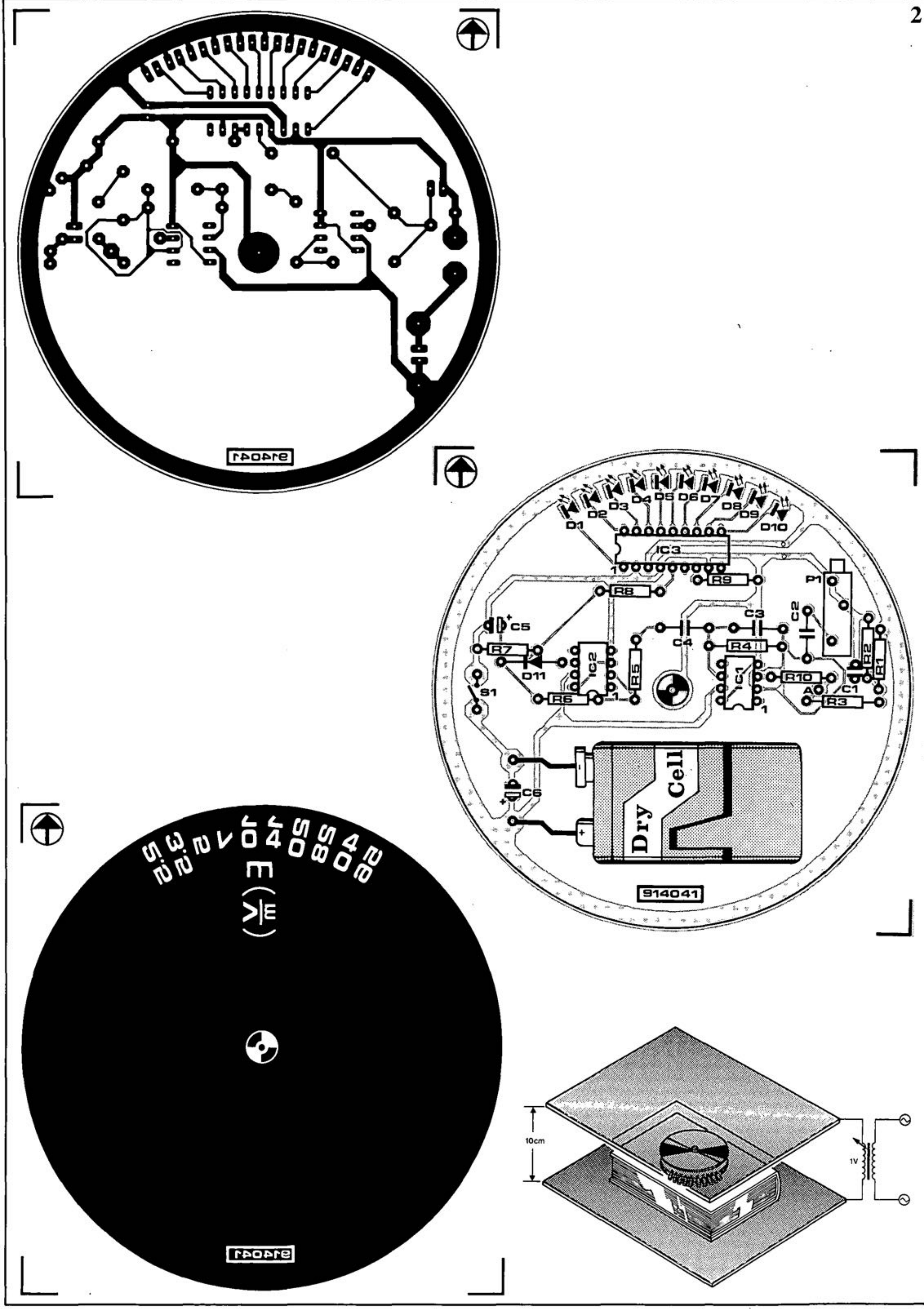
The conducting discs are formed by two round, double-sided PCBs as shown in Fig. 2. The components are mounted at the track side of one of the boards. Carefully bend the terminals of the components about 2 mm from their ends to make better contact and strengthen the solder joints. Note that C_6, S_1 and the LEDs must be fitted lying down, all the others upright.

The two boards are fixed together with the aid of non-metallic screws and 20 mm spacers.

The indicator is calibrated by turning P_1 until the LED associated with a field strength of 10 V m^{-1} just lights.

(Dipl. Ing. H. Moser 914041)

2

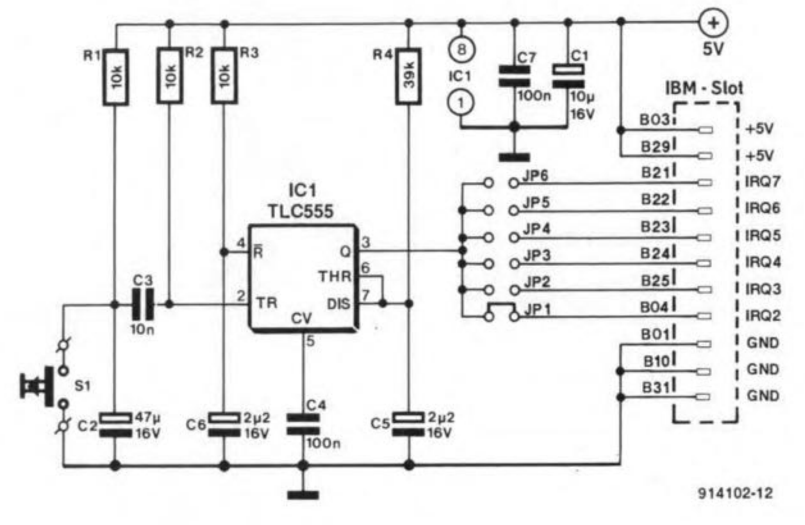

914041
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
IC3
R9
R8
P1
C5
C3
C2
C4
R7
R4
D11
IC2
R5
IC1
R10
R2
R1
S1
R6
A
C1
R3
C6
Dry
Cell
914041
10cm
1V

PC INTERRUPT HANDLER

THE program and the circuit presented here are an introduction into practical interrupt handling in IBM PCs and compatibles, a subject fraught with pitfalls to the average PC user. The program (shown in the listing) is a memory-resident utility that monitors one of the PC's interrupt request lines, IRQ2 through IRQ7. It produces a short beep on the PC's loudspeaker when a request occurs. Interrupt requests may originate from insertion cards, and serve to inform the PC that a particular event has occurred that requires the action of a servicing routine, which interrupts the currently running program. Interrupts may be used to signal the activity of, for example, a telephone ringing circuit, a temperature monitor, a voltage level monitor, or a watchdog. To help you understand the use and basic operation of interrupts, a simple circuit is given that generates an interrupt when a push-button is pressed. Taking good care to avoid conflicts with cards already installed in the PC, set the push-button interrupt line with the aid of a jumper, JP_1 through JP_6. In the program, this interrupt line should be defined accordingly by assigning the correct value to the constant 'IRQ' (see the listing).

When the push-button is pressed the TLC555 supplies a 100-ms long interrupt request pulse, which is transferred to the 8259 interrupt controller in the PC via an extension bus slot. Components R_1 and C_2 form a switch debouncing network. The circuit is readily built on the prototyping board for computer extensions described in Ref. 1.

At the end of the listing are two comment lines that serve to prevent the uninstall routine being called. If you intend to make changes to the program, we recommend that you do not attempt to make it resident straight




```
PROCEDURE UNINSTALL_INTERRUPTHANDLER;
(************************************)

(* Restore original mask and vector *)

BEGIN
  PORT[Controller+1]:=OriginalMask;
  CLI;
  SETINTVEC(IntNumber,OriginalVector);
  STI;
END;

BEGIN (* MAIN *)
  CASE IRQ OF
  0: IntNumber:= $08; (* SYSTEM CLOCK TICK          *)
  1: IntNumber:= $09; (* KEYBOARD INTERRUPT         *)
  2: IntNumber:= $0A; (* RESERVED                   *)
  3: IntNumber:= $0B; (* SECOND SERIAL PORT COM2 *)
  4: IntNumber:= $0C; (* FIRST  SERIAL PORT COM1 *)
  5: IntNumber:= $0D; (* HARDDISK INTERRUPT         *)
  6: IntNumber:= $0E; (* FLOPPYDISK INTERRUPT       *)
  7: IntNumber:= $0F; (* PRINTER INTERRUPT          *)
  END;
  End_Of_Int:=SpecificEOI+IRQ;
  INSTALL_INTERRUPTHANDLER;

  { REPEAT UNTIL KEYPRESSED;
    UNINSTALL_INTERRUPTHANDLER; }

  KEEP(0);
END. (* MAIN *)
```

914102-11

```
PROGRAM PcAlarm;
(**************)

(* Elektor V1.0/JR *)

{$M 2000,0,0}

{$R-,S-,I-,F-,O-,A-,V+,B-,N-,E+,D-,L-}

USES CRT,DOS;

CONST IRQ=3;              (* Select hardware interrupt (0...7) *)
      Controller =$20;  (* Base address of 8259 interrupt controller *)
      SpecificEOI=$60;

VAR End_Of_Int       :BYTE; (* End Of Interrupt command 8259 *)
    OriginalVector :POINTER;
    OriginalMask   :BYTE;
    IntNumber      :$08..$0F;

PROCEDURE STI;
(************)

(* Set processor interrupt enable flag *)

BEGIN;
  INLINE($FB);
END;

PROCEDURE CLI;
(************)

(* Clear processor interrupt enable flag *)

BEGIN
  INLINE($FA);
END;

{$F+}
PROCEDURE INTERRUPTHANDLER; INTERRUPT;
(************************************)

BEGIN
    SOUND(800); DELAY(200); SOUND(1200); DELAY(300); NOSOUND;
    PORT[Controller]:=End_Of_Int;
END;
{$F-}

PROCEDURE INSTALL_INTERRUPTHANDLER;
(*********************************)

VAR EnablePattern: BYTE;

BEGIN
 (* Save original vector *)
 GETINTVEC(IntNumber,OriginalVector);

 (* Install new vector *)
 CLI;
 SETINTVEC(IntNumber,@INTERRUPTHANDLER);
 STI;

 (* SAVE ORIGINAL MASK *)
 OriginalMask:=PORT[Controller+1];

 (* Enable IRQ *)
 EnablePattern:=$01;
 EnablePattern:=EnablePattern SHL IRQ;
 EnablePattern:=NOT(EnablePattern);
 PORT[Controller+1]:=(OriginalMask AND EnablePattern);
END;
```

away since the utility can then be removed from memory only by rebooting the computer. Therefore place the KEEP instruction in between braces, and temporarily add REPEAT UNTIL KEYPRESSED and UNINSTALL INTERRUPTHANDLER. This will save you a lot of time and trouble debugging your own application.

(J. Ruffell 914102)

Reference:
1. Prototyping board for computer extensions". *Elektor Electronics* July/August 1988, supplement p. 4.

SUPER VOLTAGE REGULATOR

A VOLTAGE regulator with properties like low voltage drop, 1 A current, protected against reversal and voltage peaks up to 60 V, inexpensive, and simple to design in, is indeed a super device. It concerns here National Semiconductor's LM2941C, which is an integrated device with five pins. Three pins are for the usual connections; the fourth (GND) is required for the low voltage drop; and the fifth provides an additional on-off switching function.

In the diagram, C_1 is required only if the distance to the smoothing capacitor is fairly long. Its value needs to be somewhat larger than is usual with 78xx regulators. This is also the case with C_2. It is advisable to place that capacitor as close to the regulator as possible.

Although it is normal for the quiescent current through low-drop regulators to be rather larger than required by traditional regulators, the LM2941C needs this only at voltage differences of between 0.5 V and 5 V.

The output of the circuit shown is designed to be set between 5 V and 20 V. Since the internal reference voltage is 1.275 V, it should in practice be possible to set it below 5 V. Note, however, that the makers do not guarantee satisfactory operation at such low levels.

The value of resistor R_1 must not be smaller than 1 kΩ. The value of R_2 may be calculated from

$$R_2 = R_1(U_{out}/1.2751–1)\ \Omega$$

where U_{out} is the required output voltage.

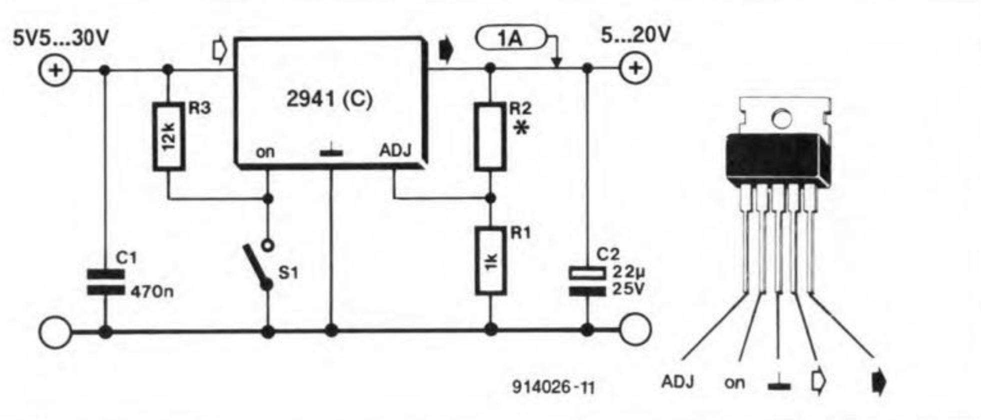
Although many three-pin regulators require an electrolytic capacitor at the ADJ output to improve stability, that is not permitted with the LM2941C: in fact, it might lead to oscillations.

A voltage difference of only 0.5 V is sufficient for an output current of 1 A. This difference may be even smaller if the current is smaller.

The input must be actuated by a positive voltage and then requires a current of about 300 μA.

Since the IC toggles with a control voltage as low as 2 V, it may be switched with either CMOS or TTL logic.

(NS application 914026)



MOMENTARY ACTION PUSH BUTTON

THE circuit described here is a kind of remote control for all sorts of equipment that must be started or switched on with the aid of a trigger pulse. The authoress actuates it with a flash of the headlights to switch on the garage lights

When light falls on to the six series-connected solar cells, T_1 is switched on, which results in T_2 being switched off. Capacitor C_2 is then charged.

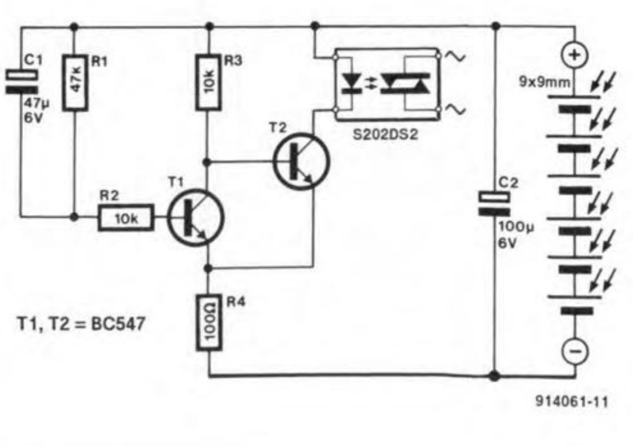
When the light is removed from the solar cells, T_1 is switched off and T_2 is switched on. Capacitor C_2 will then be discharged through the LED of the electronic relay, which is consequently energized for an instant. In that way a trigger pulse is generated for electrically isolated equipment without the need of an additional power supply.

In the diagram, C_1, R_1 and R_2 ensure a stable switching operation.

The solar cells used in the prototype gave an effective range of 2–3 m (7–10 ft).

The circuit is intended as a momentary action push button, not as a locking switch. The latter function may be obtained by adding, for example, a latching relay

(Carin Mieslinger 914061)



AUTOMATIC BATTERY CHARGER

KEEPING your car battery constantly charged when the car is not in use appreciably increases the life of the battery. Charging is, of course, normally only possible in your garage. The charger described here provides a constant charging current that may, for example, be fed to the battery via the cigarette lighter.

The charger consists of a mains transformer, Tr_1, bridge rectifier B_1 and smoothing capacitor C_1. The charging current through the regulator, IC_1, and the switched series resistors is 107 mA (47 Ω); 230 mA (22 Ω); 500 mA (10 Ω); or 1 A (5 Ω).

Diodes D_1D_4 indicate the position of the switch. Transistor T_1, R_1 and D_5 ensure constant brightness of the diodes.

When the battery is not connected, the relay is not energized and the mains is switched off.

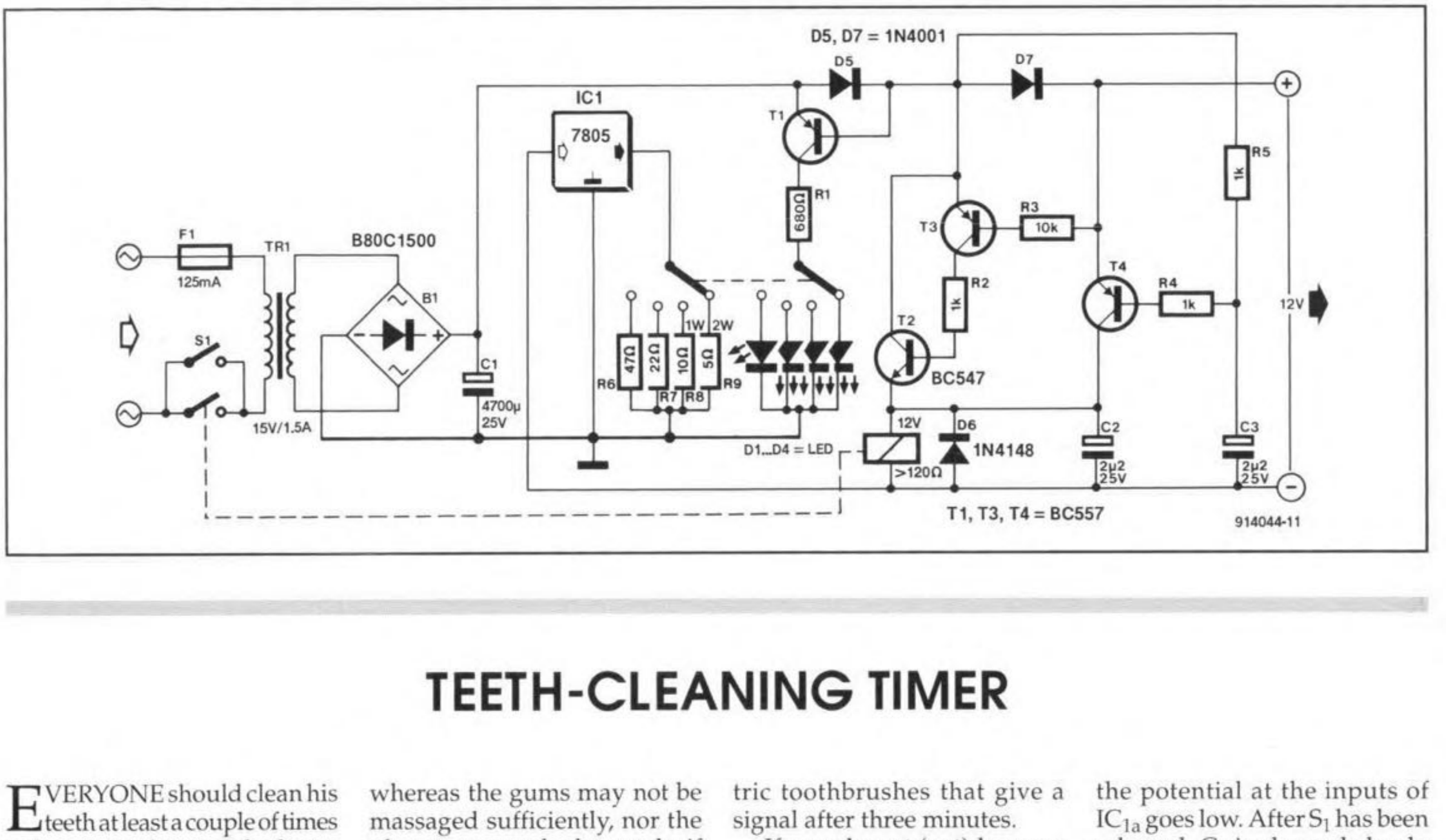
When the battery is connected, C_3 gets charged, T_4 is switched on and the relay is energized. The mains is then switched on and the battery is charged via D_7. The consequent voltage drop across D_7 causes T_3 and T_2 to be switched on, so that the relay remains energized although, since its collector is at +12 V, transistor T_4 is switched off. Resistor R_5 ensures that C_1 is kept charged so that T_4 remains off.

To ensure that the charger works with flat batteries, the relay contact may be bypassed by S_1 which enables the charger to be switched on manually.

Note that during constant charging of lead-acid batteries there is the risk that the water dissolves into hydrogen and oxygen and this will reduce the liquid in the battery. Since sealed batteries can not be topped up, the present charger is not suitable for these types of battery.

Also, do not use a current higher than necessary; in most cases 100 mA is ample. The larger currents are intended for charging large NiCd batteries.

