THE INTERNATIONAL MAGAZINE FOR ELECTRONICS ENTHUSIASTS
April 1991
UK £1·75

Elektor Electronics

MIDI programme changer

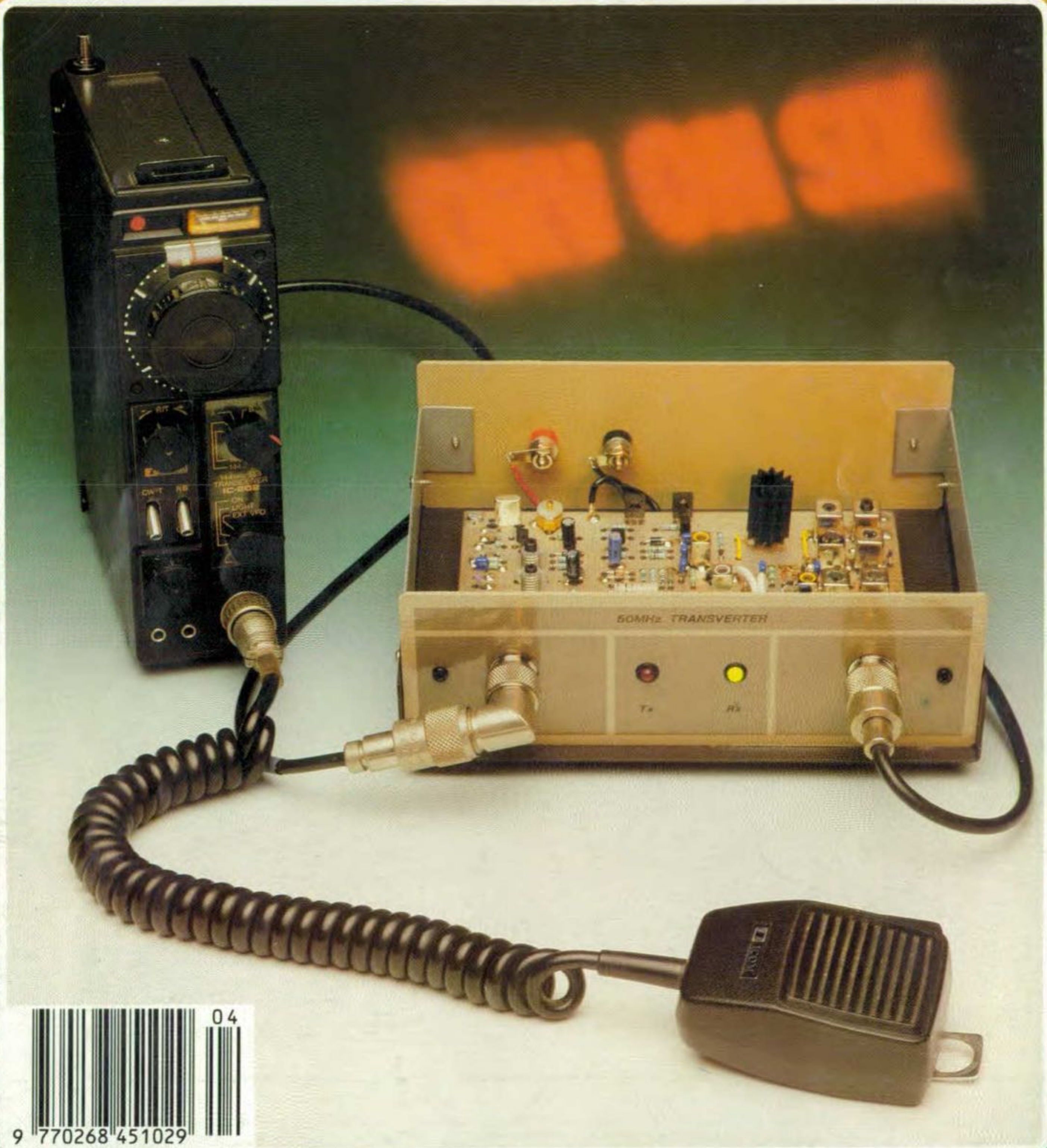
50 MHz transverter

P-U converter

Dynamic pick-up preamplifier

AM/FM receiver

Dimmer for halogen lights



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ELEKTOR Electronics
The international magazine for electronics enthusiasts

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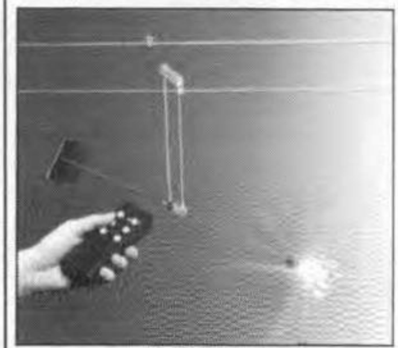
Front cover
Although it has been in use for over ten years in the UK, the 6-metre (50 MHz) band has recently gained a lot of attraction since the PTT (Post, Telephony and Telegraph) authorities of a number of continental European countries, including France, Holland, Belgium and Germany have, after a faltering start, issued the first few hundred 6-metre licences. The author, a Belgian radio amateur, invites you to take an active part in the growing 6-metre activity. The design for a transverter in this issue has a number of distinct advantages over earlier designs that have appeared in the radio amateur press.



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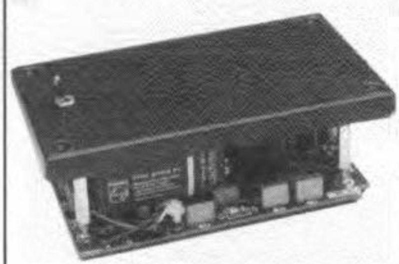

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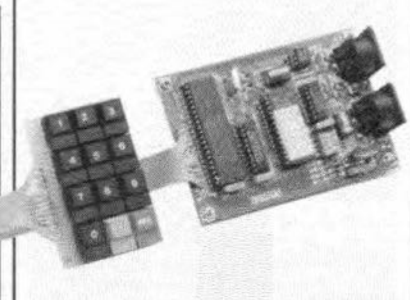

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MIDI PROGRAMME CHANGER

by R. Degen

Since virtually all electronic musical instruments are now fitted with a Musical Instrument Digital Interface (MIDI), it has become possible to control a whole array of such instruments from a small keyboard. The MIDI programme changer described in this article is based on that concept and enables a number of electrophonic instruments to be accessed quickly and efficiently.

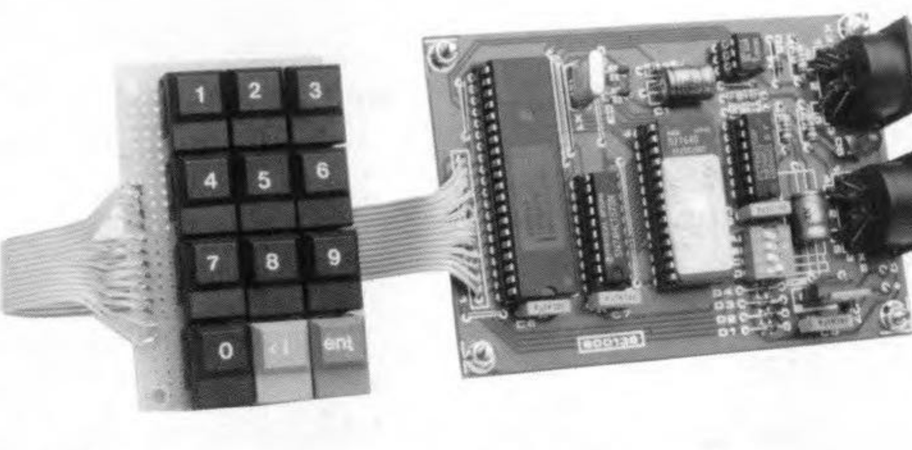
THANKS to the MIDI (Musical Instrument Digital Interface), it is now possible for all performances of a musician to be recorded digitally and stored on floppy disks. When the stored music is replayed, it sounds as natural as when it was recorded. Also, by performing a number of pieces in succession and storing them in a sequencer, the musician can simulate an entire orchestra. Furthermore, integration of the interface with a personal computer gives several new possibilities, such as the noting down of complete musical scores with the aid of a keyboard, and the transposing of pieces of music at the touch of a button.

The strength of the MIDI is its ability to exchange information rapidly in real time with the aid of a serial connection. Not only the key impressions, and the force with which these are carried out, can be transmitted via the MIDI, but also information about the tempo, the chosen preset, synchronizing pulses and complete samples. This is the reason that nowadays keyboards are frequently offered for sale together with an expander.

In principle, an expander is a complete musical instrument, the keyboard of which has been replaced by a MIDI input. It receives all the required control signals via the serial connection. In general, it offers more facilities for a smaller outlay: the money that would otherwise have been spent on a keyboard is now available for other things.

A disadvantage of the expander is that it requires a separate (MIDI-master) keyboard or sequencer to make full use of all its facilities. In particular, the changing of a preset can create problems, since most keyboards can not generate a programme change instruction without altering its own settings. Also, there are differences in the counters fitted to the keyboards: on some these operate in the decimal system, while others use the octal system.

The present programme changer enables the choosing of a different preset in the musical instrument via the MIDI. This is done by keying the desired programme change code (a decimal number of not more than three digits) on the keyboard of the changer and confirming it with 'ent' (enter). Corrections may be made with the 'clear' key. Once the code has been confirmed, the unit transmits the hexadecimal code Cx_H and the associated data to the the appropriate musical instrument.



The programme change command is made up of two bytes. The first of these is 1100nnnn, where nnnn is the binary coded number of the MIDI channel. The second is 0ppppppp, where ppppppp is the binary form of the decimal number keyed in. This number lies between 0 and 127, because the MIDI protocol has reserved seven bits for it.

Circuit description

The MIDI programme changer is a small, but complete, microprocessor system. The Type 8031 microcontroller, IC_1, processes the incoming MIDI data and scans the keyboard. The control program is contained in a Type 2764 EPROM, IC_4. The demultiplexing of the microcontroller's data/address bus is carried out by IC_2.

The microcontroller confirms that the data at gate 0 are valid address data via pin 30 (ALE/$\overline{P}$). This information is stored by IC_2 and placed on address lines A0–A7 of IC_4. The remaining address lines, A8–A12, are connected to gate 2 of the microcontroller.

The data bus of the EPROM is connected to gate 0 of IC_1. The microcontroller reads the data from IC_4 via the PSEN signal.

The $\overline{RD}$ output of IC_1 is used to read the contents of DIP switches S_{1A}–S_{1D}. Diodes D_1–D_4 ensure that the DIP switches can not adversely affect the operation of the keyboard. As soon as the $\overline{RD}$ line is high, they form a sort of three-state input.

The setting of the switches determines which MIDI channel is selected for transmission of the data. When all switches are closed, that is, ON (equivalent to logic 0), channel 0 is selected; when they are all open

Table 1

S_{1A}	S_{1B}	S_{1C}	S_{1D}	Channel
0	0	0	0	0
1	0	0	0	1
0	1	0	0	2
1	1	0	0	3
0	0	1	0	4
1	0	1	0	5
0	1	1	0	6
1	1	1	0	7
0	0	0	1	8
1	0	0	1	9
0	1	0	1	10
1	1	0	1	11
0	0	1	1	12
1	0	1	1	13
0	1	1	1	14
1	1	1	1	15

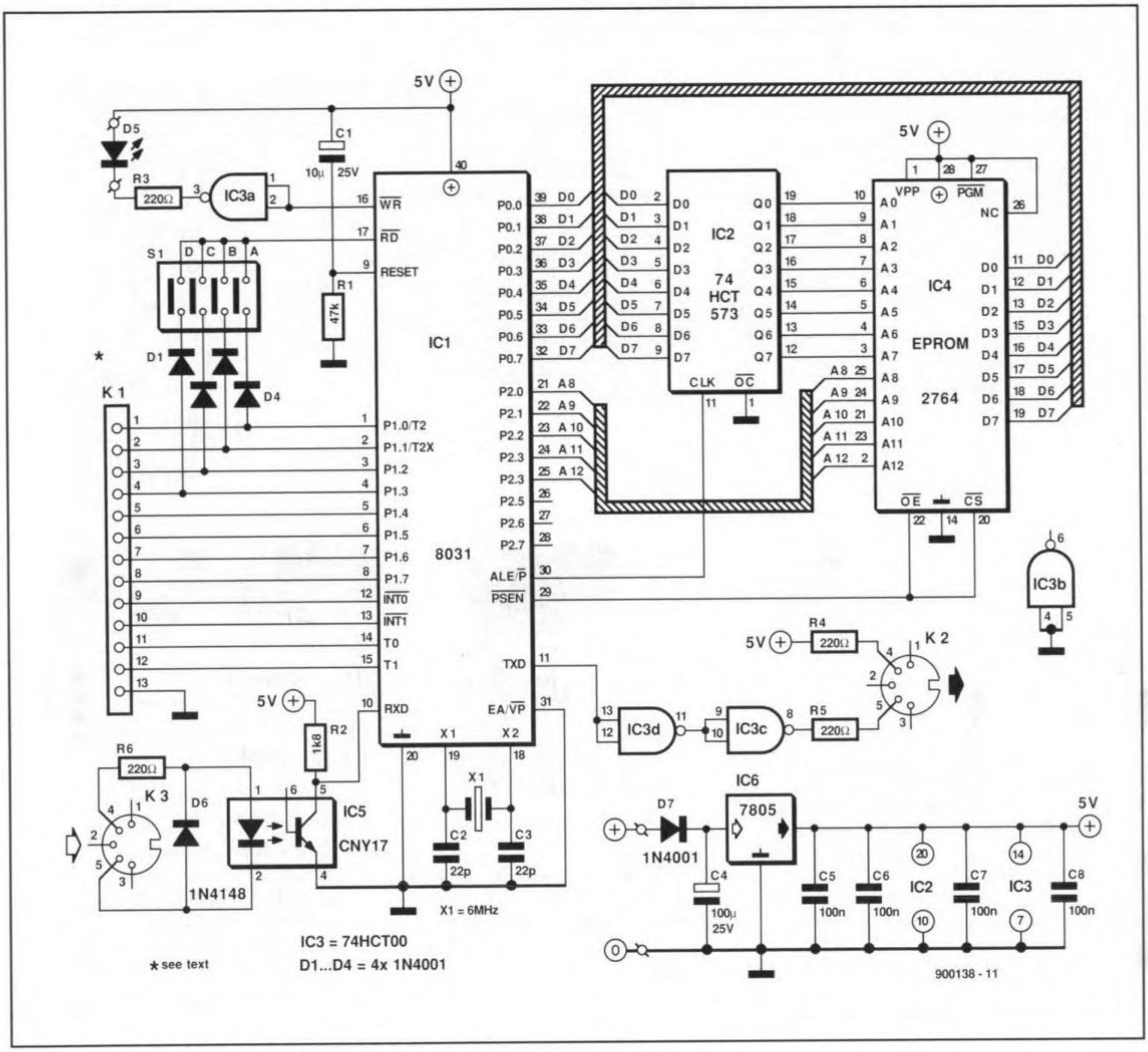


Fig. 1. Circuit diagram of the MIDI programme changer.

(OFF = logic 1), channel 15 is selected—see Table 1. When the setting of a switch is altered, the change becomes effective only after the next power-on reset.

Since the outputs of gate 1 are internally provided with a pull-up resistance, external resistors are not necessary.

All twelve keys on the keyboard are connected to a common earth on connector K_1.

The microcontroller is reset via network R_1–C_1. Every time the power is switched on, pin 9 of IC_1 goes high for an instant and the microcontroller starts processing the data in the EPROM. At the same time, the settings of the DIP switches are read.

Crystal X_1 is connected directly to the X-pins of the controller and oscillates at 6 MHz.

Diode D_5 has two functions: it lights briefly when one of the keys is impressed and it flashes when the programme mode is active. The LED is controlled by the $\overline{WR}$ output via IC_{3a}. As soon as the level at this output goes high, the diode lights.

Since the MIDI operates with a current loop and must be electrically isolated from the equipment connected to it, its input is formed by an optoisolator, IC_5. The light-emitting diode in this device is operated by the current flowing in the loop. The serial data output of the CNY17 is fed directly to the receive data input (RXD) of IC_1 for further processing.

The transmit data output, TXD, of the microprocessor is connected to two series-connected gates, IC_{3d} and IC_{3e}, that, with the aid of resistors R_4 and R_5, provide the necessary current drive.

The power supply is kept simple and uses a Type 7805 voltage regulator, IC_6. Diode D_7 serves to prevent damage should the polarity of the supply voltage be reversed. The supply is best derived from a mains adapter with an output voltage of 9–15 V. Since the current drain is small, cooling of the regulator is not necessary.

Construction

With the exception of the keyboard, all components are housed on the printed-circuit board shown in Fig. 2. Since the design is fairly simple and there is no alignment required, nothing can go seriously wrong.

The programmed EPROM is available through our Readers' services shown further on in this magazine, but you may do the programming yourself with the help of the hexdump given in Table 3.

The MIDI input is via connector K_3, while the output is transmitted via K_2.

Connector K_1 may be a 13-way single-row header, but many readers may find it more convenient to make the connection between the unit and the keyboard with a length of 13-way flat cable.

The keyboard may be any simple membrane type, but it should not have a matrix. Each key must be individiually connected to the relevant pin of K_1 or, if this is not used, to the relevant pin of IC_1. A sturdy keyboard may be constructed from twelve miniature push-button switches fitted on to a piece of vero- or other prototyping board. In many cases, the digit keys can be bought ready-made; different colour keys can then be used for the 'ent' and 'clear' keys. Table 2 shows the layout of the keyboard and the correlation between keys, function and pins.

Once the keyboard has been completed, it may be mounted above the PCB with the aid of suitable spacers, after which the unit can be mounted in an appropriate enclosure.

Table 2

1	2	3
4	5	6
7	8	9
0	ent	clear

Key	IC_1 pin	Function	K_1pin
0	1	P1.0	1
1	2	P1.1	2
2	3	P1.2	3
3	4	P1.3	4
4	5	P1.4	5
5	6	P1.5	6
6	7	P1.6	7
7	8	P1.7	8
8	12	$\overline{INT0}$	9
9	13	$\overline{INT1}$	10
Clear	14	T0	11
Enter	15	T1	12
			13

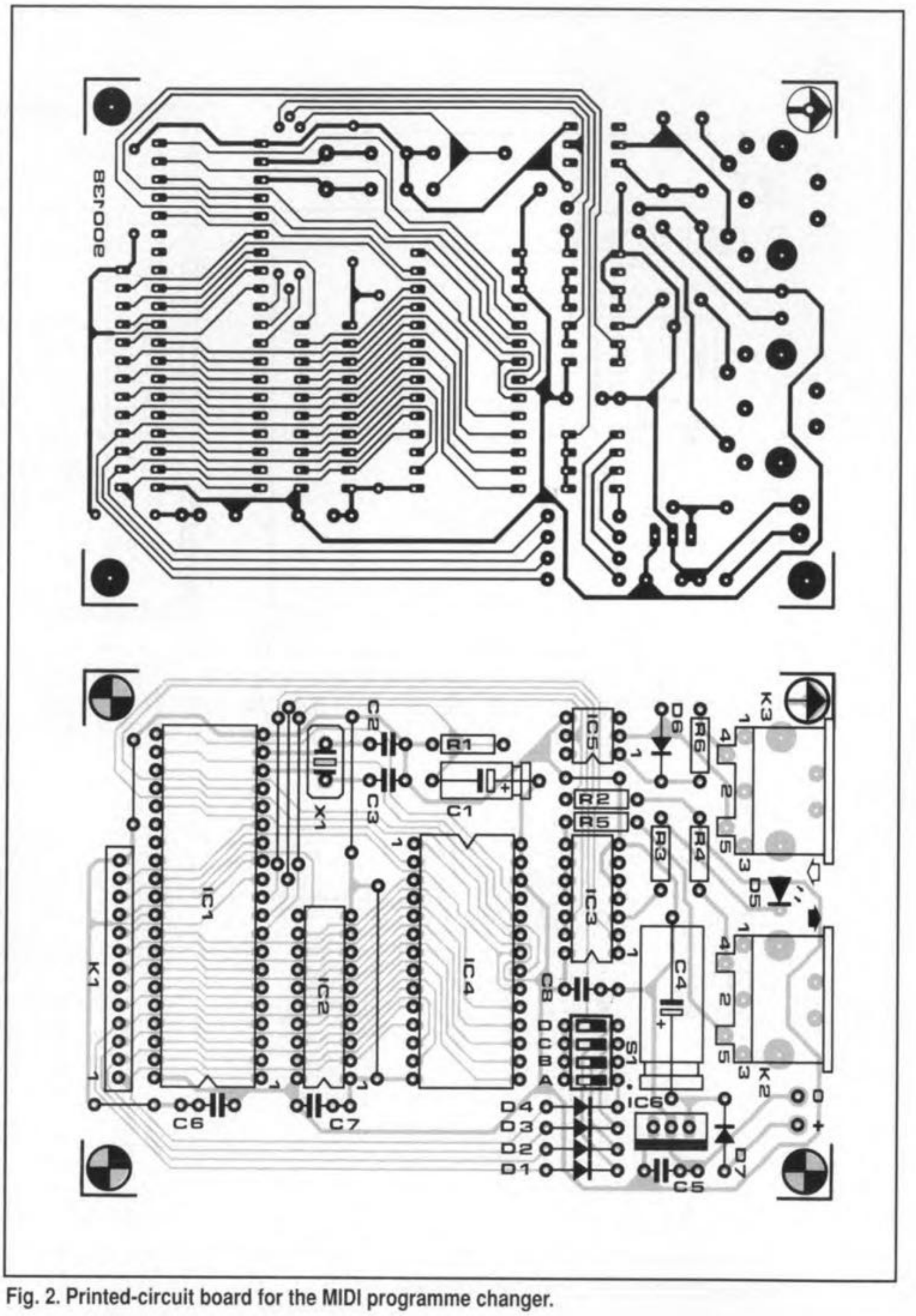


Fig. 2. Printed-circuit board for the MIDI programme changer.

Taking the unit into use

- Switch on the supply.
- Depress each key in turn, whereupon the LED should light briefly.
- Choose the wanted MIDI channel: the setting of the relevant DIP switches is shown in Table 1.

- If a different MIDI channel is to be selected during operation, press down and hold the 'clear' key.
- Press the 'ent' key, whereupon the LED should begin to flash.
- Select the wanted channel with the aid of the DIP switches and press the 'ent' key. ■

PARTS LIST

Resistors:
R_1 = 1×47 kΩ
R_2 = 1×1k8
R_3–R_6 = 4×200Ω

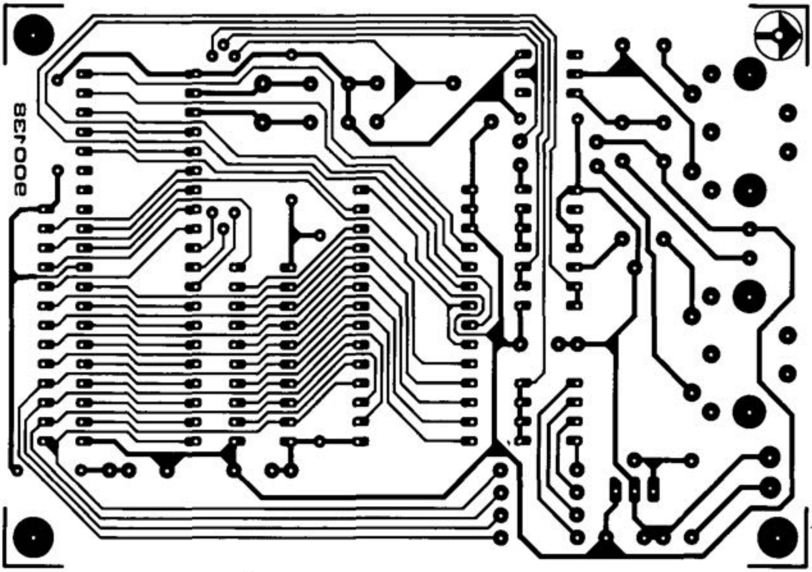
Capacitors:
C_1 = 1×10 µF, 25 V
C_2,C_3 = 2×22 pF
C_4 = 1×100 µF, 25 V
C_5–C_8 = 4×100 nF

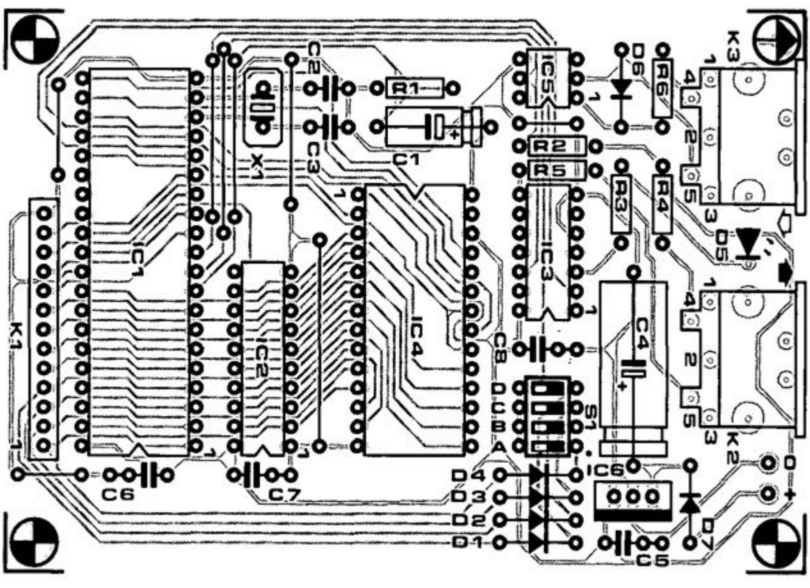
Semiconductors:
IC_1 = 1×8031
IC_2 = 1×74HCT573
IC_3 = 1×74HCT00
IC_4 = 1×2764
IC_5 = 1×CNY17
IC_6 = 1×7805
D_1–D_4,D_6 = 5×1N4148
D_5 = 1×LED (red)
D_7 = 1×1N4001

Miscellaneous:
K_1 = 1×13-pin header
K_2,K_3 = 5-pin DIN connector, 180°
S_1 = 1×quadruple DIP switch
X_1 = 1×crystal, 6 MHz
1×keyboard with 12 keys and common earth or 12×mini push-button switches
1×connector for mains adapter
PCB 900138

	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
0000	80	4E	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0010	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0020	FF	FF	FF	10	98	05	C2	99	C2	01	32	C0	D0	C0	E0	E5
0030	99	B4	F8	0E	30	01	03	30	99	FA	C2	99	D2	01	F5	99
0040	80	09	50	F0	F6	18	B8	40	02	78	70	D0	E0	D0	D0	32
0050	78	70	79	70	75	87	80	75	89	20	75	8D	FF	D2	8E	75
0060	98	50	C2	01	D2	AC	D2	AF	75	81	28	C2	00	C2	02	C2
0070	03	75	7A	00	75	90	FF	75	B0	FF	C2	04	C2	B6	C2	B7
0080	E5	90	F4	44	C0	F5	7C	D2	B7	7D	80	75	7F	00	75	7E
0090	00	75	7D	00	E8	B5	01	16	12	00	DA	30	03	F6	E5	7C
00A0	12	00	D2	E5	7A	12	00	D2	C2	03	D2	02	80	E6	E7	19
00B0	B9	40	02	79	70	20	E7	12	30	02	09	FA	74	7B	12	00
00C0	D2	C2	02	EA	12	00	D2	02	00	94	F5	7B	12	00	D2	02
00D0	00	94	20	01	FD	F5	99	D2	01	22	30	04	03	02	01	EA
00E0	20	90	04	74	00	80	59	20	91	04	74	01	80	52	20	92
00F0	04	74	02	80	4B	20	93	04	74	03	80	44	20	94	04	74
0100	04	80	3D	20	95	04	74	05	80	36	20	96	04	74	06	80
0110	2F	20	97	04	74	07	80	28	20	B2	04	74	08	80	21	20
0120	B3	04	74	09	80	1A	20	B5	04	74	0B	80	13	20	B4	04
0130	74	0A	80	0C	30	00	08	DC	06	C2	00	7C	FF	7B	FF	22
0140	30	00	2A	B4	0B	26	BB	0A	23	D2	04	7C	FF	7B	FF	7D
0150	80	75	7F	00	75	7E	00	75	7D	00	43	89	01	75	8C	00
0160	75	8A	00	D2	8C	75	79	03	D2	B6	D2	00	22	B5	03	09
0170	DC	1B	C2	B6	B4	0B	17	80	3D	B4	0A	02	80	0A	B4	0B
0180	02	80	05	BD	7D	02	80	05	D2	B6	7C	FF	FB	22	B4	0A
0190	0E	7D	80	75	7F	00	75	7E	00	75	7D	00	D2	00	22	D2
01A0	00	1D	BD	7F	04	F5	7F	80	0C	BD	7E	04	F5	7E	80	05
01B0	BD	7D	02	F5	7D	22	C0	01	A9	05	B9	80	02	80	20	87
01C0	7A	09	B9	80	02	80	18	E7	75	F0	0A	A4	25	7A	F5	7A
01D0	09	B9	80	02	80	09	E7	75	F0	64	A4	25	7A	F5	7A	D2
01E0	03	D2	00	79	80	AD	01	D0	01	22	30	8D	14	D5	79	05
01F0	B2	B6	75	79	03	C2	8C	C2	8D	75	8C	00	75	8A	00	D2
0200	8C	20	90	04	74	00	80	59	20	91	04	74	01	80	52	20
0210	92	04	74	02	80	4B	20	93	04	74	03	80	44	20	94	04
0220	74	04	80	3D	20	95	04	74	05	80	36	20	96	04	74	06
0230	80	2F	20	97	04	74	07	80	28	20	B2	04	74	08	80	21
0240	20	B3	04	74	09	80	1A	20	B5	04	74	0B	80	13	20	B4
0250	04	74	0A	80	0C	30	00	08	DC	06	C2	00	7C	FF	7B	FF
0260	22	30	00	01	22	B5	03	07	DC	17	B4	0B	15	80	31	B4
0270	0A	02	80	0A	B4	0B	02	80	05	BD	7D	02	80	03	7C	FF
0280	FB	22	B4	0A	0B	7D	80	75	7F	00	75	7E	00	D2	00	22
0290	D2	00	1D	BD	7F	04	F5	7F	80	05	BD	7E	02	F5	7E	22
02A0	C0	01	A9	05	B9	80	02	80	12	87	78	09	B9	80	02	80
02B0	0A	E7	75	F0	0A	A4	25	78	F5	78	09	E5	78	44	C0	F5
02C0	7C	D2	00	79	80	AD	01	D0	01	C2	8C	C2	B6	C2	04	22
02D0	28	43	29	20	50	52	4F	47	52	41	4D	4D	2D	43	48	41
02E0	4E	47	45	52	20	56	32	2E	30	20	20	20	20	20	52	6F
02F0	6C	66	20	44	65	67	65	6E	20	32	33	2E	38	2E	39	30
0300	20	20	20	20	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF

Table 3. Hexdump of the contents of the EPROM. A ready programmed EPROM is available through our Readers' services.




K1
IC1
IC2
IC3
IC4
IC5
IC6
C1
C2
C3
C4
C5
C6
C7
C8
R1
R2
R3
R4
R5
R6
X1
D1
D2
D3
D4
D5
D6
D7
S1
K2
K3

CORRECTIONS

Wattmeter

April 1991, p. 32-35

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

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

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

80C32/8052 Single-board computer

May 1991, p. 17-23

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

Sequential control

July/August 1991, p. 61

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

Digital phase meter

June 1991, p. 32-39

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

Universal NiCd battery charger

June 1991, p. 14-19

The parts list on page 19 should be corrected to read

C7 = 2200µF 25V

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

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

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

MIDI program changer

April 1991, p. 14-17

The contents of the EPROM should be modified as follows:

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

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

Electronic exposure timer

March 1991, p. 31-35

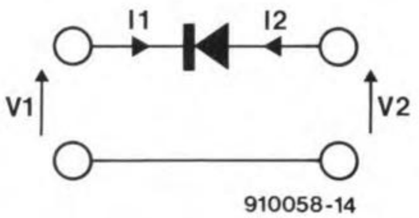
Please add to the parts list on page 32:

C16 = 33 pF

Augmented A-matrices

May 1991, p. 42-43

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



PREAMPLIFIER FOR MOVING-COIL PICK-UP

by T. Giffard

Although the analogue record player (as it is now often called) was written off by many some years ago, well-known manufacturers like Thorens, Dual and Linn continue to design and produce new models. And no wonder, because long-playing records are still widely available, in spite of the forecasts in the mid-eighties by experts that this type of record would not be seen in the nineties except in museums and personal collections. As long as these record players remain available, there will be a need of special preamplifiers. The one described here has been designed specifically for the processing of signals from high-quality moving-coil pick-up cartridges.

THE case for a new preamplifier for moving-coil pick-ups rests on two important considerations. First, vinyl long-playing records are still being produced (and, of course, there are millions of people who have large collections of them). Second, the reproduction quality of analogue records is of the highest order and, many hi-fi enthusiasts maintain, far superior to that of the compact disk.

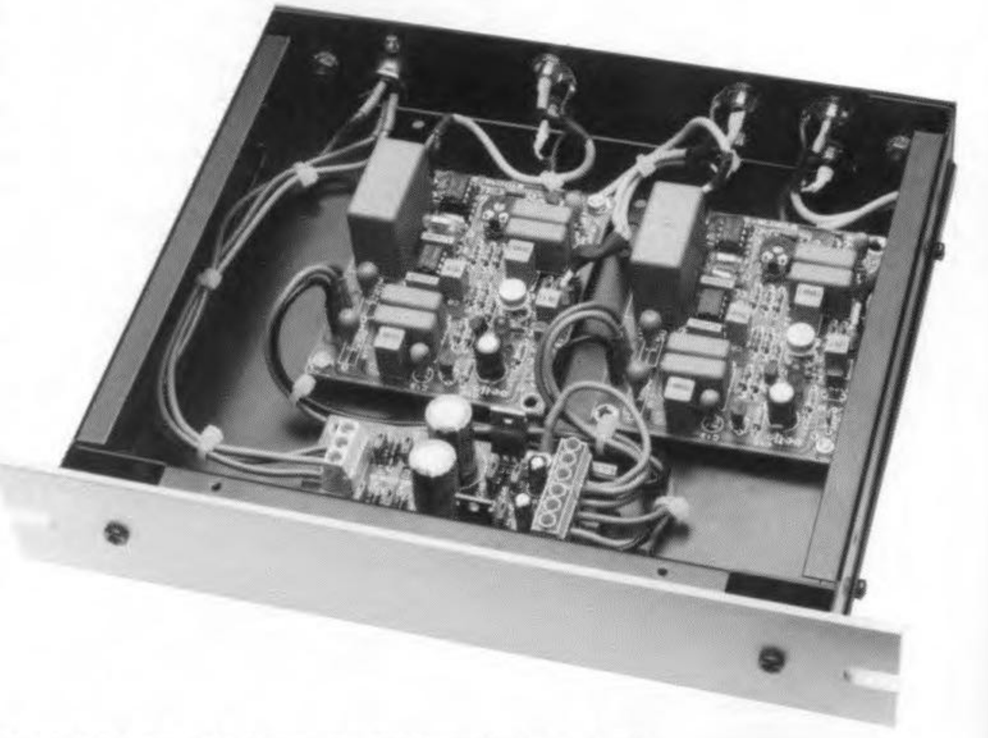


Fig. 1. General view of the stereo preamplifier and its power supply.

Design considerations

It is clear that those who have a need of a preamplifier for a pick-up put quality at the top of their list of requirements. In the design it is assumed that by far the greater majority of serious listeners use a moving-coil pick-up since this now seems to have ousted most other types.

Also, it was thought desirable for the preamplifier not to be dependent on the RIAA correction network in the main amplifier. For those readers who are not conversant with this, a short explanation. A pick-up cartridge is a velocity-to-voltage converter. During the recording, the response of the cutting stylus is constant velocity, which means that its velocity is the same for all frequencies. In the absence of any correction, the amplitude would therefore increase as the frequency drops, at the rate of 6 dB/octave: that would make it about 16 times greater at 30 Hz than at 15 kHz. Large low-frequency stylus excursions are avoided by attenuating base frequencies below 500 Hz at a rate of 6 dB/octave and boosting treble frequencies above 2120 Hz at a rate of 6 dB/octave to improve the signal-to-noise ratio. The contours roll off either side of a short flat region centred on 1 kHz, to form the RIAA (Record Industries Association of America) recording characteristic. The preamplifier needs a correction network to convert the recording characteristic back to a straight line. Both characteristics are given in Fig. 2.

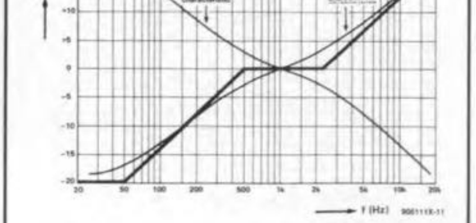


Fig. 2. RIAA recording and playback characteristics. The bold line is the theoretical recording curve.

