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April 1990

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Elektor Electronics

Video line selector

Q meter

Automatic mains switch

RS232 splitter

Bridge rectifiers revisited

Coded locking circuit

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Elektor Electronics

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- Intro scan for CD players
- The multi-MAC chip concept
- Analogue-to-digital converter

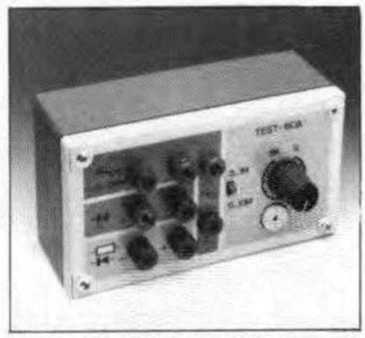
Front cover

Although MAC television pictures can not be received on current PAL TV sets, there are already two D2-MAC channels on the Astra TV satellite (which also transmits the Sky programmes). Moreover, French (TDF-1), German (TV-SAT2) and British (BSB) satellite TV programmes will be in MAC: experimental or test programmes from all three have already been transmitted for some time. The signals from all three are strong and totally noise-free over most of western Europe.

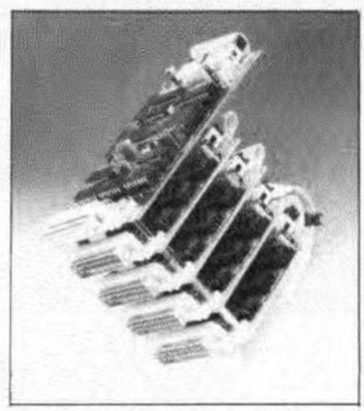
Although in Britain there are only four terrestrial channels and the Sky programmes, large parts of western Europe have a choice of over 20 different TV channels either by cable or by dish aerial. One day, British viewers will also have a choice of that many channels, but it will take time, particularly since many are not too interested in continental programmes, or are they? This is in sad contrast to Europe, where both the BBC and the ITA channels are available and watched by many.

The TV pictures shown were taken by a Dutch radio/TV amateur early this year: they clearly show the choice available to western European viewers.

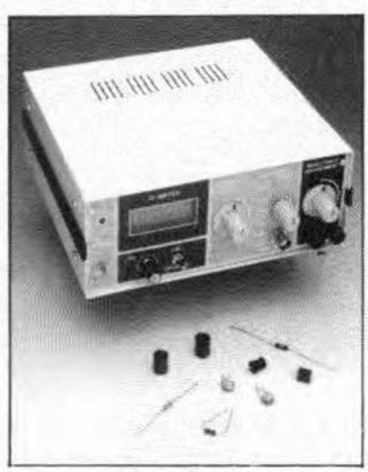
Profile of Watford Electronics p. 50



Test box - p. 51



RS-232 splitter - p. 14



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RS-232 SPLITTER

A. Rigby

Among the computer peripherals that are typically connected to an RS232 port are mice, plotters, tracker-balls, digitizers, printers, scanners and modems. Not surprisingly, therefore, many computer users are forced to switch off their machine and perform the plug exchange trick when another peripheral is to be used. The RS232 splitter eliminates this annoying problem by allowing up to 256 (yes) serially controlled devices to be selected on 1 (yes) RS232 port. Switches and the like are not required, since the selection of the peripherals is effected by software.

There is a clear discrepancy between the serial interface capabilities of the average PC and the ever growing number of peripherals purchased or built by computer users. Most PCs offer only one RS232 port, while any extension beyond two of these is relatively expensive. As result, tangled cable nests may be found behind many a PC, since a serial port may usually serve one peripheral only.

Not surprisingly, many PC users would like to see a compact, inexpensive and simple-to-use switching system for a large number of peripherals. So-called switch-boxes offered commercially generally allow two peripherals to share one RS-232 port. Apart from the fact that an increase from one to two peripherals is not exactly spectacular, these boxes must be switched by hand, which requires that they are placed near the computer.

The RS-232 splitter has none of these advantages because:

- it can handle many more than two peripherals;
- it is controlled by the computer;
- it may be installed at a considerable distance from the computer.

RS-232, a flexible interface standard

The RS-232 port has been in use for many years, mainly by virtue of its flexibility, its ability to cover long distances, its transmission speed options and good noise immunity. The most practical boon is, however, that data may be carried over a single wire. In the most rudimentary configuration, a peripheral may be connected to a computer by three wires only: TXD for transmitted data, RXD for received data, and GND (ground). By contrast, a parallel connection requires at least 10 wires: 1 for ground, 8 for the data signals and 1 for the STROBE signal. At least 11 wires are required if handshaking is used, since in that case either BUSY or ACKNOWLEDGE must be added. Although the 3-wire serial link may use the XON/XOFF protocol —i.e., software — for handshaking, a hardware alternative is often preferred in view of speed and the use of simpler I/O routines. A hardware handshaking arrangement generally uses a number of control signals, while software handshaking is based on transmission and reception of certain words that control the dataflow in accordance with the speed of the computer and the peripheral.

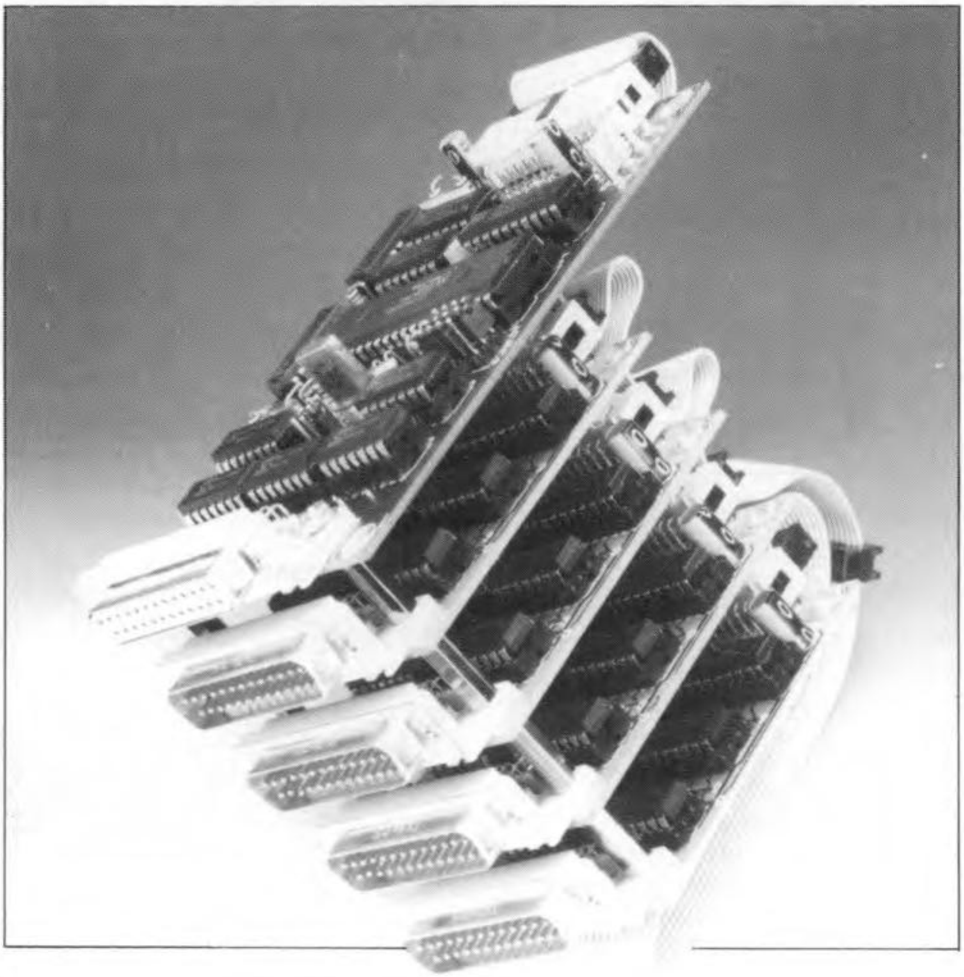


Figure 1 shows the most commonly used RS-232 link. A computer is generally classified as DTE (data terminal equipment), and a peripheral as DCE (data communication equipment). A zero-modem connection may be used in those cases where a number of control signals is not available. Control- and data-lines may also be crossed to enable two computers (both DTE) to communicate via a serial link. The best known zero-modem connections are shown in Fig. 2. The RING INDICATOR (RI) line is not shown in these drawings because it is used on some modems only to signal to the computer that the auto-answer function has been actuated. The RI line is not normally used in applications other than with modems.

Switching by software

To guarantee compatibility with many RS-232 peripherals, all eight control lines on the interface must be switched automatically. Obviously, the ground line need not be switched since it is common to all equipment.

If, for instance, the computer is to be connected to a particular printer with a serial input, all control and data signals of a particular RS-232 outlet on the splitter

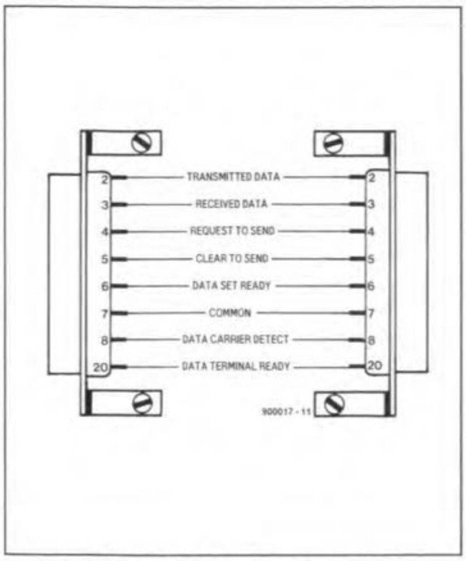


Fig. 1. Standard RS-232 connections.

(to which the printer is connected) are passed to the relevant pins of the computer's RS-232 port. All other equipment connected to the splitter is disconnected from this port.

The passing of signals between the computer and the selected peripheral must be done in the simplest way. In the case of the RS-232 splitter, this has been achieved by the use of software that transmits the peripheral selection code via the RS-232 port itself. Such a code is essentially a short trigger pulse which is sent by the computer. It is not recognized as data by the peripherals since the TXD line is briefly switched to a much higher transmission speed. The RS-232 splitter, however, does recognize the trigger pulse and is switched to receive and process the databyte that follows it. On reception of the trigger pulse, the splitter prevents the subsequent databyte being passed to the peripherals. Thus, channel selection happens unnoticed by the peripherals.

There are several ways to generate the trigger pulse. The actual method used depends on the computer type and your programming skills. Many computers allow the RS-232 port lines to be controlled by machine code or, say, a program language like C. A small program may be developed, for instance, to make the TXD line low for one clock pulse. If this does not work out, an alternative method may be to briefly select the highest bit rate on the RS-232 port and transmit character FF_H, which consists of a single low level (the start bit). The disadvantages of this approach are that the highest bit rate offered by the computer is no longer available for the peripherals, and that two *R-C* combinations must be changed in the RS-232 splitter. Some computers, such as the Commodore Amiga 500, offer a maximum bit rate as high as 250 kbit/s, which results in a single 4-µs long TXD pulse. This setting may be sacrificed to the above purpose of splitter channel control, since peripherals operating at 250 kbaud are rare.

Users of IBM PCs and compatibles are in the fortunate position of being able to order a disk which contains a simple peripheral channel selection program. The practical use of this program is simple: just enter the filename followed by the channel number of the desired peripheral.

How it works

The circuit in Fig. 3 contains the trigger pulse decoder and the channel selection logic. Every one serial channel requires one extension circuit, which is shown in Fig. 4. This is constructed on a small board and connected to the main board by a short length of flatcable. The number of extension boards may increase as the need for more serial channels develops.

The RS-232 interface of the circuit is shown to the left in Fig. 3. A total of ten buffers is used: five for input and five for output. The buffers are needed for signal level conversion since the circuit works with TTL levels (max. 5 V), while the RS-232 signals may swing between +12 V and −12 V. Note, however, that although a growing number of computers is capable of accepting TTL levels at the RS-232 port, there are good reasons to stick to positive and negative levels with a maximum of 12 V, mainly because these afford a larger noise margin.

Of all signals on the RS-232 connector, only TXD of the computer is used by the circuit —all other signals are simply switched through to the peripherals. The TXD signal, called S-IN after level conversion, triggers monostable multivibrator (MMV) IC_{5a} with each falling pulse edge. External components R_6-C_1 give the MMV a monotime of about 6 µs. If S-IN is still low after this monotime has lapsed, the pulse edge that triggered the MMV did not belong to a trigger pulse. The trigger pulse detection is, therefore, based on pulse-width comparison with the monotime. This is achieved with bistable IC_{7a}, whose clock input is connected to the Q output of IC_{5a}. During the falling pulse edge, i.e., at the end of the monotime, the bistable outputs take on levels determined by the information at the J- and K-inputs. The K-input is tied to ground. When the J-input is low owing to pulses shorter than 6 µs, the bistable output levels do not change. If, however, the pulse is shorter than 6 µs, the J-input will be high at the end. Output Q goes high to signal that the trigger pulse has been detected.

The MMV monotime is set to 6 µs to allow a safety margin of about 1.5 times between the pulse time (max. 4 µs) and the pulse detection time.

Gates IC_{6a}–IC_{6d} in combination with IC_{5b}, IC_{9a} and IC_{7b} keep the trigger pulse from being passed to the peripheral(s). Bistable IC_{5b} receives a clock pulse via IC_{6a}–IC_{6d} at every level change of S-IN. This clock pulse has a length of about 60 ns owing to the propagation delays of the HCT gates. Exactly 6 µs after the clock pulse, the Q output of IC_{5b} goes low again, so that J-K bistable IC_{7b} latches the levels present at its J- and K-input. Pulses shorter than 4 µs are not noted since they have been eliminated already and can not, therefore, appear in the serial output signal.

All other pulses that form serial data on the S-IN line are passed by the bistable. From the $\overline{Q}$ output, the S-IN signal is supplied to the peripherals via IC_{10a}. Since the Q output of IC_{7a} goes high on every trigger pulse, IC_{10a} prevents the subsequent data-

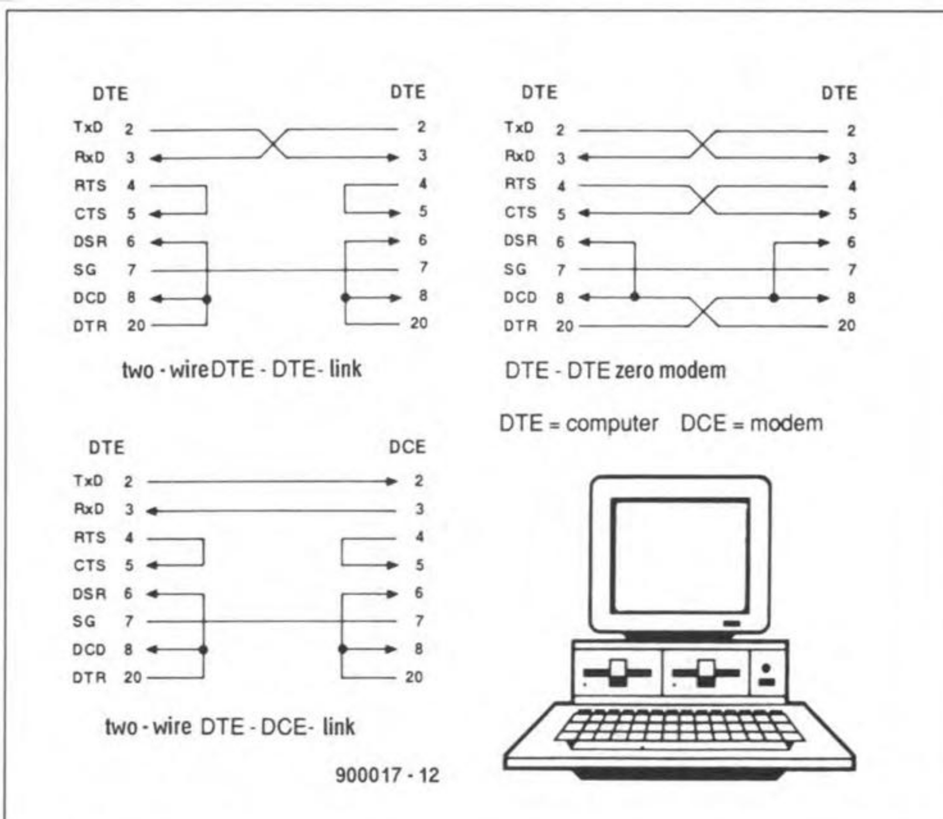


Fig. 2. In many cases, a full-blown RS-232 connection is not required. Shown here are three simple links between DTE and DCE, and between DTE and DTE (zero-modem).

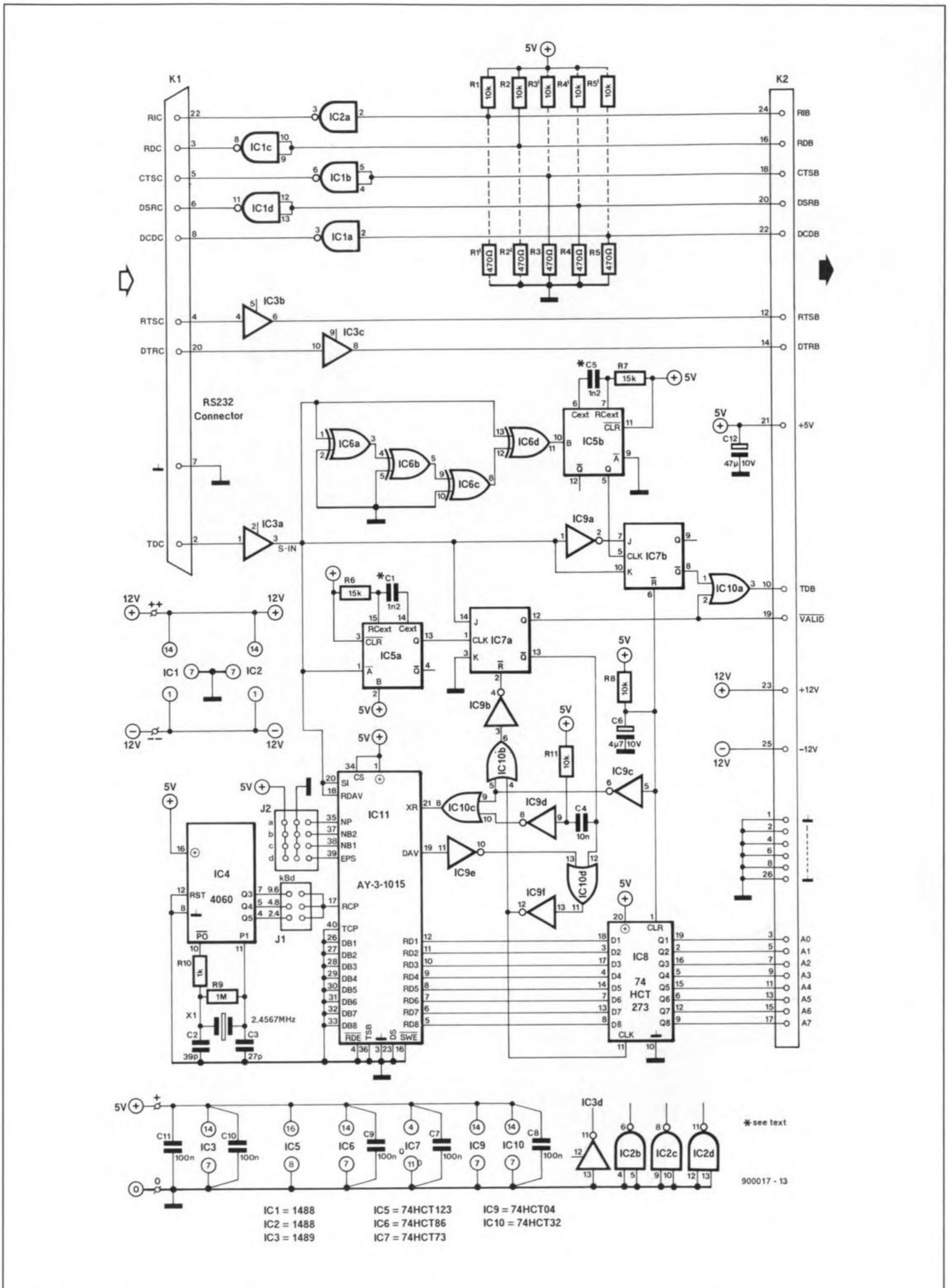


Fig. 3. Circuit diagram of the motherboard, which contains the trigger pulse decoder and channel selection logic to address individual extension boards.

word reaching the peripherals. This condition is ended as IC_{7a} is reset.

The channel number that follows the trigger pulse is decoded by a UART (universal asynchronous receiver/transmitter) Type AY-3-1015, which is an industry standard chip. After IC_{7a} has been set by the trigger pulse, the UART, IC_{11}, is reset via network R_{11}-C_4 and inverter IC_{9d}. This is done to ensure that it is cleared and ready for the reception of the dataword which determines the channel selection. The bit rate at which the dataword is sent by the computer is set with jumper J_1. Three bit rates, 2400 baud, 4800 baud and 9600 baud, are available from a quartz-crystal controlled oscillator/divider, IC_4. In practice, it will be convenient to use the same data rate for the channel selection code and the normal communication with the peripheral(s).

The DAV (data available) output of the UART goes high on reception of the channel selection code. The positive pulse edge causes the code available in parallel form to be latched into IC_8. The $\overline{Q}$ output of IC_{7a} prevents error pulses from the DAV output reaching IC_8. Error pulses may occur since the UART receives all serial data, whether these are channel selection codes or not. The high level at the $\overline{Q}$ output of bistable IC_{7a} prevents IC_{10d} blocking the DAV pulses. A valid DAV pulse resets IC_{7a}, so that the next pulses on the S-IN line are sent as normal data to the peripheral(s).

On power-up, network R_8-C_6 resets bistables IC_{7a}, IC_{7b}, register IC_8 and UART IC_{11}. This is done to make sure that the computer is connected to the peripheral on channel 0 when the system is switched on. The peripherals and the computer are not reset, however, so that the splitter may be switched on the moment it is required.

The circuit diagram of an extension board is given in Fig. 4. Every peripheral connected to the RS-232 splitter has its own extension board. Word comparator IC_{20} forms the channel code detector. Its P-inputs accept the decoded dataword from the computer, while its Q-inputs accept the pre-set channel number to be assigned to the associated peripheral. If the words match, pin 19 goes low. The channel preset is defined as a binary value with the aid of jumpers. Channel code 0 ($0000\ 0000_2$) is achieved by connecting all jumpers to ground, and channel code 255 ($1111\ 1111_2$) by connecting all jumpers to +5 V.

The actuated $\overline{P=Q}$ output of the 8-bit word comparator enables buffers IC_{23} and $IC_{21a\text{-}b\text{-}c}$ to establish the connection between the computer and the selected peripheral.

Level converters $IC_{22a\text{-}b\text{-}c}$, $IC_{24a\text{-}b\text{-}c}$ and IC_{25} ensure the correct voltage levels on the RS-232 output lines.

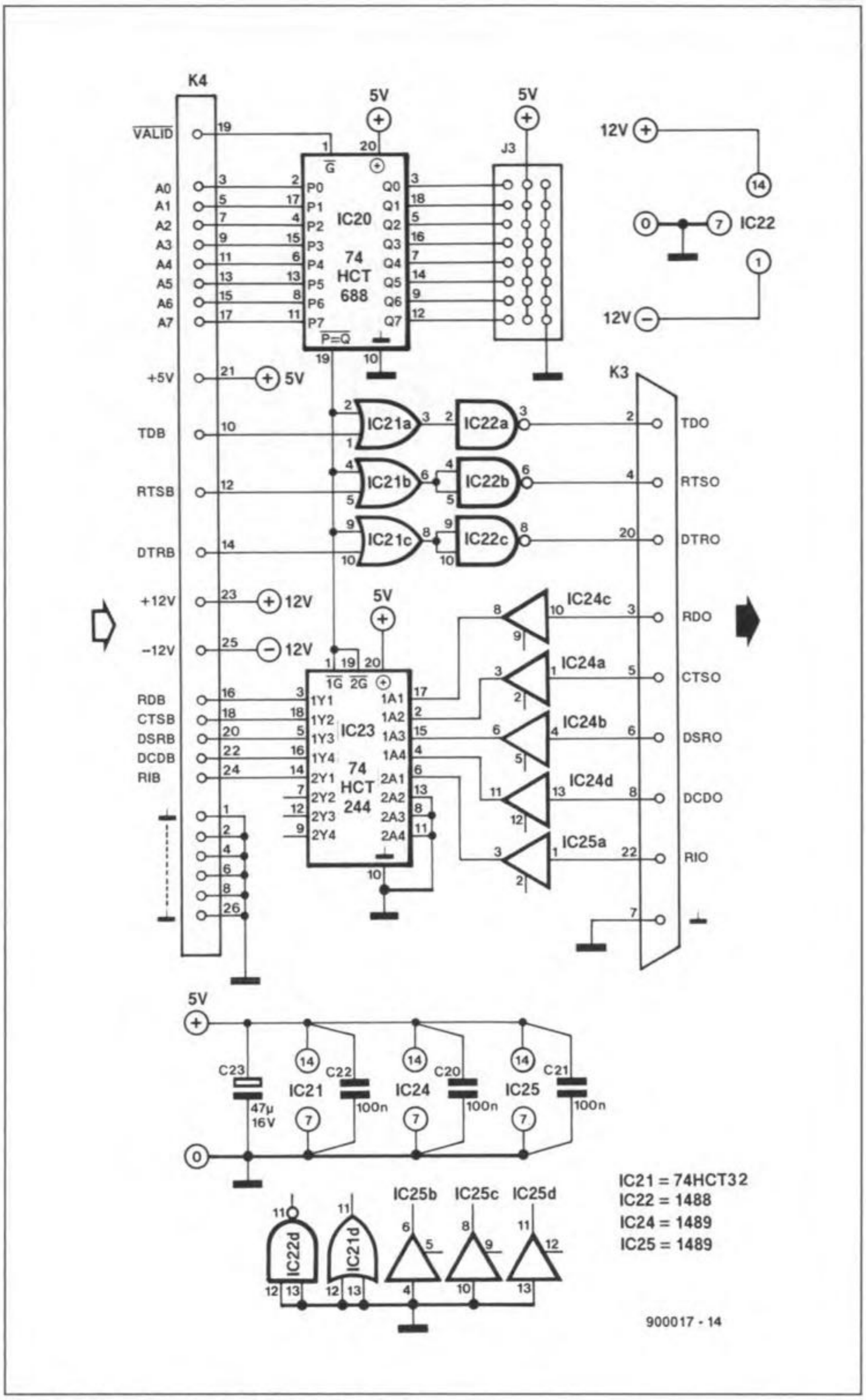


Fig. 4. Circuit diagram of extension board.

Construction

The track lay-outs and the component mounting plan of the main board are shown in Fig. 5. This board is double-sided, but not through-plated. On the ready-made printed-circuit board, the locations where a short piece of wire must be soldered as a through contact are indicated by silver-coloured pads at the component side. A few of these through contacts are made by soldering resistor terminals at the track side and the component side. If ICs are soldered direct on to the board, the white print on a few pads has to be removed. Fortunately, this is achieved almost automatically as a result of the heat developed during the soldering operation. The advantage of soldering the ICs direct is that the pins form the through-contacts, so that wires near the pins are not required. These holes must, however, have through-wires if IC sockets are used.

Do not start fitting parts on to the board before all through-contacts have been checked and found to be in order. The actual population of the main PCB is straightforward.

The extension board is shown in Fig. 6. It is single-sided and has 17 wire links, which must be fitted first. As with the main board, the decision whether or not to use IC sockets is up to you. The pin header block for the channel address setting is made either from three single-row pin headers or one dual-row and one single-row type. The extension board is

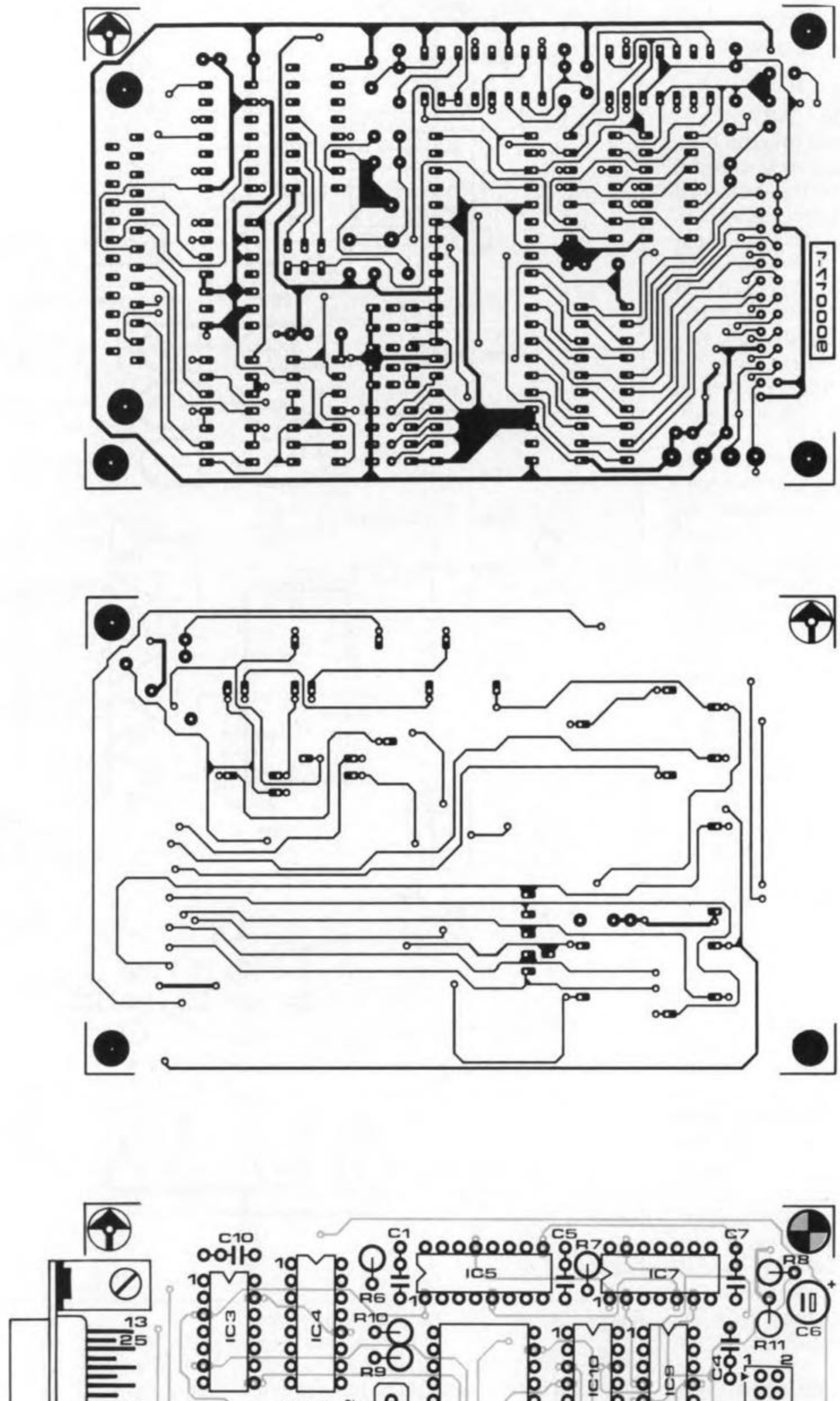


Fig. 5. Double-sided printed-circuit board for the central unit. Note that this board is not through-plated.

COMPONENTS LIST

MAIN BOARD

Resistors:

2	10k	R_1;R_2
3	470Ω	R_3;R_4;R_5
4	10k	R6;R_7;R_8;R_{11}
1	1M0	R_9
1	1k0	R_{10}

Capacitors:

1	1n2	C_1
1	39p	C_2
1	27p	C_3
1	10n	C_4
1	1n2	C_5
1	4µ7 16 V radial	C_6
5	100n	C_7–C_{11}
1	47µ 16 V radial	C_{12}

Semiconductors:

2	1488	IC_1;IC_2
1	1489	IC_3
1	4060	IC_4
1	74HCT123	IC_5
1	74HCT86	IC_6
1	74HCT73	IC_7
1	74HCT273	IC_8
1	74HCT04	IC_9
1	74HCT32	IC_{10}
1	AY-3-1015	IC_{11}

Miscellaneous:

1	quartz crystal 2.4576 MHz	X_1
1	25-way angled sub-D connector (female)	K_1
1	26-way angled pin header	K_2
1	6-way pin header	J_1
1	pin header block; 3 off 4-pin contact strips	J_2
8	jumper	
1	PCB	900017-1

COMPONENTS LIST

EXTENSION BOARD
(one required for each RS-232 peripheral)

Capacitors:

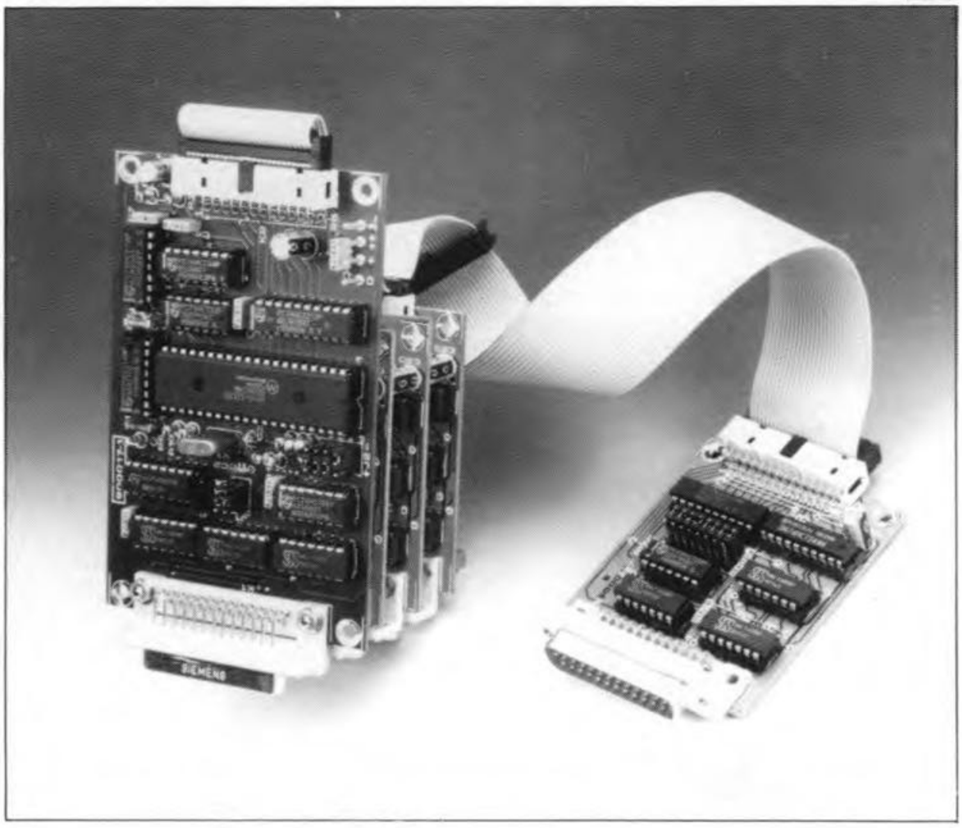
3	100n	C_{20};C_{21};C_{22}
1	47µ 16 V tantalum	C_{23}

Semiconductors:

1	74HCT688	IC_{20}
1	74HCT32	IC_{21}
1	1488	IC_{22}
1	74HCT244	IC_{23}
2	1489	IC_{24};IC_{25}

Miscellaneous:

1	25-way angled sub-D connector (male)	K_3
1	26-way angled PCB header	K_4
1	pin header block; 3 off 8-pin contact strips	J_3
1	PCB	900017-2



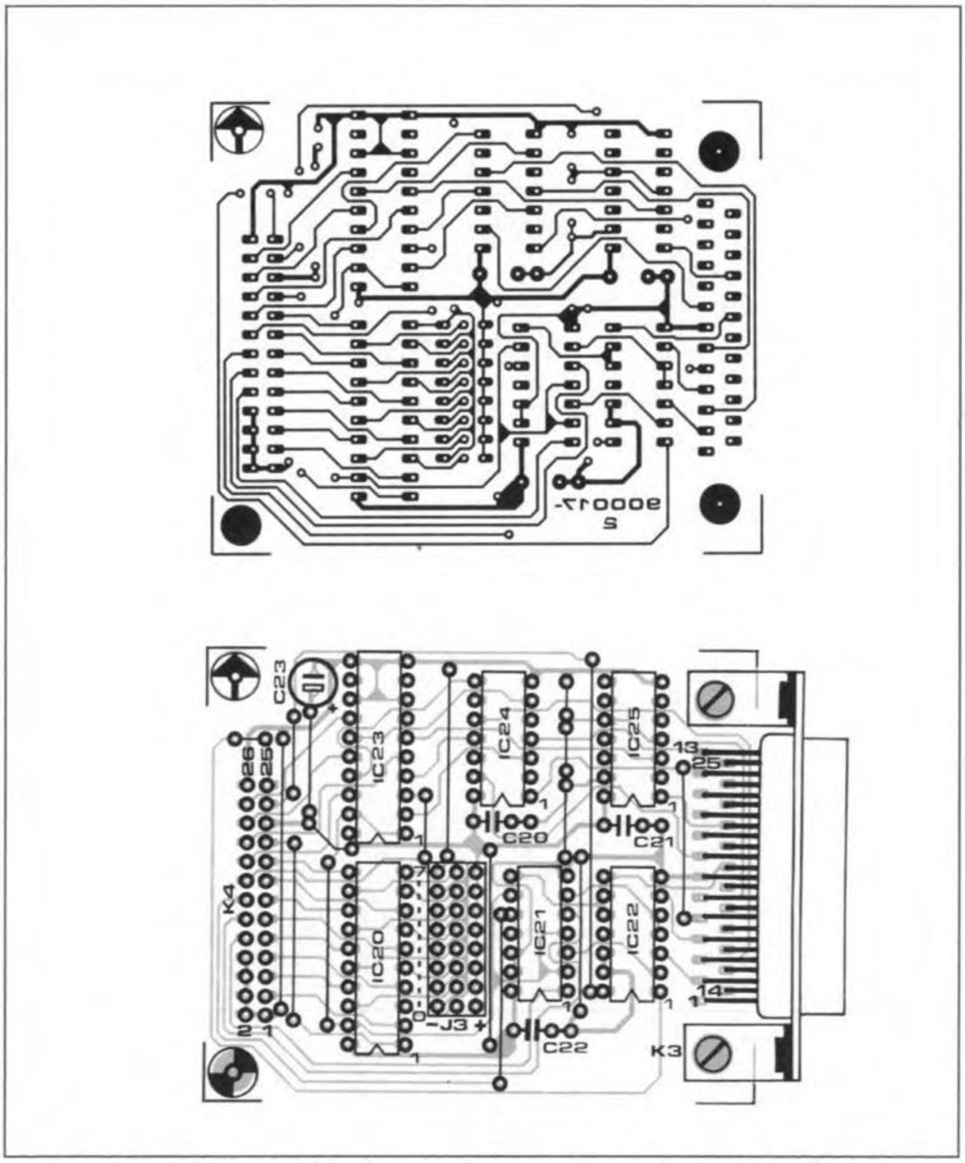


Fig. 6. Printed-circuit board for the extension (one required for each RS-232 peripheral).

connected to the main board via K_4, and to the peripheral via K_3.

Power supply and serial data format

The power supply for the circuit must have +5-V, +12-V and −12-V outputs. The current required by the circuit depends on the number of extension boards installed. In some cases, the supply voltages may be obtained from the PC.

The serial data format (start/stop bits, and parity bit) is set with jumpers J_{2b}, J_{2c} and J_{2d}. The most widely used format, one startbit, eight databits, no parity and 1 stopbit, is set with jumpers J_{2b}, J_{2c} and J_{2d} to +5 V, and J_{2a} to ground.

Software and component values

The hardware is not complete without a computer program that provides the required trigger pulse and the channel selection code to actuate a particular channel (0–255). Since the control of the TXD line is specific to the type of computer and its RS-232 interface, the model program given in Fig. 8 is based on the use of the highest baud rate for the generation of the trigger pulse. The BASIC program is simple by almost any standard, and should not be too difficult to adapt for a particular type of computer or interpreter. The bit rate for the trigger pulse is set to 9,600, so that the highest possible bit rate for normal use of the peripheral(s) is 4,800 at the highest.

If bit rates other than the ones mentioned above are used, networks R_7-C_5 and R_6-C_1 must be modified accordingly. The values shown in the circuit diagram are for a trigger pulse shorter than 4 µs. If a longer trigger pulse is used, the new *R-C* values may be calculated on the basis of the monotime, τ, obtained from

$$\tau = 0.45RC \text{ (ns)}$$

where *R* is in kilo-ohms and *C* in pico-farads. Remember that *C* must be greater than 10,000 pF (10 nF). Also note that the calculation is valid for a 74HCT123 only, **not** for a 74123 or 74LS123, which must not be used here.