(R. Kambach 914044)



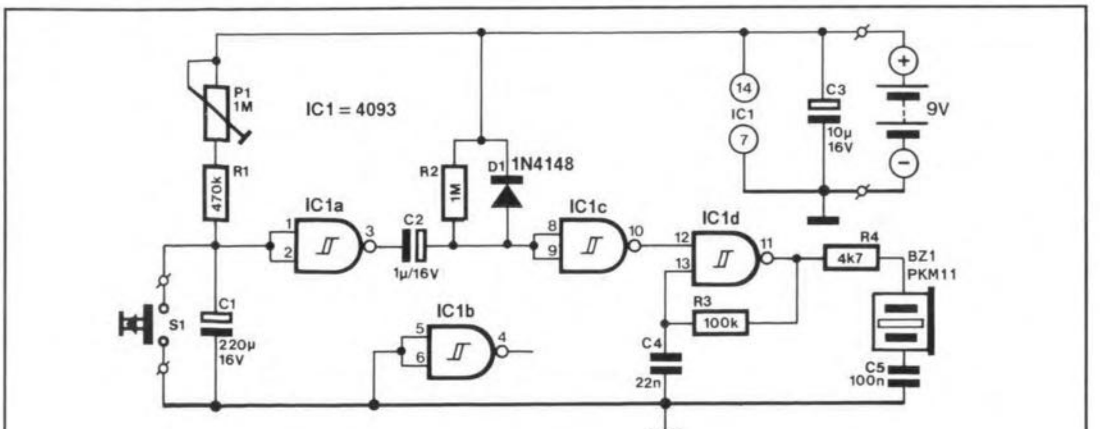
TEETH-CLEANING TIMER

EVERYONE should clean his teeth at least a couple of times a day. Dental research shows that cleaning one's teeth for three minutes at a time is best: longer periods may damage the gums, whereas the gums may not be massaged sufficiently, nor the plaque removed adequately, if the period is shorter. Some manufacturers have therefore started to build in timers in their electric toothbrushes that give a signal after three minutes.

If you do not (yet) have an electric toothbrush, the timer presented here may help. When push-button switch S_1 is pressed, the potential at the inputs of IC_{1a} goes low. After S_1 has been released, C_1 is charged slowly via P_1 and R_1, so that the voltage at the inputs of IC_{1a} rises again. When the potential across C_1 has reached a certain level, the output of IC_{1a} toggles from a high to a low level. The consequent leading edge of the negative pulse briefly actuates the oscillator based on IC_{1d}. For a time determined primarily by the time constant R_2-C_2 the buzzer then sounds to indicate that brushing time is over. The time may be set at exactly three minutes with P_1.

Since the current drawn by the circuit is minute, an on/off switch has not been provided.

(J. Ruffell 914065)



ONE-SHOT SOLID-STATE RELAY TIMER

by Dr K.A. Nigim

The solid-state relay timer described in this article is well suited to the on/off switching, at predetermined times, of a.c. loads rated at up to 5 kW. The electronic circuitry is optically isolated from the a.c. mains and incorporates a zero-crossing voltage-switching technique.

THE advantages of a solid-state relay over the conventional mechanical types are:

- it has no mechnical or moving parts that wear out;
- it gives no audible noise;
- it is resistant to shock and vibration;
- it exhibits no contact bounce
- it responds fast which reduces electromagnetic interference (EMI).

The block diagram of the timer is shown in Fig. 1. The output of the timer changes state (from low to high potential) a very short time after the start button is pressed. The time interval is determined by the time constant, τ, of the series combination preset-*C*.

The output signal of the timer is applied to a solid-state bidirectional switch, a triac. The a.c. load is connected to the mains via the triac. When the preset time elapses, the output of the timer drops to a low level and the triac is switched off, thereby disconnecting the load.

Circuit description

The complete circuit is shown in Fig. 2. The timer section is based on the well-known 555 in the IC_1 position. The timing period is initiated by pressing briefly push button S_3. If, however, this switch is kept depressed, restarting does not occur since C_3 will maintain a high potential at pin 2 of IC_1. The capacitor discharges through R_4 when S_3 is released. The timer may be reset at any instant by pressing push button S_2.

The output signal at pin 3 of IC_1 is high after S_3 has been pressed, which causes D_1 to light, indicating that an active time period has begun.

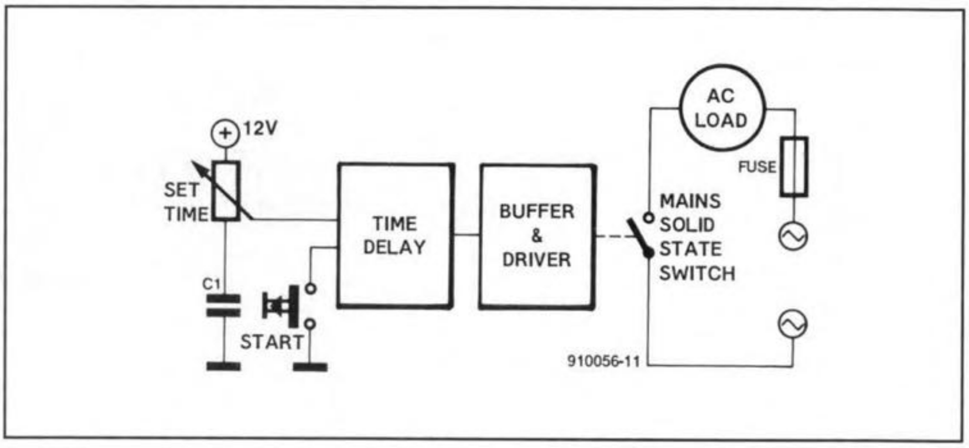


Fig. 1. Block diagram of the timer.

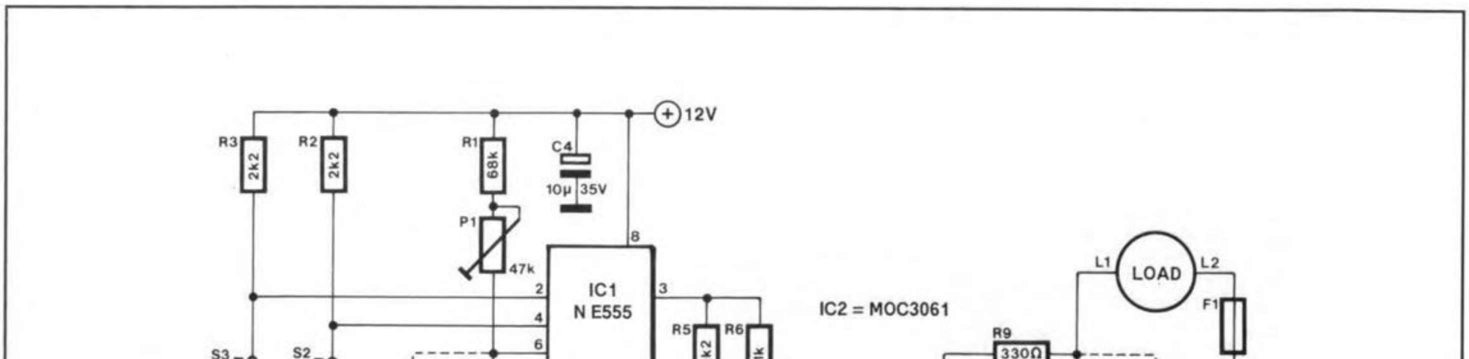


Fig. 2. Circuit diagram of the solid-state relay timer.

The period, in seconds, during which the output at pin 3 is held high is determined by the time constant,

$$\tau_{on} = 1.1C_1(R_1+P_1)$$

where R_1 and P_1 are in kΩ and C_1 in µF. With the component values indicated, time periods from 10 to 20 seconds may be obtained. That range can be extended by replacing C_1 by a switch that can select between two capacitors, C_{11} and C_{12}. When the range is in minutes, both R_1 and P_1 must be at least 100 kΩ.

The timer circuit and the triac driver are powered by a simple +12 V d.c. source, for which a suitable circuit is shown in Fig. 3.

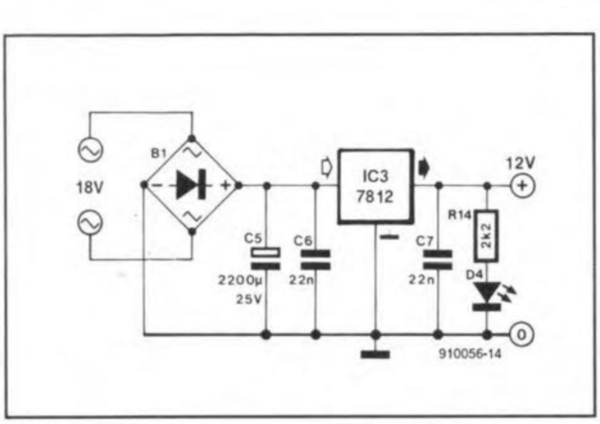


Fig. 3. Circuit of a suitable d.c. power source for the timer.

PARTS LIST

Resistors:
R1 = 68 kΩ
R2, R3, R5, R14 = 2.2 kΩ
R4 = 10 kΩ
R6, R7 = 1 kΩ
R8, R9, R10, R11, R12, R13 = 330 Ω
Rs = 30 Ω, 3 W
P1 = 47 kΩ

Capacitors:
C1, C12 = 100 µF, 16 V
C11 = 10 µF, 16 V
C2, C6, C7 = 22 nF, ceramic
C3 = 1 µF, 16 V
Cs = 0.1 µF, 400 V, polypropylene
C5 = 2200 µF, 25 V
C4 = 10 µF, 35 V, tantalum

Semiconductors:
IC1 = NIE555 P
IC2 = MOC 3061
IC3 = 7812
B1 = WO4M rectifier
D1 = LED, red
D2, D3 = 1N4007
D4 = LED, green
Tri1 = specified by load
Thy1, Thy2 = specified by load

AC supply isolation

To isolate the timer circuit from the high voltage of the mains, an opto-isolater triac, IC_2, with zero-crossing level trigger drives the main power triac, Tri_1.

The current flowing into pin 1 of IC_2 is limited by potential divider R_6–R_7–R_8 to 15 mA in accordance with the manufacturer's relevant data sheet (Ref. 1).

Surge currents at the output, pin 6, are limited by R_9. The minimum value of this resistor for 240 V mains is given by:

$$R_{9(min)} = U_{in(peak)} / 1.2 = 330\ \Omega.$$

The a.c. load is connected to the mains via Tri_1. The type of triac used depends on the r.m.s. load current rating plus a 50% safety design factor. The triac must be mounted on a suitable heat sink, particularly with large loads. For large inductive loads, such as universal motors, a snubber network consisting of R_s and C_s is connected across the triac to minimize the rate of rising voltage (commutating dv/dt). Good practical values of these components are: $R_s = 30\ \Omega$, 3 W and $C_s = 0.1\ \mu F$, 1000 V.

The circuit performance with high dv/dt is improved considerably when the triac is replaced by two thyristors connected in anti-parallel: this modification also reduces the power dissipation. The modified section of the circuit is shown in Fig. 4.

Construction

Since part of the circuit is connected to the mains, great care must be taken in handling the triac and the load. It is strongly advised to assemble and position the triac on its heat sink away from the timer circuit during intial testing.

The timer is constructed on a prototyping or vero board. Start by mounting the IC sockets and timer components.

The minimum and maximum time periods can be ascertained with the aid of a stopwatch or good wrist-watch with second-hand and setting P_1 to its maximum and minimum values. A number of settings may be marked in terms of seconds or minutes as required.

Diode D_1 should light every time S_3 is pressed and stay on until the specified time has elapsed.

After the timer circuit has been tested, assemble the triac driver circuit. Connect terminal A2 of Tri_1 with suitably rated wire to the a.c. mains and the load. Start by loading the triac with a 40–60 W light bulb. If the results are satisfactory, connect the actual load.

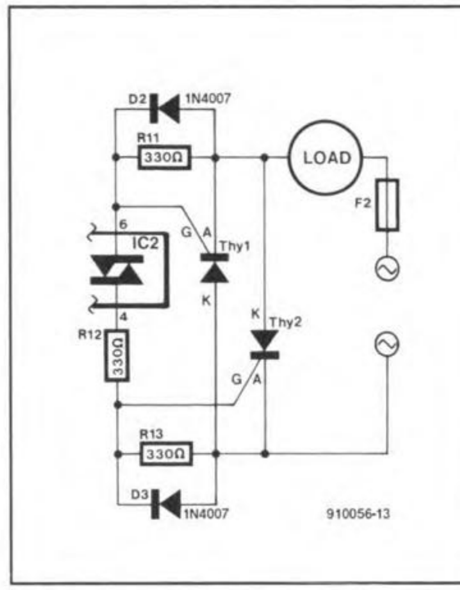


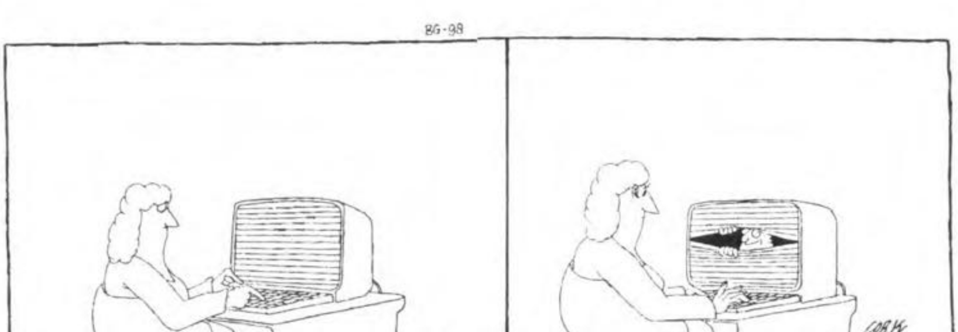
Fig. 4. When the timer is used with large inductive loads, it is advantageous to replace the triac by two thyristors connected in anti-parallel.

Applications

The circuit may replace any mechanical timer relay. Two examples for use in the home are the hot-water tank and an electric oven. In the workshop, it could be applied to impulse sealers, as on/off control of electric motors, and in spot welding control. ■

References

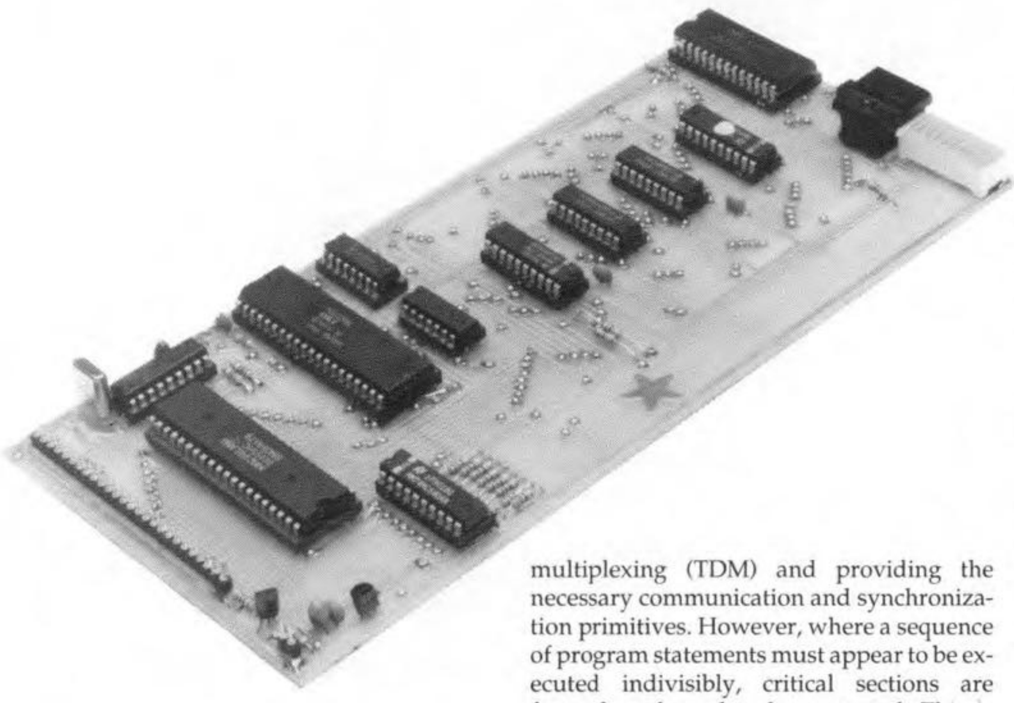
Motorola Thyristor Data Book, 2nd printing, 1988.



8088 SINGLE BOARD COMPUTER

A low-cost computer system is described that forms the perfect introduction into programming Intel's 8088 CPU. The system is complete with a serial interface and a small, PROM-resident, operating system that enables the SBC to download 1-Kbyte large chunks of object code sent by a PC running a communication program.

R. Grodzik



THE first IBM PCs were based on the 8088 microprocessor, which has a 16-bit internal architecture and an external 8-bit data bus. Today, IBM PCs proliferate the world with more powerful microprocessors — the 8086, 80286, 80386 and 80486. Their ability to keep going is mainly due to upward compatibility (the original instruction set for the 8088 has been maintained and enhanced). Hence, machine code software originally written for the 8088 continues to function on the more enhanced processors.

This design, based on the Intel 8088, connects to the RS232 port of any IBM PC configured for 9600 baud, 8 data bits, 1 stop bit, and no parity. It provides two eight-bit user ports, five auxiliary control lines and two interrupt lines. The single-board computer is externally powered, thus offering considerable protection to your costly PC, which functions as terminal.

Concurrent programming

The simultaneous execution of two or more programs by a single processor is now achievable in the domains of real-time electronics. This is achieved by time division multiplexing (TDM) and providing the necessary communication and synchronization primitives. However, where a sequence of program statements must appear to be executed indivisibly, critical sections are formed, and need to be protected. This is achieved with the aid of 'busy' functions implemented by wait loops and flags. Further measures have to be taken to prevent deadlock and guarantee liveness, i.e., the program must not crash under any circumstances. The fulfillment of this last requirement is a formidable feat of software engineering.

The problem is solved by utilizing a multi-processor environment, in which each individual processor executes its own program, and asynchronously communicates with the other processor via a serial link. This principle is adopted here, and has taken the practical shape of an 8088 single-board computer. Simply upload program data from the PC to the 8088 SBC (1 Kbyte max.), and you have your PC free to run any other program. The use of the second processor (the one on the SBC) brings concurrent programming within easy reach.

One of the features of this project is an attempt to investigate virtual memory. By using virtual memory techniques, whereby program code is downloaded in packets of 1 KBytes each, the seemingly small on-board memory of the SBC does not prohibit the execution of a substantial program which is resident in the host.

The 8088 SBC is equally at home in an educational environment, allowing the user to control external devices from a PC. Of course, all programs for the card have to be written in assembler. If the program has a bug, try again — it only takes a second to reload the new version to the board. No emulators or EPROM burning are needed here.

Operation and system architecture

The present circuit (Fig. 2) uses a multiplex/demultiplex system. The 8088 CPU has a multiplexed low-order data/address bus which needs to be demultiplexed to access the RAM and PROM in the system. Circuit IC7, a 74HC373 octal latch, provides this function. The 8155 PIO (IC3) has internal demultiplexing, and is connected directly to the 8088's lower data/address bus, with the ALE pin controlling the flow of data or address information. In addition, IC4a and IC4b provide a qualifying signal from the DEN pin of the 8088 to prevent bus contention when RAM or PROM is enabled.

Circuit IC1, a 8284, is a clock generator and driver for the 8088 microprocessor, providing all the source clocks needed by the system. The 11.0592 MHz master oscillator frequency is divided by three by the clock generator to give a 33% duty factor 3.6864-MHz signal to the CLK input of IC2. This frequency is further divided by two to present a frequency of 1.8432 MHz to IC3 pin 3, a PIO with internal timer, where it is again divided down by three to output a 614.4 KHz square wave signal at pin 6. This signal feeds IC6, a 8251 UART. An internal divider in the UART (divisor 64) finally produces the baud rate of 9,600 required for asynchronous communications with the host PC.