The filters required to obtain the desired playback characteristic are prominent in the block diagram of the preamplifier in Fig. 3. Note that since passive filters would give rise to amplifier overdrive and higher noise and hum levels, active ones are used, except for that providing a high-pass response below 20 Hz. That filter serves to counter the effect of the IEC standard that requires the recording signal below 20 Hz to be amplified at 6 dB/octave so as to eliminate any adverse effects of rumble filters in playback systems.

As usual in this type of preamplifier, it needs a large voltage amplification factor, coupled with a very low hum and noise level. These requirements can not be met by inexpensive components.

Some readers may wonder why the block diagram is more complex than one might expect. Indeed, if the preamplifier was intended for frequency correction only, its design would probably consist of a single opamp with a suitable correction network in its feedback loop. However, since signals of only 250 μV (average output level of a moving-coil cartridge) have to be raised to line level, a voltage amplification factor of about 800 is required. That means at least one more amplifier and then it becomes logical to split the correction network over the two stages. The input stage serves primarily to keep the noise and hum level as low as feasible.

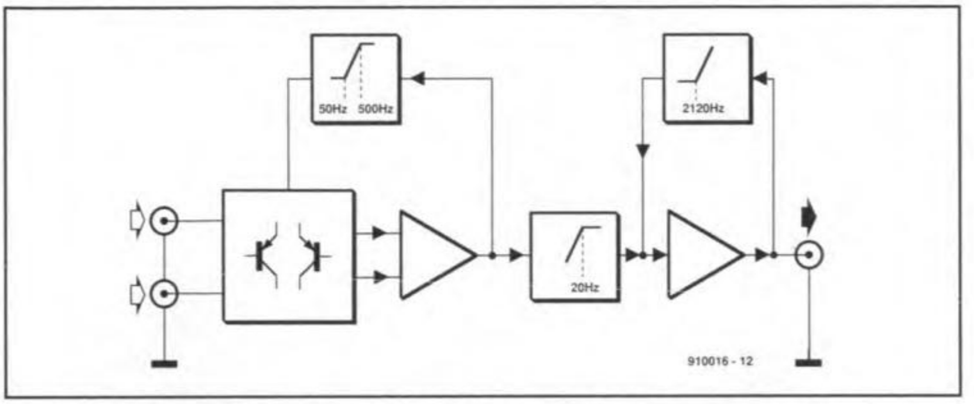


Fig. 3. Block diagram of (one channel of) the stereo preamplifier for a moving-coil pick-up.

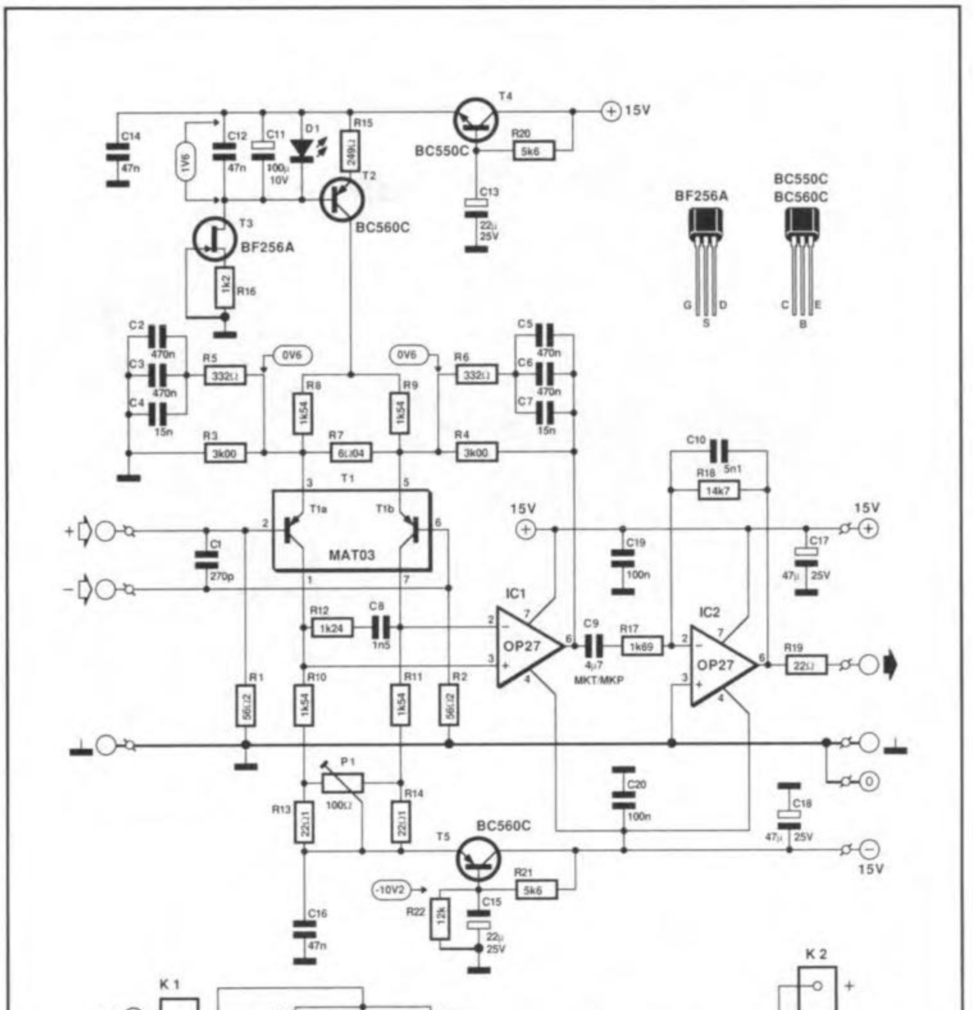


Fig. 4. Circuit diagram of (one channel of) the stereo preamplifier for a moving-coil pick-up.

Note, by the way, that the filter curves in Fig. 3 are the mirror images of the playback characteristic in Fig. 2, since the correcting networks are located in the feedback loop of the amplifiers.

Circuit description

The diagram in Fig. 4 shows only one channel of the stereo amplifier circuit.

The input stage is formed by differential amplifier T_1, which is a very-low-noise double opamp Type MAT03. At very low signal levels, this p-n-p type gives an even better noise performance than its n-p-n counterpart, the MAT02. The use of this excellent opamp also means that IC_1 and IC_2 need not be super high-quality types. This stage will be discussed in more detail later on.

The first amplifier is formed by T_1 and IC_1. The feedback network, located between the output of IC_1 and the emitters of T_{1a}–T_{1b}, contains the first part of the RIAA correction filter. For that reason, C_2–C_7 and R_3–R_6 must be high-stability types. More about that later on.

The passive 20 Hz high-pass filter is formed by R_{17}–C_9. With values as specified, its cut-off frequency is exactly 20.037 Hz.

The second amplifier is formed by IC_2, the feedback network of which, R_{18}–C_{10}, gives a cut-off frequency of 2120 Hz. With values of these components as specified, the theoretical deviation from this frequency is only 0.05%. The printed-circuit board allows for C_{10} to consist of two MKT type capacitors should the specified 1% polystyrene type prove difficult to obtain.

The last item in the preamplifier, R_{19}, looks insignificant, but is not, since it prevents any tendency to instability when the load is capacitive. This would be the case if the cable between preamplifier and main equipment were very long.

The symmetrical ±15 Vpower supply is fairly straightforward. Additional ceramic capacitors across the electrolytic types and the rectifier diodes improve the HF performance.

The input stage

The most important part of the preamplifier is the input stage. This provides a symmetrical input and has been designed to allow the pick-up cartridge to be direct-coupled. This obviates the nasty large input capacitor found in so many preamplifiers.

These facilities meant that the differential amplifier had to be designed very carefully. This is borne out by the additional filters in the supply lines, T_4 and T_5 and associated components, to reduce the hum and noise on these lines to an absolute minimum.

A stable d.c. operating point for T_1 is ensured by current source T_2. This source derives its reference voltage from D_1, the current through which is kept constant by a second current source, T_3.

The symmetrical input meant that the feedback loop of the input stage had to be symmetrical. To ensure good common-mode

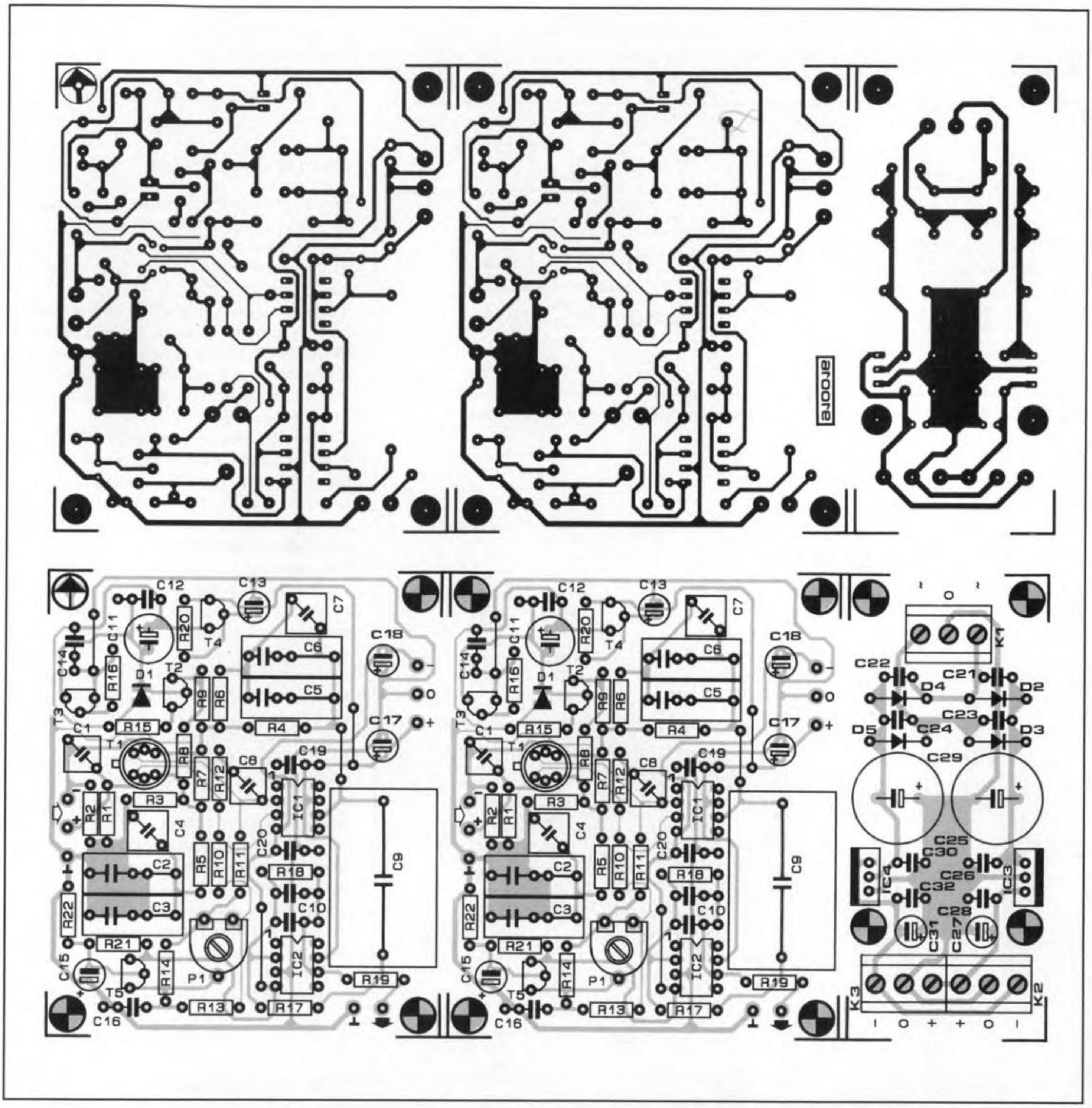


Fig. 5. Printed-circuit board for the stereo amplifier. Note that this consists of three sections, which may be separated before construction begins. Two of the sections are for the (left-hand and right-hand channel) preamplifiers and the third is for the common power supply.

PARTS LIST (Amplifier – one channel)

Resistors:

R_1, R_2 = 56Ω2; 0.1%
R_3, R_4 = 3k0; 1% (to be matched)
R_5, R_6 = 332Ω0; 0.1%
R_7, R_{29} = 6Ω04; 1%
R_8–R_{11} = 1k54; 0.1%
R_{12} = 1k24; 1%
R_{13}, R_{14} = 22Ω1; 1%
R_{15} = 249 Ω; 1%
R_{16} = 1k2
R_{17} = 1k69; 1%
R_{18} = 14k7; 1%
R_{19} = 22 Ω
R_{20}, R_{21} = 5k6
R_{22} = 12 k
P_1 = 100 Ω preset

Capacitors:

C_1 = 270 pF; polystyrene
C_2, C_3, C_5, C_6 = 470 nF; MKT or MKP
C_4, C_7 = 15 nF; 1%; polystyrene
C_8 = 1n5; 1%; polystyrene
C_{10} = 5n1; 1%; polystyrene
C_{11} = 100 μF; 10 V; radial
C_{12}, C_{14}, C_{16} = 47 nF; ceramic
C_{13}, C_{15} = 22 μF; 25 V; tantalum
C_{17}, C_{18} = 47 μF; 25 V; tantalum
C_{19}, C_{20} = 100 nF

Semiconductors:

D_1 = LED; red
T_1 = MAT03
T_2, T_5 = BC560C
T_3 = BF256A
T_4 = BC550C
IC_1, IC_2 = OP27

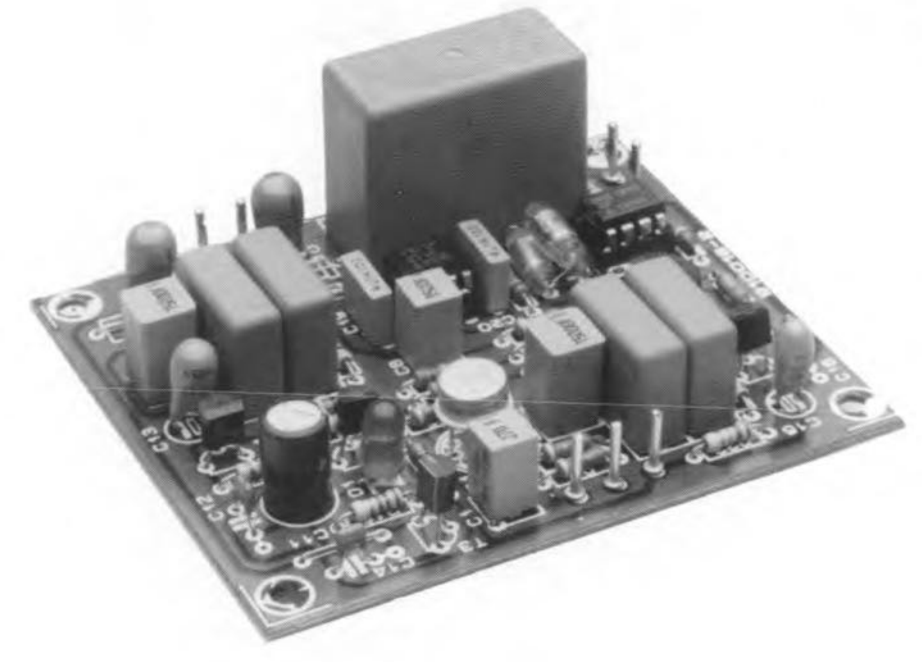


Fig. 6. Finished amplifier board (one channel).

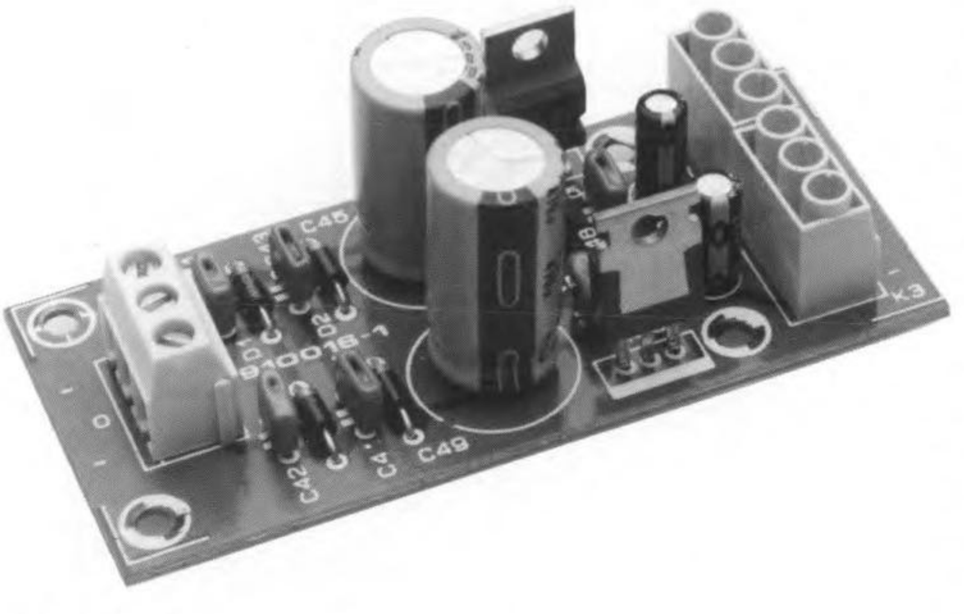


Fig. 7. Finished power supply board.

PARTS LIST (PSU)

Capacitors:
C_{21}, C_{24}, C_{26}, C_{28}, C_{30}, C_{32} = 47 nF; ceramic
C_{25}, C_{29} = 470 µF; 40 V; radial
C_{27}, C_{31} = 47 µF; 25 V; radial

Semiconductors:
D_2–D_5 = 1N4001
IC_3 = 7815
IC_4 = 7915

Miscellaneous:
K_1, K_2, K_3 = 3-way PCB terminal block
PCB Type 910016

SOME TECHNICAL DATA

Input sensitivity	250 µV
Input impedance	100 Ω
Output level	200 mV
Terminating impedance	>2 kΩ
Signal-to-noise ratio	75 dB (A-weighted)
Accuracy of RIAA curve	±0.1 dB
Distortion	<0.006%
Supply voltage	±15 V
Current drain	Abt 24 mA

suppression, networks R_3-R_5-C_2-C_3-C_4 and R_4-R_6-C_5-C_6-C_7 must be identical. This means that the capacitors must be selected to within 1%. The theoretical value of each of the parallel threesomes is 955.3 nF.

To ensure that the circuit operates symmetrically, it is essential the output is set to exactly 0 V. The d.c. operating point is determined by R_{13}-R_{14}-P_1. If, after a short warming-up period, P_1 is set correctly and components of the specified value, stability and tolerance have been used, the d.c. offset at the output will be zero. This is so, because the emitter potentials of T_{1a} and T_{1b} will be identical. Since these transistors are matched, the currents through their base junction, and thus the voltage drop across R_1 and R_2, will be identical. There is then no potential difference across the input terminals, so that no direct current can flow through the pick-up cartridge connected to the terminals.

Construction

The printed-circuit board—see Fig. 5—consists of three sections, which may be separated from one another before construction is begun. Two of the sections are for the two amplifiers (left-hand channel and right-hand channel) and the third is for the symmetrical power supply. If you do not separate the sections, note that the power lines on the three sections are not inter-connected.

The amplifier boards allow C_{10} to consist of two capacitors and also the use of either polyester (MKT) or polypropylene (MKP) types in the C_2, C_3, C_5, C_6, and C_9 positions. The MKP types (which are slightly larger) are for those who want the very best.

The mechanical rounding off and building in of the amplifier are left to the constructor's taste and specific requirements. If the record player has the space, it is worthwhile considering building the amplifier and power supply in that space. Another solution is, of course, a stand-alone enclosure. In either case, use a separate mains adapter to power the supply: this will prevent annoying mains hum in the amplifier.

With some record players the symmetrical input may give a problem. If their pick-up cartridge is provided with an asymmetrical output, the signal return and earth connections are usually linked. In the present preamplifier, however, these must be separate. Normally, this problem is easily overcome, because in the cable running through the pick-up arm the signal return and earth connections are always separate.

It is advisable to provide the record player with separate two-core screened audio cables for the left-hand and right-hand channels. Each of the preamplifier channel outputs can then be taken via two phono sockets, of which the central pins are used for the "+" and "–" signal paths. The outer case of the four sockets can then serve as a common earth. That arrangement worked very well in our prototype.

The output of the preamplifier is asymmetrical, so one phone socket per channel will suffice. ■

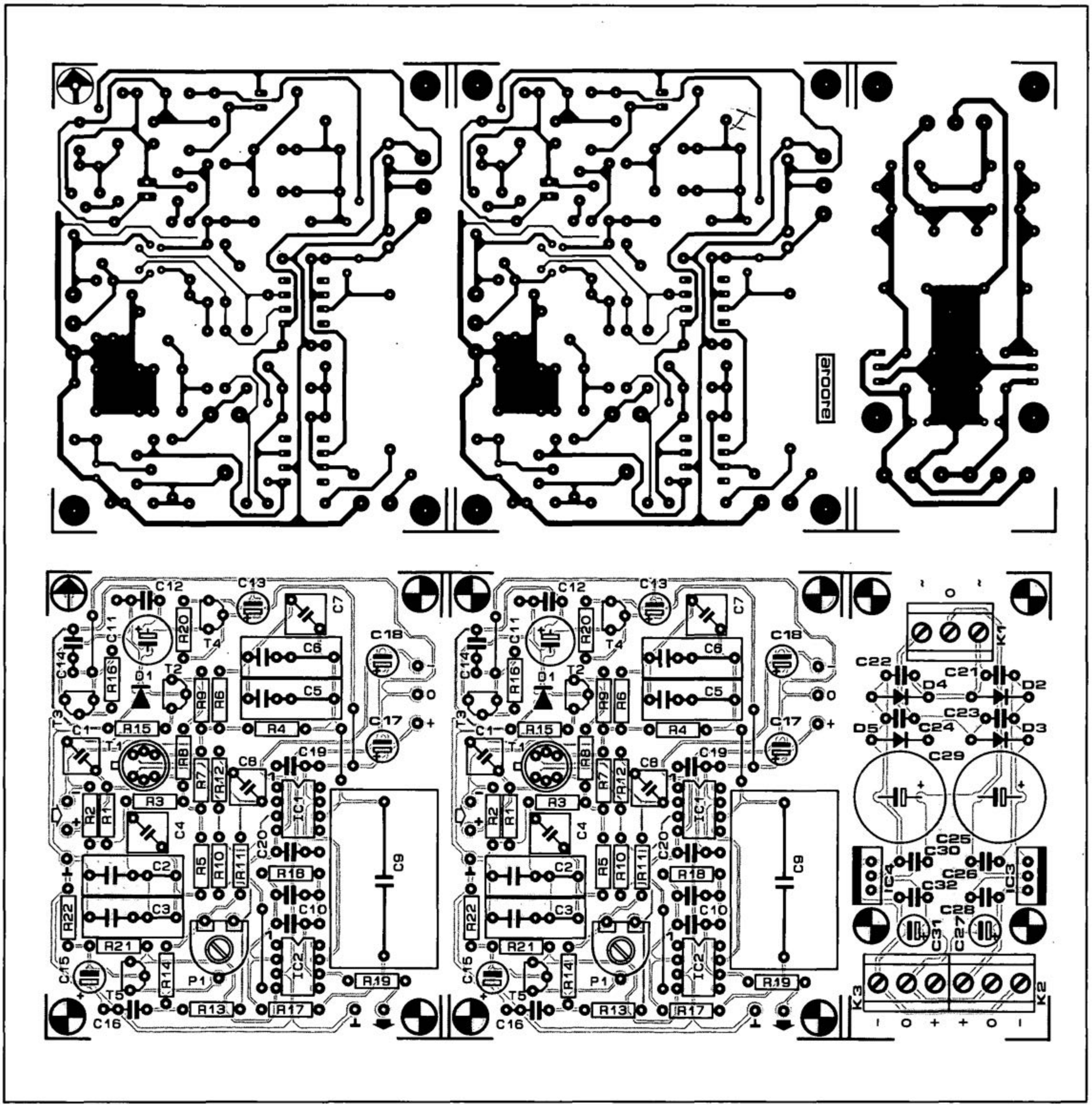


Fig. 5. Printed-circuit board for the stereo amplifier. Note that this consists of three sections, which may be separated before construction begins. Two of the sections are for the (left-hand and right-hand channel) preamplifiers and the third is for the common power supply.

PARTS LIST (Amplifier – one channel)

Resistors:

R_1, R_2 = 56Ω2; 0.1%
R_3, R_4 = 3k0; 1% (to be matched)
R_5, R_6 = 332Ω0; 0.1%
R_7, R_{29} = 6Ω04; 1%
R_8–R_{11} = 1k54; 0.1%
R_{12} = 1k24; 1%
R_{13}, R_{14} = 22Ω1; 1%
R_{15} = 249 Ω; 1%
R_{16} = 1k2
R_{17} = 1k69; 1%
R_{18} = 14k7; 1%
R_{19} = 22 Ω
R_{20}, R_{21} = 5k6
R_{22} = 12 k
P_1 = 100 Ω preset

Capacitors:

C_1 = 270 pF; polystyrene
C_2, C_3, C_5, C_6 = 470 nF; MKT or MKP
C_4, C_7 = 15 nF; 1%; polystyrene
C_8 = 1n5; 1%; polystyrene
C_{10} = 5n1; 1%; polystyrene
C_{11} = 100 μF; 10 V; radial
C_{12}, C_{14}, C_{16} = 47 nF; ceramic
C_{13}, C_{15} = 22 μF; 25 V; tantalum
C_{17}, C_{18} = 47 μF; 25 V; tantalum
C_{19}, C_{20} = 100 nF

Semiconductors:

D_1 = LED; red
T_1 = MAT03
T_2, T_5 = BC560C
T_3 = BF256A
T_4 = BC550C
IC_1, IC_2 = OP27

LOGIC ANALYSER - PART 3

by K. Nischalke and H.J. Schulz

The control board

ALTHOUGH the operating instructions for the logic analyser come from the computer, the commands are processed entirely by the control board. How the analyser is controlled has already been discussed in Part 1 with reference to Fig. 2. What has not yet been discussed is how the controller is driven by the computer and this will be done now with reference to Fig. 12.

Communication between computer and control board is via an interface that serves not only as a staging post for the data but also as a detector of differences between Atari and IBM or compatible computers.

The data from the computer are stored in the four eight-bit registers on the control board. Registers 1 and 4 are used exclusively to provide data to the two trigger-counters, while registers 2 and 3 provide data to the window-counter and the logic circuits. Note, however, that when the window-counter is active in the 100 MHz mode, the logic functions controlled by register 2 are not active and vice versa.

Control logic

Although the control logic circuit consists of only one GAL (gate array logic) IC, it is involved in all operations of the logic board. The use of a GAL circuit reduces the parasitic capacitances, which is particularly important when the clock frequency is 100 MHz. It is, of course, true that the 100 MHz signal does not pass through the GAL circuit, but the edges of the signals processed and output by that circuit must remain in step with the clock.

Another advantage of a GAL circuit is that it may be reprogrammed electrically: ultraviolet erasing is not required.

The GAL, clock-select and post-trigger-counter circuits are shown diagrammatically in Fig. 13. Internally, the GAL resembles a PAL (programmable array logic). It has a similar matrix on to which the desired functions are programmed. In addition, however, the function of each "output" (OLMC = output logic macro cell) may be programmed as an input, output or register output, either inverting or non-inverting or three-state. In the control board most OLMCs are used as input and only four as output.

The internal 1 MHz clock is connected to pin 1. The reason that the other two internal clocks, 25 MHz and 100 MHz, are not connected to the GAL is that this has not enough inputs and outputs. By passing these signals first through a clock-select circuit (IC55), a larger (and more expensive) GAL is not needed.

If three internal clocks are not sufficient, an external clock may be connected to pin 2.

The two qualifier inputs are connected to pins 3 and 4. These inputs form a kind of external stop/start line, which enable the analyser to accept data only when the level at them corresponds to the set logic level (high, low or don't care). This makes it possible to restrict the read data to those that are of interest to the user.

The signals at pins 2,3 and 4 can be switched on and off by means of the enable inputs at pins 5, 6 and 7. This is not sufficient, however, because it is also necessary to indicate whether these input signals are active high or low. That is made possible by the polarity inputs at pins 8, 9 and 11. The enable and polarity inputs are controlled directly by the computer, that is, via the registers on the control board and the computer interface.

There is one more input that is under direct control of the computer: the single-step input. Via this input, the computer controls the reading of data from the RAM cards. Since the computer software determines the reading rate via this input, there are no problems with the timing (that is, the speed of the computer is irrelevant).

The remaining three inputs and four outputs are associated directly with the operation of the analyser.

Trigger-counter 1 indicates via pin 16 that triggering has taken place. The GAL circuit then starts passing clock pulses to the post-trigger counter via pin 12. The counter signals to the GAL circuit when the the second half of the RAMs is full. When that happens, the outputs of IC55 are made low and the clock-pulse-, the read/write-control-, and the data-clock-outputs are disabled via the ready-input (pin 15).

The function of the data clock becomes clearer when the various states of the clock-select circuit, IC55, are considered. The circuit has four sequential states: off (as shown in Fig. 13); 100 MHz mode; 25 MHz mode; and the 1 MHz/external clock mode. The state is determined by two lines (mode and 100/25 MHz) that are controlled by the computer. When the clock-select circuit is off, the computer reads the RAM-ICs byte by byte. The single-step signal enables the GAL circuit to pass appropriate pulses to the the data-clock output that clocks the address counter of the RAM-ICs and to hold the R/WCTRL line high (the RAM-ICs are read).

When the clock-select circuit is in the 100 MHz state, the 100 MHz signal is passed directly to the shift registers on the RAM card. Writing data into the memory and the counting of the post-trigger counter take place at 25 MHz, however. The lower half of the IC55 therefore sends a signal at that frequency to the clock input (pin 13) of the GAL-IC. That circuit thereupon produces appropriate sig-

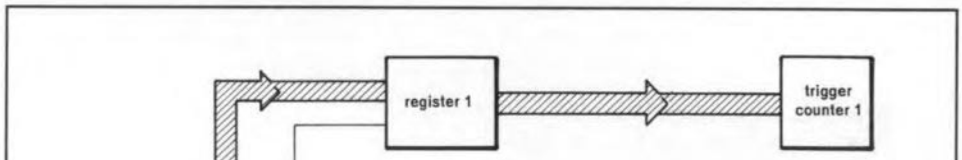


Fig. 12. Block diagram showing the con nections between the control card and the computer.

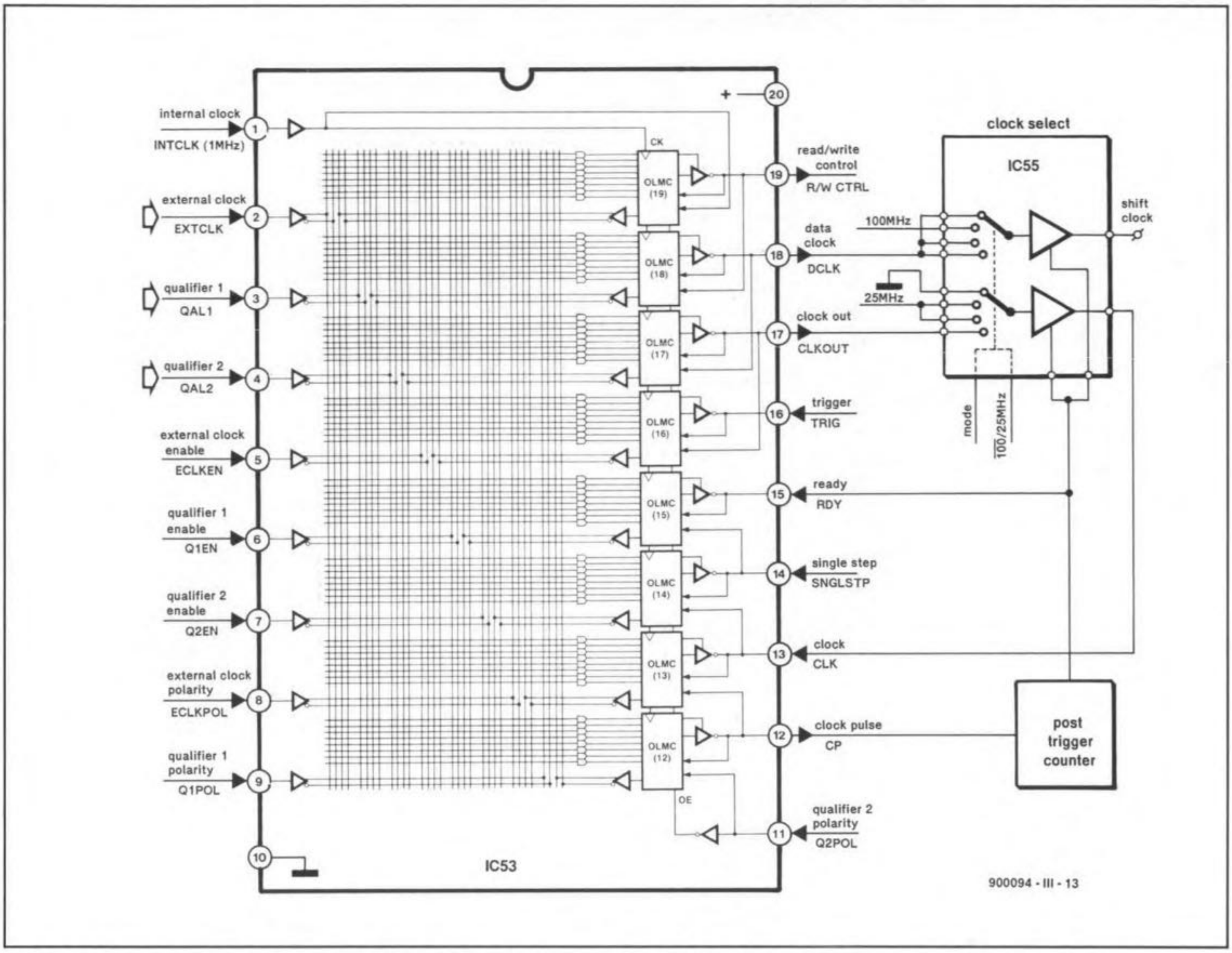


Fig. 13. The programmed gate array logic —GAL—IC plays an important role on the control board.

nals for the post-trigger counter (clock pulse); the address counter of the memory (data clock); and the RAM-ICs (read/write control).

When the clock-select circuit is in the 25 MHz state, a 25 MHz signal is again applied to the clock input of the GAL-IC. Since the shift registers are then used in the parallel-load mode, they can be clocked at that frequency, and are therefore connected to the data clock of the GAL-IC. A similar arrangement exists for the 1 MHz internal clock and the external clock, which are connected to the the slock-select circuit via the clock output (pin 17), depending on the signal at the external clock enable input (pin 5). Whatever clock signal has been selected, it is fed to the clock input (pin 13) via the clock-select circuit so that the GAL circuit can ensure that the signals at pins 12, 18 and 19 remain in step with it.

Circuit description

The clock generator is formed by T2 and T3-see Fig. 14. The output of the generator is buffered by T3, after which it is converted to TTL level and buffered again by R25, C39, IC50a-d and D1. The 100 MHz signal at the output of IC50 is processed in IC55 (clock select) and two frequency dividers, IC51 and IC52. These dividers provide clocks of 1 MHz, 25 MHz and 50 MHz. The 50 MHz signal is used only for clocking trigger counters IC36-IC37 and IC44-IC45. The period that can be counted by these circuits may be set from between 20 ns and 5.1 µs in 20 ns steps.

The window-counter, IC40-IC42, which is used only in the 100 MHz mode, is provided with a 25 MHz clock via IC55. That circuit also provides a clock to the RAM cards (of which there may be up to four). Each RAM card gets its own clock, which is first buffered by the gates in IC57, via a short length of coaxial cable. Note that the 100 MHz indications at the connections is for guidance only: the real frequency there is the set clock.

The resistors between the gates and the outputs suppress any reflections in the lines.

The three external inputs of the control board are taken to external circuits via connector K19, whose layout is identical to that of the input connectors on the RAM cards. This arrangement makes it possible to use the probes for the cards also to connect external inputs to the control board. As with the RAM cards, these probes obviate problems caused by parasitic capacitances and reflections.

To drive the control board, the computer has available lines card select (CRDSL), write (WR), register address (RA0, RA1); data (D0--D7) and, in the case of the Atari, single step (SNGL step). If the computer is not an Atari, that line is driven indirectly via a register and the data lines.

Via the card select, write and the register address lines, the computer indicates whether the data are destined for the control board and, if so, for which register (IC34, IC38, IC39, IC43). These lines are taken to address decoder IC35, which converts the computer signals into control signals for the registers. The data written into IC34 and IC43 are fed direct to trigger counters IC36-IC37 and IC44-IC45 respectively.