If, for example, a bit rate of 9,600 is chosen, the associated pulse time is

$$1/9600 \text{ s} = 104 \text{ µs}$$

To ensure a safe margin between the pulse time and the monotime, the latter is made roughly 1.5 times longer, i.e., 150 µs. The shortest pulse time that can occur in a datastream of 4,800 bits/s is 210 µs, i.e., much longer than the monotime of 150 µs. Starting from a capacitor value of 12 nF (12,000 pF), an associated resistance of

$$150{,}000/(0.45 \times 12{,}000)$$

or roughly 27 kΩ should give adequate results.

In conclusion, for a system in which the trigger pulse is transmitted at 9,600 baud, and the peripheral data at 4,800 baud, both networks R_6-C_1 and R_7-C_5 consist of 27-kΩ resistors and 12-nF capacitors. ■

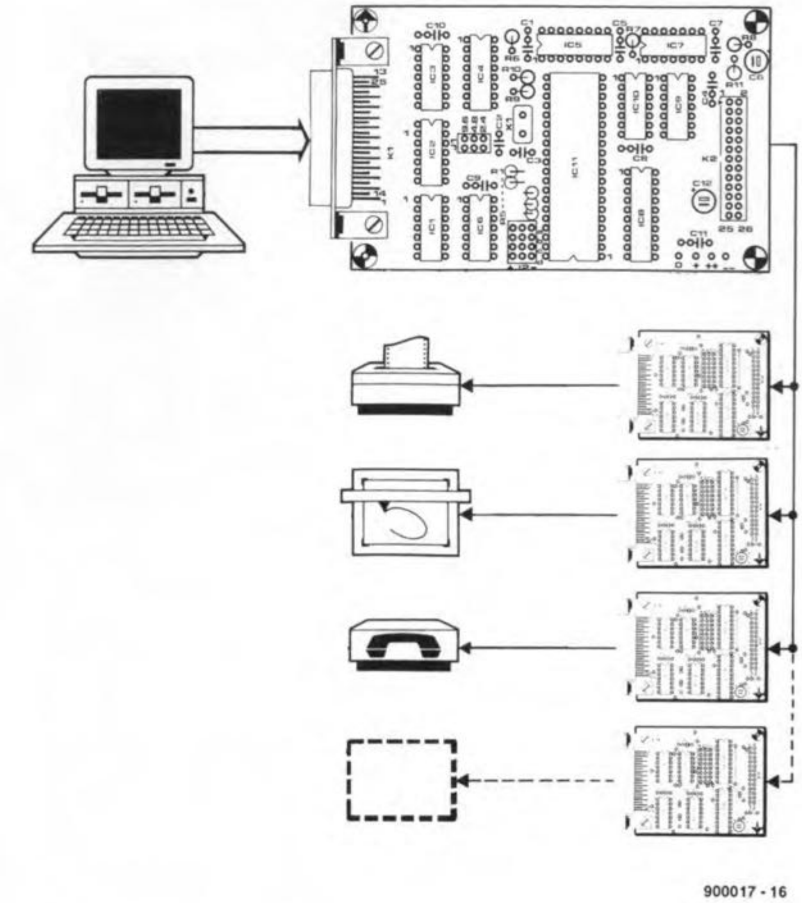


Fig. 7. Basic connections between the PC, the motherboard, the extension cards and the RS-232 peripherals (example).

UART SETTINGS

data format	J2b	J2c
5 bit	gnd	gnd
6 bit	gnd	+
7 bit	+	gnd
8 bit	+	+

parity bit	J2d
enable	+
disable	gnd

parity	J2a
even	+
odd	gnd

```
100 CLOSE
110 REM 9600 baud, no parity, 8 bits, 1 stopbit
120 OPEN "com1:9600,N,8,1" AS #1
130 INPUT "RS232 address",J
140 PRINT #1,CHR$(255); : REM SEND PULSE
150 PRINT #1,CHR$(J); :   REM SEND ADDRESS
160 CLOSE
170 REM 4800 baud, no parity, 8 bits, 1 stopbit
180 OPEN "COM1:4800,N,8,1" AS #1
190 FOR I=&H20 TO 80
200 PRINT #1,CHR$(I); : REM PRINT CHARACTER
210 NEXT
220 PRINT #1,CHR$(13),CHR$(10) : REM END OF LINE
230 GOTO 100
```
900017 - 15

Fig. 8. Model BASIC control program to control the serial port of an IBM PC or compatible.

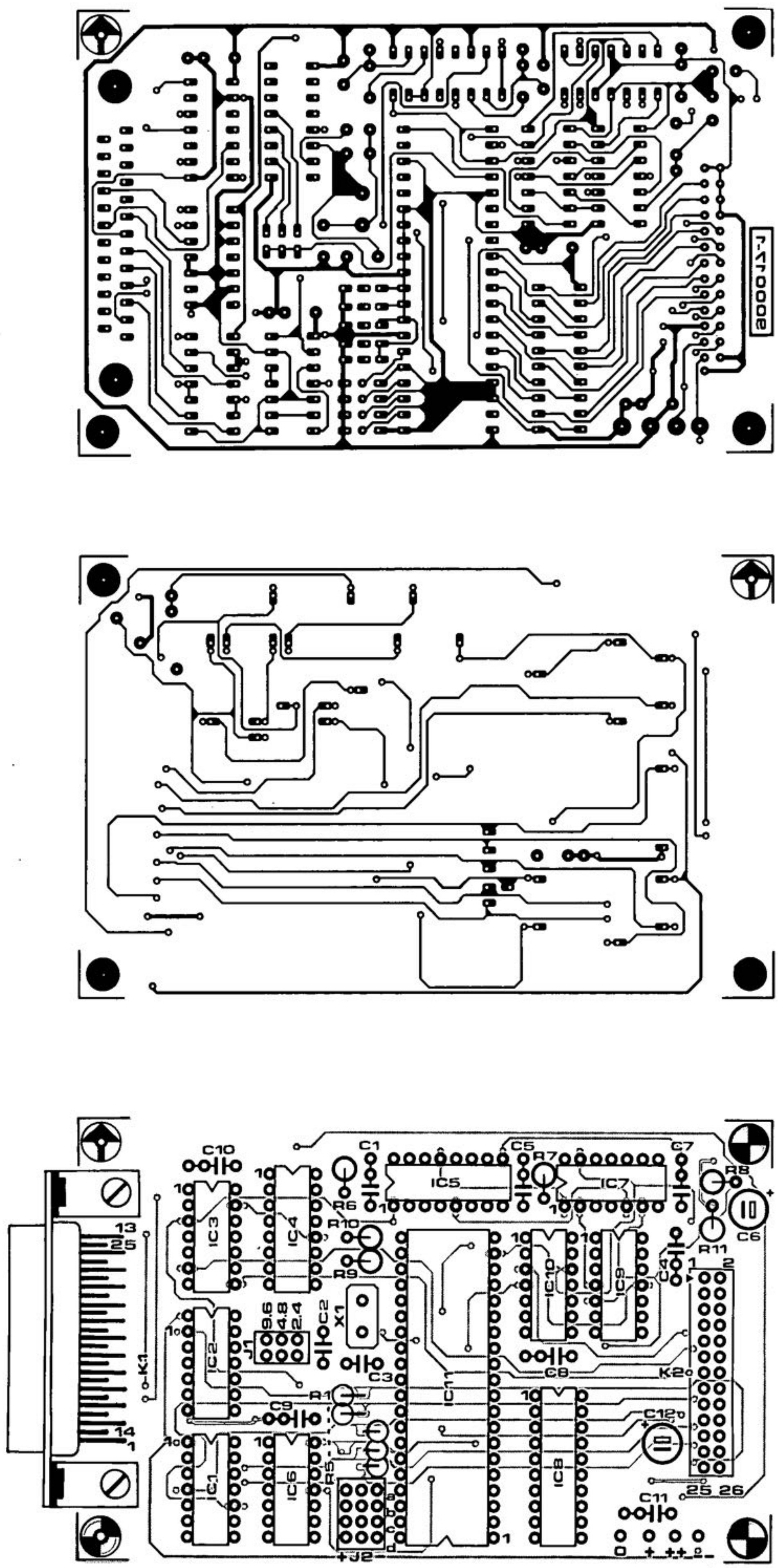


Fig. 5. Double-sided printed-circuit board for the central unit. Note that this board is not through-plated.

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Resistors:

2	10k	R_1;R_2
3	470Ω	R_3;R_4;R_5
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1	1M0	R_9
1	1k0	R_{10}

Capacitors:

1	1n2	C_1
1	39p	C_2
1	27p	C_3
1	10n	C_4
1	1n2	C_5
1	4µ7 16 V radial	C_6
5	100n	C_7–C_{11}
1	47µ 16 V radial	C_{12}

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1	4060	IC_4
1	74HCT123	IC_5
1	74HCT86	IC_6
1	74HCT73	IC_7
1	74HCT273	IC_8
1	74HCT04	IC_9
1	74HCT32	IC_{10}
1	AY-3-1015	IC_{11}

Miscellaneous:

1	quartz crystal 2.4576 MHz	X_1
1	25-way angled sub-D connector (female)	K_1
1	26-way angled pin header	K_2
1	6-way pin header	J_1
1	pin header block; 3 off 4-pin contact strips	J_2
8	jumper	
1	PCB	900017-1

COMPONENTS LIST

EXTENSION BOARD
(one required for each RS-232 peripheral)

Capacitors:

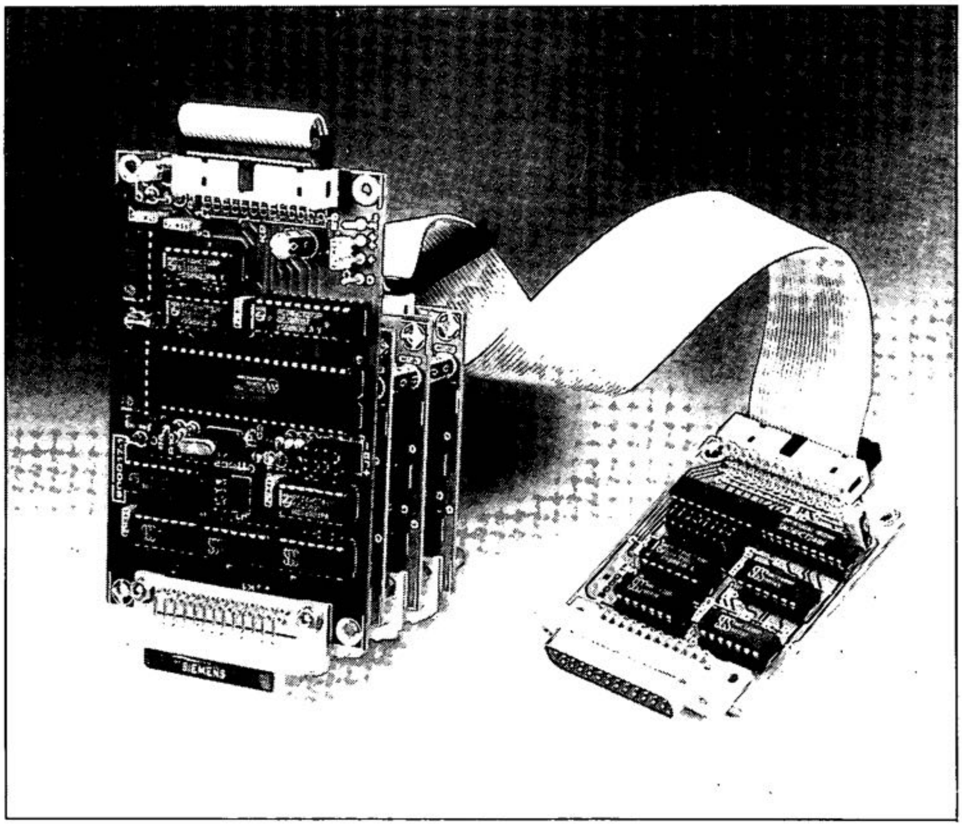
3	100n	C_{20};C_{21};C_{22}
1	47µ 16 V tantalum	C_{23}

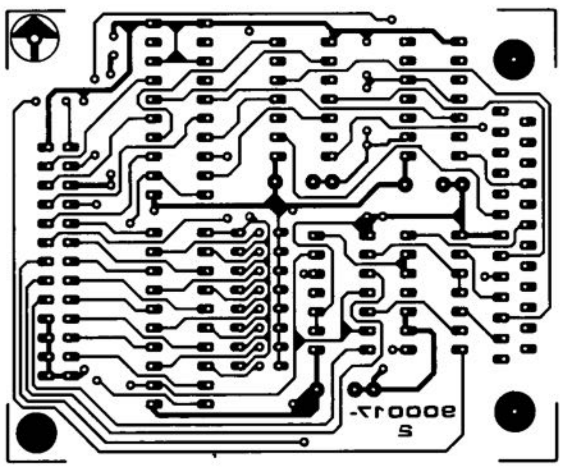
Semiconductors:

1	74HCT688	IC_{20}
1	74HCT32	IC_{21}
1	1488	IC_{22}
1	74HCT244	IC_{23}
2	1489	IC_{24};IC_{25}

Miscellaneous:

1	25-way angled sub-D connector (male)	K_3
1	26-way angled PCB header	K_4
1	pin header block; 3 off 8-pin contact strips	J_3
1	PCB	900017-2





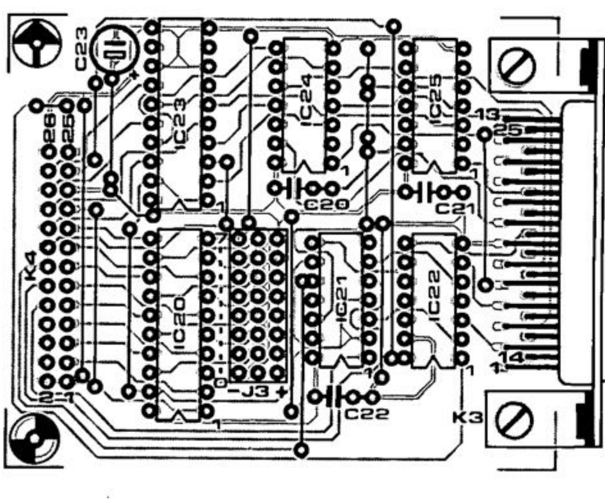


Fig. 6. Printed-circuit board for the extension (one required for each RS-232 peripheral).

BBD SOUND EFFECTS UNIT

FINAL PART

In this second and final instalment of the article we deal with the operation of the circuit as well as with the construction and alignment.

T. Giffard

Circuit description

Figure 8 shows the BBD chip and the associated clock driver as the central parts in the circuit diagram of the sound effects unit. The basic internal structure of the Panasonic BBD chip is given in the block diagram in Fig. 7.

Each output of the BBD chip, IC_1, has a pull-up load resistor and a coupling capacitor (C_{11}–C_{16}) that feeds the delayed signal to a potentiometer (P_3–P_6) to allow the individual delay levels to be set. Inverting opamp A_3 adds the delay signals at unity gain.

Identical low-pass filters with steep slopes are connected to the input and the output of the BBD chip. Each low-pass consists of an active part (A_4/A_5) and an *L-C* π-filter (L_1-C_6–C_9/L_2-C_{18}–C_{21}). The filters are eighth-order types for a bandwidth of about 4 kHz. This value allows the maximum delay time of the BBD chip to be used at a clock frequency of 10 kHz. The filter attenuation at 10 kHz is 60 dB. A larger bandwidth may be achieved by scaling the capacitor values in the low-pass filters. For a bandwidth of 8 kHz, for instance, the values of these capacitors are simply halved. Bear in mind, however, that this also requires the clock frequency to be increased to 20 kHz.

Opamp A_1 at the input of the circuit is a non-inverting buffer which provides a relatively low output impedance. The next opamp, A_2, is configured as an inverter with an amplification of 10. Opamp A_3 is also set up as an inverter, so that there is no phase reversal between A_1 and A_5. Opamp A_6 inverts the signal at the output,

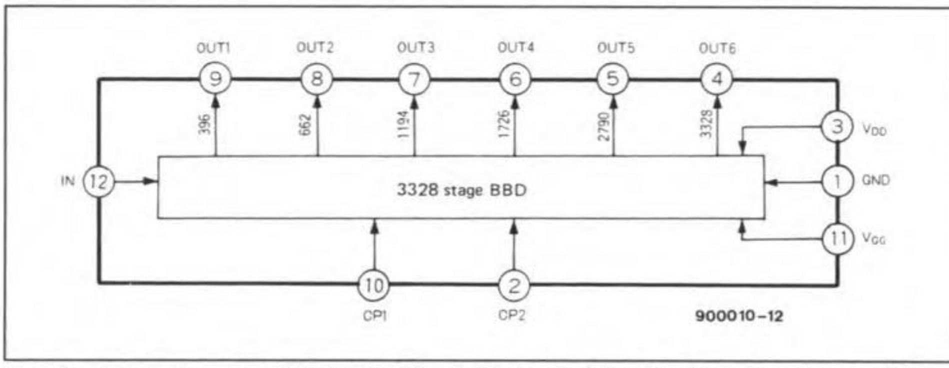


Fig. 7. Block diagram of the MN3101 bucket-brigade delay line (courtesy Panasonic).

and at the same time mixes the input signal (from P_9-R_{30}) with the delayed signal (from R_{29}). The simulated sound reflections (echoes) are created with the aid of potentiometer P_2 which feeds the longest delay (from IC_1 pin 6) back to the non-inverting input of A_2.

The clock frequency is determined by the components at pins OX1, OX2 and OX3 of the clock driver chip, IC_2. The components network contains two frequency-determining elements: potentiometer P_{10} and varicap D_2. If P_{10} is set to its maximum value (500 kΩ), the varicap control voltage allows a frequency range of 12.5 kHz to 18 kHz (maximum delay). If P_{10} is set to minimum resistance, the clock frequency may be varied between 65 kHz and 96 kHz (minimum delay).

The varicap voltage is provided by a modulation oscillator, A_7-A_8, which supplies a low-frequency triangular sweep signal. The frequency may be set with P_{11}, and the modulation depth with P_{12}.

The power supply of the circuit is symmetrical. The optimum direct voltage setting for the BBD chip is achieved by creating a slight unbalance between the positive and negative rail. This setting is effected with preset P_{13}.

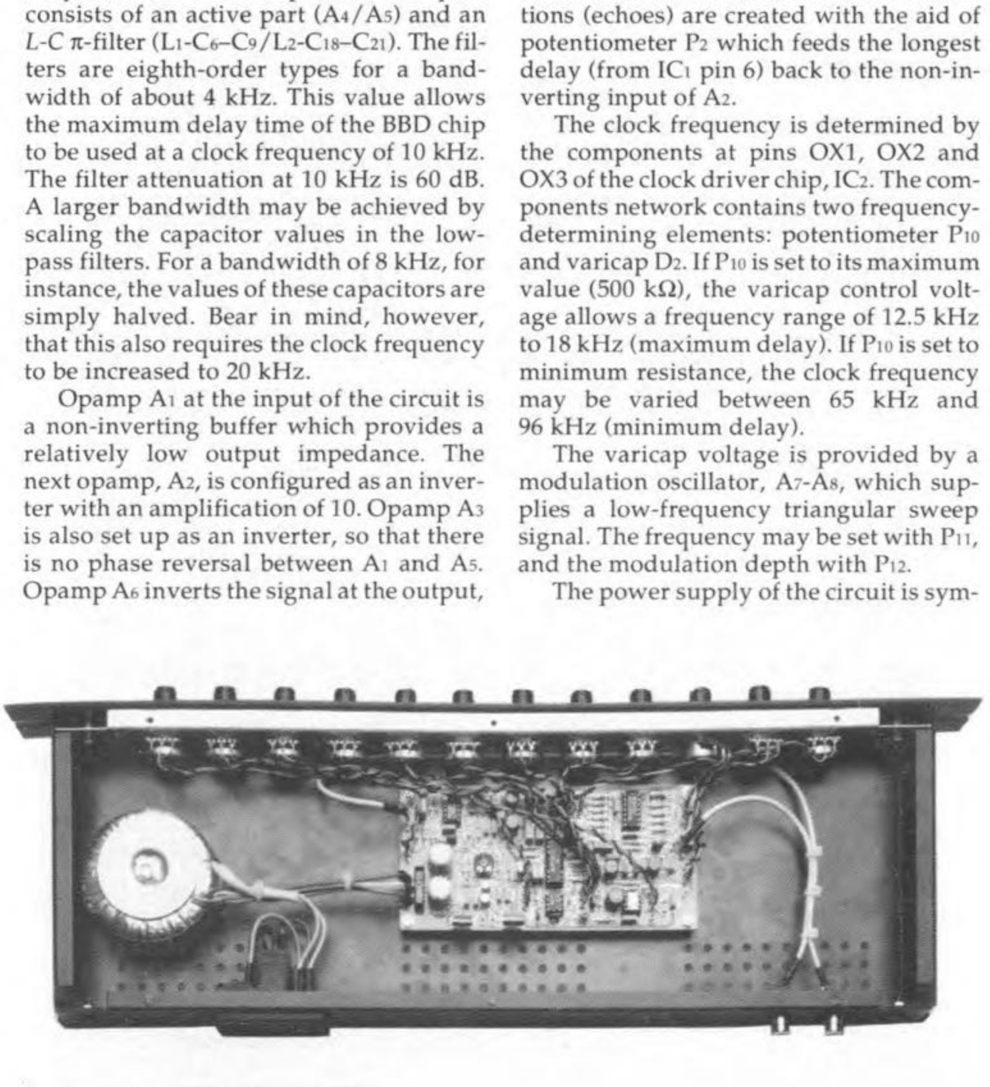
Practical notes

The 4-kHz bandwidth of the delayed signals may appear too small. In practice, however, it is hardly a problem since higher frequencies are also attenuated with natural reverberation. Some applications of the sound effects unit may, however, require a higher bandwidth (see the notes in Part 1 on redimensioning of the two low-pass filters). Whatever bandwidth is used, the clock frequency must be at least 2.5 times the roll-off frequency of the low-pass filters. The use of the maximum clock frequency of 100 kHz results in a bandwidth of 40 kHz, which is ample for hi-fi applications.

If difficult to obtain, the BB204 varicap may be replaced by similar types with sufficiently high C_{max}/C_{min} ratio, e.g., the BB104, BB204B or BB304. It is also possible to use a parallel combination of two varicaps, such as the BB130 or BB212.

The printed-circuit board has no provision for the signal feedback arrangement shown in Fig. 4. Fortunately, this is simple to implement by a few changes:

- connect R_3 to the output of A_3 instead of to pin 4 of IC_1;
- connect the wiper of P_2 to pin 6 of IC_3 via a 10-kΩ resistor;
- connect pin 5 of IC_3 to ground.



Another interesting sound effect may be obtained by mixing the input signal in inverted form with the output signal. This

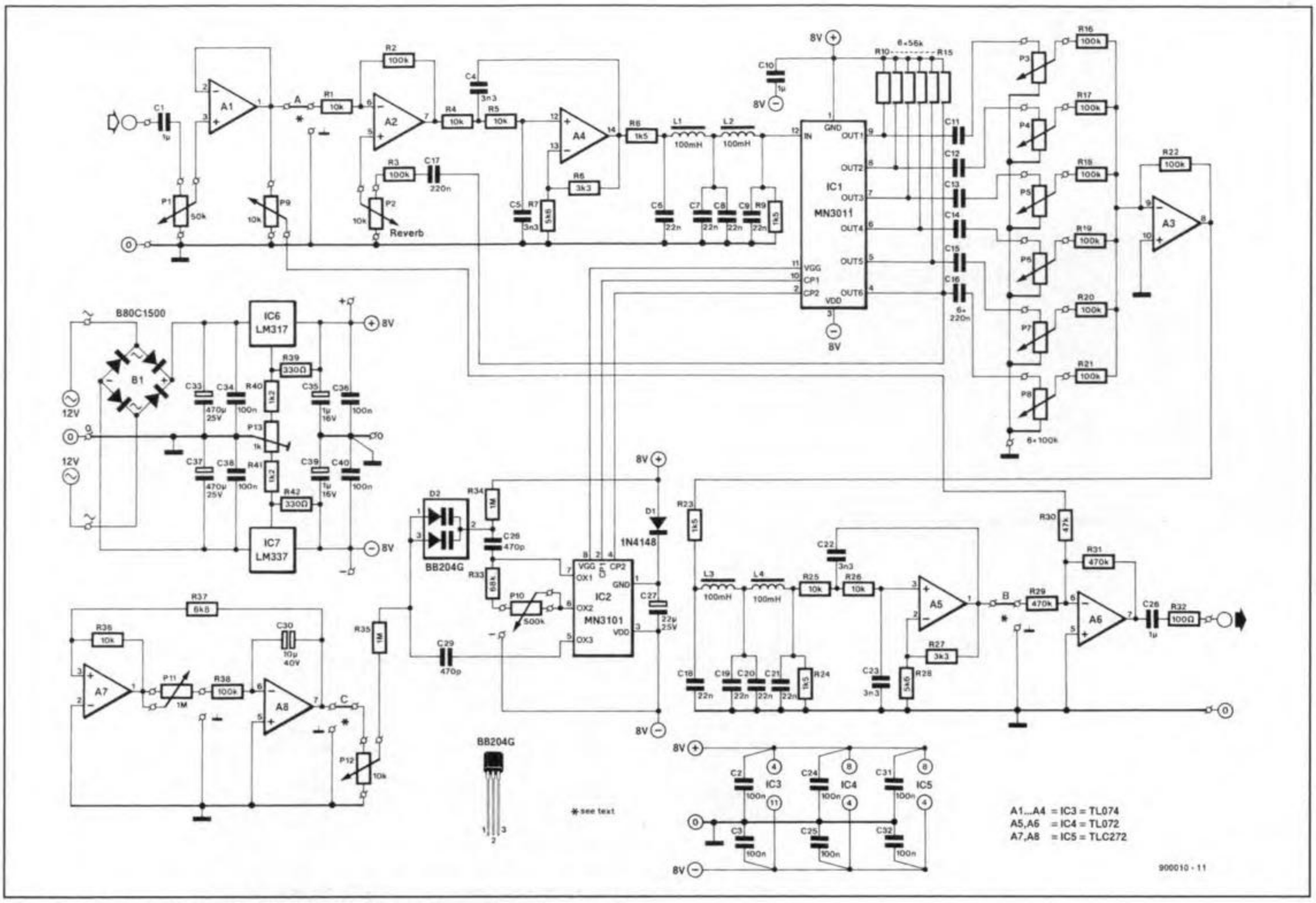


Fig. 8. Circuit diagram of the bucket-brigade sound effects unit.

may be achieved by connecting P_9 to the output of A_2 instead of A_1.

Wire links A and B are provided to allow a compander (compressor/expander) to be inserted into the signal path. If used, the compressor circuit replaces wire link A, and the expander replaces wire link B. Wire link C is removed to allow an external modulation voltage to be applied to P_{12}.

Construction and alignment

Although a fairly complex circuit, the BBD sound effects unit should not present difficulties in the construction. The population of the single-sided printed circuit board shown in Fig. 9 is straightforward.

The Panasonic ICs must be treated with care as they may be damaged by static discharges. Play it safe and leave these chips in conductive foam until they are due for fitting in the circuit (as the very last components). Never solder them direct on to the PCB.

Note that C_{10} is a bipolar electrolytic capacitor. If difficult to obtain, it may be replaced by two standard 22-µF types of which the negative terminals are interconnected.

Use screened wire to connect the potentiometers on the front panel to the respective terminals on the PCB. Potentiometers P_3–P_8 may share a single cable screen. Their wipers are connected to the numbered terminals on the PCB, while their fixed connections (the ones with the signals on them) go to the terminals at the sides of capacitors C_{11}–C_{16}.

Leave the Panasonic ICs out of the circuit as yet. Provisionally fit wires between pin 12 (IN) and pins 4–9 of the socket for IC_1. Turn P_2 and P_9 to their minimum volume settings, an apply power.

Set P_3 for equal positive and negative voltages (±8 V). Check the supply voltages at a number of points. Next, check that all opamp outputs, with the exception of A_7 and A_8, are at about 0 V (all potentiometers must be connected for this test). The output of A_7 should supply a voltage which toggles between +8 V and –8 V (the toggle rate is adjustable with P_{11}). Opamp A_8 should supply a slowly varying signal.

With P_2 and P_9 set to minimum volume and with a signal applied to the input, the effects unit should supply an output signal whose bandwidth is clearly limited (i.e., it lacks high-frequency components). Check that the volume of this signal is adjustable with P_3–P_8. Turn up P_9 —the signal must become louder and contain more treble. Turn up P_2 and check that the volume increases further at a slight sound change. If these tests check out so far, the power may be switched off and the Panasonic ICs fitted.

Switch the power on again. The BBD chips work if the effects unit produces output sound with P_2 and P_9 set to minimum volume. Turn up P_3–P_8 in succession to test the single-reflection function. Increase the input level until the output signal is distorted. Next, adjust P_{13} for minimum distortion, and increase the input level for a second adjustment. Optimize the drive margin in this way until no further improvement is noted.

Adjust P_{10} to check that it changes the echo distances. Turn up P_{12} —the vibrato effect becomes audible. Set a short delay time (signal from P_3 only; P_{10} set to high clock rate) and slowly turn up P_9 to check that the vibrato effect changes into phasing.

Finally, test the reverberation function. Turn P_{12} fully counter-clockwise and turn up P_2 carefully. Next, turn up the delay controls in succession to obtain different reverberation effects. ■

CONTROLS OVERVIEW

P_1:	input signal level
P_2:	feedback (=reverberation time)
P_3–P_8:	individual reflection levels
P_9:	input signal level at output
P_{10}:	clock frequency (=delay in IC_1)
P_{11}:	vibrato/phasing modulation frequency
P_{12}:	vibrato/phasing modulation depth
P_{13}:	distortion adjustment (IC_1)

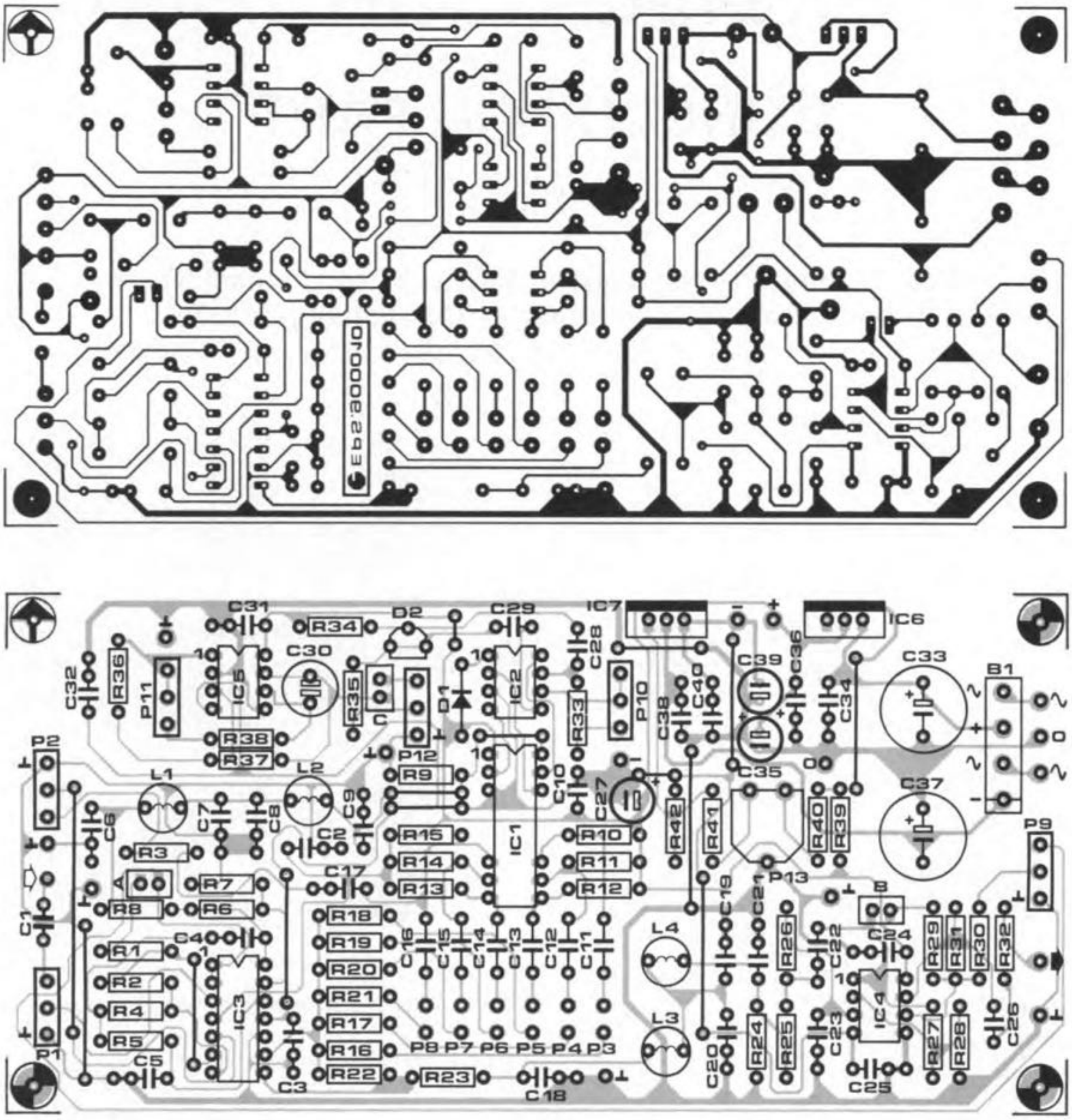


Fig. 9. Track layout (mirror image) and component overlay of the single-sided printed circuit board for the BBD sound effects unit.

COMPONENTS LIST

Resistors:

6	10k	R1;R4;R5;R25;R26;R36
10	100k	R2;R3;R16–R22;R38
2	3k3	R6;R27
2	5k6	R7;R28
4	1k05	R8;R9;R23;R24
6	56k	R10–R15
2	470k	R29;R31
1	47k	R30
1	100Ω	R32
1	68k	R33
2	1M0	R34;R35
1	6k8	R37
2	330Ω	R39;R42
2	1k2	R40;R41
1	50k linear potentiometer	P1
2	10k linear potentiometer	P2;P12
6	100k logarithmic potentiometer	P3–P8
1	10k logarithmic potentiometer	P9
1	500k linear potentiometer	P10
1	1M0 linear potentiometer	P11
1	1k0 preset H	P13

Capacitors:

3	1µ0; MKT	C1;C10;C26
10	100n	C2;C3;C24;C25;C31;C32;C34;C36;C38;C40
4	3n3	C4;C5;C22;C23
8	22n	C6–C9;C18–C21
7	220n	C11–C17
1	22µ; 25 V radial	C27
2	470p	C28;C29
1	10µ; 40 V; bipolar (radial)	C30
2	470µ; 25 V (radial)	C33;C37
2	1µ0; 16 V	C35;C39

Semiconductors:

1	1N4148	D1
1	BB204G	D2
1	B80C1500	B1
1	MN3011	IC1
1	MN3101	IC2
1	TL074	IC3
1	TL072	IC4
1	TLC272	IC5
1	LM317	IC6
1	LM337	IC7

Miscellaneous:

4	100 mH radial choke Toko 181LY-104	L1;L2;L3;L4
1	printed-circuit board	900010.

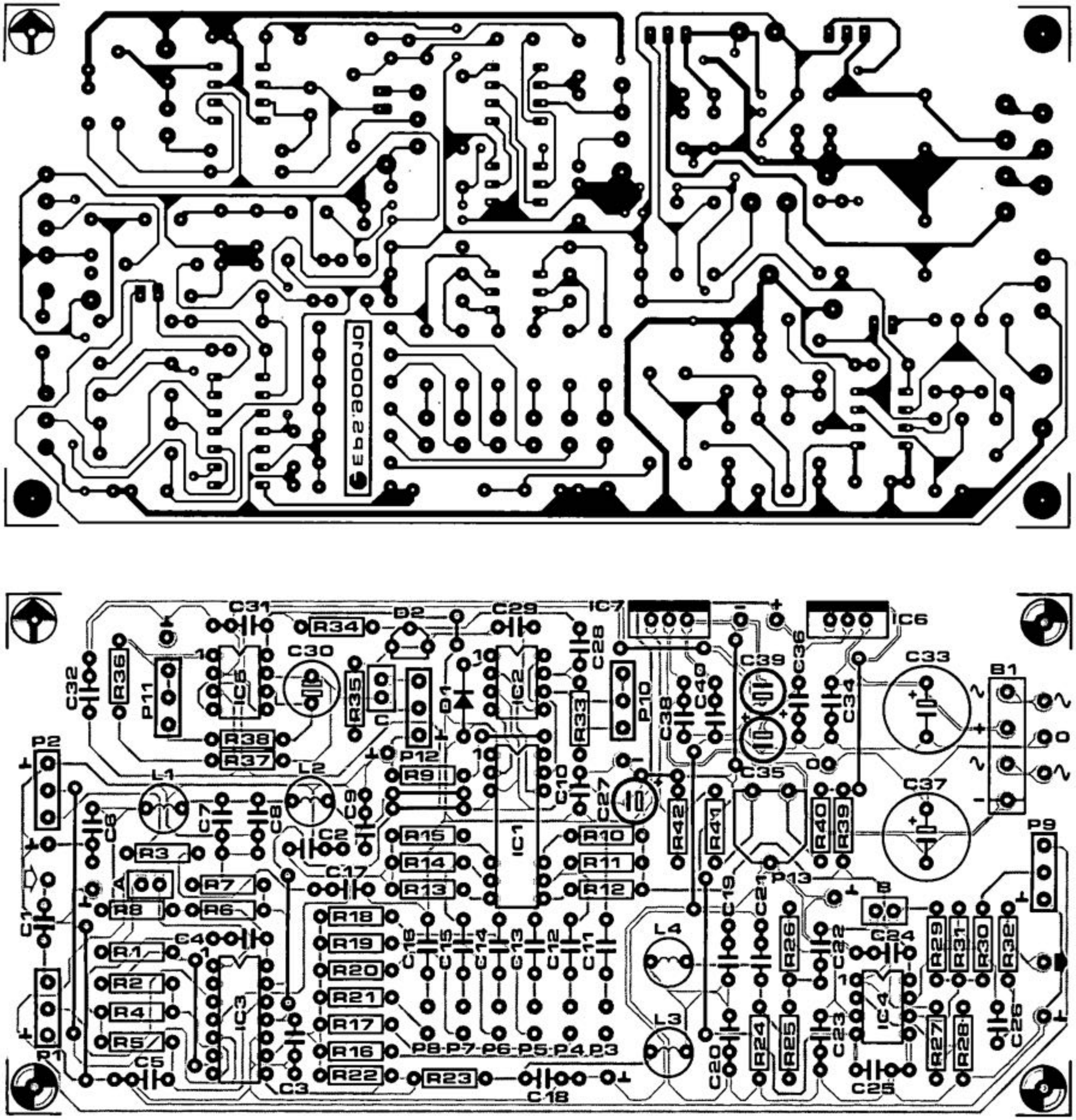


Fig. 9. Track layout (mirror image) and component overlay of the single-sided printed circuit board for the BBD sound effects unit.

87291 - XII + XIII

THE DIGITAL MODEL TRAIN

CONCLUDING PART

by T. Wigmore

The concluding part of the article discusses an alternative to the two-rail locomotive decoder, a coach lighting decoder and front and tail lights

Parts 2 and 3 of this article described the design and construction of the locomotive decoder and two-rail adaptor. There will, no doubt, be some modellers who do not want to build those units and rather buy the ready-made Märklin decoder.

Since the Märklin decoder is intended for use with three-rail systems only, a suitable adaptor is needed before it can be used with a two-rail system. Fortunately, our two-rail adaptor can be combined with the Märklin decoders to enable these to be used with two-rail tracks.

The adaptor monitors the logic level during the intervals between the data bytes. Depending on this level, the incoming data are, or are not, inverted by N4.

The adaptor has four terminals: input, output, positive supply and negative supply (earth). The supply is taken from across the 47 µF, 6 V, capacitor on the PCB of the Märklin decoder.

The input is connected to the brown terminal of the decoder, while the output is taken to pin 15 of the 16-pin IC (Märklin or Zymos type) in the decoder.

The printed-circuit board for the adaptor is available in combination with our locomotive decoder board, Code 87291-2/3 or with the coach lighting decoder board described below, Code 87291-10. Note that the board is intended for surface mount components.

Coach lighting decoder

The coach lighting decoder is intended for all

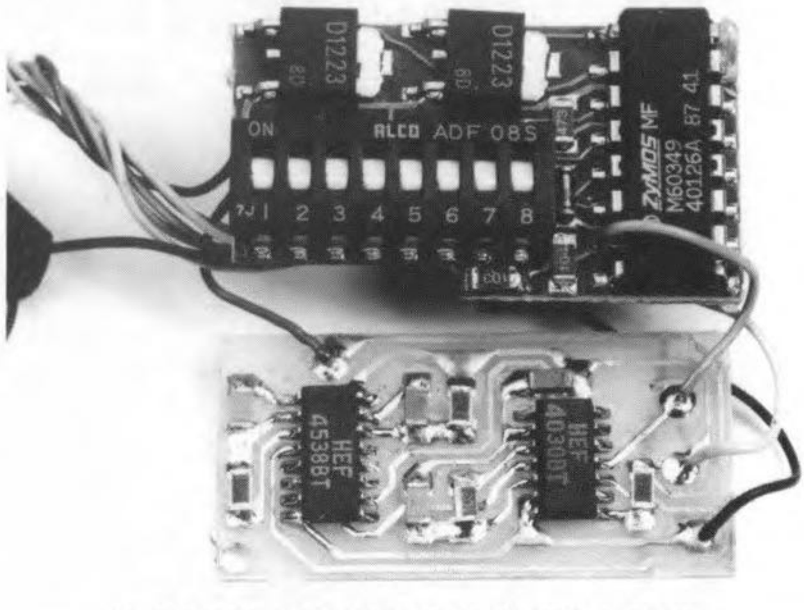


Fig. 84. The completed alternative two-rail locomotive decoder.