The operating system

The control software required to boot up the system resides in a bipolar PROM, IC10, which is mapped into the system memory as

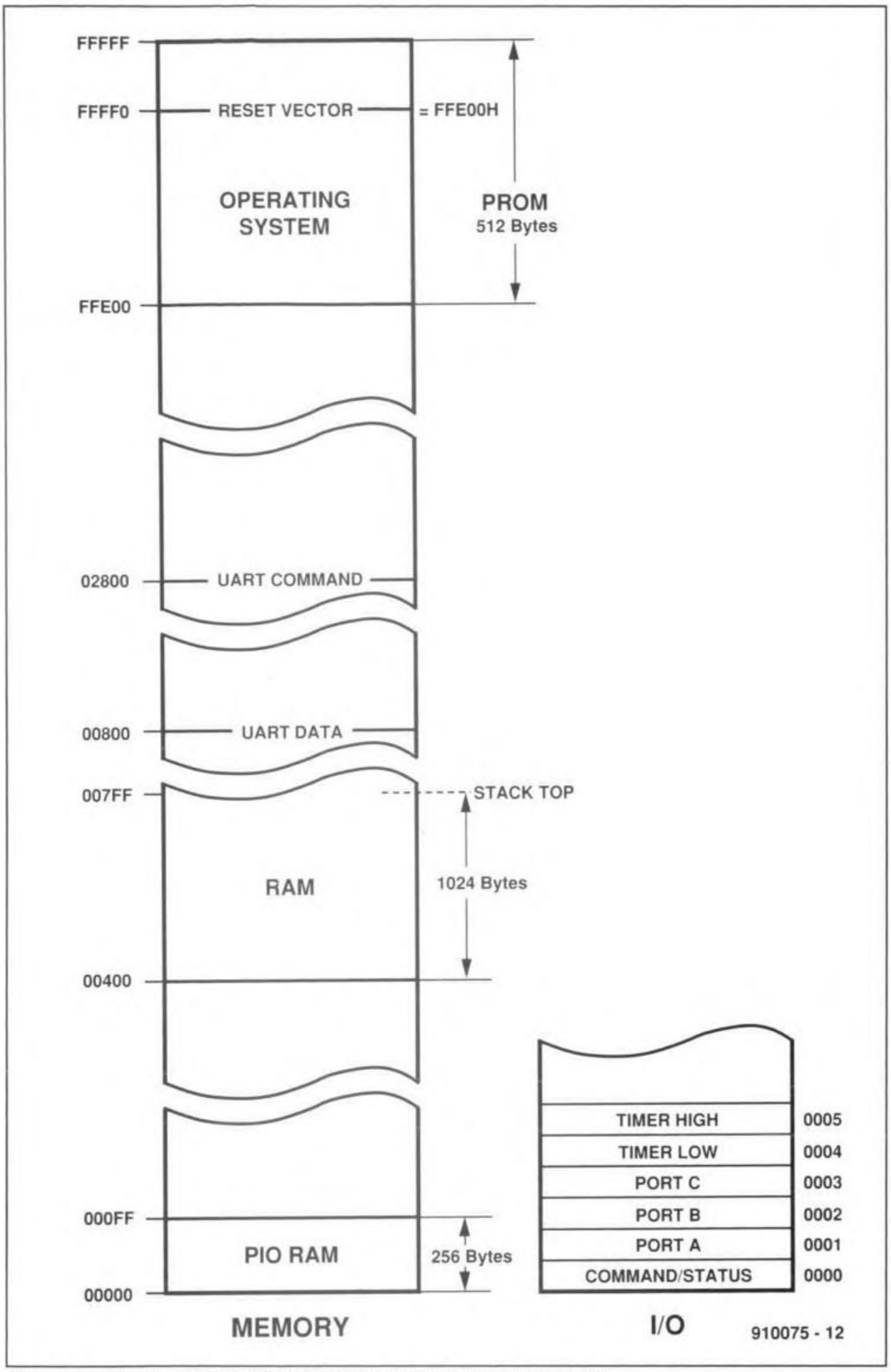


Fig. 1. Memory structure of the 8088 single-boardf computer.

shown in Fig. 1. The code burned in the PROM performs the following functions:

- provide the reset vector address (FFE0:0000) - FFE00H PROM start address;
- initialize data, stack and extra segments to zero;
- initialize the stack pointer to RAM top (007FFH);
- initialize ports A, B, and C to outputs;
- configure the on-board timer of IC3;
- initialize the UART (9600 baud, 1 stop bit, 8 data bits, no parity);
- load binary data received from the host PC to the RAM (00400-007FF).

Once the SBC has received 1 KBytes of data, execution of the program starts automatically from address (0000:0400) - 00400H (RAM start; see Fig. 1).

For those of you with access to a PROM programmer, the contents of the system PROM, a 74S472, are given in Fig. 3.

Construction and connecting up

This should be relatively straightforward using the ready-made double-sided and through-plated board, and the component mounting plan, supplied by the author. Just use a hot iron, ensuring at all times that the bit is clean and tinned. Dry solder joints should really be a thing of the past. Watch out for solder bridges and missed connections.

All port lines and data connections are brought out on connector K1, a single-in-line 26-way pin header. The 5-V supply is connected to a separate 2-way header. On the host computer, connect a dual screened lead to the 0V, RxD and TxD pins of the serial port. Also tie the RTS and CTS pins together (see the insert in the main schematic diagram).

COMPONENTS LIST

Resistors:
(all 0.25W 5%)

5	7kΩ5	R1,R2,R3,R5,R6
12	220Ω	R4,R7-R14,R17, R18,R19
2	4kΩ7	R15,R20
2	47kΩ	R16,R18

Capacitors:

1	10pF	C1
2	10µF tantalum bead	C2,C3
12	10nF	decoupling C

Semiconductors:

2	BC548	T1,T2
1	1N4148	D1
1	1N4002	D2
3	LED	D4;D5;D6
1	8284	IC1
1	8088	IC2
1	8155	IC3
1	74HC32	IC4
1	74HC138	IC5
1	8251	IC6
1	74HC373	IC7
2	2114	IC8,IC9
1	PROM *	IC10
1	74HC640	IC11

Miscellaneous:

1	n.o press switch	S1
1	11.0592MHz quartz crystal	X1
1	26-way pin header	K1

* Pre-programmed PROMs and printed-circuit boards for this project are available from the author:
R. Grodzik, 53 Chelmsford Road, Bradford BD3 8QN, ENGLAND. The price of the PROM is £15.00 including P&P.

Programming

The MSDOS operating system for any IBM PC contains a machine code debugging facility named DEBUG.COM, in which assembly code can be written, assembled, and saved to disk. To start DEBUG, simply type the following:

DEBUG FILENAME.BIN <CR>

Adjust the maximum number of bytes to be saved to disc (1 K). Type

RCX <CR>

and then

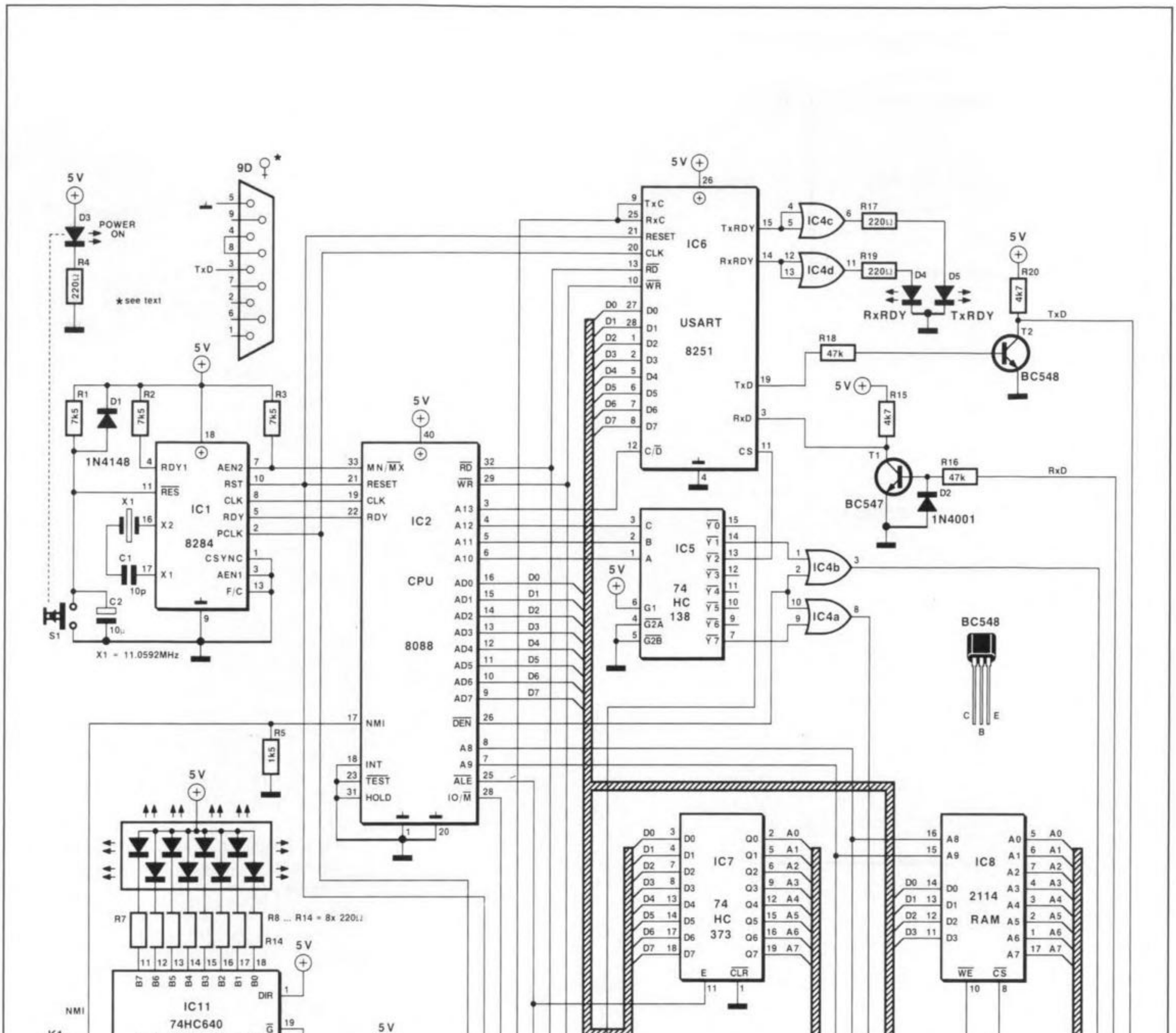


Fig. 2. Circuit diagram of the SBC.

```
National Semi DM74S472

00000:  B8 00 00 8E D8 8E D0 8E  C0 BC FF 07 FA BA 00 00   '................'
00010:  B0 0F EE BA 01 00 B0 00  EE BA 02 00 B0 00 EE BA   '................'
00020:  05 00 B0 40 EE BA 04 00  B0 03 EE BA 00 00 B0 CF   '...@............'
00030:  EE BD 00 04 BF 00 00 B4  00 B0 4F A2 00 28 B0 06   '..........O..(..'
00040:  A2 00 28 90 90 90 90 90  A0 00 28 24 02 3C 02 75   '..(.......($.<.u'
00050:  F7 A0 00 08 90 90 90 90  90 90 90 90 88 03 47 81   '..............G.'
00060:  FF FF 03 75 D9 EA 00 04  00 00 00 00 00 00 00 00   '...u............'
00070:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00080:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00090:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
000A0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
000B0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
000C0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
000D0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
000E0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
000F0:  EA 00 00 E0 FF 00 00 00  00 00 00 00 00 00 00 00   '................'
00100:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00110:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00120:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00130:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00140:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00150:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00160:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00170:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00180:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
00190:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
001A0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
001B0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
001C0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
001D0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
001E0:  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   '................'
001F0:  EA 00 00 E0 FF 00 00 00  00 00 00 00 00 00 00 00   '................'
```

Fig. 3. Contents of the system PROM, a 256-byte large 74S472.

```
400    <CR>
```

Next, invoke the resident assembler by typing

```
A 100    <CR>
```

followed by the lines of assembly code, e.g.:

```
MOV DX,0000    ;(all ports output)
MOV AL,0F
OUT DX,AL
MOV DX,0001    ;(send 55H to port A)
MOV AL,55
OUT DX,AL
               ;(wait)
```

Press the carriage return key twice to exit the assembler. Next, type

```
W    <CR>
```

1 Kbytes are written to disk as 'filename.bin'. Next, Enter

```
Q    <CR>
```

to leave DEBUG. The binary file contents of 'filename.bin' can now be sent to the 8088 SBC via the RS232 port using any communications software utility.

Three ports are available on the 8155: ports A and B are 8-bit wide, and port C 6 bits. The direction of data flow is controlled by the command register of the 8155 (at address 00000), and is programmed as follows:

```
MOV DX,0000
MOV AL,X
OUT DX,AL
```

where X is the value to configure the ports, taken from Table 1.

Once the command register is programmed, it is a simple matter to send or receive data to or from port A (address 0001), port B (address 0002), or port C (address 0003). For example:

```
MOV DX,0000    ;port command register
MOV AL,02      ;port C input, port B
               output, port A input
OUT DX,AL
MOV AL,A5      ;data
MOV DX,0002    ;port B address
OUT DX,AL      ;A5 sent to port B
MOV DX,0003    ;port C address
IN AL,DX       ;read port C
MOV DX,0001    ;port A address
IN AH,DX       ;read port A
```

To provide a virtual memory facility, whereby the 8088 board may request a further 1 KBytes of program or data from the host PC, the following routine is used:

```
MOV DI,00
MOV BP,0400      ;(RAM start)
JMP FFE0:0045    ;(operating system
                 routine)
```

Running this three-line program will clear the RAM, preparing it for another 1 KBytes of program. ■

Note:

Various publications are available from Intel, detailing the programming of the 8088:

- *8086/8088 Assembler Language Programming*, by L.A. Leventhal. RS Components order code 904-851.
- *8086/8088 16 bit Microprocessor Primer*, by Morgan & Waite. RS Components order code 904-845.
- Data sheets on the 8088 available from Intel at: Intel Corporation (UK) Ltd., Pipers Way, Swindon, Wilts. SN3 1RJ. Telephone: (0793) 696000.

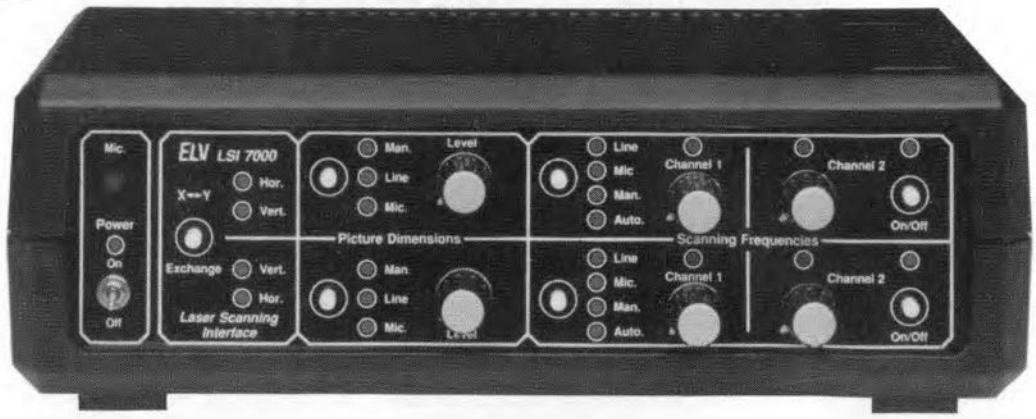
Table 1. 8155 port programming

Port C	Port B	Port A	X
output	output	output	0F
output	output	input	0E
output	input	output	0D
output	input	input	0C
input	output	output	03
input	output	input	02
input	input	output	01
input	input	input	00

LASER

PART 3: OPERATION AND CONSTRUCTION

In this third and last instalment on the show laser we tackle the construction and practical use of the LSI7000 control unit.



Continued from the June 1991 issue

The electronic switches in the user interface of the laser control unit are controlled by small push-buttons fitted on a printed-circuit board. Figure 13 shows the circuit diagram of the control interface and the power supply, which consists of two 10-V fixed voltage regulators. Regulator IC306 powers the coil drivers, and must be fitted with a heat-sink. The rest of the circuit is powered by IC305. Diode D307 protects the circuit against reverse input voltages supplied by the mains adaptor (here, a 12-15 V d.c. type is used).

Depending on their function, the switches take the form of bistables built from two inverters (for electronic switches with two positions), or counters (for electronic switches with 3 or 4 positions).

The counters are types with an internal binary coded decimal (BCD) to decimal decoder of which one output is active at a time, controlling an electronic switch. Each of the counters is incremented by a clock pulse supplied by an *R-C* debouncing network associated with a particular switch. If the counter is at the last state we want to use, it will still advance to the next higher (non-used) state on receiving a clock pulse. An *R-C* network, however, translates the decoded output state into a reset pulse, which returns the switch to its first function. The same *R-C* network also resets the switch to the first function when the laser control unit is switched on.

The switches with two positions consist of two inverters with a feedback arrangement that results in a change of the logic output level any time the push-button at the input is pressed. This creates a simple toggle function. The remaining inverters are used as buffers to drive the LEDs that indicate the position of the electronic switches.

Controls on the front panel

The front panel of the laser control unit (Fig. 14) has a fair number of switches and push-buttons. Describing the function of these controls, we feel, is more useful than analyzing in detail the position of each individual electronic switch on selection of a particular function.

At the left of the front panel we find the on/off switch and the associated LED. The internal microphone of the control unit is fitted behind a small hole in the front panel, straight above the on/off LED. The larger part of the front panel is divided into two identical, horizontal, sections. The upper section is for the left channel, the lower section for the right channel. The area to the right of the on/off switch contains the 'exchange' switch that allows you to swap the drive signals for the horizonal and vertical output amplifier. The next area on the front panel is marked 'picture dimensions'. When the laser control unit is switched on, it is automatically set to manual control, with the size of the laser pattern determined by the position of the 'level' control. When the push-button is pressed, the switch is set to the 'line' position. This enables the audio signal applied to the LINE or LS input to control the size of the laser pattern. The maximum size of the pattern, however, is set with the 'level' control. This also applies when the next switch function, microphone input, is selected.

The front panel area marked 'scanning frequencies' is used for the control of the frequency components that determine the shape of the laser pattern. On power-up, the two source selections are set to manual. In this, and the automatic, mode, one or both generators are switched on. The manual mode allows the generator output frequency to be set by the front panel controls, whose activity is indicated by the LEDs fitted above them. For example, the LED above the 'channel 2' (generator 2) knob is off when the generator has been switched off with the push-button to the right of the knob. In 'automatic' mode, both controls are disabled, and the associated LEDs are off. You may switch on the second generator, however, by pressing the on/off switch for channel 2.

That concludes the description of the position and the basic function of the controls on the front panel of the LSI7000. To get started with the system, however, you will need to know the order in which the knobs and switches are controlled, as well as the best position of the laser exciter.

The size of the laser pattern increases at about 30 cm per meter of distance between the exciter and the projection surface. This means that a distance of 3.3 metres (10 ft. 9 in.) gives you a maximum pattern size of about 1 metre (3 ft. 3 in.). At distances greater than 10 m (34 ft.) or so the projected image will lose sharpness owing to beam divergence. To increase the sharpness over larger distances, you may want to fit a lens between the beam aperture on the exciter and the mirrors. However, even without a lens the laser is capable of covering distances of 20-30 metres (65-98 ft.).

Initially, it is best to position the exciter such that the beam hits the centre of the projection surface at right angles when the mirrors are not driven. Once you have acquired more experience in setting up the system, you may want to see what happens when the beam is not at right angles with the projection surface, or when a projection surface is used that is not flat.