The outputs of IC38 and IC39 are split between IC53 and window counter IC40-IC42. To that end, outputs Q0-Q5 of IC38 have a double function: they drive either IC53 or the window counter. This is possible, because the counter is active in the 100 MHz mode only, when it is not possible to operate with an external clock and qualifiers. The associated drive inputs of IC53 are then disabled and they may therefore be used for the window counter. In all other modes, the situation is reversed: the window counter is inactive and the lines are used to control IC53.

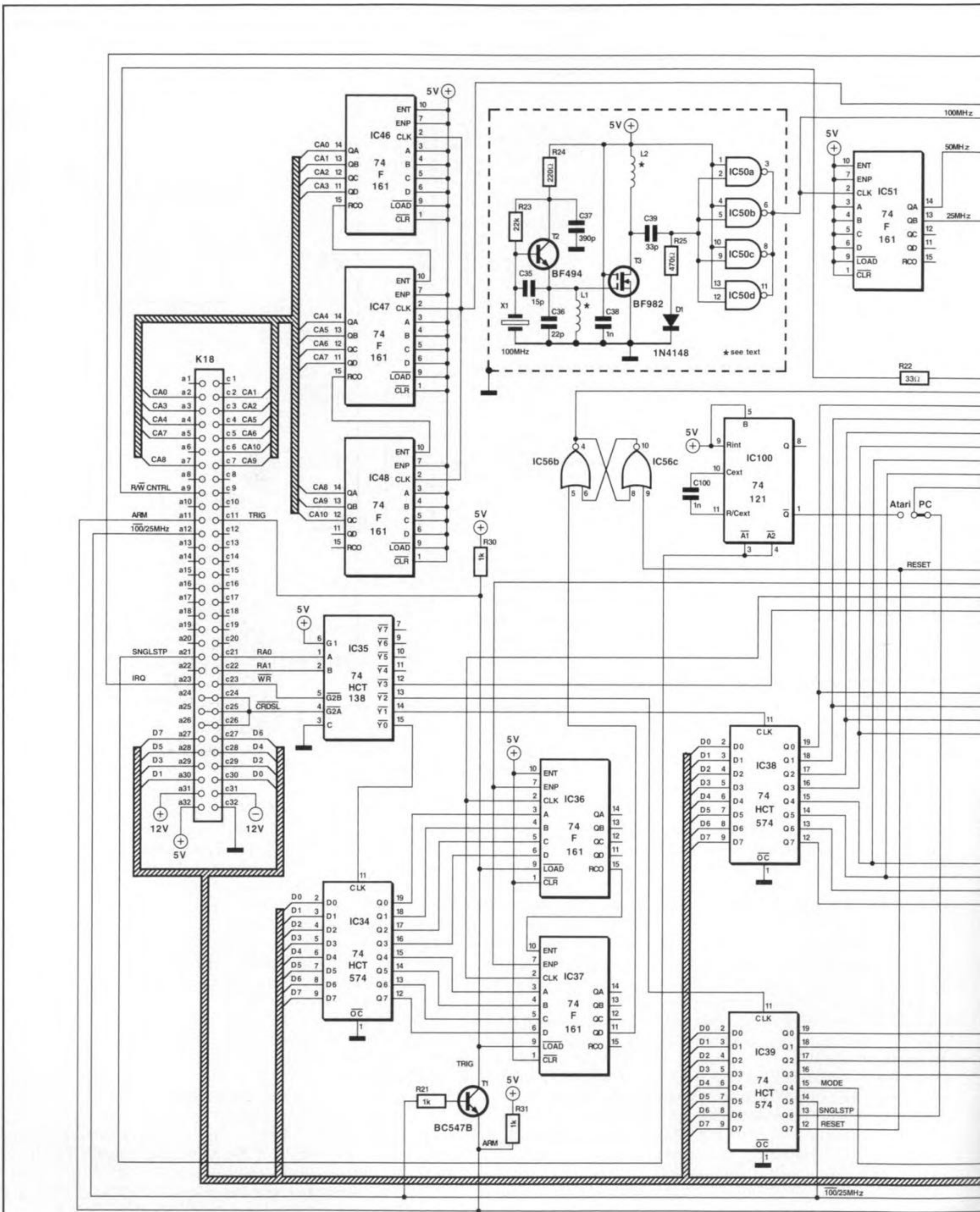
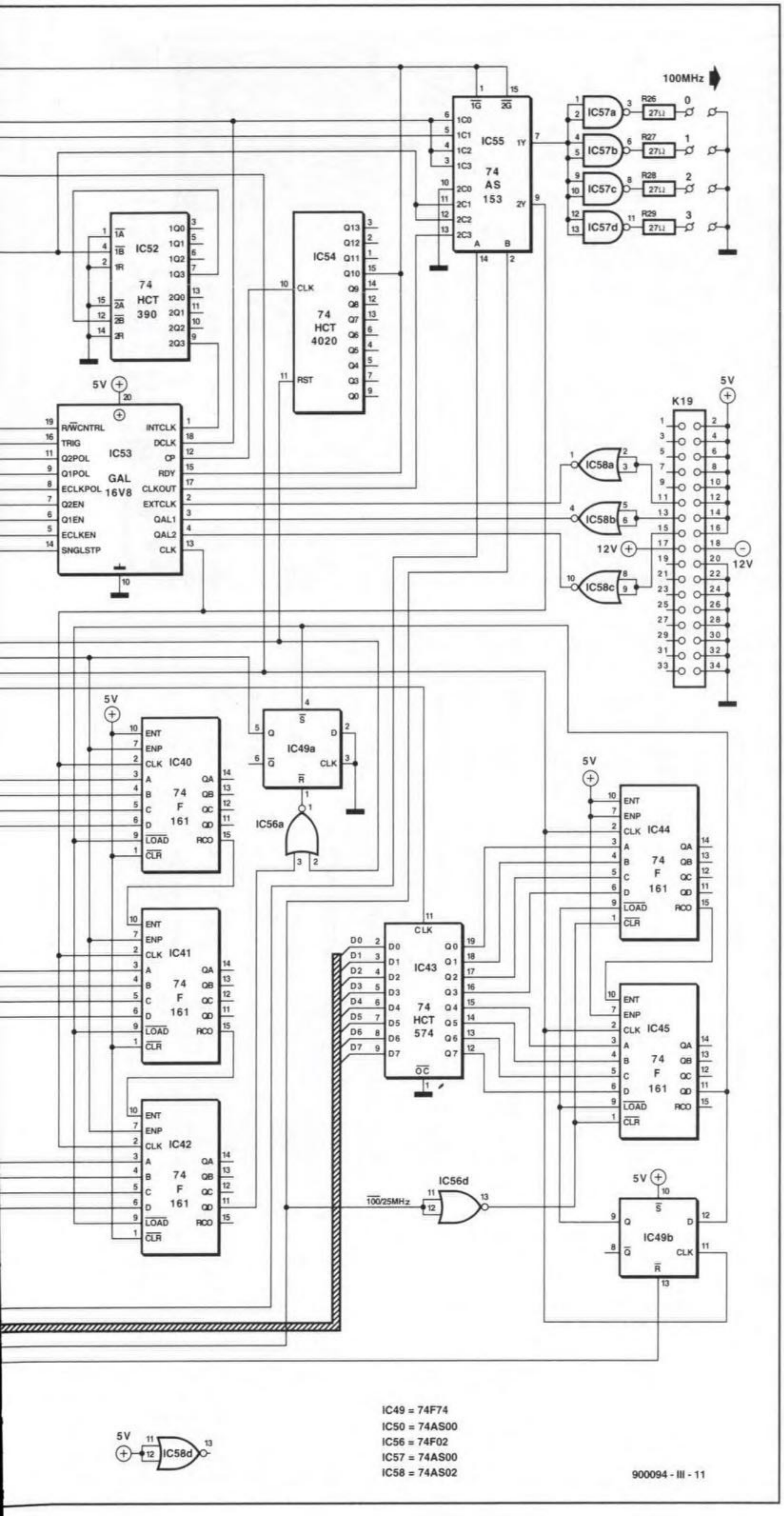


Fig. 14. Circuit diagram of the control board.



PARTS LIST

Resistors:

R_{21}, R_{30}, R_{31} = 1 kΩ
R_{22} = 33 Ω
R_{23} = 22 kΩ
R_{24} = 220 Ω
R_{25} = 470 Ω
R_{26}–R_{29} = 27 Ω

Capacitors:

C_{35} = 15 pF
C_{36} = 22 pF
C_{37} = 390 pF
C_{38}, C_{100} = 1 nF
C_{39} = 33 pF
C_{40}–C_{62}, C_{101}, C_{102} = 100 nF
C_{63} = 100 μF; 25 V

Inductors:

L_1 = air-cored; 10 turns enamelled copper wire 0.5 mm; inside diameter 3 mm
L_2 = air-cored; 25 turns enamelled copper wire 0.5 mm; inside diameter 3 mm

Semiconductors:

D_1 = 1N4148
T_1 = BC547B
T_2 = BF494
T_3 = BF982
IC_{34} IC_{38}, IC_{39}, IC_{43} = 74HCT574
IC_{35} = 74HCT138
IC_{36}, IC_{37}, IC_{40}–IC_{42}, IC_{44}–IC_{48}, IC_{51} = 74F161
IC_{49} = 74F74
IC_{50}, IC_{57} = 74AS00
IC_{52} = 74HCT390
IC_{53} = programmed 16V8-10 (not yet available)
IC_{54} = 74HCT4020
IC_{55} = 74AS153
IC_{56} = 74F02
IC_{58} = 74AS02
IC_{100} = 74121

Miscellaneous:

K_{18} = 64-way male PCB connector; 90° (DIN41612)
K_{19} = 34-way male PCB header; 90°
X_1 = 5th overtone crystal, 100 MHz; Series HC49
PCB Type 900094-5

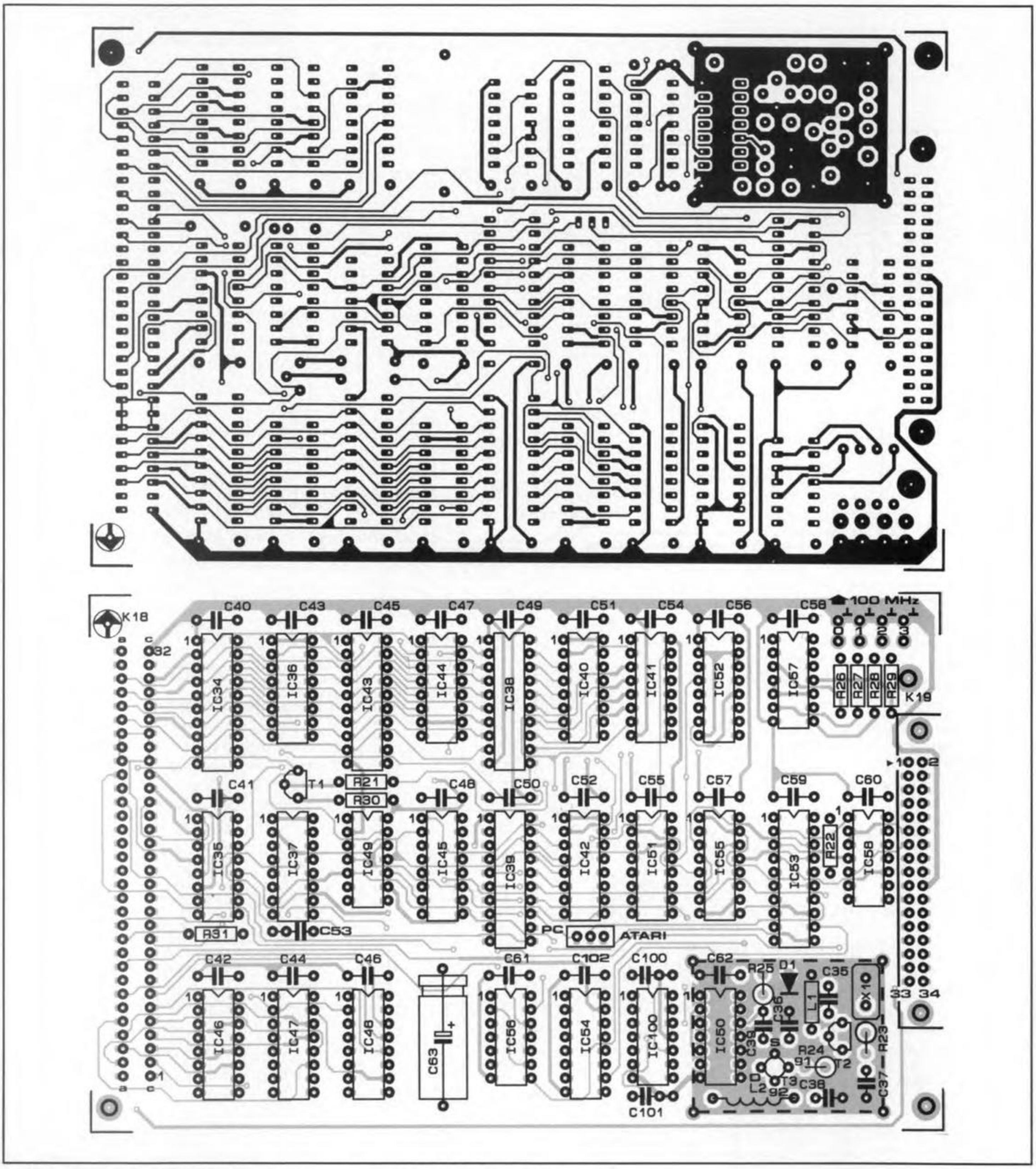


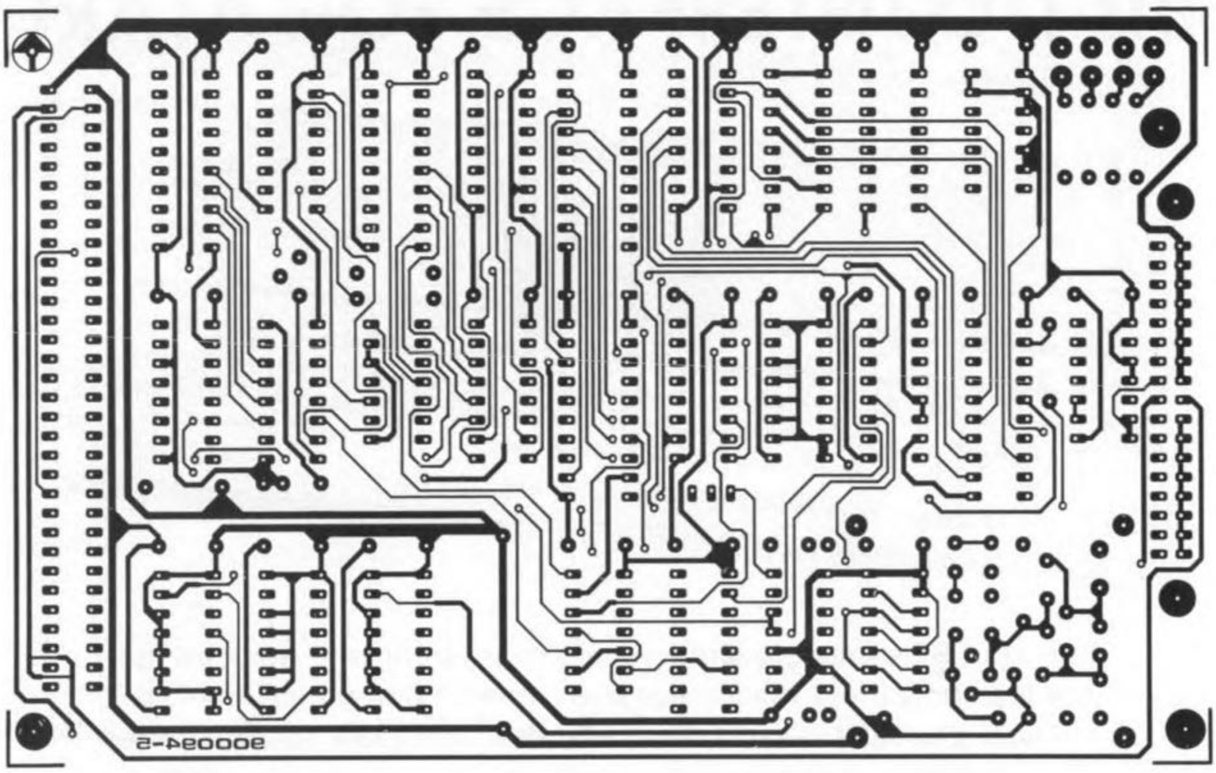
Fig. 15. The printed circuit board for the control circuits is double-sided and through-plated.

Measurement cycle

Before a measurement can be made, the control card must be set to a certain mode: 100 MHz, 25 MHz, 1 MHz, or external clock, of which the last three are identical but for the clock frequency. Therefore, if reference is made in the following to the 25 MHz mode, the 1 MHz mode and the external-clock mode are included. For instance in the line indication "100 MHz/25 MHz" (Q5 of IC39), the "25 MHz" really means "not 100 MHz".

Apart from line 100 MHz>/25 MHz, the line mode (Q4 of IC39) co-determines which clock frequency is selected. Once the mode has been selected, the controller is put on standby by a reset (Q7 of IC39). After the reset, the control card sends clock pulses to the shift registers at the inputs of the RAM cards and write pulses (via R/W-CNTRL) to the RAM ICs. After each write pulse, the address counter, IC46--IC48, is increased by one so that data read to the RAM cards at the subsequent clock pulse are stored in the next memory location.

This cycle of writing and storing data goes on continuously. When all memory locations have been filled, the oldest data are replaced by new data. This continues until the word recognizers on the RAM cards recognize the trigger conditions. In the 100 MHz mode, there are two trigger lines, TRIG and ARM, each of which has its own function. In the other modes, these two lines are inter-



linked via T1 (possible because they are driven from open-collector outputs).

When a non-100 MHz mode is selected, the load inputs of trigger counter IC36-IC37 go high, whereupon the counter begins counting from the position written in register IC34. If the trigger signal is of sufficient duration, the counter counts to the maximum position, whereupon bistable (flip-flop) IC56b-IC56c is set. If, however, the trigger signal goes low before the maximum position is reached, the counter is loaded again with the value in the register and the trigger pulse is not accepted as valid.

Assuming that the bistable is set, IC53 receives the signal "trigger acceptable". The writing of data then continues undiminished and IC53 also starts the post-trigger counter, IC54. This circuit ensures that the writing stops when the number of data samples written into the memory after the trigger pulse is exactly half the available memory locations. The memory then contains a block of data that indicates what happened before the trigger pulse and another block that indicates what happened after the trigger pulse.

The operation stops when output Q10 of IC54 goes high, whereupon IC53 gets the signal ready", IC55 is switched off (its outputs go low) and the computer interface gets a ready signal via the IRQ line. The control board is then completely under the control of the computer, which first reads all the data in the RAM cards. This is done via the single-step line, which is provided by a signal in a slightly different way if an Atari is used than if an IBM or compatible is used. For each pulse on this line, the address counter is increased by one. Since this counter stopped at the last addressed sample with the newest data, the next address is that of the sample with the oldest data. From there, all 2048 memory locations can be read byte by byte from the RAM ICs. Once all data have been read and processed, the analyser may be started again with a reset.

Basically, operation of the controller in the 100 MHz mode is little different from that in the other modes; only the triggering is slightly more complex. The TRIG and ARM lines are separated and have their own function. A sort of warning signal is given via the ARM line, whereupon the trigger circuit is put on standby for a short time. The real trigger signal, TRIG, must arrive within that time to ensure that the triggering is accepted. The triggering process thus starts with the signal ARM. When this goes high, trigger counter 2, IC44-IC45, starts counting. If this counter can count to the maximum position (like counter 1), the ARM triggering is accepted and the window counter starts. This counter checks the time during which a valid triggering signal must be given via the TRIG line and trigger counter 1. If that does not happen, bistable IC49a is reset, whereupon trigger counter 1 is disabled, and the window counter is reset in anticipation of a new ARM trigger. However, as long as the window counter counts, triggering is possible. If the TRIG pulse is long enough, the start bistable (flip-flop), IC56b-IC56c) is set and the analyser can start sampling again.

Finally

The printed-circuit board for the controller is shown in Fig. 15. Populating it is straightforward, although it is even more important than with other projects that the work is carried out very carefully, interspersed with frequent checks. It is better to check too often than once too seldom, because faultfinding at a later stage is not easy.

Note that IC50 is better not mounted in a socket, since that will result in additional parasitic capacitances in the oscillator circuit. In the prototype, all other ICs are fitted in a socket: this has not resulted in any noticeable deterioration. One of the prime benefits of sockets is that it reduces the likelihood of damage to the ICs, some of which are not cheap.

The inductors are best wound around a 3mm drill bit from enamelled copper wire as specified in the parts list.

It is advisable to screen the oscillator circuit, not so much to improve its operation as to prevent its radiating outside the analyser. It is also advisable, again in view of radiation outwards, to fit the entire analyser in a metal enclosure.

Forthcoming instalments of this article will deal with the power supply, an interface for IBM or compatible, an interface for the Atari ST, an overview of the various interconnections and building the analyser into an appropriate enclosure and software. It is the intention to make the software available together with a programmed GAL IC. ■

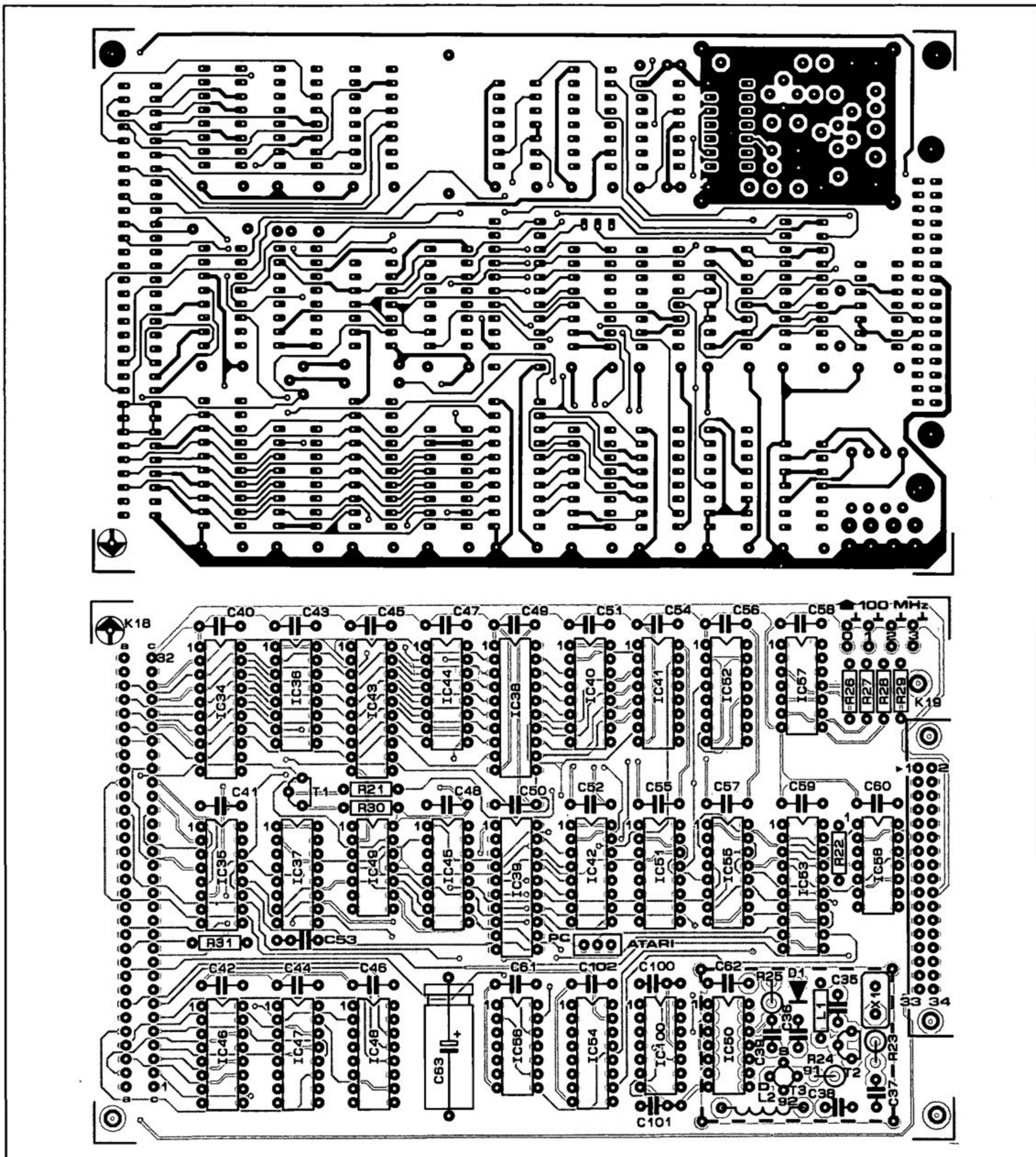


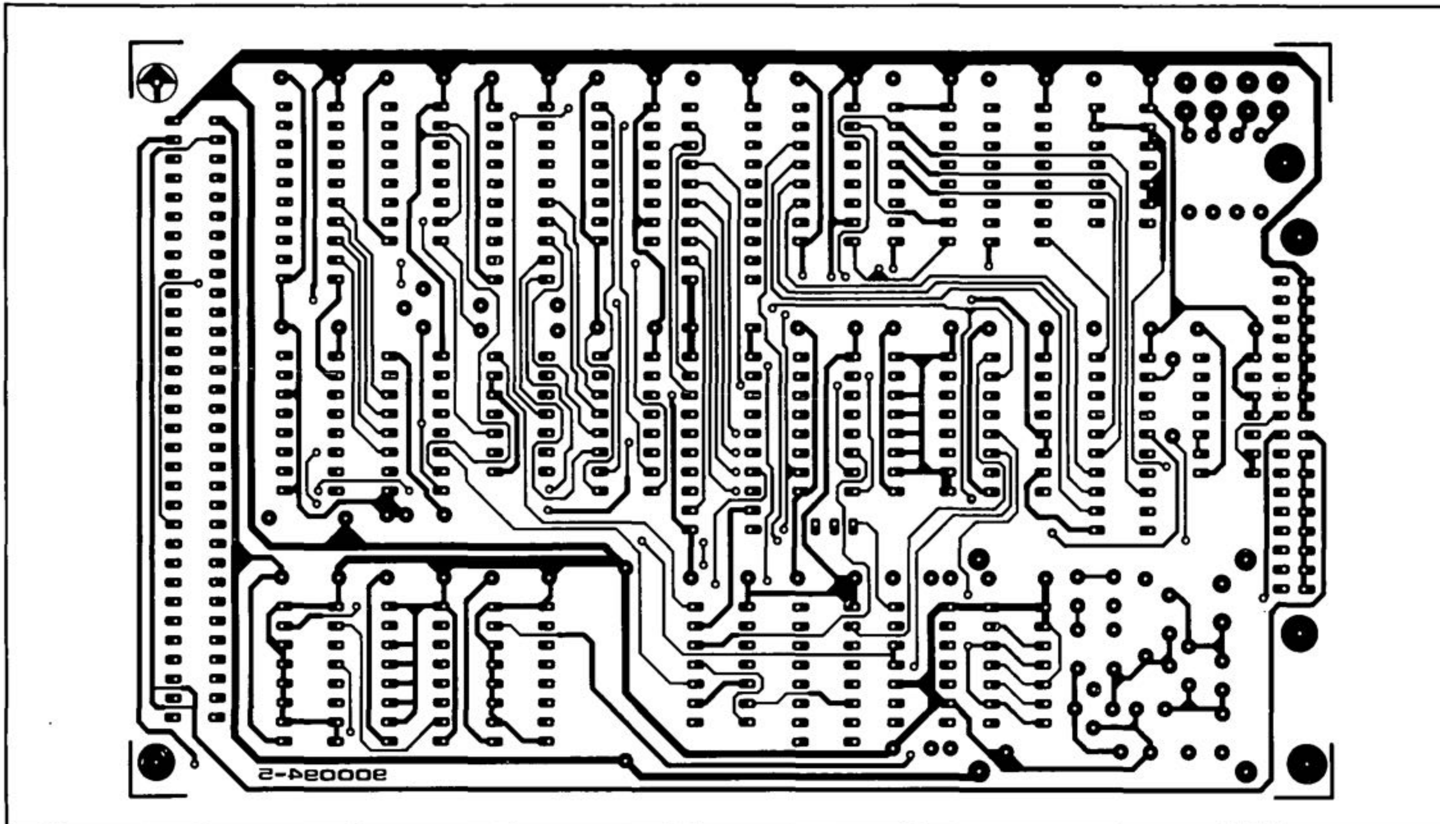
Fig. 15. The printed circuit board for the control circuits is double-sided and through-plated.

Measurement cycle

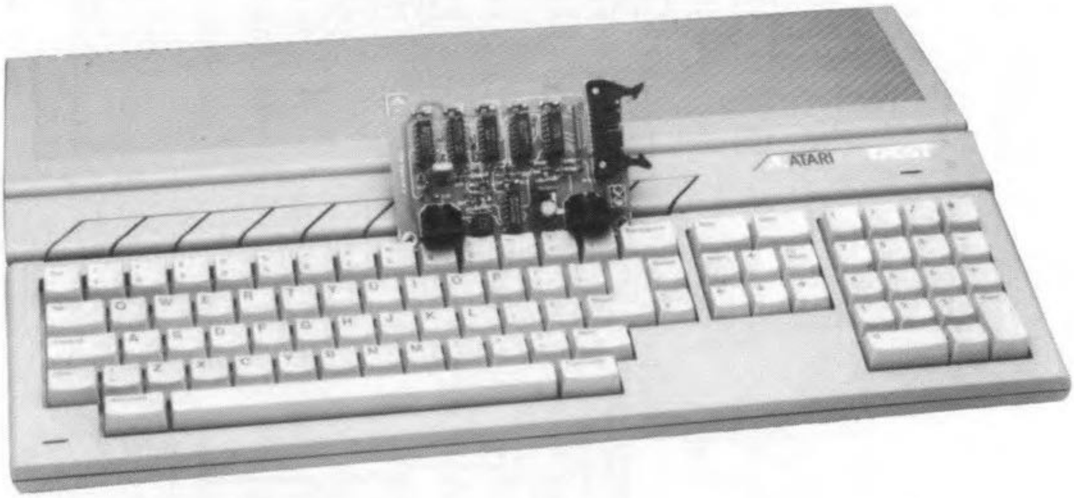
Before a measurement can be made, the control card must be set to a certain mode: 100 MHz, 25 MHz, 1 MHz, or external clock, of which the last three are identical but for the clock frequency. Therefore, if reference is made in the following to the 25 MHz mode, the 1 MHz mode and the external-clock mode are included. For instance in the line indication "100 MHz/25 MHz" (Q5 of IC39), the "25 MHz" really means "not 100 MHz".

Apart from line 100 MHz>/25 MHz, the line mode (Q4 of IC39) co-determines which clock frequency is selected. Once the mode has been selected, the controller is put on standby by a reset (Q7 of IC39). After the reset, the control card sends clock pulses to the shift registers at the inputs of the RAM cards and write pulses (via R/W-CNTRL) to the RAM ICs. After each write pulse, the address counter, IC46--IC48, is increased by one so that data read to the RAM cards at the subsequent clock pulse are stored in the next memory location.

This cycle of writing and storing data goes on continuously. When all memory locations have been filled, the oldest data are replaced by new data. This continues until the word recognizers on the RAM cards recognize the trigger conditions. In the 100 MHz mode, there are two trigger lines, TRIG and ARM, each of which has its own function. In the other modes, these two lines are inter-



8-BIT I/O INTERFACE FOR ATARI ST



The Atari ST series computers have their strong and weak points. For instance, these machines have a powerful graphics interface, but lack a parallel I/O port. The latter deficiency is a spot of bother when it comes to connecting certain non-Atari peripherals and, of course, home-made extensions. The circuit presented here solves this problem elegantly by means of … music! A handful of standard, inexpensive components and a small control program written in BASIC, C or assembler language turn the MIDI channel of the Atari ST into an 8-bit I/O port that achieves a maximum data rate of 1 kBit/s. No modifications are required in the computer.

M. Breuer

IN principle, the MIDI (Musical Instrument Digital Interface) on a computer works just like any other serial communication port. Each databyte is transmitted on a bit-by-bit basis via a serial connection. According to the MIDI standard, a logic high bit corresponds to no current through the serial link, while a logic low bit corresponds to a current of about 5 mA. In the receiver, this current is passed through an opto-coupler that ensures electrical insulation between the transmitter and the receiver. This insulation allows MIDI equipment with different supply voltages and ground potentials to be interconnected without problems.

The serial data format used on a MIDI port equals that specified in the RS-232C protocol. Each transmission starts with a start bit, which is always a 0. Then follow the eight databits, headed by the LSB (least significant bit). The transmission is terminated with a stop bit, which is always a 1. When the dataline is not in use, it carries no current, so that a logic high level is produced in the receiver.

The data rate on a MIDI channel is standardized at 31,250 bits per second (31.25 kBaud). Although the conversion of serial data into parallel form is fairly simple to realize with a UART (Universal Asynchronous Receiver/Transmitter), the present interface uses a less expensive alternative to accomplish this function. The circuit we have in mind is based on a couple of standard CMOS ICs that perform the parallel-to-series and series-to-parallel conversions at reasonable speed.

Circuit description

The circuit diagram of the interface is given in Fig. 1. The heart of the circuit is formed by IC6, a Type 4060 14-bit counter with an onboard oscillator. The clock signal divided by 128 is present at pin 6 of the 4060. From there, the signal is fed to three shift registers IC3, IC4 and IC5, and a decimal counter, IC7. Since the oscillator on board the 4060 operates with a 4-MHz quartz crystal, the shift registers and the counter are clocked at 31,250 Hz, which equals the bit rate on the MIDI channel.

A 5-way DIN socket, K1, is connected to the MIDI output of the computer via a cable. The serial data arrive at the interface via optocoupler IC1. After being cleaned and shaped by two logic gates, IC2a and IC2b, the data arrives at the D (data-) input of IC3. The falling edge of the start bit is used to generate a needle pulse that serves to reset IC6 and IC7. This pulse is supplied by diode D2, gate IC2c and capacitor C2. The reset pulse ensures that all counters are in a predefined state at the start of a data transmission. Output Q9 of IC7 is low after a reset pulse, and blocks any further reset pulses with the aid of diode D3. Output Q9 does not go high until after the tenth clock pulse, when the start bit of a new dataword causes the next reset. The rising edge of the pulse at Q9 charges C1 and causes a strobe pulse at the STR input of IC3. As a result, the received data is fed to the parallel data outputs of this IC. To protect the IC inputs, diodes D4 and D5 limit the negative pulses supplied by the differentiators to a voltage of –0.6 V. The digital data at outputs Q0 to Q7 of IC3 are applied direct to the user interface connector, K3.

The timing diagram in Fig. 2 illustrates the operation of the circuit by showing the time relation between the most important signals. The measuring points are found back as letter codes in the circuit diagram.