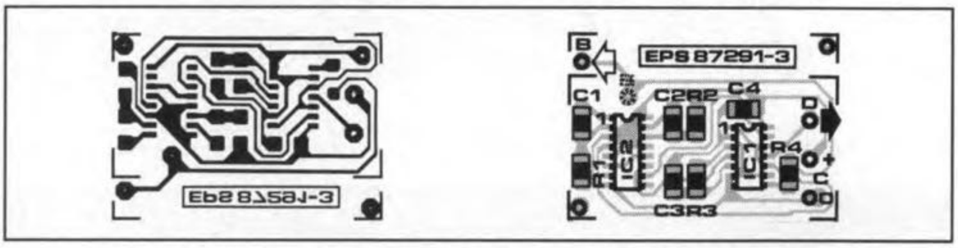


Fig. 85. The printed-circuit board for the alternative two-rail locomotive decoder.

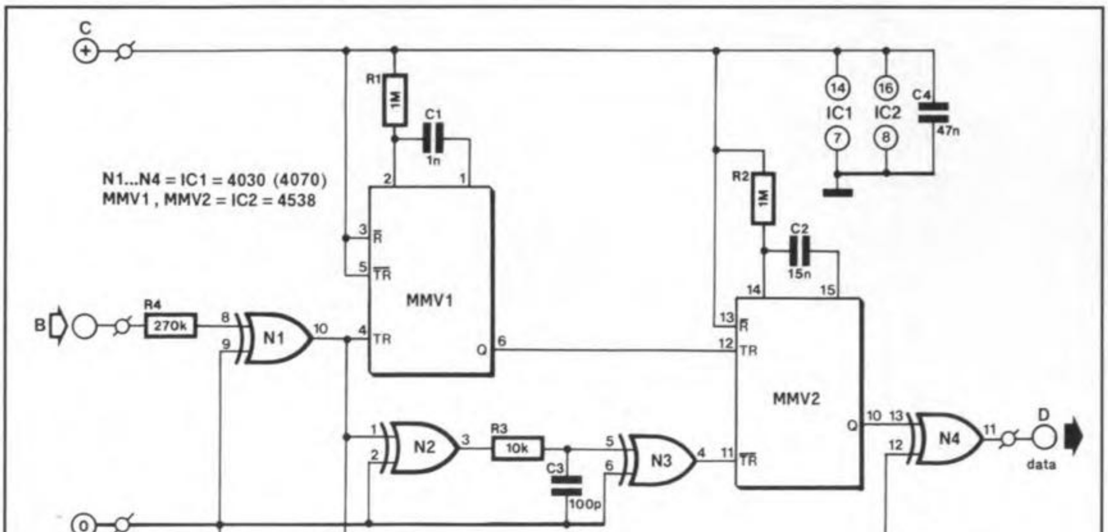


Fig. 86. Circuit diagram of the alternative two-rail locomotive decoder.

PARTS LIST

All components must be suitable for surface mounting.

Resistors:
R1, R2 = 1M0
R3 = 10 k
R4 = 270 k

Capacitors:
C1 = 1n0
C2 = 15 n
C3 = 100 p
C4 = 47 n

Semiconductors:
IC1 = 4030 or 4070
IC2 = 4538

PCB 87291-2/3 or 87291-10

rolling stock and provides four independent switching functions. It makes possible, for instance, the control of coach lighting, the giving of whistles or the operating of smoke generators. It can be used only in conjunction with the Elektor Electronics or Märklin Digital Train System.

The circuit of the decoder—see Fig. 87—is a combination of the locomotive decoder (see Parts 2 and 3) and the universal signals and switching decoder (see Part 4). The data on the rails are decoded by IC_1. When the address (A_1–A_5) of the data byte on the rails corresponds to that set at pins 1–5 of IC_1, the next four bits are compared internally with the previous data and, if they agree, passed on to outputs D_6–D_9. These outputs are connected to a number of darlingtons that enable a particular function to be selected.

Because the first three outputs are each connected to two darlingtons in parallel, they can switch somewhat higher currents (up to 1 A) than the fourth output. Note also that the four outputs can not all deliver their maximum current at the same time, since that would overload IC_2 as well as rectifier bridge D_1–D_4. It is, therefore, advisable to switch not more than 1 A per decoder at any one time.

Since IC_2 has internal freewheeling diodes, inductive loads (coils and solenoids) may be switched without a problem.

The printed-circuit board Code 87291-10 is a four-fold design that enables two coach lighting decoders and two two-rail adaptors to be constructed. Part of the PCB is double-sided, but through-plated. It is, therefore, necessary to solder some components at both sides of the board. For this reason it is not advisable to use IC holders.

Diodes D_1–D_4 should preferably be Type 1N4935 (or -36 or -37), but Type 1N4001 may also be used, although this is slower than the

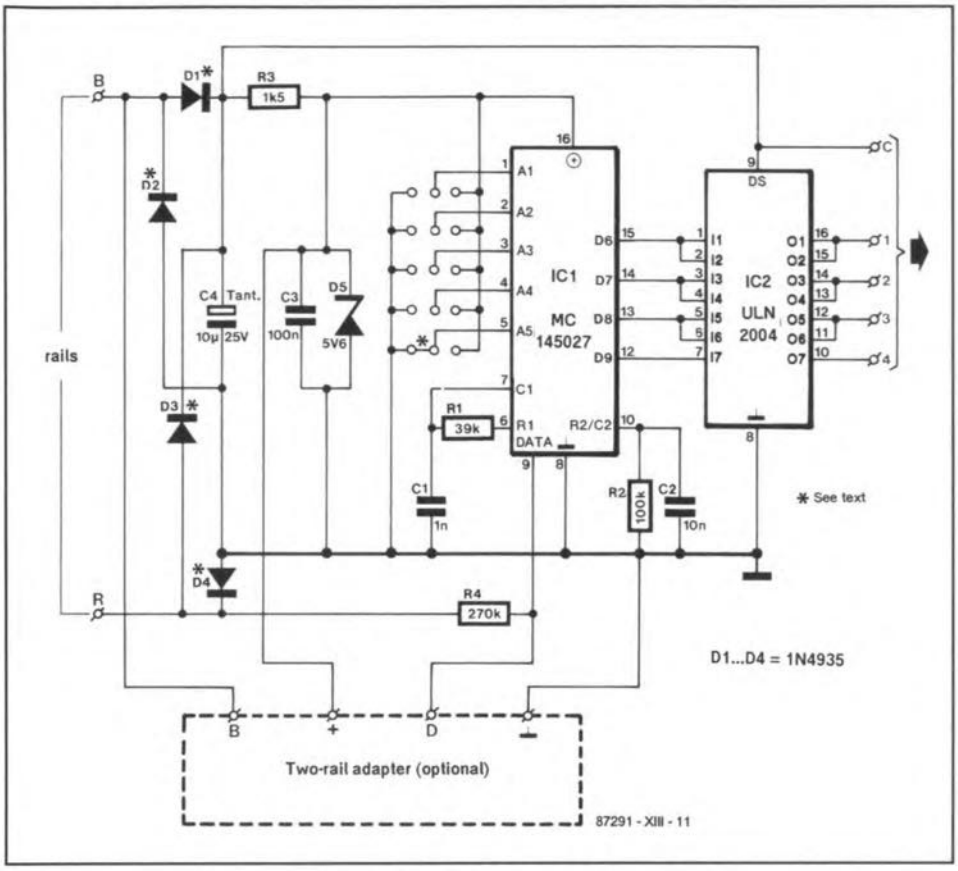


Fig. 87. Circuit diagram of the coach lighting decoder.

PARTS LIST
(For ONE coach lighting decoder)

Resistors:
R1 = 39 k
R2 = 100 k
R3 = 1k5
R4 = 270 k

Capacitors:
C1 = 1n0 (ceramic)
C2 = 10 n (ceramic)
C3 = 100 n(ceramic)
C4 = 10 µF, 25 V (tantalum)

Semiconductors:
D1–D4 = 1N4935 or 1N4001
D5 = 5V6, 400 mW zener diode
IC1 = MC145027
IC2 = ULN2004

PCB 87291-10

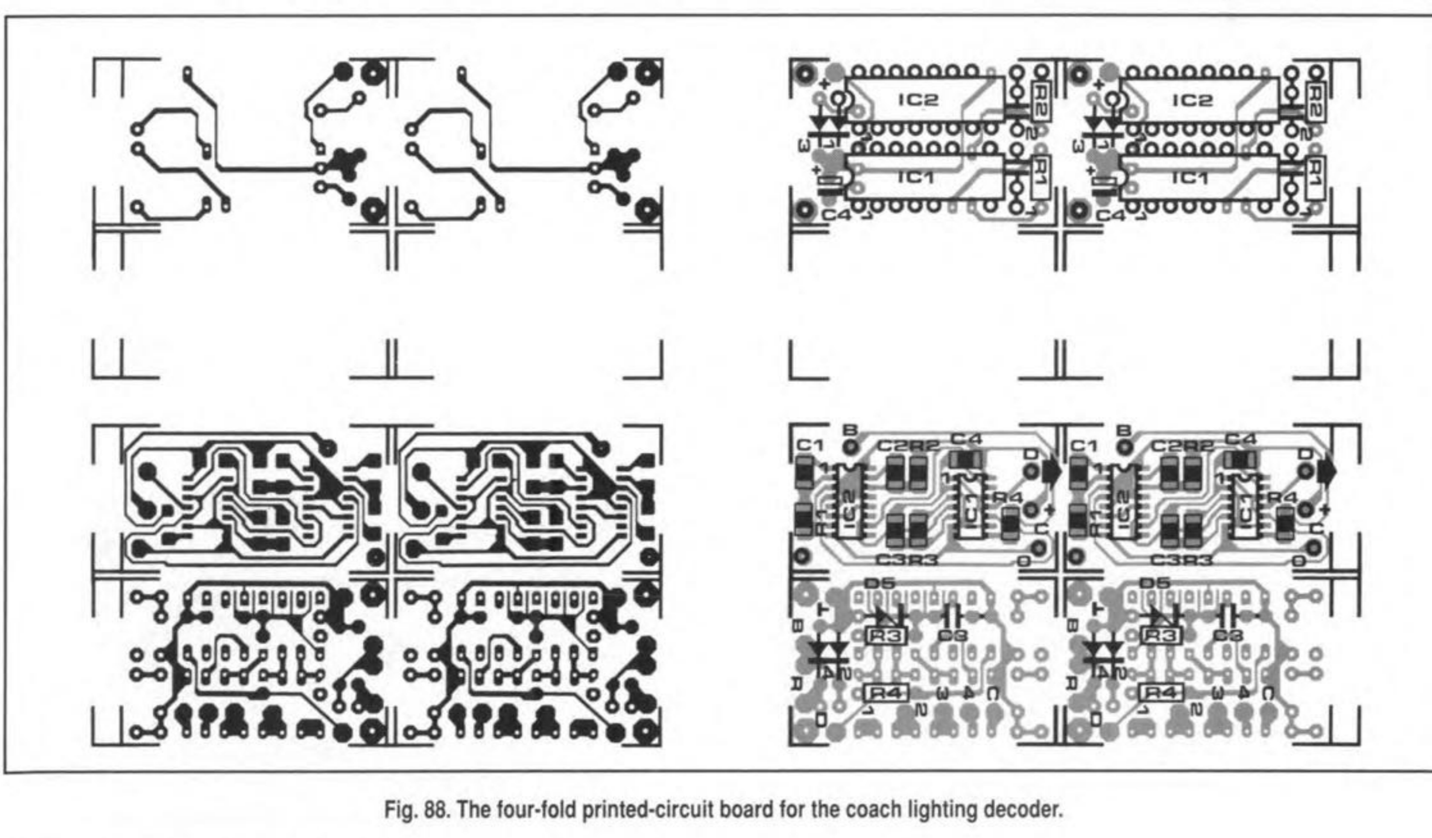


Fig. 88. The four-fold printed-circuit board for the coach lighting decoder.

1N4935.

The tantalum capacitor may be bent flat on to the board after it has been soldered in place.

Note that some components must be soldered at the track (copper) side of the board.

The outputs are switched to earth when they are active. Loads must therefore be connected between an output and the positive supply rail. The (common) positive rail is indicated on the board by 'C'.

The output voltage is equal to the potential provided by the booster unit less the drop across the bridge rectifier and the output transistor. If the EEDTS booster is used, it is about 15 V. The load must be matched to this voltage by connecting lamps in series or by using series resistors.

The decoder addresses must be set in the same way as a locomotive decoder – see Table 10 and Fig. 89. This is done by means of soldered wire bridges.

Bit 5—the function bit in the case of a locomotive decoder—is here used as an address bit. To that end, the relevant input of IC1 has already been connected to earth on the PCB. This means that the decoder must be accessed with the additional function at 'on' (Märklin data format) or, as it were, a locomotive in the next state (EEDTS data format).

If desired, the connexion between IC1 pin 3 and earth may be cut and input D5 linked to the positive supply rail. The decoder may then be accessed with the additional function bit 'on' or as a locomotive in the previous position. This enables twice as many coach lighting decoders (162) to be accessed as locomotive decoders. No coach address should, of course, be the same as a locomotive address.

Coach lighting decoders may be controlled via the locomotive controllers or via the RS232 interface. Depending on the state of a controller, a certain combination of outputs will be active.

Note that instead of using potentiometers for the locomotive controllers switches may be used. If, for instance, the input of a locomotive controller (pin 3 of the DIN connector) is connected to earth, all outputs will be active. However, in order to use the relevant input, it is necessary, just as with potentiometer-type controllers, to connect pin 4 or pin 5, or both, of the DIN connector to pin 2—see Fig. 90.

number of locomotive	address				number of locomotive	address			
	A1	A2	A3	A4		A1	A2	A3	A4
01	1	0	0	0	41	X	1	1	1
02	X	0	0	0	42	0	X	1	1
03	0	1	0	0	43	1	X	1	1
04	1	1	0	0	44	X	X	1	1
05	X	1	0	0	45	0	0	X	1
06	0	X	0	0	46	1	0	X	1
07	1	X	0	0	47	X	0	X	1
08	X	X	0	0	48	0	1	X	1
09	0	0	1	0	49	1	1	X	1
10	1	0	1	0	50	X	1	X	1
11	X	0	1	0	51	0	X	X	1
12	0	1	1	0	52	1	X	X	1
13	1	1	1	0	53	X	X	X	1
14	X	1	1	0	54	0	0	0	X
15	0	X	1	0	55	1	0	0	X
16	1	X	1	0	56	X	0	0	X
17	X	X	1	0	57	0	1	0	X
18	0	0	X	0	58	1	1	0	X
19	1	0	X	0	59	X	1	0	X
20	X	0	X	0	60	0	X	0	X
21	0	1	X	0	61	1	X	0	X
22	1	1	X	0	62	X	X	0	X
23	X	1	X	0	63	0	0	1	X
24	0	X	X	0	64	1	0	1	X
25	1	X	X	0	65	X	0	1	X
26	X	X	X	0	66	0	1	1	X
27	0	0	0	1	67	1	1	1	X
28	1	0	0	1	68	reserved			
29	X	0	0	1	69	0	X	1	X
30	0	1	0	1	70	1	X	1	X
31	1	1	0	1	71	X	X	1	X
32	X	1	0	1	72	0	0	X	X
33	0	X	0	1	73	1	0	X	X
34	1	X	0	1	74	X	0	X	X
35	X	X	0	1	75	0	1	X	X
36	0	0	1	1	76	1	1	X	X
37	1	0	1	1	77	X	1	X	X
38	X	0	1	1	78	0	X	X	X
39	0	1	1	1	79	1	X	X	X
40	1	1	1	1	80	0	0	0	0

Table 10. Address settings for the lighting decoder are identical to those for the lcomotive decoder. Note that if the address of a locomotive is 00, the adress settings A1–A4 remain open (×).
× = open
*** = can not be set digitally with Märklin decoder**

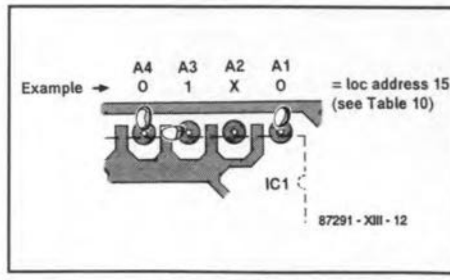


Fig. 89. How to set addresses (at pins A1–A4 of IC1).

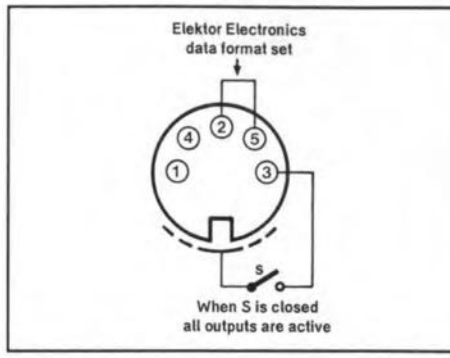


Fig. 90. When pin 3 of the DIN connector is linked to earth, all outputs are active.

Instruction	Active outputs			
<0><address>	All			
<1><address>		2		
<2><address>	1	2		
<3><address>				3
<4><address>	1		3	
<5><address>		2	3	
<6><address>	1	2	3	
<7><address>				4
<8><address>	1			4
<9><address>		2		4
<10><address>	1	2		4
<11><address>			3	4
<12><address>	1		3	4
<13><address>		2	3	4
<14><address>	1	2	3	4
<15><address>	1			

Table 11. Summary of instructions for operating the coach lighting decoder via the RS232 interface. Note that if pin A5 of IC1 is linked to the positive supply rail, all instructions must be increased by <16>.

Control via the RS232 interface makes it rather easier to keep the switching functions independent of one another. The relevant instructions are summarized in Table 11.

Head and tail lights

One of the first things that is omitted from economically priced model trains is any form of lighting. The circuit in Fig. 91 enables any d.c. locomotive to be provided with direction-dependent head and tail lights. Since LEDs are used, a very long life is guaranteed.

The circuit is very simple and is really nothing more than a number of LEDs connected in a bridge. The FET in the centre of the bridge ensures a constant current as long as the supply voltage remains above about 4.5 V. The brightness of the lights is, therefore, virtually independent of the speed at which the train travels.

The LEDs are connected in parallel pairs to keep the minimum operating voltage as low as possible. To ensure good current distribution, it is essential that only LEDs of the same type and colour are used for each pair. Note that D1–D4 should be yellow (head lights) and D5–D8 should be red (tail lights). If tail lights are not needed, the relevant LEDs should be replaced by a wire bridge. Do not remove diodes D9 and D10, however, as these are required at all times for the correct operation of the other LEDs. ■

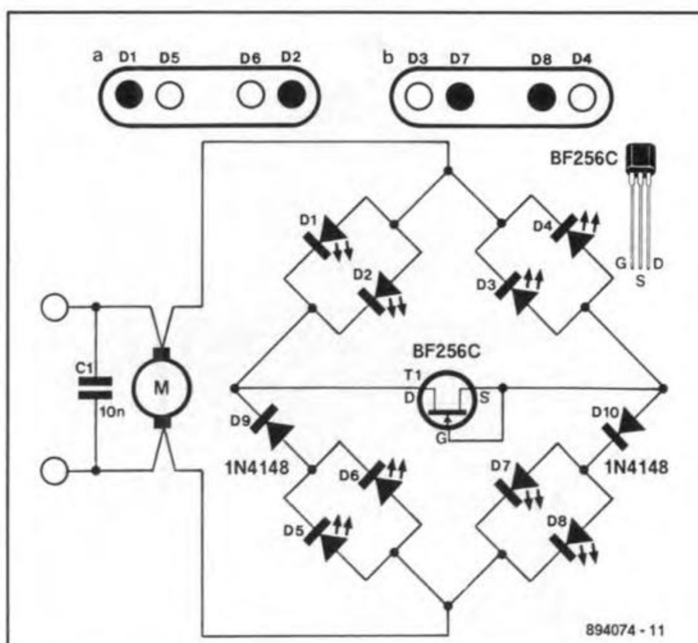


Fig. 91. Circuit diagram of head and tail lights prov ision.

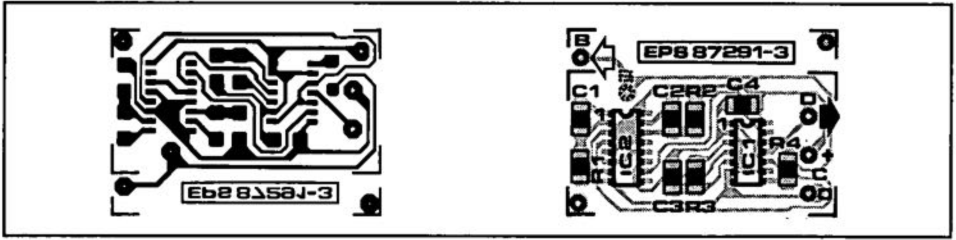


Fig. 85. The printed-circuit board for the alternative two-rail locomotive decoder.

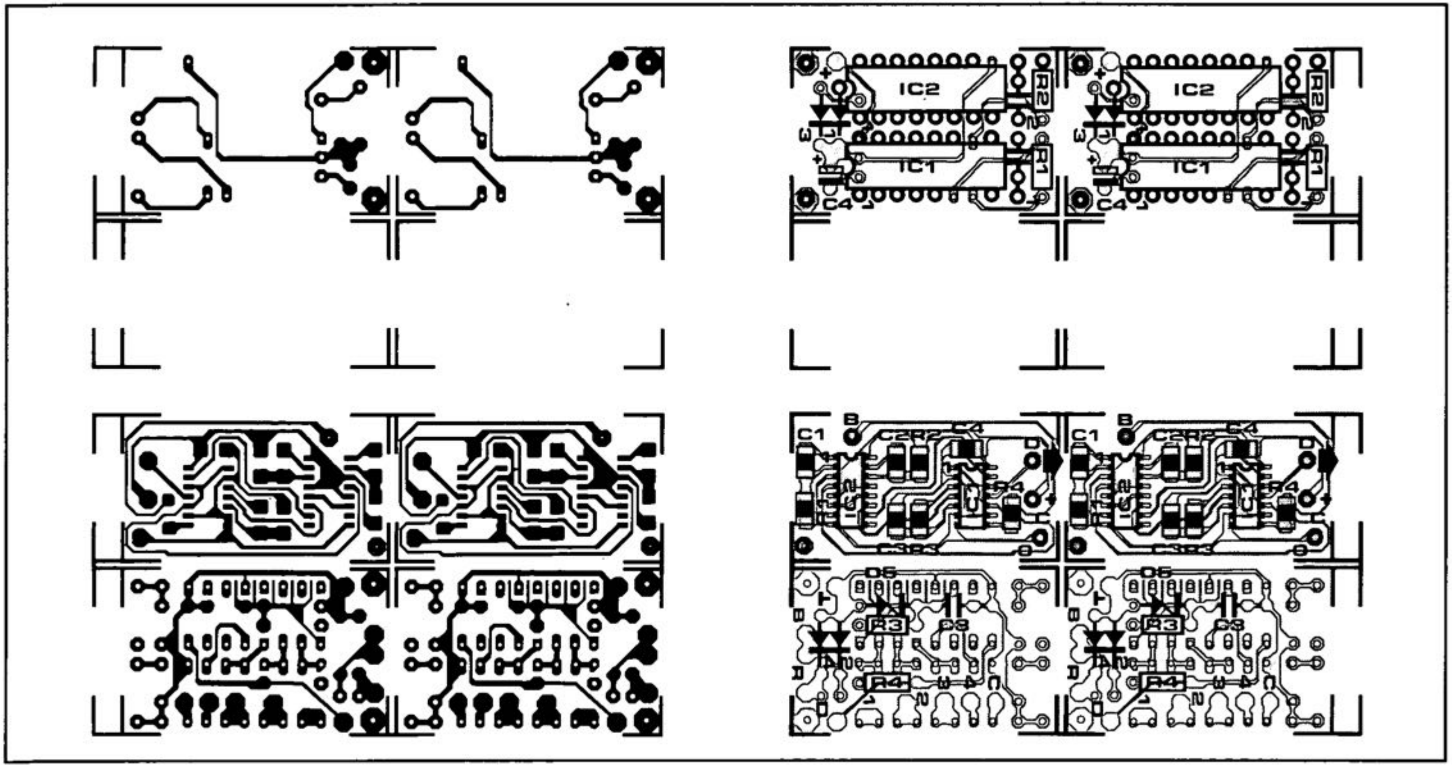
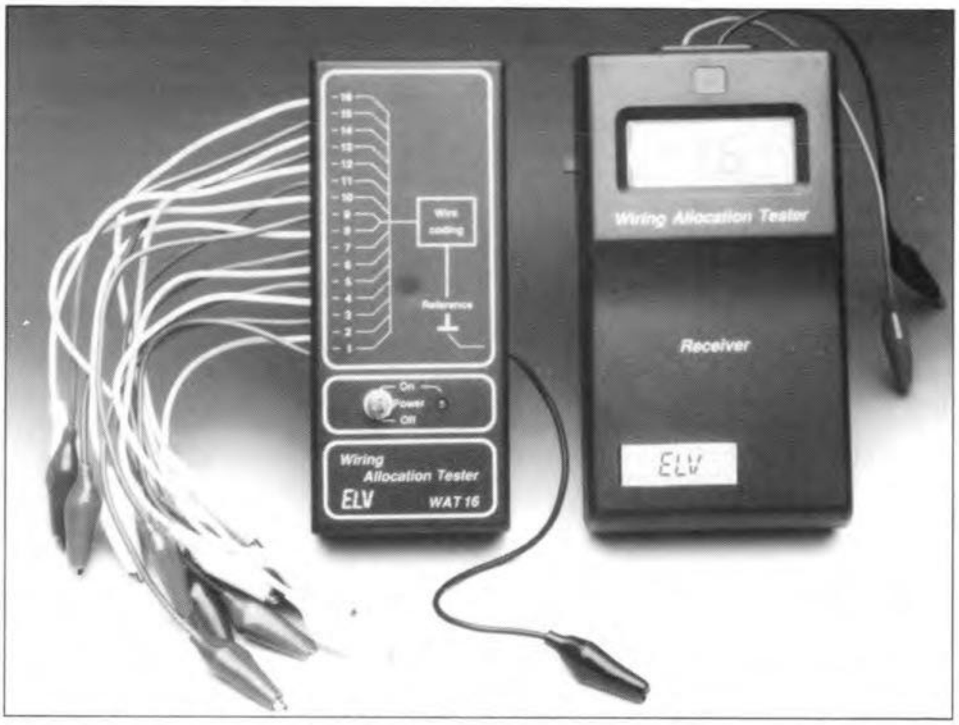


Fig. 88. The four-fold printed-circuit board for the coach lighting decoder.

909503

WIRING ALLOCATION TESTER

This set of handy test instruments, designed by ELV, takes the hassle out of conductor identification and trouble-shooting during cable installation work.



Any one who has ever installed a multi-way cable between two locations in, say, a home or an office, is probably familiar with the wire identification problem. Often, the connections must be made in difficult-to-reach places, and communication with the 'other end' is difficult or impossible. Multi-way cables are commonly used in telephone systems, intercoms and alarm systems.

Obviously, these problems do not occur if the cable has only 2 conductors, or if each of its conductors has a unique colour identification. In alarm systems, however, cables with non-coloured conductors are in common use for reasons of security. The wiring allocation problem may also arise if a cable is extended by inserting a length of multi-way cable that happens to be available.

In these cases, it is reassuring to be able to check and record the function or number of each conductor in the cable. The wiring allocation tester described here allows this to be done in a time-efficient manner that eliminates the risk of wrong connections. A code transmitter is used at one end of the cable, and a special receiver with digital read-out at the other end. Both the transmitter and receiver are light-weight, battery-powered units in rugged ABS enclosures.

Operation and controls

As already stated, the wiring allocation tester consists of two units: one is a code transmitter for use with up to 16 conductors at a time, the other is a receiver with a digital read-out that indicates the number of the conductor.

The transmitter is connected to the conductors in the cable by means of 16 small crocodile clips. If a cable has fewer than 16 conductors, the remaining transmitter connections are simply not used. If there are more than 16 conductors in the cable, these are allocated in the respective number of passes of 16 at a time.

It is important to make sure that the conductors to be allocated are potential-free and not connected at any point.

At the transmitter side, the conductor ends are labelled with small adhesives marked 1–16, corresponding to the numbers printed on the front panel of the transmitter. The single lead at the opposite side of the transmitter enclosure is marked REFERENCE and must be connected, for any test, to the corresponding lead on the receiver. In most cases, this is possible by making use of the cable screening braid, or a conductor with a colour or thickness that makes it different from the others. If neither of these possibilities is available, the REFERENCE leads on the transmitter and the receiver may be clipped to a nearby earth connection, a water supply pipe, or a central heating pipe.

The receiver has two leads, one for ground (REFERENCE), and one for the conductor to be allocated at the far end of the cable. Both receiver leads have crocodile clips as used on the transmitter. The signal input lead of the receiver is connected to any one conductor in the cable. The instrument indicates the conductor number defined at the transmitter side (1–16) on a liquid-crystal display (LCD). Short-circuits to the REFERENCE potential are indicated by a display reading of '36'.

Both the transmitter and the receiver are powered by a 9-V battery. The battery in the transmitter may be installed by unlocking the cross-slotted screw at the back of the instrument, and removing the top half of the enclosure. The receiver has a separate battery compartment that may be opened without unlocking a screw.

The transmitter battery will typically last for about 400, the receiver battery for about 2,000, hours of operation, assuming that a 9-V PP3-size Alkali-Manganese type is used.

A red, flashing, LED is used on the transmitter to indicate that the unit is on. The LED goes out if the battery voltage drops below about 6.5 V, at which voltage the instrument will, however, continue to operate for a couple of hours.

The receiver's on/off slide switch is located on the left-hand side panel of the instrument. A conductor number is displayed when the signal input receives a valid code from the transmitter. It is, in principle, possible to have the transmitter power the receiver via the two conductors in the cable. This option obviates the need for a battery in the receiver, but does not enable the short-circuit tracing function ('36' reading) to be used.

Transmitter circuit

The circuit diagram of the transmitter is given in Fig. 1. The 9-V supply voltage is applied to buffer capacitor C_3 via switch S_1 and resistor R_6. The voltage across C_3 is used to power all transmitter circuits with the exception of the LED. The actual circuit supply voltage is of relatively little importance and lies between 5 V and 8 V depending on the number of conductors connected (remember that CMOS ICs such as the ones used here can usually operate from supplies between 3 V and 15 V).

The oscillator in IC_1 operates at 32.768 kHz as determined by quartz crystal Q_1. The following dividers (bistables) in IC_1 provide a number of control signals which are used in the rest of the circuit. Output Q5 supplies a frequency of 1,024 Hz. This signal clocks four shift registers Type CD4015, IC_2-IC_3 (note that each of these contains two shift registers).

The data input of the top shift register is tied to the positive supply voltage. This results in output Q1 changing from low to high on the first clock pulse received from the Q5 output of IC_1. Output Q2 changes from low to high on the second clock pulse. Similarly, Q3 and Q4 go high on the third and fourth clock pulse respectively.

Output Q4 of the top shift register is connected to the data input, pin 15, of the second shift register. Consequently, Q1 of the second shift register goes high on the fifth clock pulse applied to IC_{2a}. Outputs Q2, Q3 and Q4 go high on the sixth, seventh and eighth clock pulse respectively. The last shift register output that goes high is Q4 of IC_{3b}. Shortly after, the low-to-high transition at Q10 of IC_1 causes all shift register outputs to go low again. This reset state has the same duration as the preceding series of 16 clock pulses. When Q10 goes low again after 32 clock pulses, the shift registers are enabled again and accept the clock pulses supplied by Q5 of IC_1. The above sequence is repeated, starting with the low-to-high transition of Q1 of IC_{2a}. The on- (logic high) time of a shift register output becomes shorter as it is further down the cascade. Hence, Q1 of IC_{2a} has the longest on-time of 16 clock periods, while Q4 of IC_{2b} is high for one clock period only. These times are processed in the receiver to recognize the 16 conductors that carry the associated signals.

Inverters IC_4-IC_5-IC_6 also act as buffers. Pin 2 of IC_4 supplies a low signal with a duration of 16 clock pulses, while pin 10 of IC_6 supplies a low signal with a duration of one clock pulses.

A red LED, D_4, functions as an on/off indicator on the transmitter. Its anode is connected to the 9-V supply voltage directly behind the contact of switch S_1. Its cathode is connected to the collector of transistor T_1 via a 4.7 V zener diode, D_5. The transistor and associated parts D_6-D_7-R_5 forms a 10-mA current source. The LED will light at constant brightness as long as the battery voltage exceeds about 6.7 V. This value is obtained by subtracting the sum of the voltage drops across R_5 (0.7 V), D_5 (4.7 V), and D_4 (1.3 V) from the nominal battery voltage of 9 V. The relatively small current passed by T_1 results in a virtually negligible voltage drop across the collector-emitter junction. If the battery voltage drops below 6.7 V, the brightness of the LED reduces rapidly, until it goes out at about 6.0 V.

The current source around T_1 is pulse-controlled to keep the overall current consumption of the LED low. The duty factor of the control signal, and with it the LED current, is about 0.14 (pulse/pause ratio of 1:7) as determined by diodes D_1-D_2-D_3 which combine three counter output signals of IC_1 to provide a LED flash rate of about 2 Hz. This arrangement results in a power saving of about 12.5%.

Receiver circuit

The circuit diagram of the receiver is given in Fig. 2. Like the transmitter, the receiver is powered by a 9-V battery via a switch and an *R-C* network, R_8-C_3. Resistor R_8 has a relatively high value which ensures a circuit supply voltage of around 5 V. Since the receiver circuit does not contain current-hungry parts, the battery

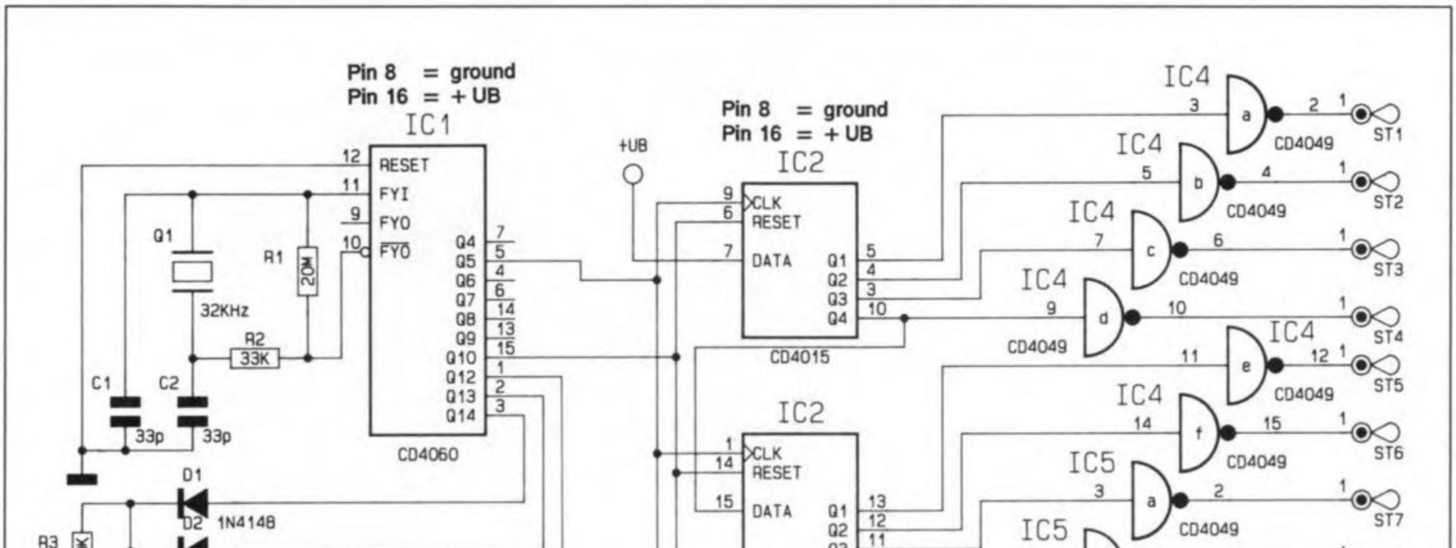


Fig. 1. Circuit diagram of the transmitter unit.

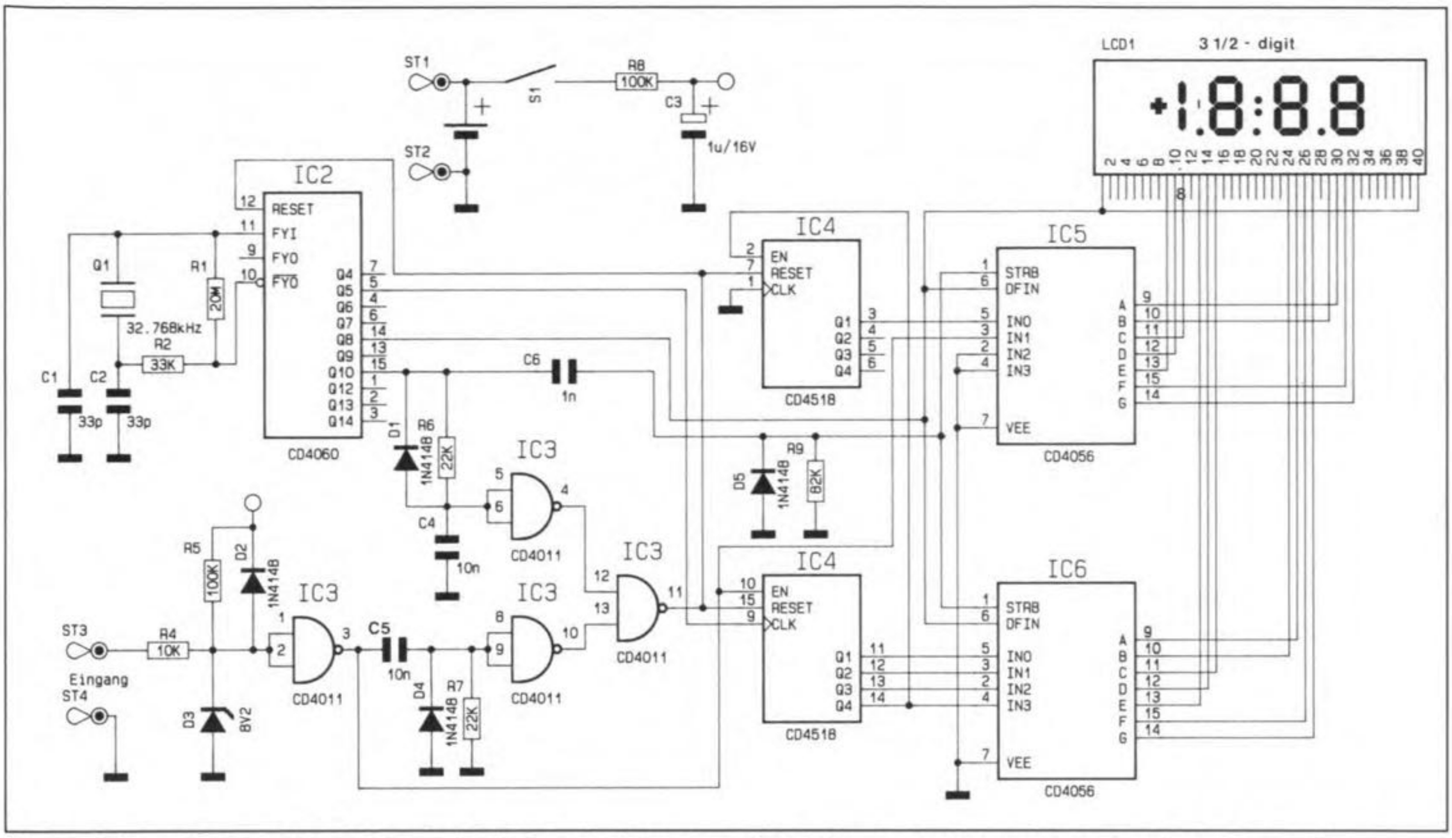


Fig. 2. Circuit diagram of the receiver unit. The use of a battery is optional since the circuit may be powered by the transmitter.

capacity will be sufficient for about 2,000 hours of operation.

Like the transmitter, the receiver uses a Type CD4060 oscillator/divider as the central clock source. The clock pulse frequency at output Q5 is also 1,024 Hz as determined by quartz crystal Q_1 (32.768 KHz). The clock signal is applied to the count input, pin 9, of IC_4. The number of clock pulses that can be counted is determined by the length of the counter enable signal applied to pin 10.