The simplest settings of the control unit are 'manual' for the picture dimensions, and 'auto' for the scanning frequencies. These settings still allow you to switch channel 2 on

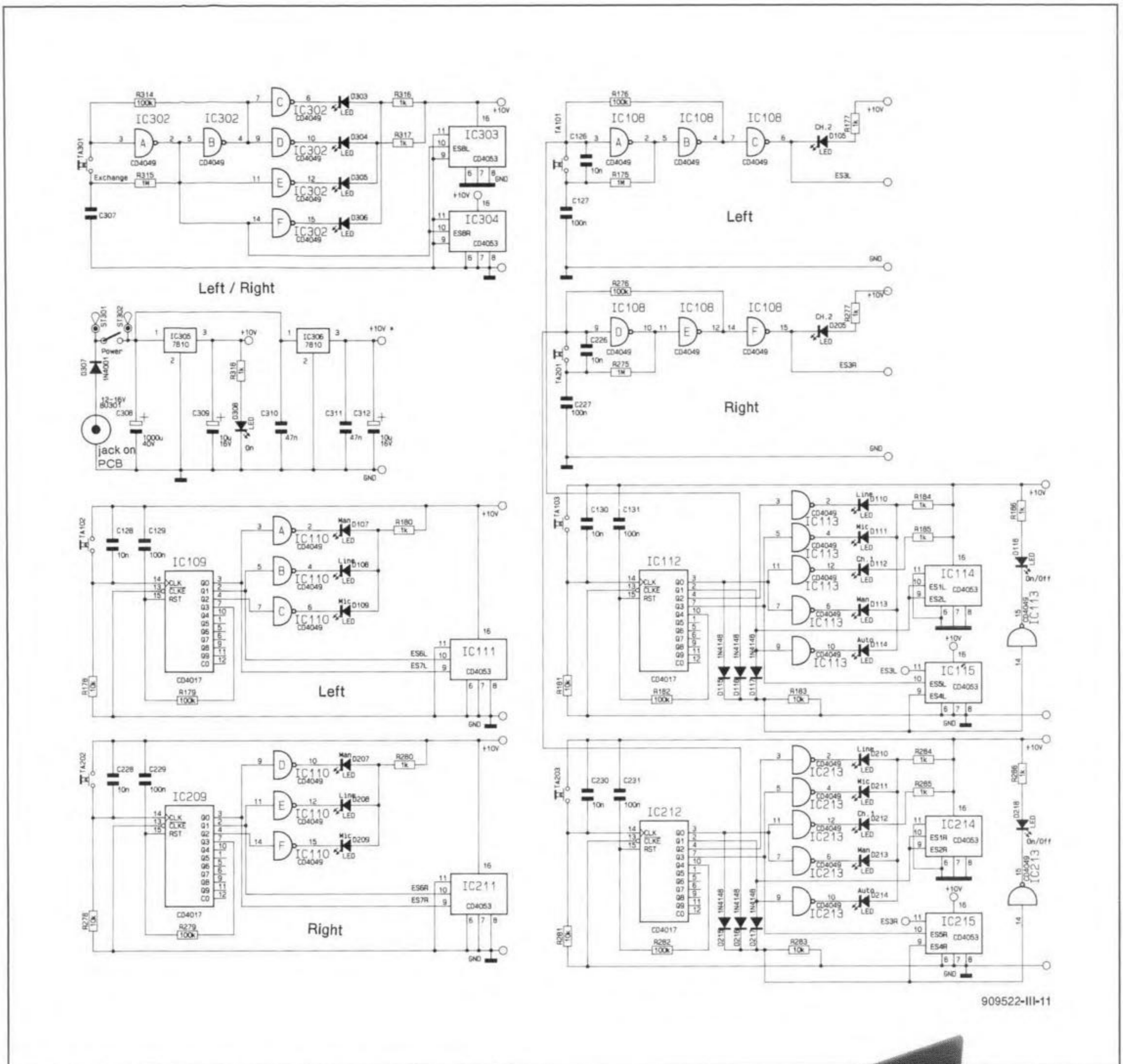
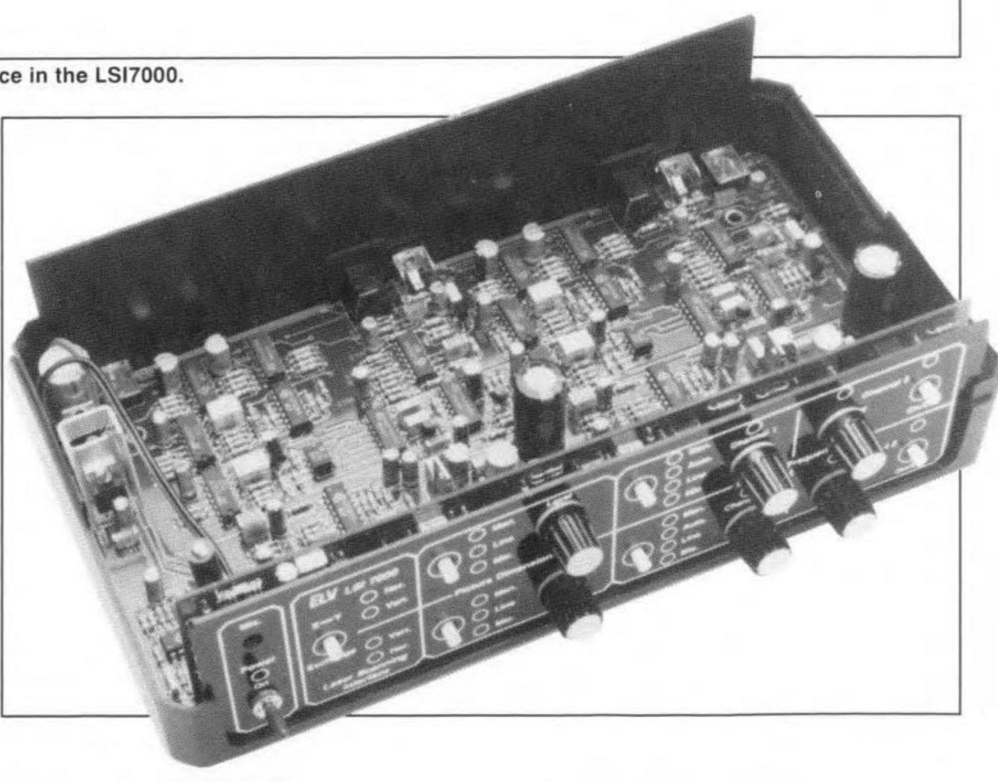


Fig. 13. Circuit diagram of the control interface in the LSI7000.

or off. The size of the projected pattern is set with the 'level' controls.

With 'scanning frequencies' set to 'manual' on the left and right channel, have a first go at projecting a decent pattern. Switch off both 'channel 2' generators. Turn one of the 'channel 1' controls to about ¾ of the maximum frequency. Next, operate the other control until a suitable pattern is produced. The best setting is that where a pattern is not repeated for a second or so. Faster changes will result in an unsteady image, which makes further adjustments difficult. Once a stable pattern is obtained, switch on one additional generator (channel 2), and stabilize the pattern again by turning the associated control. If this works, switch on the fourth generator, or set one of the other controls to a different function. The thing to remember about the initial settings is that you must work from one stable pattern to an-



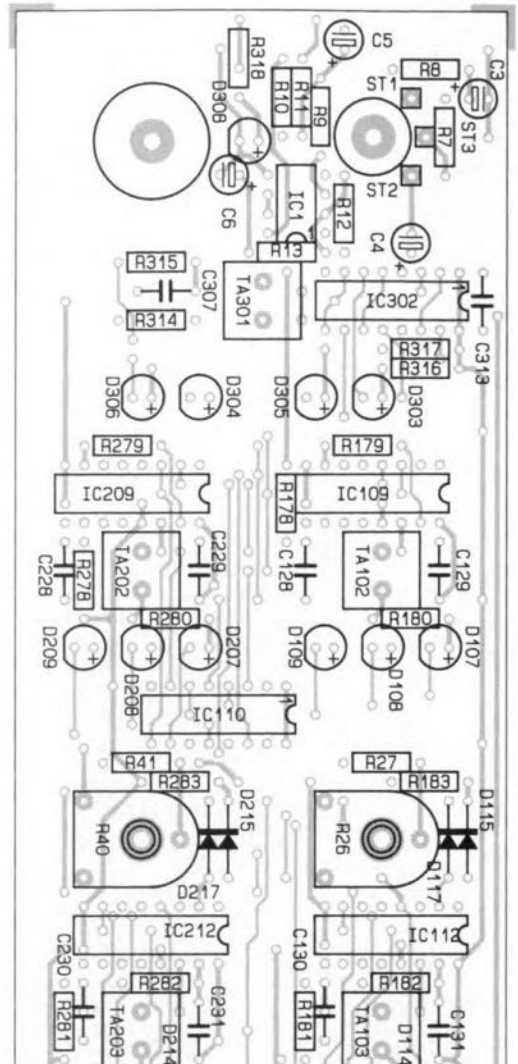


Fig. 14. Component overlay of the controls board.

other by operating one control at a time. If you do not follow this procedure, the pattern will become so unsteady that the effect of operating a control is hard to trace.

Having acquired the feel of the static control of the laser beam, you are ready to examine the possibilities of the audio interfaces and the internal microphone. While experimenting, bear in mind the potential hazard of the laser beam. Always make sure that the laser spot is moving (a straight line is all right as a kind of minimum pattern). Therefore, in the interest of your audience's safety, make sure there is always at least one modulation signal for the laser. Never select audio drive of the picture size on both channels — when one signal fails, the stationary laser beam creates a possibly hazardous situation.

Construction

As already noted, the laser control unit is a complex project that will keep you busy soldering for several hours. The layouts of the two double-sided through-plated printed-circuit boards used to build the LSI7000 are shown in Figs. 15 and 16. The smaller PCB (Fig. 16) containing all controls and the LEDs is fitted vertically behind the front panel.

Take your time to assemble the two boards. Look carefully at the component overlay, and make sure you do not insert a component wire in a hole that serves as a through-contact between the tracks at the component side and the solder side.

Start the construction by fitting the 100-kΩ resistors, followed by those of 10 kΩ and 1 MΩ. This clears the bulk of the resistors. The remaining resistors are best fitted in order of ascending value, according to the components list.

Proceed with the diodes, the solid capacitors, the electrolytic capacitors (those on the controls board are fitted horizontally), the transistors, switches and connectors. Since transistor T301 is fitted directly under the on/off switch, it must be pushed as far as possible towards the PCB before it is soldered.

Before soldering the connectors, make sure they align with the rear panel of the enclosure. The same goes for the presets on the controls board, which must be positioned such that they are straight behind the holes provided in the front panel. The plastic shafts are cut to a length of 20 mm (excluding the clamps) before they are press-fitted into the presets.

The integrated circuits are fitted on the board last. Start with IC306, and fit it to the heat-sink supplied with the kit. Check and double-check the orientation of each IC on the boards.

The microphone element is inserted from the solder side, so that its front side is at about 8 mm (3/8") above the component side of the board. The connecting pins for the microphone, ST1, ST2 and ST3, are fitted at the solder side. The microphone housing connection (a small copper track) is soldered to the centre PCB pin, ST3. The wire marked

COMPONENTS LIST

Content of kit supplied by ELV

Resistors:

18	1MΩ	R1;R4;R104;R105;R108;R149;R151; R175;R204;R205;R208;R249;R251; R275;R304;R305;R308;R315
4	33kΩ	R2;R5;R158;R258
40	10kΩ	R3;R6;R7;R8;R14;R15;R16;R24;R25; R28;R29;R30;R38;R39;R42;R43;R46; R47;R65;R67;R109;R110;R159;R160; R164;R165;R178;R181;R183;R209; R210-R259;R260;R264;R265;R278;R281; R283;R309;R310
72	100kΩ	R9;R10;R11;R21;R35;R50-R53;R64;R66; R68;R89;R101;R103;R106;R107;R114; R115;R116;R120;R123;R125;R126;R132; R136;R137;R138;R143;R144;R154;R156; R157;R169-R172;R176;R179;R182;R201; R203;R206;R207;R214;R215;R216;R220; R223;R225;R226;R232;R236;R237;R238; R243;R244;R254;R256;R257;R269-R272; R276;R279;R282;R301;R303;R306;R307; R314
1	470kΩ	R12
1	4kΩ7	R13
4	2kΩ2	R17;R31;R135;R235
8	47kΩ	R18;R19;R32;R33;R121;R174;R221;R274
20	1kΩ	R20;R34;R48;R49;R111;R177;R180;R184; R185;R186;R211;R277;R280;R284;R285; R286;R311;R316;R317;R318
2	68kΩ	R22;R36
15	22kΩ	R23;R27;R37;R41;R112;R128;R130;R139; R145;R212;R228;R230;R239;R245;R312
2	10kΩ preset H	R40;R26
5	220kΩ	R44;R45;R133;R233;R246
2	390Ω	R54;R58
2	220Ω	R55;R59
2	4Ω7	R56;R60
1	1Ω	R57;R61
6	15kΩ	R62;R63;R119;R173;R219;R273
3	470Ω	R102;R202;R302
3	5kΩ6	R113;R213;R313
2	120kΩ	R124;R224
7	330kΩ	R127;R142;R148;R227;R240;R242;R248
2	150kΩ	R129;R229
2	8kΩ2	R131;R231
3	270kΩ	R134;R146;R234
5	390kΩ	R140;R153;R155;R253;R255
4	100kΩ preset H	R141;R147;R241;R247
4	820kΩ	R150;R152;R250;R252
8	100kΩ	R161;R162;R166;R167;R261;R262;R266; R267
4	3kΩ3	R163;R168;R263;R268
4	680kΩ	R187;R188;R287;R288

Capacitors:

10	47nF	C1;C2;C116;C117;C118;C216;C217;C218; C310;C311
3	47µF 16V	C3;C11;C16
24	10µF 16V	C4;C5;C6;C12;C17;C22;C29;C105;C107; C108;C111;C112;C114;C123;C205;C207; C208;C211;C212;C214;C223;C305;C309; C312
2	180nF	C8;C13
2	220nF	C9;C14
2	15nF	C10;C15
7	100µF 16V	C18;C24;C31;C119;C120;C219;C220
12	1µF 16V	C19;C21;C104;C106;C122;C125;C204;C206; C222;C225;C304;C306
20	100nF	C20;C25;C26;C28;C32;C34;C36;C101;C103; C127;C129;C131;C201;C203;C227;C229; C231;C301;C303;C307
2	470µF 16V	C23;C30
2	4700µF 16V	C27;C35
5	2nF2	C102;C113;C202;C213;C302
2	470nF	C110;C210
4	1µF solid	C121;C124;C221;C224
7	10nF	C126;C128;C130;C226;C228;C230;C313
1	1000µF 40V	C308

Semiconductors:

16	1N4148	D1-D4;D101;D102;D115;D116;D117;D201; D202;D15;D216;D217;D301;D302
4	DX400 *	D103;D104;D203;D204
25	LED red 3mm	D105;D107-D114;D118;D205;D207-D214; D218;D303-D306;D308
1	1N4001	D307
6	BC548	T1-T4;T102;T202
3	BF245B	T101;T201;T301
5	LM358	IC1;IC2;IC107;IC207
1	TDA1074A	IC4
2	TDA2003	IC5;IC6
9	LM324	IC101-IC104;IC201-IC204;IC301
4	XR2206	IC105;IC106;IC205;IC206
5	4049	IC108;IC110;IC113;IC213;IC302
4	4017	IC109;IC112;IC209;IC212
8	4053	IC111;IC114;IC115;IC211;IC214;IC215; IC303;IC304
2	7810	IC305;IC306

* changed w.r.t. circuit diagram.

Miscellaneous:

7	PCB mount press key	TA101;TA102;TA103;TA201;TA202; TA203;TA301
2	DIN type LS socket	BU1;BU3
2	PCB mount RCA socket	BU2;BU4
1	PCB mount 3.5mm jack socket	BU301
1	PCB mount 3.5mm jack socket, stereo	BU5
1	miniature on/off switch	
1	electret microphone	
1	heat-sink for IC306	
1	printed circuit board (main circuit)	
1	printed circuit board (controls circuit)	
1	ABS enclosure	

Note: owing to space restrictions the track layouts of the two double-sided printed circuit boards are not included here. Readers wishing to make their own PCBs for this project may obtain the necessary artwork from our editorial offices, quoting 'ELV laser control LSI7000'.

with a small '+' sign is connected to ST1, and the wire marked with a '–' sign to ST2. Although not strictly necessary, you want to secure the microphone element with a drop of glue.

Perform a thorough visual check on the completed PCBs. With over 500 components handled during the construction, small mistakes occur easily, and can force you to spend hours of precious time faultfinding. For example, on our own prototype, we forgot to solder two of the eight pins of an IC. Fortunately, this error was detected during a careful visual inspection.

The lower half of the enclosure serves as a kind of template for the fitting of the main board. The front side is the side with the air slots. Remove the small protruding parts at the inside of the slot in the rear side. These parts normally serve to keep the rear panel in place, and must be removed here because the PCB reaches up to the rear panel. Slide the main board into the enclosure, and place the controls board and the front panel in front of it. Adjust the position of the main board such that the connecting copper pads on it and the controls board align. Make sure that the controls board is at right angles with the main board. First, join the connections at the far sides of the boards with a small amount of solder. If necessary adjust the position of the boards before joining the connecting pads with solder.

Remove the PCB assembly from the enclosure, and fit the remaining connections between the main board and the controls board. Finally, connect the lower two terminals of the on/off switch to PCB terminals ST301 and 302.

The circuit is electrically functional at this point, and ready for testing. To prevent short circuits caused by stray component wires left on the workbench, fit the PCB assembly in the lower half of the enclosure. Do not connect the mirror galvanometers as yet, and insert an ammeter in the input supply line. Switch off immediately and investigate for construction errors if the unit draws more than 300 mA.

The following LEDs should be on after then unit is switched on: D107, D112, D113, D118, D207, D212, D213, D218, D303, D304 and D308. Check the selection functions by pressing the push-buttons. Each action must cause the next LED to light. If this does not work, investigate the relevant part of the circuit.

If the above tests check out, the laser exciter may be connected to the control unit. If you do not want to use the exciter at this stage, connect an oscilloscope set to *X-Y* mode to the mirror coil outputs.

The final assembly of the laser unit is fairly simple: place the PCB assembly, together with the front and rear panel, in the lower enclosure half. Next, insert the four bolts from the underside, and fit a washer and a PCB pillar on each of them. Place the top half of the enclosure on the lower half. If necessary, use a small screwdriver to align the PCB pillars until the end of the bolt passes through the hole in the mounting boss in the top half of the enclosure. Next, fit the nut in the mounting boss, and tighten the bolt. Finally, fit the feet on the lower half of the cabinet, and the cover caps on the top cover. ■

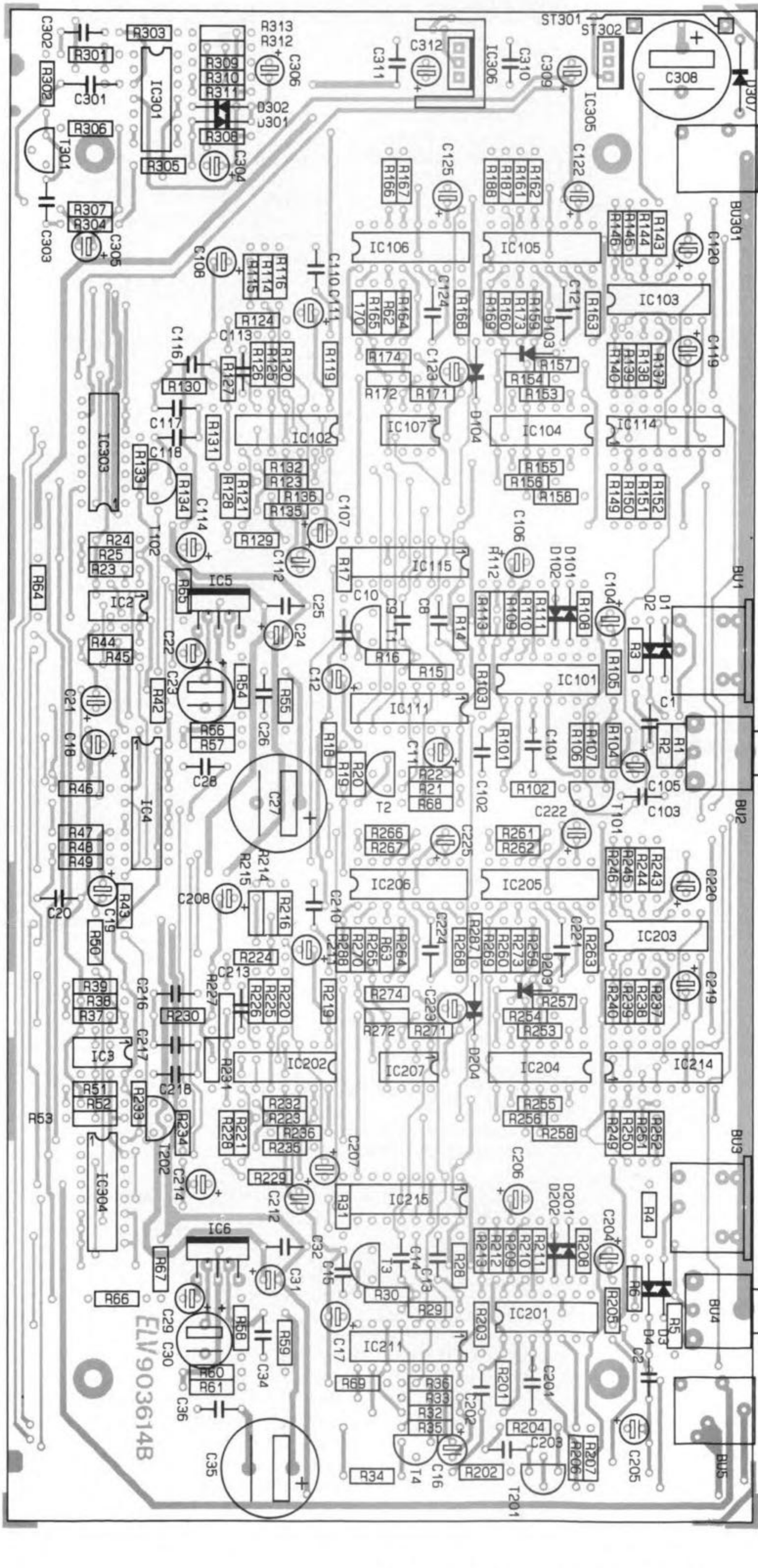
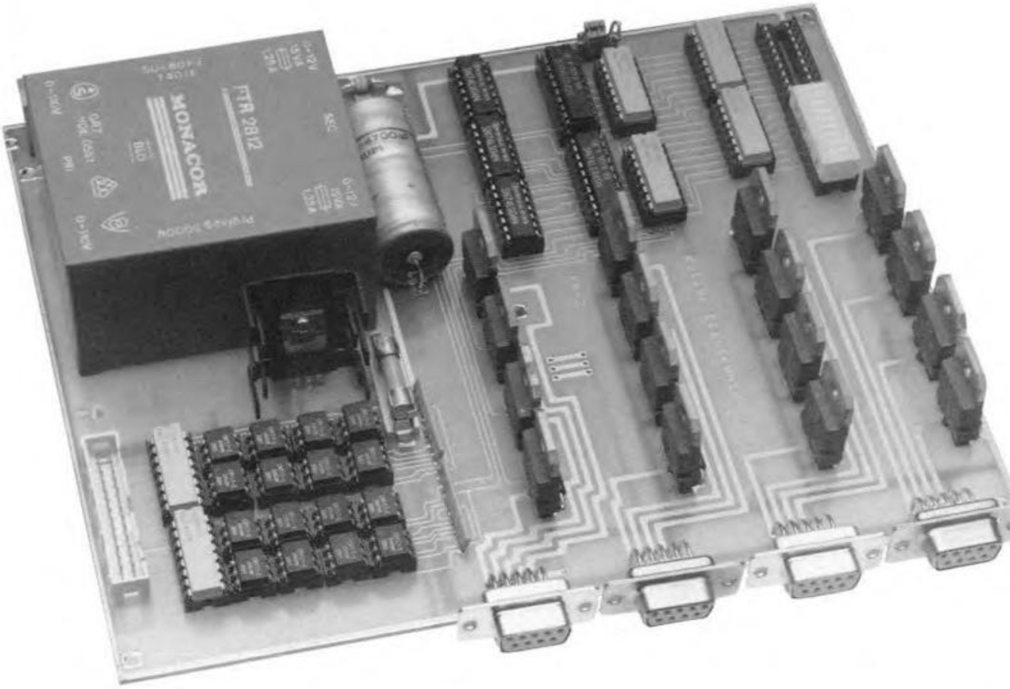


Fig. 15. Component overlay of the double-sided, through-plated, main board in the LSI7000.