When the first databit appears on the serial channel, decade counter IC7 supplies a high level at output Q1. This results in the signals at inputs I0 to I7 of K3 being read into

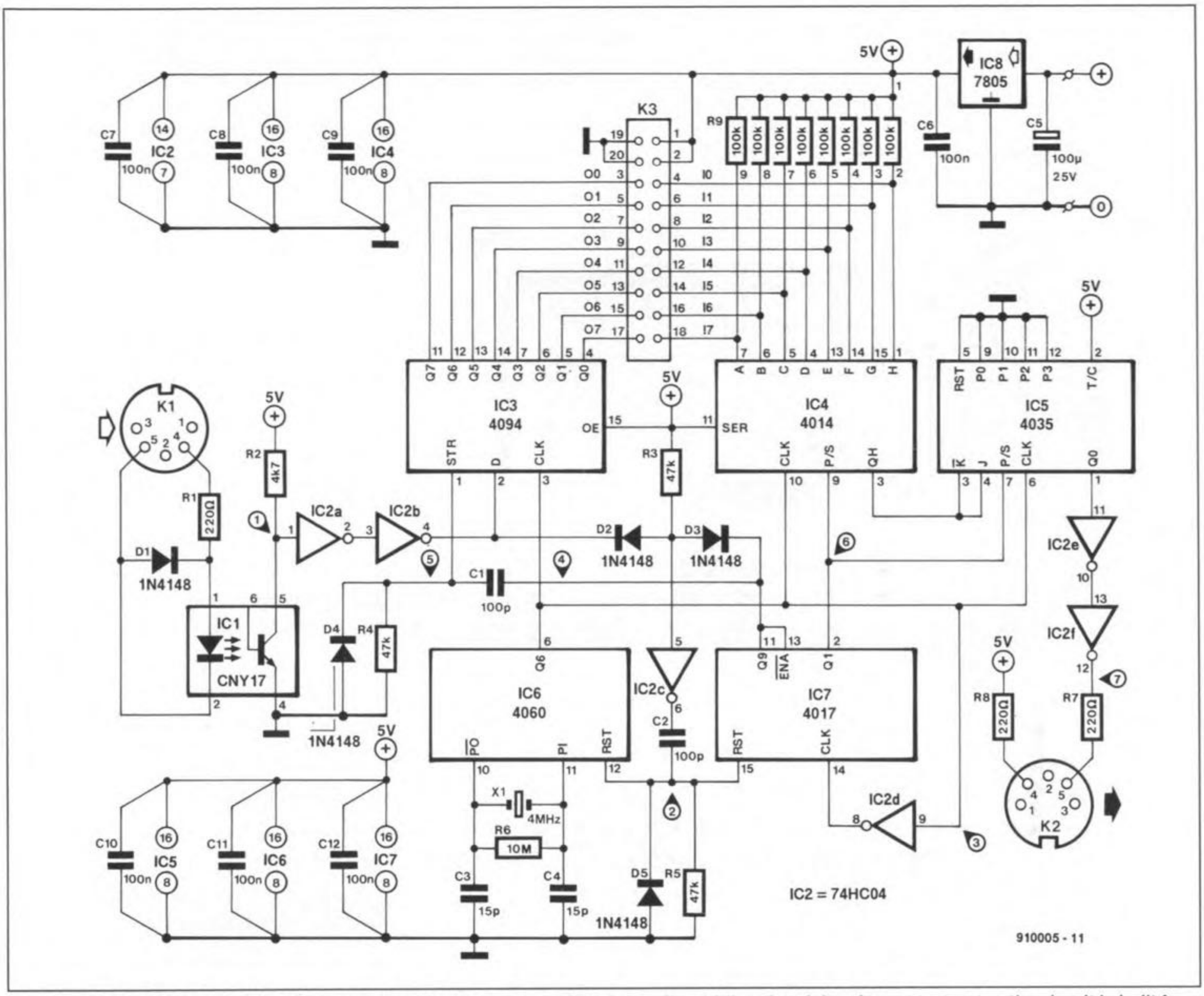


Fig. 1. Circuit diagram of the MIDI-to-parallel interface for Atari STs. Basically a bidirectional data format converter, the circuit is built from standard CMOS ICs.

the parallel register of IC4. On the first falling edge of the clock pulse, the P/$\overline{S}$ input of IC4 goes low again, and the IC starts to shift out the bits that make up the parallel dataword. The shift-out operation is timed by the clock signal, and the serial bits appear at the QH output of IC4. The serial data is accepted by IC5 at its J and $\overline{K}$ inputs. Meanwhile, the low level at the Q1 output of IC7 has been read at the P0 input of IC5. This low level is placed before the data, and thus serves as the start bit.

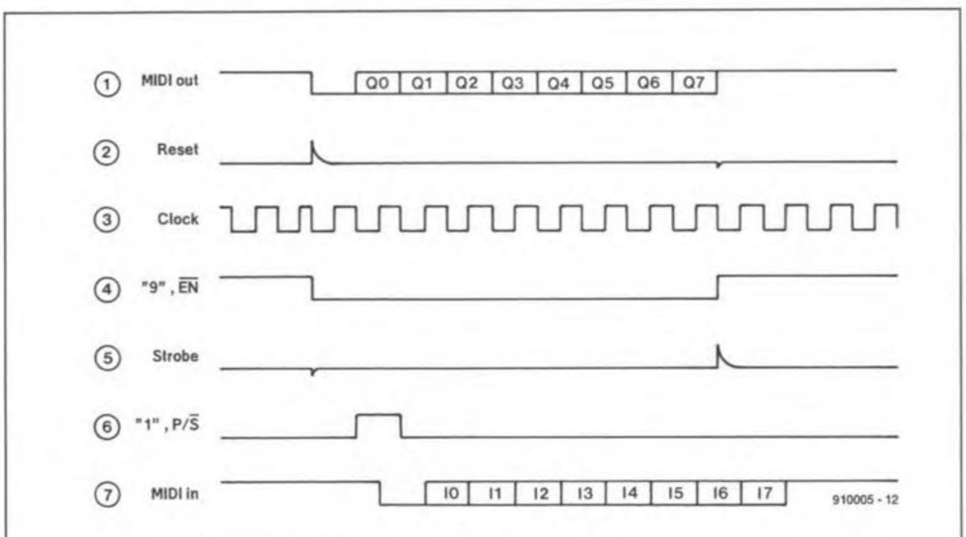


Fig. 2. Timing diagram to illustrate the operation of the circuit.

The serial output data that appears at the Q0 output of IC5 are applied to buffer IC2e. This in turn drives IC2f, which forms a current source together with resistor R7. In this way, we have created a standard MIDI output.

Following the start bit, the eight databits are shifted out and fed to the current source. The LSB is transmitted first. Since the serial input of IC4 is connected to the positive supply voltage, the eighth databit is followed by a series of logic 1s. This is done to keep the MIDI channel 'off', with no current flow through the cable.

The MIDI data produced by the interface is fed to the computer via a second 5-way DIN connector, K2. As you will have gathered from the circuit diagram, two cables are required to connect the interface to the Atari computer.

Control software

Although the interface can be used with any computer sporting a MIDI connection, the control software discussed below was designed specifically for the Atari ST. Fortunately, the BIOS ROM in this computer offers a simple way of controlling its internal MIDI. Since most compilers for the ST support the use of the available BIOS routines, higher-language control software is relatively simple to write.

The present interface is tested in three steps. First, data is transmitted for the output on the I/O bus. Next, the program performs a number of status requests on the input register of the ST's MIDI. If reading back data from the I/O card is not successful after a certain period, you are likely to have made an error of some kind in the construction or connection of the interface. The listing in Fig. 5 shows the outline of a routine written in C for the control of the I/O interface.

An example of the screen graphics presented by a test and debugging program for the I/O interface is shown in Fig. 4. The window shows the status of each input and output bit. In the 'auto' (automatic) mode, a software counter increases the output value on the I/O bus by one every four seconds. In the 'manual' mode, the mouse may be used to toggle the logic level of each individual bit. When the I/O interface is not connected, the text in the input boxes is grey instead of black.

The programs on the diskette supplied for this project should help you on the way in developing a more extensive quasi-multitasking control utility which runs in the background. An interesting application is realized by using the interrupt from timer A in the 68901 to transmit a byte via the MIDI every millisecond. Provided the MIDI buffer in the ST is given its maximum size of 32 kByte, it is even possible to create relatively long intervals (say, several tens of seconds) between the updating of the buffer content.

Users of computers other than the Atari ST may use the structure of the program described here as a starting point to write control routines geared to their machines.

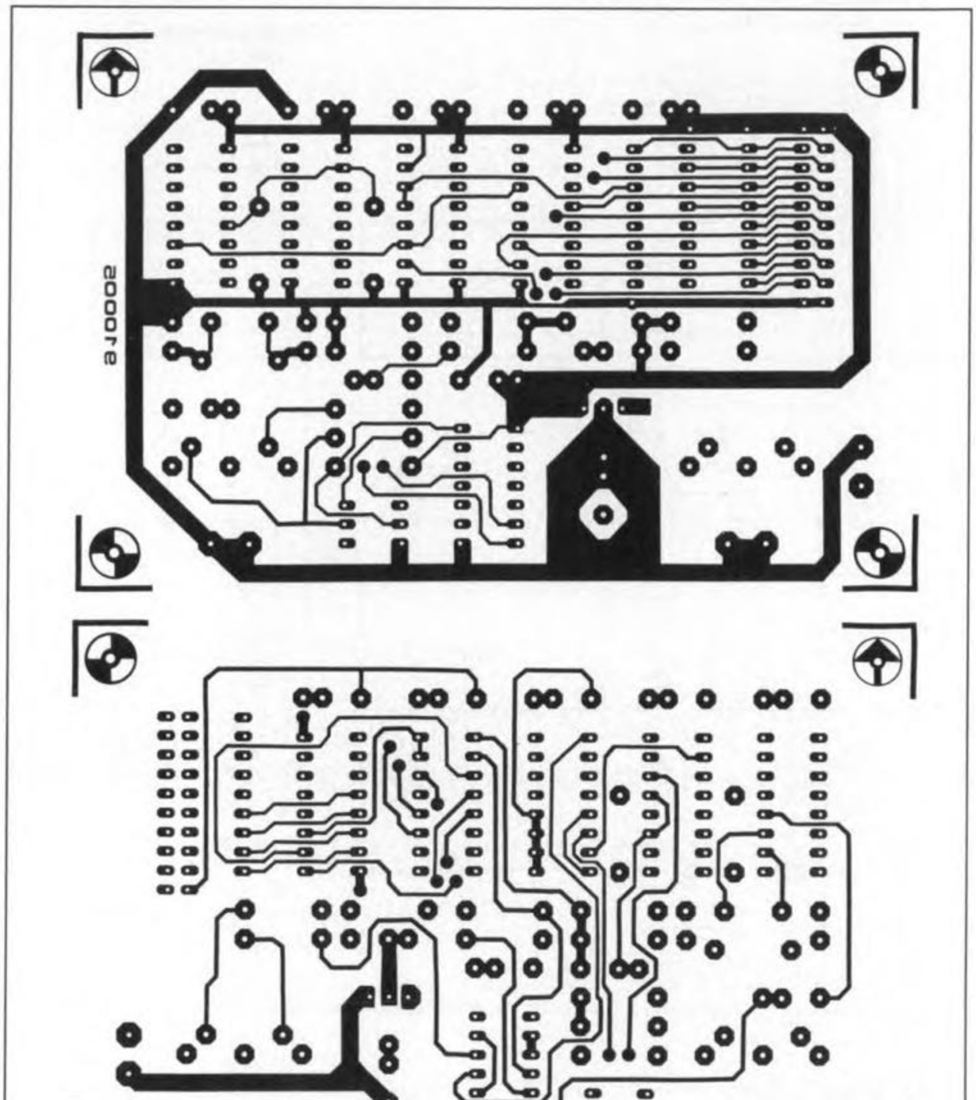


Fig. 3. Double-sided through-plated printed-circuit board for the interface.

Construction

No problems here, even for those with relatively little experience in building electronic

COMPONENTS LIST

Resistors:

3	220Ω	R1;R7;R8
1	4kΩ7	R2
3	47kΩ	R3;R4;R5
1	10MΩ	R6
1	8×100kΩ SIL resistor array	R9

Capacitors:

2	15pF	C3;C4
2	100pF	C1;C2
7	100nF	C6-C12
1	100µF 25 V	C5

Semiconductors:

5	1N4148	D1-D5
1	4014	IC4
1	4017	IC7
1	4035	IC5
1	4060	IC6
1	4094	IC3
1	74HC04	IC2
1	7805	IC8
1	CNY17	IC1

Miscellaneous:

2	5-way PCB-mount DIN socket	K1;K2
1	20-way PCB box header	K3
1	4 MHz quartz crystal	X1
1	printed-circuit board	910005

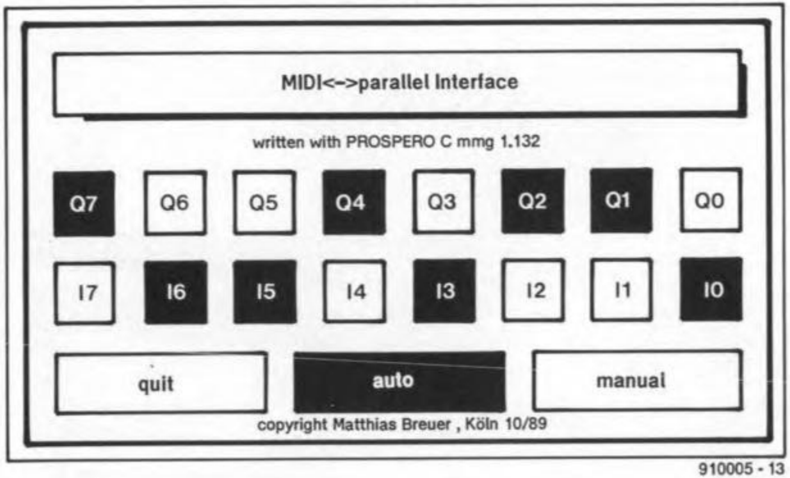


Fig. 4. Screendump of the test program.

```
bios(3, 3, outvalue);
i = 10;
while (i > 0 && bios (1, 3) !=-1) {
     i = i -1;
}
if (i > 0) {
     invalue = bios (2, 3);
} else {
     printf("MIDI 8-bit I/O-interface not found\n");
}
```

910005 - 14

Fig. 5. Use this routine written in C to check the basic function of the interface.

circuits. The ready-made printed-circuit board for this project is double-sided and through-plated (see Fig. 3). The construction is a matter of fitting all the parts on to the board. If you can not secure the specified 8-way single-in-line resistor network, R9, use eight vertically mounted discrete resistors instead. A short piece of wire connects the top terminals of these resistors, and forms the 'common' terminal, pin 1.

The I/O interface is best powered by a ready-made mains adapter with an output voltage of about 9 VDC. To prevent data errors, the length of the cables between the computer and the interface should not exceed 5 m. ■

SOFTWARE SERVICE

The project described here is supported by a control program which is available on an Atari-format diskette as order code ESS 1571. The diskette also contains the source code listing written in C, and the machine language listing, including the graphics support. For details on cost and ordering of this diskette please refer to the Readers Services page elsewhere in this issue. This item is available exclusively for Atari ST computers.

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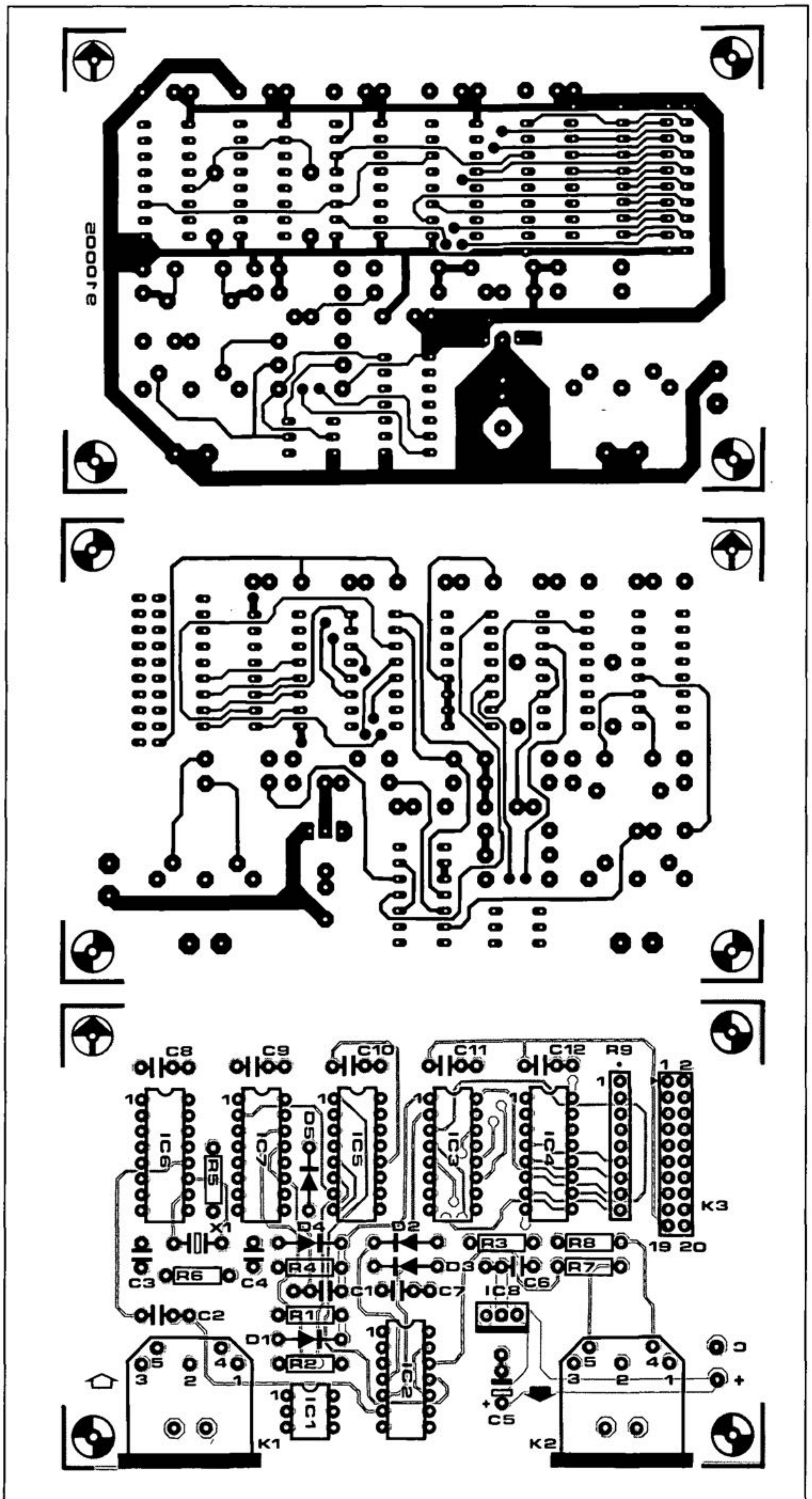

Fig. 3. Double-sided through-plated printed-circuit board for the interface.

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No problems here, even for those with relatively little experience in building electronic

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1	CNY17	IC1
Miscellaneous:		
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1	20-way PCB box header	K3
1	4 MHz quartz crystal	X1
1	printed-circuit board	910005

DIGITAL RESEARCH DOS 5.0 BRINGS BACK YOUR MEMORY

DIGITAL Research has recently introduced what can safely be called the most memory-efficient operating system for PCs. Apart from being a very powerful and simple to use operating system, DR DOS 5.0 ends the hassle with TSRs and drivers eating up large portions of the PC's base 640 kByte memory. If you, like this reviewer, use two or three TSRs, and a less than usual system configuration file, you may well have 450 kByte or less available after booting the system. I certainly do not like to be told that there is 'insufficient memory' to run, say, Wordperfect 5.0 or Ventura 2.0 when my PC, an AT 286, has a comfortable 4 MByte of extended memory.

Every new IBM DOS and MSDOS release has seen an increase in used up base memory. True, the performance of these systems has increased significantly, and from MSDOS 4.0 on it is possible to select a 'minimum' DOS configuration during the installation. Unfortunately, this minimum system still eats up more than 100 KByte, and slows the computer down considerably by swapping large data blocks between the main memory and the hard disk.

DRDOS 5.0, unlike any operating system I have seen before (with or without fancy 'memory managers'), runs almost entirely outside of the valuable 640 KByte memory area. By virtue of MemoryMAX™, DRDOS is capable of moving TSRs and drivers into high memory, the 384 KByte area between the top of the main memory (640 KByte) and the start of upper memory (1024 KByte). In my case, I was pleased to see that I had 595 KBytes of available memory after installing DRDOS plus my network driver, a really large display driver and all of my system configuration stuff. I upgraded from MSDOS 4.01, which left me a frustrating 420 KByte, just under the minimum required to run my DTP package, Ventura 2.0.

The installation of DR DOS 5.0 is straightforward, although it must be said that to fine-tune the performance you will need to be familiar with quite a few internal specifications of the PC you are using. In particular, the use of high memory and extended memory must be known in detail. Fortunately, the default selections presented during the installation are in most cases perfectly acceptable to achieve good results, even if you do not understand the meaning of all available options. A superb feature of DR DOS is that it can be re-installed from hard disk.

J. Buiting

DR DOS RELEASE 5.0

- **Fully compatible with all applications written for DOS**
- **Advanced memory management that allows over 620 kByte of free memory**
- **HILOAD and HIDEVICE to load drivers, TSRs and networking software outside the 640 Kbyte memory area**
- **Filelink file transfer program**
- **ViewMAX user interface**
- **Support for disk partitions greater than 32 MByte**
- **Menu-driven INSTALL and SETUP**
- **LIM expanded memory support using EMM386.SYS and EMMXMA.SYS**
- **Advanced disk-caching utility**
- **Ideal for use on NEAT-based PCs**
- **Password protection for files and directories**
- **Built-in help for each utility using /H switch**
- **Full-screen text editor**

More information on DR DOS 5.0 from **Digital Research (UK) Ltd., Oxford House, Oxford street, Newbury, Berkshire RG13 1JB. Telephone: (0635) 35304. Fax: (0635) 35834.**

WATTMETER

It is an unfortunate but well-known fact that measuring the active power of a mains-powered apparatus can be quite tricky. While non-reactive loads such as bulbs are mostly plain sailing, appliances that present inductive or capacitive loads force us to brush up our knowledge of waveform theory. Unless …

L. Lemon

SINCE inductive and capacitive loads cause a phase shift between current and voltage, their real active power can not be measured by multiplying the applied voltage with the measured current. Such a measurement yields reliable results only when the phase shift angle is known and included in the calculation of the active power. A similar problem arises with non-sinusoidal waveforms. These are often supplied by dimmers, whose output voltages seem to take almost any shape except that of a pure sine-wave. Although an oscilloscope could be used to establish the active power of a load powered by a dimmer, this type of measurement is cumbersome and inaccurate.

A much simpler way of measuring a.c. active power is to use a four-quadrant multiplier. This analogue calculation device is capable of measuring the current through a load, and the instantaneous voltage across it, simultaneously. Next, the two values are multiplied, and the result is shown on a display. If this sounds like a complex set of functions, we are fortunate to have these multipliers available in the form of integrated circuits. What's more, a four-quadrant multiplier is almost all we require for the instrument we intend to build. Add a power supply, a potential divider, two opamps, a few presets, and you have your wattmeter with a measuring capability of up to 3.5 kW.

The circuit

The circuit diagram of the wattmeter is simple and readily analysed. It consists of two parts — the meter circuit proper, and the display circuit.

The schematic in Fig. 1 is that of the power-voltage (*P-U*) converter, while Fig. 2 shows the liquid crystal display (LCD) section. In the top left-hand corner of Fig. 1 we see a load resistor, R_L, which is connected to K_2. This is where the mains-powered load, for instance, a motor, a bulb, a TV set, etc., is connected. Two parallel-connected shunt resistors, R_6 and R_7, pass the current drawn by the load. The effective resistance and power rating of the shunt are 0.05 Ω and 10 W respectively. The two resistors turn the current flow into a proportional voltage, which is amplified about 6 times by opamp IC_{3a} before it is applied to the input of the four-quadrant multiplier, IC_4. Switch S_1 at the input of the opamp forms a range selector.

A potential divider (p.d.) formed by R_3-R_4 and R_5 is connected in parallel with the load. Resistor R_8 feeds the output voltage of this p.d. to the VX+ input of the multiplier, IC_4. Two series-connected resistors are used in the upper branch of the p.d. to stay well below the maximum voltage that may be applied to a 0.125 W resistor. Since this voltage is usually specified at about 200 V, it is safer to use two identical resistors in series considering that the mains voltage may rise to 250 V. With two identical resistors in series, the voltage across each of them is unlikely to exceed the maximum permissible value.

Diodes D_1 to D_4 protect the opamp and multiplier inputs by diverting positive and negative voltage surges to the supply lines.

The basic operation of the analogue multiplier, a Type MC1495L from Motorola, is apparent from the internal structure shown in Fig. 3. The IC uses the input voltages, V_x and V_y, to supply an output voltage, V_o, that is described by

$$V_o = k\, V_x\, V_y \qquad [1]$$

In this equation, the constant, *k*, is determined by external components:

$$k = 2\, R_L / R_x\, R_y\, I_3 \qquad [2]$$

In the present circuit, R_L is composed of two 150-Ω resistors, R_{22} and R_{24}, at the output of the multiplier IC, while R_x and R_y are formed by the resistors connected to IC pins 10-11 and 5-6. The current I_3 in equation [2] flows from pin 3 of IC_4 into the ground line, and can be adjusted with the SCALE FACTOR preset, P_6. Presets P_4 and P_5 each supply an off-set compensation voltage at the VX– and VX+ inputs. These voltages serve to set the differential voltage at the relevant multiplier input.

The second opamp in the circuit, IC_{3b}, amplifies the multiplier output signal before this is applied to the display driver.

The circuit diagram of the LCD section based on the ICL7106 is shown in Fig. 2. Preset P_7 in the multiplier circuit is used for off-set compensation. The ICL7106 contains an analogue-to-digital converter (ADC) and a liquid crystal display driver. The chip is used in a standard application circuit, which requires a handful of external components for the on-board oscillator (R_2-C_2), the autozero function (R_3-C_4) and the capacitive reference (C_3).

MAIN SPECIFICATIONS

- **Accurate a.c. active power indication**
- **Four-quadrant multiplier handles ohmic and reactive loads**
- **3½-digit LCD**
- **Simple to connect**
- **Two ranges; resolution 1 W or 10 W**
- **Measures up to 3,500 W**

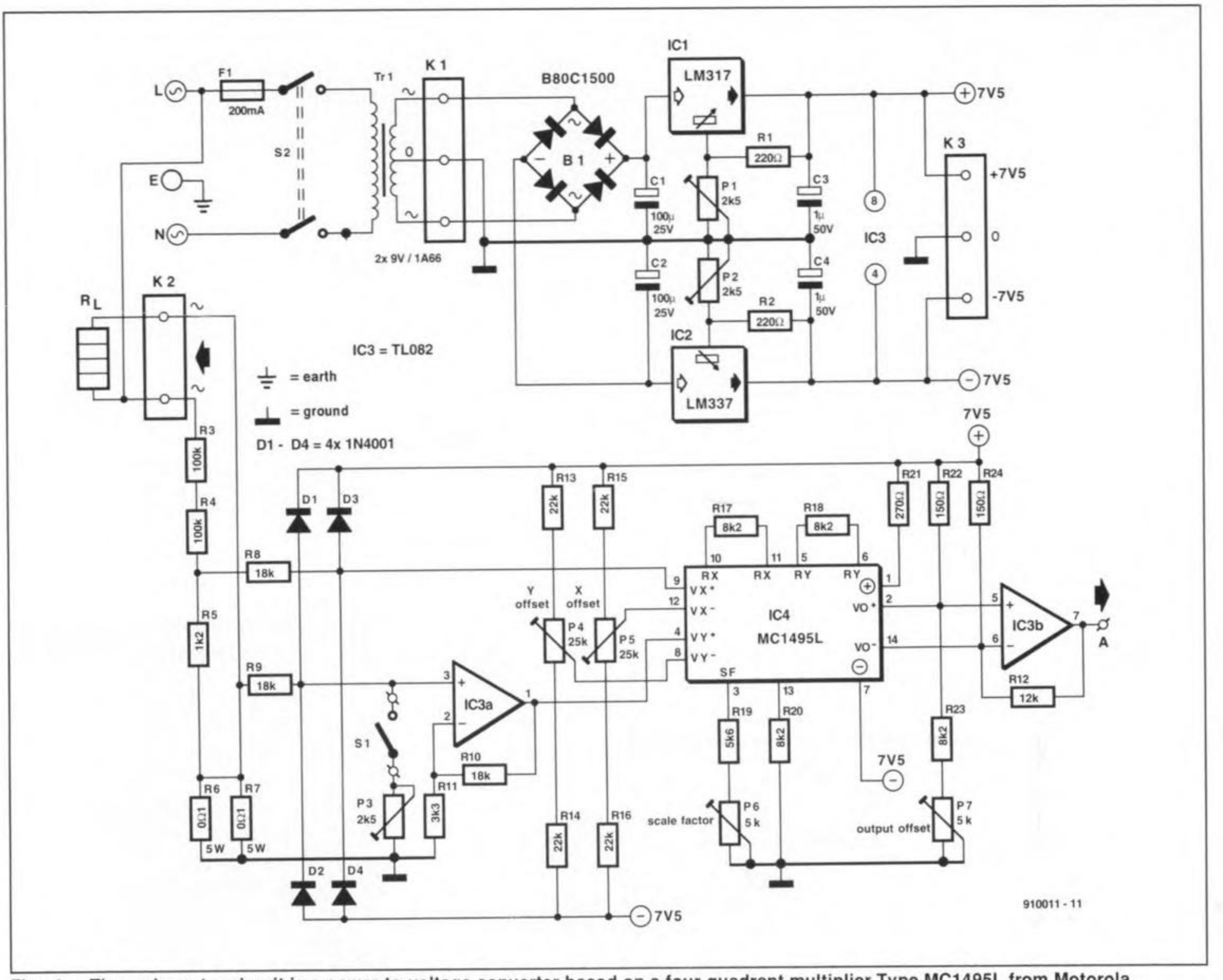


Fig. 1. The main meter circuit is a power-to-voltage converter based on a four-quadrant multiplier Type MC1495L from Motorola.

Returning to Fig. 1, the power supply is based on two adjustable precision voltage regulators Type LM317/LM337. Fixed voltage regulators are not suitable here in view of the required stability of the supply voltages. Also, the ±7.5 V supply voltage must be exactly symmetrical, which requires the voltage regulators to have an adjustment facility. In the present circuit, the supply voltages are matched with the aid of presets P1 and P2.

Construction: safety first

Since the circuit is connected direct to the mains, the construction demands great care and attention to prevent any risk of electrical shock. With this in mind, it is not surprising that the wiring of the instrument requires much more attention than the construction of the two printed-circuit board, which are relatively simple designs (see Figs. 4 and 5). Although it is possible to use a fixed mains input cord inserted through a rubber grommet and fitted with a strain relief at the inside of the enclosure, it is safer to use a mains appliance socket rated at 13 A. The output of the circuit is connected to a mains socket fitted on the front panel of the enclosure.

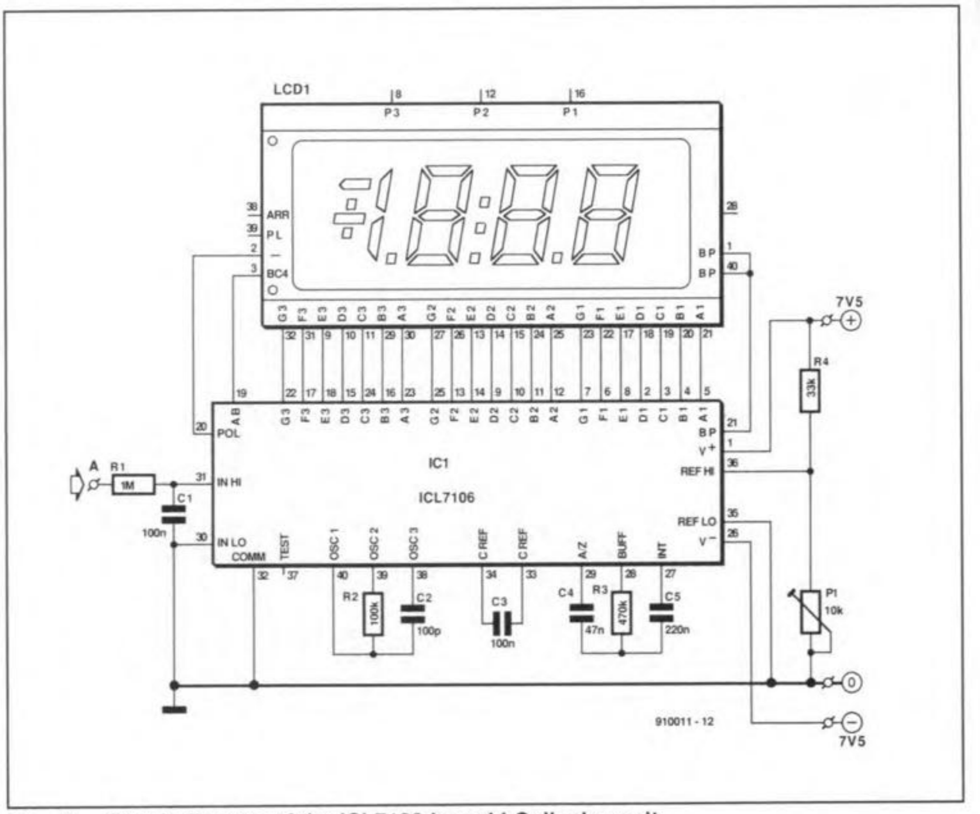


Fig. 2. Circuit diagram of the ICL7106-based LC display unit.

This connection must be made with wire with a cross-sectional area of 2.5 mm^2 or greater. For the sake of safety, cover each solder joint between a wire and a connector or terminal in heat-shrink sleeving or insulating tape. All metal parts of the wattmeter enclosure must be connected to earth.

The front panel is cut and drilled to accept the mains socket, the display, the on/off switch and the range switch. Note that although an IEC-style earthed mains socket is shown fitted on the front panel of the prototype, the actual type of mains socket used depends on local regulations. There should be no problem fitting an U.S. or U.K. style mains socket. A ready-made self-adhesive two-colour foil is available to give the wattmeter a finished appearance. The layout of this front panel is apparent from the introductory photograph.

Finally, fit a 3-mm thick plastic or ABS plate between the display PCB and the front panel of the enclosure. This plate functions as an insulator, and must be at least 3 mm longer and wider than the display PCB.

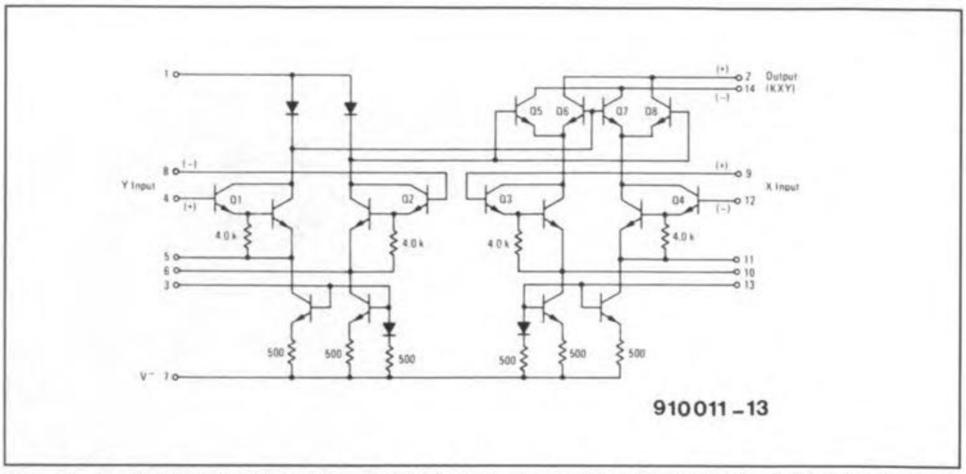


Fig. 3. Internal schematic of the MC1495L four-quadrant multiplier (*illustration reproduced by courtesy of Motorola*).

Adjustment

The wattmeter is adjusted with the aid of a digital multimeter (DMM) and a sine-wave generator.

First, adjust presets P1 and P2 until the circuit supply voltages are exactly +7.5 V and –7.5 V. Next, connect the sine-wave generator to pin 3 of IC3. Set the generator to an output voltage of 3 V, and a frequency between 50 Hz and 200 Hz. If applicable, set the DC-offset at the generator output to 0 V.

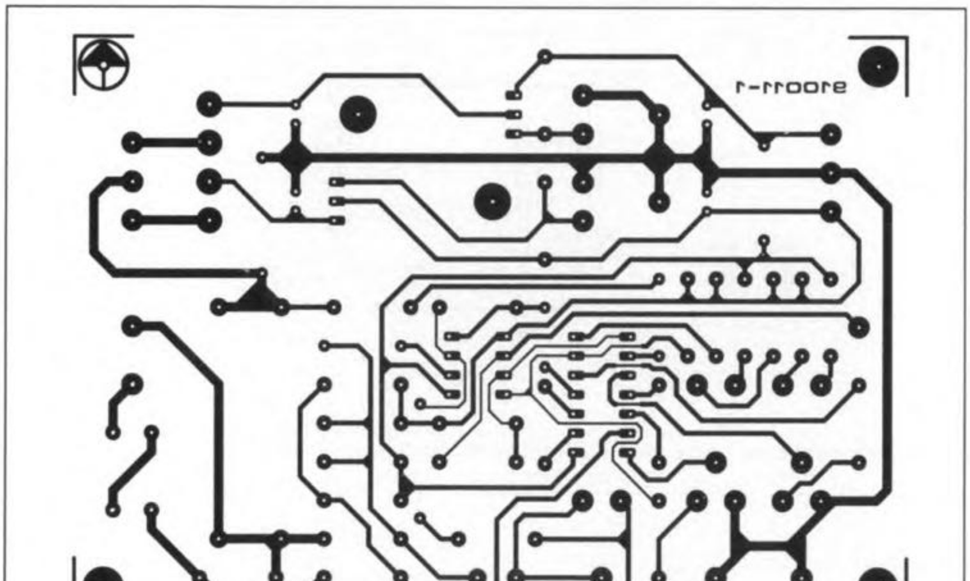


Fig. 4. Single-sided printed-circuit board for the power-to-voltage converter.