The following description of the receiver timing sequence starts with the moment output Q10 of IC_2 supplies a reset pulse. This low-to-high transition is delayed by network R_6-C_4 and subsequently applied to the input of inverter IC_{3a}. As a result, inverter IC_{3c} supplies a low-to-high transition that resets the counters in IC_4 as well as the oscillator/divider, IC_2. At the same time, output Q10 of IC_2 goes low, and the reset pulse supplied by IC_{3c} is ended. The circuit is ready for a new count cycle.

Assuming that inputs ST3 and ST4 are not connected, the inputs of gate IC_{3d} are pulled high by R_5. Since IC_{3d} is an inverter, its output then supplies a low level that keeps IC_{4b} disabled, although this counter receives clock pulses. The display indicates '00' in this condition.

If inputs ST3 and ST4 are connected, IC_{3d} supplies a high level that enables counter IC_{4b}. The gate simultaneously supplies a pulse, via C_5, to IC_{3b}, which passes it on to IC_{3c}. The needle pulse at pin 11 of IC_3 resets the two counters in IC_4, as well as the oscillator/divider, IC_2. Since the pulse is very short, these circuits are re-enabled almost immediately afterwards, so that the clock pulses supplied

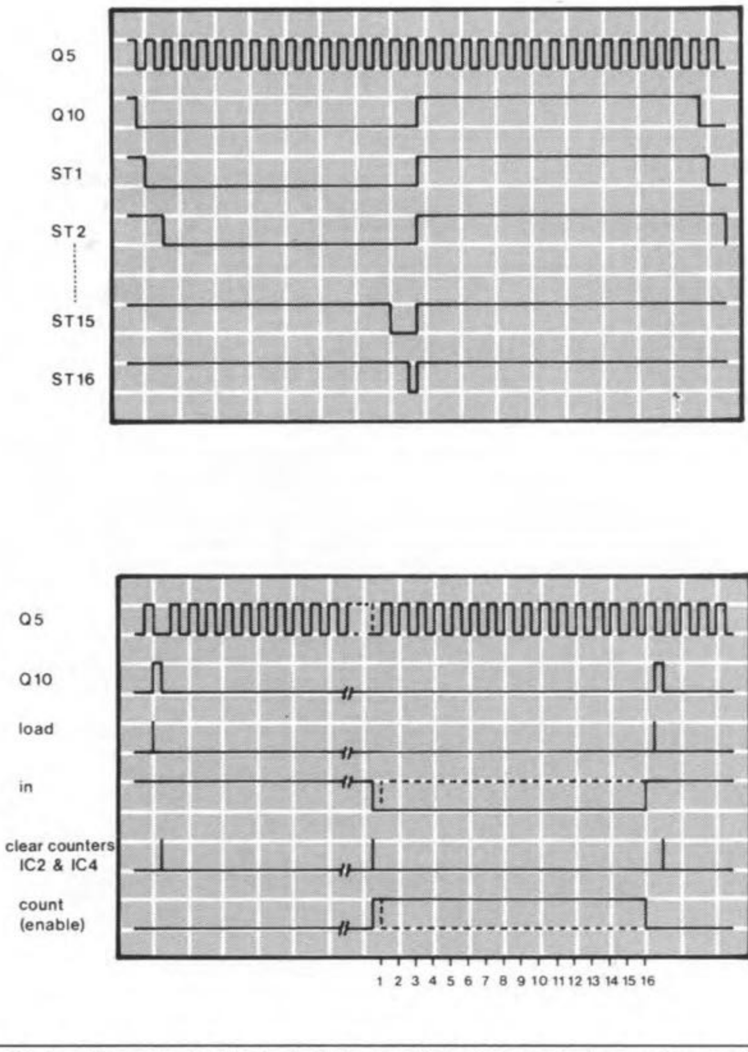


Fig. 3. Timing diagrams to illustrate the operation of the code transmitter and receiver.

by the Q5 output of IC_2 may be counted by IC_{4a} and IC_{4b}.

After counter IC_{4b} has reached state '9', a carry is effected to IC_{4a} via the Q4 output and the enable (EN) input of the respective counters. In this manner, 16 clock pulses are counted until output Q10 of IC_2 changes from low to high.

When that happens, a high pulse reaches the strobe inputs of decoders/LCD drivers IC_5 and IC_6. This event causes the current BCD counter value (e.g., 16) to be latched and displayed.

Since the most-significant counter, IC_{4a}, need discriminate only between 0 and 1 (higher values than 16 are do not occur), Q1 is connected to the least-significant input of the associated decoder/LCD driver, IC_5. The next higher input of IC_5, pin 3, is driven by IC_{3d}. If a short-circuit exists between a conductor and the reference potential, this gate supplies a permanent logic high level that causes the input value of IC_5 to be increased by '2'. As a result, the value '1' determined by IC_4 pin 3 changes into '3'. Hence, short-circuits in the cable are indicated by the value '36' on the display.

Shortly after the strobe pulse, IC_{3c} clears IC_2 and counters IC_{4a}-IC_{4b} with the aid of a delayed (R_6-C_4) reset pulse. Since the previously established counter states are latched in IC_5 and IC_6, the display reading does not change. When the input terminals, ST3-ST4, are disconnected, the display changes to '00' after the next count cycle. Since the measurement rate is about 30 per second, the display reading follows the wire probe operations virtually immediately.

For the following description of the conductor decoding operation, it is assumed that the signal input, ST3, is connected to conductor number 8 in the cable. In the stand-by state, the transmitter supplies a high level, so that the output of IC_{3d} is low. As soon as the input signal goes low, this output changes to high. Capacitor C_5 supplies a reset pulse to IC_2 and the counters in IC_4. Next, the count cycle starts. Counter IC_{4b} counts the clock pulses supplied by the Q5 output of IC_2 until the output of IC_{3d} goes high. In this example, input ST3 is low for 8 clock pulses, then reverts to high. The resultant low level at the output of IC_{3d} disables IC_{4b} and so stops the counters at output state 08.

After 16 clock cycles, Q10 of IC_2 changes to high and causes the counter state to be latched in the LCD drivers. The readout is '08' in this case. Next, network R_6-C_4 causes the counters to be reset, and a new measurement cycle to begin.

The input of IC_{3d} is protected by R_4-D_2-D_3. The latter is a zener diode because the circuit has a relatively high series resistor in the power supply line to minimize the current drain, and also because D_2 alone would not afford sufficient protection against serious input overload conditions.

When the receiver is used without a battery, the circuit is powered by the transmitter, via the cable wires, the input terminals ST3-ST4, R_4-D_2 and C_3. The latter is a buffer device which retains sufficient charge to power the receiver circuit during the low parts of the input signal. Obviously, the receiver can not work without a battery if its inputs are either open or short-circuited.

A frequency of 128 kHz taken from Q8 of IC_2 is applied to the DFIN (display frequency in) terminals of the LCD drivers, ICC_5-IC_6, and to the backplane terminal, pin 2, of the 3½-digit LC display.

Construction

Transmitter

The transmitter is constructed on a single printed-circuit board. Population of this board is straightforward with reference to the parts list and the component overlay plus photograph in Fig. 3.

Start the construction by fitting the low-profile parts such as the wire links, the diodes, ICs and resistors (IC sockets are not used).

Push the terminals of the miniature switch, S_1, as far as possible into the relevant holes, then solder them at the track side. Solder terminals are not required at any point during the construction of the transmitter or the receiver.

Fit the LED such that the lower side of its plastic body is about 15 mm above the board surface.

Connect the battery clip wires to solder points ST18 (+; red wire) and ST19 (–, black wire).

Seventeen crocodile clips and flexible leads are provided with the kit for use in the transmitter. Arrange the leads into a

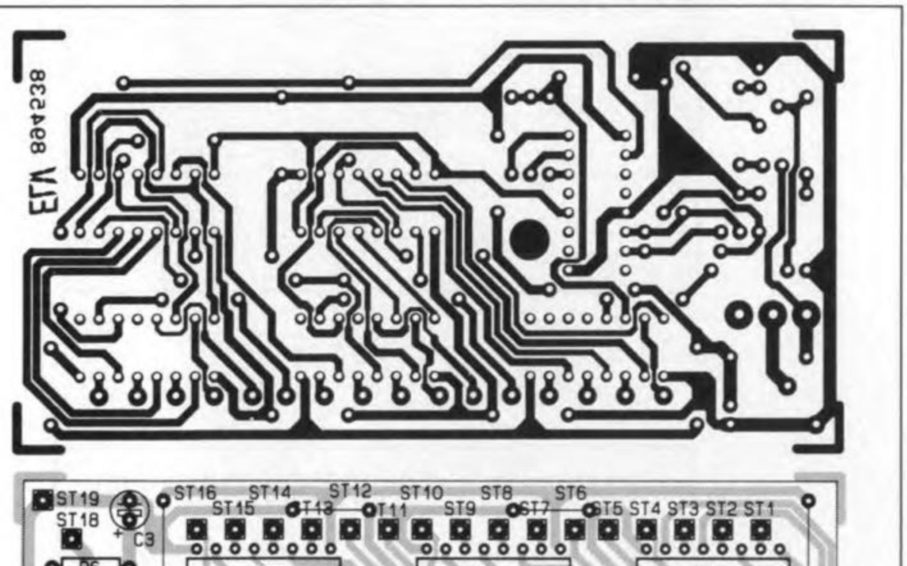


Fig. 4. Printed-circuit board for the transmitter.

COMPONENTS LIST

TRANSMITTER

Resistors:
R_5 = 68Ω
R_4;R_6 = 10k
R_2 = 33k
R_3 = 100k
R_1 = 20MΩ

Capacitors:
C_1;C_2 = 33p
C_3 = 100µ 16V

Semiconductors:
IC_1 = CD4060
IC_2;IC_3 = CD4015
IC_4;IC_5;IC_6 = CD4049
T_1 = BC548
D_5 = ZPD 4V7
D_1;D_2;D_3;D_6;D_7 = 1N4148
D_4 = LED; 3 mm; red

Miscellaneous:
Q_1 = 32.768 kHz miniature quartz crystal.
S_1 = miniature toggle (SPDT) switch.
Qty. 1: battery clip.
Qty 17: flexible test lead with crocodile clip.
23 cm silvered wire.

regular colour distribution, and use either black or white for the separate reference connection. Insert the free end of each lead into the respective hole in the side panel of the top half of the transmitter enclosure. Make a knot in each lead at the inside of the enclosure to provide a strain-relief. Leave a lead length of about 10 mm at the inside of the enclosure. Connect all 16 signal input leads, and the single reference lead, to the respective points on the PCB.

Carefully fit the completed PCB into the lower half of the enclosure. Install and connect the battery.

Remove the nuts on the switch shaft. Place the top half of the enclosure on to the lower half while carefully drawing out the 17 leads up to the strain-relief knots.

Secure the top and the bottom halves of the enclosure with the self-tapping screw provided. Make sure that the top of the LED is about level with the front panel surface.

Receiver

The construction of the receiver is also straightforward. A few points should be noted, though.

The LC display is not fitted direct on to the board. Instead, insert it into two 20-way contact strips, which are previously soldered on to the board. These contact strips raise the LC display a little so that its face is at the correct height for the front panel of the enclosure.

Fit capacitor C_3 and crystal Q_1 horizontally. Cut off three 10-mm long pieces of silver-plated wire (provided in the kit) and fit these into the holes for the slide switch, S_1. Solder these wires at the track side, making sure they remain vertical. Next, solder the terminals of the slide switch to the free wire ends.

The receiver input leads are fitted and connected as discussed with the transmitter. The red wire goes to PCB spot ST3, the black (or white) one to PCB spot ST4. The battery clip is connected as with the transmitter —the red wire goes to ST1 (+); the black wire to ST2 (–).

Fit the PCB with the LC display facing down into the top half of the enclosure. Push the PCB down until the face of the LCD is about level with the front panel surface. Secure the PCB with two self-tapping screws at the side of the battery compartment. Apply a little glue at the side of the input terminals to secure the PCB locally.

Remove the battery cover and place the bottom half of the enclosure on to the top half. At the same time, draw out the two input wires and guide the battery clip wires to the battery compartment, through the slot provided. If necessary adjust the position of the battery clip in the compartment.

Join the two enclosure halves with the screws provided, and install the battery.

The wiring allocation tester is ready for use at this stage. Alignment is not required. ■

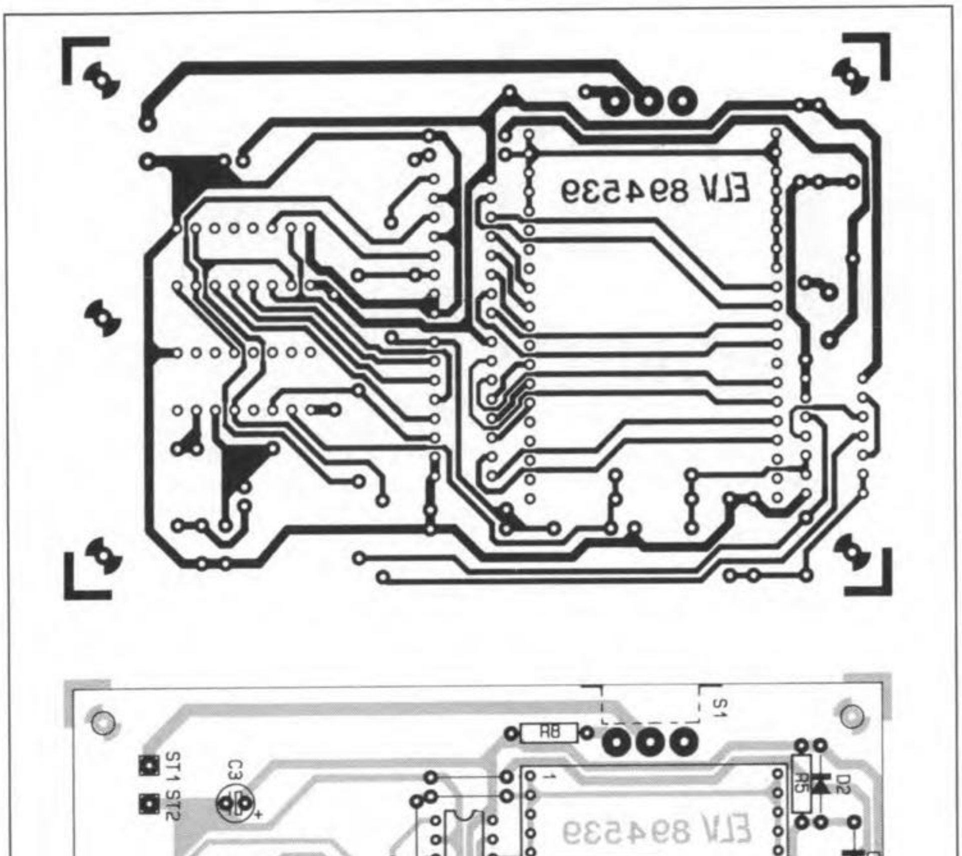


Fig. 5. Printed-circuit board for the receiver.

A complete kit of parts for the wiring allocation tester is available from the designers' exclusive worldwide distributors (regrettably not in the USA and Canada):

ELV France
B.P. 40
F-57480 Sierck-les-Bains
FRANCE
Telephone: +33 82837213
Fax: +33 82838180

COMPONENTS LIST

RECEIVER

Resistors:
R_4 = 10k
R_6;R_7 = 22k
R_2 = 33k
R_9 = 82k
R_5;R_8 = 100k
R_1 = 20MΩ

Capacitors:
C_1;C_2 = 33p
C_6 = 1n0
C_4;C_5 = 10n
C_3 = 1µ0 16V

Semiconductors:
IC_2 = CD4060
IC_3 = CD4011
IC_4 = CD4518
IC_5;IC_6 = CD4056
D_3 = ZPD 8V2
D_1;D_2;D_4;D_5 = 1N4148

Miscellaneous:
Q_1 = 32.768 kHz miniature quartz crystal.
LCD_1 = 3½-digit display.
S_1 = SPDT slide switch.
Qty. 1 :battery clip.
Qty. 1: 40-way IC socket (for LC display).
Qty. 2: flexible test lead with crocodile clip.
39 cm silvered wire.

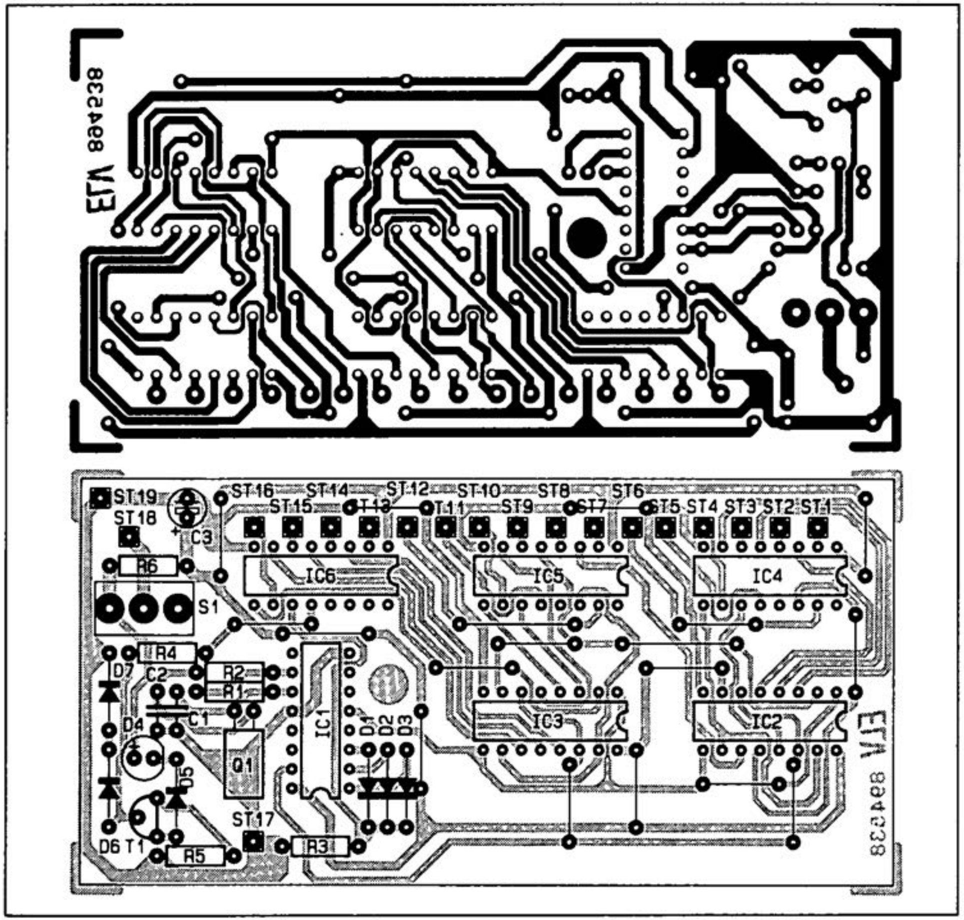


Fig. 4. Printed-circuit board for the transmitter.

COMPONENTS LIST

TRANSMITTER

Resistors:

R_5 = 68Ω
R_4;R_6 = 10k
R_2 = 33k
R_3 = 100k
R_1 = 20MΩ

Capacitors:

C_1;C_2 = 33p
C_3 = 100μ 16V

Semiconductors:

IC_1 = CD4060
IC_2;IC_3 = CD4015
IC_4;IC_5;IC_6 = CD4049
T_1 = BC548
D_5 = ZPD 4V7
D_1;D_2;D_3;D_6;D_7 = 1N4148
D_4 = LED; 3 mm; red

Miscellaneous:

Q_1 = 32.768 kHz miniature quartz crystal.
S_1 = miniature toggle (SPDT) switch.
Qty. 1: battery clip.
Qty 17: flexible test lead with crocodile clip.
23 cm silvered wire.

input wires and guide the battery clip wires to the battery compartment, through the slot provided. If necessary adjust the position of the battery clip in the compartment.

Join the two enclosure halves with the screws provided, and install the battery.

The wiring allocation tester is ready for use at this stage. Alignment is not required. ■

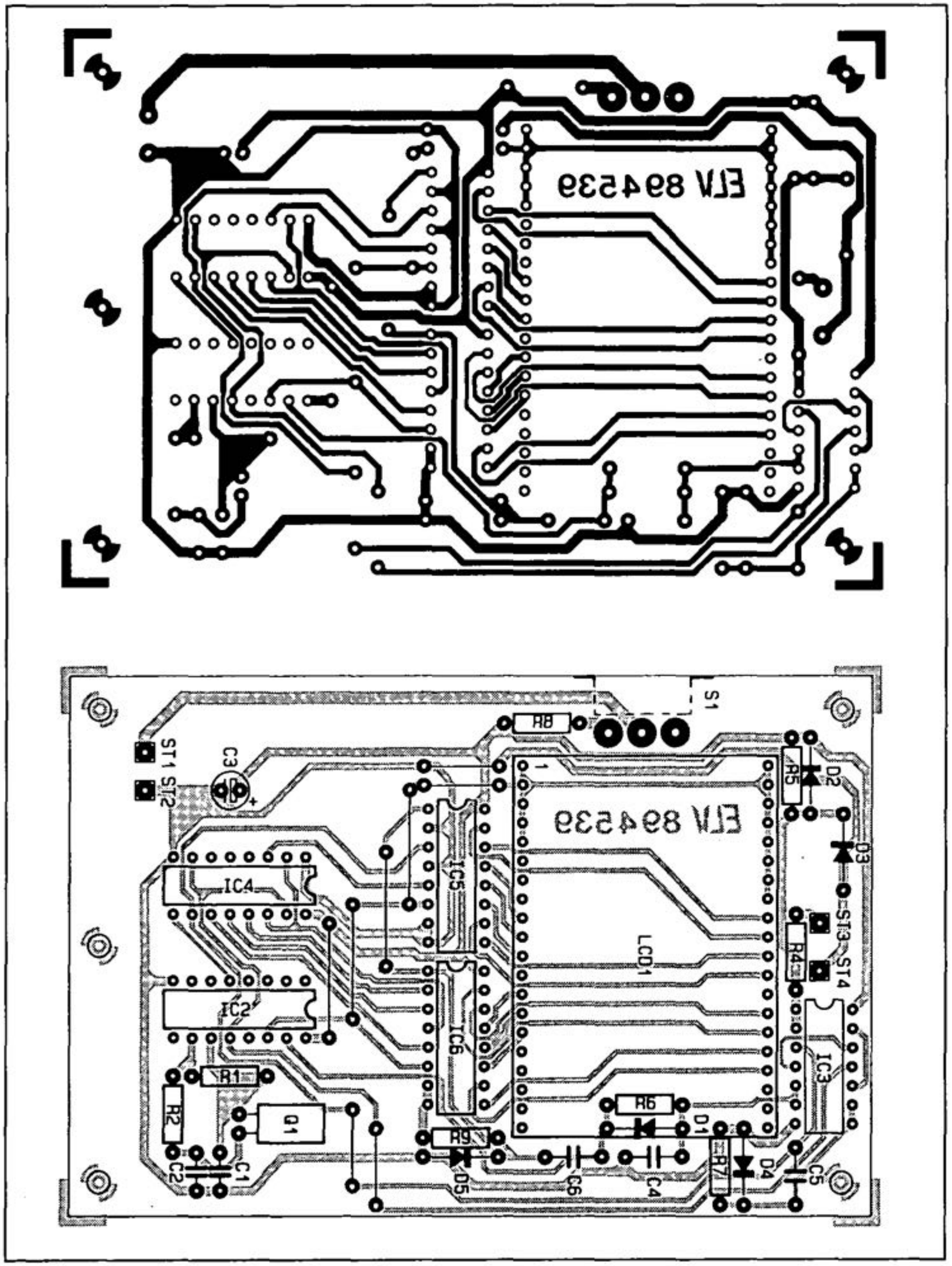


Fig. 5. Printed-circuit board for the receiver.

COMPONENTS LIST

RECEIVER

Resistors:

R_4 = 10k
R_6;R_7 = 22k
R_2 = 33k
R_9 = 82k
R_5;R_8 = 100k
R_1 = 20MΩ

Capacitors:

C_1;C_2 = 33p
C_6 = 1n0
C_4;C_5 = 10n
C_3 = 1μ0 16V

Semiconductors:

IC_2 = CD4060
IC_3 = CD4011
IC_4 = CD4518
IC_5;IC_6 = CD4056
D_3 = ZPD 8V2
D_1;D_2;D_4;D_5 = 1N4148

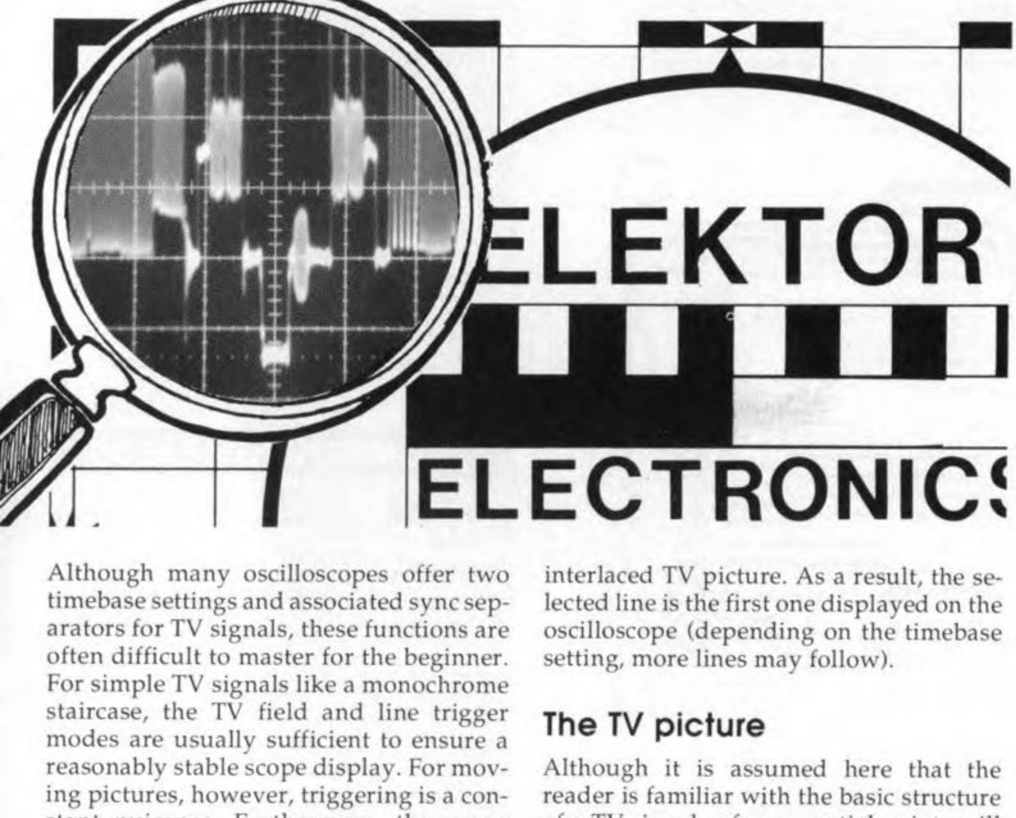
Miscellaneous:

Q_1 = 32.768 kHz miniature quartz crystal.
LCD_1 = 3½-digit display.
S_1 = SPDT slide switch.
Qty. 1 :battery clip.
Qty. 1: 40-way IC socket (for LC display).
Qty. 2: flexible test lead with crocodile clip.
39 cm silvered wire.

VIDEO LINE SELECTOR

from an idea by C.J.A. Kuppens

This low-cost line selector is a must for any one working on television and video circuits. The reason is plain: an oscilloscope, even when set to TV field or line triggering, will not usually allow you to study the video content of one specific line in the picture. This is simply because it is re-triggered by every next sync pulse instead of a single, user-defined, one. The present instrument ends the hassle in keeping your scope triggered on a video signal. Applications are manifold and interesting as you will soon discover. In particular, the 'invisible' test lines transmitted as an extra service by most TV stations are indispensable for aligning video circuits as well as for bandwidth- and picture-quality assessment.



Although many oscilloscopes offer two timebase settings and associated sync separators for TV signals, these functions are often difficult to master for the beginner. For simple TV signals like a monochrome staircase, the TV field and line trigger modes are usually sufficient to ensure a reasonably stable scope display. For moving pictures, however, triggering is a constant nuisance. Furthermore, the scope user often has no idea which picture line he is monitoring.

The function of a video line selector is not unlike that of a word comparator for, say, a logic analyzer. Both circuits allow the user to define a certain trigger condition for the displaying instrument (usually an oscilloscope). This condition is necessary to extract only the wanted information from a composite signal, and to prevent all other information arriving at the display, where it causes confusion and display irregularity. In the case of the logic analyzer, the trigger condition is defined as a combination of logic levels. In the case of the video line selector, it is defined as the number of a specific line in the TV picture. The present circuit has a block of thumbwheel or other switches with BCD outputs to set up a trigger condition for any one of 625 lines (PAL) in an interlaced TV picture. As a result, the selected line is the first one displayed on the oscilloscope (depending on the timebase setting, more lines may follow).

The TV picture

Although it is assumed here that the reader is familiar with the basic structure of a TV signal, a few essential points will be covered briefly in the interest of the circuit description. The discussion applies mostly to the PAL I/B/G TV standards.

A moving TV picture is not a series of still images projected on the screen in rapid succession. Rather, it is produced by the light emission of individual pixels (picture elements) at the inside of the picture tube. These pixels are actuated by a fast scanning electron beam. The intensity of this beam is accurately controlled to actuate certain pixels, while 'skipping' adjacent ones. In this way, the picture is built up from many hundreds of thousands pixels. Since the actuation and light emission times of the pixels are finite, the picture must be 'refreshed' at a sufficiently fast rate. This is achieved by having the electron beam perform a scanning movement as shown in Fig. 1. The picture is, in fact, composed of two fields, which together form a raster or picture. To allow sufficient time for the blanked beam to travel from the bottom of a raster to the top of the next one, and to prevent display flicker, the scanning is interlaced, i.e., two fields are written in succession. After the blanking period (vertical flyback), the beam starts to write, in a zig-zag manner, the first (or 'odd') field, starting at the top centre of the picture. The number of complete pictures (rasters) is 25 per second, which is obtained by displaying 50 interlaced fields per second.

Since a PAL picture consists of 625 lines, each field must have 312.5 lines to maintain the correct relationship with the other field due to the interlacing. The sequence is, therefore, 1-314-2-315-3-316, etc. (see Fig. 1).

A number of lines at the top and the bottom of the picture shown in Fig. 1 fall inside the field blanking and are therefore not normally visible on the TV. On many older TV sets they can be made visible, however, by reducing the vertical picture width. In practice, about 10% of the available number of picture lines (625 for PAL) fall within the vertical flyback (blanking) period, which contains the vertical synchronization pulse and a number of other signals.

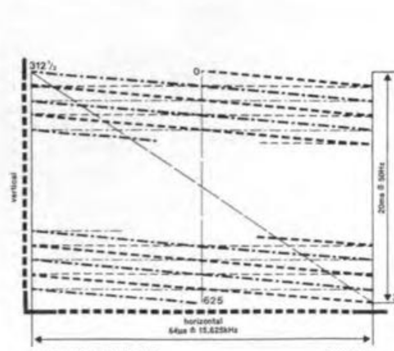


Fig. 1. One TV picture (or raster) consists of two interlaced fields.

TV lines in a PAL picture have a duration of 64 µs, which corresponds to a line frequency of 15,625 Hz. About 52 µs of each line contains picture information — the rest (invisible to the left and the right) is allocated to the line blanking interval. One picture is built up in 20 ms, i.e., the vertical sync runs at 50 Hz.

Inside the field blanking period

At the end of each field (312.5 lines), the scanning beam has to be repositioned to point to the top of the screen. The (simplified) drawings in Fig. 2 show a staircase video signal in two successive fields. The raster synchronization pulse starts at instant FDW, the field datum word, and lasts 2.5H (H = one line period). A problem may occur with the line synchronization, which must continue during the field synchronization. Normally, in a composite video signal, the line synchronization is detected as a pulse that goes lower than the reference black (or blanking) level. Since the field sync pulse already reaches the lowest possible level, the TV would miss out on at least 2 line sync pulses if they were not inserted 'upside-down' in the field sync interval. This can be done with impunity since most line sync processors in TV sets and monitors use the negative edge of the pulse (in Fig. 2, these are marked with a small dot).

Since each raster consists of an odd number of lines, a field consists of an even number of lines plus one half line. This means that instant FDW coincides with the start of a full line (number 1) in the first field, and with the centre of a line (number 313) in the second field. As a result, the inverted line-sync pulses occur at different instants in the odd and even fields. Without special measures, this may lead to incomplete interlacing and, as a result, a light display flicker.

The cause of this (possible) problem lies with the synchronization separator circuits in the TV. In general, the line- and field-sync signals are obtained in two ways with the aid of different circuits. The line-sync is obtained by *differentiating* the sync pulse train, whereas the field-sync is obtained by *integrating* the sync pulse train. Without going into details on these operations, it will be clear that the instant the field-sync pulse for the first field arrives, it will be one line period (H) after the last line sync pulse. For the second field, however, it follows at only 32 µs (0.5H) after the last line sync pulse. This situation would lead to timing problems with the regeneration of the field-sync pulses (obtained from integration, which is a time-based operation) for the two fields, and, as a result, small, but visible, interlace imperfections.

The solution to this problem has been found in the use of equalizing pulses which precede and follow the field-sync pulse as shown in Fig. 3. These pulses, which are 2.35-µs long, are inserted into

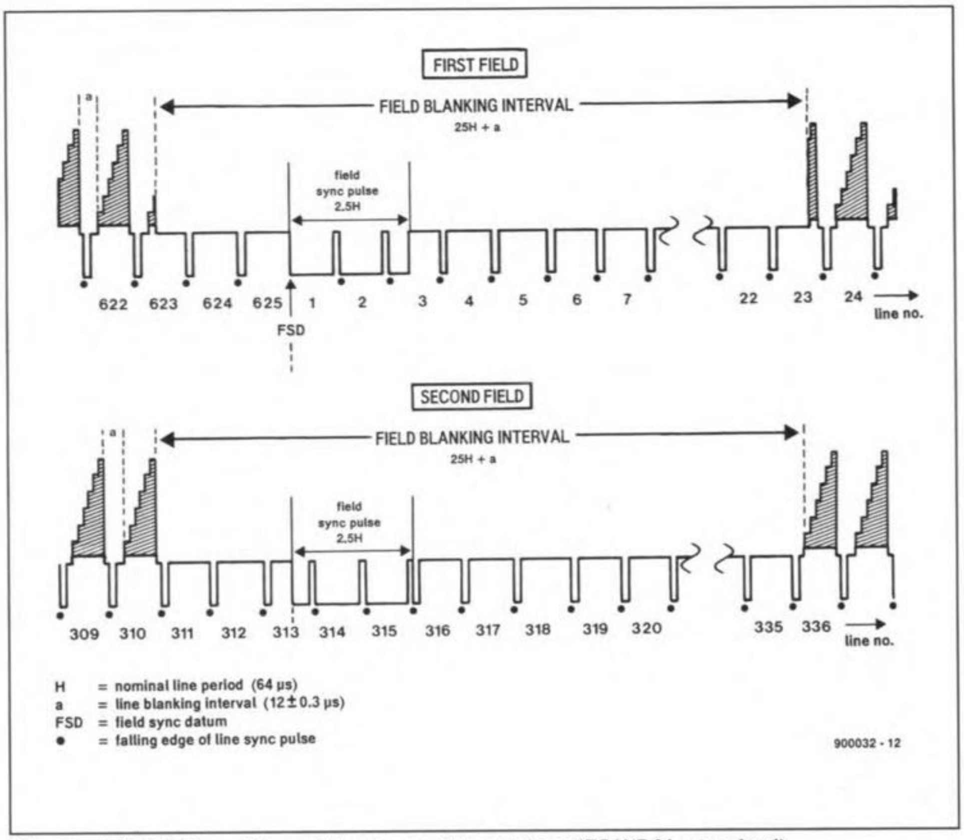


Fig. 2. TV-field transition without equalizing pulses (EBU/PAL standard).

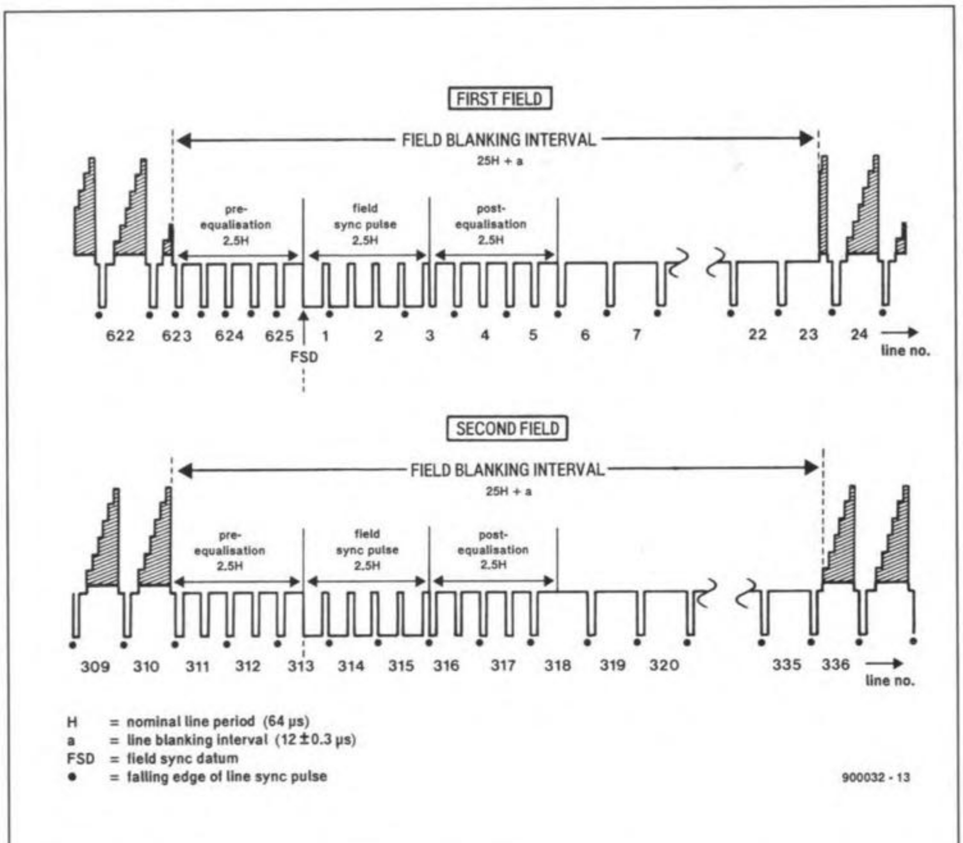


Fig. 3. TV-field transition including equalizing pulses to ensure near-perfect interlacing (EBU/PAL standard).

2.5H-long slots before and after the field-sync pulse. The frequency of the equalizing pulses is 2 times that of the line frequency, while their width is half that of a line-sync pulse.

The beneficial effect of the equalizing pulses is that the integrator output voltages provided by the picture sync separator are made equal for both fields. The result is near-perfect interlaced scanning.

Although the first 20 lines after the field-sync fall within the field blanking period, they are not normally empty (i.e., black with no video content). Indeed, the lines in the blanking period are often the most interesting to the video technician.

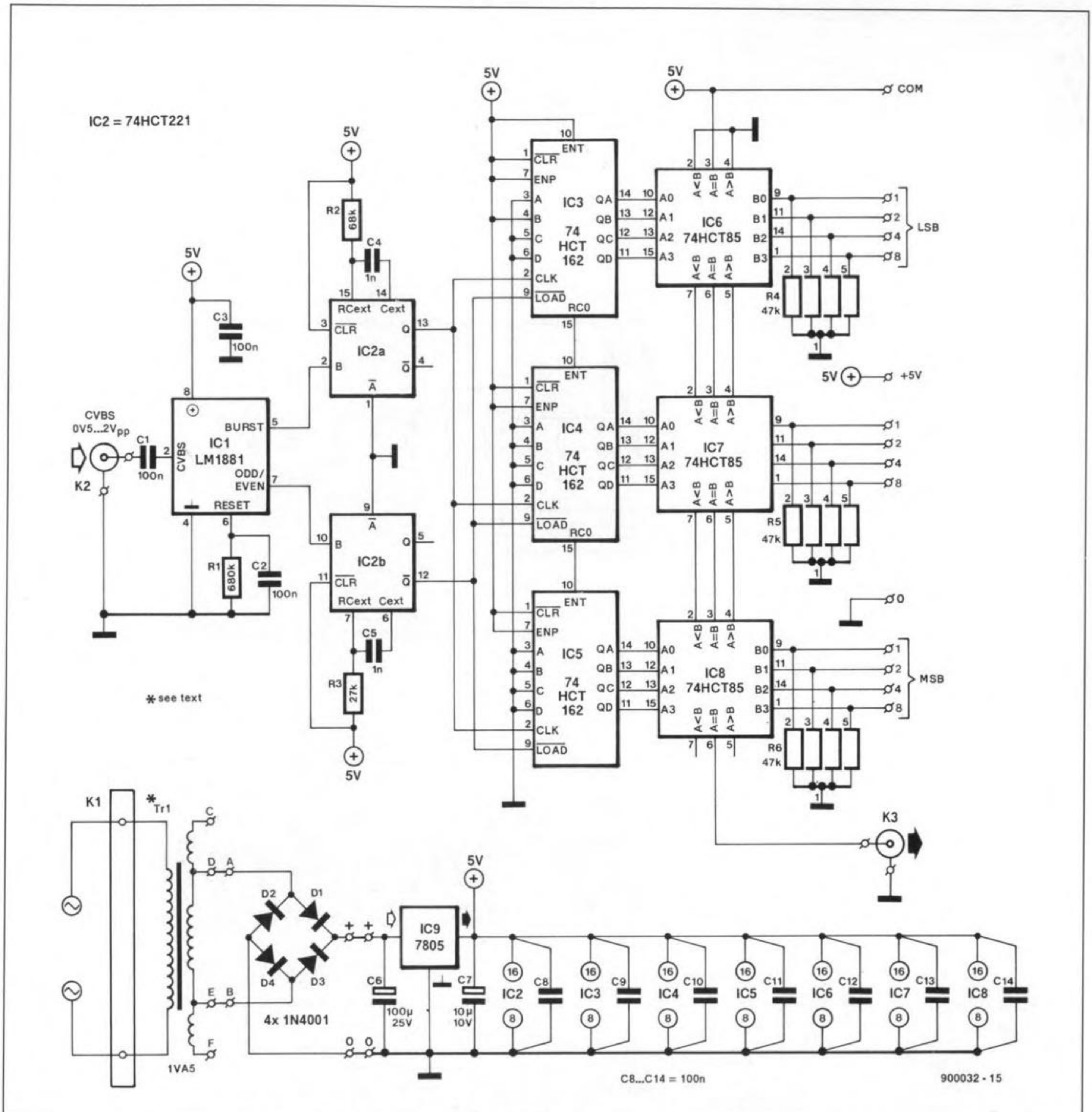


Fig. 4. Circuit diagram of the video line selector. The heart of the circuit is formed by an integrated synchronization separator, IC1.