STEPPER MOTOR BOARD



PART 2: THE POWER DRIVER BOARD

In this second and final instalment of the article we discuss the power driver board that sits between the PC interface described last month, and the stepper motors. Although designed to work with the PC interface, the power driver card can be connected to any other type of computer that provides a 16-bit wide I/O port.

H. Kolter

Continued from the June 1991 issue.

Tables 1 and 2, which could not be included in part 1 of this article, are given here.

TTL-to-current converter

The function of the power driver board is quite simple: it converts 16 TTL-level signals into an equal number of outputs with a drive capability of 2 A each. Provided a separate transformer is used, the same board can be used to power loads up to 3 A at 23 V.

An application example of the stepper motor control was discussed last month: a CNC-controlled fraise machine weighing no less than 250 kg. If you do not have such a weighty application in mind, rest assured that the control described is suitable for any other project where up to four unipolar stepper motors are to be driven.

The circuit

The operation of the circuit shown in Fig. 5 is identical for all 16 channels. At the input we find a double-row pin header, K2. This connector forms the **only** point where the ground of the PC interface card or any other TTL-compatible port is connected to the power driver card. Each TTL input signal controls a LED in an optocoupler (IC2-IC17) via a series resistor. Note that the cathodes of the LEDs are taken to a common input ground connection. The series resistors are contained in two DIL (dual-in-line) arrays of 8 resistors each. The arrays are fitted in IC sockets, which enables the resistor value to be changed as required when optocouplers other than the CNY17-2 are used. The emitters of the transistors in the optocouplers are also commoned and taken to the ground connection of the board. Each collector is connected to a pull-up resistor to the +5-V supply line. Like the LED series resistors, the pull-up resistors are contained in 8-way arrays (AR3; AR4). Note, however, that these are SIL (single-in-line) arrays rather than DIL arrays. Each optocoupler transistor is followed by an inverter (IC18; IC19), which passes the signal to a driver contained in a 74LS245 (IC21; IC22). This LS-TTL IC is capable of supplying the necessary base current for the power transistors, T1-T16.

The logic level applied to the DIR input (pin 1) of the 74LS245 defines the data direction. Since DIR is tied permanently to +5 V, the bit pattern supplied by the inverters is fed direct to the power transistors and the two LED arrays, LED1 and LED2. The active-low ENABLE ($\overline{G}$) inputs of the bus drivers are taken logic high by pull-up resistors, but can be made low by fitting a jumper (J1; J2). When J1 or J2 is removed, the relevant 74LS245 is switched to its high-impedance output mode (three-state), so that all eight power transistors driven by it are switched off. When required, the jumpers may be replaced by a double on/off switch that acts as an emergency stop control.

The base currents of the 16 TIP3055s are limited by 100-Ω resistors contained in arrays AR5 and AR6. When a transistor is switched on, the associated LED in array LED1 or LED2 lights. Each LED in these arrays is driven by a 74LS245 output via a 1-kΩ series resistor. The LED arrays are intended mainly to assist you while running an initial test on the stepper motor control. The LED bars show the status of all 16 motors at a glance, and will be found much more handy than a TTL probe, a multimeter or an oscilloscope.

Each collector-emitter junction of the power transistors is shunted by a diode Type 1N4007, which suppress back-e.m.f. pulses generated when inductive loads are switched. The collectors of the power transistors are taken to a connector pin in groups of four. The connectors used are 9-way sub-D types (K3-K6). Besides the collector voltage, each connector carries the unregulated motor supply voltage, and ground.

The supply circuit of the power driver board is conventional. The 12-V secondary windings of the mains transformer, Tr1, are

MAIN SPECIFICATIONS

- Power driver board for 4 unipolar stepper motors
- Handles loads up to 24 V at 3 A
- May be used for any 1-16 channel driver application
- Electrically isolated TTL-comaptible inputs
- Fnctional indication based on LED bars
- On-board power supply
- Optional external power supply

connected in parallel. The rectified and smoothed voltage is fed to connectors K3-K6, and to the input of voltage regulator IC1, whose 5-V output voltage is used for the 74LS ICs on the board only.

Construction

The printed-circuit board used to build the power driver is shown in Fig. 6. It is recommended to use of sockets to fit the ICs, optocouplers, resistor arrays and LED arrays. The latter may taken from their sockets on the board and mounted on the front panel of the enclosure. This requires two lengths of flatcable and a handful of IDC-style plugs and sockets.

The four rectifier diodes, D1-D4, may run fairly hot and must be fitted at a distance of 1-2 mm above the board. The voltage regula-

Table 2. Overview of port lines and control functions.

Port A:	bit 0 - 3 = Motor 1 (X)
	bit 4 - 7 = Motor 2 (Y)
Port B:	bit 0 - 3 = Motor 3 (Z)
	bit 4 - 7 = Motor 4 (reserved)
Port C:	C0 = Timer 0
	C1 = Timer 1
	C2 = Timer 2
	C3 = emergency switch
	C4 = output
Input port (IC4):	
Bit 0:	end switch X0
Bit 1:	end switch X1
Bit 2:	end switch Y0
Bit 3:	end switch Y1
Bit 4:	end switch Z0
Bit 5:	end switch Z1
Bit 6:	end switch W0
Bit 7:	end switch W1

Table 1. Register addresses.

Base address: 0DEO$_H$

PPI 8255 (IC1)	
Port A:	base + 0
Port B:	base + 1
Port C:	base + 2
Status:	base + 3
PIT 8253 (IC5):	
Timer 0:	base + 4
Timer 1:	base + 5
Timer 2:	base + 6
Timer 3:	base + 7
Input port (IC4):	
Read at:	base + 8

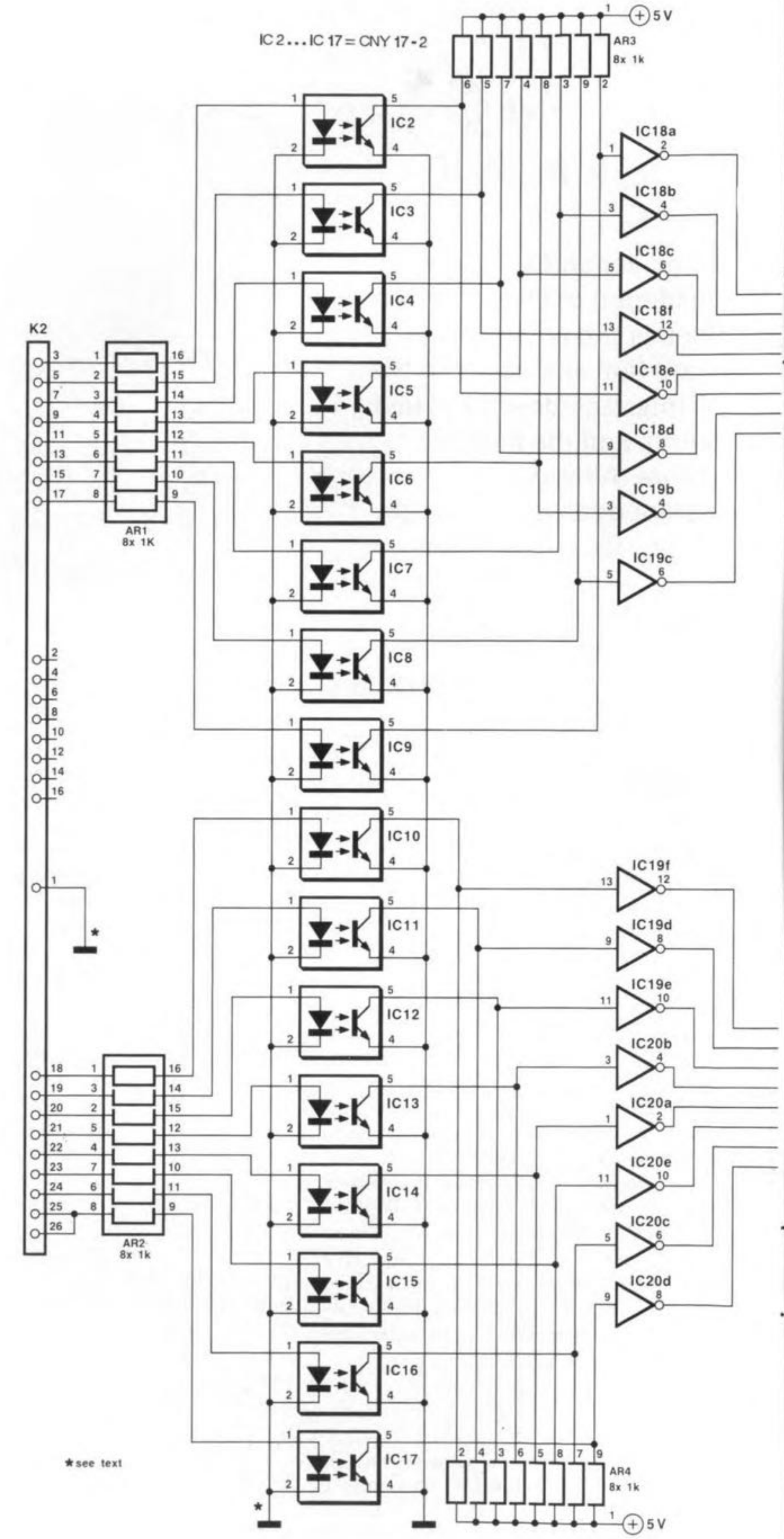
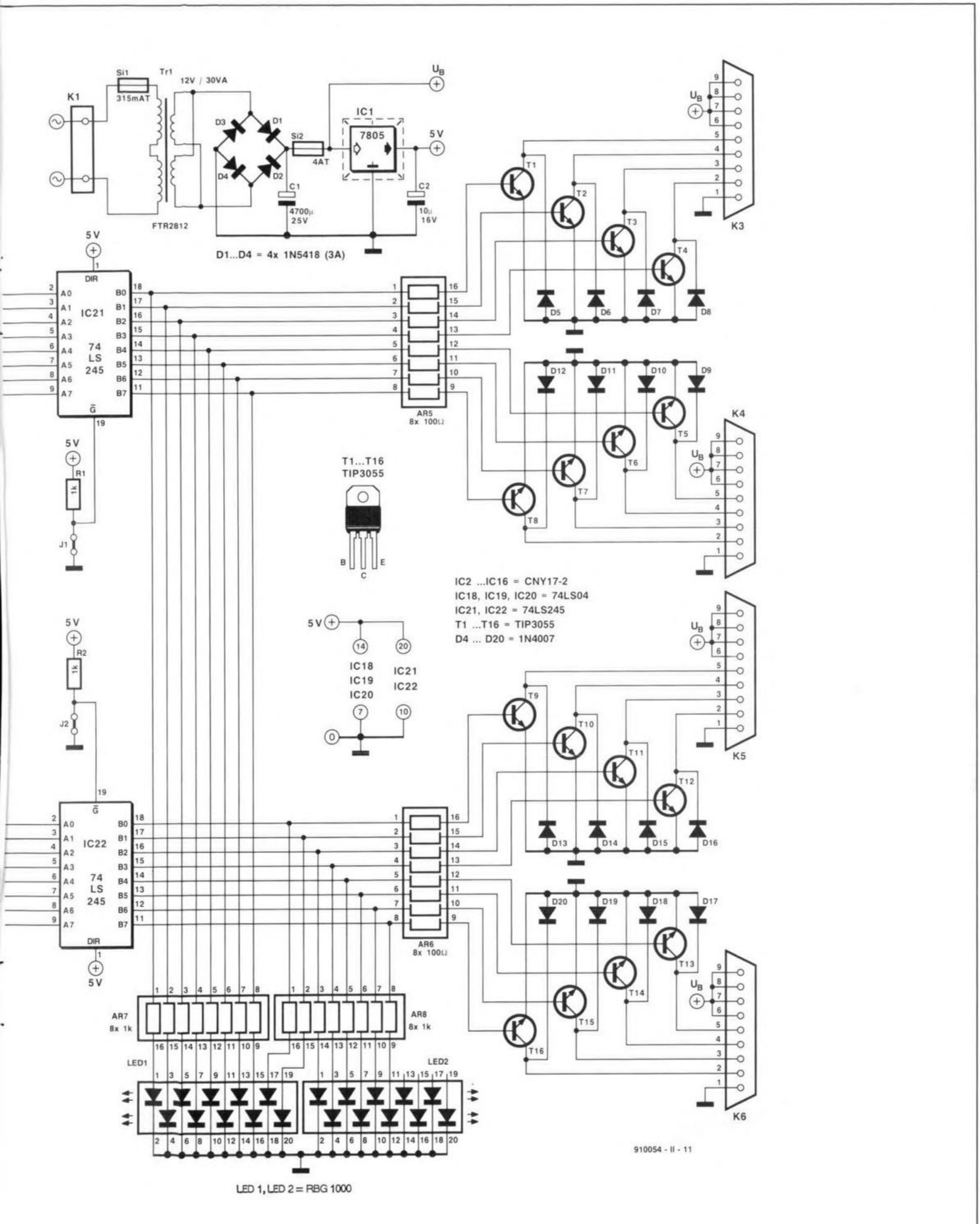


Fig. 5. Circuit diagram of the 16-channel booster for stepper motors. The circuit accepts TTL-



LED 1, LED 2 = RBG 1000

level input signals, and is capable of powering loads up to 3A when an external power supply is used. The on-board supply is good for 2 A.

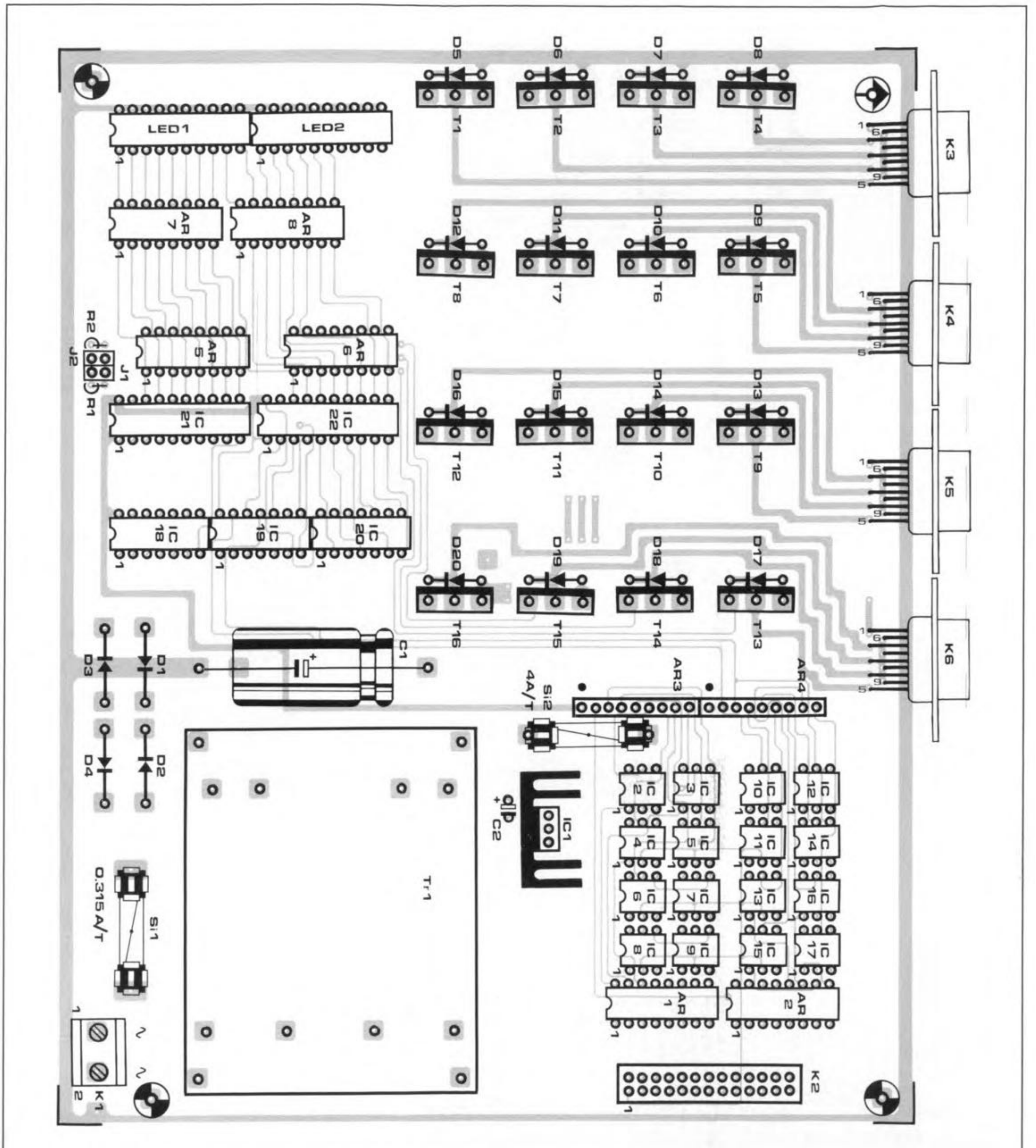


Fig. 6a. Component overlay of the stepper motor interface board.

COMPONENTS LIST

Resistors:

2	1kΩ	R1;R2
4	8-way 1kΩ DIL	AR1;AR2;AR7; AR8
2	8-way 1kΩ SIL	AR3;AR4
2	8-way 100Ω DIL	AR5;AR6

Capacitors:

1	4700μF 25V	C1
1	10μF 16V radial	C2

Semiconductors:

4	1N5418	D1-D4
16	1N4007	D5-D20
16	TIP3055	T1-T16
2	RGB1000 (Siemens)	LED1;LED2
1	7805	IC1
16	CNY17-2 (Telefunken)	IC2-IC17
3	74LS04	IC18;IC19;IC20
2	74LS245	IC21;IC22

Miscellaneous:

1	2-way PCB terminal block	K1
1	26-way PCB mount box header	K2
4	9-way PCB mount sub-D socket with angled pins	K3-K6

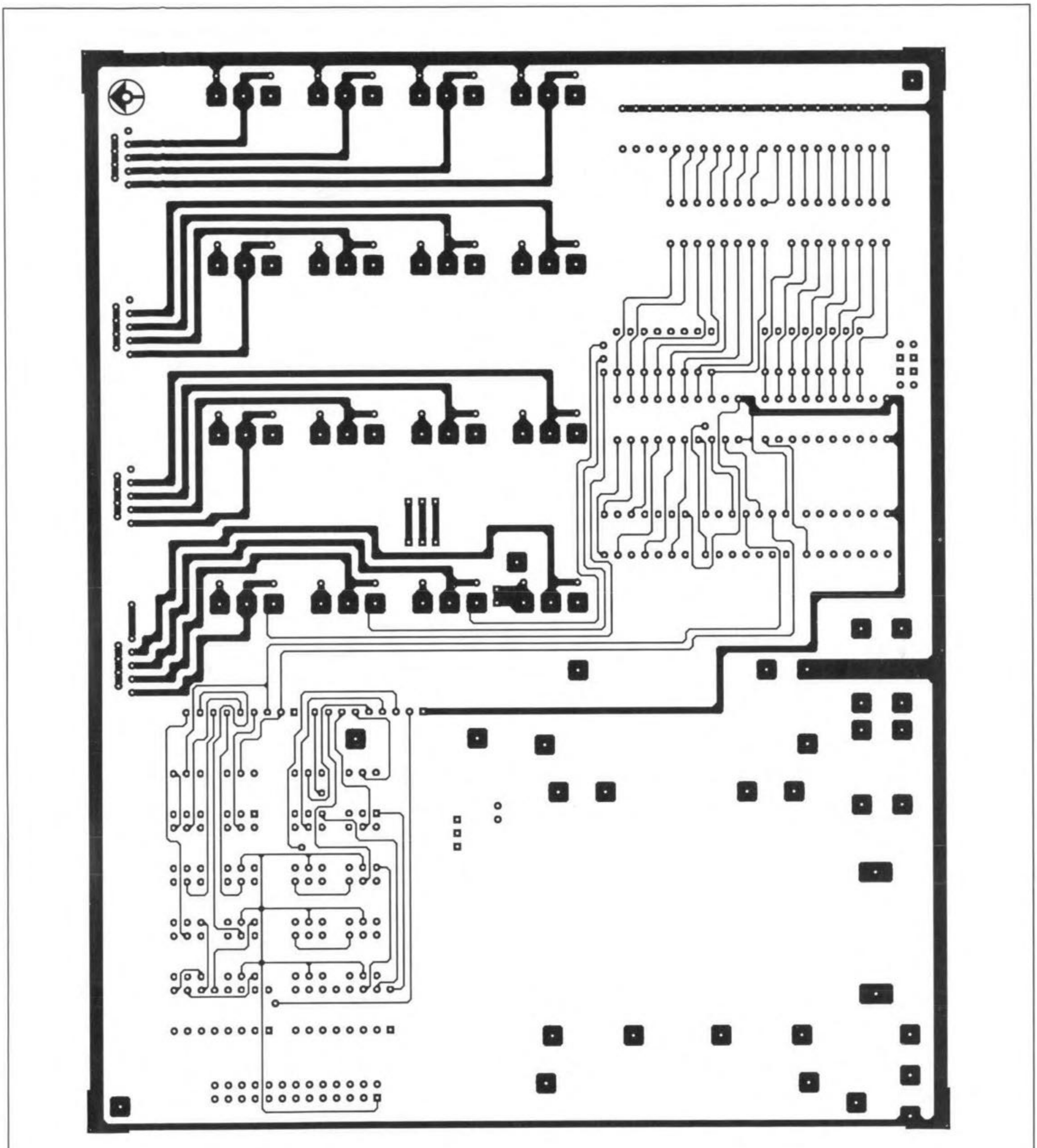


Fig. 6b. Component side track layout (mirror image).