COMPONENTS LIST

METER BOARD

Resistors:

2	220Ω	R1;R2
2	100kΩ	R3;R4
1	1kΩ2	R5
2	0Ω1 5W	R6;R7
3	18kΩ	R8;R9;R10
1	3kΩ3	R11
1	12kΩ	R12
4	22kΩ	R13-R16
4	8kΩ2	R17;R18;R20;R23
1	5kΩ6	R19
1	270Ω	R21
2	150Ω	R22;R24
2	5kΩ preset H	P6;P7
3	2kΩ5 preset H	P1;P2;P3
2	25kΩ preset H	P4;P5

Capacitors:

2	100µF 25V radial	C1;C2
2	1µF 63V radial	C3;C4

Semiconductors:

4	1N4001	D1-D4
1	LM317	IC1
1	LM337	IC2
1	TL082	IC3
1	MC1495L	IC4
1	B80C1500	B1

Miscellaneous:

3	3-way PCB-mount screw terminal block	K1;K2;K3
1	SPST switch	S1
1	fuse 200mA slow	F1
1	mains transformer 2×9V @ 1.66A	Tr1
1	DPDT mains-rated switch	S2
1	printed-circuit board	910011-1

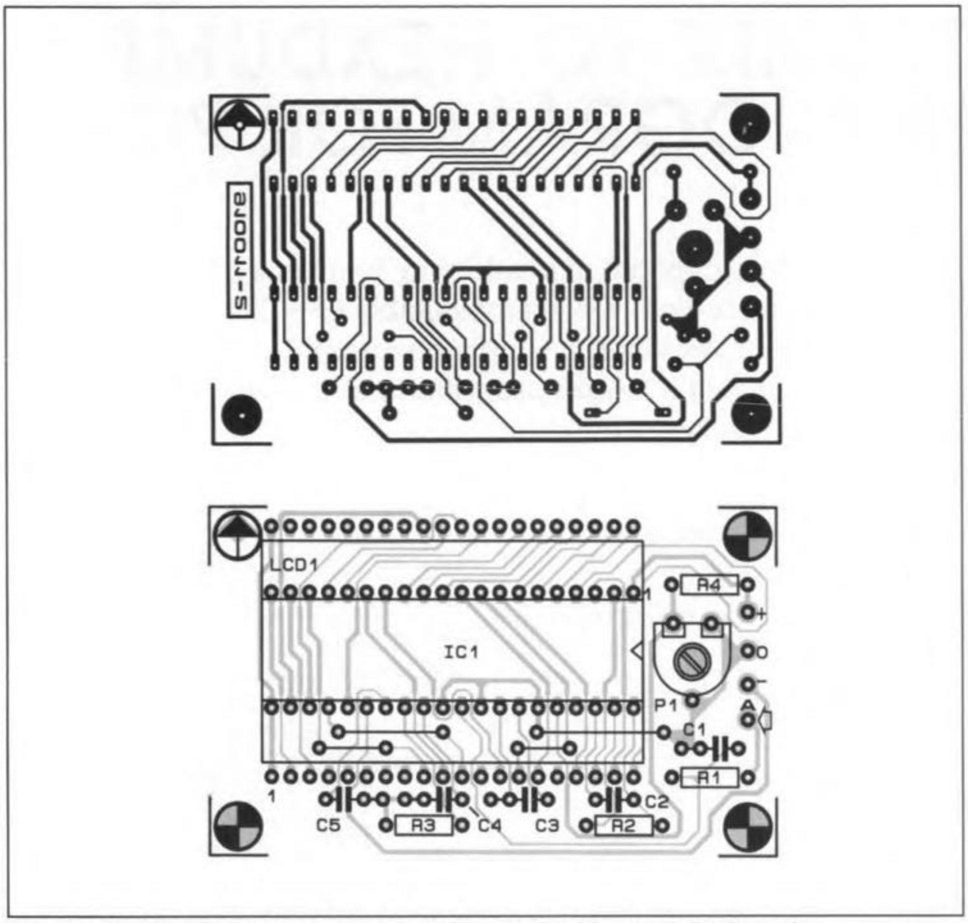
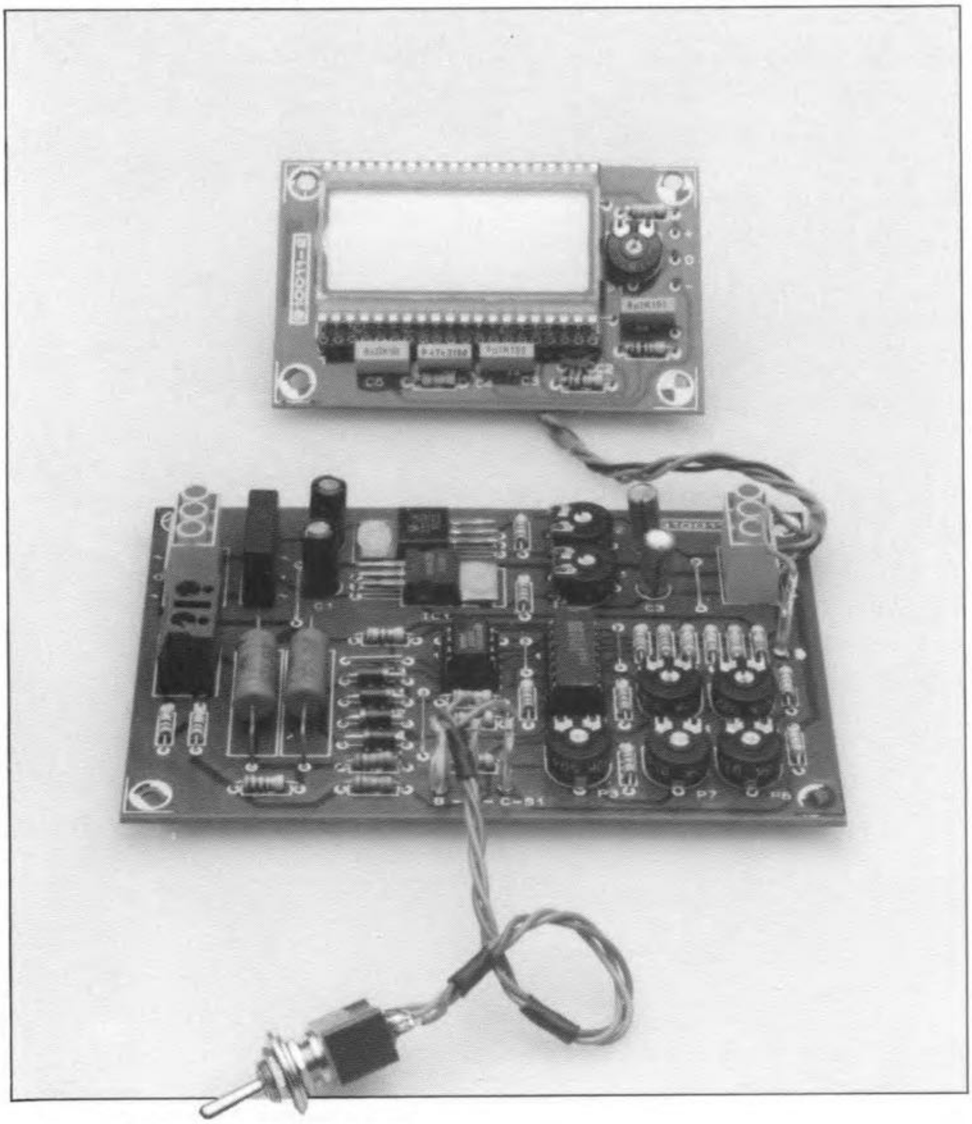


Fig. 5. Single-sided printed-circuit board for the liquid crystal display unit.



COMPONENTS LIST

DISPLAY BOARD

Resistors:

1	1MΩ	R1
1	100kΩ	R2
1	470kΩ	R3
1	33kΩ	R4
1	10kΩ preset H	P1

Capacitors:

2	100nF	C1;C3
1	100pF	C2
1	47nF	C4
1	220nF	C5

Semiconductors:

1	7106	IC1

Miscellaneous:

1	3½-digit LCD	LCD1
1	printed-circuit board	910011-2

If you do not have a sine-wave generator, use a small mains transformer with a 3-V secondary.

Short out R10, the feedback resistor of IC3a, Connect pin 9 of IC4 to ground, and open switch S1. Adjust preset P4 (VX offset) for minimum alternating voltage at output A of the main meter board (all voltages are measured with respect to ground).

Connect the generator output to pin 9 of IC4. Connect pin 3 of IC3a to ground. Adjust preset P5 (VY offset) for minimum alternating voltage at output 'A' of the main meter board. Next, minimize the d.c. component at the output terminal, 'A', by adjusting preset P7.

Connect a non-reactive load, e.g., a 100-W bulb, to the output of the wattmeter. Measure the voltage across the bulb, and the alternating current. This measurement is preferably carried out with a true-RMS meter. Calculate the active power of the bulb. The direct voltage at terminal 'A' should be about 100 mV, corresponding to a sensitivity of 1 mV/watt. If necessary, correct the setting of P6. Next, adjust P1 on the display board until the calculated active power appears on the display.

The last adjustment involves the second measurement range. Close S1, and adjust preset P3 until the voltage at terminal 'A' is one tenth of the previously measured value. This completes the adjustment of the wattmeter.

You are now ready to test the wattmeter with 'real' loads whose active power you want to check against the manufacturer's specification, You can measure up to 3.5 kW. The accuracy of the instrument is about 5% even under less favourable conditions, for example, when a heavily capacitive or inductive load is connected, or when the mains voltage is distorted by a dimmer circuit. ■

Fig. 6. Completed boards, interconnected and ready for adjustment.

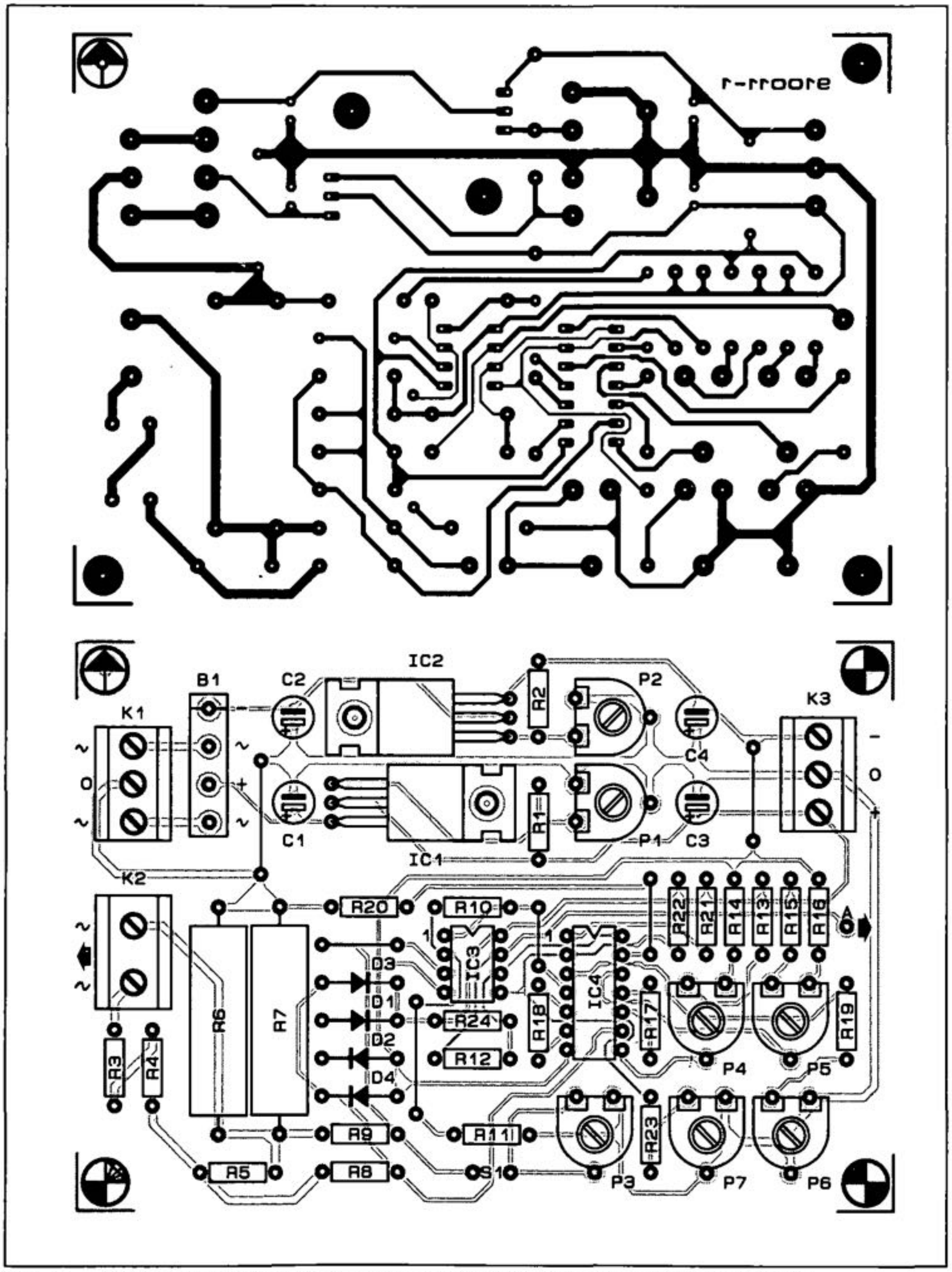


Fig. 4. Single-sided printed-circuit board for the power-to-voltage converter.

COMPONENTS LIST

METER BOARD

Resistors:

2	220Ω	R1;R2
2	100kΩ	R3;R4
1	1kΩ2	R5
2	0Ω1 5W	R6;R7
3	18kΩ	R8;R9;R10
1	3kΩ3	R11
1	12kΩ	R12
4	22kΩ	R13-R16
4	8kΩ2	R17;R18;R20;R23
1	5kΩ6	R19
1	270Ω	R21
2	150Ω	R22;R24
2	5kΩ preset H	P6;P7
3	2kΩ5 preset H	P1;P2;P3
2	25kΩ preset H	P4;P5

Capacitors:

2	100µF 25V radial	C1;C2
2	1µF 63V radial	C3;C4

Semiconductors:

4	1N4001	D1-D4
1	LM317	IC1
1	LM337	IC2
1	TL082	IC3
1	MC1495L	IC4
1	B80C1500	B1

Miscellaneous:

3	3-way PCB-mount screw terminal block	K1;K2;K3
1	SPST switch	S1
1	fuse 200mA slow	F1
1	mains transformer 2×9V @ 1.66A	Tr1
1	DPDT mains-rated switch	S2
1	printed-circuit board	910011-1

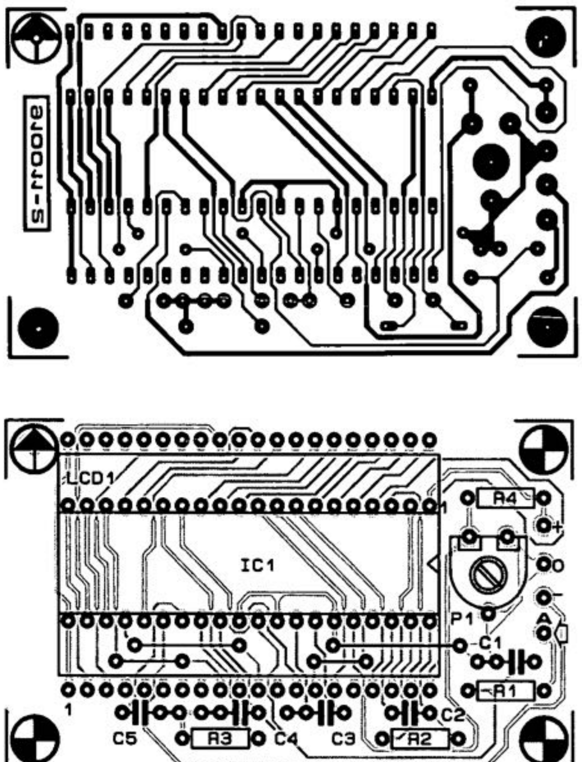


Fig. 5. Single-sided printed-circuit board for the liquid crystal display unit.

COMPONENTS LIST

DISPLAY BOARD

Resistors:

1	1MΩ	R1
1	100kΩ	R2
1	470kΩ	R3
1	33kΩ	R4
1	10kΩ preset H	P1

Capacitors:

2	100nF	C1;C3
1	100pF	C2
1	47nF	C4
1	220nF	C5

Semiconductors:

1	7106	IC1

Miscellaneous:

1	3½-digit LCD	LCD1
1	printed-circuit board	910011-2

If you do not have a sine-wave generator, use a small mains transformer with a 3-V secondary.

Short out R_{10}, the feedback resistor of IC_{3a}, Connect pin 9 of IC_4 to ground, and open switch S_1. Adjust preset P_4 (VX offset) for minimum alternating voltage at output A

CORRECTIONS

Wattmeter

April 1991, p. 32-35
With reference the circuit diagram, Fig. 1, the right-hand terminal of the lower section of switch S2 should be connected to the circuit ground. This point is indicated by a dot.

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

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

80C32/8052 Single-board computer

May 1991, p. 17-23
When a CPU type 8031 or 8052AH-BASIC is used, IC1, IC2, IC3, and IC8-IC12 must be 74HCT types. Jumper B is erroneously reffered to as Br2 in the text under "On-board EPROM programmer". Contrary to what is stated, this jumper must be fitted only when an EPROM is to be programmed — for all other use of the SBC, it must be removed. Also note that jumper B may only be fitted when the programming LED is out.

Sequential control

July/August 1991, p. 61
Motor M should be a d.c. type, not an a.c. type as shown in the circuit diagram.

Digital phase meter

June 1991, p. 32-39
In Fig. 5, the switch between input 'A' and IC1 should be identified 'S1', and that between input 'B' and IC2 'S2'. Switch S4 is an on/off type, not a push-button as shown in the diagram. Capacitors C3 and C6 are shown with the wrong polarity. The component overlay of the relevant printed-circuit board (Fig. 8) is all right.

Universal NiCd battery charger

June 1991, p. 14-19
The parts list on page 19 should be corrected to read

C7 = 2200µF 25V

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

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

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

MIDI program changer

April 1991, p. 14-17
The contents of the EPROM should be modified as follows:

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

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

Electronic exposure timer

March 1991, p. 31-35
Please add to the parts list on page 32:
C16 = 33 pF

Augmented A-matrices

May 1991, p. 42-43
The drawing below was erroneously omitted in the left-hand bottom corner of page 43.

910058-14

INTEL/TEKTRONIX-TO-HEXDUMP CONVERTER PROGRAM FOR PCs

Those of you who run assemblers capable of producing Tektronix or Intel format output files have a problem when an available EPROM programmer is not 'intelligent', or when a simple hexdump is required of the object code. Here is a BASIC program to end your misery.

from an idea by S. Mitra

INTEL hex format and Tektronix Hex format are two very popular file formats used for uploading and downloading data between a host computer (such as a PC) and an intelligent EPROM programmer. That is why most popular cross assemblers and file linkers supplied with different in-circuit emulators provide Intel/Tektronix format file output in addition to executable file output.

During system software development, it is often required to generate a hexadecimal dump listing from the Intel/Tektronix format for documentation or debugging. Doing such a conversion manually takes a lot of

```
10 ' HEXDUMP.BAS software listing.
20 ' Intel/tektronix Hex format to Standard Hex Dump Listing convertor
30 ' Written by  -----------------------------
40 '            |   Soumya Mitra              |
50 '            |   15/2 Rani Sankari Lane    |
60 '            |   Calcutta 700 026          |
70 '            |   West Bengal               |
80 '            |   INDIA                     |
90 '             -----------------------------
100 '
110 ON ERROR GOTO 1030
120 KEY OFF : CLS : CLOSE : FLAG=0 : EXIST=-1 : COLOR 14,6
130 PRINT "Intel/Tektronix Hex Format to standard hexdump  Version 1.00"
140 PRINT "               Written by Soumya Mitra 1990"
150 COLOR 14,0
160 LOCATE 7,1 : INPUT "Input File                : ", INFILE$
170 OPEN "I",#1, INFILE$
180 CLOSE : FORMAT$= ""
190 LOCATE 8, 1 : INPUT "Output File              : ", OUTFILE$
200 LOCATE 9, 1 : PRINT "Intel/Tektronix  (I/T) : "; : A$=INPUT$(1)
210 IF A$="i" OR A$="I" THEN FORMAT$=":" : GOTO 240
220 IF A$="t" OR A$="T" THEN FORMAT$="/" : GOTO 240
230 IF FORMAT$= "" THEN 200
240 PRINT A$
250 LOCATE 23, 1 : COLOR 11, 0 : PRINT "Esc - to exit    any key to continue"
260 A$=INKEY$ : IF A$= "" THEN 260
270 IF A$=CHR$(27) THEN END
280 CLS : PRINT "Please wait a moment."
290 OPEN "I", #1, OUTFILE$
300 IF NOT EXIST THEN 370
310 CLS : LOCATE 10,20 : COLOR 28, 8
320 PRINT OUTFILE$; " exists, overwrite (Y/N)"
330 COLOR 7, 0 : GOSUB 1180
340 A$=INKEY$ : IF A$="" THEN 340
350 IF A$="y" OR A$="Y" THEN 370
360 IF A$="n" OR A$="N" THEN END ELSE 340
370 COLOR 7, 0 : CLS : PRINT "Please wait a moment" : CLOSE
380 OPEN "I", #1, INFILE$
390 OPEN "O", #2, OUTFILE$
400 PAGE=1
410 LINENUM=1
420 HEADER$=SPACE$(9)
430 FOR C=0 TO 15
440    HEADER$=HEADER$ + HEX$(C) + SPACE$(3)
450 NEXT
460 CLS : PRINT "Please wait, scanning"
470 PAGEHEAD$=DATE$ + "                   Hex dump of " + INFILE$
480 PAGEHEAD$=PAGEHEAD$ + " software     Page " + STR$(PAGE)
490 LOCATE 19, 1 : PRINT  PAGEHEAD$
500 PRINT #2, PAGEHEAD$
510 PRINT
520 PRINT #2, ""
530 PRINT
540 PRINT #2, ""
550 PRINT HEADER$
560 PRINT #2, HEADER$
570 PRINT
580 PRINT #2, ""
590 LINENUM=LINENUM + 5
600 WHILE 1
610    LINE INPUT #1, BUFFER$
620    BUFFERLEN=LEN(BUFFER$)
630    TESTPOSITION=1
640    WHILE 1
650       TESTSTRING$=MID$(BUFFER$, TESTPOSITION, 1)
660       IF TESTPOSITION >=BUFFERLEN THEN 970
670       IF TESTSTRING$=FORMAT$ THEN 700
680       TESTPOSITION=TESTPOSITION +1
690    WEND
700    BUFFERLEN=BUFFERLEN - TESTPOSITION
710    IF FORMAT$=":"  THEN GOSUB 1230 ELSE GOSUB 1310
720    IF BYTECOUNT=0 THEN 980
730    HEXDUMP$="    "
740    FOR X=1 TO BYTELEN STEP 2
750       HEXDUMP$=HEXDUMP$ + MID$(BYTE$, X, 2) + SPACE$(2)
760    NEXT
770    IF LINENUM<>22 THEN 940
780    PRINT
790    PRINT  "Press any key to continue"
800    P$=INPUT$(1)
810    PAGE=PAGE +1
820    LINENUM=1
830    PAGEHEAD$=DATE$ + "                   Hex dump of " + INFILE$
840    PAGEHEAD$=PAGEHEAD$ + " software               Page " + STR$(PAGE)
850    PRINT #2, CHR$(12)
860    PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT  PAGEHEAD$
870    PRINT #2, PAGEHEAD$
880    PRINT : PRINT :PRINT HEADER$ : PRINT
890    PRINT #2, ""
900    PRINT #2, ""
910    PRINT #2, HEADER$
920    PRINT #2, ""
930    LINENUM=LINENUM + 5
940    PRINT ADDRESS$ + HEXDUMP$
950    PRINT #2, ADDRESS$ + HEXDUMP$
960    LINENUM=LINENUM +1
970 WEND
980 FOR X=LINENUM TO 22
990    PRINT
1000 NEXT
1010 PRINT #2, CHR$(12)
1020 CLOSE : END
1030 CLS : COLOR 28, 0 : LOCATE 12, 30
1040 IF ERR=53 AND ERL=290 THEN EXIST=0 : RESUME NEXT
1050 IF ERR<>53 THEN 1090
1060 PRINT "File not found" : GOSUB 1180
1070 COLOR 7, 0 : LOCATE 23, 1 : PRINT "Press any key to continue"
1080 A$=INPUT$(1) : RESUME 120
1090 IF ERR<>71 THEN 1130
1100 PRINT "Drive not ready" : GOSUB 1180
1110 LOCATE 14, 25 : COLOR 7, 0 : PRINT "Press any key to continue"
1120 A$=INPUT$(1) : CLS : PRINT "Please wait a moment." : RESUME
1130 IF ERR=61 THEN PRINT "Out of disk space" : GOTO 1160
1140 IF ERR=62 THEN PRINT "WRONG FILE FORMAT!" : GOTO 1160
1150 LOCATE 14, 23 : PRINT "Basic error "; ERR; " has occured"
1160 GOSUB 1180
1170 COLOR 7, 0 : END
1180 FOR COUNTER=1 TO 3
1190    SOUND 2500, .8 : SOUND 20000, 1
1200 NEXT
1210 SOUND 20000, 8
1220 RETURN
1230 ' INTEL FORMAT CONVERSION *********************************
1240 BUFFER$=MID$(BUFFER$, TESTPOSITION + 1, BUFFERLEN - 2)
1250 BYTECOUNT=VAL(MID$(BUFFER$, 1,2))
1260 IF BYTECOUNT=0 THEN 1300
1270 ADDRESS$=MID$(BUFFER$, 3, 4)
1280 BYTELEN=BUFFERLEN - 10  ' BUFFERLEN-(BYTECOUNT+ADDRESS+BLOCKTYPE+CHKSUM)
1290 BYTE$=MID$(BUFFER$, 9, BYTELEN)
1300 RETURN
1310 ' TEKTRONIX FORMAT CONVERSION ******************************
1320 BUFFER$=MID$(BUFFER$, TESTPOSITION + 1, BUFFERLEN - 2)
1330 BYTECOUNT=VAL(MID$(BUFFER$, 5, 2))
1340 IF BYTECOUNT=0 THEN 1380
1350 ADDRESS$=MID$(BUFFER$, 1, 4)
1360 BYTELEN=BUFFERLEN - 10
1370 BYTE$=MID$(BUFFER$, 9, BYTELEN)
1380 RETURN
```

900136-11

Fig. 1. Listing of HD.BAS, the file format converter, written in BASIC.

```
:10000000414210400042000000000000000000000DB
:100010003E002175F9068077230520FB21007F1122
:10002000F5F9018000EDB011008D062A21F5F923C4
:100030007E3273FA237E3274FAFD2A73FAFD19FDBB
:100040002273FA2B3A73FA77233A74FA772305204E
:10005000DE21807F1175FA018000EDB011000021D2
:10006000F5F90E007E835F3E008A57230D20F521AF
:10007000F3F97323723E00327AF9CD38011F1FE67F
:100080000306004F21C1FC0986217AF977CB7E282F
:100090000C21C5FC097EE60C217AF98677003E002A
:1000A0003277F93278F93279F9F501FF1FC521C1AC
:00000001FF

02-06-1991                 Hex dump of A:HEX.HEX software       Page  1

         0   1   2   3   4   5   6   7   8   9   A   B   C   D   E   F

0000    41  42  10  40  00  42  00  00  00  00  00  00  00  00  00  00
0010    3E  00  21  75  F9  06  80  77  23  05  20  FB  21  00  7F  11
0020    F5  F9  01  80  00  ED  B0  11  00  8D  06  2A  21  F5  F9  23
0030    7E  32  73  FA  23  7E  32  74  FA  FD  2A  73  FA  FD  19  FD
0040    22  73  FA  2B  3A  73  FA  77  23  3A  74  FA  77  23  05  20
0050    DE  21  80  7F  11  75  FA  01  80  00  ED  B0  11  00  00  21
0060    F5  F9  0E  00  7E  83  5F  3E  00  8A  57  23  0D  20  F5  21
0070    F3  F9  73  23  72  3E  00  32  7A  F9  CD  38  01  1F  1F  E6
0080    03  06  00  4F  21  C1  FC  09  86  21  7A  F9  77  CB  7E  28
0090    0C  21  C5  FC  09  7E  E6  0C  21  7A  F9  86  77  00  3E  00
00A0    32  77  F9  32  78  F9  32  79  F9  F5  01  FF  1F  C5  21  C1
```
900136 - 12

Fig. 2. Example of an Intel format input file and the hexdump produced by HD.BAS.

```
/00001001064010FE3E38D3C032434097D3C12100A0
/0010100240010020 7E2F777E2F77BE280176EDA1C6
/00201003EA14003100489711004206 00CD28069784
/00301004324A403EC932004B182C4544695453209B
/00401005766572736 96F6E20312E302C20636F70B1
/00501006797269676874204 56C656B7475757220B5
/0060040A3139383927
/0066100DF33100489732534021 0A0E0130407E027D
/0076100E23033E40B920F73E40ED4706000EE111A9
/0086100FFFFFD93E73D3E2D3E33E4FD3E23EFFD331
/00961010E33E9CD3E33E3AD3E33E17D3E33EFBD30C
/0000000000

02-06-1991                 Hex dump of tek.tek software       Page  1

         0   1   2   3   4   5   6   7   8   9   A   B   C   D   E   F

0000    06  40  10  FE  3E  38  D3  C0  32  43  40  97  D3  C1  21  00
0010    40  01  00  20  7E  2F  77  7E  2F  77  BE  28  01  76  ED  A1
0020    EA  14  00  31  00  48  97  11  00  42  06  00  CD  28  06  97
0030    32  4A  40  3E  C9  32  00  4B  18  2C  45  44  69  54  53  20
0040    76  65  72  73  69  6F  6E  20  31  2E  30  2C  20  63  6F  70
0050    79  72  69  67  68  74  20  45  6C  65  6B  74  75  75  72  20
0060    31  39  38  39
0066    F3  31  00  48  97  32  53  40  21  0A  0E  01  30  40  7E  02
0076    23  03  3E  40  B9  20  F7  3E  40  ED  47  06  00  0E  E1  11
0086    FF  FF  D9  3E  73  D3  E2  D3  E3  3E  4F  D3  E2  3E  FF  D3
0096    E3  3E  9C  D3  E3  3E  3A  D3  E3  3E  17  D3  E3  3E  FB  D3
```
900136 - 13

Fig. 3. Example of a Tektronix format input file and the hexdump produced by HD.BAS.

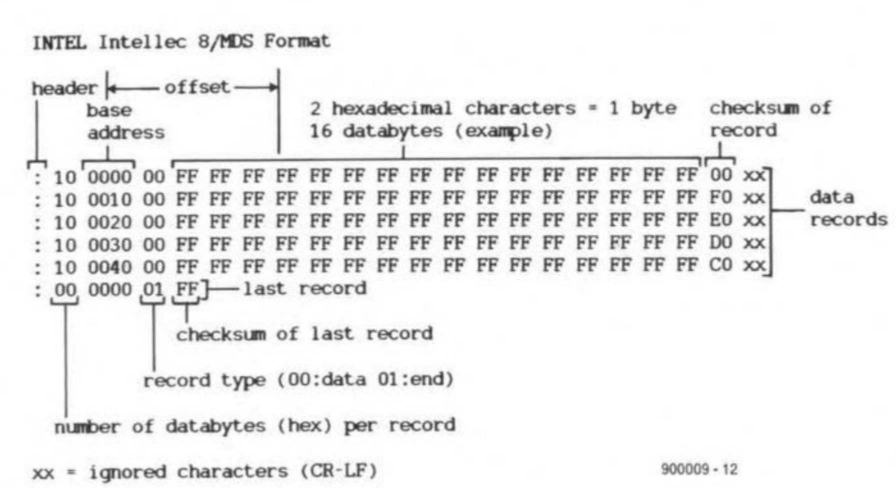


Fig. 4. Analysis of Intel-hex record format.

SOFTWARE SERVICE

The program described here is available on a 5¼-inch 360 kB MS-DOS formatted floppy disk under order number ESS1581. For details on price and ordering, please refer to the Readers Services page elsewhere in this issue.

time, and is therefore much better left to the computer. The program described here reads an Intel or Tektronix format data file and will turn it into a hex dump ASCII print file.

The program

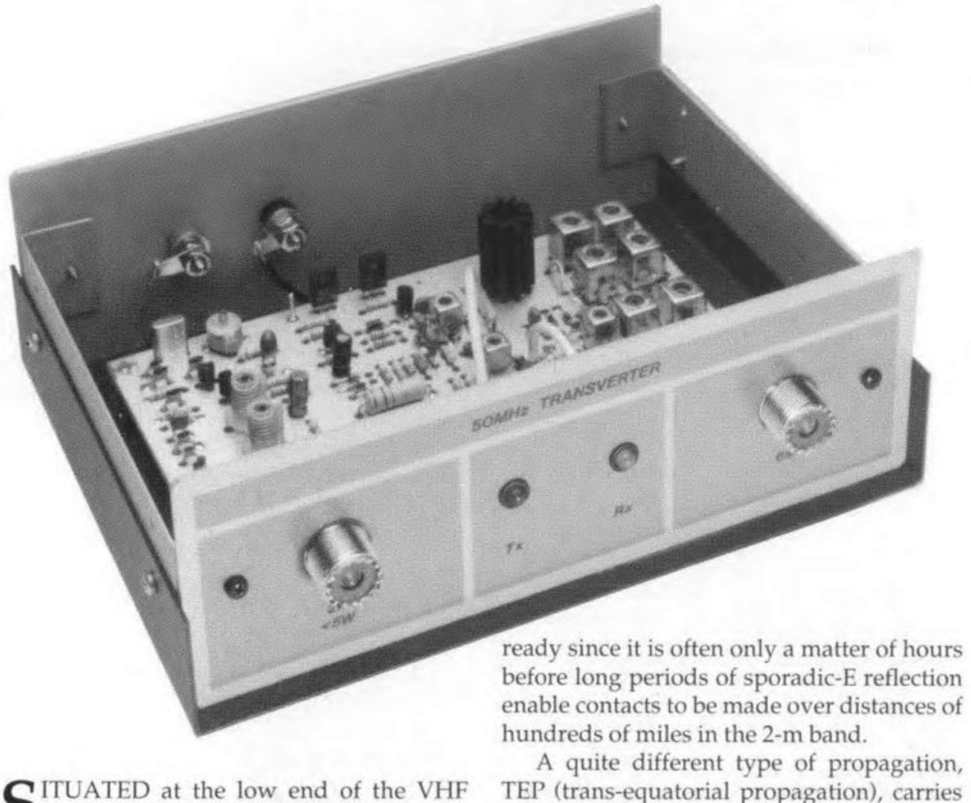
The listing of the file converter, HD.BAS, is given in Fig. 1. The program has quite a few error trapping routines, and will handle almost any type of error without crashing your PC. On being run from GWBASIC, the program asks you to enter the input and output file names. Next, it verifies the file format type. If a wrong format is detected, the program terminates with an error message. If the file format is correct, the conversion is started, and you can see the hex dump listing scrolling on your PC screen, while the output file is written to the disk. After each screenful of data, the program will stop and prompt you to press a key to continue.

Two examples of the use of HD.BAS are given in Figs. 2 (Intel format) and 3 (Tektronix format). As you can see, the program is capable of turning what many of you will regard as a cluttered block of data into a neatly formatted hexadecimal dump. ■

6-METRE BAND TRANSVERTER

Although it has been in use for over ten years in the UK, the 6-metre (50 MHz) band has recently gained a lot of attraction since the PTT authorities of a number of continental European countries including France, Holland, Belgium and Germany have, after a faltering start, issued the first few hundred 6-metre licenses to die-hard home brewers. The author invites you to partake actively in the growing 6-m activity. As shown in the 'specs' box on this page, the present transverter has quite a few distinct advantage over earlier designs that have appeared in the radio amateur press.

Pedro Wyns, ON4AWQ



MAIN SPECIFICATIONS

- P-I-N-diode Rx/Tx switching; no relays
- Packet/Amtor compatible
- Output power approx. 1.5 W at 2 W input power (peak effective levels)
- Sensitivity approx. 0.2 μV for 20 dB SINAD
- VOX/ALC output
- Tx 'hang' time set by user
- Ready-made inductors for easy construction and adjustment
- Eurocard-size PCB (10×16 cm)

SITUATED at the low end of the VHF band, the amateur radio frequency segment between 50 and 52 MHz has some very exciting propagation characteristics. Thanks to atmospheric reflection, transcontinental radio contacts using very low powers have been made 'on six'. Radio amateurs working on the VHF and UHF bands know that the reception quality of signals from VHF Band-1 (48-68 MHz) TV transmitters can rise within minutes from very poor to quite acceptable. This often happens in the summer and early autumn, when there are temperature inversions in certain layers of the atmosphere. In the UK, where the VHF-1 band is no longer used for TV broadcast services, it is common practice among VHF radio amateurs to monitor the field strength of certain Dutch and Spanish TV transmitters. First, the syncs are audible, then the pictures seem to arise from the noise. The next thing to do is get the logbook out and the rig ready since it is often only a matter of hours before long periods of sporadic-E reflection enable contacts to be made over distances of hundreds of miles in the 2-m band.