Depending on the TV station and operating authorities, lines 15–21 and 328–334 usually contain special test signals. These video insertion test (VIT) signals may be fed to an oscilloscope to assess the reception quality or the response of certain subcircuits in the receiver. In a number of cases, these lines are also used for remote monitoring of transmitter linearity and for information exchange between a central microwave distribution tower and TV relay stations. The use of these lines appears to be little-known, which makes them even more interesting (also for certain satellite-TV transmissions).

In Europe, Teletext is normally carried in lines 15, 16, 20, 21, 328, 329, 333 and 334.

The circuit

The practical circuit of the video line selector is fairly simple —see Fig. 4. The circuit may be divided in two parts: a sync separator (IC1 and IC2) and a counter plus word comparator (IC3–IC8).

The circuit has two inputs and one output. One of the inputs is for the composite video signal (CVBS at connector K1), and the other for the BCD switch block (or discrete switches) used for setting the video line number. The output supplies a CMOS-compatible, digital, signal with a swing of 5 V for connecting to the trigger input of an oscilloscope.

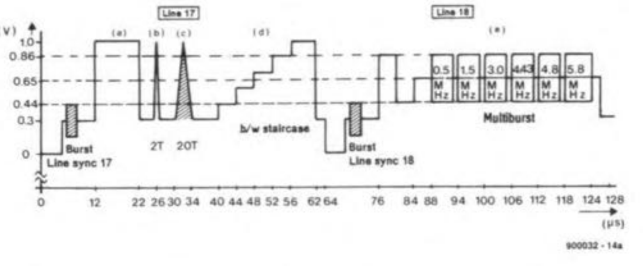
The key component in the sync separator is IC1, a Type LM1881 from National Semiconductor. This chip contains everything that is necessary to extract the synchronization pulses from a composite video signal applied to its input, pin 2. In addition, it is capable of identifying, on the basis of their different sync-pulse structures, the odd and even fields that make up a raster. Only the BURST and ODD/EVEN outputs are used in the present application. The BURST output goes low for about 4 µs to mark the approximate location of the chrominance colour burst (4.43 MHz for PAL; 3.58 MHz for NTSC) on the back porch of the line blanking period. The burst pulse is used here for line counting since the LM1881 lacks a line-sync output. Provided the timing is corrected, this can be done with impunity

BACKGROUND TO VIDEO INSERTION TEST (VIT) LINES

VIT lines enable the quality of TV reception as well as the quality of TV and video equipment to be checked and optimized. A number of test signals are available, and their function is discussed briefly. The contents of the VIT lines are in accordance with the relevant EBU recommendtions for PAL G/B/I transmissions (CCIR Specification 624-2).

Attention: the use and function of VIT lines are recommendations, not standards. Differences may therefore occur depending on the type of transmitter (terrestial/satellite; high/low power; TV-band; etc.), as well on services and broadcasting authority.

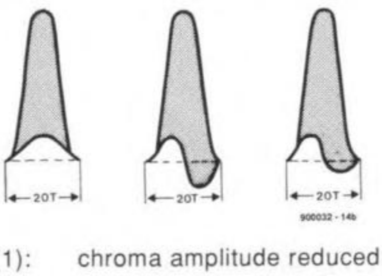
VIT lines 17 and 18



(a) *Reference bar* to establish max. black and white levels. Test: LF-response of receive system.

(b) *2T-pulse* for picture resolution assessment. *T* is the shortest possible rise-time in a system in which the highest frequency of a sinusoidal signal is f_C. Hence, $T=1/2f_C$. In a PAL TV system, f_C=5 MHz so T=0.1 µs. The 2T pulse has sinusoidal slopes and a width of 0.2 µs. Test: amplitude reduction of the 2T pulse with respect to the reference bar means loss of high frequencies in the system. For normal TV reception, a loss of 20% is acceptable.

(c) *20T-pulse* for testing chroma- and luminance response and possible interactions between these components. The 20T pulse is actually a 20T-long chroma burst. Since 20T≡0.5 MHz and the chroma frequency is 4.43 MHz, these components are affected differently by bandwidth limiting factors in the transmission system. Test: the 20T pulse serves to identify amplitude and phase distortion:



response (1): chroma amplitude reduced

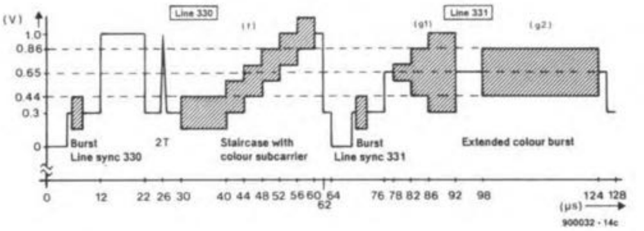
response (2): different phase delays for chroma and luminance

response (3): combination of (1) and (2)

(d) *Monochrome staircase* for linearity assessment. Steps are 140-mV level increments. Test: irregular step size means non-linearity.

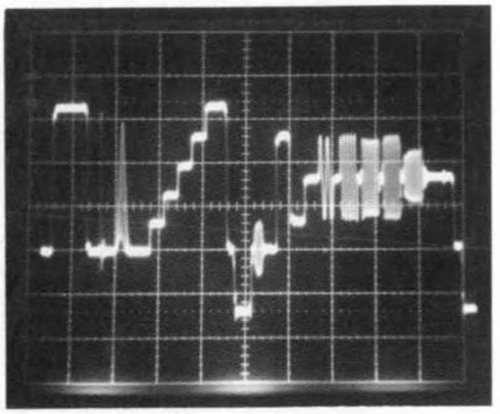
(e) *Multiburst* for frequency response measurement. The bursts have a nominal amplitude of 420 mV_{pp} and are preceded by a 8-µs long 125 kHz reference signal. Test: high-frequency loss is marked by reduced amplitude, which is first noted with the last three bursts.

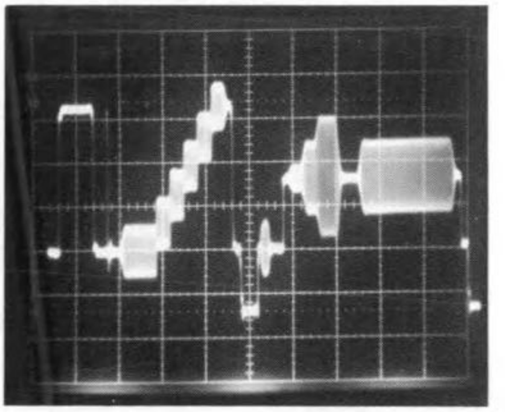
VIT lines 330 and 331



(f) *Staircase with colour subcarrier* for differential gain or phase error detection. The subcarrier level is 280 mV_{pp}. Ideally, the colour separator in the receiver removes the luminance component and supplies a 30-µs long 4.43 MHz burst of 280 mV_{pp}. Test: phase or amplitude irregularities on the step instants (40-44-48-52-56 µs). Use an oscilloscope for amplitude test, and a vectorscope for phase test.

(g) *Colour subcarrier signals and extended colour burst* for measurement of intermodulation between chrominance and luminance components. After filtering out the chroma subcarrier (4.43 MHz), the luminance level should be constant at 0.65 V. Test: amplitude irregularities occurring between 78–92 µs indicate intermodulation caused by chroma changes (g1) or luminance changes (g2; subcarrier level of 420 mV_{pp}). ❑





From theory to practice. Left-hand oscillogram: lines 17-18. Right-hand oscillogram: lines 330-331. Scope used: Iwatsu 100 MHz.

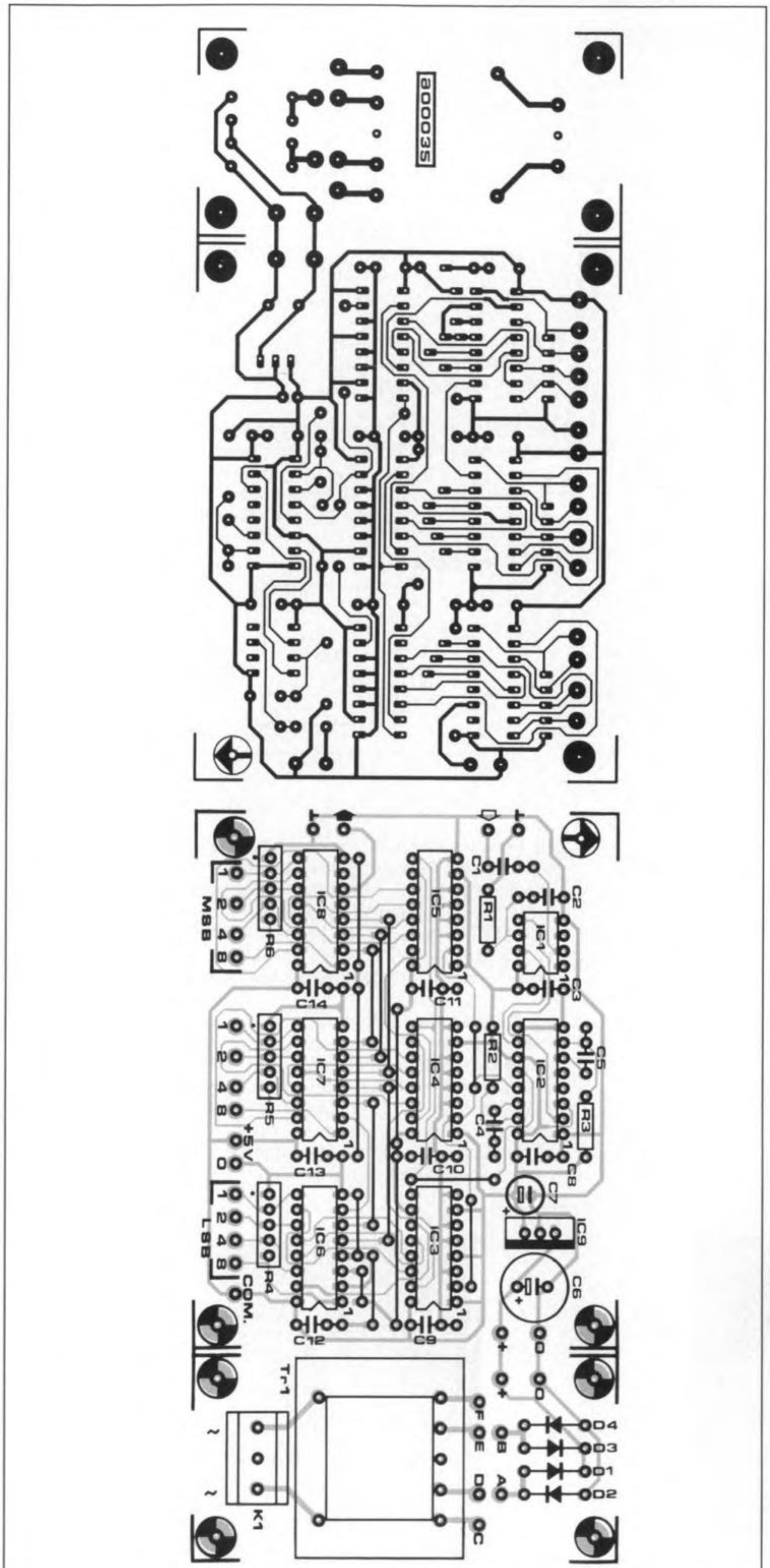


Fig. 5. Track lay-out and component mounting plan of the single-sided printed-circuit board for the line selector.

since every line blanking period has a rear porch (whether a burst is actually present in the CVBS signal is irrelevant here).

Both the ODD/EVEN and the BURST signals are lengthened by a non-retriggerable monostable contained in IC_2.

The ODD/EVEN output toggles on the rising edge of the first equalizing pulse in the field-sync pulse for the first field. The counters in the word comparator, however, are preset on the falling edge of this pulse. Since that instance occurs half-way through the first line, a preset value of 2 (0010) is loaded into IC_3 by tying its B-input to the +5-V line. The result, however, would be that triggering occurs half a line too early for the first 5 lines, which requires a correction at the end of the last equalizing pulse. Timer IC_{2b} is triggered on the rising edge of the ODD/EVEN signal. The $\overline{Q}$ output of this timer is connected to the LOAD inputs of the counters IC_3, IC_4 and IC_5. These are actuated on the rising edge of the clock signal, when the preset values are loaded.

The BURST/BACK PORCH signal supplied by the LM1881 is not used direct for controlling the load operations in the counters. Instead, a non-retriggerable monostable, IC_{2a}, is used to prevent the counters being advanced five lines too many by the equalizing pulses. The monotime of IC_{2a} is set to about 48 μs by R_2-C_4. If the monostable triggers on a equalizing pulse, this monotime ensures that the next one is 'skipped'. In principle, the monotime could be made a little shorter, but also a little longer, e.g, 62 μs or so, to elimi-

COMPONENTS LIST

Resistors:

1	680k	R_1
1	68k	R_2
1	27k	R_3
3	47k 4-way SIL array	R_4;R_5;R_6

Capacitors:

9	100n	C_1;C_2;C_8–C_{14}
1	100n ceramic	C_3
2	1n0	C_4;C_5
1	100μ 25V radial	C_6
1	10μ 10V radial	C_7

Semiconductors:

4	1N4001	D_1;D_2;D_3;D_4
1	LM1881	IC_1
1	74HCT221	IC_2
3	74HCT162	IC_3;IC_4;IC_5
3	74HCT85	IC_6;IC_7;IC_8
1	7805	IC_9

Miscellaneous:

1	mains transformer. Options: VR1109 (Block) or 207-863 (RS components (see text).	
1	PCB terminal block	K_1
1	BNC or phono socket	K_2
1	BNC socket	K_3
1	PCB	900032

ABBREVIATIONS USED IN THIS ARTICLE

BCD	binary coded decimal
CCIR	Comité Consultatif International de Radio
CVBS	chroma-video-blanking-synchronization
FDW	field datum word
PAL	Phase Alternation Line
VIT	Video Insertion Test

nate the risk of IC_{2a} being triggered by noise in the blanking period.

The three-digit binary line number supplied by the three counters is compared to a three-digit number set on BCD switches. The line number word and switch word are applied in groups of 4 bits to the A_n and B_n inputs of three cascaded 4-bit comparators Type 74HCT85. The A=B output of the last comparator, IC_8, goes high if the counted line number matches the number set on the BCD switches. This instant marks the triggering of the oscilloscope timebase, so that the content of the relevant line is displayed. The actual trigger instant coincides with the end of the colour burst at about 4 µs after the positive edge of the line-sync pulse.

The 5-V regulated power supply of the circuit is standard and requires no further discussion. Provision is made to fit three different mains transformers, as will be discussed below.

Construction

The single-sided printed-circuit board for this project is shown in Fig. 5. Depending on the enclosure you intend to use, it may have to be cut into two to separate the power supply section from the rest of the circuit.

Start the construction of the main board by fitting all 14 wire links, followed by the passive parts. The components in positions R_4, R_5 and R_6 are preferably 4-resistor, 5-pin single-in-line (SIL) arrays. Discrete resistors may also be used if such arrays are difficult to obtain. In that case, fit four 47-kΩ resistors upright on to the board and cut their free terminals short. Join the free terminals with a horizontally running wire that goes to the PCB hole marked with a dot.

Voltage regulator IC_9 can make do without a heat-sink as it dissipates little heat.

IC sockets are not strictly required but you may prefer to use them to make replacement of an IC easier if a fault is suspected.

Three different types of transformer may be fitted on the power supply board. The choice between these depends on availability and the mains voltage (UK: 240 V; other European countries: 220 V). For operation from 240-V mains, fit a 2×4.5 V (1.2 VA) transformer from RS Components. For 220-V mains, use either a Block 1×9 V (1.5 VA) or a 2×6 V (1.5 VA) type. Install insulated wire links if necessary:

- RS 2 × 4.5 V: B—F and A—C
- Block 1 × 9 V: B—E and A—D
- Block 2 × 4.5 V: A—C; B—F and D—E

The mains is connected to terminal block K_1.

The choice of the BCD switches is all yours. Thumbwheel switches with BCD outputs are available from several sources. Their only disadvantages are that they are usually relatively large and not as quickly to operate as rotary types. Before connecting the BCD switches to the circuit, be sure you know the pin assignment (A-B-C-D and +/common). A mistake here makes the selection of a particular video line a matter of chance. If in doubt, check out the pin functions of the switches you intend to use with a multimeter. The inputs marked '1' on the PCB must be connected to the least-significant bit, i.e., the switch terminal whose output level changes every time the switch is operated. Similarly, the terminals that change every second, fourth and eight switch turn are connected to the PCB pins marked 2, 4, 8 respectively.

The PCB(s) and the BCD switches are fitted into a suitably sized ABS enclosure. The type shown in the photographs has an outside size of 165×115×75 mm (L×W×H). A mains socket with integral fuseholder is fitted on the rear panel. Two video input sockets are fitted on the front panel to enable the line selector to be connected in parallel with an existing video link. Alternatively, a single BNC input socket may be fitted. In that case, a T-junction is used to make the parallel connection. The trigger output of the circuit is a BNC socket to allow ready use of available test cables.

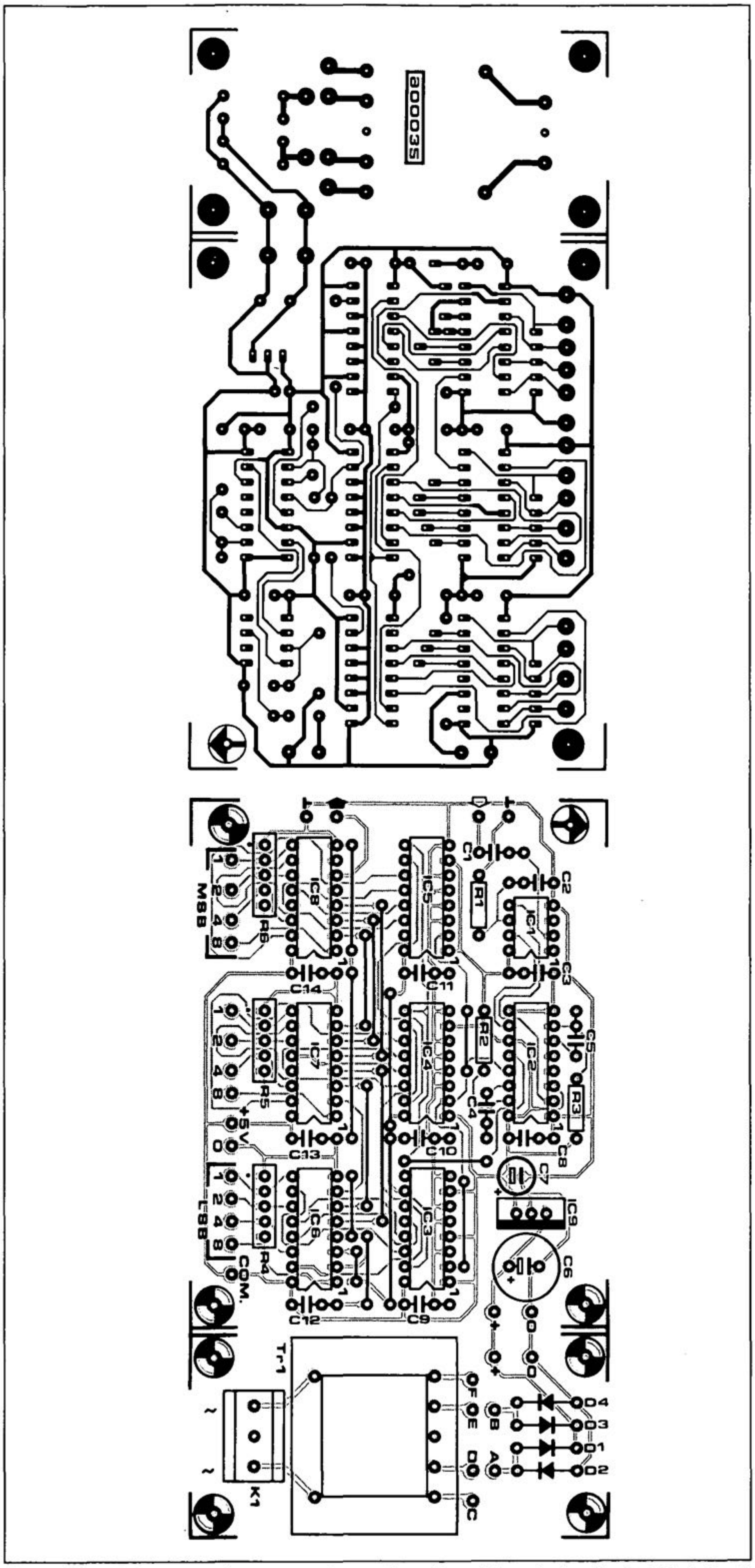
Prototype of the video line selector fitted in an ABS enclosure. BCD thumbwheel switches are fitted on the front panel for easy line setting. The video output socket (second from the left) enables the instrument to be hooked up in parallel with existing video connections.

Practical use

Since the LM1881 has a maximum input voltage rating of 3 V_{pp}, it is recommended to provide the input of the circuit with a 10 kΩ linear potentiometer as a level control. Remember that the input impedance of the LM1881 is about 10 kΩ, and the CVBS signal must be negative-going, i.e. the sync pulses point down and represent the lowest instantaneous voltage.

Connect the trigger output of the circuit to the external trigger input of the oscilloscope. The composite video signal is applied simultaneously to the line selector, the oscilloscope input and a video monitor to assist in tuning to a TV station. Set the scope to external triggering, and select the TV H+ mode if available. Set the timebase to 20 µs. The scope should display three successive lines, starting with the number set on the line selector (line 17 is suitable for a start).

Finally, in view of the relatively fast signals that occur in TV pictures, particularly in the VIT lines, it is recommended to use an oscilloscope with a bandwidth of at least 20 MHz. You will notice that a relatively high trace intensity setting is required for a close examination of the test line contents. ■



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SCIENCE & TECHNOLOGY

PARALLEL PROCESSING FOR FASTER COMPUTING

by Brian Kellock

Scientists and engineers at Hydraulics Research Ltd, a company based near Oxford, are involved in the massive task of constructing a three-dimensional computer model of the North Sea. The project aims to simulate the movement of fine sediments and heavy metals under the action of tides and currents.

For time-consuming modelling of this kind, increased use is being made in Britain of parallel-processing computers. These have many processors operating in parallel, enabling many tasks to be carried out concurrently. In this way, data needed for constructing models can be obtained much faster than by conventional single-processor serial computers.

Among other uses of parallel processing is the design of new generations of aero engines whose development depends on the availability of fast computing. At Derby, Rolls-Royce is exploring the potential of parallel processing as a tool for speeding up the study of airflow through engines as well as for predicting stress and vibration of engine components.

Expertise exploited

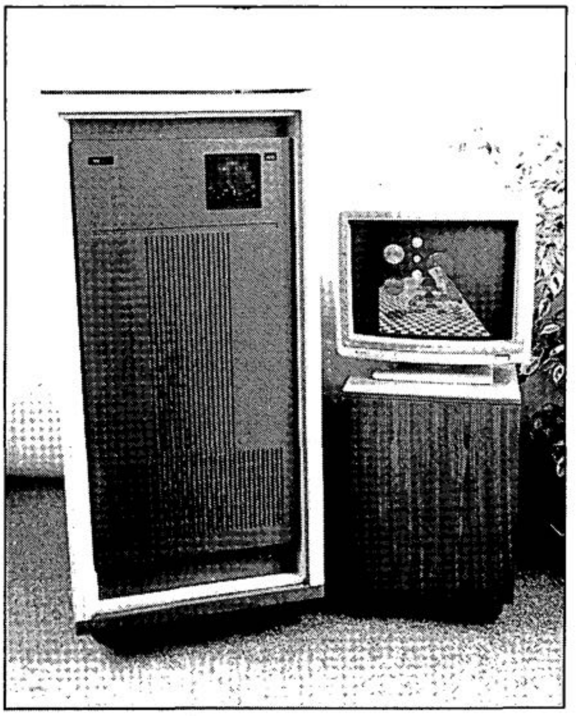
Elsewhere, parallel processing is playing a vital role in fundamental scientific and medical research. For the Imperial Cancer Research Fund in London as part of an international collaborative project to map the human genome, holder of the "blueprint of life", parallel processing promises to speed up the process of cracking its code considerably.

In these applications and others like them, it is the parallel computers and processing expertise of British companies that are being exploited. Such applications represent the leading edge in the industrial use of a technology for which the United Kingdom is pioneering both hardware and software.

Parallel processing is developing mainly along two lines. These are determined by the type of problems to be solved and are reflected in the architecture of the computers. In both cases, the object is speed with the one-operation-at-a-time concept of the conventional computer being replaced by architectures that make multitudes of simultaneous operations possible.

One form of architecture is the single instruction multiple data stream (SIMD) in which an array of simple processors is linked to enable many identical operations to be done simuiltaneously. The other is the multiple instruction multiple data stream (MIMD) where many more powerful networked processors carry out various related operations at the same time.

The Distributed Array of Processors (DAP) from Active Memory Technology (AMT) is an established example of an SIMD parallel computer. It is this make that is used for both the Hydraulics Research and Imperial Cancer Research Fund projects.



The DAP 610 parallel processing computer contains 4096 single-bit processors and will perform up to 40 billion operations per second.

There are two versions of DAP: the DAP 610 with an array of 4096 one-bit processors, each with up to 64 kbits of local memory; and the DAP 510, which has 1024 processors.

In operation, all of a DAP's one-bit processors will do the same task, but each uses different data. Large amounts of input data can be split into parallel streams for simultaneous processing at up to 40 billion operations per second.

Systems sold

DAP technology was pioneered in Britain by International Computers Ltd (ICL) before the product was taken over by AMT for further development. Another British user is Queen Mary College, London, which provides a DAP service to around 1000 users world-wide.

Last September, AMT had sold 69 DAP systems to universities, government department and industrial users. Of these, 25 were in the United Kingdom, 37 in the USA, six in Continental Europe, and one in Japan. Applications range from molecular physics and medical imaging to fluid dynamics and radar processing.

One of the most recent contracts has been from the US Army for a DAP 610 (cost $360,000) for mounting in a helicopter to process airborne scanner imagery for minefield detection.

As Britain's premier computer manufacturer, ICL has a continuing interest in developing parallel-processing machines. It is currently the prime contractor in a consortium of European companies that work together as part of an Esprit 2 project, EP 2025 (European Declarative Systems) to build an MIMD type parallel computer that uses off-the-shelf RISC computer chips.

Britain has been responsible for developing the key component used today in several MIMD parallel-processing computers. This is the transputer, a British invention developed by Inmos.

In 1985, six members of the team that developed the Inmos transputer set up Meiko Scientific to exploit it for parallel processing.

Meiko has developed a computer called Computing Surface, a reconfigurable and expandable machine in which the application software is used to alter the geometry of connexions between processors to suit the problem. Because it contains a large number of networked transputers, each one a computer with its own processor and memory, this will carry out a variety of different operation simultaneously. Rolls-Royce is currently experimenting with such a computer.

To date, more than 200 Computing Surface machines have been sold to industrial, military and research customers. Meiko's largest one is at Edinburgh University, where the Edinburgh Concurrent Super Computer Project now operates the largest parallel computer in Europe. With 400 processors, this can perform 400 million arithmetic calculations per second.

World leader

Inmos's Type T800 transputer is the basic component of a parallel-processing computer developed by Southampton University and its co-partners of the now completed Esprit 1 Reconfigurable Transputer Project 1085.

What began in 1985 as a research project resulted in 100 man-years in a commercially available reconfigurable computer. With the use of architecture developed at Southampton, up to 1024 transputers can be linked in a single machine.

Southampton University is continuing to help maintain the country's position as a world leader in the development and application of parallel processing.

It is especially active in working on new communications architectures aimed at enhancing communication between processors at large bandwidths. Poor communication is a weakness currently limiting the number of processors that can be put together. In this work, the university believes itself to be ahead of the rest of the world. ■

TECHNOLOGICAL ADVANCES IN CRIME DETECTION

by David Pead

When robbers hijacked a lorry carrying £300,000 worth of cigarettes in London, they thought the police had been left far behind as they lost themselves in the city's busy rush-hour traffic. They did not realize that the lorry contained a low-frequency transmitter that broadcast its position wherever it went. The thieves were soon arrested.

The system, called Datatrak, was developed by Securicor-Wimpey, the private security firm, and the speedy tracking of the hijacked cigarette lorry was so impressive that police forces around Britain are studying other possible uses.

Vehicles are fitted with a computer that picks up signals from transmitters all over the country. The computer uses these to plot the vehicle's position against a grid reference map and then relays it to a network of base stations. The base stations determine the position of the vehicle within seconds to an accuracy of 50 metres.

The innovation is just one of the many crime prevention techniques developed by British experts that are making life much harder for criminals.

Perhaps the most important advance of the past five years is the genetic fingerprinting technique that is now used all over the world. This enables any individual to be identified from a drop of blood or saliva as uniquely as if his fingerprints had been taken. When the technique was first used by British officers on a difficult case involving the murder of two teenage girls, it immediately showed that their prime suspect was in fact innocent.

Murderer caught

As the murders had taken place in a normally quiet country area in Leicestershire, police officers asked local people if they would volunteer to take the genetic test to help narrow the inquiry.

Eventually, 5000 men provided small samples of blood for analysis. The murderer was discovered when one of the volunteers told police that a work colleague had tried to persuade him to take the test for him. Tests on the colleague proved positive and he is now serving a life sentence in prison.

The technique was developed by Dr Alex Jeffries at Leicester University and

The pattern of chemical signals in the DNA molecule is unique to every individual and it can be represented graphically. British police can now use these patterns to take bodily traces, such as blood or saliva, and connect them to one person.

depends on hyper-variable mini-satellites of deoxyribonucleic acid (DNA) that occur in the chromosomes of every body cell.

These small segments of DNA are dotted about the chromosomes in patterns that are unique to every individual. Dr Jeffries and his team discovered a segment of genetic material that can be used to probe for these mini-satellites. The probe splits up the genes and generates a pattern of bands that can be printed on X-ray film.

Identifying criminals has always been one of the most difficult parts of police work, and genetic fingerprinting has now given officers another effective tool that can be used in a completely new area.

Visual memory

Many crimes are solved through witnesses identifying those responsible. Traditionally, this has meant witnesses poring over albums of photographs of know criminals or attempting to describe the suspect's features from memory to a police artist, who attempts to draw a likeness based on the description or build an image with the aid of identikit equipment.

Witnesses looking through photograph albums can soon become confused by the sheer mass of faces that they see. Identikit systems, where witnesses build up faces from pre-drawn segments, can also prove confusing and police artists are always dependent on how good the witness is at articulating visual memories.

Researchers at the Government's scientific and research branch of the Home Office have now come up with a system called E-Fit that appears to overcome some of these problems.

Working with a psychology team from Aberdeen University, they have designed the system so that witnesses' memories are actually enhanced rather than put under pressure. Witnesses describe the most striking thing they remember about the criminal. From a computer library of all the main variations of facial features that are possible, equivalent features are shown on screen one at a time.

When the witness is happy with a particular feature (such as a curly moustache or a cauliflower ear), the next feature he or she remembers is subjected to the same process of identification.

Features library

Eventually, the computer presents all the chosen features together in a suggested face likeness on the screen, and the witness can then alter it in any way to get it right. The face can be widened, flattened, or stretched in any conceivable way to make the likeness conform as accurately as possible to the witness's memory.

When the system was put on trial in a number of British police forces, arrests soon followed. In one force, a man who had committed a sexual assault was caught by a uniformed officer referring to the E-Fit likeness the very first time the system was used.

In another force, the E-Fit compiled by a policewoman in a murder case was directly responsible for the murderer's eventual arrest.

The system's developers at first concentrated only on building a library of the facial features of white males. They believe that good likenesses of 99.9% of the British population of white males can now be made in E-Fit. As the system seems to be operating well in police forces, work has now begun on building libraries covering white women and ethnic minorities, as well as making up whole-body composites.

The system will eventually link in to FACES, another development from the research group. This is an updating of the old photographic albums of known criminals and is proving very successful.

Photos of known criminals are stored in a computer, but before a witness looks at any he gives the police officer as good a description as possible. This description is fed into the computer, which breaks down the key elements, such as "big nose and a mole on his cheek".

Likely suspects

The computer then sorts all its photographs and will only offer known criminals with big noses and moles on their cheeks. It presents them on a screen in small groups, starting with the criminals with the closest likeness to the witness's description.

If the witness says none of them is the criminal, the computer will offer the next closest possibilities—perhaps those with a slightly smaller nose, but still with a mole on the cheek.

This cuts down by an enormous amount the number of photographs witnesses have to look at, as well as quickly offering up the most likely suspects. ■

ROBOTS FOR THE RAG TRADE

by Jim Kelsey

Robots with built-in sewing machines are about to revolutionize the garment industry in Britain—known traditionally as the rag trade—by producing made-to-measure clothes within 24 hours of order.

Manufacturers predict that by the year 2000 clothes shops will be stocked with sample garments only. The customer will be measured, the data transmitted to the factory, and the clothes tailored by robots to the customer's needs, bank balance and body shape.

This radical change in the world of the seamstress is already being introduced by wholesale clothing manufacturers, but there is still one garment the robot finds difficult to make. Ask it, for instance, to make a pair of underpants and, to coin a popular phrase, it definitely gets its knickers in a twist.

However, this problem will soon have been resolved by a £171,000 project at Hull University where 15 robots, linked to sewing machines, have been programmed to make a pair of underpants for men or knickers for women every 30 seconds.

Sponsored by Corah, a garment manufacturer from Leicester, who supplies briefs to large retailers such as Marks & Spencer, the project is backed by the Clothing Technology Centre, responsible for promoting good design in the industry.

Problematical production

The research team is led by Dr Antony Wilkinson and Professor Paul Taylor. It has long been possible to provide automated production lines for clothing, provided they are dedicated to a particular design of garment.

Briefs and knickers present great problems to a labour-intensive industry. A typical pair of briefs is made from four pieces of cloth, two of which are roughly triangular for the front and back. Two squares are required to make up the gusset. At the start of the production line are stacks of cloth, cut in bulk and the robot has to pick up one for every garment made.

Inititally, this task proved impossible. The robot dropped the piece and could not pick it up with his pincers. However, some years ago for another project, Hull University researchers developed the Kemp gripper, which blew air on to the top of the stack of material to be sewn, causing the fabric edges to lift. A thin pincer could then slide in and pick up the top piece.

This technique was taken up in the latest project and now enables the robot to handle the fabric.

In the manufacture of underpants, the first two sewing operations create a piece of cloth shaped like an hour-glass, with a double thickness gusset sewn to the two triangles. At this stage it is still two-dimensional and can be laid flat on a conveyor belt.

After the next stage, where on of the waist seams is sewn and elastic run along the leg hole, the half-completed briefs turn into a tangle of cloth and elastic which is a complex shape difficult to describe in computerized modelling programs.

Central computer

The Hull team has had to overcome numerous problems. The double-knit cotton used for briefs has a good deal of lint on its surface which causes rucking in alignment and the fabric tends to stretch. Such difficulties have had to be overcome in creating the hardware and software to make underwear.

The technicians are using a central computer to control a number of personal computers, each responsible for a single, complex operation, such as destacking or stitching a gusset. The computers take data from sensors and send commands to the robots which then begin production.

The researchers are using RTX robots built by one of Britain's largest manufacturers, UMI. This firm specializes in educational robotics, producing thousands of robots for research purposes and designed to perform boring and dirty jobs in industry.

At Hull, an electrostatic gripper has been designed that can lift not only fabric, but paper, leather, nylon and carbon fibre. It makes the fabric stick to a flat plate with the aid of only a 9 V battery.

There is practically no such thing as a standard body shape, so, for the customer, robot production is good news.

In shops, purchasing staff will be able to see the latest trousers, hats or socks before a manufacturer begins making prototypes. The same data will be fed into the bulk cutting machine and used for costings. ■

Q METER

J. Bareford

Among the main electrical properties of an inductor are its self-inductance, its quality (Q) factor and its self-resonance frequency. An instrument to measure the Q factor is described here. Based on resonance frequency measurement, the instrument can be used for testing inductors at frequencies up to about 50 MHz.

Many electronics experimentalists shy away from the design and use of inductors because they feel that these components are difficult to test and measure. Also, often owing to lack of experience and suitable test instruments, these constructors are not always aware of the relative importance and meaning of inductor properties like the self-inductance and the quality factor. Instruments for measuring self-inductance have been described for low-frequency and high-frequency inductors in Ref. 1 and Ref. 2 respectively. The Q-factor, which is equally important for many applications, may be measured at reasonable accuracy with the present instrument. The Q meter discussed is not intended for laboratory use where high accuracy and repeatability are prime considerations. Rather, it is a low-cost test instrument for comparative Q measurements with an accuracy of about 10%. Its usable frequency range extends from 70 kHz to about 50 MHz, while Q factors up to about 200 can be measured with reasonable accuracy.

The principle

Since Q factor measurement is covered in detail in many electronics textbooks, a recap may suffice to explain the basic operation of the instrument —see Fig. 1.

A generator, G, with an internal resistance R_G is connected to an inductor and a variable capacitor. The voltage across the capacitor, U_o, is measured. The inductor, L_x, is actually a combination of an inductance and a series resistance, R_s. The variable capacitor is adjusted until the *L-C* tuned circuit resonates at the frequency set on the generator. At the resonant frequency, ω (= 2πf), the voltages on the capacitor and the inductor are in opposite phase, so that

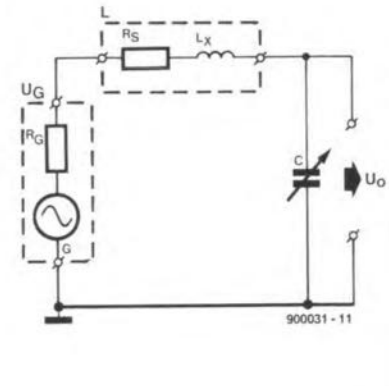


Fig. 1. Principle of Q factor measurement.

$$U_{(Lx)}/U_G = \omega L_x/(R_G+R_s) = Q_L$$

In other words, the loaded Q factor, Q_L, is the inverse of the loss factor of the inductor. The higher its Q, the better the inductor, or in more practical terms, the more selective the parallel- or a series-tuned circuit that can be made by connecting it to a capacitor.

From the above formula, the internal resistance of the generator, R_G, determines the Q factor along with the self-inductance, the resonant frequency and the inductor's internal resistance. Assuming that $R_G \ll R_s$, the real (or unloaded) Q factor may be calculated from

$$Q = \omega L_x/R_s$$

The unloaded Q factor exists in theory only since there is always a generator resistance, however small.

A few points should be noted here. The loss resistance, R_s, is not simply the resistance measured by, say, an ohmmeter. For most small inductors, the d.c. resistance is formed by the wire turns and remains smaller than 1 Ω or so. The actual value of R_s, however, is a function of frequency because it is determined by the skin-effect which forces high-frequency currents to be 'pushed' towards the surface of the wire. The skin effect thus reduces the effective wire diameter and increases ohmic losses in the inductor owing to dissipation. As a result, R_s of an inductor is often much higher than the ohmic resistance.

The second point to note is evident from the equations: the internal resistance of the generator must be as low as possible to prevent large deviations of the measured Q factor of inductors with a relatively small R_s.

Finally, losses in the tuning capacitor and stray capacitance in the test circuit may lower the measured Q factor. In practice, deviations of up to 10% must be allowed for, but these are not usually a problem in practical electronics work.