1	315mA slow fuse with PCB-mount holder	Si1
1	4A slow fuse with PCB-mount holder	Si2
1	12V/30VA mains transformer, e.g. Monacor/Monarch type FTR 2812	Tr1
1	TO-220 style heatsink for IC1	
2	2-way pin header plus jumpers	
1	printed-circuit board	910054-2

tor and the power transistors do not require heat-sinks when the indicated 12-V transformer is used. However, if you use a higher motor supply voltage (which is possible by using an external transformer), the TIP3055s will require additional cooling. The layout of the PCB allows ready use of a common heat-sink for groups of four transistors. Note that the transistors must be electrically isolated from another by means of mica washers and plastic bushes.

The 9-way sub-D connectors on the PCB are types with angled solder pins. This enables them to be fitted horizontally and protrude from the enclosure rear panel.

To ensure proper earthing, the enclosure for the power driver board is preferably a metal type. The earth line is then connected to the bottom as well as to the front plate.

A simple test program

The source code of a small Turbo-Pascal program given in Listing 1 allows you to run a

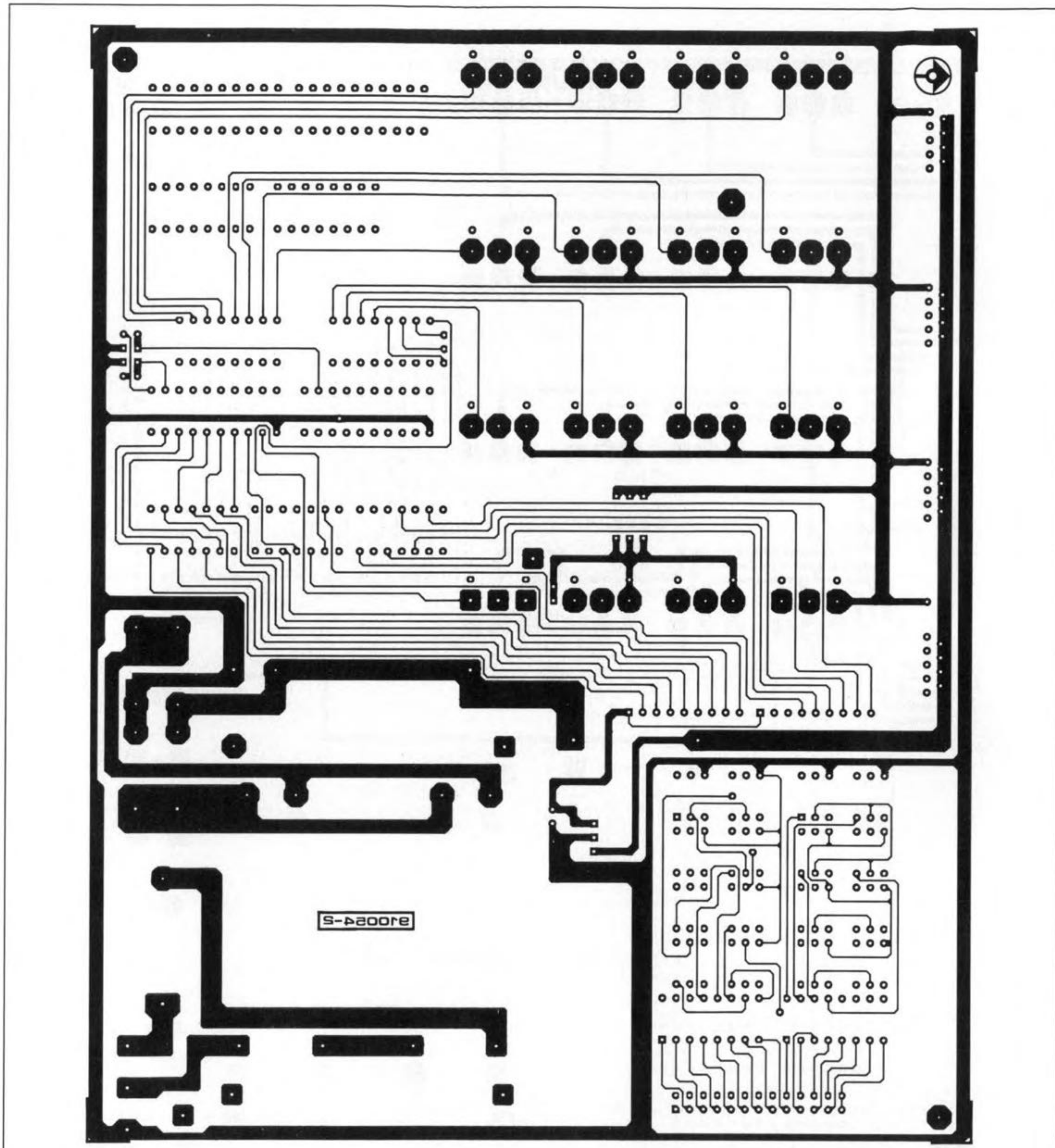


Fig. 6c. Solder side track layout (mirror image).

quick test on the complete stepper motor control system.

When the two PCBs (PC insertion card and power driver card) are complete, connect them with a length of flatcable via K_2 at the PC side, and K_2 at side of the power driver board. The flatcable simply connects all pins with the same numbers at either side.

Connect a unipolar stepper motor to K_3. Unipolar motors usually have four windings (phases), but only six connecting wires since pairs of two windings each are interconnected in the motor. This means that you will have to find the common connection first with the aid of an ohmmeter, and then connect it to the +Ub pins on the 9-way connector (see the pinning of K_3). The four remaining wires belong with two windings. Identify the windings with an ohmmeter, and connect the associated wires to two adjacent transistors on the power driver board. For instance, winding 1 is connected to T_1-T_2, and winding 2 to T_3-T_4.

After connecting the stepper motor, load the test program, compile it and start it. The software slowly increases the speed of the motor to the maximum, and then reduces the speed. The programming steps responsible for this speed control are readily traced in the listing. You may find the ramp-based delay routine in the test program useful for your own applications. If so, simply copy the relevant routine, adapt it (if necessary), and insert it in your own software. After changing the port addresses the same program may be used to test the other three motor channels.

Tuning

In many cases, the stepper motors used will be too slow. Also, the maximum step fre-

```
{ Test program for 4-Phase/unipolar motor. }
{ 8253 Timer and end switches are not read. }
{ Programmed with TURBO-PASCAL 5.5 from Borland. }

uses crt,dos,graph;

const   sx = $0DE0; { Port adresses on card (PPI 8255) }
        sy = $0DE1; { PA = 0de0, PB = 0de1, PC = 0de2 }
        sf = $0DE2; { Status port = 0de3, see INIT. }

        A =   1;    { Motor : Phases on Port 8255 (const) }
        B =   2;
        C =   4;
        D =   8;
        AB =  3;
        BC =  6;
        CD = 12;
        DA =  9;

        E =  16;
        F =  32;
        G =  64;
        H = 128;
        EF =  48;
        FG =  96;
        GH = 192;
        HE = 144;

type parms = record
        driver                  : integer;
        mode                    : integer;
        end;

var     i                       : integer;
        W                       : char;
        param                   : parms;
        vl,vz                   : integer;

procedure init;         { Initialise via status port. }
begin
port [$0de3] :=128;  { set all Ports to output }
sound (2000);
delay (50);
nosound;
end;

procedure verz;         { Delay!  Ramp for start/stop }
begin
for vz := 0 to vl do
begin                   { relative delay, depends on PC speed }
end;
 vl := vl - 1;
 if vl < 450 then vl := 450;
 if i >  250 then vl := vl +2;
end;


procedure test1;                    { test turbo mode with T key. }
begin
vl := 850;                  { value of start ramp in VL }

port[$0DE1]:= 16 ;                  { Init TURBO-MODE }
for i := 1 to 300 do                { X-Axis 300 x 8 Steps to left }
begin
        port [sx] := A ; verz;  { full delay }
        port [sx] := AB; verz;  { motor runs clockwise }
        port [sx] := B ; verz;
        port [sx] := BC; verz;
        port [sx] := C ; verz;
        port [sx] := CD; verz;
        port [sx] := D ; verz;
        port [sx] := DA; verz;
end;
port [sx] :=0;                      { switch off phases }
vl := 850;
for i := 1 to 300 do                { and return! }
begin
        port [sx] := DA; verz;  { full delay }
        port [sx] := D ; verz;  { motor runs anti-clockwise }
        port [sx] := CD; verz;
        port [sx] := C ; verz;
        port [sx] := BC; verz;
        port [sx] := B ; verz;
        port [sx] := AB; verz;
        port [sx] := A ; verz;
end;
port [sx]     :=0;                  { switch off phases }
port [$0de1] :=0;                   { IMPORTANT !!! }
vl := 850;
end;


begin           { MAIN PROGRAM }
W :='A';
init;

detectgraph(param.driver ,param.mode);{ Graphics card }
initgraph(param.driver ,param.mode,' ');

   setfillstyle(1,0);  { screen init }
   BAR (0,0,748,348);
   setfillstyle(0,0);
   setcolor(0);
   setBKColor( 1);
   BAR (2,203,468,347);

setcolor(15);
 repeat;
  repeat;
   outtextXY ( 10, 10,'T - Test run X-axis' );
   outtextXY ( 10, 30,'Q - Quit');
    until keypressed;
       w :=readkey;
       case w of
       't','T' : test1;
     end;
     until w = 'q';
    clrScr;
   writeln('Ende');
  TextMode(80);
end.
```

Listing 1. This Turbo-Pascal program controls the X-axix motor with the aid of a start/stop ramp, which is one of the most important functions required for smooth operation of a steppr motor.

quency is often difficult to ascertain from the motor's data sheets. In practice, the value stated must be divided by the number of phases (windings) of the motor. This leaves you with a much lower frequency, which is, however, a more realistic indication of the maximum speed of the motor. So, do not suspect the hardware or the software when your motor fails to run as fast as promised in the datasheet — you may well have achieved the real maximum already.

The author has implemented a 'turbo' mode for the control of the CNC fraise machine mentioned in part 1 of this article. In this mode, the stepper motors are operated at two times their nominal supply voltage of 12 V, which, according to the datasheets supplied by Oriental Motors, does not exceed their specifications, since the maximum step rate is achieved at 24 V. The software developed by the author programs motor channel 4 (K_6) such that it supports the 'turbo' function. Transistor T_{13} is connected to a relay that switches the supply voltage of the stepper motors between 12 V and 24 V. The 'turbo' mode results in much higher motor speeds, which can be quite useful in a number of applications. Interestingly, the motors used do not run hot even when running at the maximum speed for long periods. It should be noted, though, that doubling the supply voltage is not possible on all stepper motors. To find out whether a particular type is suitable for the 'turbo' mode, consult the datasheets, or simply try it out. ■

CONTROL SEQUENCES FOR UNIPOLAR STEPPER MOTORS

Four-phase unipolar stepper motors are controlled by switching windings (phases) on and off as shown below. The control word sequences given result in clock-wise rotation of the motor spindle. The motor reverses when the order of the sequences is reversed.

Full-step mode

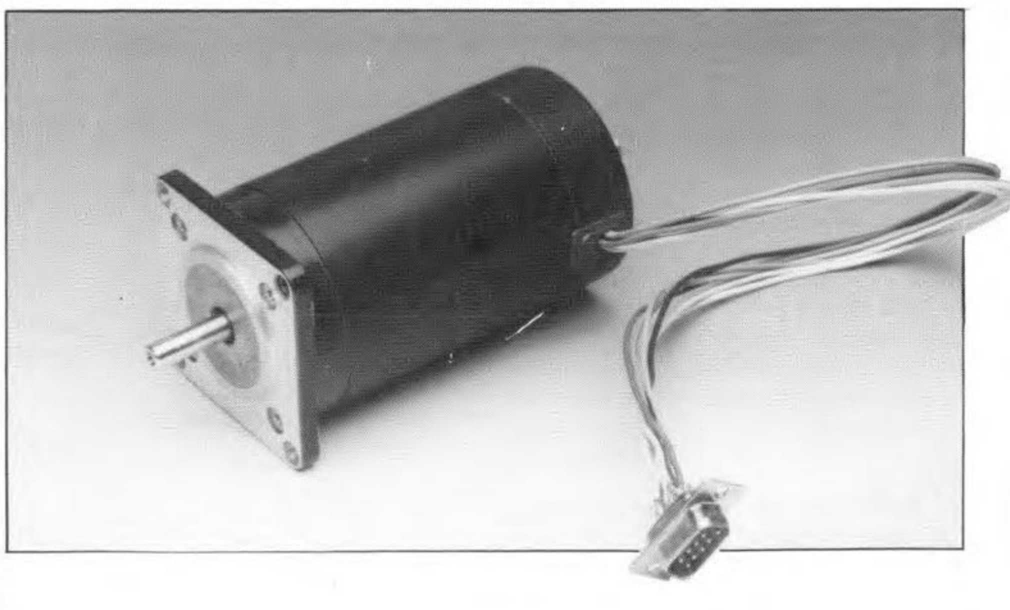
Step	T1	T2	T3	T4
1	1	0	1	0
2	1	0	0	1
3	0	1	0	1
4	0	1	1	0
1	1	0	1	0

Half-step mode

Step	T1	T2	T3	T4
1	1	0	1	0
2	1	0	0	0
3	1	0	0	1
4	0	0	0	1
5	0	1	0	1
6	0	1	0	0
7	0	1	1	0
8	0	0	1	0
1	1	0	1	0

1 = transistor on
0 = transistor off

Note that although the minimum step distance of a mechanical device operated by a stepper motor is halved by using the motor in half-step mode, this results is a reduction of the maximum rotational torque and maximum step rate. The cause of this degraded performance in half-step mode is that only one motor winding is actuated during the intermediate steps (2, 4, 6 and 8). By contrast, in full-step mode two phases are always actuated.



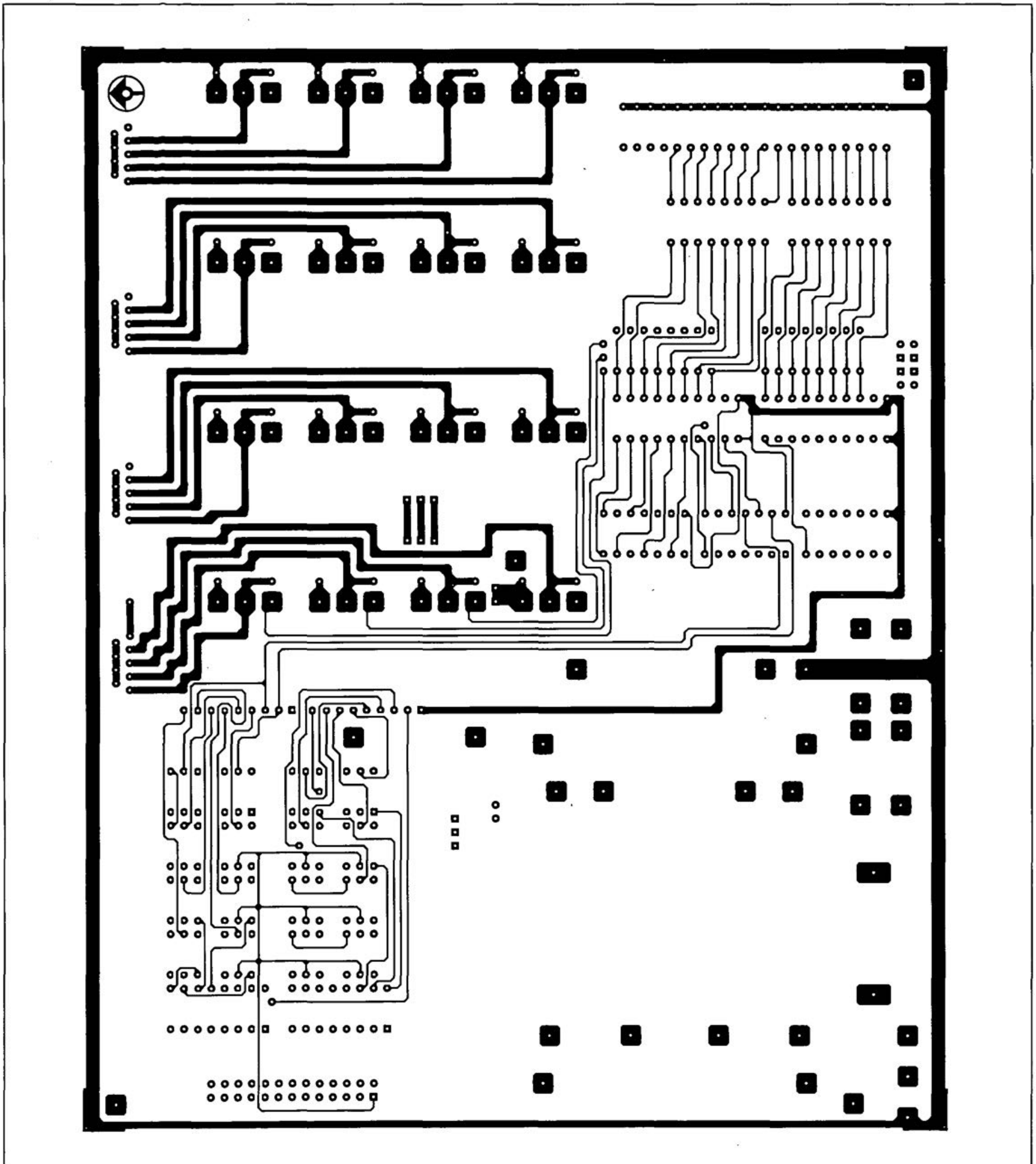


Fig. 6b. Component side track layout (mirror image).