A quite different type of propagation, TEP (trans-equatorial propagation), carries 6-m signals across the oceans, reaching stations thousands of miles away. Contacts have been made between European radio amateurs and stations in Rhodesia, South Africa, Namibia and Brazil, using CW on six metres.

In Europe, equipment for the 6-m band is mostly of the home-brew type, although Japanese 'black box' transceivers are starting to become available. The 6-m band is not crowded, and equipment being mostly experimental with modest transmit power there is a certain distinction in being QRV on six.

From two to six and vice versa

The word transverter is an acronym for transmitter-converter. The circuit described here transposes received signals in the 6-m band to the 2-m band (144-146 MHz; in the USA: 144-148 MHz), while the transmit signal of the 2-m rig is transposed to the 6-m band (50-52 MHz; in the USA: 50-54 MHz). Basically, a transverter is a linear bidirectional mixer connected to an RF input stage and an RF power amplifier. Take a look at the block diagram in Fig. 1. When the transverter is in the receive mode, signals picked up by the 6-m antenna are passed through a filter before they are amplified by T4. Via an electronic RF switch based on p-i-n diodes, the 6-m signal arrives at the LO (local oscillator) input of a mixer. This may appear unusual, but it should be borne in mind that the LO and IF (intermediate frequency) inputs of the mixer are electrically interchangeable.

A local oscillator (LO) chain consisting of a quartz oscillator and two multiplier stages supplies a signal of 94 MHz to the IF input of the mixer. The up-converted 2-m signal is taken from the RF connection, and fed to the 2-m transceiver.

When the 2-m transceiver is switched to transmission, its RF output signal is rectified to control the electronic Tx/Rx (transmit/receive) switch based on T7-T10. The Tx LED lights, and the transverter is switched to

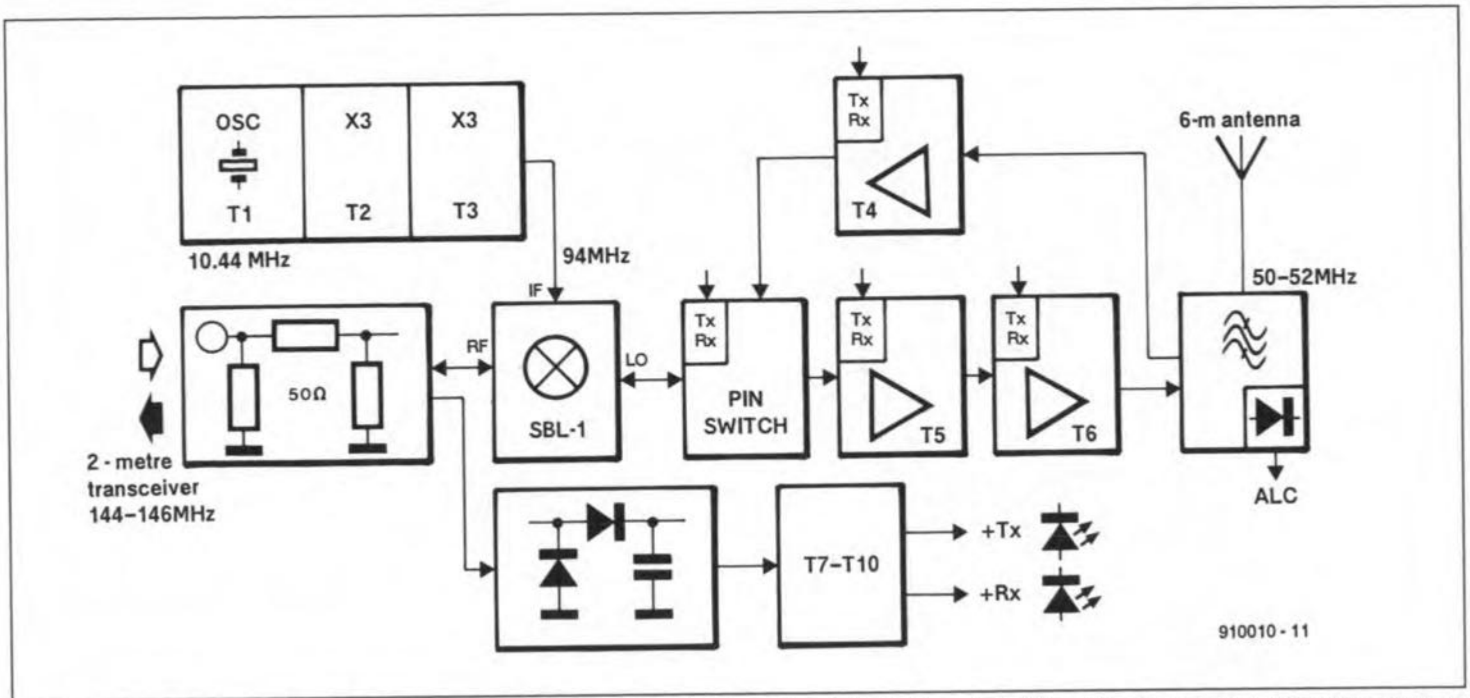


Fig. 1. Block diagram of the 6-m transverter. Not shown here for the sake of clarity is an L-C filter at the transceiver side of the DBM. In receive mode, this section forms a series filter tuned to 144 MHz. In transmit mode, it forms a 50 MHz notch. The switching is effected with a VHF p-i-n diode.

transmit mode. The 2-m signal is first attenuated before it is mixed with the 94 MHz LO signal. The mixer output frequency, 50 MHz (with the 2-m rig tuned to 144 MHz), is fed to the input of an amplifier, T5. Then follow the RF power stage and the antenna filter. A signal rectifier in the output filter provides an ALC function or a simple RF signal level meter that may be used to monitor the transverter's output power. The 'hang' time of the Tx/Rx switcher may be adapted by the user to individual requirements.

The input and output impedance of the transverter are 50 Ω. The circuit is powered from a 12-V supply, which makes it suitable for mobile use.

Look: no relays!

The circuit diagram of the transverter, Fig. 2, follows the block schematic quite closely. At the heart of the circuit is a Type SBL-1 double-balanced mixer (DBM) from Mini Circuits Laboratories. This is a 7-dBm-LO, 1-dB-RF DBM for use up to 500 MHz. The SBL-1 is familiar to most VHF radio amateurs as it is used in many home made converters and transverters. An equivalent of the SBL-1, the IE500, may also be used in this circuit. An excellent discussion of DBM operation and selection criteria is given in Ref. 1.

Receive mode

Let's assume that the transverter is in the receive mode, and start the description of the circuit diagram with the 94-MHz local oscillator chain. In the lower left-hand corner of the diagram we see a Colpitts-type quartz oscillator based on T1 and a 10.44 MHz quartz crystal, X1. The oscillator operates with the crystal resonating at its fundamental frequency. An overtone oscillator running at 94 MHz was found less suitable here in view of the required stability and tuning capability. The output signal of the oscillator is multiplied by three to give 31.32 MHz at the collector of T2. A further tripler, T3, supplies the LO end frequency of 94 MHz at a power of about 10 mW. Via a short length of 50-Ω coax, the LO signal is fed to the SBL-1 (Mix1) which mixes it with the 50 MHz signal supplied by the receive amplifier, MOSFET T4.

Since the Rx supply line is at about +11 V, diode D4 is forward biased, while its Tx counterpart, D5, blocks. This 2-way p-i-n switch provides a high degree of RF isolation between the output of the receive amplifier, T4, and the output of the transmit amplifier, T5, ensuring that the switched-off circuit does not load the active circuit.

The RF signal picked up by the 6-m antenna is taken through a 50 MHz bandpass filter before it arrives at the G1 (gate-1) terminal of T4. The two antiparallel diodes, D1 and D2, form a clamping circuit that protects the MOSFET input and at the same time function in the Tx/Rx switching (remember, the RF power transistor, T6, is switched off because the +Tx supply line is at virtually 0 V). The amplifier based on T4 guarantees excellent sensitivity in the 6-m band, and has ample gain to compensate the mixing loss in the DBM. At the output of the receive amplifier, C31 forms part of a matching network that works in the both the transmit and the receive mode, while components R21 and C30 are used to bias the p-i-n diode.

The 94 MHz LO signal mixed with the amplified 50 MHz signal yields 144 MHz at the RF connection of the DBM. The 144-MHz signal is filtered by a series *L-C* network, C48-C49-L18 to bypass the transmit attenuator, before it is fed to the input of the 2-m transceiver.

Transmit mode

When the 2-m transceiver is switched to transmission, its RF output signal is rectified by D9-D10-C47. Consequently, transistor T8 is turned off so that T10 is turned on. The Tx LED lights, and the Tx supply line in the circuit is at about 11 V, while the +Rx line is at about 0 V. The +Tx voltage causes p-i-n diode D11 to conduct, which detunes the *L-C* series network and causes it to act as a 50-MHz notch. The 144-MHz CW or SSB signal is applied to a 50-Ω dummy load and attenuated by R32-R33 to give a suitable driving level for the DBM. Since the LO signal is permanently present, the IF connection of the DBM supplies the heterodyne frequency of 50 MHz. Diode D5 conducts, and the mixer output signal is applied to an amplifier stage based on MOSFET T5. This driver supplies an output power of about 40 mW to the RF power transistor, T6. The MRF237 used in this position is a VHF power transistor from Motorola. To ensure that the device operates linearly, its quiescent current is set to about 75 mA. The RF stage has an output power of up to 1.5 W, depending on cooling and the transistor characteristics. The quiescent current can be measured as a voltage across the 10-Ω supply resistor, R25. The typical voltage on R25 will be around 1 V.

A twelve-pole pi-type elliptical low-pass filter based on adjustable inductors is inserted between the RF amplifiers and the antenna connection. This filter has an additional notch, L15-C40, to trap the second harmonic (100 MHz).

The diode detector based on D7 and D8 may be used for output power level monitoring, adjustments or ALC (automatic level control) applications. The latter function however requires the two diodes to be reversed. The output may also be used to provide a basic RF power indication. The transverter has ample output power to drive a 6-m linear amplifier. The use of high power in the 6-m band is not advocated, however,

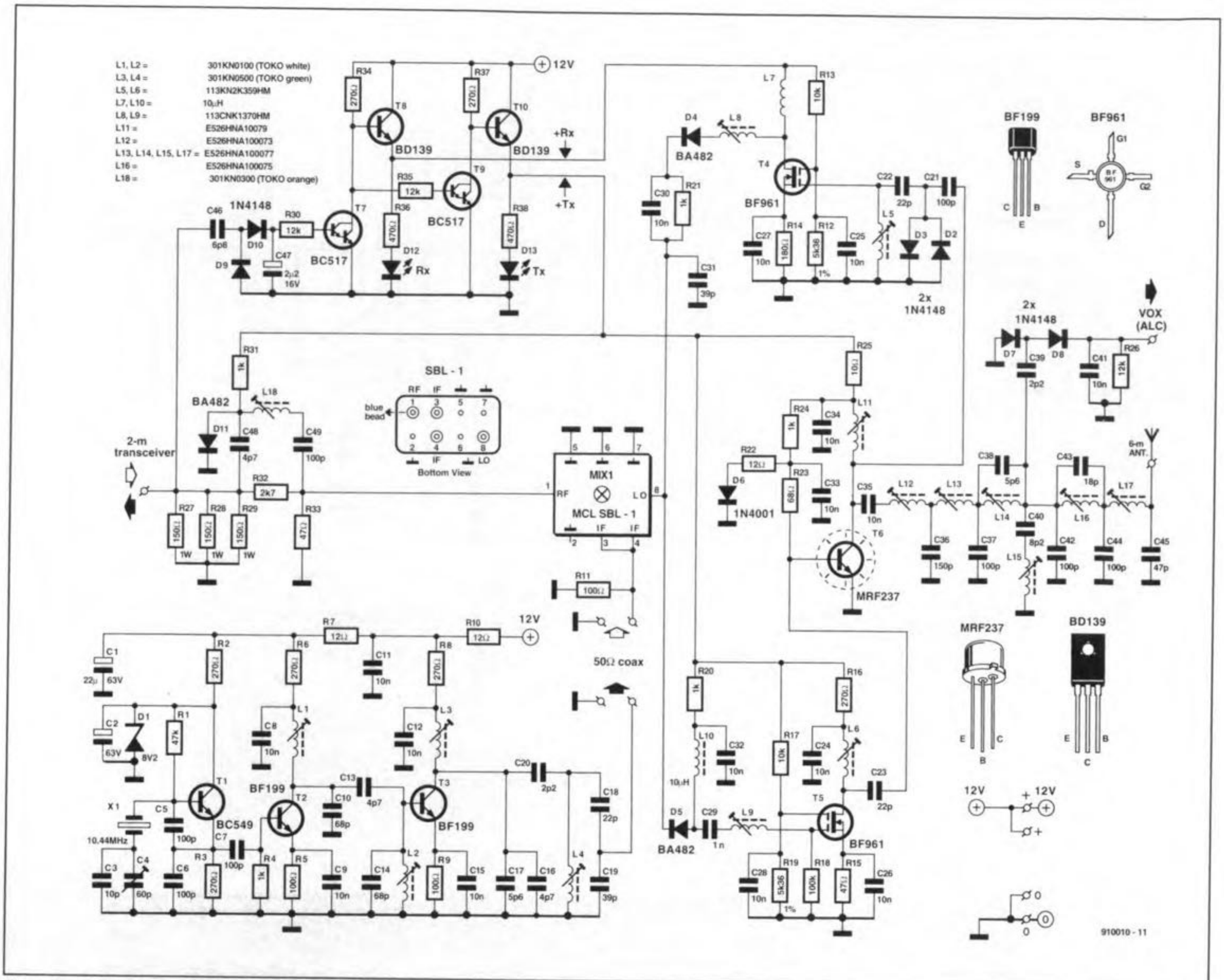


Fig. 2. Circuit diagram of the 6-m transverter.

and constructors should observe the maximum permissible EIRP level stated in their license. In practice, the 1.5 to 2 watts or so furnished by the transverter will scrape the EIRP limits when a directional antenna is used, say, a five-element yagi with 10 dB gain. Do not spoil the experimental character of the 6 m band by using excessively high power levels. QRP is much more fun!

Tx/Rx switching

It will be noted that the circuit is totally solid-state, i.e., the dreaded transmit/receive relay does not come into play. All Tx/Rx switching is performed by p-i-n diodes, whose short response time allows the transverter to be used for Packet Radio and Amtor, where Tx/Rx switching is computer-controlled. Note, however, that your licence may not allow these communication modes on six. The 'hang time' of the electronic Tx/Rx switch is determined by the 2.2 μF capacitor, C47. You may want to change this value to meet your individual requirements.

Construction

The transverter is best built on the double-sided printed circuit board shown in Fig. 3. The complete circuit is accommodated on this Eurocard-size (10×16 cm) board which has a pre-tinned copper ground plane at the component side to ensure screening and decoupling of the RF signals. Since ready-made inductors are used, the construction is really quite straightforward. A few points must be noted, though.

Start by fitting the capacitors, resistors and diodes. All parts must be fitted with the shortest possible terminal length. Grounded component terminals must be soldered to the ground palne at the component side of the PCB. Proceed with mounting the RF power transistor, T6. Experienced constructors may solder the case of this transistor flush to the copper screen at the component side of the board (see Fig. 4). If you are less confident of your construction skills, push the transistor firmly on the PCB surface, and solder the three terminals at the track side only. Remember that the case of the MRF237 is connected to the emitter, so that any direct contact between it and the ground plane is perfectly all right. Soldering the MRF237 to the board makes for minimum stray capacitance and optimum cooling, which helps to ensure the stability of the RF power stage. Carefully remove the solder resist mask locally with a sharp knife. Next, pretin the area. Remove excess solder and solder resin with the aid of desoldering braid and alcohol. Push the transistor firmly in place, and solder the rim on the case to the pretinned area. Solder as quickly as you can, and go all around the case. The solder joint should be smooth. If you have reason to believe that your solder iron is not powerful enough to do this job quickly, pre-heat the transistor with the solder bit until it is so hot that you can just pick it up and fit it on the board. The MRF237 **must** be fitted with a heat-sink, preferably of the type shown in the photograph of the prototype. **Never** test the transverter without a heatsink fitted on the MRF237: the destruction of this fairly expensive device will be imminent.

Fit the mixer on the board, noting its orientation from the circuit diagram and the indication on the component overlay. Push the device flat on the PCB surface, and solder all eight pins at the track side.

Next, mount the inductors. There are quite a few, and the type numbers can be confusing, so make sure you fit each of them in the right position. The screening cans are soldered to ground.

The last components to be mounted are

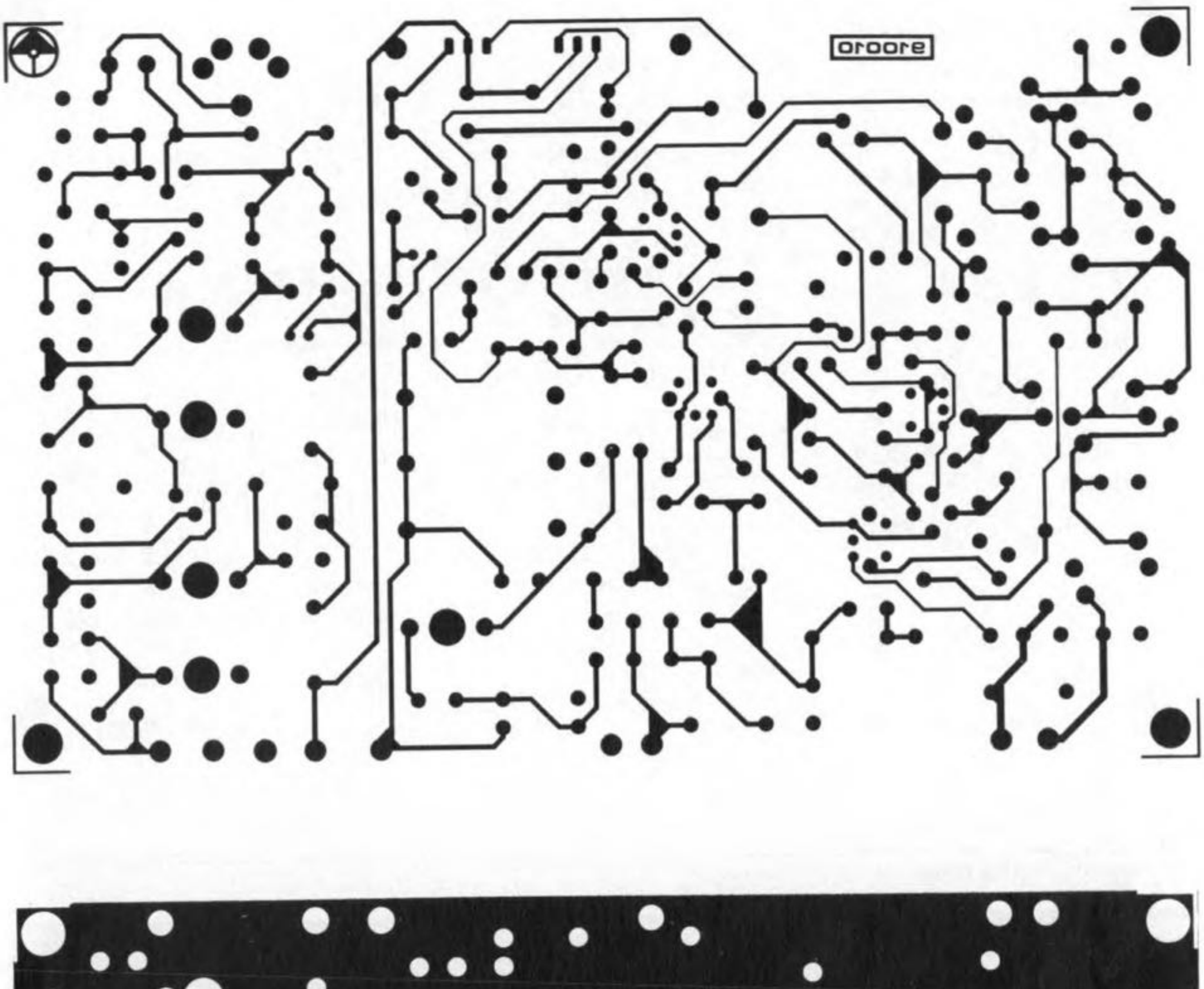


Fig. 3a. Double-sided printed-circuit board for the transverter.

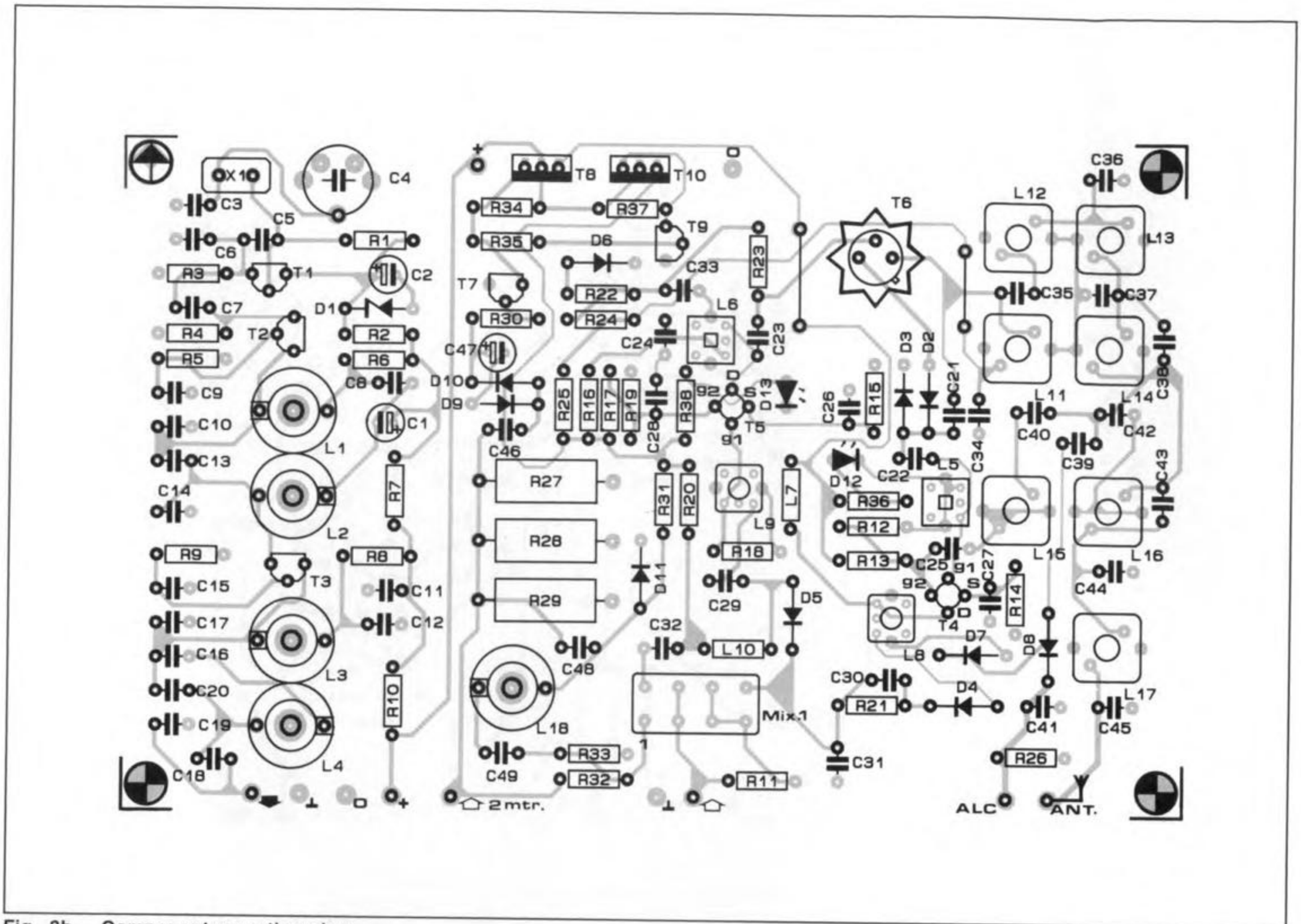


Fig. 3b. Component mounting plan.

COMPONENTS LIST

Resistors:

1	47kΩ	R1
5	270Ω	R2;R3;R6;R8; R16
2	270Ω 0.5W	R34;R37
5	1kΩ	R4;R20;R21;R24; R31
3	100Ω	R5;R9;R11
3	12Ω	R7;R10;R22
2	5kΩ36 1%	R12;R19
2	10kΩ	R13;R17
3	150Ω 1W	R27;R28;R29
2	47Ω	R15;R33
1	100kΩ	R18
1	68Ω	R23
1	10Ω	R25
3	12kΩ	R26;R30;R35
1	180Ω	R14
1	2kΩ7	R32
2	470Ω	R36;R38

Capacitors:

1	2µF2 25V tantalum	C2
1	22µF 63V radial	C1
1	2µF2 16V radial	C47
1	60pF trimmer	C4

Ceramic capacitors:

1	10pF	C3
8	100pF	C5;C6;C7;C21; C37;C42;C44;C49
16	10nF	C8;C9;C11;C12; C15;C24-C28; C30;C32-C35;C41
2	68pF	C10;C14
3	4pF7	C13;C16;C48
2	5pF6	C17;C38
3	22pF	C18;C22;C23
2	39pF	C19;C31
2	2pF2	C20;C39
1	1nF	C29
1	150pF	C36
1	8pF2	C40
1	18pF	C43
1	47pF	C45
1	6pF8	C46

Inductors:

2	301KN0100 (white)	L1;L2
2	301KN0500 (green)	L3;L4
2	113KN2K359HM	L5;L6
2	10µH choke	L7;L10
2	113CNK1370HM	L8;L9
1	E526HNA100079	L11
1	E526HNA100073	L12
4	E526HNA100077	L13;L14;L15;L17
1	E526HNA100075	L16
1	301KN0300 (orange)	L18

(All inductors from Toko Inc.)

Semiconductors:

1	8V2 0.4W zener diode	D1
6	1N4148	D2;D3;D7-D10
3	BA482	D4;D5;D11
1	1N4001	D6
1	green LED	D12
1	BC549	T1
2	BF199	T2;T3
2	BF961	T4;T5
1	MRF237 (Motorola)	T6
2	BC517	T7;T9
2	BD139	T8;T10
1	red LED	D13
1	SBL-1 (Mini Circuits Laboratories)	Mix1

Miscellaneous:

1	10.444 MHz quartz crystal	X1
1	heatsink TO-39 style for T6; length 25 mm	
1	printed-circuit board	910010

Coax cable RG174/U

Note:

The author can supply a number of components for the transverter, including the DBM (IE500 or SBL-1), the 10.444 MHz quartz crystal and all inductors. For further information, contact

Pedro Wyns ON4AWQ, Mechelsesteenweg 13, 2220 Heist-op-den-Berg, Belgium.

The majority of components for the transverter are available from

Bonex Ltd, 12 Elder Way, Langley Business Park, Slough, Berkshire SL3 6EP. Telephone: (0753) 49502, fax: (0753) 43812.

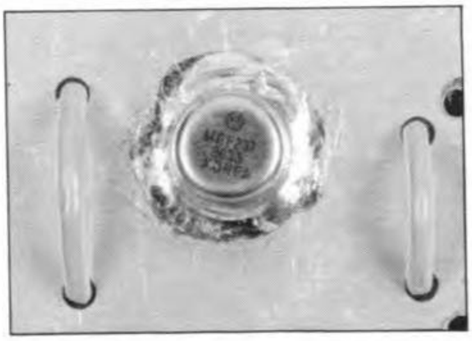


Fig. 4. Not for the faint-hearted: soldering the case of the MRF237 straight to the PCB ground plane.

the transistors. While the BF199s, BC517s and BD139s will pose little problems, pay attention to the MOSFETs. Do not remove the BF961s from their protective packaging until they are due for mounting. Aluminium kitchen foil is fine for storing these devices. Leave them on the foil while you run a thin, short wire around the transistor body, connecting the four terminals. Next, bend the terminals as required, and insert them in the PCB holes. **Check the orientation of the MOSFETs: the terminal with the tab at one side is the source. Also note that T4 is fitted upside down, i.e., its type indication faces the PCB.** Solder the terminals of the MOSFET before removing the shorting wire.

Inspect the board carefully for incorrectly fitted parts and bad solder joints. Next, connect a short piece of RG174U (dia. 3 mm) coax cable between the output of the LO chain and the IF input of the mixer. Two pairs of solder terminals are available for this connection. Finally, note that the local oscillator section of the board may be cut off to function as a separate module.

The completed board (see Fig. 5) is fitted in a metal enclosure. The size of our prototype is 200×150×70 mm (W×D×H). The Tx and Rx indicator LEDs are best fitted on the front panel, with short wires connecting them to the board. UHF-style (Amphenol SO-239) sockets are used for the 2-m and 6-m connections. Use short lengths of RG58 or similar 50-Ω coax cable to connect the sockets to the appropriate PCB terminals. The screening must be connected at both ends of the cable. At the side of the socket, this means that you may have to use a solder lug.

The power supply is best connected via a chassis-mount plug of the type used on mobile transceivers. These plugs have two insulated pins, and connect to a screw-type cable socket. Both items are commonly available as spare parts from amateur radio retailers. It is recommended to insert a 2.5 A fuse in the positive supply line to the transverter.

The ALC output is optional, and since there appears to be no standard for this connection, any suitable combination of a plug and a socket may be used to carry the signal to other equipment.

Adjustment

The transverter is adjusted in steps as described below. First, however, build the RF signal detector shown in Fig. 6. This circuit is used to probe the RF signal levels at various locations in the circuit. The moving-coil meter may, of course, be formed by your multimeter set to the most sensitive current range. The preset in the detector, P1, is adjusted depending on the signal level measured. To adjust the inductor cores, you will also require a gate dip meter and a plastic Allen key. **Never** use a screwdriver or a metal Allen key to adjust the inductor cores.

Local oscillator chain adjustment

1. Connect the probe to the hot side of R4 (1 kΩ), and check for oscillator activity.

2. Tune the gate dipper to 31 MHz, hold it close to L1, and adjust the inductor for maximum reading.

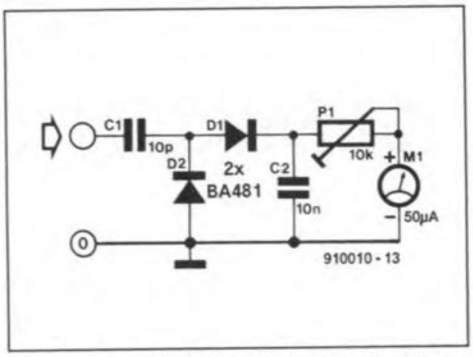


Fig. 6. Circuit diagram of a simple RF signal level meter used during the adjustment of the transverter.

3. Tune the gate dipper to 94 MHz, hold it close to L3, and adjust L2 and L3 for maximum reading.

4. Repeat steps 2 and 3.

5. Connect the RF probe to the hot side of R11 (100 Ω).

6. Adjust L3 and L4 for maximum reading. Check that the LO frequency is 94.00 MHz. If not, adjust C6.

Tx chain adjustment

7. The green LED (Rx) should light. Short the collector of T7 (BC517) to ground. The green LED goes out, and the red LED (Tx) comes on. Measure the voltage across R25 (10 Ω). This should be between 0.75 and 1 V. Remove the core from L9.

8. Connect a dummy load/power meter or an antenna to the 6-m output. Apply a continuous power of 100 to 500 mW to the 2-m input.

9. Adjust inductor L6 for maximum output power.

10. Adjust inductors L11, L12, L13, L14, L16 and L17 for maximum output power. Repeat steps 9 and 10.

11. Adjust inductor L15 for minimum signal at 94 MHz (use an FM radio for this adjustment).

Rx chain adjustment

12. Remove the short at the collector of T7. Connect an RF signal source to the 6-m input. Alternatively, ask a nearby ham to transmit a test signal on six. Tune the 2-m receiver to the test signal. Adjust L5, L8 and L18 for best reception. If necessary, gradually reduce the level of the test signal.

This completes the adjustment of the 6-m converter. The absolute maximum 2-m input power to the transverter is 5 W. In most cases, however, the maximum output power of about 2 W will be achieved with 2.5 W or less on 2 m. Switch the 2-m transceiver to SSB or CW, connect your 6-m antenna, and away you go. You are now QRV on six! International calling frequency: 50.110 MHz. ■

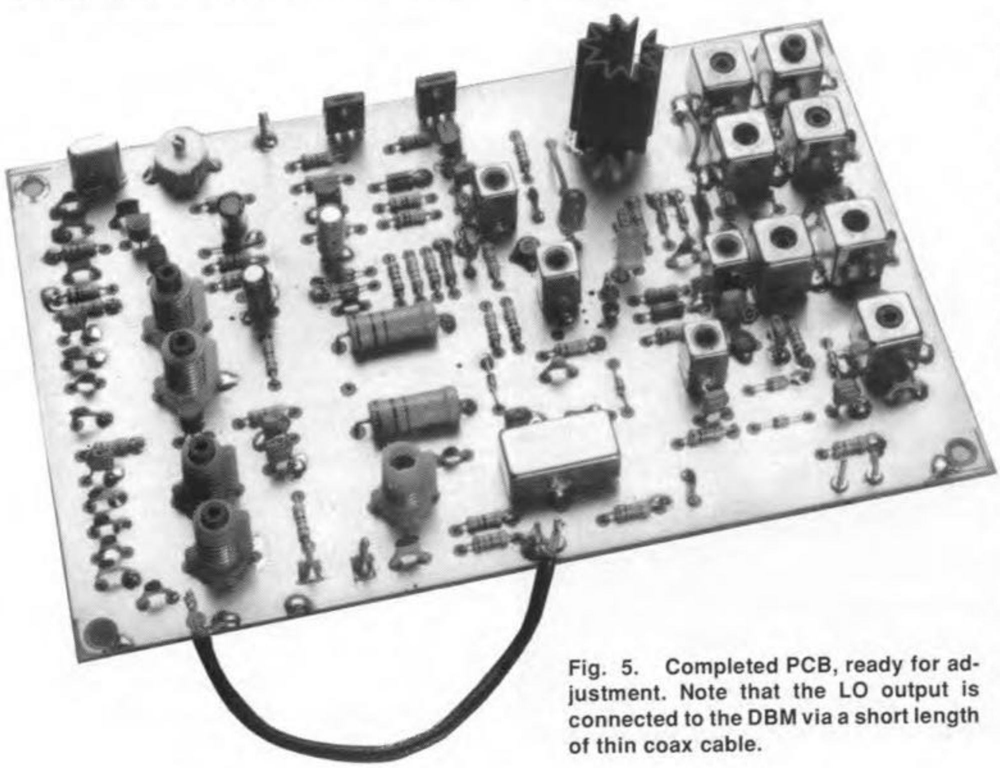


Fig. 5. Completed PCB, ready for adjustment. Note that the LO output is connected to the DBM via a short length of thin coax cable.