A more practical approach to Q factor measurement is illustrated in Fig. 2. The voltage across an *L-C* tuned circuit is

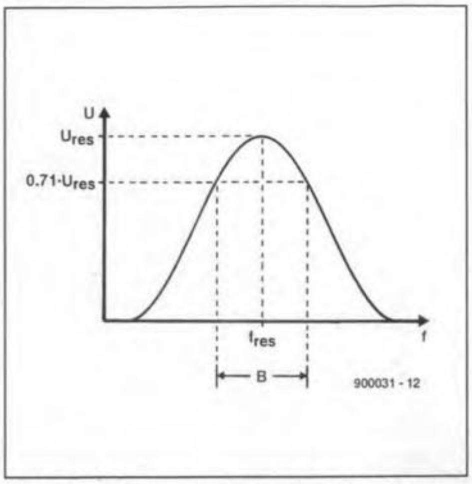


Fig. 2 3-dB bandwidth test method for establishing the Q factor of an inductor in a tuned circuit.

measured at the resonant frequency. This voltage is called the reference level, U_{res}. Next, the generator is tuned up and down to determine the frequencies at which the voltage drops to 0.71 U_{res}. These two frequencies are the –3-dB roll-off points, and the range between them is the 3-dB bandwidth, *B*. A parallel combination of an ideal capacitor and inductor would result in a tuned circuit with an infinitely small bandwidth. In practice, however, there are small losses, so that

$$Q \approx f_{res}/B$$

This test method may be applied in practice with the aid of an RF signal generator to supply the required signal at the resonant frequency, and an oscilloscope to find the –3 dB points. Care should be taken, however, to couple these instruments as lightly as possible to the tuned circuit. Also, the previously mentioned loss factors in *L* and *C*, as well as stray inductance and capacitance, must be taken into account.

Practical circuit

All the ingredients mentioned in the context of theoretical Q measurement are found back in the circuit diagram in Fig. 3.

The RF signal generator is realized by an amplitude-controlled oscillator, T_5 with six frequency ranges. The oscillator is tuned by a variable capacitor, C_{13}, at the pole of the range selector, S_1. Amplitude stabilization is achieved by rectifying the oscillator output signal and using the direct voltage so obtained to control the current sunk by differential amplifier T_1-T_2. The RF rectifier for this purpose is formed by C_5 and D_1-D_2. The latter are two Schottky-barrier diodes Type HP2800 from Hewlett Packard. The voltage at the gate of FET T_4 goes more negative as the oscillator amplitude increases. Since the amplification of T_1 is inversely related to the negative control voltage, a tendency of the oscillator to produce a higher output voltage is counteracted by a smaller gain of T_1. When the oscillator starts, C_5 is rapidly charged and causes the gain control circuit to reduce the output amplitude until a stable level is achieved.

The function of the amplitude stabilization circuit is, of course, bound by practical limits. The actual oscillator output voltage varies between 0.9 V_{pp} and 1.6 V_{pp} at the lowest frequency in any range (C_{13} set to maximum capacitance). This variation may be greater in the highest frequency range as stray capacitance and inductance in the circuit become significant.

FETs T_6 and T_7 form a complementary power output amplifier capable of driving the 50-Ω RF test output, K_1, and impedance transformer L_8. The quiescent current of the power output stage is determined by P_1, which is adjusted for minimum distortion of the oscillator output signal.

Switch S_2 selects between the rectified oscillator output voltage (position B) and the rectified voltage developed across tuning control C_{24} (position A). Both voltages are obtained with the aid of virtually identical MOSFET buffers, T_8/T_9, which are followed by signal rectifiers D_3-D_4-C_{23}/D_5-D_6-C_{27}. The ratio of the resonant voltage to the reference voltage (= oscillator output voltage) is a direct measure of the Q factor of the inductor, L_x.

Inductor L_8 forms a wideband impedance transformer to ensure a low generator series resistance and stray capacitance. The importance of these characteristics is evident from the earlier discussion on basic Q measurement.

Opamp IC_1 forms the meter output driver. The maximum output voltage of 2 V corresponds to a Q of about 200. The actual read-out may be digital on a ready-made 3-digit LCD module, or analogue on a small moving-coil meter with a full-scale deflection of 2 V.

The circuit is powered by a symmetrical ±5 V supply obtained in a conventional manner by creating a virtual ground with the aid of an opamp, IC_3. The input voltage to the circuit may be unregulated between 12 VDC and about 18 VDC supplied by a low-power mains adapter. The current consumption of the circuit is smaller than 30 mA.

If used, the LCD must be powered by a separate battery, which will provide ample power for at least 200 hours of operation.

Construction

The first and foremost consideration that must be given to the construction of the instrument is to keep the connections between the inductor under test and the terminals marked Lx as short as possible. This is the reason that the printed-circuit board (see Fig. 4) is fitted vertically behind the front panel of the enclosure, a Type LC850 from Telet, which has been used for previous instruments in this series.

Inductor L_8

Start the construction by winding L_8 as shown in Fig. 5. Use 0.5 mm dia. enamelled copper wire. Winding A is simple to make because it consists of 40 turns on the ferrite ring core. Spread the turns evenly along the core, and at the same time ensure that the connections end up close together.

The low-impedance winding, B, consists of ten parallel-connected sub-windings on the ring core. Each of these sub-windings is formed by ¾ wire turn, the top and lower connection of which are connected to others by common wires that run round the outside of the ring core. First, make the ten sub-windings from 20-mm long pieces of enamelled copper wire, of which the enamel must be carefully removed over a length of about 1 mm at both ends. Next, cut off two 65-mm long pieces of the same wire, and remove the enamel at the ends as well as at ten locations at 6-mm intervals. Clamp the ten sub-windings on to the ring core; the connections are at the outside. Run the first common wire around the outside of the core and join the ten top connections of the sub-windings. Next, do the same with the second common wire and the lower connections of the sub-windings. Press the common wires in place and bring their free ends together. Connect the B terminals to the respective points on the PCB —the wire that joins the top connections of the sub-windings goes to ground on the PCB. Solder the A terminals to the respective PCB connections.

The Type G.2-3/FT16 ring core from Micrometals may be hard to find locally. To enable constructors to find equivalents, the main electrical characteristics of it are given below.

outside diameter:	16 mm
inside diameter:	9.6 mm
height:	6.3 mm
relative permeability (μ):	4300
A_L value:	3280–5500
frequency range:	0.1– 50 MHz

Printed-circuit board

The printed-circuit board for the Q meter is double-sided but not through-plated. The large copper surface at the component side forms an earth plane to assist in RF decoupling.

Mount the six trimmer capacitors on to the board, making sure that they are soldered rapidly to prevent deformation of the PTFE material by overheating. Next, fit the associated six inductors. Note that these are mounted alternately vertically and horizontally to prevent inductive coupling. As a further precaution, reverse the orientation of every second inductor. This is easiest done by noting the position of the coloured tolerance ring at one of the sides of the body.

The remainder of the passive parts on the printed-circuit board are fitted in the usual manner. Voltage regulator IC_2 is fitted upright (like all resistors) and does not need a heat-sink as it dissipates little heat under normal circumstances. Part terminals not shown with a small circle on

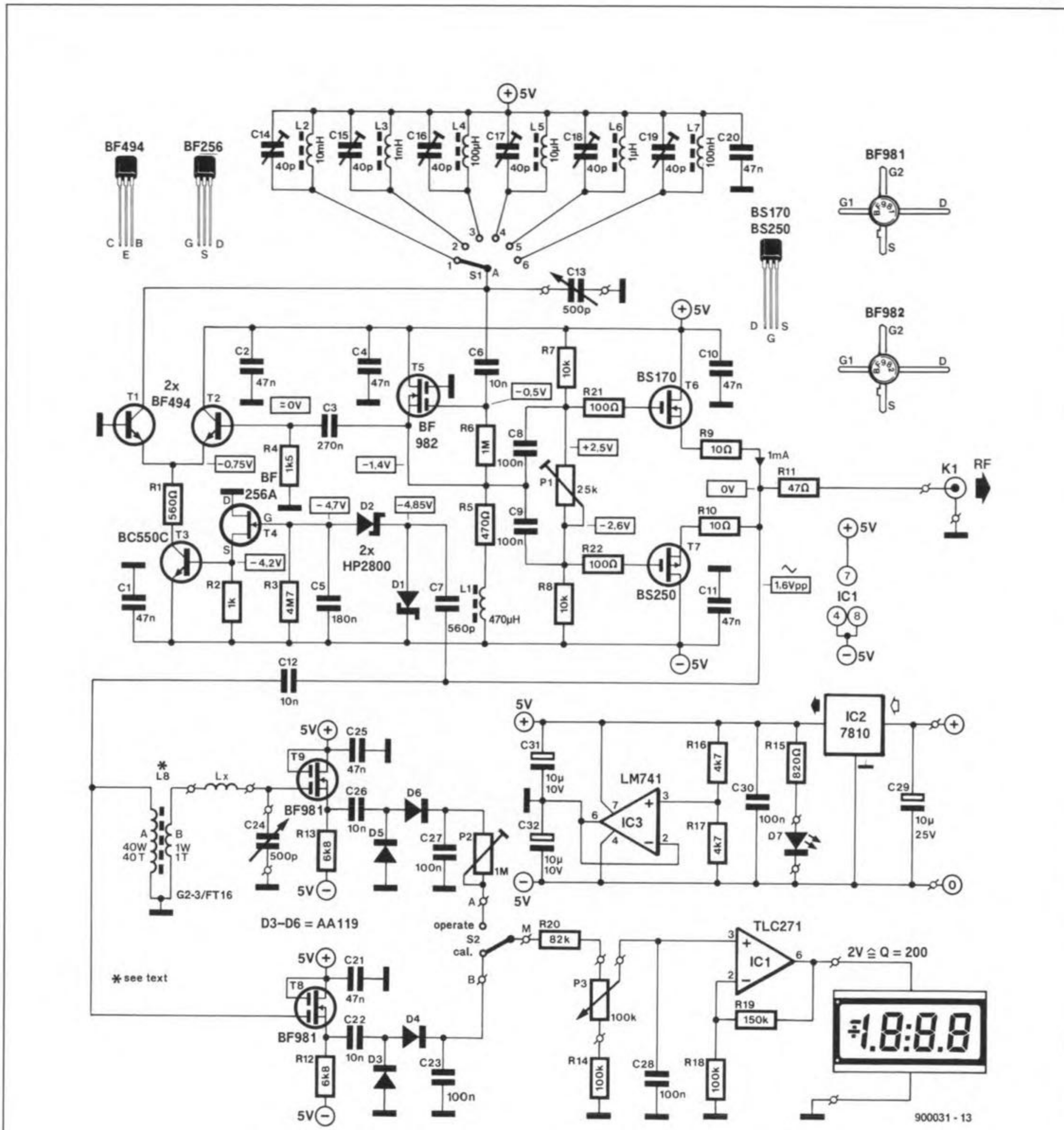


Fig. 3. Circuit diagram of the Q meter. The read-out is either digital in the form of an LCD module, or analogue in the form of a moving-coil meter —the choice between these is entirely up to the constructor.

the component overlay are soldered direct to the copper surface at the component side of the board.

Solder rotary switch S_1 direct on to the board (do **not** use a type with wire connections; these, however short, introduce unacceptable stray inductance). Only one section of a dual-pole 6-way switch is used.

The FETs are static sensitive and their terminals must remain short-circuited by a small piece of aluminium foil until they have been soldered on to the board. The actual solder operation should be as brief as possible, and take place with the solder tip connected to the ground surface of the PCB.

Finally, fit solder terminals for all external connections.

Mechanical work and connections

Study the lay-out of the front-panel (Fig. 6) and determine the location of the PCB to the right. Drill the front panel, using the ready-made adhesive as a template. At this stage, you have to choose between a digital read-out and a moving-coil meter before cutting the required clearance. If used, the moving-coil meter must be provided with a scale of 0–200. The f.s.d. voltage must be 2 V (if necessary fit the required series resistors to make this voltage correspond to the f.s.d. current of the meter).

Provisionally fit all controls and sockets on the front panel. Mark the location of the four holes in the PCB corners at the outside of the front-panel, to the right where the PCB is to be fitted vertically. Drill holes for M3×50 screws with countersunk heads. Insert these screws from the outside of the aluminium front panel. Secure them at the inside with a nut and a locking ring. Next, slide approximately 30-mm long plastic PCB spacers over the screws and install the board with the components facing the inside of the front panel. Determine how much space you need for the tuning capacitors, the FREQ. BNC socket and the Lx terminals, then cut the PCB spacers to the minimum required length. The Lx terminals are medium-duty binding posts for panel mounting.

Remove all controls and terminals from the front panel and apply the self-adhesive, two-colour, front panel foil. Mount all controls and sockets and tighten them without damaging the foil. Cut the spindle of the CAL. potentiometer, P_5, to enable the knob to be fitted. Do the same with the spindle of the rotary switch on the PCB. Solder wires to the terminals of all controls and the meter (or LC display): those to the tuning capacitors, the FREQ. socket and the Lx terminals must be kept as short as possible. Their length, inclusive of the cable connector, must not exceed 30 mm. Coax cable (RG174/U) may be used for the FREQ. output, but given the short length ordinary screened cable is also suitable.

OPERATION AND CONTROLS

POWER switch: switch instrument on and off.

FREQ. socket: oscillator output for test purposes.

Lx sockets: connect to inductor to be tested. Do not use test leads.

METER: digital (LCD) or analogue (moving-coil); max. scale indication: 200.

CAL. control (P_3): adjust to set meter reading of 100 in calibate mode.

CAL./OPERATE switch (S_2): select between calibrate and Q measurement modes.

TUNING COARSE switch (S_1): select test frequency range. Always start measurement in 20–70 MHz range, switch to next lower ranges if no resonance is found.

INDUCTANCE ADJUSTMENT control (C_{24}): turn to find resonant frequency in selected range. Use before FINE TUNING control.

TUNING FINE control (C_{13}): peak resonant voltage indication on meter or display.

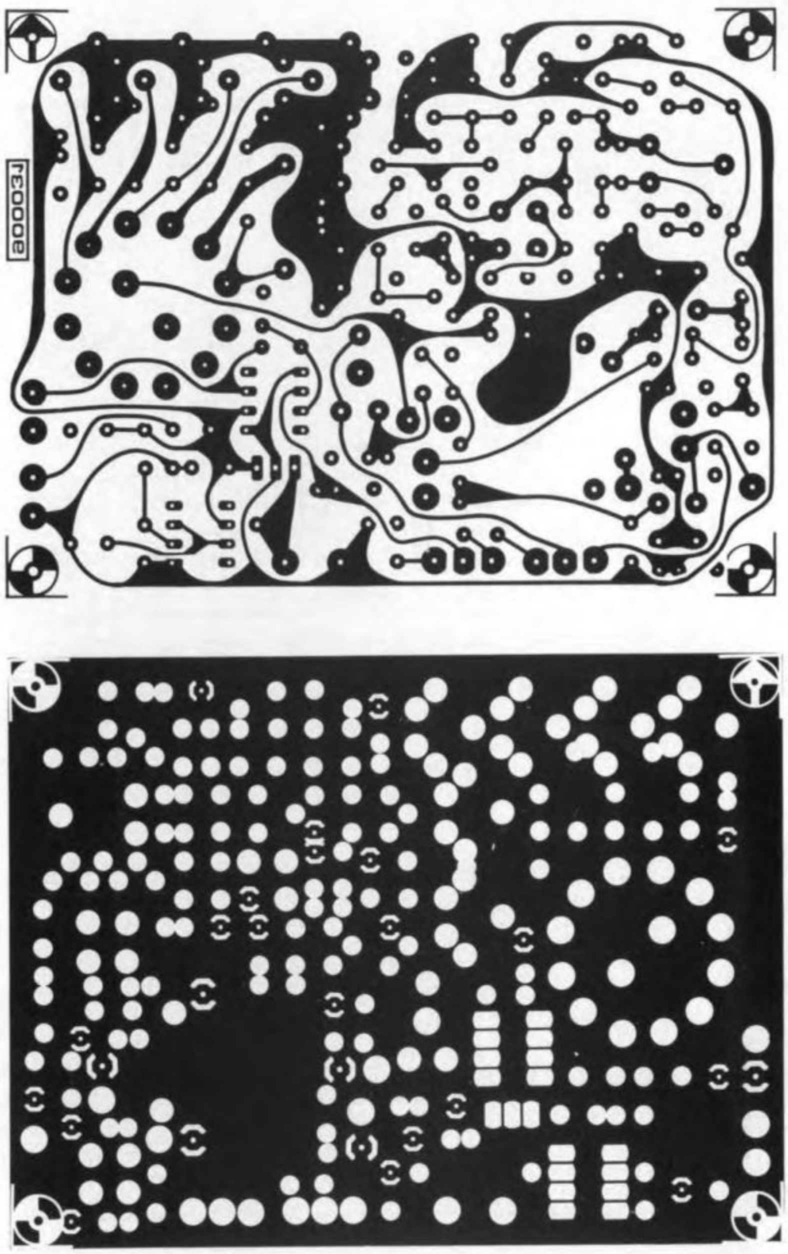


Fig. 4. Double-sided printed-circuit board for the Q meter.

Finally, drill a suitably sized hole in the back panel of the enclosure to enable the adapter (d.c. input) socket to be fitted. If you use an LC display, install a battery holder for a single 9-V PP3 size battery, and use a double-pole (DPDT) on/off switch to power the display and the instrument simultaneously but separately.

Ready for testing

Provisionally connect the PCB to the wires from the controls, the meter, the FREQ. output socket and the binding posts. Set all trimmers, P_2, and the front panel controls to the centre of their travel. Only P_1 is set to minimum resistance (fully clock-wise).

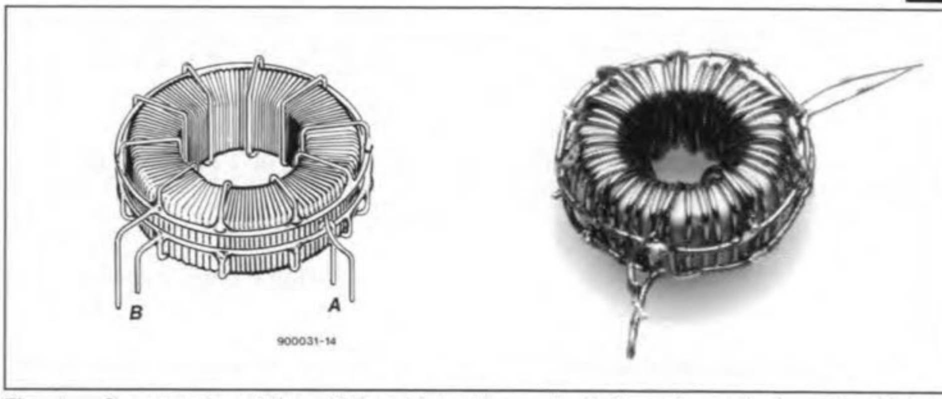


Fig. 5. Construction of the wideband transformer, L_8 (left), and practical version (right).

Setting up

Although the meter may be set up without the help of an oscilloscope and a frequency meter, it is recommended to use these instruments to achieve the best operation.

Set the coarse tuning control to the lowest range (70 kHz). Switch on and use the scope to check the presence of a signal at the FREQ. output on the front panel. Adjust P_1 for minimum distortion of the sine-wave. Do this for all ranges. In the highest range, a compromise will have to be reached between an acceptable output level and minimum distortion. If you do not have an oscilloscope, use the meter on the instrument to adjust P_1: set C_{13} to maximum capacitance (fully cw) and adjust P_1 until the amplitude in the highest range (70 MHz) is not more than half that in the lowest ranges.

The calibration preset, P_2, is adjusted with the aid of an inductor whose Q factor is accurately known (read the section on practical use below to find out how the Q factor is measured). Unfortunately, there is practically no other way to calibrate the instrument. Owners of an oscilloscope and an RF signal generator may, however, use the previously discussed 3-dB bandwidth method to approximate the Q factor of a particular inductor. If this method can not be used, or if a reference inductor is not available, P_2 is simply left at the centre of its travel.

Some manufacturers of small chokes and other inductors, e.g., Siemens and Toko, state the approximate Q factor of their products in the related datasheets, extracts of which are often reproduced in catalogues of electronics mail-order firms. These values may be used as a guidance to verify the correct operation of the meter, and to provide the best possible setting of P_2 in the absence of a reference inductor.

The frequency ranges may be calibrated, although this is not strictly necessary. If desired, connect a frequency meter to the FREQ. output, and adjust trimmers C_{14}–C_{19} in the respective ranges for the maximum frequency indicated on the front panel. Fine tuning control C_{13} is set to minimum capacitance (fully ccw) for this adjustment.

COMPONENTS LIST

Resistors:

1	560Ω	R1
1	1k0	R2
1	4M7	R3
1	1k5	R4
1	470Ω	R5
1	1M0	R6
2	10k	R7;R8
2	10Ω	R9;R10
1	47Ω	R11
2	6k8	R12;R13
2	100k	R14;R18
1	820Ω	R15
2	4k7	R16;R17
1	150k	R19
1	82k	R20
2	100Ω	R21;R22
1	25k preset H	P1
1	1M0 preset H	P2
1	100k lin. potentiometer	P3

Capacitors:

8	47n	C1;C2;C4;C10; C11;C20;C21;C25
1	270n	C3
1	180n	C5
4	10n	C6;C12;C22;C26
1	560p	C7
6	100n	C8;C9;C23;C27; C28;C30
2	500p mica-foil tuning capacitor	C13;C24
6	40p PTFE foil trimmer	C14–C19
1	10μ 25V axial	C29
2	10μ 10V axial	C31;C32

Semiconductors:

2	BF494	T1;T2
1	BC550C	T3
1	BF256A	T4
1	BF982	T5
1	BS170	T6
1	BS250	T7
2	BF981	T8;T9
2	HP2800	D1;D2
4	AA119	D3–D6
1	LED	D7
1	TLC271	IC1
1	7810	IC2
1	LM741	IC3

Inductors:

1	470μH	L1
1	10mH radial	L2
1	1mH	L3
1	100μH	L4
1	10μH	L5
1	1μH	L6
1	100nH	L7
1	G.2-3/FT16 ferrite toroid	L8

Enamelled copper wire 0.5 mm dia.

Miscellaneous:

1	6-way rotary switch for PCB mounting; 2 poles	S1
1	miniature SPDT switch	S2
1	BNC socket	K1
2	binding post	
1	PCB	900031
1	front-panel foil	900031-F
1	enclosure LC-850 (Telet)	

Practical use

The meter is simple to operate: connect the inductor to be tested to the terminals Lx and set S_2 to OPERATE. Starting in the highest range, find the resonant frequency by operating the FINE TUNING and INDUCTANCE ADJUSTMENT controls. Step down to the next lower range if you do not find a clear resonance indication, which is marked by a sudden increase in the meter reading.

When the resonant frequency has been found, the two tuning controls are adjusted for a maximum meter indication. Switch S_2 to CAL. and adjust P_3 (CAL.) for ½ f.s.d. on the meter (indication '100'). Switch S_2 back to OPERATE and check that the resonance is still there by carefully turning the FINE TUNING control. The Q factor of the inductor can be read from the meter.

In the highest frequency range, it may be impossible to make the meter indicate 100 in the calibrate mode. In that case, adjust the CAL. control to set a reading of '50' and multiply the meter reading in the OPERATE mode by a factor of two. ■

References:

1. Self-inductance meter. *Elektor Electronics* September 1988.
2. RF inductance meter. *Elektor Electronics* October 1989.

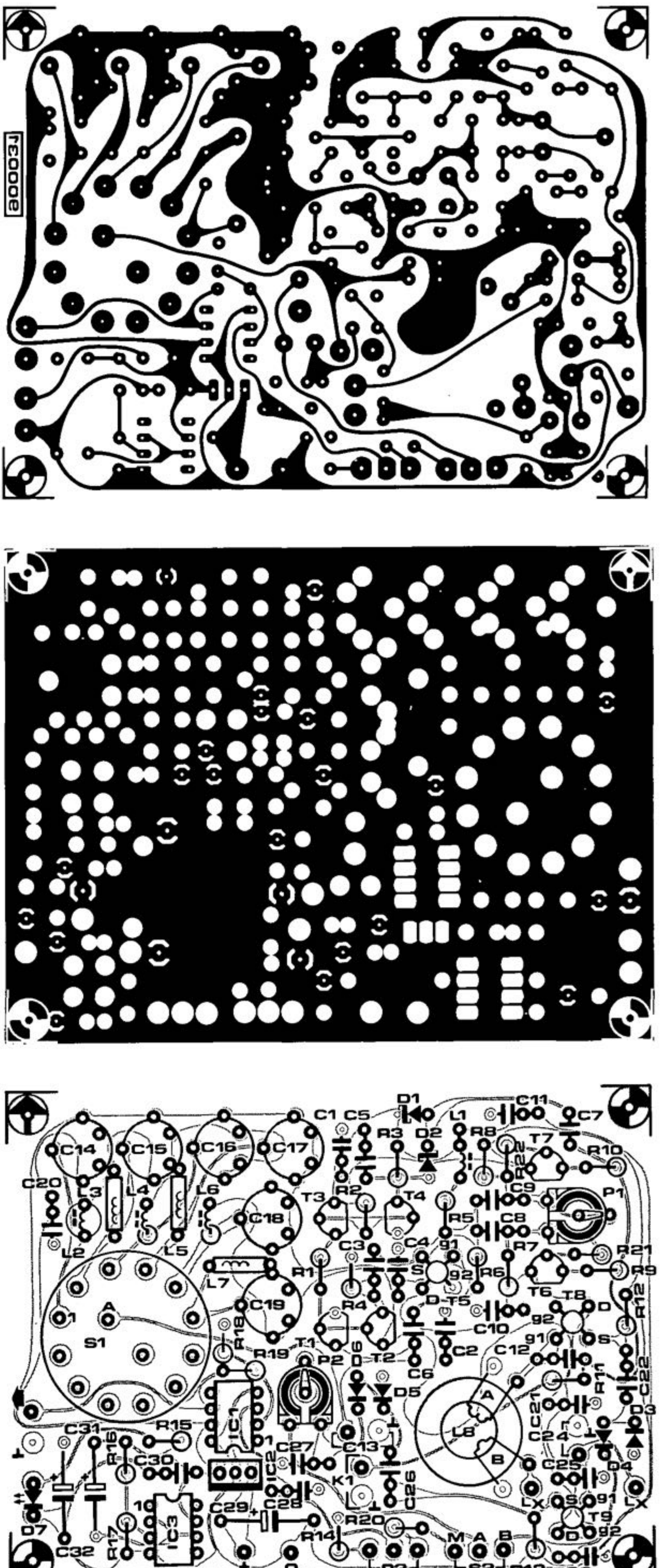


Fig. 4. Double-sided printed-circuit board for the Q meter.

VIDEO MIXER

FINAL PART: CONSTRUCTION, ALIGNMENT AND PRACTICAL USE

A. Rigby & G. Dam

In this final instalment of the article we deal with the connecting-up of the completed printed-circuit boards, and the assembly into the enclosure. Also, a detailed setting-up procedure is given, which is no luxury given the complexity of the video mixer. Notes on the practical use of the unit round off the article.

Mechanical work on the ESM enclosure may be started when the three modules described in previous instalments (switching board, remodulator board, keyboard and power supply), are complete and ready for interconnecting.

The sloping panel of the ESM enclosure probably requires most mechanical work. Fortunately, the drilling template supplied with the front-panel foil for the mixer allows the panel to be cut and drilled in a straightforward manner. To begin with, fix the template to the inside of the front panel with the aid of a few drops of glue. Next, use a jig-saw to cut out the slots for the slide potentiometers and the holes for the switches. Work carefully and take your time to reposition the workpiece if required for a particular sawing angle.

Determine the locations of the holes in the rear side of the enclosure through which the video in/out sockets are accessed. Drill these holes at a relatively small diameter, then use a reamer to provide the necessary clearance. The use of a reamer is preferred over a larger drill because its larger cutting surface results in less vibration of the workpiece and, as a result, better holes.

The screw holes in the front panel are drilled and carefully enlarged to accept countersunk M3 screws. The heads of these screws must be flush with the surface of the front panel to prevent the self-adhesive foil being damaged. Secure each M3 screw at the inside of the front panel with a drop of glue or Lock-tite (if you can get hold of it). Next, turn 10-mm long metal PCB spacers with internal M3 threading on to the screws. The spacers hold the keyboard PCB, and allow this to be removed without the need of loosening the screws underneath the front-panel foil, which is likely to be damaged by such an operation.

The photograph in Fig. 16 illustrates the way in which the printed-circuit boards are arranged in the enclosure. Provisionally install the boards in the case to obtain a like arrangement. Mark and drill the holes in the bottom plate to enable the switching board and the transformer board to be secured on it. Next, mark and cut a rectangular clearance in the left side panel of the enclosure to accept the mains socket with its integral switch and fuse.

First test

For a first test, install the switching board and the transformer board in the enclosure. Connect the input terminals of the transformer board to the mains socket, and the output terminals to the switching board. The complete wiring diagram of the video mixer is given in Fig. 17. Points where the supply voltage may be measured are indicated to assist in checking and fault-finding.

After powering up, it will be found that the MAX452s on the switching board run fairly warm. This is perfectly normal, however, and no cause for alarm.

First, the presence of the synchronization signals is checked with the aid of an oscilloscope. Apply a composite video signal to socket K_3 (VIDEO-1 input), and adjust P_2 until the signal at pin 13 of IC_5 is high for 60 µs. Similarly, adjust P_3 for a 'low' duration of 11 µs.

Testing the keyboard PCB

A global test is carried out on the keyboard PCB before it is secured to the inside of the front panel. First, connect the keyboard to the switching board by means of the short flatcables mentioned in the relevant parts list. Next, make a cable tree to connect P_1, P_4 and the power supply of the keyboard to the switching board. The connections of P_1 and P_4 must be made in screened wire. The screening braid is connected at the side of the switching board only. The cable trees should have a length that obviates the need of disconnecting them when the video mixer is disassembled for tests and adjustments.

After switching on, it will be noted that most keyboard controls are inactive if no video signal is applied, since this ensures the presence of the central synchronization. With a signal applied, it must be possible to control each LED by actuating the associated key. Effects are, however, not achieved at this stage since the modulation board is not yet connected. None the less, the passing of the video signal from K_3, K_4 and K_5 to outputs K_6, K_7 and K_8 may be verified by actuating S_5–S_{12}. The KEYLOCK function may also be checked. When actuated, it should negate any effect of S_{14}–S_{29} being pressed. If these tests check out so far, mount the modulation board at the rear side of the switching board (their copper sides face one another). Ensure sufficient distance between the boards by using 10-mm long PCB spacers.

Potentiometers P_{20} and P_{15} may be connected to the modulation board by normal, light-duty wire without screening.

The construction of the video mixer is, in principle, complete after connecting the power supply lines. Figure 18 shows some of the pre-folded flatcables that interconnect the boards.

Alignment

Having got this far you are probably anxious to see the first effects from your video mixer. Start the alignment by connecting a composite video source to the VIDEO-1 input, and a monitor to the output. Neither INPUT-2 nor INPUT-3 is provided with a video signal so as to achieve a black

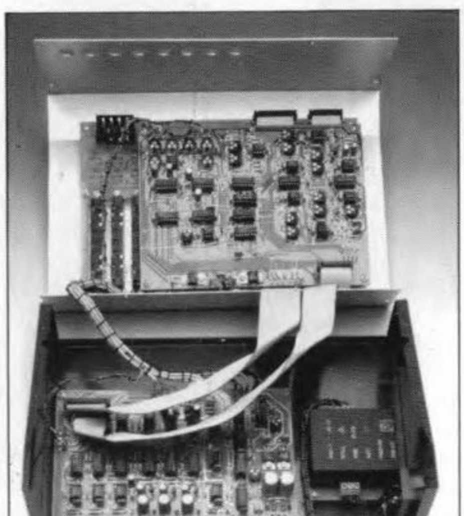


Fig. 16. Inside view of the completed prototype.

background when these inputs are selected. The black background is required initially to adjust the effects.

The effects shown in the pictograms with potentiometers P_{15} and P_{20} may be tested already. Very likely, however, they are not as they should be because the PCB has not yet been aligned. Run a quick check on the other video inputs by applying the video signal and selecting them with the functions SEL 1, SEL 2 and SEL 3. To make the effects visible at output K_6, K_7 or K_8, switches S_8 and S_{12} must be actuated.

Modulation board

The adjustment of the modulation board is fairly extensive. For clarity's sake, it is, therefore, listed in Table 2. Before starting the adjustment procedure, set all presets on the modulation board to the centre of their travel.

Initially, switches S_1, S_8, S_{12}, S_{14} and S_{30}–S_{34} are actuated. Only S_1–S_4 are used during the adjustment —all other switches are left at the above settings.

Apply the video signal to socket K_3. First, the span of P_{15} and P_{20} is optimized. This is achieved when the extreme values of the control voltages correspond to the peak values of the horizontal amd vertical ramp voltages. The effects used for the adjustments are, therefore, the vertical and horizontal curtain-type wipe, both of which make use of the associated ramp voltages.

Switches S_1 and S_{14} select the horizontal wipe effect with video-1 to the left and video-2 (black) to the right. Actuate slide potentiometer P_{15} to check that a vertical line moves across the screen. The line marks the transition between two video signals. Adjust P_{16} and P_{20} until the extreme positions of P_{15} correspond to the extreme left and right side of the screen respectively. These adjustments interact to some extent and must be repeated a few times for best results. Presets P_{19} and P_{21} are adjusted similarly for the vertical wipe effect. They set the lower and upper limits that can be reached by P_{20}.

The above adjustments should be carried out with some precision as they are important for a number of other effects. If necessary, reduce the vertical and/or horizontal picture width on the monitor to ensure that the whole of the picture is visible. After the adjustments, these controls are returned to their original settings to move the blanking transitions out of the visible area.

First, the triangular voltages are adjusted. Initially, select the double horizontal wipe effect and concentrate on symmetry. The wipe is opened to the extent that the disappearing video signal is just about visible to the left of the horizontal curtain (S_1 or S_3). Adjust P_6 until the narrow area with the video signal in it is equally wide at both sides of the curtain. Move P_{15} to the other extreme setting and adjust P_7 until the curtain just about closes (look at the top of the triangle).

The vertical double wipe (S_2 or S_4) is adjusted in a similar manner. Preset P_{10} is adjusted until one picture line only is visible at the top as well as at the bottom of the picture. Slide P_{20} to the other extreme setting and adjust P_{11} until the curtain just does not open.

The next step in the adjustment involves the unity-gain amplifier. Select the diagonal curtain (S_{16} and S_1 or S_3). Adjust P_{18} until the video signal applied covers the whole of the picture area. During this adjustment, P_{15} must be set such that the curtain is not, or practically not, visible. Presets P_{17} and P_{22} are adjusted until the curtain can be moved just off both sides of the screen (both with S_1 and S_3). Next, complete the adjustments listed in Table 2. Small corrections may be effected by P_{17}, P_{18} and P_{22}.

Next, set up the inverter. Once more use the diagonal curtain (S_{16}), but this time with the other two selections (S_2 or S_4). Adjust P_{23} until the curtain disappears from the screen at the extreme settings of P_{15}. As with the unity-gain amplifier, the other effects may be used to check the correct setting of P_{23}.

The parabolic voltage is the last adjustment on this board. Use either S_{21} and S_2/S_4 (horizontal parabola), or S_{20} and S_2/S_4 (vertical parabola). Preset P_5 defines the symmetry of the horizonal parabola; P_8 the amplitude; and P_9 the d.c. setting. These presets must be adjusted to prevent unwanted side-effects in the picture as P_{15} is operated. Presets P_{12} and P_{13} are adjusted likewise to shape the vertical parabola.

This completes the adjustment procedure and the video mixer should now provide all functions. If small corrections are required for particular effects, consult Table 2 to see which presets are involved. Since a number of adjustments interact, it may be necessary to repeat the entire setting-up procedure a few times. Always remember, however, that any change in any one setting affects the following adjustments.

Presets	Effects selection	Adjustment of
P14; P16	S14, S1 or S3	span of P15
P19; P21	S14, S2 or S4	span of P20
P6; P7	S15, S1 or S3	symmety and amplitude of H- triangle
P10; P11	S15, S2 or S4	symmetry and amplitude of V- triangle
P17; P18; P22	S16; S1 or S3	unity-gain amplifier
	S17, S1 or S3	
	S18, S1 or S3	
	S28, S1 or S3	
P23	S16, S2 or S4	inverter
	S17, S2 or S4	
	S18, S2 or S4	
	S26, S2 or S4	
P5; P8, P9	S21; S1 or S3	shape, amplitude and d.c. setting of H- parabola
P12; P13	S20, S2 or S4	amplitude and d.c. setting of V- parabola
P17; P18; P22	S19, S2 or S4	unity-gain amplifier
	S20, S2 or S4	
	S21, S1 or S3	
	S27, S2 or S4	
	S28, S2 or S4	
	S29, S2 or S4	
P23	S20, S1 or S3	inverter
	S21, S2 or S4	
	S27, S1 or S4	
	S29, S1 or S3	

Table 2. Overview of adjustments.

For scope owners

The adjustment of the video mixer is greatly facilitated if an oscilloscope is available. The adjustment of P_{15} and P_{16}, for instance, merely entails matching the maximum voltage at the potentiometer with the peak value of the ramp at pin 6 of IC_{26} (P_{15}) and pin 6 of IC_{30} (P_{16}). Similarly, the minimum value of the potentiometer voltage is made to correspond to the minimum value of the relevant ramp. These levels are simple to observe and set with the aid of an oscilloscope. The adjustment of the remaining waveforms is

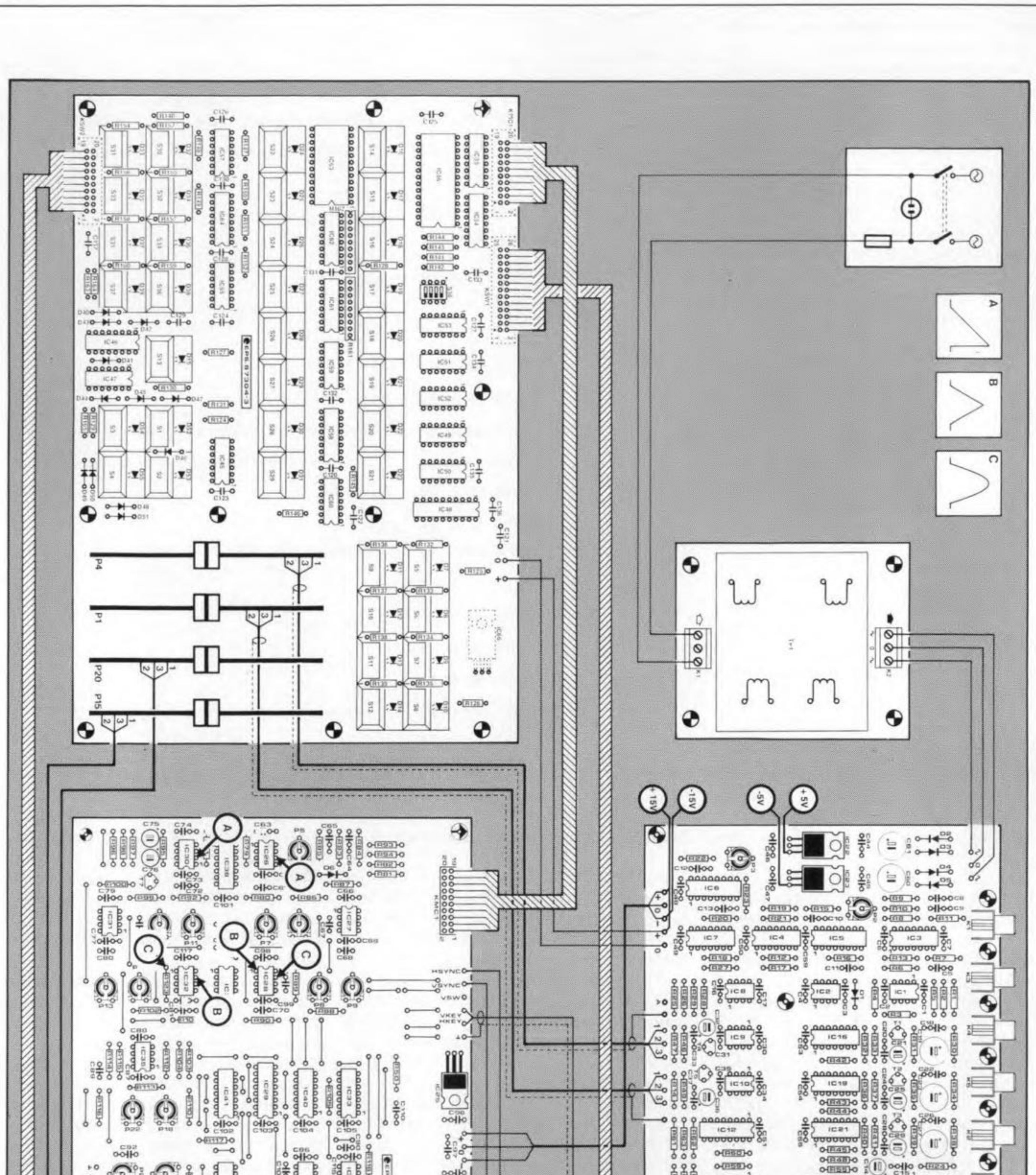


Fig. 17. Wiring diagram of the video mixer. Supply voltages and waveforms are shown inset to assist in fault-finding, if necessary.