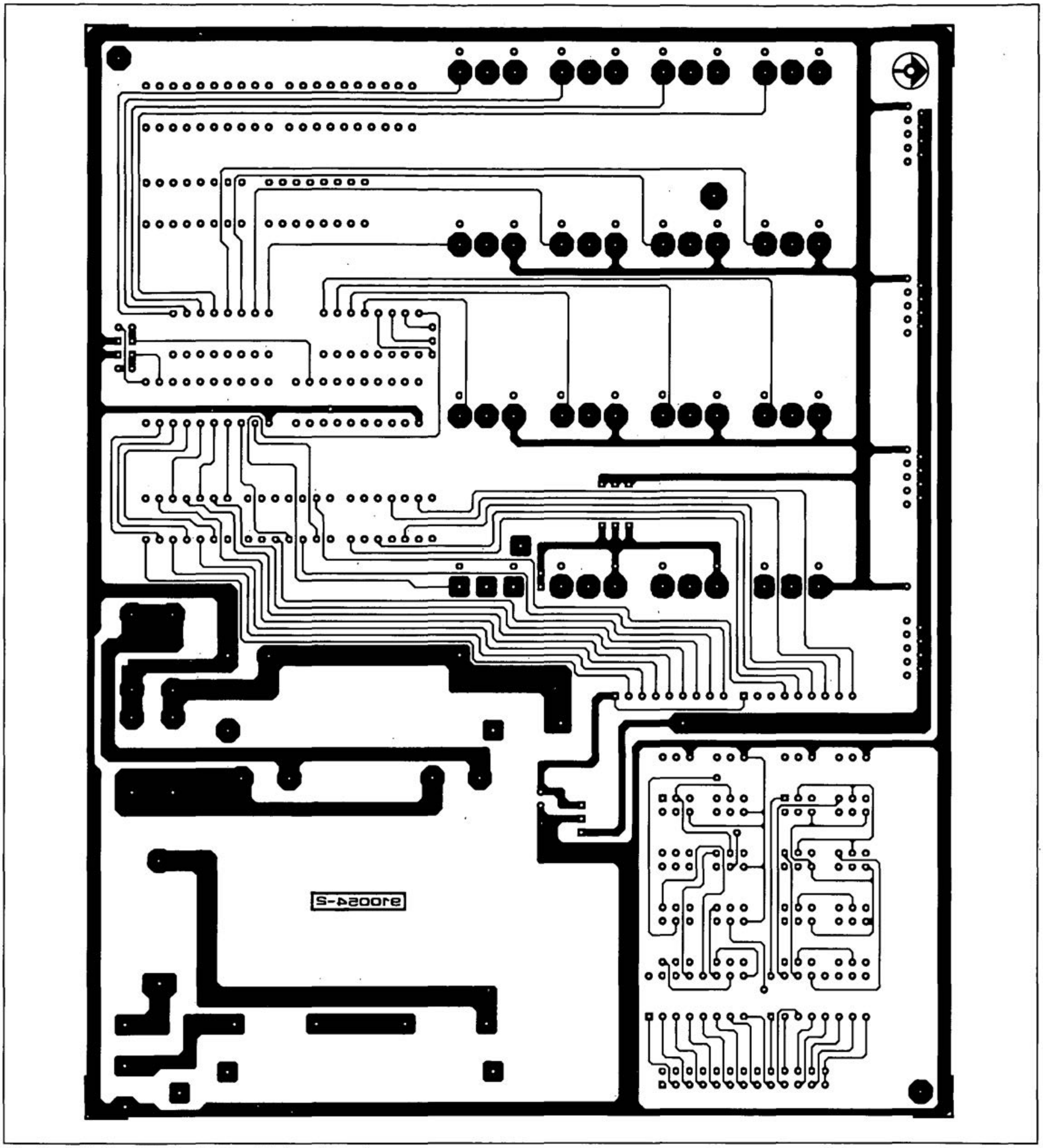


Fig. 6c. Solder side track layout (mirror image).

MEASUREMENT TECHNIQUES – PART 6

Faultfinding in analogue circuits

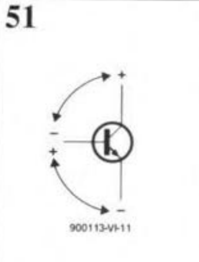
by F.P. Zantis

Voltage analysis

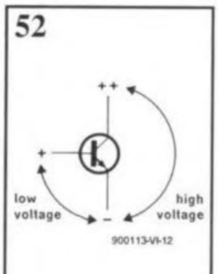
If a circuit ceases to function and it shows no visible damage, a voltage analysis should be the first step in locating the fault. Voltages can normally be measured without the need of breaking connections or the removal of components. The level and polarity of a voltage are two aspects that indicate the state of a component or circuit. Because of that, many circuit and wiring diagrams give the voltage level and polarity at important junctions. Such indications are a great help in faultfinding, but even without them, the voltage at many points in a circuit is known. For instance, the potential across a p-n junction of a diode or the base-emitter junction of a transistor should be 0.2–0.4 V (germanium) or 0.6–0.8 V (silicon).

Polarity, too, may be an indication whether a single semiconductor is defect or not. For example, in the case of an n-p-n transistor with correctly set operating point, the base is always positive with respect to the emitter and negative with respect to the collector—see Fig. 51. If the emitter voltage is taken as reference, the base potential should be +0.20.6 V, while the collector should have a much larger positive potential—see Fig. 52. These polarities are reversed in p-n-p transistors.

51



52

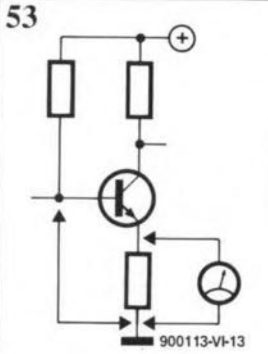


If the measurements do not accord with what has been said, either the transistor itself or a component determining its operating point may be defect. Note, however, that there are applications in which, for instance, the base of an n-p-n transistor is purposely negative with respect to the emitter.

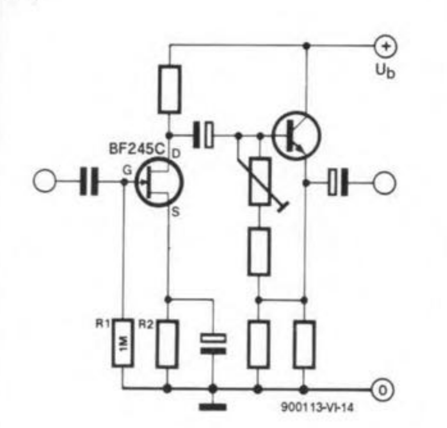
Usually, the collector current decreases when the base-emitter voltage is reduced, while the collector-emitter voltage rises. A simple test is, therefore, measuring the collecttor-emitter voltage and, while the equipment is on, short-circuiting the base-emitter junction.

If there is a resistor in the emitter circuit, the voltage across that may be measured—see Fig. 53—while the base is short-circuited to ground; the collector current will then drop to zero. Consequently, the voltmeter will show a large reduction in the potential drop across the emitter resistor.

53

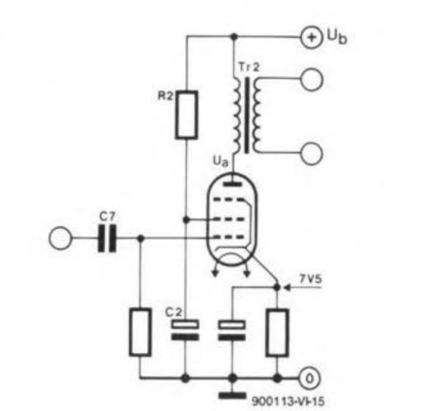


54

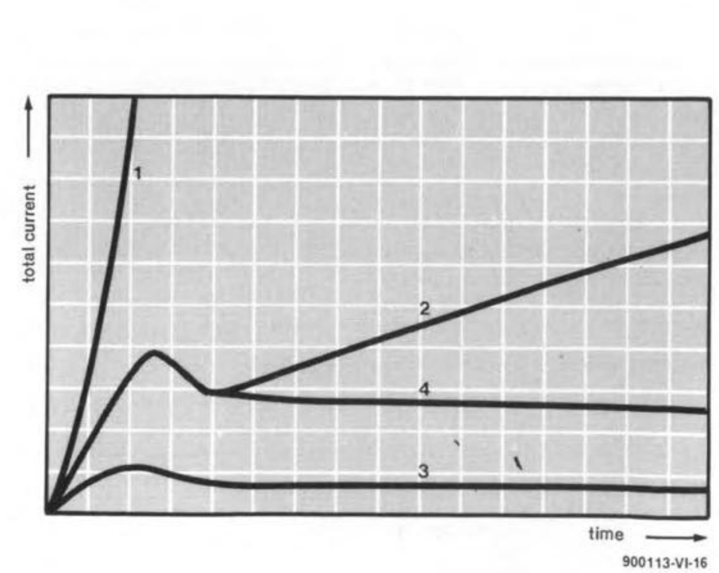


Similar measurements may also be carried out on field-effect transistors—FETs—but in these the correct interpretation of the various voltage ratios is rather more difficult owing to the large number of different types (although there are only six basic types). The most frequently encountered type is the n-channel, insulated-gate FET, shown in a typical circuit in Fig. 54. Taking the source (S) terminal as reference, there should be a small negative voltage at the gate (G) and a large positive voltage at the drain (D). If the circuit ground is taken as reference, there should be no voltage at the gate, since no current flows through gate resistor R_1. If the circuit of Fig. 54 is in actual operation, it should be borne in mind that the measurements

55



56



greatly reduce the input impedance of the circuit and thus affect the circuit.

For voltage measurements in a valve circuit as shown in Fig. 55, ground is taken as the reference. The full supply voltage, decoupled by R_2 and C_2, should exist at the screen grid. Owing to the drop across the d.c. resistance of the output transformer, the voltage at the anode will be slightly smaller than that at the screen. The usual voltage at the cathode is 3–8 V. There should be no discernible voltage at the signal grid; if there, is, either the valve or capacitor C_7 is defect.

Current analysis

Current measurements normally mean breaking connections, involving time and effort, and are, therefore, normally only carried out when voltage analysis has failed to come up with an answer. There are, of course, circuits that facilitate current measurements by the incorporation of special wire bridges that are easily removed, or even of the plug-in type. Battery connections are often easily broken at the battery. Fuses also provide an easy means of measuring current.

Figure 56 shows the results of some current measurements in an audio amplifier. If the current rises sharply immediately the amplifier is switched on—curve 1—the cause is almost certainly a short-circuited output transistor. Curve 2 possibly indicates incorrect stabilization of the operating point or a defect regulator in the mains supply. If the current remains at a steady low level, the fault is normally an open connection (often in the output transistor circuit—curve 3. The correct current is indicated by curve 4: initially it rises sharply but soon tails off to its normal level.

Bias setting

Examples of both voltage and current analysis will be given on the basis of setting the bias voltage in an audio output stage with feedback—see Fig. 57. The potential at point P, with respect to earth, must be half the supply voltage, U_b, and this is set accurately with the aid of P_1. The quiescent direct current is set with P_2.

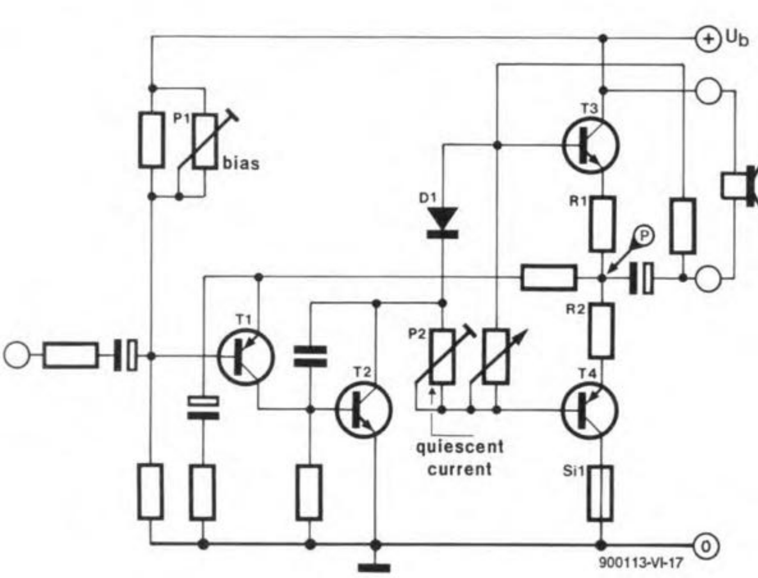
The quiescent current is measured by replacing fuse F by an ammeter or by measuring the voltage across R_1 or R_2. In the first case, the current may be read directly on the ammeter, while in the second case it is calculated according to Ohm's law. In direct current measurements, the internal resistance of the ammeter will affect the readingt. The meter resistance in voltage measurements may be ignored, since it is much smaller than the value of either R_1 or R_2. The voltage is fairly small: 100–300 mV. It is advisable, before starting the measurement, to calculate the approximate voltage level, then measure it on the correct meter range, and finally adjust the potentiometer. If, for instance, both R_1 and R_2 are 0.82 Ω, and the required quiescent current is 50 mA, the voltage across either resistor should be 41 mV. The voltmeter should thus be set to the 100 mV range.

Resistance analysis

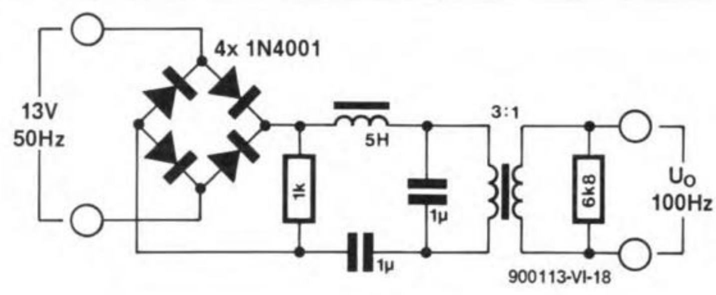
Resistance analysis is used in faultfinding when the fault has already been isolated by voltage or current analysis. It is, of course, also useful if the equipment can not be switched on during faultfinding.

In valved equipment, whole sections may be examined for short circuits, open circuits or leakage. This is normally not possible in solid-state circuits, since the internal resistance of semiconductors is invariably low and, moreover, its value varies according to the polarity of the meter. Before the power to a section of a circuit is switched on, it is

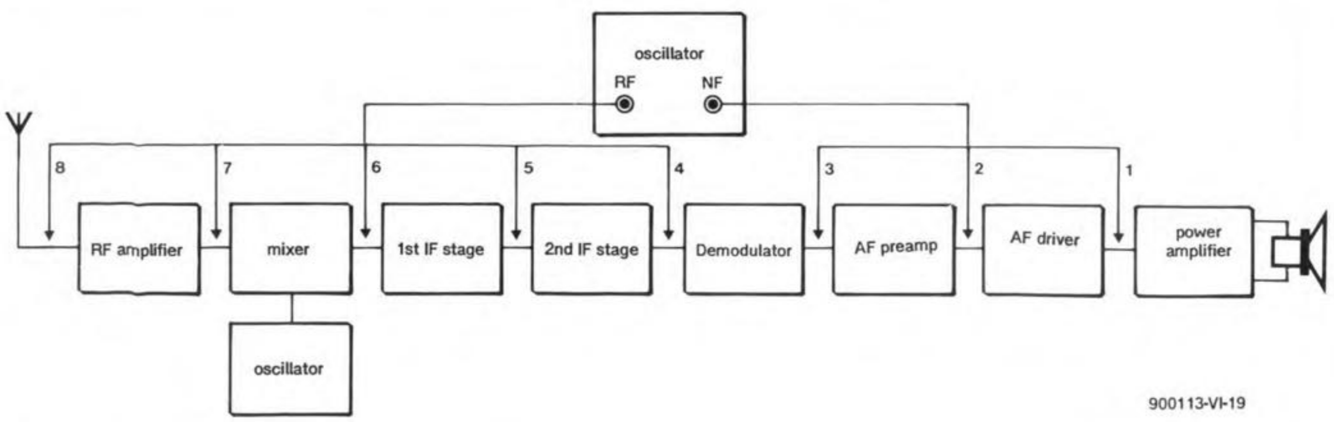
57



58



59



strongly advisable to check with an ohmmeter that there are no short circuits in either the components or the connecting wires or tracks in case of a PCB.

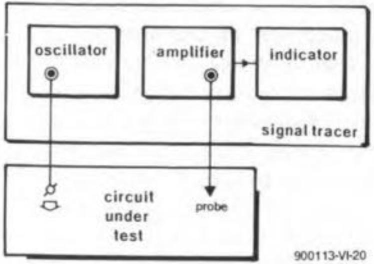
Signal tracing

A fault in a multi-stage audio amplifier is rapidly tracked to a particular stage with the aid of a signal applied to each stage individually or to the input and traced through the amplifier.

In the first case, a signal from an a.f. signal generator, or from a circuit as shown in Fig. 58, is applied first to the output stage and the output measured. If that is all right, the signal is applied to the driver stage(s) and the output checked. In this way, the signal is applied to the various stages backwards from the output, until the faulty stage is found.

The signal may also be applied to the input of the amplifier and then traced from the input onwards to the output. That stage which does not process the signal correctly, or not at all, is the faulty one.

60



All further faultfinding can now be concentrated on the faulty stage.

These methods of faultfinding may also be used in r.f. and i.f. amplifiers, but an appropriate r.f. or i.f. signal generator must then, of course, be used for the stages preceding the audio section—see Fig. 59.

As before, signal tracing is carried out from the input onwards. The input may be the first stage of an a.f. amplifier or the antenna input of a radio or television receiver. The output of each successive stage must then be inspected; this may be done with the aid of headphones in an audio amplifier. A sudden disappearance, distortion or attenuation of the signal at the output stage will indicate a faulty stage. If faultfinding is carried out frequently, it is advisable to obtain a signal tracer, which replaces a fairly expensive a.f. or r.f. generator and millivoltmeter. The principle of such an instrument is shown in Fig. 60—see also Ref. 1. (900113-VI)

References

"LF/HF Signal Tracer", *Elektor Electronics*, December 1989, pp. 20–23.

A REVIEW OF BOARDMAKER

by David J. Silvester

NEW to the European market, but firmly established in the United Kingdom are the range of integrated software packages for PCB and schematic drawing that are produced by Tsien in the English countryside close to the university town of Cambridge.

There are three packages in the range from the introductory version BoardMaker–1, which is for the occasional use professional and amateur markets, up to BoardRouter, which is a full autorouteing design package to rival many costing ten times as much. Since the more comprehensive packages are based on the facilities of BoardMaker-1, it is proposed to start at this point and work up noting the siginificant differences in the range.

BoardMaker-1

Any PCB designer familiar with the use of pre-drawn symbols, pads and tapes will find little difficulty in using the software equivalent of his or her manual method. BoardMaker–1 is exactly that, an introductory package that allows the designer to produce as a computer file the basic data necessary to produce an output on a ploter or laser printer that can be converted into an actual circuitboard either in-house or by an outside agency.

Readers who have already seen EasyPC from Number One Systems will find that BoardMaker-1 is very similar but has added to it a number of features that enhance its ease of use to a large extent. Loading of software is carried out by typing INSTALL from the A: prompt and following thr rest of the on-screen instructions. On starting the program, there is an initial menu screen that offers the choice of PCBN drawing, schematic drawing or entry to the library building options. If it sounds like EasyPC, that is not too surprising. With shades of Silicon Valley in the English countryside, Tsien was formed by a break-away group from Number One, who could not see the full potential that the Tsien guys could see for ther product.

There is little point in trying to give all the basic details of BoardMaker-1's capabilities in a review such as this, since it would be impossible to cover everything and the job is done much better by the demonstration package that Tsien supply free. TYhe demonstration pack comes with an excellent 68-page manual. Having spent the time to go through it thoroughly, you will be left in no doubt as how to operate the software and its full capabilities.

At £95, BoardMaker-1 must be compared directly with EasyPC at £98. All BoardMakers run on any PC or compatibvle from the XT to the latest 386 machines and if working away from the office on portable machines. BoardMaker is designed principally to work with EGA or VGA monitors and with these there are six colour options to display layers, witrh white reserved as a seventh for items on all layers such as IC pads. All BoardMakers can make use of eight trackable layers with two others for the upper and lower silk screens. All of the ten possible layers are held in memory and can be shown by selecting a colour for the layer although on,y six can be shown at any one time. In the case of CGA monitors, the colours are limited to red, blue and white. With the CGA or Hercules graphics in a portable PC, there is no colour but the software is still fully operational although the author would tend to limit its use to schematic drawing where the layers of a PCB are disabled and colours insignificant. In fact, in such a way BoardMaker would make an ideal service engineer's toll where all the latest schematics coul;d be held on file and examined in detail without the reproduction problems of other methods.

Outputs are available as HPGL, Gerber and NC Drill files so that the output can be used in-house or sent away for PCB manufacture.

BoardMaker-1 offers a number of advantages that any occasional PCB designer will find extremely helpful. The colour advantage prevents BoadMaker-1 from being a toy and puts it into the occasional usage professional, educational and amateur markets, where manual routeing and low cost are expected. Symbol design is included in the package as each designer will have his own requirement and it is a waste of space and cost to have a vast range of symbols most of which will never be used. However, a good starter pack is included for PCB layouts, less so for schematic symbols.

If, from the initial menu we take the route into the PCB drawing, we are presented with a windows type menu with seven across the top and a band across the bottom with details about the current status. In the centre is a box representing the full 17×17 inch drawing area and a smaller cursor cross in the centre. The menus are best described in the demonstation manual, but the most important part is that from intial entry the whole of the software is menu, and therefore mouse-driven.

Initial investigations should be made in the configuration menu to set up the mouse speed and type, although a quick look around in this menu reveals some of the vast range of capabilities. Pressing 'escape' or the right-hand mouse key pulls you back up the menus to the intital screen.

To load a drawing, you simply place the cursor on the 'load' menu and press the left-hand mouse key. This changes the bottom line to ask the file name. Nop need to worry of you can't remember the name of the file you want: a second press of the left-hand mouse key pulls down the window with all of the file names and the one needed can be dragged on to the drawing screen with the mouse. This is not to say that the keyboard can not be used as all of the pull-down menus have quick access routes through the keyboard and as the user becomes more familiar with the software he will tend to work with one hand on the mouse and the other on the keyboard.

Adding to this a highlighter to check track connections and a design rule checker for pad-pad, pad-track and track-track clearances gives the occasional user a high-quality package that can be expanded at a later date. For boards where a ground-plane is needed, there is a flood fill facility that will make BoardMaker–1 ideal for the RF designer when other facilities found in more expensive packages may be unnecessary.