Reference:

1. RF/IF signal processing handbook. Published by Mini Circuits Laboratories, P.O. Box 166, Brooklyn, New York, U.S.A.

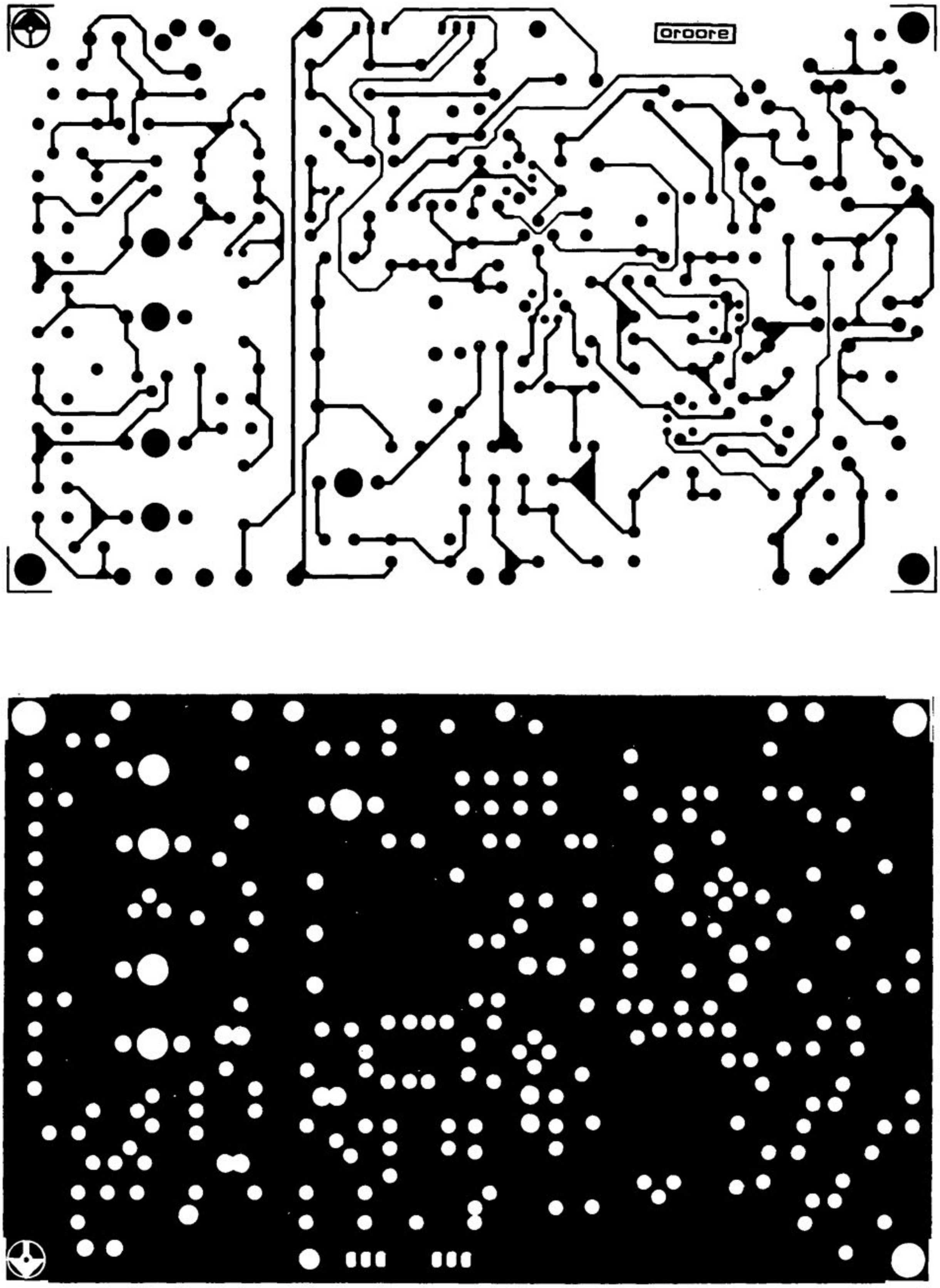


Fig. 3a. Double-sided printed-circuit board for the transverter.

CORRECTIONS

6-metre band converter

April 1991, p. 38-43

The components list and the inductor overview in the top left hand corner of the circuit diagram should be corrected to read:

L1, L2 = 301KN0800.

Capacitor C16 (4.7 pF) must not be fitted on the board.

Finally, a few constructional tips:

- Fit a 10 nF ceramic decoupling capacitor at junction L7-R36.
- Fit a 18 kΩ resistor between the base of T3 and ground. This reduces the Q factor of L2, and prevents too high signal levels at the base of T3.
- For improved tuning, inductor L9 may be replaced by a Toko Type 113KN2K1026HM.

Multifunction measurement card for PCs

January and February 1991

We understand that the 79L08 (IC17) is no longer manufactured and, therefore, difficult to obtain. Here, the IC may be replaced by a 7908, which, although physically larger than the 79L08, is pin-compatible, and should fit on the PCB.

Dimmer for halogen lights

April 1991, p. 54-58

In the circuit diagram of the transmitter, Fig. 2, pin 14 of the MV500 should be shown connected to pin 13, not to junction R1-R2-C2. The relevant printed-circuit board (Fig. 6) is all right.

RDS decoder

February 1991, p. 59

Line A0 between the 80C32 control board and the LC display is not used to reset the display, but to select between registers and data.

We understand that the SAF7579T and the associated 4.332 MHz quartz crystal are difficult to obtain through Philips Components distributors. These parts are available from C-I Electronics, P.O. Box 22089, 6360 AB Nuth, Holland. For prices and ordering information see C-I's advertisement on page 6 of the May 1991 issue.

S-VHS-to-RGB converter

October 1990, p. 35-40

Relays Re1 and Re2 must be types with a coil voltage of 5 V, not 12 V as indicated in the components list. Constructors who have already used 12-V relays may connect the coils in parallel rather than in series.

Suitable 5-V relays for this project are the 3573-1231.051 from Günther, and the V23100-V4305-C000 from Siemens.

The components list should me modified to read:

6	33nF	C57-C62

PC-CONTROLLED SEMICONDUCTOR TESTER PC-TT 90

PART 2: CIRCUIT DESCRIPTION, CONSTRUCTION AND SETTING UP

Continued from the March 1991 issue

On-board power supply

The circuit diagram of the power supply, Fig. 19, shows that the semiconductor tester has an on-board step-up voltage converter that is powered from the 12-V supply in the PC. The 5-V supply of the PC is also used to power certain parts of the circuit. The 12-V supply of the PC is connected to a step-up converter via a 4-way connector as used for floppy disks and hard disks. The current requirement of the 12-V input is about 2.2 A. If this current is not available in your PC, it is still possible to use the semiconductor tester with a correspondingly reduced maximum collector current for the device under test. The input current of the voltage doubler in the power supply is about 2.2 times the output current. Hence the 2.2 A input current requirement if a maximum collector current of 1 A is to be achieved. The quiescent current drawn by the power supply is about 150 mA.

The power supply is essentially a switch-mode circuit based on a dedicated controller Type UC3524A, IC1, and two power MOSFETs, T1 and T2. The MOSFETs are connected to a ferrite transformer, Tr1, which doubles the input voltage to 24 V, and in addition provides a floating 15-V output. The

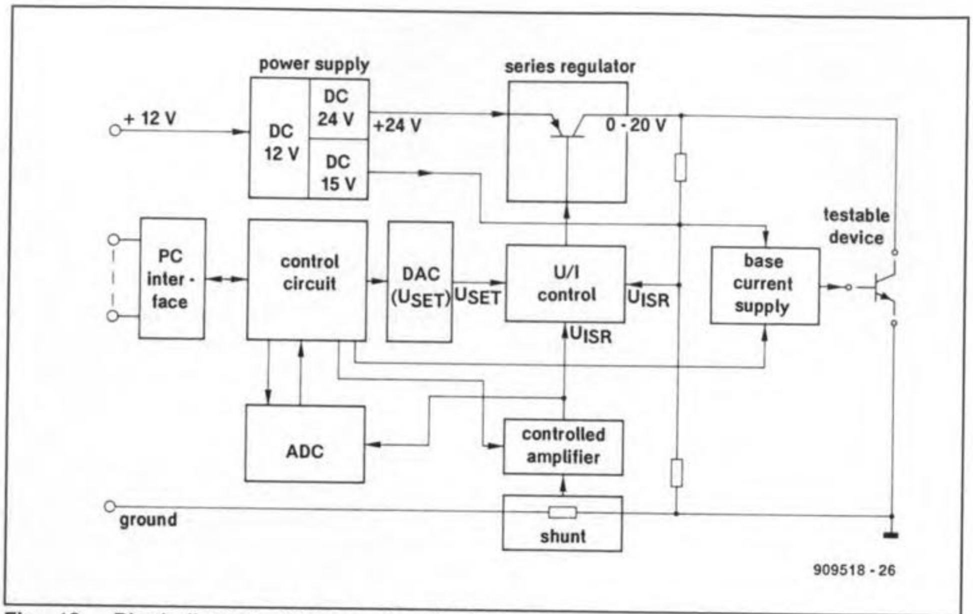
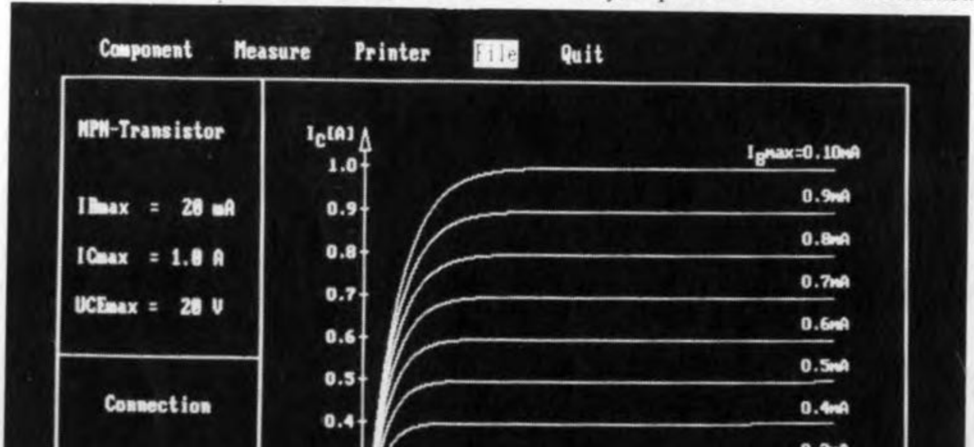


Fig. 18. Block diagram of the semiconductor tester.

15-V output of the transformer is rectified and smoothed by diodes D4-D5 and capacitor C8. Next, the rectified voltage is stabilized at 15 V by a Type 7815 fixed voltage regulator. The floating 15-V supply is used for the base voltage generator, which must operate potential-free, that is, at a potential that can not be measured with respect to ground.

Finally, capacitors C11-C24 are included for stabilization, decoupling and noise suppression.



Main circuit

Figure 20 shows the circuit diagram of the main digital and analogue sections of the semiconductor tester. The PC bus interface is shown in the top left-hand corner of the diagram. Data lines D0 to D7 (bus contacts A02 to A09) are connected to bidirectional bus driver IC10, a 74LS245, which forms the data link between the PC and the insertion card. Address lines A0 and A1 (bus contacts A30 and A31) drive inputs A and B of the two binary-to-decimal decoders contained in IC11. These two decoders control the operation of the various bus drivers. Bus signals $\overline{IOWC}$ and $\overline{IORC}$ (bus contacts B13 and B14) drive the enable inputs of IC11 via IC9C and IC9D.

The RESET line (bus contact B02) has an important function in the circuit because it ensures that all relays are de-actuated when the PC is switched on, preventing undefined switch configurations and short-circuits on power-up.

Address lines A2 to A9 (bus contacts A22 to A29), together with the address enable line, AEN (bus contact A11), are connected to an address decoder based on IC12, a Type 74LS688. The insertion card is normally addressed at I/O location 300_H, but may be given a different address by changing the setting of the 8-way DIL switch. Details on the address setting of the card are given in the READ.ME documentation file on the floppy disk supplied with the kit.

The digital control information supplied by the PC is latched and distributed by IC14, IC15 and IC16. Circuits IC14 and IC15 have direct control over relays Re1 to Re10, while IC14 additionally controls the switch for the range selection in the current measurement circuit. IC16 forms the interface between the PC and optocouplers IC18 to IC21.

The input data of bus driver IC13 is supplied by outputs Q6, Q7 and Q8 of IC6, by R35, which provides the current protection information supplied by IC6C, and by the $\overline{INTR}$ output of the A-to-D converter.

As already noted in the introductory instalment of this article, the collector-emitter voltage of a device under test rises in the range 0 to 20 V. This voltage is supplied by T3, a power transistor Type BD250C, which is driven via transistor T4 and opamp IC6A. The output voltage is applied to the input of the opamp, pin 3, via a potential divider consisting of R30, R110 and IC6B. In this arrangement, IC6B merely forms a differential amplifier that serves to shift the reference potential from output terminal ST5 to ground.

The set (i.e. required) output voltage is applied to pin 2 of IC6A via R25 and electronic switch IC17A. The PC supplies the set voltage in digital form to inputs D0 to D7 of DAC (digital-to-analogue converter) IC3. Depending on the value of the dataword sent to the DAC via the PC interface, a voltage between 0 and −2.55 V is available at pin 6 of buffer opamp IC5.

With switch IC17A set to the position shown in the circuit diagram, R25 feeds the ADC (analogue-to-digital converter) output voltage to the voltage control opamp, IC6A. The subsequent voltage amplifier based on transistors T3 and T4 supplies an output voltage of 0 to 20.45 V at terminals ST3-ST5. When IC17A is set to the other position, the control voltage is reduced by potential divider R27-R28. This is done to increase the resolution of the output voltage in the lower range. A control voltage of −2.55 V at pin 6 of IC5 results in an output voltage of +3.6 V at ST3-ST5.

The collector current of the device under test is measured with the aid of series resistor R54 inserted into the supply line. Resistor R43 feeds the voltage drop across R54 to pin 3 of a low-drift opamp Type TLC271, IC7. In the feedback circuit of this opamp we find resistor R41, while the ground path consists of switch IC8 and either one or two of 11 resistors R44 to R53 plus R108. The resistor selection is accomplished by IC8, whose internal resistance may be ignored as it is very small with respect to the resistor values. In this set-up, the amplification of IC7 can be set to a number of fixed values between 2 and 200. The control information required for the gain selection is supplied by latch IC14 to the control inputs, A, B and C, of IC8.

At the maximum output current of 1 A, R54 drops exactly 1 V. This results in 2 V at the output, pin 5, of IC6. In the most sensitive measurement range, 10 mA, R54 drops a maximum of 10 mV. This also results in a maximum of 2.0 V at the output of IC6 because the gain of IC7 is then set to 200.

The measured and subsequently amplified voltage is fed to the input, pin 6, of the 8-bit ADC, which converts the input voltage range of 0 to 2 V into a corresponding digital value that can be processed by the PC.

The reference voltages used in the circuit are derived from a Type 7805 fixed voltage regulator, IC29. Resistors R14-R17 and R20 supply a reference of 2.55 V for the DAC, and 1.0 V for the ADC.

The current measurement circuit has a built-in electronic fuse based on IC6C. Pin 13 of this opamp is held at a reference level of 2.25 V, while the other input, pin 12, is at a voltage proportional to the measured current. Since this voltage is supplied by IC7, the full-scale value is 2 V. When this value is exceeded by about 10%, the output of IC6C changes from low to high, causing transistor T5 to conduct. As a result, T4 switches off the current amplifier, T3, so that the output current is interrupted, preventing damage to the device under test. Diode D7 provides a hold function for the actuated electronic fuse. The output current remains off until the PC clears the hold condition by opening

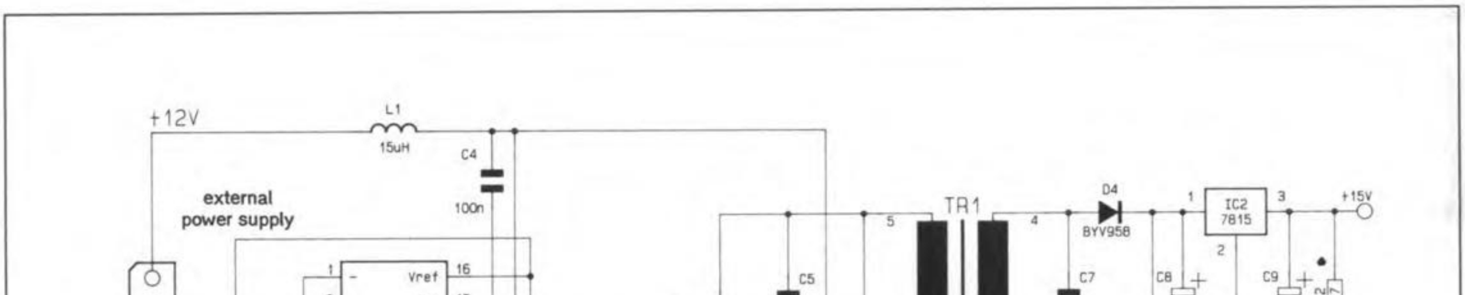


Fig. 19. Circuit diagram of the power supply section.

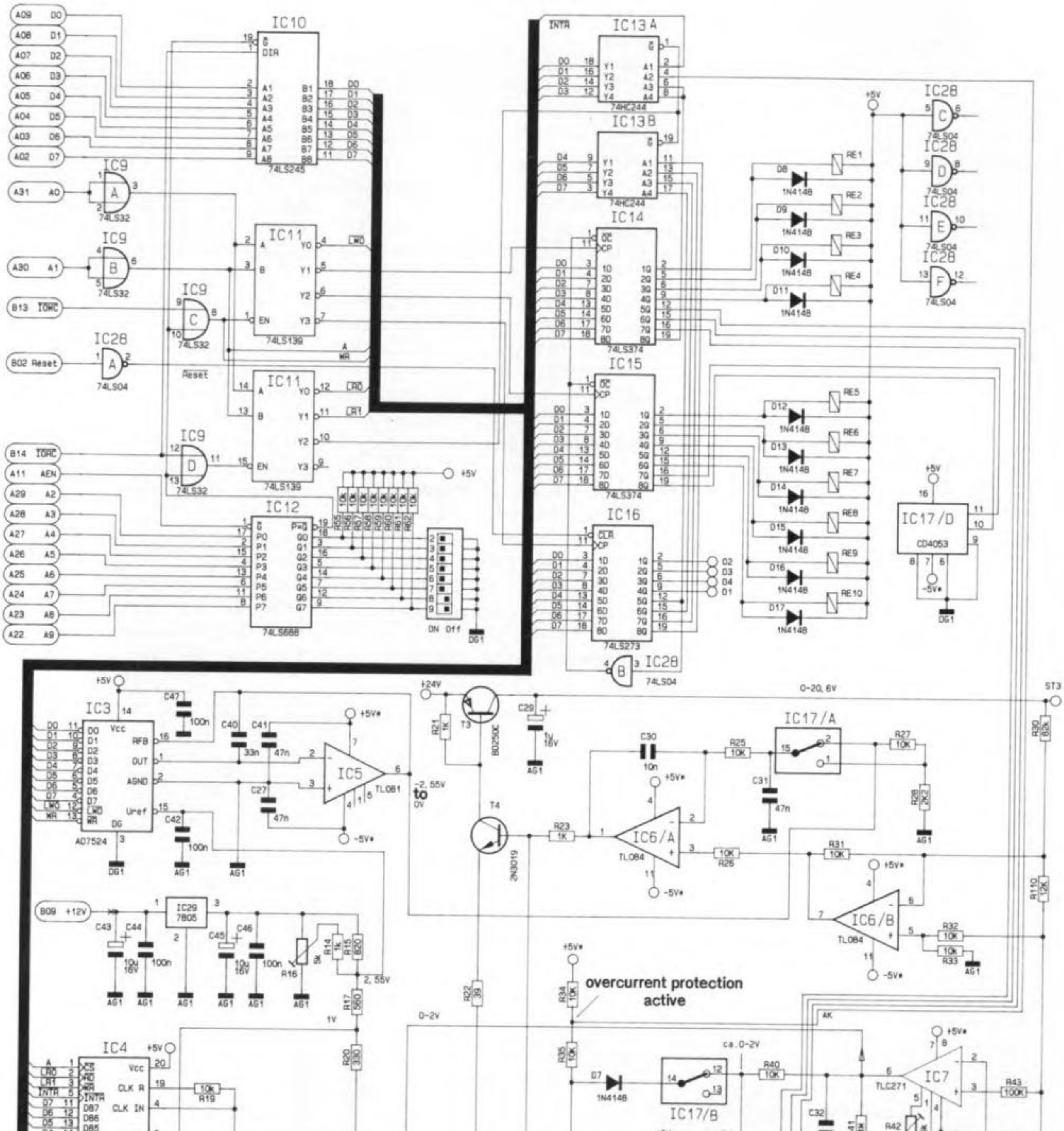


Fig. 20. Circuit diagram of the PC I/O interface, the relay control logic, and the variable-gain measurement amplifier.

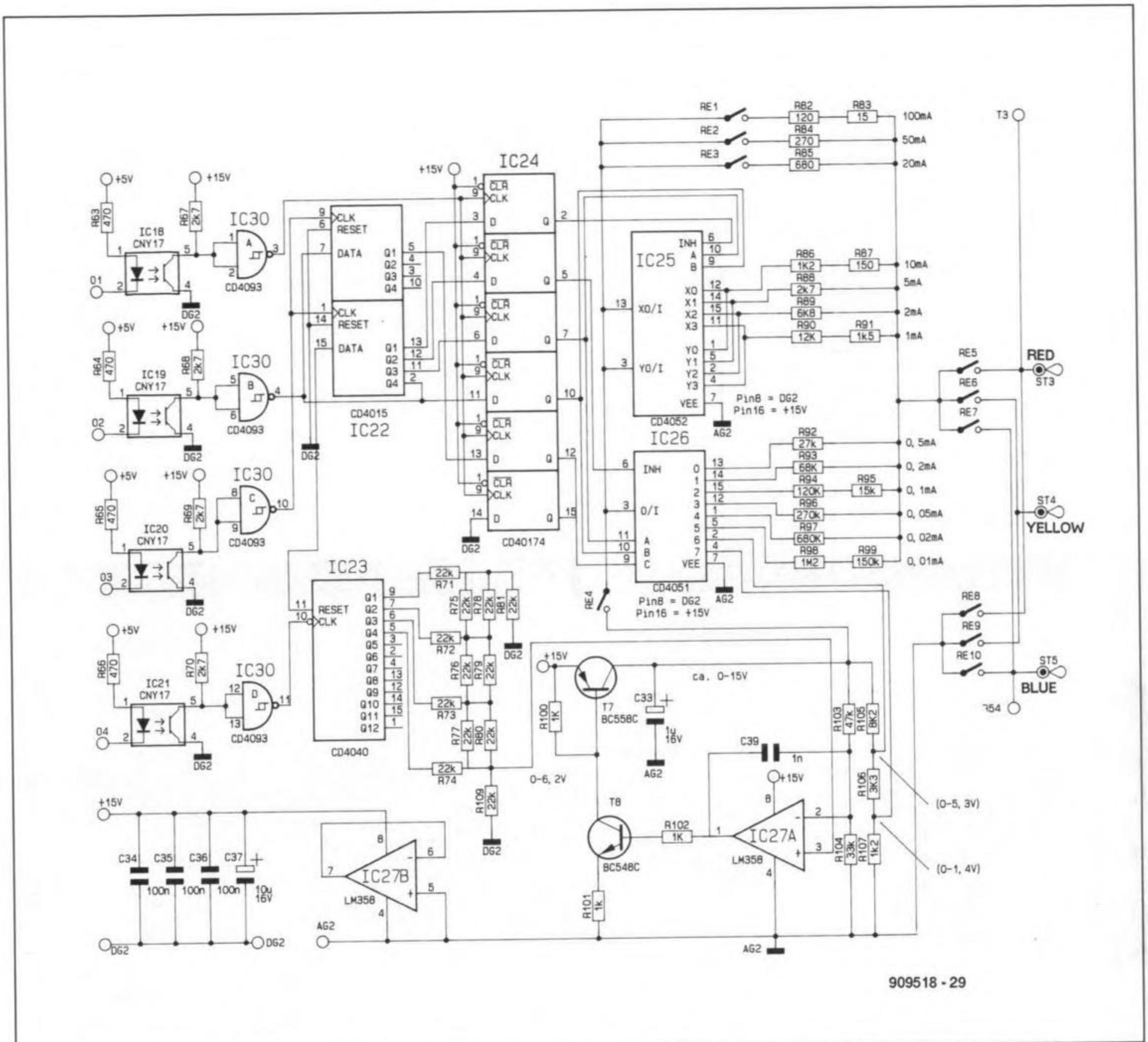


Fig. 21. Circuit diagram of the PC-controlled base current supply. Note that the 15-V supply for this circuit floats with respect to ground.

switch IC17B. The overcurrent condition is signalled to the PC via potential divider R34-R35 and opamp IC13A.

The base current supply

Since the base current of the device under test is either positive or negative, it is supplied with reference to the positive collector-emitter voltage terminal, ST3, or to the negative terminal, ST5. This means that the base current supply must float with respect to ground — hence the separate 15-V section in the power supply discussed earlier.

As shown in the circuit diagram in Fig. 21, an electronic regulator based on IC27A, T8 and T7 supplies an output voltage between 0 and 15 V, adjustable in 10 steps of 1.5 V. The required output voltage of the regulator is supplied by a DAC based on IC23 and a resistor ladder network, R71-R81 and R109. The clock input of IC23 receives the required output voltage in digital form via optocoupler IC21. Following a reset (via pin 11 and IC19), the first clock pulse that arrives via the optocoupler sets an output voltage of 1.5 V. Every clock pulse increases the output voltage of the resistor network by 1.5 V, until the maximum value of 15 V is reached.

Relay Re4 takes the required output voltage (at the collector of T7) to the switches contained in IC25 and IC26, and to the contacts of relays Re1, Re2 and Re3. Next, resistors R82-R99 convert the output voltage of the regulator into a proportional base current for the device under test. When, for example, the contact of Re1 is closed, a regulator output voltage of 15 V corresponds to a base current of 100 mA, and one of 1.5 V to 10 mA. Smaller base currents, starting at 1 µA and up to 10 µA, are generated in a similar manner. The total number of available base currents is 130.

The previously mentioned reference terminal, ST3 or ST5, is selected with the aid of two relay clusters, Re5-Re6-Re7 and Re8-Re9-Re10.

The base current supply is also capable of generating a gate voltage for the testing of FETs. This is achieved by opening the contact of Re4, so that the collector voltage of T7, reduced by R105-R107, is fed to the relevant test terminal via electronic switch IC26 (from pin 2 or pin 4 to pin 3) and relay Re1.

The PC determines which switch, IC25 or IC26, is actuated. This selection is effected via optocouplers to ensure that the base current supply floats with respect to ground. The actual selection is carried out by means of clock pulses. Five pulses are applied to the two inputs of 8-bit shift register IC22, a Type 4015. Each clock pulse causes the relevant data level to be loaded. After the fifth clock pulse, IC24 receives a latch pulse from IC18. This pulse enables IC24 to copy the 5-bit wide dataword supplied by IC22. The outputs of IC24, pins 2, 5, 7, 10, and 12, then drive the output multiplexers, IC25 and IC26.

Construction

All circuits discussed so far are accommodated on a single, double-sided and through-plated printed-circuit board. The size of this board is approximately 337 × 100 mm, to which 8 mm must be added for the bus contact area.

Before assembling the kit, it is recommended to read this entire section. This will help you keep a few points in mind that require special attention.

The construction of the printed-circuit board follows the component mounting plan printed on the PCB and shown separately in Fig. 22. Start with fitting the low-profile parts, followed by the higher parts, and solder each of these at the solder side of the board. Soldering at the component side is not required since the board is through-plated. During the construction, pay attention to the following points:

1. Transistors T1 and T2, and voltage regulator IC29 are fitted horizontally on to the board, without heatsinks, and without screws to secure them.

2. The output transistor, T3 (a BD250C) and the positive voltage regulator IC2 (a 7815) are also fitted horizontally. Both components are, however, secured to the board by means of an M3×6 mm screw and a single M3 nut. The tinned copper PCB surface underneath these components has no solder resist mask, and assists in cooling the devices.

3. The ferrite transformer, Tr1, is fitted with the side with terminals 1 and 5 on it pointing to transistors T1 and T2. The terminals marked 6 to 10 point to capacitor C7. Note that although the symmetrical arrangement of its connecting terminals allows the transformer to be fitted the other way around from indicated, this must not be done for electrical reasons.

4. Electrolytic capacitors C6 and C10 must be fitted horizontally.

5. Inductors L1 and L2 are mounted as close as possible to the PCB surface.

6. A total of five wire links must be fitted on the board. The first is about 30 mm long and runs underneath IC13 (a 74HC244) as shown on the component overlay. Use the insulated wire supplied with the kit, and take care to avoid short-circuits with the nearby IC pins. The remaining four wire links have a length between 180 mm and 210 mm. As shown on the photograph of the assembled board, one wire connects the two points marked A, one the two points marked B, one the two points marked C, and one the two points marked D.

7. A part of the circuit has a metal screening box around it. This screening serves to ensure the noise margin of the preamplifier, and surrounds the circuit sections that take care of the voltage setting, the current measurement, and the amplifier gain selection. These functions involve IC6, IC7, IC8 and

COMPONENTS LIST

Resistors:

1	0Ω1 3W	R9
1	1Ω 0.5% 1W	R54
1	15Ω	R83
2	33Ω	R5;R6
1	39Ω	R22
1	56Ω	R4
4	100Ω	R2;R3;R10;R11
2	120Ω	R82;R107
1	150Ω	R87
4	220Ω	R7;R8;R11;R19
1	270Ω	R84
1	330Ω	R106
4	470Ω	R63-R66
1	680Ω	R85
2	820Ω	R15;R105
8	1kΩ	R13;R14;R17;R21; R23;R24;R100; R102
1	1kΩ2	R86
1	1kΩ5	R91
2	2kΩ2	R28;R117
7	2kΩ7	R1;R12;R67-R70; R88
1	4kΩ7	R101
1	6kΩ8	R89
24	10kΩ	R19;R25;R26;R27; R31-R37;R40;R52; R53;R55-R62; R108;R20
3	12kΩ	R46;R90;R110
6	15kΩ	R39;R95; R113-R116
1	18kΩ	R38
6	22kΩ	R71-R81;R109
1	27kΩ	R92
2	33kΩ	R50;R104
1	47kΩ	R103
1	56kΩ	R112
2	68kΩ	R48;R93
1	82kΩ	R30
2	100kΩ	R43;R47
2	120kΩ	R51;R94
1	150kΩ	R99
1	220kΩ	R49
1	270kΩ	R96
1	330kΩ	R45
1	680kΩ	R97
2	1MΩ	R41;R44
1	1MΩ2	R98
1	500Ω preset V	R118
1	5kΩ preset V	R16
1	25kΩ preset V	R42

Capacitors:

1	10pF	C32
3	100pF	C7;C28;C40
1	1nF	C39
1	2nF2	C5
1	4nF7	C1
1	10nF	C30
2	47nF	C27;C41
1	56nF	C33
7	100nF	C2;C4;C29;C42; C44;C46;C47
15	100nF ceramic	C11-C21;C23;C34; C35;C36
6	10µF 16V	C22;C24;C37;C38; C43;C45
2	10µF 40V	C3;C9
1	47µF 40V	C8
2	1,000µF 40V	C6;C10

Semiconductors:

1	ADC0804	IC4
1	AD7524	IC3
1	UC3524A	IC1
1	74LS04	IC28
1	74LS32	IC9
1	74LS139	IC11
1	74HC244	IC13
1	74LS245	IC10
1	74LS273	IC16
2	74LS374	IC14;IC15
1	74LS688	IC12
1	CD4015	IC22
1	CD4040	IC23
2	CD4051	IC8;IC26
1	CD4025	IC25
1	CD4053	IC17
1	CD4093	IC30
1	CD40174	IC24
1	TLC271	IC7
1	LM358	IC27
1	TLO81	IC5
1	TL084	IC6
4	CNY17	IC18-IC21
1	7805	IC29
1	7815	IC2
1	2N3019	T4
1	BD250C	T3
2	BUZ71	T1;T2
1	BC327	T7
1	BC337	T8
1	BC548	T5
2	BYV958	D4;D5
2	1N5822	D2;D3
12	1N4148	D1;D7-D17

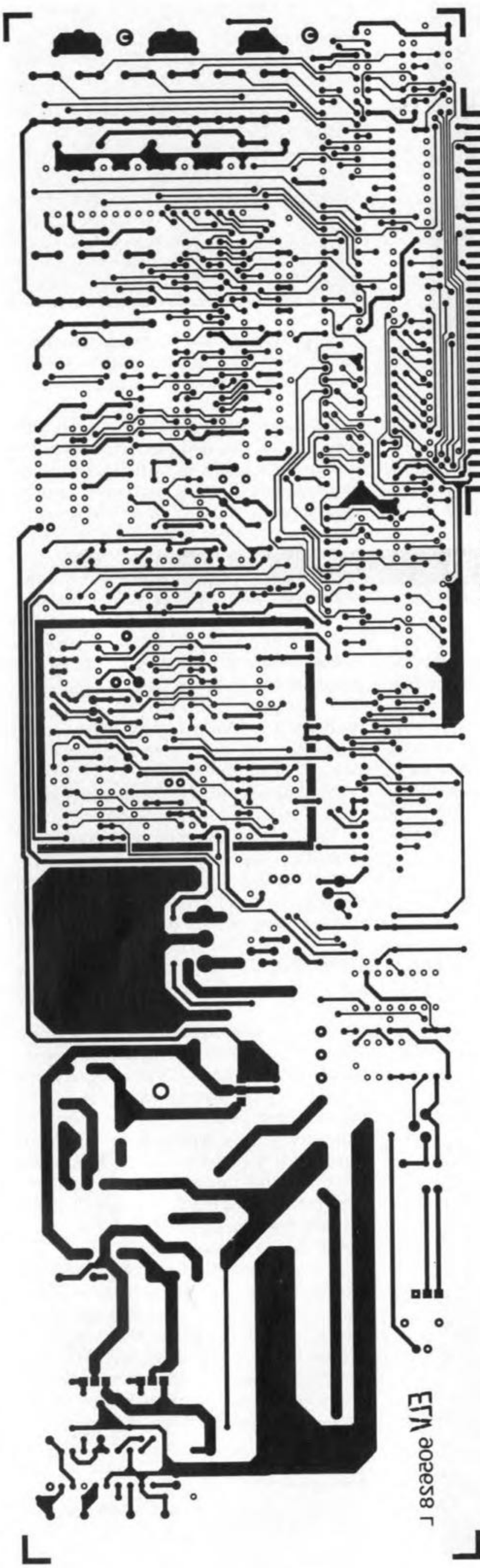
Miscellaneous:

10	PCB-mount reed relay	Re1-Re10
2	15µH inductor	L1;L2
1	EF20 transformer	Tr1
2	4-way DIP switch	
1	4-way PCB-mount DIN plug	
6	screw M3×6	
4	nut M3	
1	screening box	
1	PC card fixing bracket	
2	aluminium bracket	
1	rubber grommet dia. 4 mm	
3	solder pin	
3	crocodile clip	

1m insulated wire, red, 1 mm²
1m insulated wire, blue, 1 mm²
1m insulated wire, yellow, 1 mm²
85cm insulated wire, 0.22 mm²

Release note:

R117-R120 new in circuit diagram; components R17, R101, R105-R107, R112, C28, C29, C33, C40, IC4, T7 and T8 changed with respect to circuit diagram.



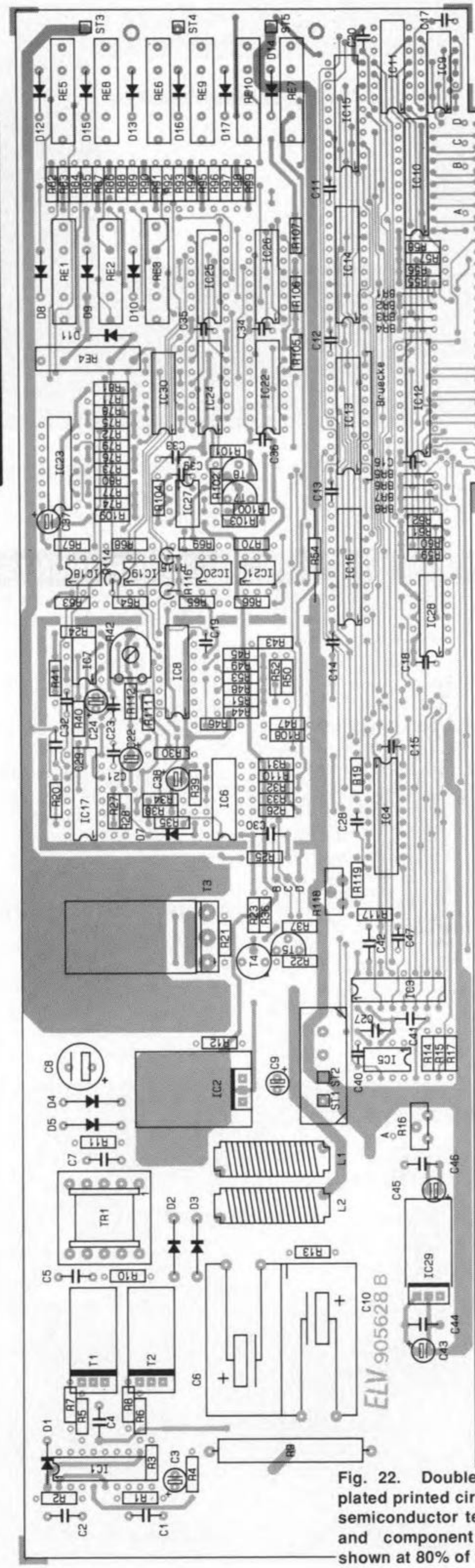
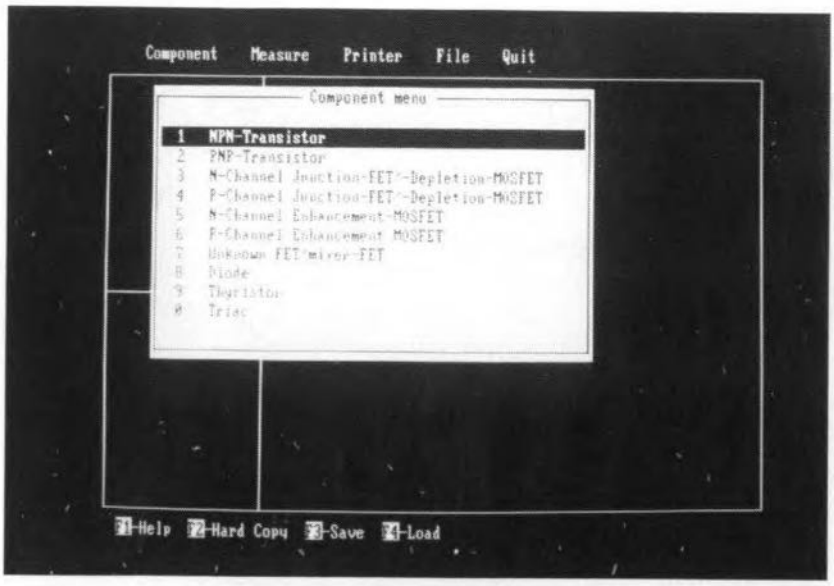


Fig. 22. Double-sided through-plated printed circuit board for the semiconductor tester. PCB layout and component mounting plan shown at 80% of true size.