Fig. 18. Flatcables with IDC sockets used for interconnecting the boards.

equally simple: the signal levels must correspond to the effective span of potentiometers P_{15} and P_{20}. Presets P_6, P_7, P_{10} and P_{11} define the level of the triangular voltage, while P_5, P_8, P_9, P_{12} and P_{13} are used for the calibration of the parabolic voltages.

The scope is used to give P_{17}, P_{18} and P_{22} settings that results in identical signals at pin 9 of N_{59} and pin 7 of IC_{35B}, independent of the setting of P_{15}. Finally, P_{23} is adjusted until the direct voltages of the signals at pin 7 of IC_{35B} and pin 6 of IC_{36} are at an equal level.

Let's use it

To close the article, some hints are given as regards the practical use of the many functions offered by the mixer.

To begin with, we make a short tour around the keyboard areas. The source selection is effected in the top right-hand corner. Here, the user selects the video signals which are sent to the recorder or monitor. If, for instance, video signal 1 (S_5 selected) is being recorded, the preview output may be connected to a monitor to watch the signals at inputs VIDEO-1 (S_{10}) and/or VIDEO-3 (S_{11}). Also, the preview mode (S_{12}) allows a particular picture effect to be pre-selected. This is useful in many cases to 'practice', i.e., to get the effect right beforehand so as to prevent it giving the wrong results once actually applied.

The fading controls effectively cause the mixer to switch between two video sources. These sources are selected with the aid of keys SEL-1/SEL-2 (S_{32} and S_{33}) as well as with SEL-2/SEL-3 (S_{34} and S_{35}).

The superimpose switches, S_{30} and S_{31}, are located at the left-hand bottom corner of the front panel. The superimpose effect is obtained by first wiping to a double picture with P_1, followed by swapping the superimpose selection with S_{23} and using P_1 again for the fade-out. In this way, the superimpose function is used to change between two video signals. Functions SIMP-1 and SIMP-2 therefore correspond to the SEL-1/2 and SEL-2/3 keys, S_{32}–S_{35}, so that the superimpose function may be used to switch between all possible video sources.

The function of effects switches S_1–S_4 will be evident after having followed the setting-up procedure. A few additional points should be noted, however. Switches S_{14}–S_{21} are fitted along a blue line on the front panel, and switches S_{26}–S_{29} along a white line. The effects along the blue line are grouped such that the selected video sources are switched when changing from the top options (S_3 or S_4) to the lower options (S_1 or S_2). For the 'mixed out' function (S_8 and/or S_{12}) this means that a 'hard' transition, or cut, can be made. Another advantage of the arrangement in groups is that effects may be changed in the 'mixed out' mode without problems with fading controls P_{15} and P_{20} set to their extreme positions. Since these settings do not affect the mixed-out signal, it is possible to switch from video source 1 to video source 2 via effect A. Both A and B are effects found along the blue line.

The effects joined by the white line do not offer the above possibilities. The use of 'white' effects first requires the currently displayed video source to be selected via the output function (so, apparently nothing happens). Next, the desired effect along the white line is selected, and the relevant potentiometers are set such that the signal at the preview mix output is an exact copy of that at the recorder output. Next, the mix output is re-enabled (nothing happens so far) and, finally, the desired effect selected. This may look complicated on paper, but is really quite straightforward in practice. Most differences in the operation arise from the differences between the two types of effect.

Switch S_{22} allows externally defined effects to be selected. The range of these effects is practically without limits and invites the use of experimental circuits.

Among the possible external effects is, for instance, the placing of a particular video signal inside a frame, with another signal in the background. This may be achieved by providing K_4 (VIDEO-2) with a signal that consists of maximum black-to-white transitions, e.g., a rectangular wave. Further, connect the KEY-OUT output of the switching board to the HKEY input of the modulation board. This arrangement allows the signals at inputs VIDEO-1 and VIDEO-3 to be combined under the control of the signal at input VIDEO-2. Slide control P_{15} is used in this mode to control, depending on the signal supplied by source 2, the grey level at which the switching between sources 1 and 3 takes place. This option may be made permanently available on the mixer by fitting a pair of extra connectors at the rear panel. The horizontal and vertical effects may be extended in a similar manner.

Figure 19 shows the circuit diagram of an experimental effects generator which is intended to get you started with your own experiments with the video mixer (remember that external effects are selected by S_{22}). The generator consists of two oscillators whose output frequencies are determined with the aid of presets. The horizontal and vertical synchronization pulses stop the oscillators and enable the diodes to discharge the timing capacitors. This is done to ensure correct synchronization as with mixed video signals.

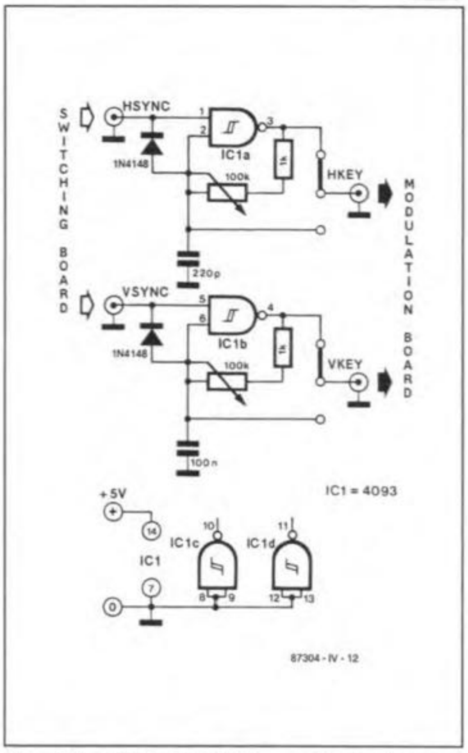


Fig. 19. Experimental rectangular-wve generator.

The outputs of the NAND gates are connected to the H-KEY and V-KEY inputs to create bars and rectangles in the picture (depending on the selection made by S_1–S_4). The number of rectangles is determined by the oscillator frequency settings. The generator is, of course, intended as guidance only for the design of more complex external effects generators, which should give the user of the video mixer even more possibilities to use his creative power. ■

Video Mixer —publications overview:

- Part 1 (switching board): January 1990
- Part 2 (modulation board): February 1990
- Part 3 (keyboard): March 1990
- Part 4 (construction; alignment; practical use): April 1990

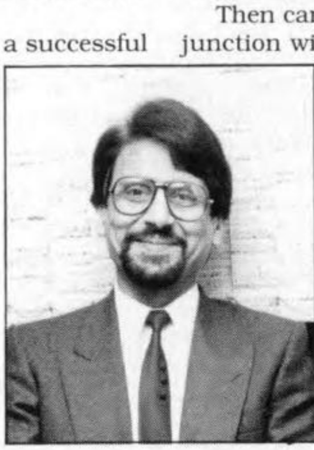
PROFILE: WATFORD ELECTRONICS

by Bernard Hubbard

Speedy response, quality of components, and competitive pricing are the ingredients that have transformed a home-based business supplying electronic components to the hobbyist into a multi-million pound operation.

Watford Electronics began life in the home of Nazir Jessa in 1972 when the former NHS optician went into business with a qualified electrical engineer. Today, the direct mail and retail electronic component and computer business has an annual turnover in excess of £10 million and is one of the best known suppliers of Acorn and BBC microcomputers in the United Kingdom.

The story behind the determination to build a successful business goes back to Nazir's roots. Son of a wealthy Indian trading family, Nazir grew up in Tanzania where, at the age of 11, he was sent to work in one of the family's factories after school instead of being able to go out to play with his school chums. "We were taught that business comes first", states Nazir as if he was recounting something akin to the Hippocratic oath.



Nazir Jessa

Perhaps more than any other, one incident had a marked effect on the young Nazir. At the age of 15, he had just failed to complete a deal on behalf of his family at the local market when a callous uncle said: "We are not a businessman, are we?". Despite his assured future, Nazir knew that one day he would not be able to contain his resentment at this unfair treatment and that sooner or later he would have to make his own way in the world without having to rely on the Jessa business empire.

That day came during a particularly hot spell when, driving his uncle's pick-up truck in Dar es Salaam, Nazir suddenly made up his mind to go to England and qualify as an optician. To the complete astonishment of the Jessa family, Nazir had flown to England and enrolled on a course only a few days later. His office is still decorated with the certificates stating his qualifications as an optician.

In spite of his qualifications, Nazir found that his salary working for the NHS only just about covered his living expenses, so that when an opportunity arose for a qualified optician in Libya, he applied and got the job.

During his two-and-a-half year spell abroad, Nazir budgeted carefully and, although by the time his contract had come to an end he had not saved a fortune, he was able to buy a house in England and still had £2500 left to start a small business.

Shrewdly, Nazir managed an optician's practice during the day to keep his drawings on the fledgling Watford Electronics to a minimum and worked in the electronics business during the evening. "I would rush home from work and begin processing the orders so that we could get them in the post by 9 p.m. in order for them to be delivered the next day. At weekends, we would hang a sign in the window of the front room and people would call for their orders. Often, there would be customers waiting in the lounge, the hall and even in the drive for their components."

In spite of his lack of knowledge of electronics and his partner leaving the business after a while, Nazir managed to earn a reputation for Watford Electronics. He confesses: "I didn't have a clue. When I ordered transistors, I was expecting something like radios instead of those three-legged beasties to appear."

But Nazir is a quick learner. Monitoring the activities of his competitors in the specialist trade magazines, he bought and sold accordingly. Very soon he was advertising in his own right under the Watford Electronics banner. Within a short time, he was also able to take on his first employee: his brother Raza, who is still his right-hand man today. After two years trading, the turnover of Watford Electronics had risen to £10,000.

Then came several boosts to the young company. In conjunction with a trade magazine, Watford Electronics ran a project that involved presets. In no time at all, the company had sold 150,000 units. Then followed a TV game: Watford sold 25,000 in a matter of weeks. Perhaps the biggest seller was a drum rhythm machine based on an SGS chip that was featured in *Practical Wireless*. "I used to groan when I heard the postman arrive with yet another bagload of orders. In fact, at one stage, I was working until 3 a.m. every day in a bid to clear the backlog."

Almost by accident, Nazir and Raza stumbled on another lucrative market—that for the BBC micro. Watford suddenly found Acorn dealers buying printer cables from them. "We could not get enough of them, because we had to be careful: if our supplier had found out who our customers were, he might have decided to cut us out and sell direct."

The Jessa brothers found a way around this tricky problem. They began to buy single-ended cable from one source, connectors from another and fit the two together on their own premises. For months, they sold 100 a day without either of their suppliers getting a hint of the lucrative market.

Helping owners of the BBC Model A computer upgrade to a Model B was another high-growth area for Watford Electronics. The Jessa brothers began marketing their own kit in direct competition with Acorn. Needless to say, the computer manufacturer was not too pleased with Watford undercutting the hardware makers by quite a margin. Soon, dealers from all over the UK were comming to Watford Electronics, especially since the company had simplified the marketing by giving them an option of kit 1, 2, 3, or 4.

Today, Watford Electronics has grown to generate an annual turnover of more than £10 million with a staff of 45. Eighty per cent of the business comes from mail order sales, which means processing an average of 500 orders a day. Even so, during the writer's visit (on a Thursday), there were customers queuing to buy computer-related products in the retail shop that forms the ground floor frontage of the company's headquarters in Watford High Street.

As to the future, Nazir said: "I don't see people spending hours on electronic projects and building their own computers when they can buy them so cheaply; instead, they will be looking for add-on boards for their computers and tailoring software to suit their own requirements."

Despite his running a Mercedes as well as a Rolls-Royce and the fact that his 9000 sq. ft. business property is worth about 12 times what he paid for it a few years ago, Nazir finds one of the greatest sources of satisfaction his being a respected member of the Watford business community. His roots, he says, "are firmly here—in Watford." ■

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.

TEST BOX

D. Schijns

Test equipment, however simple, is essential at almost any level in practical electronics. In many cases, one grows fond of certain test gear of which all the shortcomings and inaccuracies are thoroughly familiar. In not a few cases, the good old continuity tester or the battered multimeter remains in use for years for no other reason than that it is there and easy to use. The instrument described as this month's intermediate-level project has so many uses that it may well become one of your favourites on the test equipment shelf.

Although the multimeter is without doubt the best instrument for many tests and measurements in practical electronics, there are also situations in which a cheaper, less sophisticated tester/indicator is equally useful. This is particularly so for quick fault-finding where the presence or polarity of a voltage is of more immediate importance than the actual value.

The second application of the present test box, LED (light-emitting diode) testing, is not often found even on top-grade multimeters. An ohmmeter is, of course, the thing for accurate resistance measurements. The test box, however, by virtue of its built-in buzzer, is eminently suited to rough resistance indications, testing diodes, tracing short-circuits in multiwire cables, and checking the operation of all sorts of contacts. The test box may also be used as a flooding indicator in a bathroom, in a cellar, or near the washing machine. A further application in combination with an LDR (light-dependent resistor) is a light detector as part of an alarm system. Finally, a PTC or NTC resistor may turn the test box into a temperature alarm.

Circuit description

The circuit diagram shown in Fig. 1 consists of three parts, each with its own function.

The simplest part consists of battery Bt_1 and series resistor R_4. These two components form a LED tester. The battery supplies the required voltage, while R_4 limits the LED current to a safe value. Because the polarity of modern LEDs can no longer be determined by looking through the device and spotting the cathode as the larger surface, the LED under test must be reversed if it does not light when connected to the test box. If it still does not light, it is almost certainly faulty.

The second part of the test box consists of three components, D_2, D_3 and R_7, which form a voltage indicator. Like R_4, R_7 is a series resistor to prevent the diodes being overloaded. Both LEDs light when an alternating voltage is applied to the input terminals. Direct voltages cause either D_2 or D_3 to light, depending on the polarity. The use of a particular colour for the LEDs as well as the input terminals may assist in determining the polarity quickly (a good colour selection is red for the +). The LEDs do not light at input voltages lower than about 3 V (the actual level depends on the type of LED used).

The third part of the circuit is a little more complicated than the previous two because it contains an amplifier which functions not unlike a comparator. This part is for resistance indications, diode tests and conductance tests. The component marked Bz_1 is an active buzzer that produces a loud beep if the resistance value of the component connected to the input terminals is below a certain predefined value. Components that may be tested in this manner include resistors, diodes, switches and relays. The activity of the buzzer may be verified by short-circuiting the input terminals. In that condition, transistor T_2 conducts and powers the buzzer.

T_2, a pnp transistor, is normally off because its base is connected to the positive supply voltage via R_3 and R_2, which prevent base current flow. This situation does not change until T_1, a field-effect transistor (FET), starts to conduct. This causes the left-hand terminal of R_3 to be held at virtually 0 V (ground potential) so that T_2 receives base current. The result is that the buzzer is actuated.

FET T_1 is switched on and off by the voltage at its gate, which is connected to a potential divider. This consists of R_1 and the resistance at the input terminals on the one hand, and either R_5-P_1 or R_6 on the other hand. The selection between the combination of the resistor-preset combination and the single resistor is made with switch S_1. The voltage across the potential divider is supplied by a second 9-V battery, Bt_2. Diode D_1 protects the gate of T_1, which is extremely sensitive because of its high input resistance, against static discharges.

When the input terminals are not connected to a component, the FET can not conduct because of the negative voltage at its gate. When the test inputs are short-circuited, however, the gate voltage rises to a level just below 0 V. As a result, the FET starts to conduct and causes the buzzer to be actuated.

The resistance (at the input terminals) at which the FET starts to conduct is determined by the settings of potentiometer P_1 and range switch S_1. When S_1 is set to position A—C, the buzzer is actuated at resistance values smaller than 10 MΩ (mega-ohm). This position is, therefore, suitable for finding short-circuits in low-voltage cables (e.g., a length of coax cable). Switch position A—B (indication 0–1M on the front panel) reduces the sensitivity of the circuit so that the buzzer sounds at resistance values lower than 1 MΩ (with P_1 set to maximum resistance).

Potentiometer P_1 may be provided with a resistance scale which is 'calibrated' by connecting, in succession, a number of resistors of different values from the E12 series. The positions of P_1 at which the buzzer sounds are marked with the value of the resistor connected to the test terminals.

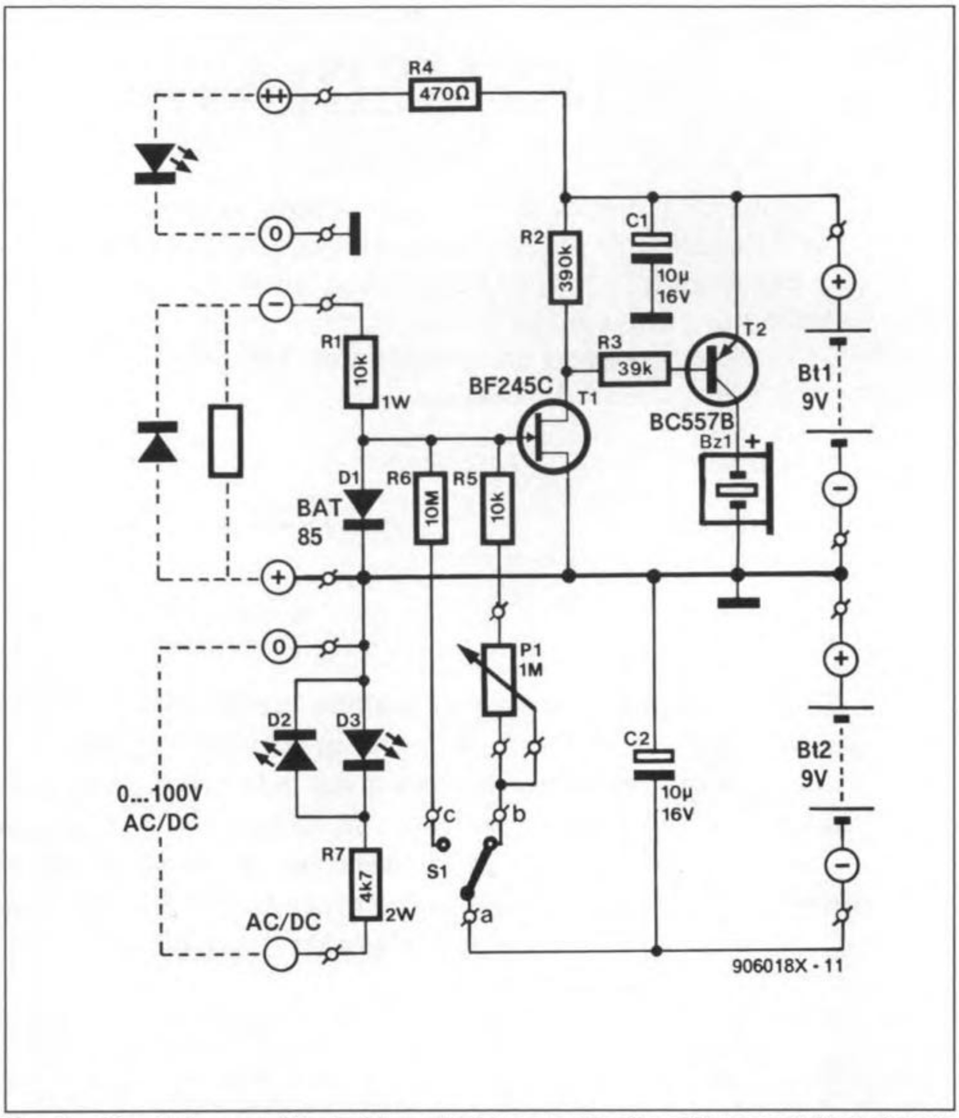


Fig. 1. Circuit diagram of the test box, which is a combination of three useful test circuits.

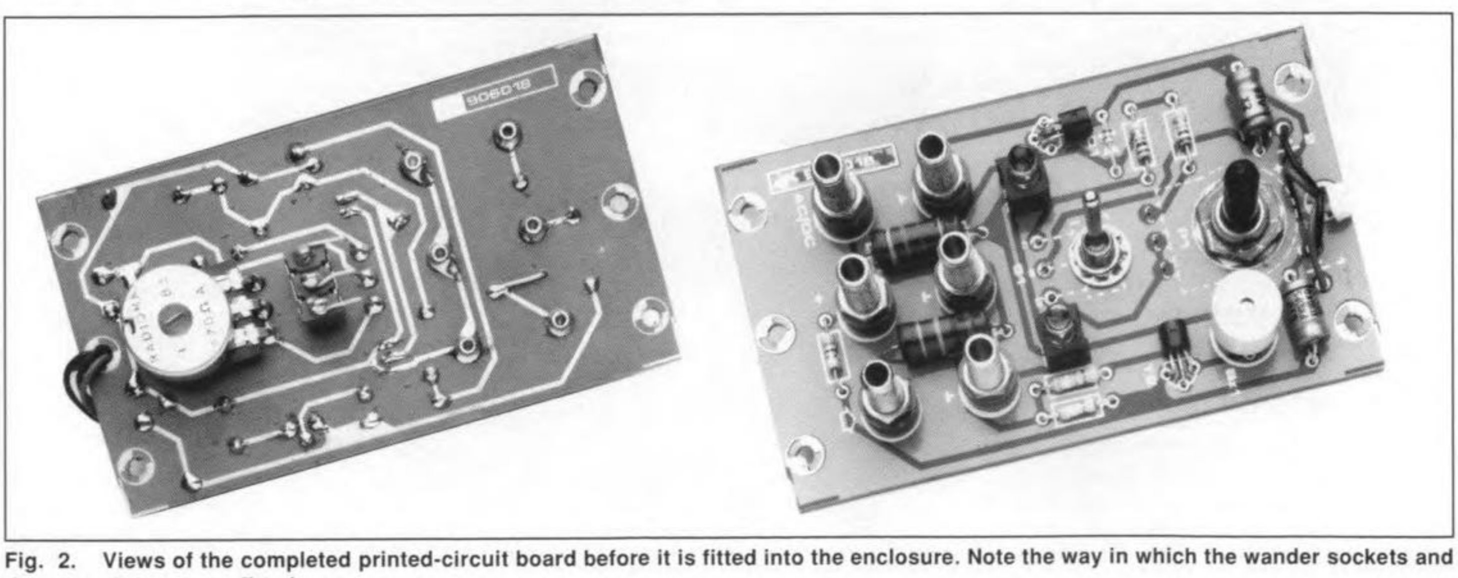


Fig. 2. Views of the completed printed-circuit board before it is fitted into the enclosure. Note the way in which the wander sockets and the potentiometer are fitted.

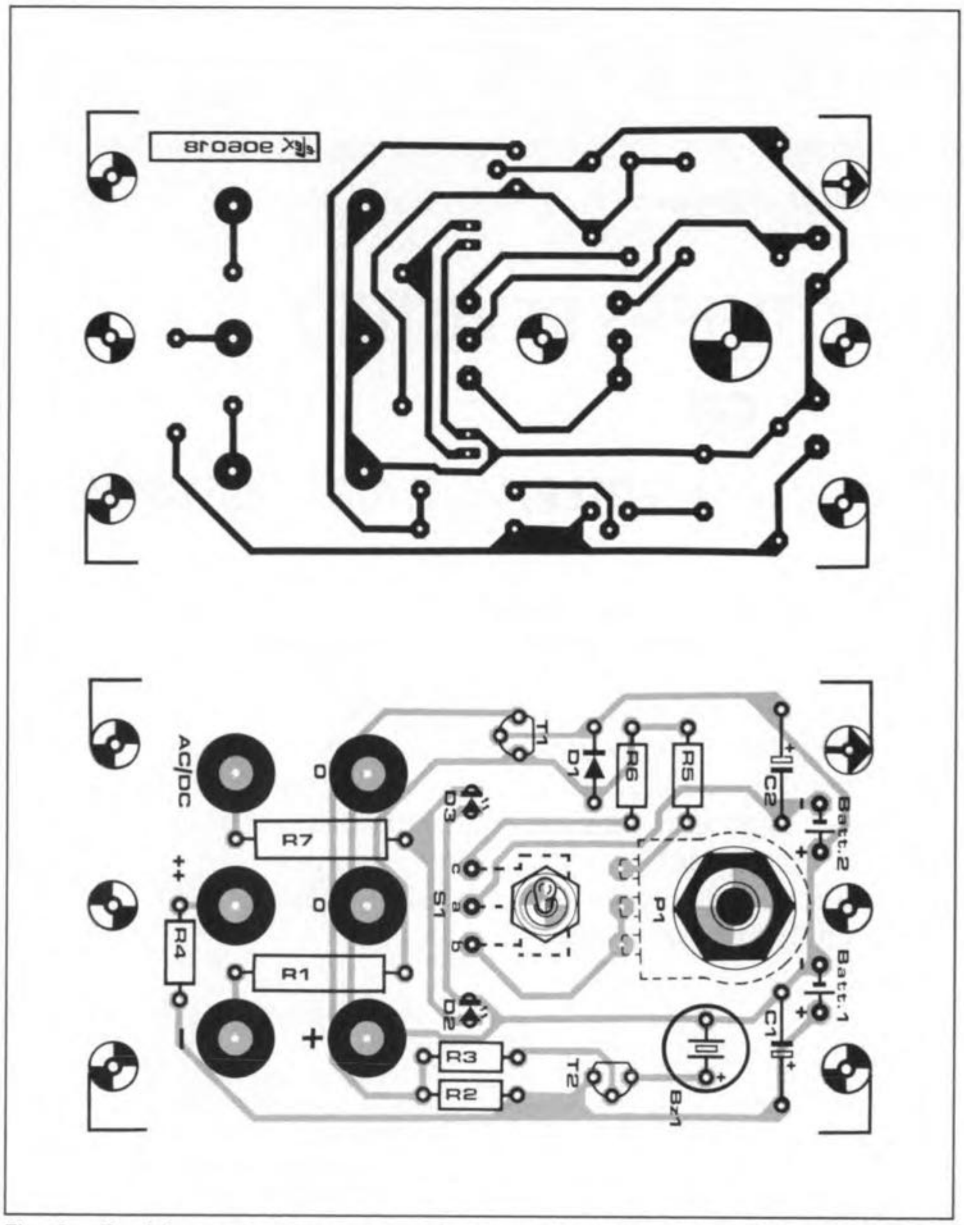


Fig. 3. Track lay-out (mirror image) and component mounting plan of the printed-circuit board for the test box.

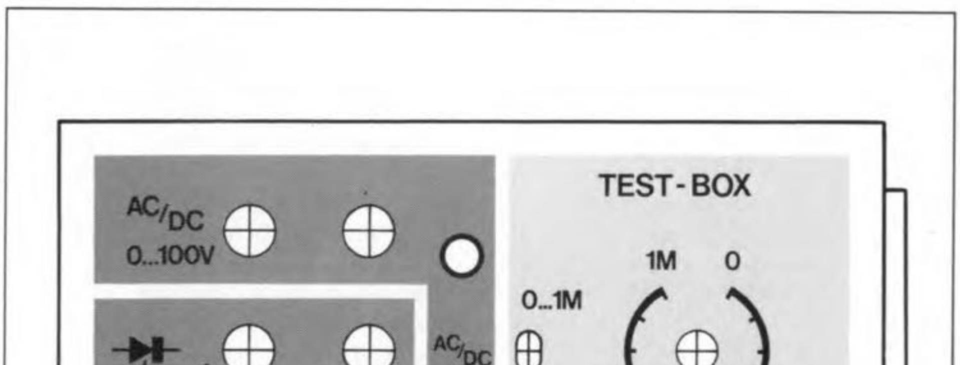


Fig. 4. Suggested lay-out and lettering of the front-panel.

COMPONENTS LIST

Resistors:		
1	10k 1W	R_1
1	390k	R_2
1	39k	R_3
1	470Ω	R_4
1	10k	R_5
1	10M	R_6
1	4k7 2W	R_7
1	1M0 lin. potentiometer	P_1
Capacitors:		
2	10μF 16V	C_1;C_2
Semiconductors:		
1	BAT85	D_1
2	LED	D_2;D_3
1	BF245C	T_1
1	BC557B	T_2
Miscellaneous:		
1	miniature on/off switch	S_1
1	12-V active buzzer	Bz_1
1	PCB	906018

The test box does not have an on/off switch because neither T_1 nor T_2 conduct until a component is connected to the input terminals. When the circuit is not used, T_1 and T_2 draw a negligible current. The voltage/polarity indicator does not consume battery current, while the LED tester consumes battery current only when a LED is connected.

Construction

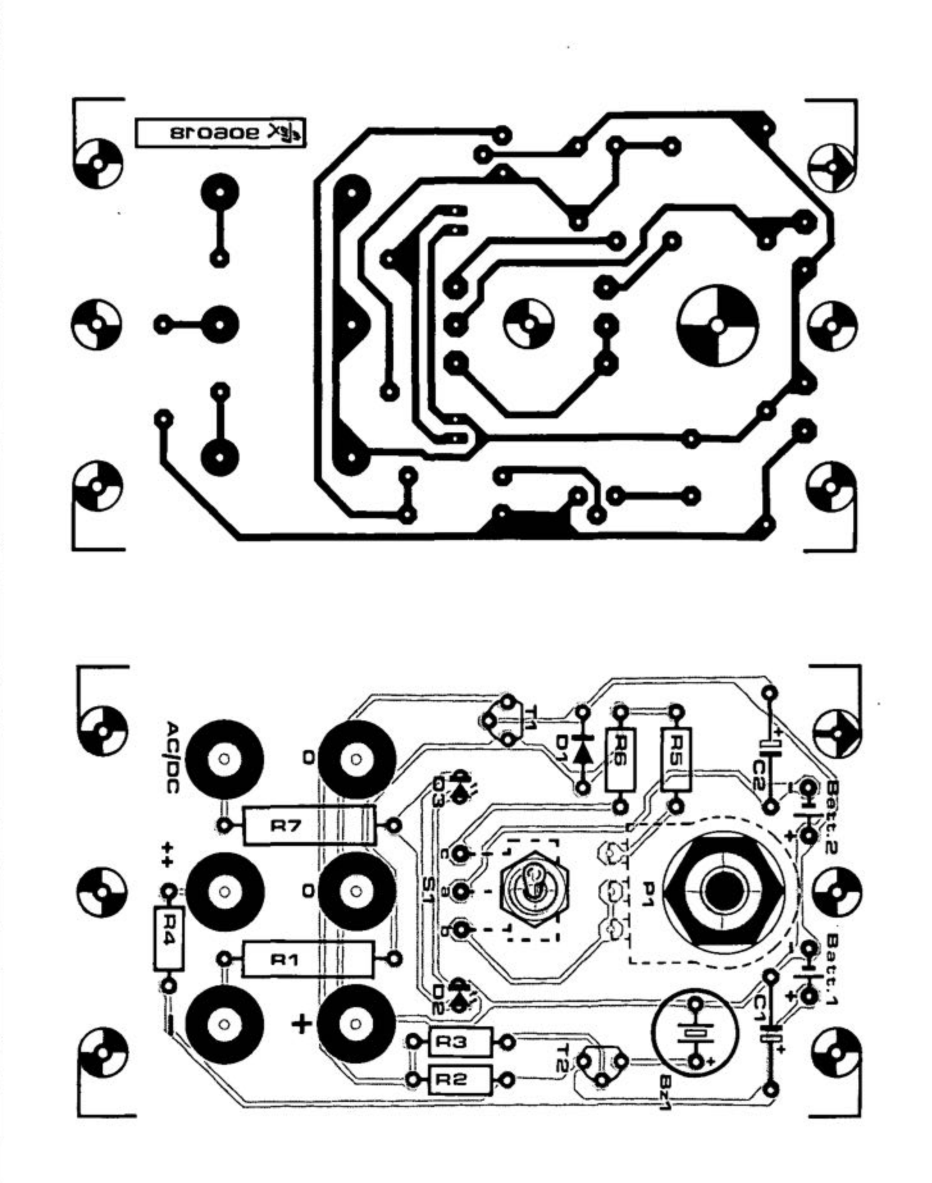
The printed-circuit board for the test-box is shown in Fig. 3. The mirror image of the track lay-out is shown to make the production of this board as simple as possible by photocopying and transferring to a film.

All components, with the possible exception of the BAT85, are fairly standard and should be available from various sources. The buzzer must be an active or self-oscillating type, which means that it produces a tone when connected to a direct voltage.

The photographs in Fig. 2 illustrate the arrangement of the range switch, the binding posts and the resistance control potentiometer on the board. These parts, and the LEDs, protrude from the front panel, to which they are attached.

As already mentioned, the use of coloured components is recommended. Red is particularly suited to 'positive', while blue, black or green are typically associated with 'negative' or ground.

The application as a flooding indicator requires a kind of sensor made from a piece of printed-circuit board onto which pairs of parallel copper traces are etched. This sensor is connected to the resistance inputs of the test box. Any drop of water or increased humidity that forms a resistance lower than the value set on the test box will set off the alarm. ■



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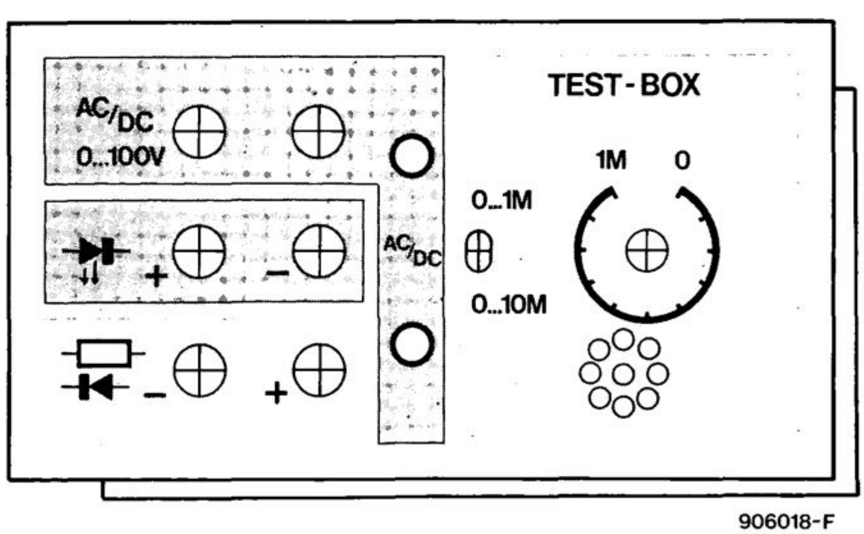

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1	10k	R_5
1	10M	R_6
1	4k7 2W	R_7
1	1M0 lin. potentiometer	P_1
Capacitors:		
2	10µF 16V	C_1;C_2
Semiconductors:		
1	BAT85	D_1
2	LED	D_2;D_3
1	BF245C	T_1
1	BC557B	T_2
Miscellaneous:		
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DESIGN IDEAS

The contents of this column are based solely on information supplied by the author and do not imply practical experience by *Elektor Electronics*

BRIDGE RECTIFIERS REVISITED

OR

HIGH-EFFICIENCY AC-DC CONVERTER/VOLTAGE MULTIPLIER

From an idea by D. A. J. Harkema

This article discusses an extension of the well-known single-phase, full-wave bridge rectifier to provide a high-efficiency voltage multiplier. The extension is based on a circuit developed by Dip.Eng. Th. Gisper, a Swiss engineer, who described his design in a paper entitled *HF-DC-Converter-Schaltung in der passiven Telemetrie* (Eidgenössische Technische Hochschule—ETH— Zürich 26 February 1988)

A conventional bridge rectifier is shown in Fig. 1. When terminal a of the transformer is positive, diodes D_2 and D_3 conduct and current flows through load R_L. When terminal b becomes positive, on the alternate half cycles of the transformer voltage, D_4 and D_1 conduct and current flows in R_L in the same direction and at the same level as before. The voltage across the load is equal to the peak value of the voltage across the transformer secondary less the potential drops across the diodes.

There are various ways of increasing the output of the rectifier and some of these are shown in Fig. 2, Fig. 3 and Fig. 4: a single-ended, a balanced and a bridge voltage doubler respectively. The circuit of Fig. 3 is used when a balanced d.c. output (with respect to earth) is required.

In Fig. 2, when a is positive, D_1 conducts and capacitor C_1 charges to the peak value of the a.c. input voltage. On the reverse half-cycle, D_2 conducts and C_2 also charges to the peak value of the input voltage. The charge on C_1 is retained, since D_1 is reverse-biased. Therefore, both capacitors charge to the peak value of the input voltage, so that the d.c. output voltage is equal to twice the peak input voltage. This is only true, however, when no load is connected across the output terminals.

With a load connected across the output, current is supplied to it by the discharge of the capacitors. On alternate half cycles, the capacitors are recharged. This means that the output voltage is a direct voltage with an a.c. ripple superimposed on it. This ripple is minimized by making the capacitors as large as is practically possible, taking into account the current drain and the frequency of the a.c. input voltage.

The circuit in Fig. 4 is a better type of voltage doubler. It has two important advantages over that of Fig. 3. The first is that the frequency at which the capacitors are charged is twice as high, so that the ripple voltage is reduced. The second is that the load on the transformer remains the same even when the loads on the two d.c. outputs are different.

The Gisper development is basically a combination of the bridge rectifier of Fig.1 and the voltage doubler of Fig. 2 as shown in Fig. 5a, or a synthesis of the circuits of Fig. 3 and Fig. 4. as shown in Fig. 5b.

Briefly, the circuit of Fig. 5a works as follows. It will be assumed that the a.c. input is sinusoidal and has a peak value of 20 V. During the first quarter of a period, capacitors C_2 and C_3 are charged via diodes D_4 and D_6 to a potential of +20 V. When the a.c. input decreases, D_4 is re-

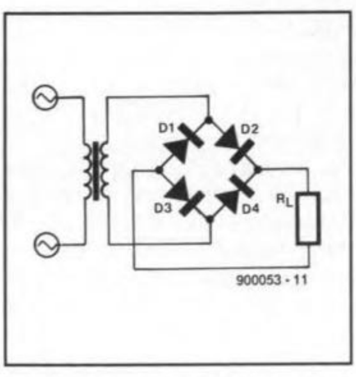

Fig. 1. Conventional bridge rectifier.

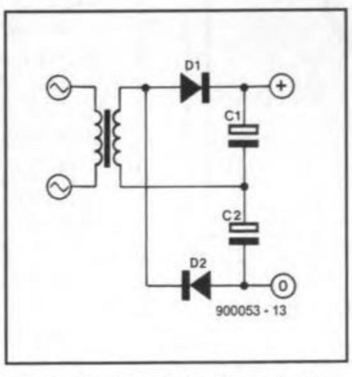

Fig. 2. Single-ended voltage doubler.

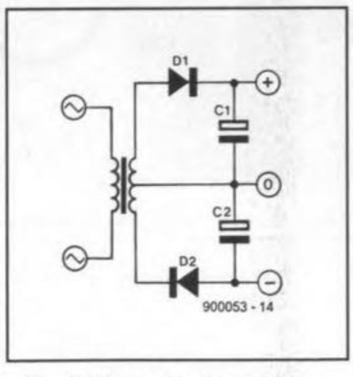

Fig. 3. Balanced voltage doubler.

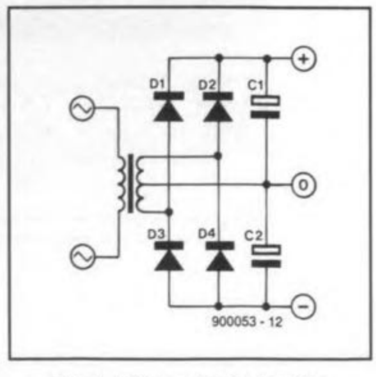

Fig. 4. Bridge voltage doubler.

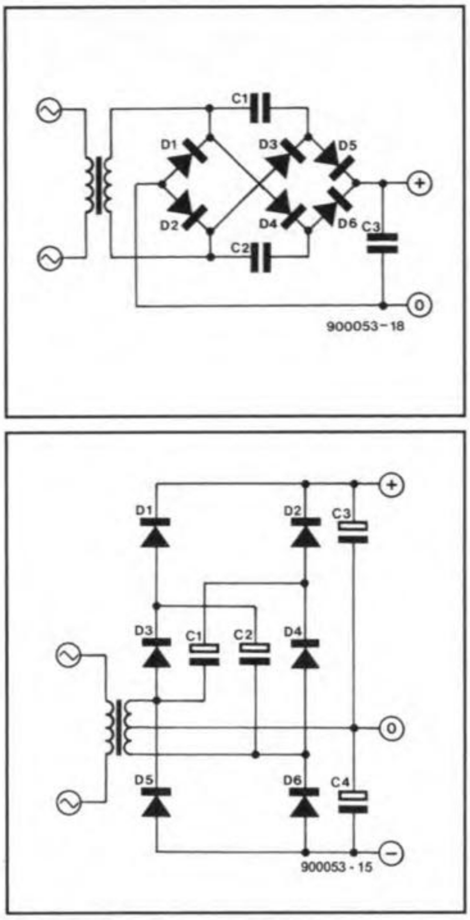

Fig. 5. The Gisper design is a combination of the bridge rectifier of Fig. 1 and the voltage doubler of Fig. 2 as shown in (a) or a synthesis of the rectifier in Fig. 3 and the voltage doubler of Fig. 4 as shown in (b).

verse biased and the voltages across C_2 and C_3 are maintained at +20 V.