BoardMaker-2

Adding £200 to the cost of BoardMaker-1 and with the addition of netlisting and ratsnest creates Boardmaker-2. Thus, BoardMaker–2 forms the heart of a comprehensive PCB/Schematic design package. At present, no integrated schematic package is available, but this is on the way. In the mean time, netlists can be imported from practically any schematic capture package via translators generated as an ASCII file and imported or created through the ratsnest facility on the PCB drawing screen.

Adding netlisting adds vastly to the checking capabilities of BoardMaker-2, ensuring a correct PCB at first try, and adds aneighth menu option at the top of the screen. This extra menu relates to the netlisting facilities.

For those unfamiliar with the concept, a netlist is the ASCII file that describes in great detail the connections in a schematic diagram, their relationship to the components on a PCB via the pin numbers and to the board layout itself. Their visualization on the PCB drawing is a set of crossing lines that indicate all of the connections that must be made on the final PCB. Once seen, the reason for their common name of ratsnest is obvious.

The reason that ratsnests are so important is that the original information fromes from a circuit diagram and is thus more likely to be correct tha any attempts at designing a board without the schematic drawing stage. When pulled into the PCB drawing, the ratsnest lines allow the designer to place each component in the best position for theb tracks to be placed. As an example, a PCB drawn by hand and admittedly rather well spaced occupied a 6×4 inch board. After reworking with a netlist and ratsnest this was reduced to a 4×2 inch board, an area reduction of ×3 and therefore a board cost of a third of the original.

Back annotation files can be created for altering the schematics after the PCB is renumbered. BoardMaker-2 is for the professional design office, where manual routeing is not a problem, but auto checking of the design is desired, and where it forms a parallel workhorse to an expensive design system. An improvement of 15–20∞ in efficiency over BoardMaker-1 is achieved owing to the checking facilties, but the symbols that are used for BoardMaker-2 are much more complicated than those for simple packages without netlisting, since they must contain details of their pin con nections.

BoardRouter

Top of the range and adding £200 to the cost of BoardMaker-2 is BoardRouter, which is the integrated package of BoardMaker-2 plus a channel-routeing autorouter. Being a channel router, it works well with both with pinned devices on a 0.1 inch or 0.05 inch matrix or surface mount and D-type connectors with a metric matrix. The speed of routeing is dependent on the operating speed of the PC itself, but still works on anything from an XT to a 386.

The additions of the autorouter adds a single menu option in the netlisting facilities, but this takes the user into the autorouteing option. Autorouteing is aimed at professional PCB designers although that is not to say that many other uisers of BoardMaker–2 will not want to upgrade to the autorouteing package. Once you have got the PCB layout with ratsnest, told the the net information of any special rules or track widths (say for power tracks), you can leave the software to sort out the routeing. That operation may take some time, many hours in some cases, but less than the designer would need to do the job himself. Once a track is laid, it can not be ripped up by the software and re-laid, so there will always be some tracks to be completed by hand and some tyding up to do. This is of little significance compared to the time that a board would take to be tracked by the designer alon e and, of course, it is possible to do other work while autorouteing is in progress. During the autoroutering, the software can automaticvallly save the results it has obtained after a tikme interval set by the user so that shoud the power failr all the work is not lost. However, autorouteing is rteally applicable only to double-sided boards or multi-layer boards so that one layer can have vertical tracks while the other carries horizontal tracks. Thus it is not suitable for simple boards, RF circuits or for layouts where the board can be single-sided with a few zero ohms links on the components side to jump tracks. For designers of logic and complicated analogue bnoards, where at least two layers are needed, autorouters can save an awful lot of work by the designer.

Problems

There are only a few minor criticisms that I have about the software as it stands at the present. The package allows a n umber of back-up copies of PCB drawings to be held on disc memory in case of a problem that results in the loss of the last working copy. In this case, there is no way that I have found whilst in BoardMaker to get at one of these back-ups. The only way appears to be to leave BoardMaker and use DOS to rename a file or use something like Xtree.

A similar problems exists with file organization or deletion or to make copies on floppy fopr archiving without a lot of work in the configuration menu.

The lack of schematic capture for BoardMaker-2 is being address and this will ease the problem of having to look outside Tsien for the necessary software. I shall look forward to revieiwing the schematic package when it becomes available.

Finally

With its BoardMaker and BoardRouter range, Tsien provides a comprehensive selection of PCB design packages for use by all persons interested in PCB design, from the amateur to the dedicated professional user. A policy of penalty-free upgrade means that it is possible to buy BoardMaker-1 as a trial and upgrade at a later time without incurring any extra expense over having bought the more sophisticated package in the beginning.

At their price, the capabilitiers of any of the packages leaves little extra to be desired. Do not be deceived by the low cost of the software packages. Experience has shown that many electronic designers are abandonming their in-house design offices to use BoardMaker or BoardRouter running on a PC in their own department. Tsien with their easy-to-use PCB-CAD packages have put PCB design back where it belongs: in ther hands of electronics engineers.

I should like to end by saying that, although impressed by the BoardMaker range of software, I have no commercial connection with Tsien. My thansk to Tsien who provided the copy of BoardRouter and the demonstration software for this review.

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Fax (0223) 277 747
who will be pleased to supply the demonstation software. One of the full packages may be ordered directly using any of the major credit cards. Boardmaker-1 = £95; BoardMaker–2 = £295; BoardRouter = £495. (910069)

LOGIC ANALYSER - PART 5

by K. Nischalke and H.J. Schulz

ALTHOUGH the software described in this final part of the article was developed for the Atari ST and TT series, it has been adapted for use on all personal computers using an MS-DOS. The respective floppy disks are available through our Readers' services. The software for the Atari consists of the compiled program only, whereas that for other MS-DOS computers embraces the program proper and the source code in Turbo C.

Note that the description in this article is based on the Atari program. However, both programs are so accessible as to make detailed user instructions superfluous. All matters that are concerned directly with the measurements are shown on the screen. All supported functions, such as reading, storing of data, and printing, are accessible via pop-up menus (Atari) or certain keys on the keyboard.

Display

Distinction is made between physical and logic channels. The former, of which there are up to 64, are inputs of the analyser stored on the RAM card(s), whereas the latter are outputs of the analyser, of which there are also up to 64. Since the space on the screen is limited, only 16 logic channels are shown at any one time.

When the program is started, the physical and logic channels are linked directly, that is, input 1 of card 1 corresponds to logic channel 1, and so on. However, the software makes it possible to link the channels in any way the user wants. It is even possible to link one physical channel, for example, the one connected to the clock, to several logic channels. The clock will then appear at several locations in the timing diagram on the screen. The relation between that signal and associated signals is then very evident.

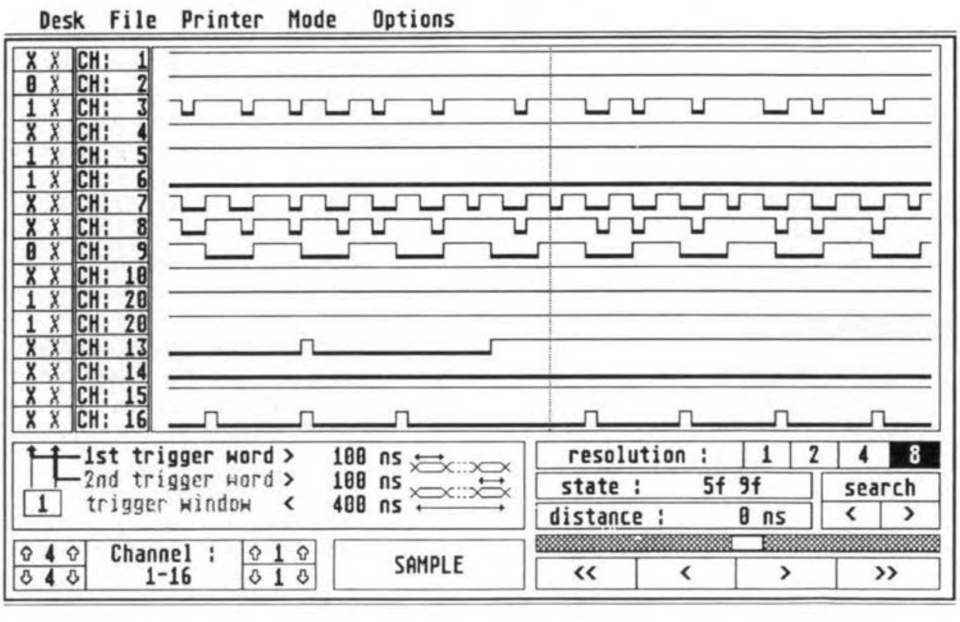
So as not to lose track of the various signals, the column alongside the timing diagram—see Fig. 5—shows which channel belongs to which trace and vice versa. What is shown in this column depends on the selections made via the options menu. A choice may be made, for instance, between text or the number of the physical channel. When the program is started, the numbers of the logic channels are shown in the column. A click with the mouse in the relevant channel box will produce a box on the screen, in which may be indicated which physical channel is required to be associated with the chosen logic channel, and which text belongs to it. This text may contain up to six characters. If a physical channel is linked to a second (or third) logic channel, the text associated with that channel is copied automatically. Furthermore, alterations in the text, irrespective of in which logic channel these are effected, are copied automatically to any other logic channels that may be associated with the particular physical channel.

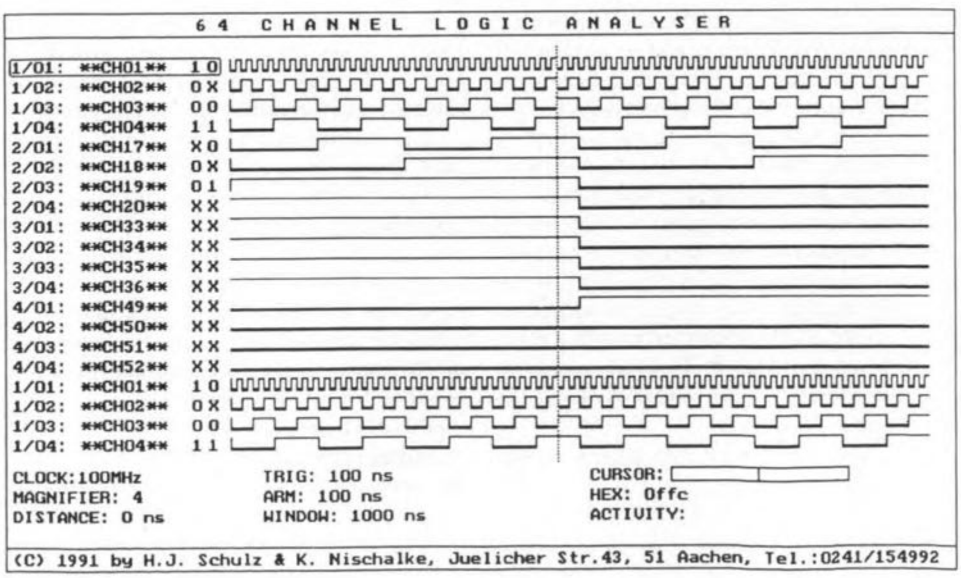
Triggering

The trigger word is linked to physical channels. If a physical channel is associated with more than one logic channel, the software ensures that alterations in the triggering are copied to all the associated logic channels.

The trigger word is shown at the left of the timing diagram on the screen. By clicking with the mouse on an appropriate bit, the trigger bit may be set to 1, 0, or X (don't care). In the 100 MHz mode, the second trigger word is set in a similar manner.

Other aspects of the triggering are shown in the window at the bottom left-hand side of the screen. The number in the small rectangle indicates which trigger words have been chosen; note that during measurements up to four trigger words may be used. Clicking with the mouse suffices to select another





word. Also shown are the times that indicate the required width of the trigger pulses. Click on the number to choose the correct time. The computer will select the nearest value that may be set on the analyser.

When the pulse width of trigger word 2 is set, the program ensures that the trigger window is always wider than the trigger pulse to prevent a situation in which the analyser can not be triggered. That situation may, of course, arise also if the trigger condition is not contained in the measurand (quantity to be measured). In that case, the analyser should be stopped by pressing any key on the keyboard. The analyser is started again by clicking on SAMPLE.

Screen functions

It is not possible to place all recorded data legibly and simultaneously on to the screen; therefore, only 16 channels are shown at any one time. The remainder of the channels may, of course, be scrolled into view, one or four channels at a time. The scroll function is shown at the bottom lefthand side of the screen. Number and direction are selected by clicking with the mouse.

In the same window is shown which logic channels are shown in the timing diagram. These may be shifted by moving the diagram horizontally with the cursor shift (<<, <, >, >>, at the bottom right-hand side of the screen: the mouse is pointed, clicked (and held) at the blank box in the shaded bar, after which the box can be moved as required.

There is also a search facility, for which the first trigger word serves as the search pattern. Click the mouse on the desired direction and the search is started. The cursor then stops at the sought sample, which is to the right of the cursor. In the status window is shown hexadecimally what data are shown at the cursor position.

The distance window enables the distance between two points to be measured. Point the mouse at the starting point and click on the left-hand button, hold this, and point at the stop position; when the button is released, the window will show the distance in nanoseconds.

Clicking on the numbers following "resolution" makes the computer portray the sample in 1, 2, 4, or 8, pixels.

Menus

A number of functions that are not related directly to the measurements and their display are enabled via a number of menus.

File/SAVE enables the recorded data to be stored in a file on disk. These data may be used at a later stage for comparison with newly recorded data. The data so stored may be read again via File/LOAD. The program is terminated by clicking File/EXIT.

Hard copy may be obtained in two ways: Printer/SCREEN allows the printing of only those data that are displayed on the screen, while Printer/ALL allows the printing of all recorded data.

The clock is set via Mode. If an external clock is used, the qualifier inputs may be set via CLOCK SET.

With Options/TEXT selected, a text is shown together with the channels; the default text is the number of the logic channel.

With Options/NUMBER selected, the number of the physical channel is shown (card plus input).

With Options/SAVE TEXT selected, the set links between the physical and logic channels are stored, together with the associated text and trigger words. The data so stored may be selected again with Options/LOAD TEXT.

With Options/COLOR selected, the background colour of the image is selected. If that is black, the colour changes to white and vice versa. (900094-VI)

Correction

It is regretted that in Part 4, under "Overview", it was stated erroneously that a '10 kΩ resistor must be soldered between pins 11 and 16 of IC_{29}' on the RAM card; the value of the resistor should have read 330 Ω.

Radio Data Systems:

a few facts and figures

The concept

Most of us are familiar with the teletext services offered by the BBC and the IBA in the UK and television stations in most other countries. These services enable us to keep up-to-date with news, finance, sport, weather and traffic conditions by means of information that is transmitted as part of the normal sound and picture, but which is not apparent during normal viewing.

Radio Data System operates in a broadly similar way on transmissions in the VHF radio band by using that part of a transmitted signal that lies outside the audio bandwidth.

This concept has been used for many years as the one that enables stereo signals to be transmitted and received without the need of tuning to two transmitters at the same time.

Driving with RDS

RDS is more than stereo transmission methods and more than the Teletext idea. It forms the basis of an information and entertainment centre for drivers when comfort and safety ensure that the all-important aspect of concentration on the road is maintained.

For instance, your radio will make sure that you do not need to keep re-tuning, because it keeps track of the most powerful transmitter and automatically and inaudibly changes frequency for you. It switches between two sound levels, one for speech and one for music, and it will automatically read aloud traffic announcements in your language, wherever you may be in Europe. In fact, a radio equipped with RDS will make these announcements even if the cassette player is operating, or when the radio is on stand-by. So, you will never be cut off from important road traffic information.

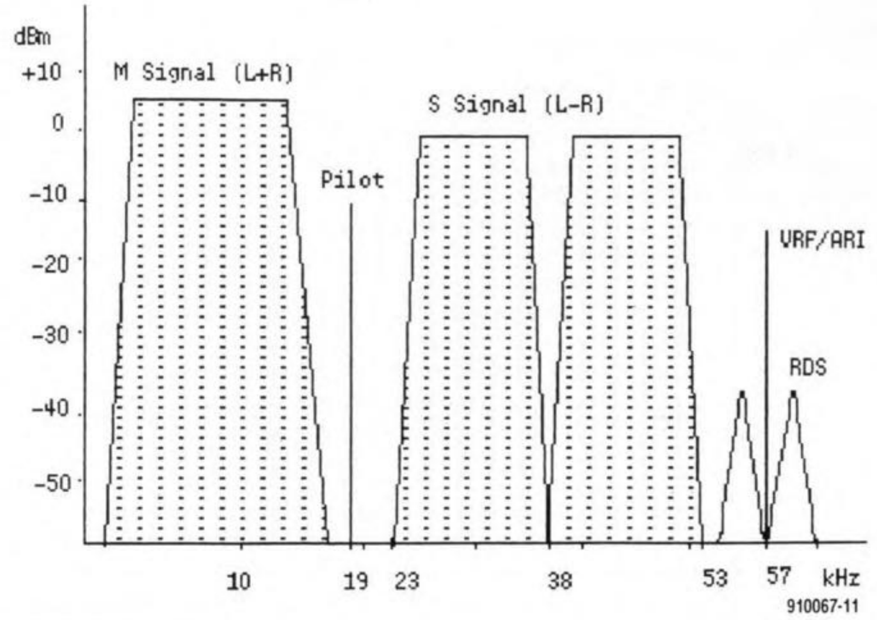
To further enhance driver confidence, a built-in paging service informs you to call home, office or one of several other designated numbers.

Thus, RDS provides the ultimate in in-car entertainment with a complete information service built in. Technically, RDS is a system for the simultaneous transmission of digital data and the normal stereo broadcast. The digital data itself consists of two parts: the static data, such as the identity of the station concerned; and the dynamic, or variable, data that changes constantly.

The transmitter combines the digital data with the broadcast without decreasing the signal quality. The receiver decodes the signal and routes the data to the display and the programme to the loudspeakers.

Some technical details

The system is limited to the VHF bands owing to the wide bandwidth assigned to each station. The sub-carrier frequency chosen



for the system is 57 kHz, which is three times the pilot tone used for the stereo frequency response threshold. To prevent interference, the RDS sub-carrier is phase-locked to the stereo pilot tone. The diagram shows a graphic representation of a stereo multiplex baseband with RDS. The signal is amplitude modulated by coded information representing the 0s and 1s of the data stream. The transmission rate of this stream is 730 bps, which enables a fast update of information that is itself transmitted in groups of four 26-bit blocks.

Services provided by the RDS include Programme Identification (PI), which includes a location and a programme reference number; Programme Service Name (PN), which displays the station identity on the radio display; Alternative Frequencies (AF), which provides information on other frequencies transmitting the same programme; Traffic Programme Identification (YTP) and Traffic Announcements (TA), which combine to indicate whether the station carries traffic news and the content of that news.

Other services provide Clock Time (CT) and Paging (PG), while a sophisticated test feature, used by broadcasters, is also available as an In-house application (IH).

RDS equipment

Just as a stereo broadcast is impossible without the proper equipment, RDS can not work without appropriate hardware. Suitable equipment is manufactured by RE Instruments, whose products have been approved by the German broadcasting authorities. The three mains products required are and RDS Generator, and RDS Encoder, and an RDS Decoder.

Encoding the data for RDS

An RDS encoder is perhaps the most important item needed to transnmit a digital data stream. Accepting the 19 kHz pilot stereo tone to create the 57 kHz sub-carrier, the Type RE531 Coder is programmed with the static and dynamic data. The most appropriate means of programming the Coder is a computer or a network interface. Once the Coder has been programmed with the static data, that information will be retained permanently. The dynamic data is updated as required.

Monitoring and re-broadcast

To ensure that the transmitted data is error-free, a suitable decoder, such as the RE331, is required. The task of this unit is to monitor the transmission and confirm the RDS signals involved. The unit may perform two functions: (a) checking the data and raising alarms if the data fails to conform to programmed parameters, and (b) routeing the dynamic signals transmitted by one station to another that is broadcasting the same programme.

Testing RDS receivers

The Type RE530 RDS Generator is an instrument designed to allow comprehensive testing of RDS receivers. An RDS generator has to emulate an RDS transmitter on the test bench to enable a full analysis of the RDS receiver to be carried out. The Type RE201 Dual Channel Audio Test System may be combined with the RE530 to provide a full and comprehensive automatic system to test all RDS radios.

Approvals and Standards

Radio Data Systems have been established in Europe for some time. During 1982, five different systems were tested by the European Broadcasting Union (EBU), who decided that the Swedish PI system was the best and would form the basis for future development. Field trials held in Germany led the EBU to issue and agreed standard: EBU Doc. Tech. 3244, March, 1984. All RDS equipment in western Europe must be manufactured in accordance with that standard.

Development of RDS equipment continues, however, and since 1984 new features have been added and, no doubt, others will be added in the future.

While it is important that equipment be designed to conform to EBU standards, it is equally vital that approval by the national broadcasting authorities be granted. The RE Instruments range of RDS products have full approval from the German ARD and FTZ authorities.

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