When the a.c. input passes through zero, D_3 conducts and C_1 is charged to +20 V. At the same time, C_2 discharges via D_6 and C_3 via D_1 to a value of +10 V. The voltage at the junction D_1-C_1 changes from +20 V to –20 V. This causes C_3 to be charged to +30 V. The potential across D_1+D_2 is then –20 V.

As soon as the a.c. input rises, D_1 is reverse biased. The voltage across capacitors C_1 and C_2 remains +10 V and +20 V respectively. This causes the potential at junction C_1-D_3-D_5 to rise and reach a value of +30 V when the input reaches +10V. When the input rises to +20 V, the

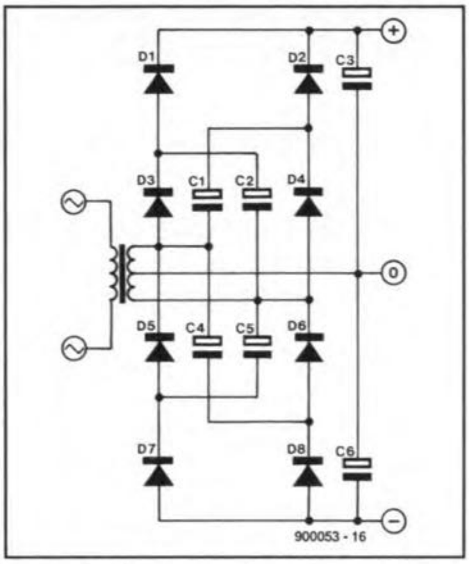

Fig. 6. The Gisper bridge may be extended as shown. The addition of each pair of diodes and capacitors raises the d.c. output voltage by a value equal to that across one half of the basic bridge rectifier.

potential across C_3 rises to +34 V.

At the moment the input exceeds +10 V, the voltage across C_2 rises from +10 V to +20 V, while that across C_1 decreases to +16 V.

When the input decreases, D_5 is reverse biased. The voltage across C_2 remains +20 V and that across C_1, +16 V. As soon as the a.c. input becomes more negative than –16 V, C_1 is charged via D3 to +20 V. At the same time, the potential across C_2-D_6-C_3-D_1 attains a value of –20 V, that across C_2 drops to +17 V, and that across C_3 rises to +37 V.

When the a.c. input increases again, the process described repeats itself. Within a few cycles, the voltage across C3 has risen to +40 V and that across C_2 to +20 V.

It appears that the Gisper bridge can be extended as shown in Fig. 6 and Fig. 7. The addition of each pair of diodes and capacitors raises the output voltage by a value equal to that across one half of the bridge rectifier. It is also possible when further extending the circuit of Fig. 6 to tap voltages at various points of the diode network as shown by the dotted lines in Fig. 7. ■

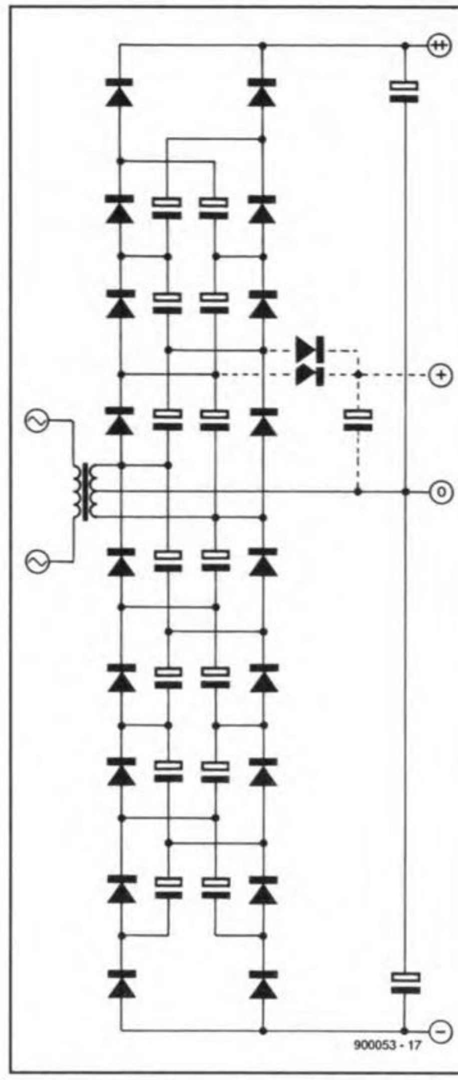

Fig. 7. When further extending the circuit of Fig. 6, it becomes possible to take off voltage at various points in the circuit as shown here by the dashed lines.

Sources:

Th. Gisper: *HF-DC-Converter-Schaltungen in der passiven Telemetrie*: Semesterarbeit an der Professur für elektrotechnische Entwickelungen und Konstruktionen, ETH Zürich, 26 February 1988.

Elektronica, 17 November 1989, "Spanningsverdubbelaar met hoog rendement".

Protecting electronic circuits

The protection of electronic circuits against the effects of hostile environments, a frequent cause of malfunction, is made easier by the 'Prelude Concoating System' from Concoat Ltd, who specialize in the application of conformal coatings.

The system is intended for small to medium-sized companies and incorporates all the equipment needed for the initial cleaning, masking, automatic dip coating and inspection: a two-stage cleaning system; a dip-coating unit; an UV inspection boot and a drying cabinet; a portable viscometer for monitoring the liquid coatings; and a microdot precision dispenser to mask out non-coatable parts with an impermeable latex compound.

The process uses 'Humiseal' conformal coatings: a plastic film of acrylics, epoxies, polyurethanes, etc., which conforms to the profile of the PCB. The speed of the process is such that Eurocards can be treated in batches of 10 at an overal rate of more than 120 per hour.

Concoat Ltd, Alasan House, Albany Park, Frimley Road, CAMBERLEY GU15 2PL, England. ■

DIGITALLY CONTROLLED PREAMPLIFIER

by K. J. Thouet

The idea presented here concerns the combination of digital and analogue techniques to produce an intelligent preamplifier with integral time switch

The digital section of the preamp is based on a standard PC motherboard that has adequate RAM, place for a ROM, and two or three expansion slots. A keyboard interface, and often a V24 interface, is normally supplied free of charge with the board and these are all that's needed to connect the board to a personal computer.

The unit must be provided with a good but not too expensive small screen. Modern one- or two-row LCDs with driver are ideal for this purpose.

Because of the available loudspeaker interface, the preamp can be made to alert the user audibly to any operating error.

Also needed is a timer if that is not already available on the motherboard.

To enable the control unit to operate correctly in the stand-by mode, a larger CMOS RAM and higher capacity battery are not a luxury in some cases.

Last but not least, an interface is needed to the analogue section and this may consist of a couple of 8-bit ports.

Since the unit has no on-off switch, the stand-by timer is switched off by software. This happens in a well-defined sequence: the loudspeakers are switched off first and then the equipment connected to the system. When that is done, the PC ascertains from stored time switch data when the system should be switched on again.

At a pre-determined time, the timer switches the power supply on again and restores the states of input level, volume, outputs used, and so on, to what these were before the system was switched off.

Both the remote control and the keyboard on the proposed unit have 28 keys so that a normal infra-red RC system is perfectly suitable. The many keys add to the ease of operation. The software must be sufficiently tolerant for the control circuits to provide the exact action that is required. A possible layout of the front panel of the remote control unit is shown in Fig. 2.

The interface to the analogue section should have special consideration since it has to deal with latches on the one hand (PC) and relays and opto-isolators on the other. A stepper-motor-controlled potentiometer would be eminently suitable here. If that is used, it is only necessary, in order to set a specific level, that the zero position is easily detected (in a similar way as in a disk drive unit). From the zero position, the potentiometer may be set manually without upsetting the automatic control.

A few points regarding the software. It is clear that the quality of a unit of this nature is directly dependent on the quality of the software.

As programming language, Pascal, C, or any other high-level language may be used.

It is, of course, an advantage if the interface cards could first be used in a normal PC, as this would enable the software to be checked without the need of having to program a PROM. If difficult to clear faults are experienced, it may help to use the EPROM simulator published some months ago [1].

Finally, there is also the possibility of downloading the program and timer data via a V24 interface for testing the completed RC unit or for further development.■

[1] *Elektor Electronics*, Dec. 1989. p.14.

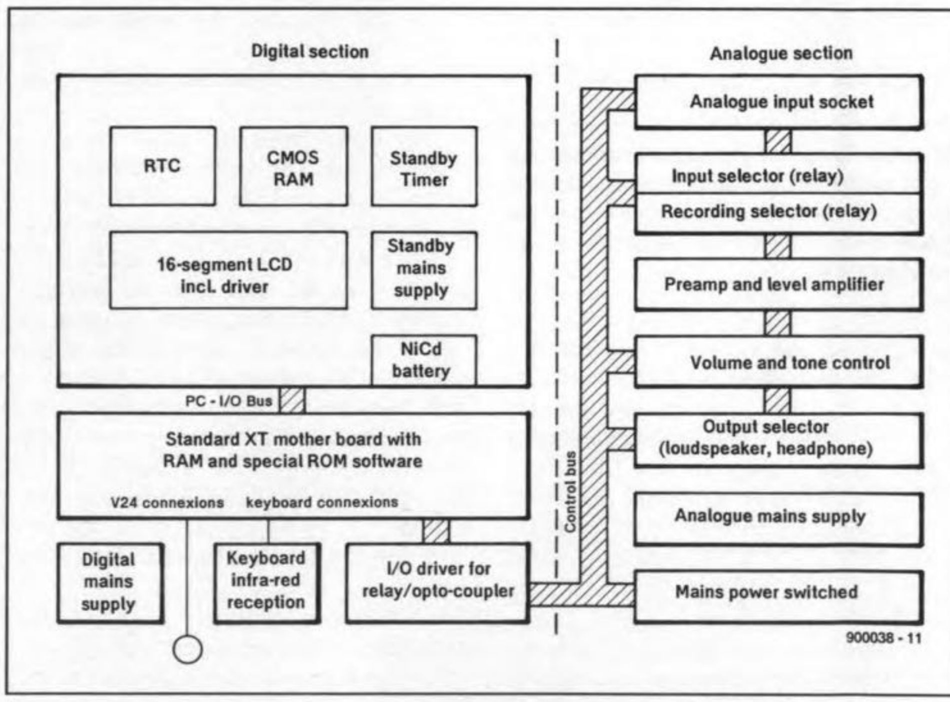

Fig. 1. Block diagram of the proposed digitally controlled preamplifier.

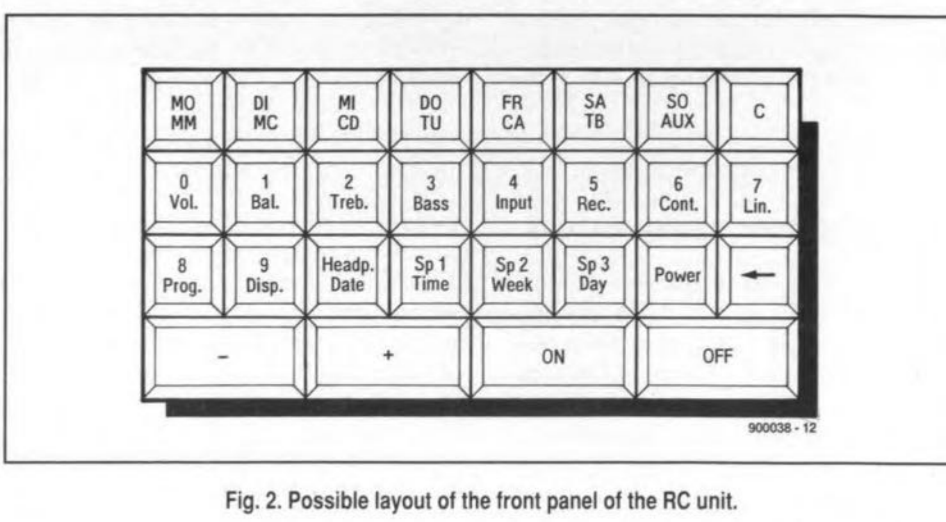

Fig. 2. Possible layout of the front panel of the RC unit.

AUTOMATIC MAINS ISOLATING SWITCH

by R. Ernst and A. Wahr

It is an undeniable fact that electric and magnetic fields affect living organisms. How strong a field the human body can withstand without ill effects is a matter of argument between scientists and environmentalists. We leave it for the reader to decide whether he deems it of benefit to fit the mains switch described here in a number of (to him) critical locations in his home or to dismiss the whole idea as scare-mongering.

Man lives in an electro-magnetic environment: the surface of the earth is surrounded by innumerable electrical and magnetic fields, from static to very high frequency ones. Although virtually everyone knows of the earth's magnetic field, few of us are aware of the 250 kV potential that exists between the earth and the ionosphere or of the cosmic radiation between 300 MHz and 350 GHz that bombards the earth unceasingly. Through centuries of evolution, life on earth has learned to live with those natural phenomena, but what about the artificial electro-magnetic fields that man has been creating for the past 150 years?

Some scientists and physiologists have worked out the recommended maximum periods that we can remain within the fields created by electrical installations without suffering long-term ill effects. For instance, the German medical scientist Dr Hubert Palm has drawn up a formula according to which we should not stay too long within a distance of 1.20 m to the south and 30 cm to the north, east and west of mains wiring or electrical equipment.

Most of us spend the larger part of our lives at work and in bed. In most bedrooms there are a number of mains outlets, some quite close to the headboard. If, like us, you believe that the electro-magnetic field around the mains wiring affects your well-being adversely, the automatic mains isolating switch described here should be of interest to you.

The isolating switch, the circuit diagram of which is shown in Fig. 1, is intended primarily to be inserted into the mains wiring where it enters the room. When, with the switch fitted, all mains-operated equipment in the room is switched off, only a small, biologically acceptable, direct voltage remains on the wiring. When a light or other apparatus is switched on, the mains voltage is immediately reconnected to the bedroom wiring.

Since the maximum allowable currrent through the switch is limited, the unit is provided with a plug and a socket outlet that enable it to be bypassed when required.

Circuit description

In Fig. 1., diodes D1 and D2 form a full-wave rectifier for the alternating voltage at the secondary of transformer Tr1. When there is no load on output socket K2, that is, all connected equipment is switched off, the potential across C1 is about 12 V. This voltage is applied to all equipment connected to K2 via R5 and the contacts of relay Re1. Resistor R5 limits the current to a safe value in case of a short-circuit at K2. As long as this situation pertains, no current flows and the circuit remains in its quiescent state.

When any of the loads, rated at not less than 3.5 W, is switched on, a direct current flows through it and this causes a forward drop of about 2.4 V across diodes D4–D6. This results in a current through R3 and the transmit diode of opto-isolator IC2. The ensuing light emitted by that diode results in the receive transistor in IC2 to be switched on and this in turn gives rise to C2 being discharged via R2 to a potential of about 2Ub/3. The ensuing output at pin Q of timer IC1 is amplified by emitter follower T1 to a value sufficient to energize relay Re1.

The relay contacts then change over and output socket K2 is connected direct to the mains via plug K1, so that the relevant load is powered.

Diode D3 ensures that both half cycles of the mains voltage can pass, although IC2 is driven during one half cycle only. Capacitor C2, however, buffers the voltage to the trigger input of the timer.

When the relevant load is switched off, the current through D5-D4-D6 and the transmit diode in IC2 ceases. The receive transistor in the opto-isolator switches off

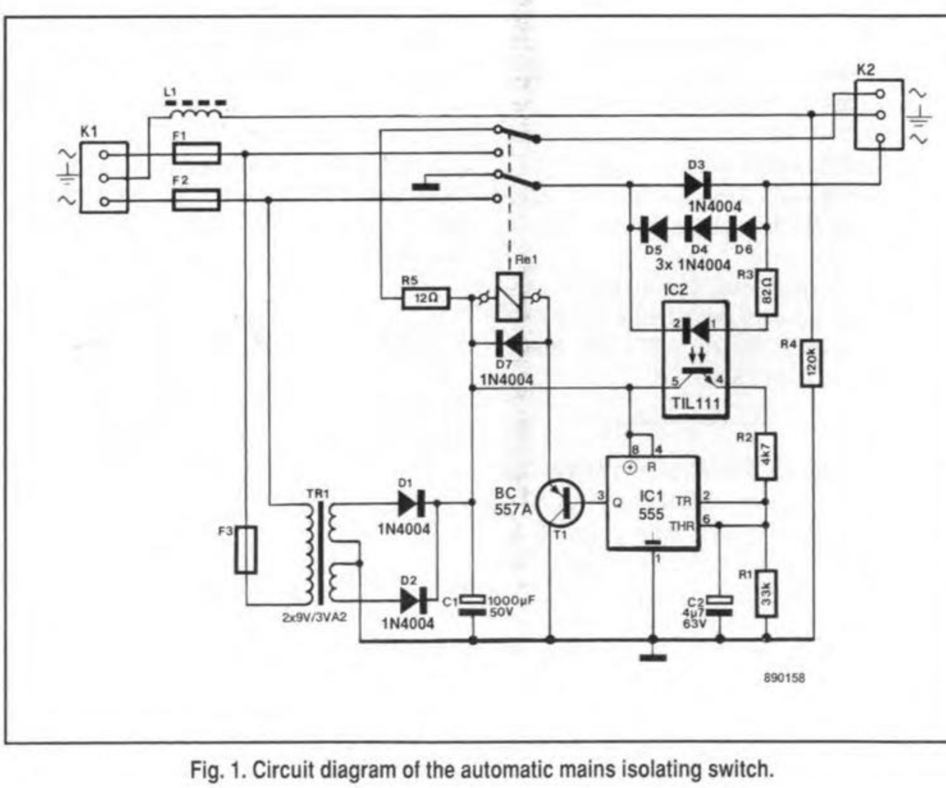

Fig. 1. Circuit diagram of the automatic mains isolating switch.

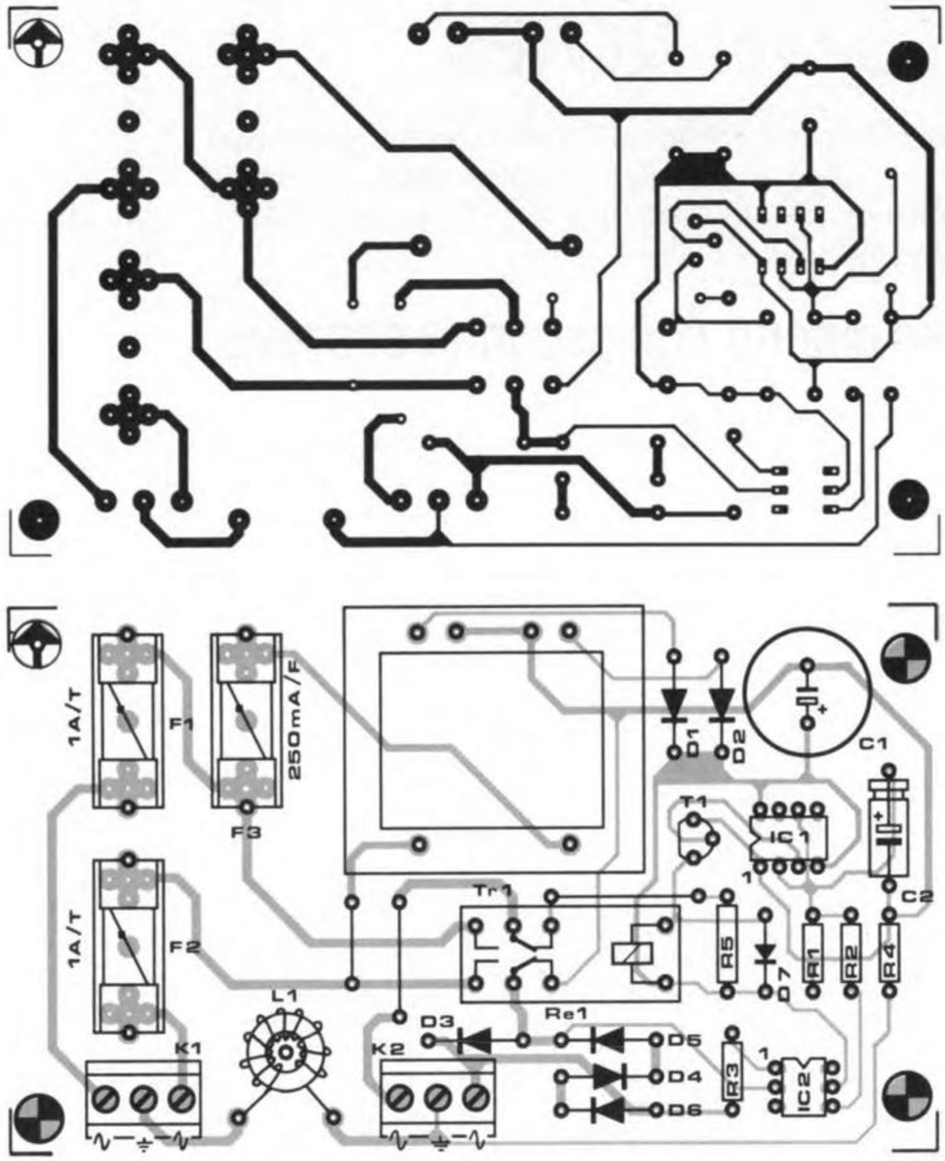

Fig. 2. Printed-circuit board for the automatic mains isolating switch.

and capacitor C2 discharges slowly via R1 (the high-impedance inputs of IC1 have virtually no effect). After about 100 ms, the potential across C1 drops below the lower voltage threshold of the input comparator: the output of IC1 is then insufficient to energize the relay and the circuit returns to its quiescent state.

Diode D7 protects T1 and the integrated switching circuit against voltage peaks caused by the back-emf of the relay coil.

Diodes D3–D6 have a maximum current rating of 1 A. They and the relay contacts are protected against overloads by anti-surge fuses F1 and F2 at the mains input. The primary of Tr1 is protected by quick-blow fuse F3.

Inductor L1 is intended as an h.f. decoupling element, since spurious signals in the 100 MHz band, resulting from the on /off switching of all kinds of electrical household equipment, are propagated by capacitive or inductive coupling over the earth line in the mains wiring.

PARTS LIST

Resistors:
R1 = 33 k
R2 = 4k7
R3 = 82 R
R4 = 120 k
R5 = 12 R

Capacitors:
C1 = 1000 µF, 50 V, radial
C2 = 4µ7, 63 V

Semiconductors:
D1–D7 = 1N4004
T1 = BC557AS
IC1 = TLC555
IC2 = TIL111

Miscellaneous:
F1, F2 = fuse, 1 A, anti-surge
F3 = fuse, 250 mA, quick-blow
3 PCB type fuseholders
Tr1 = PCB type mains transformer, 9V, 3.2 VA
K1 = mains plug outlet for panel mtg
K2 = mains socket outlet for panel mtg
2 three-way terminal block for PCB mtg
Re1 = relay, 12 V, with 2 change- over contacts rated at 1 A (e.g. Siemens Type V23037-A0002-A101)
L1 = decoupling coil, 40 µH, 1 A
Mains noise/pulse suppression filter
Suitable metal housing

Construction

The isolating switch is best constructed on the printed-circuit board shown in Fig. 2: the construction should then not present any undue problems.

Inductor L1 is a low-resistance, 40 µH decoupling coil, rated at 1 A. If a proprietary type is not readily available, it may be made as follows.

Using cardboard, make a 50 mm long tube with an outside diameter of 25 mm. On this, lay three layers of 15 turns each of insulated (yellow/green) equipment wire of 1.5 mm² cross-sectional area. Leave the ends of the wire about 20 cm long (until the coil is wired in). Use insulating tape to fix the windings in place.

The switch unit must be housed in a properly earthed metal case.

Finally, it is advisable to use a proprietary mains filter at the input to the unit. ■

HIGHER FUNDAMENTAL FREQUENCY CRYSTALS

Euroquartz has introduced a range of crystals that operate at up to 350 MHz in the fundamental mode.

Manufactured by Hi-Q Crystals of the USA, the new range of crystals have a better temperature coefficient, a higher Q and lower insertion losses than surface acoustic wave (SAW) devices.

Frequency calibration at 25 °C is typically within ±50 ppm with better tolerances available on request. The temperature coefficient is ±50 ppm over the range –55 °C to +105 °C, or ±25 ppm over the same range to special order. Euroquartz claims a TC of just ±5 ppm over the range –5 °C to +60 °C and almost zero between +25 °C and +100 °C.

The new crystals are designed for use in applications where fundamental frequency operation is essential, such as filters and oscillators.

Euroquartz Ltd, Blacknell Lane Industrial Estate, CREWKERNE TA18 7HE, England.

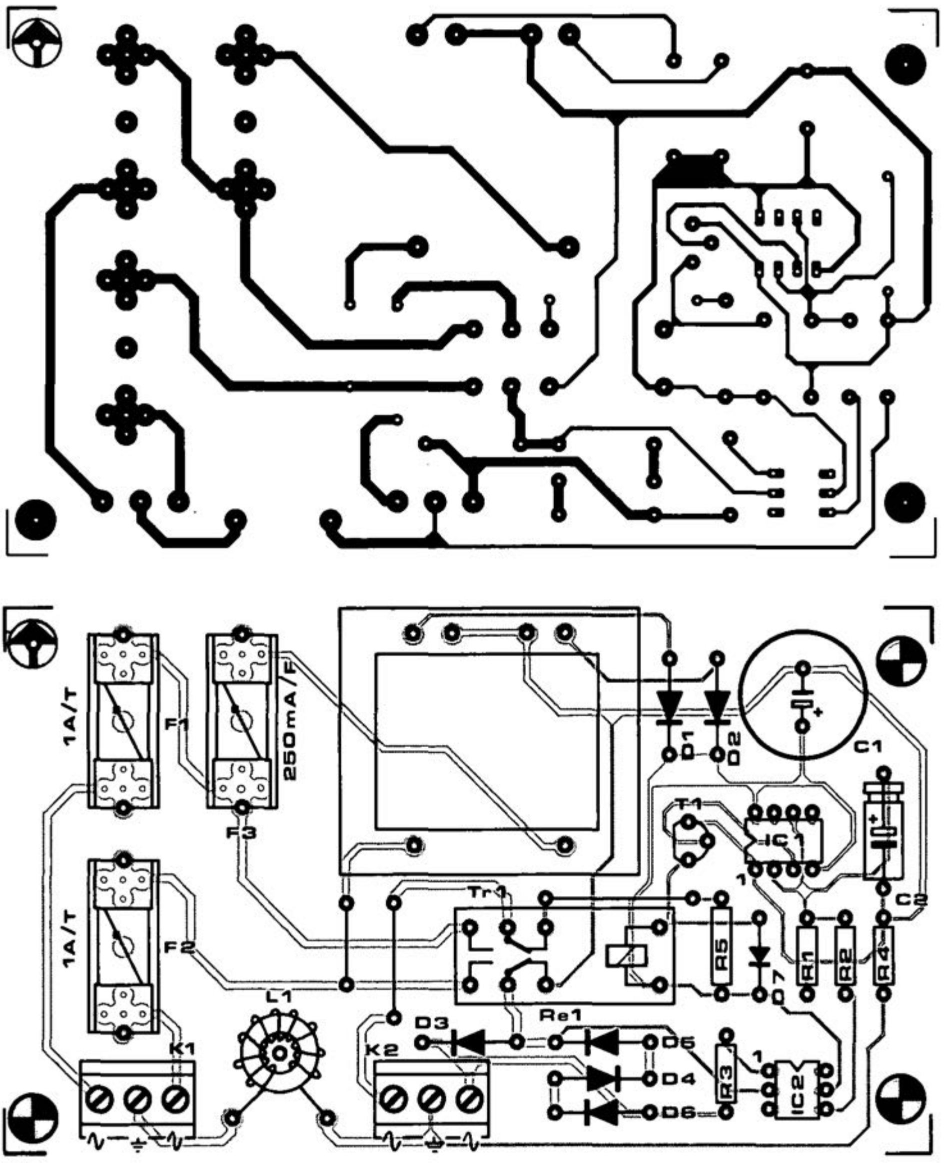

Fig. 2. Printed-circuit board for the automatic mains isolating switch.

DESIGN NOTES

The contents of this column are based on information obtained from manufacturers in the electrical/electronics industry and do not imply practical experience by *Elektor Electronics* or its consultants.

CODED LOCKING CIRCUIT FOR SECURITY SYSTEMS

General description

The TEA5500 from Philips is a coder/decoder circuit for security systems. The TEA5500 is housed in a 16-lead DIL case (SOT38) and the TEA5500T in a 16-lead mini-pack (SO16L; SOT162A).

The system has the ability to transmit a complex code between a coding and decoding unit by infra-red radiation. The device can operate as coder or decoder depending on the external circuitry connected to the data input. The code is made by the ten input pins E1–E10 by connecting them either to ground (LOW) or to the positive supply (HIGH), or leaving them floating (∞). This allows 3^{10}–2 combinations. Two combinations are prohibited: E1–E10=HIGH and E1–E9=HIGH, E10=LOW.

Coding

In the coding mode, the data input is connected to Vp and both outputs (S1, S2) are connected to a p-n-p output transistor which drives an infra-red radiation emitting diode.

After every start the coder completes three coding runs and then stops automatically.

The code consists of 24 bits. Each bit is represented by presence or absence of a data pulse following a clock pulse. The first four bits form the recognition code. The following ten pairs of bits are determined by the connexions of the input pins (E1–E10). For the corresponding code in the decoding mode, the order of the input pins is reversed and connexions L (low) and ∞ (floating) are interchanged.

Decoding

In the decoding mode, an infra-red sensitive diode is connected to the data input via an amplifier. If the input data is recognized, the data input of the decoder is closed temporarily (disregarding immediately following data) and one of the outputs is actuated for a predetermined time, after which the following start will actuate the other output.

If the data input is not recognized, nei-

CHARACTERISTICS

T_{amb} = 25 °C; voltages with respect to pin 1; unless otherwise specified

parameter	conditions	symbol	min.	typ.	max.	unit
Supply						
Supply voltage (pin 16)		V_P	3	4.5	6.5	V
Supply current	V_P = 4.5 V	I_P	1.8	2.5	3.2	mA
Output current (pins 3 and 4)	V_P = 4.5 V	I_O	25	–	–	mA
Inputs E1 to E10						
Input voltage HIGH		V_{IH}	V_P –0.3	–	–	V
Input voltage LOW		V_{IL}	–	–	0.3	V
Input voltage floating		V_{IFL}	1	–	V_P –1	V
Input current HIGH		I_{IH}	2	7	12	μA
Input current LOW		I_{IL}	–4	–9	–15	μA
Input current floating		I_{IFL}	–	–	2	μA
Data input						
Input voltage						
for decoding mode HIGH		V_{dH}	V_P –0.6	V_P	V_P + 0.3	V
for decoding mode LOW		V_{dL}	–	–	0.5	V
Input current						
in coding mode		I_{dc}	8	16	25	μA
in decoding mode HIGH	V_P = 4.5 V	I_{ddH}	–	–	2	μA
in decoding mode LOW	V_P = 4.5 V	I_{ddL}	–8	–16	–25	μA
Minimum pulse width of DATA input signal		τ_{dp}	2	–	–	μs

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parameter	conditions	symbol	min.	typ.	max.	unit
Oscillator characteristics	V_P = 4.5 V					
Switching voltage thresholds						
high level		V_{th}	3.10	3.32	3.50	V
low level		V_{tl}	0.65	0.71	0.90	V
Input current						
after switching high level		I_{th}	27	36	45	μA
after switching low level		I_{tl}	–6.7	–9	–11.3	μA
Ratio I_{th}/I_{tl}		ΔI_{osc}	3	4	5	
Duration of oscillator pulse						
in coding mode	note 1	τ_c	20	$0.4 \cdot C_{osc}$(pF)	–	μs
in decoding mode		τ_d	$3 \cdot \tau_c$	$0.4 \cdot C_{osc}$(pF)	$5 \cdot \tau_c$	μs
Oscillator capacitor						
in coding mode	notes 1 and 2	C_{osc}	56	–	–	pF
Duration of						
output active status		τ_o	–	$384 \cdot \tau_d$	–	
data input disabled status		τ_x	–	$576 \cdot \tau_d$	–	
Influence of temperature on duration of oscillator pulse		$\frac{\Delta\tau_c/\tau_c}{\Delta T}$	–	0.002	–	$°C^{-1}$
Influence of supply voltage on duration of oscillator pulse		$\frac{\Delta\tau_c/\tau_c}{\Delta V_P}$	–	–	0.16	V^{-1}
Zener diode voltage across supply		V_z	6	–	8	V

Notes to the oscillator characteristics

1. Minimum value coder – capacitor must provide minimum pulse width of DATA pulse τ_{dp} (= 1/5 τ_c).
2. Ratio coder/decoder capacitor 1:3.

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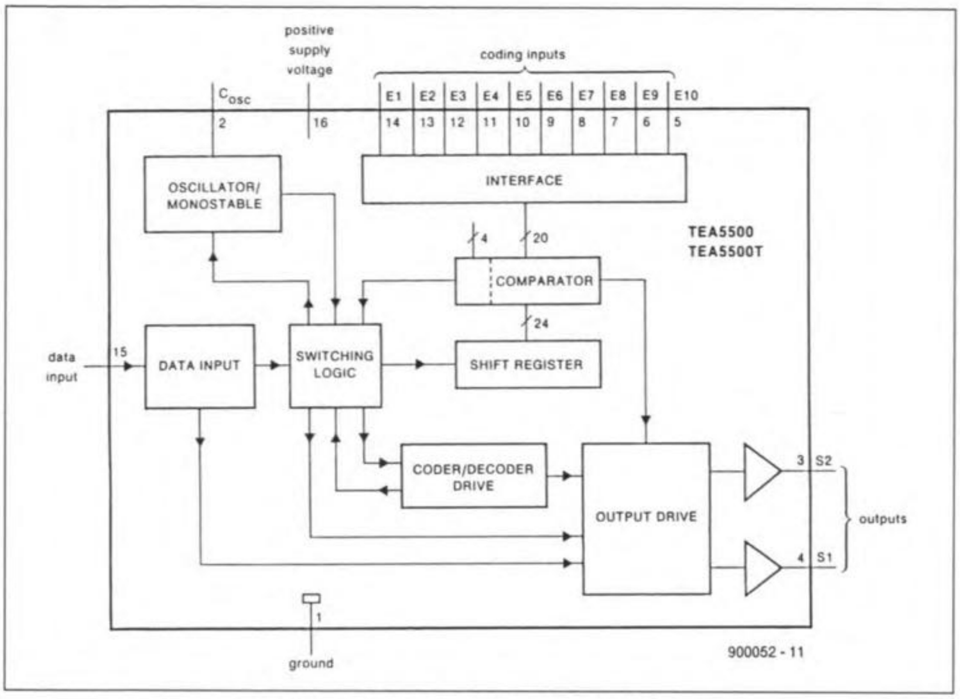
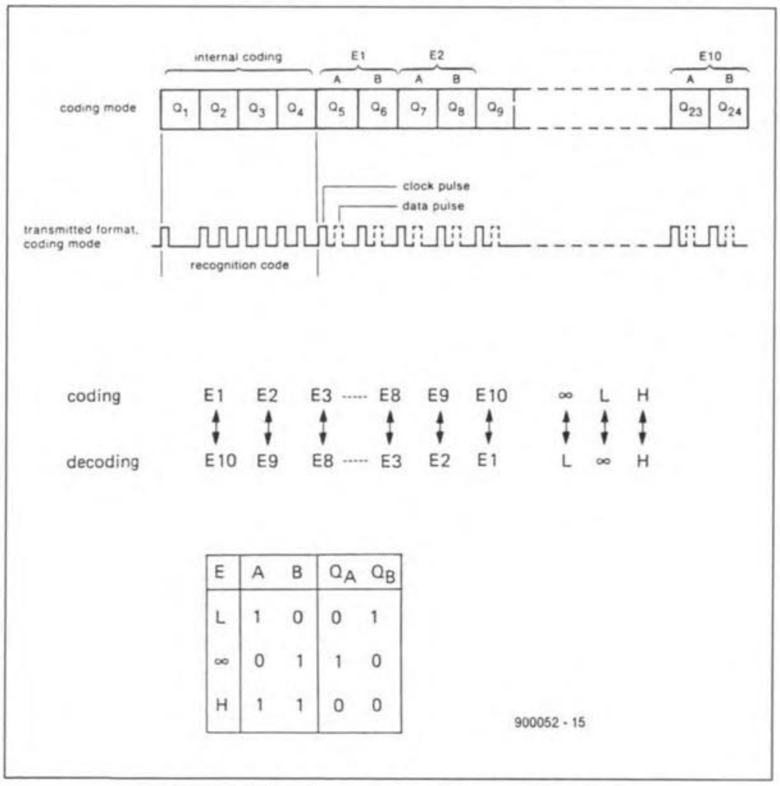


Fig. 1. Block diagram of the TEA5500/TEA5500T.



E	A	B	Q_A	Q_B
L	1	0	0	1
∞	0	1	1	0
H	1	1	0	0

Fig. 2. Timing diagram of the TEA5500/TEA5500T.

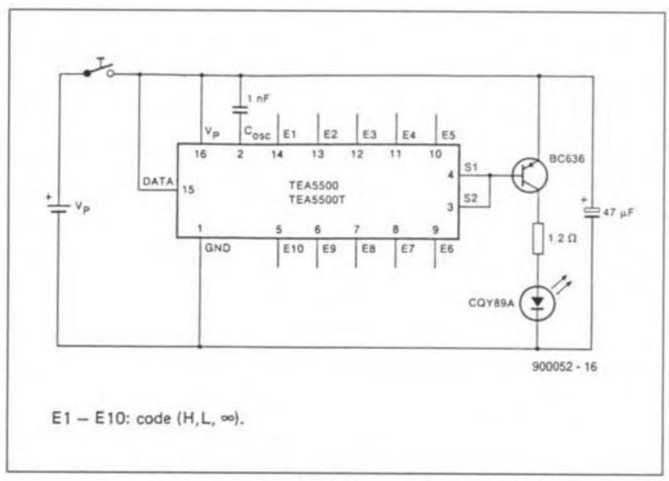


Fig. 3. Application diagram – coding mode.

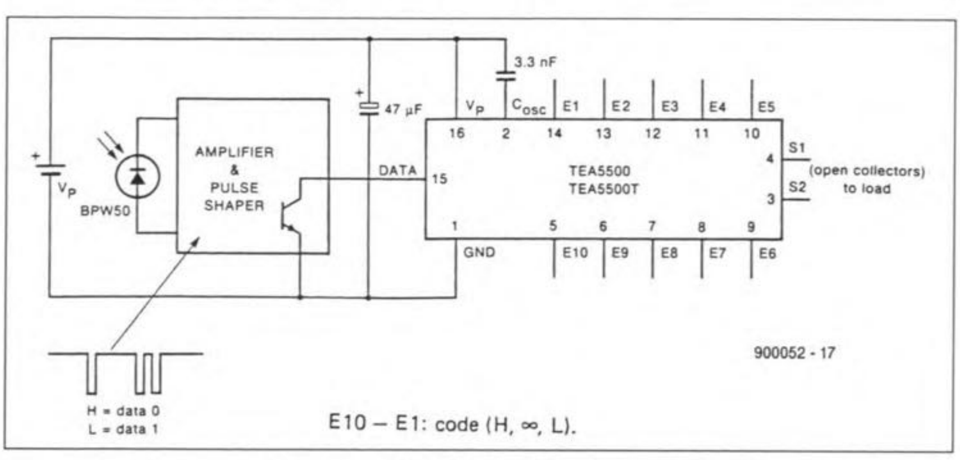


Fig. 4. Application diagram – decoding mode.

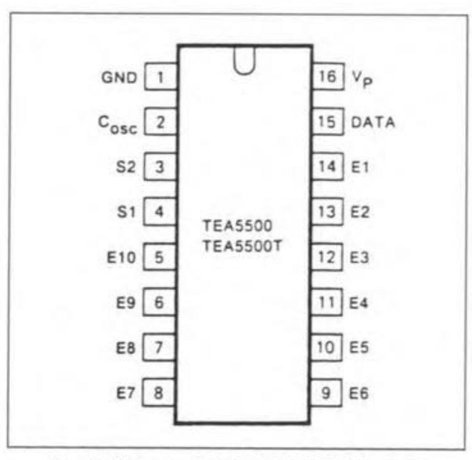


Fig. 5. Pinout of the TEA5500/TEA5500T.

ther of the outputs is actuated; after the third coding run has been completed, the data input of the decoder is closed temporarily.

Soldering (by hand)

Plastic mini-packs

Fix the device by first soldering two diagonally opposite end leads. Apply the iron to the flat part of the lead only. Contact time must be limited to 10 seconds at up to 300 °C. When proper tools are used, all other leads can be soldered in one operation within 2–5 seconds at 270–320 °C. (Pulse-heated soldering is not recommended for SO packages).

Plastic DIL packages

Apply the soldering iron below the seating plane (or not more than 2 mm above it). If its temperature is below 300 °C, it must not be in contact for more than 10 seconds; if between 300 °C and 400 °C, for not more than 5 seconds. ■

(Philips Data Sheet TEA5500/TEA5500T)