A complete kit of parts for the PC-controlled semiconductor tester is available from the designers' exclusive worldwide distributors:

ELV France
B.P. 40
F-57480 Sierck-les-Bains
FRANCE

Telephone: +33 82837213
Facsimile: +33 82838180

IC17. The screening around these sections is fitted at the component side as well as at the solder side of the board. A cover is fitted on both screens.

First, bend the metal plate to give the box the required shape, and join the ends of the plate by soldering them where they meet. Next, place the 15-mm high screen on to the component side of the board. The small slots in the plate are to clear some parts on the PCB, preventing the underside of the screen causing short-circuits between PCB tracks. Solder the inside of the screen flush to the tracks it rests on, except where insulated tracks pass underneath the slots. A similar screen with a height of 4 mm is secured to the solder side of the PCB. Here, the same measures apply as regards the tracks that must be left clear by the underside of the screen. At the solder side of the board, the component terminals inside the screened area are cut to a length of 1 to 2 mm to prevent short-circuits when the cover is fitted.

Once again check the screened areas on the PCB for short circuits, then fit the covers at both sides, and solder these securely to the screens. The cover at the component side of the PCB is positioned such that the hole for the off-set adjustment is over preset R42.

8. Secure the two angled aluminium pieces to the lower side of the PCB with the aid of two M3×5 mm screws and associated nuts. As shown in the photograph of the completed board, these brackets are used to secure the fixing bracket to the PCB.

9. Finally, twist the three 1-m long flexible wires to make the cable used for connecting the testable devices to the circuit. Insert the cable through the rubber grommet in the PCB plate, and make a knot at the inside to create a strain relief. Connect the red wire to ST3, the yellow wire to ST4, and the blue wire to ST5. The other ends of the wires are fitted with miniature insulated crocodile clips.

Adjustment and first run

Switch off the PC, open it and remove a fixing bracket associated with a free slot. Fit the completed card into this slot, and bolt the fixing bracket to the rear casing of the PC. Connect an unused disk supply cable in the PC to the connector below capacitor C9 on the PCB. This connection carries the high current (2.2 A max.) 12-V supply voltage required for the on-board switch-mode power supply.

Switch on the PC, but do not yet run the software for the semiconductor tester. At power-on the hardware on the insertion card automatically switches to the most sensitive measurement range, in which the three adjustments described below are to be carried out.

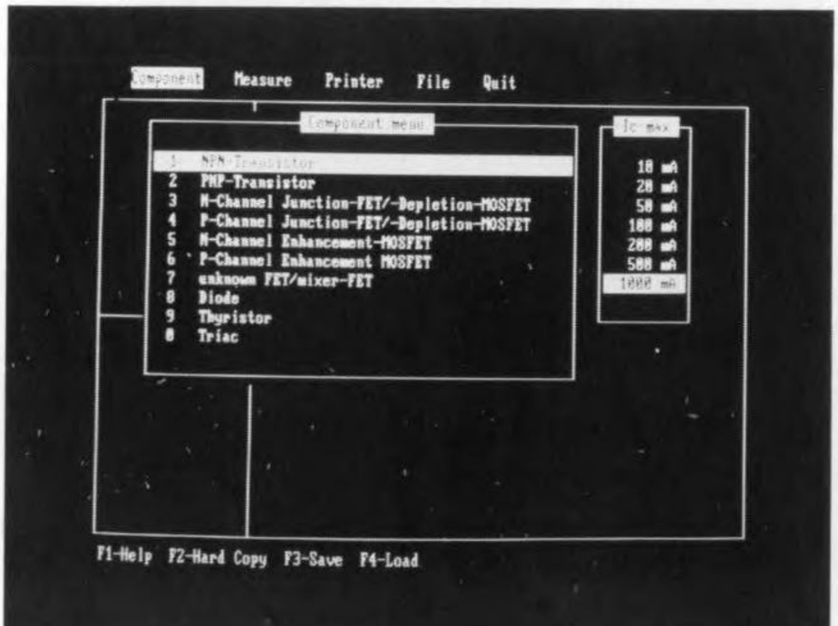
All measurements are carried out with a multimeter, with reference to AG1 (analogue ground). Connect the negative terminal of the multimeter to the lower terminal of power resistor R9 (this terminal is located about 6 mm to the left of the ELV logo, below C10). Connect the positive lead of the multimeter to pin 9 of IC4. Next, adjust preset R118 until the reference voltage of the ADC, IC4, is 1.000 V.

Next, adjust preset R16 until the reference voltage at pin 15 of IC3 is +2.55 V.

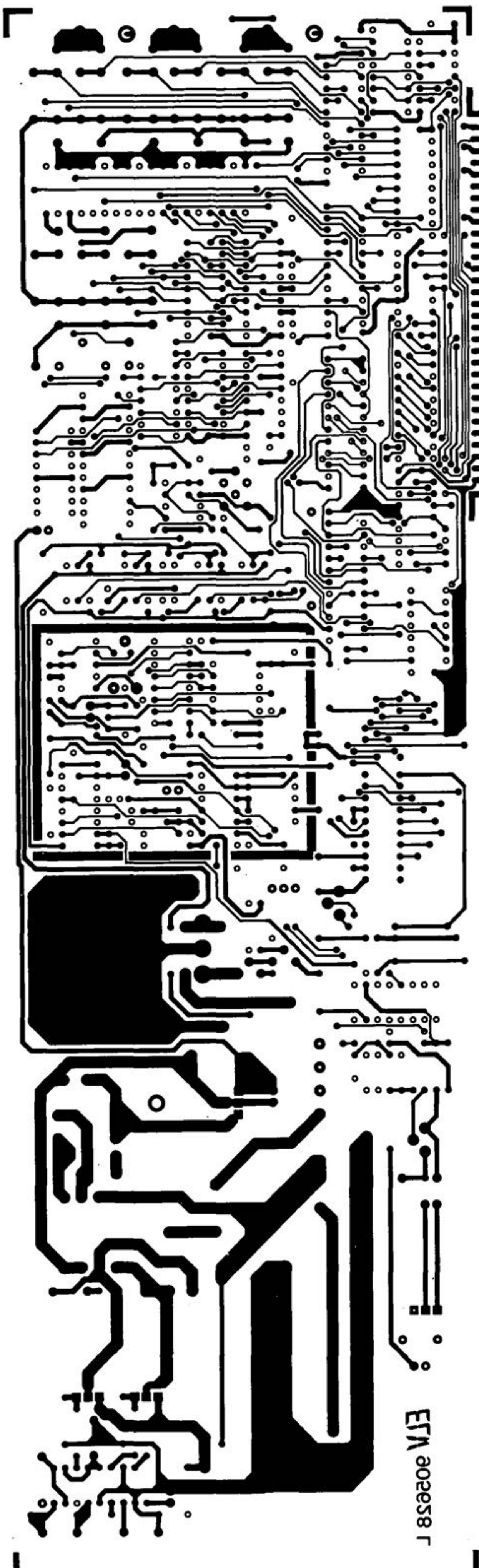
To adjust the off-set of the measurement amplifier, connect the positive lead of the multimeter to pin 6 of the ADC, IC4. Insert the trimming tool through the hole in the cover of the screening box, and adjust preset R42 for a multimeter reading of 0.00 V. A tolerance of ±10 mV is acceptable here. This completes the adjustment of the insertion card.

The software supplied with the kit provides semi-automatic tests of the most essential parts of the circuit. The installation of the control software is straightforward, and requires no further detailing at this point. The hardware address setting of the card is accomplished with the two 4-way DIP switch blocks at either side of IC12, a 74LS688. The right-hand switch block corresponds to the contacts marked 2 to 5, and the left-hand switch block to contacts 6 to 9.

In cases where the default address, 300_H, can not be used, the DIP switches are set to the required address. More information on how to do this in hardware and software may be found in the READ.ME file on the distribution diskette supplied with the kit. Ready-assembled semiconductor tester cards supplied by ELV are set to operate at address 300_H. ■



Reference:
1. Integrated-circuit tester". *Elektor Electronics* December 1989.



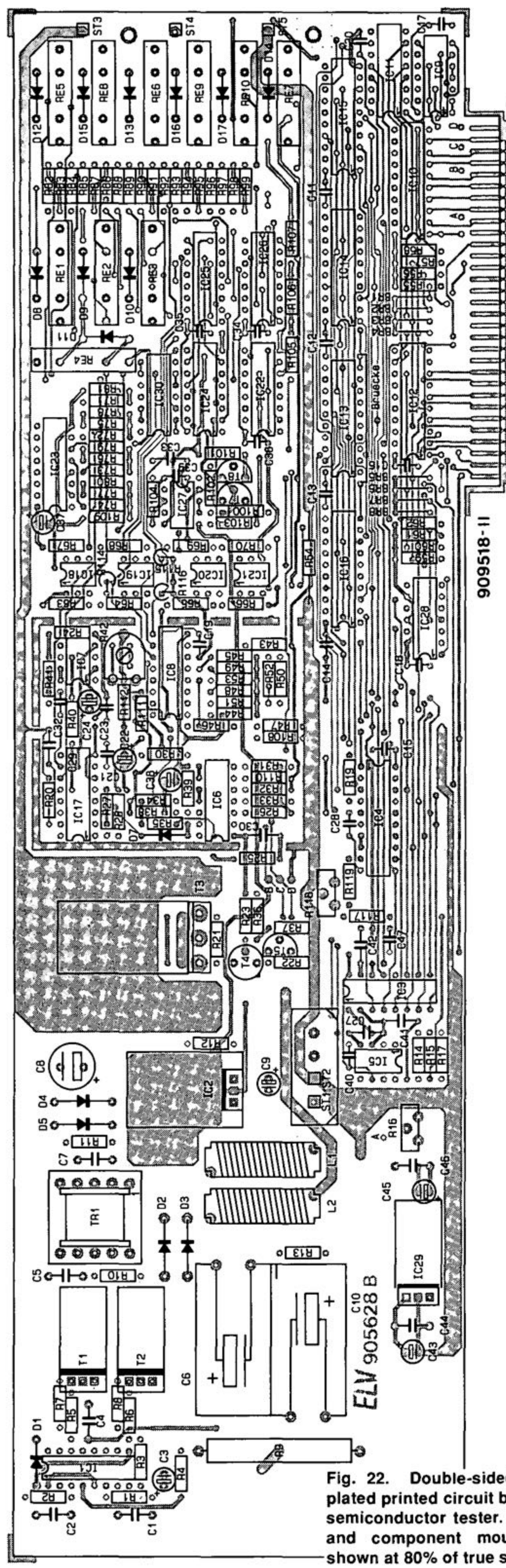
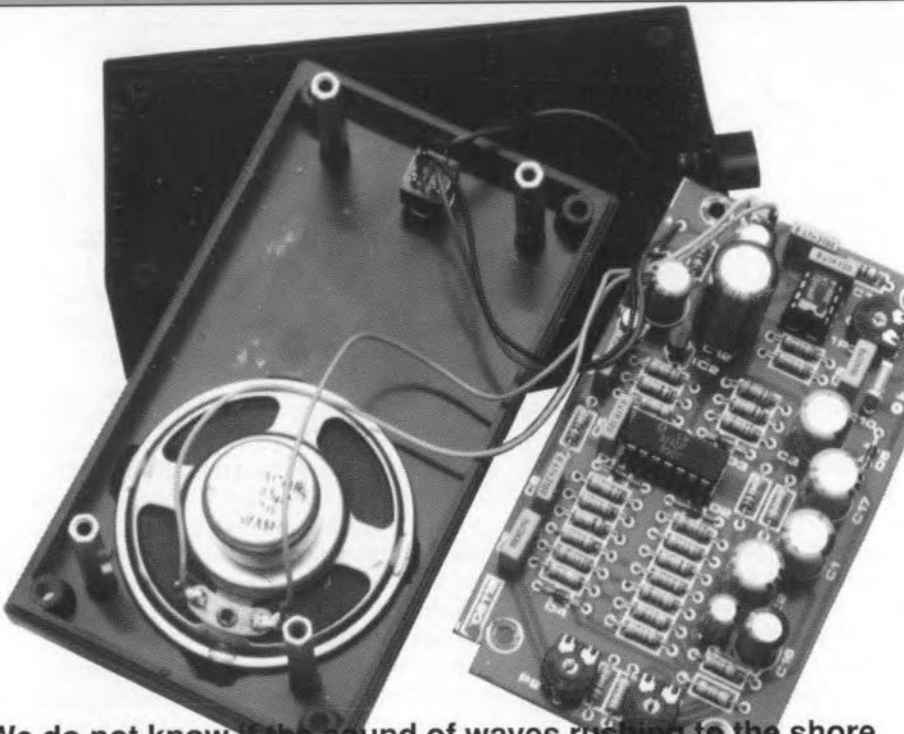


Fig. 22. Double-sided through-plated printed circuit board for the semiconductor tester. PCB layout and component mounting plan shown at 80% of true size.

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.

SURF GENERATOR



Those of you who have ever spent a summer's day at the beach will affirm that the sun, the wind, the sand and the water can have a reposing effect (we're not talking about the bikinis here). Interestingly, the sound of surf alone is reported to evoke impressions of the ocean, so that it can be used as a perfectly healthy and non-addictive 'tranquilizer' in these hectic modern days. We do not know if the sound of waves rushing to the shore can help you feel relaxed, or fall asleep quicker. We are pretty sure, however, that the electronic circuit presented here provides a quite convincing imitation of the sound of ocean surf.

from an idea by W. Cazemier

LET's leave the subjects of applied psychology and summer pleasures, and return to more familiar ground with the discussion of the block diagram of the surf generator shown in Fig. 1. In the lower left-hand corner of the diagram we find a noise generator. The output of this generator is passed through a voltage-controlled filter (VCF) and a voltage-controlled amplifier (VCA). The operation of the VCA and the VCF is controlled by a single voltage. In the case of the VCF, the control voltage determines the frequency response of the filter, while in the case of the VCA it determines the gain or attenuation of an amplifier. The latter function may be compared to that of a volume control with electronic drive. The control of the VCF and the VCA allows a wide variety of 'noisy' sounds to be produced. As shown in the block diagram, the VCA may be followed by an AF power am-

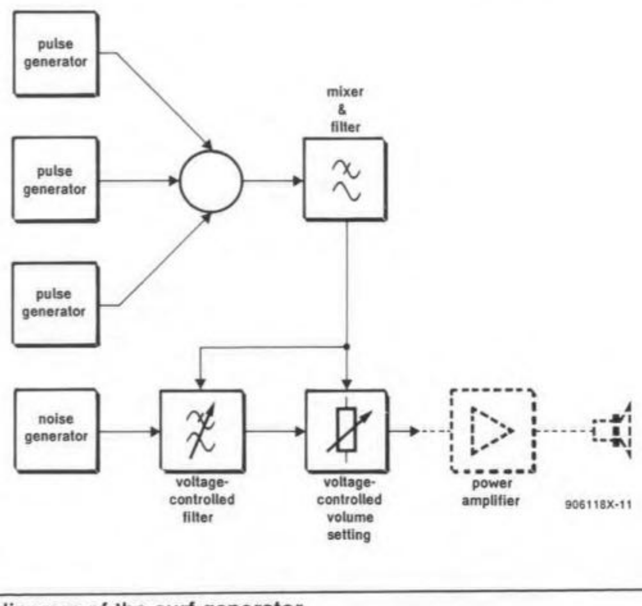


Fig. 1. Block diagram of the surf generator.

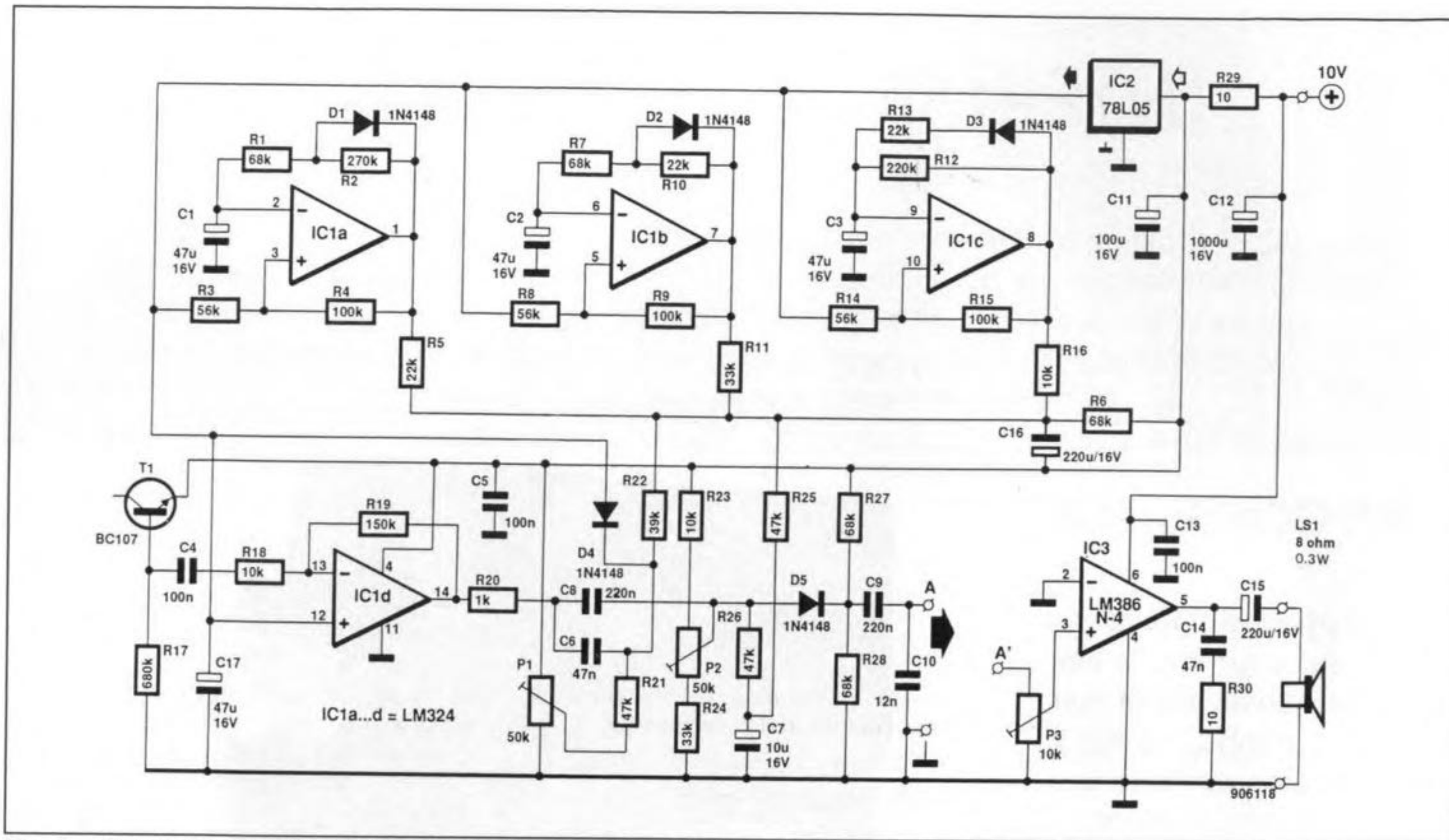


Fig. 2. Circuit diagram of the surf generator. The use of the LM386-based AF power amplifier is optional.

plifier with sufficient output power to drive a small loudspeaker.

The VCF/VCA control voltage is generated with the aid of three pulse generators, whose output signals are mixed. A filter at the output of the mixer provides some smoothing of the control voltage. The result is a quasi-random control voltage, whose erratic character is just what we need to imitate the sound of surf.

Three pulse generators

The circuit diagram in Fig. 2 shows the three pulse generators based on opamps IC1a, IC1b and IC1c. Each pulse generator is derived from the 'classic' square-wave generator, whose basic layout is shown in Fig. 3a. The duty factor (pulse on/off ratio) of this generator is 0.5. By changing the duty factor, the square-wave generator is turned into a pulse generator. Usually, the duty factor is changed by making the charge time of capacitor C different from its discharge time. Figure 3b shows how this can be achieved. Capacitor *C* is charged by *R*1+*R*2, and discharged by *R*1 alone.

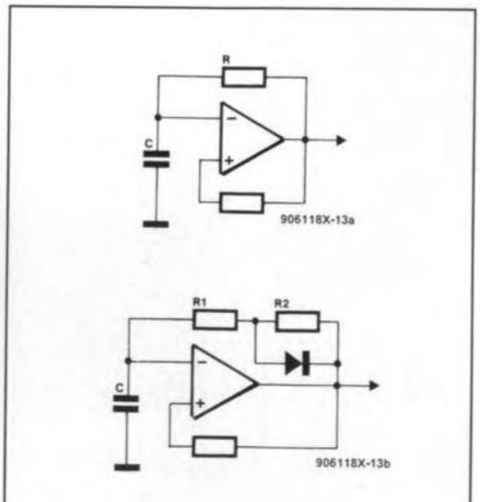


Fig. 3. Basic square-wave generator (a) and variable-duty factor pulse generator (b).

Returning to the circuit diagram, the +inputs of the three pulse generator opamps are held at half the supply voltage with the aid of a 5-V regulator, IC2, and resistors R3, R8 and R14. The output signals of the opamps are mixed by resistors R5, R11 and R16. The previously mentioned smoothing function is realized by R6 and C16. The 'random' control voltage is pulled to the +10 V supply line by R6.

Noise generator and filter

Applying an wrongly polarized voltage to a base-emitter junction of a transistor causes a zener effect in the diode junction. This effect is known to cause a considerable amount of noise. In the circuit diagram, the noise generator is formed by transistor T1 and current limiting resistor R17.

Coupling capacitor C4 feeds the noise voltage supplied by T1 to opamp IC1d, which provides an amplification of about 15 times. This amplification can be increased if desired by making R19 larger (the maximum value is 560 kΩ).

The first circuit section at the output of the noise amplifier is the VCF. The practical realization of the VCF is extremely simple, as illustrated by the basic schematic in Fig. 4a. Components R20 and C6 form an *R-C* low-pass filter, in which diode D4 acts as a resistor whose value is controlled by U_{ctrl}. The diode conducts when U_{ctrl} is lower than $\frac{1}{2}U_b$–0.7 V, with the internal resistance of D4 decreasing with the control voltage. As illustrated by the equivalent circuit in Fig. 4b, the control voltage determines the response of the filter with the aid of a variable resistance. The filter is most effective when the resistance is low. Thus, we can set the high-frequency content of the noise signal by varying U_{ctrl}.

In the circuit proper, the control voltage consists of two voltages: one is applied to the VCF via R21 to provide the basic filter setting, and another is applied via R22 to set the con-

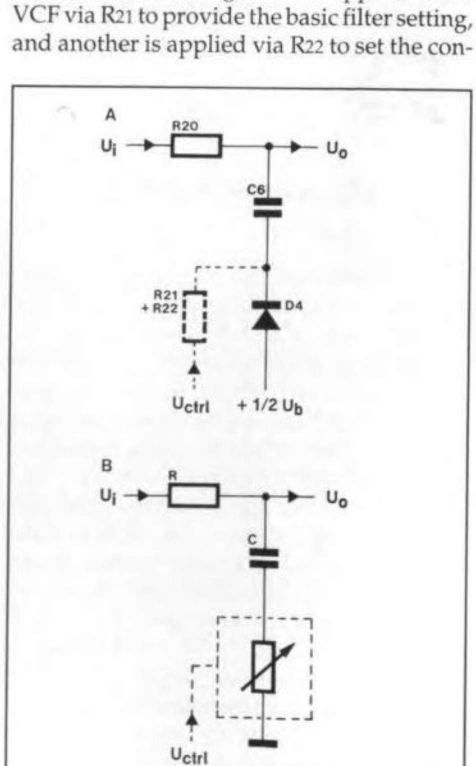


Fig. 4. Basic operation of the VCF circuit.

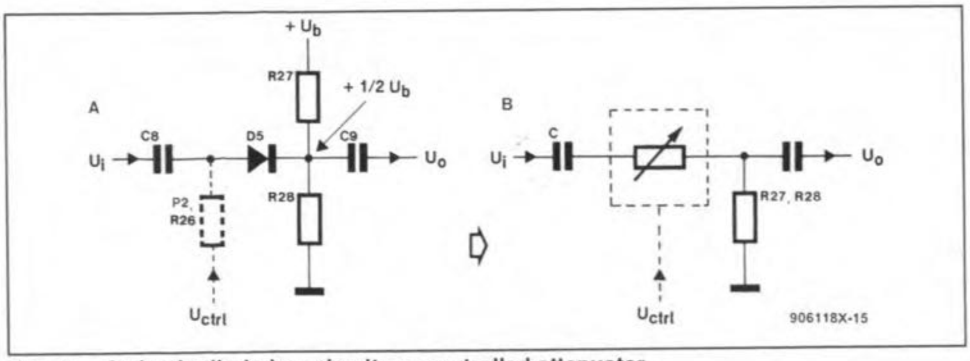


Fig. 5. A simple diode-based voltage-controlled attenuator.

trol voltage proper. Preset P1 is used to set the basic filter response.

VCA and power amplifier

The VCA is actually a voltage-controlled attenuator. Its basic operation is illustrated in Fig. 5a. As in the VCF, a diode functions as a variable resistance. The diode blocks when the control voltage, U_{ctrl}, is below $\frac{1}{2}U_b$. The output voltage, U_o, is then nought. When U_{ctrl} rises above $\frac{1}{2}U_b$+0.7 V, D5 starts to conduct, and its internal resistance drops as the control voltage rises. The equivalent circuit of the VCA is shown in Fig. 5b — the level of U_o can be set by varying U_{ctrl}.

As with the VCF, the VCA is controlled by two voltages: one for the 'coarse' setting, and one for the actual variation of the volume. The latter control level is derived from the random control voltage via R26 and a low-pass filter, R25-C10. Preset P2 determines the average output volume, while the second control voltage provides the required random variation.

The output signal of the circuit is available at terminal 'A', and can be fed to any suitable AF amplifier. Capacitor C10 shunts the generator output to limit the high-frequency content of the signal.

A small AF amplifier is provided in the circuit to enable an 8-Ω low-power loudspeaker to be driven. This amplifier is based on IC3, the well-known LM386. If you want to use the output amplifier, fit a wire link between points A and A' on the PCB.

Power supply and construction

To make sure that the noise generator functions properly, a minimum supply voltage of 10 V must be observed. Unfortunately, the circuit will not work on a 9-V battery. The half supply potential, $\frac{1}{2}U_b$, is supplied by a 5 V fixed voltage regulator Type 78L05 (IC2). The +10 V supply line is decoupled by C11 at the input of the regulator, and by C12-C13 at the AF power amplifier.

Figure 6 shows the track layout and component mounting plan of the printed-circuit board designed for the surf generator. Start the construction by fitting the wire links. The ICs are best fitted in sockets. The LM386-based AF power amplifier is optional and may be omitted where a separate (headphone-) amplifier is used. When the on-board amplifier is used, fit wire link A—A'. When an external amplifier is used, connect its input to terminal 'A' and ground via a length of screened cable.

The circuit draws about 20 mA at a supply voltage of 10 V. The supply voltage may be furnished by a mains adapter with a regulated 10 to 12 V d.c. output, or by seven 1.5-V penlight batteries fitted in one holder for four batteries, and one holder for three batteries. Whatever power supply is used, make sure that its connecting wires are as short as possible. This is a must to prevent oscillation which unfortunately occurs readily in the circuit.

Finally, the photograph in this article show a suggested construction of the surf generator in an ABS enclosure of dimensions 125×49×50 mm. The prototype has a built-in loudspeaker and operates from a 9-V PP3 battery with one 1.5-V penlight battery in series. ■

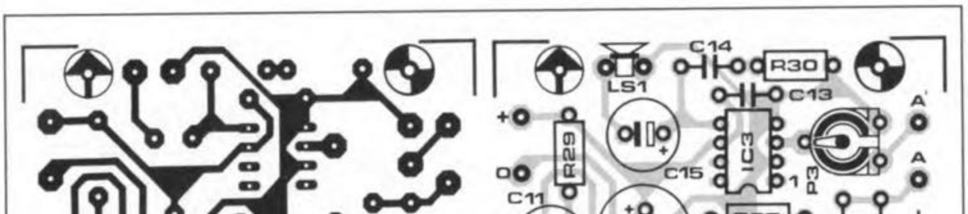


Fig. 6. Printed-circuit board for the surf generator.

COMPONENTS LIST

Resistors:		
5	68kΩ	R1;R6;R7;R27;R28
1	270kΩ	R2
3	56kΩ	R3;R8;R14
3	100kΩ	R4;R9;R15
3	22kΩ	R5;R10;R13
2	33kΩ	R11;R24
1	220kΩ	R12
3	10kΩ	R16;R18;R23
1	680kΩ	R17
1	150kΩ	R19
1	1kΩ	R20
3	47kΩ	R21;R25;R26
1	39kΩ	R22
2	10Ω	R29;R30
2	50kΩ preset H	P1;P2
1	10kΩ preset H	P3
Capacitors:		
3	47μF 16V radial	C1;C2;C3
3	100nF	C4;C5;C13
2	47nF	C6;C14
1	10μF 16V radial	C7
2	220nF	C8;C9
1	12nF	C10
1	1000μF 16V radial	C12
2	220μF 16V radial	C15;C16
1	47μF 16V radial	C17
Semiconductors:		
1	BC107	T1
5	1N4148	D1-D5
1	LM324	IC1
1	78L05	IC2
1	LM386N-4	IC3
Miscellaneous:		
1	8Ω 0.3W loudspeaker	LS1

As with the VCF, the VCA is controlled by two voltages: one for the 'coarse' setting, and one for the actual variation of the volume. The latter control level is derived from the random control voltage via R26 and a low-pass filter, R25-C10. Preset P2 determines the average output volume, while the second control voltage provides the required random variation.

To make sure that the noise generator functions properly, a minimum supply voltage of 10 V must be observed. Unfortunately, the circuit will not work on a 9-V battery. The half supply potential, $\frac{1}{2}U_b$, is supplied by a 5 V fixed voltage regulator Type 78L05 (IC2). The +10 V supply line is decoupled by C11 at the input of the regulator, and by C12-C13 at the AF power amplifier.

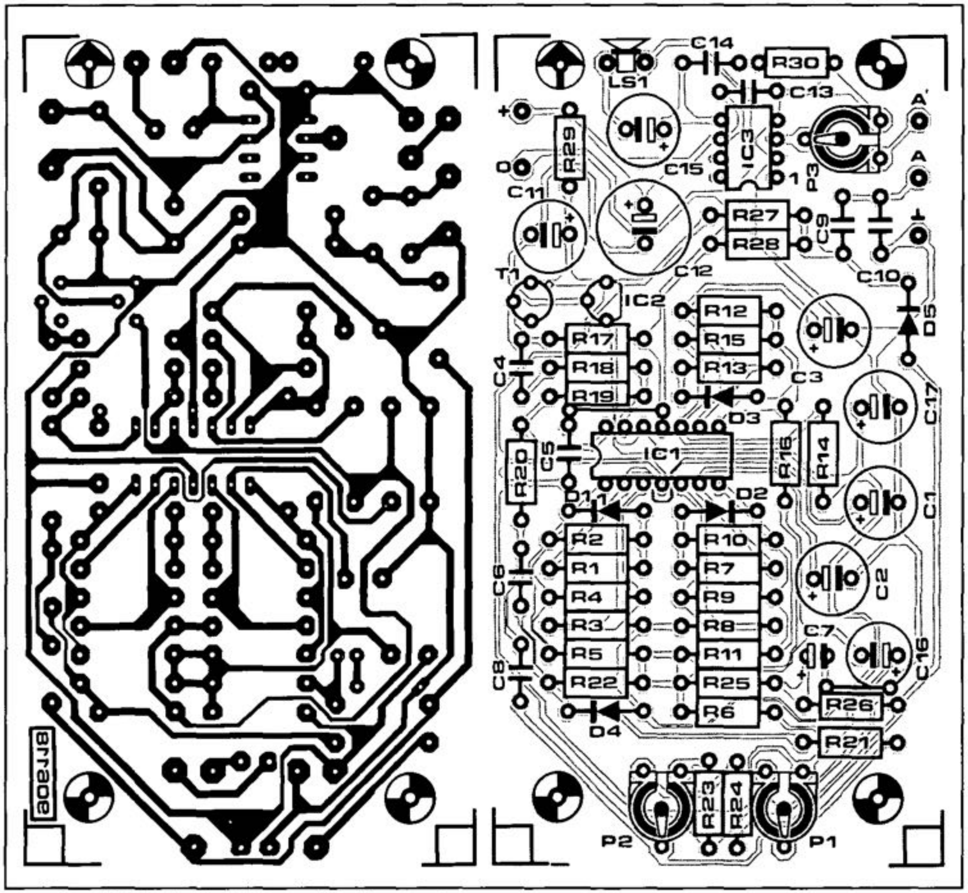


Fig. 6. Printed-circuit board for the surf generator.

COMPONENTS LIST

Resistors:		
5	68kΩ	R1;R6;R7;R27;R28
1	270kΩ	R2
3	56kΩ	R3;R8;R14
3	100kΩ	R4;R9;R15
3	22kΩ	R5;R10;R13
2	33kΩ	R11;R24
1	220kΩ	R12
3	10kΩ	R16;R18;R23
1	680kΩ	R17
1	150kΩ	R19
1	1kΩ	R20
3	47kΩ	R21;R25;R26
1	39kΩ	R22
2	10Ω	R29;R30
2	50kΩ preset H	P1;P2
1	10kΩ preset H	P3
Capacitors:		
3	47µF 16V radial	C1;C2;C3
3	100nF	C4;C5;C13
2	47nF	C6;C14
1	10µF 16V radial	C7
2	220nF	C8;C9
1	12nF	C10
1	1000µF 16V radial	C12
2	220µF 16V radial	C15;C16
1	47µF 16V radial	C17
Semiconductors:		
1	BC107	T1
5	1N4148	D1-D5
1	LM324	IC1
1	78L05	IC2
1	LM386N-4	IC3
Miscellaneous:		
1	8Ω 0.3W loudspeaker	LS1

DIMMER FOR HALOGEN LIGHTS

Based on an idea by H. Peter

Low-voltage halogen lights are becoming fashionable, which is not surprising when one considers the advantages of these small units. They offer low colour temperature, relatively low heat radiation, low operating voltage, wide-angle light emission, illumination that is two to three times brighter than that of conventional lamps for the same energy consumption and far better efficiency than traditional light sources.

MANY commercial lighting controls operate at the primary side of a transformer and this means that all lights in a circuit are switched or dimmed simultaneously. When a room contains a number of lights, that is a distinct disadvantage. The dimmer described in this article is based on the concept that each individual light in a two-wire system can be remotely controlled without any effect on the other lights in the system. A hand-held infra-red remote controller provides four functions:

- light on;
- light off;
- light brighter;
- light less bright.

Each light is connected across the 12-V secondary of a mains transformer. To enable it being operated individually, it is fitted with its own infra-red receiver. To enable the lights being switched on from the entrance to a room, an additional, fixed infra-red controller is fitted beside the door opening.

Each remote controller has six operating channels, so that six lights or groups of lights can be controlled. The cost of the small receiver fitted in the lights is about equal to the cost of two traditional light bulbs.

All switching of the lights takes place at the zero crossing, which ensures a long life.

Remote control transmitter

The remote control transmitter is based on Plessey's Type MV500 IC, the block diagram of which is shown in Fig. 1. Apart from a keyboard, an oscillator and a driver for the infra-red diodes, this IC contains all that is necessary for a 32-channel infra-red transmitter. Since the receiver board must of necessity be kept small (about 50×40 mm), the present transmitter is restricted to six channels: see Fig. 2. Because of the need to keep the receiver board small, the circuit of the transmitter is rather larger than Plessey's standard application circuit.

The MV500 IC is a CMOS type that, thanks to the power control block, which automatically switches the transmitter on or off, draws an almost negligible current during quiescent operation. When one of the keys is pressed, the current drain from a 9-V battery is only a few milliamperes even though the (pulsed)

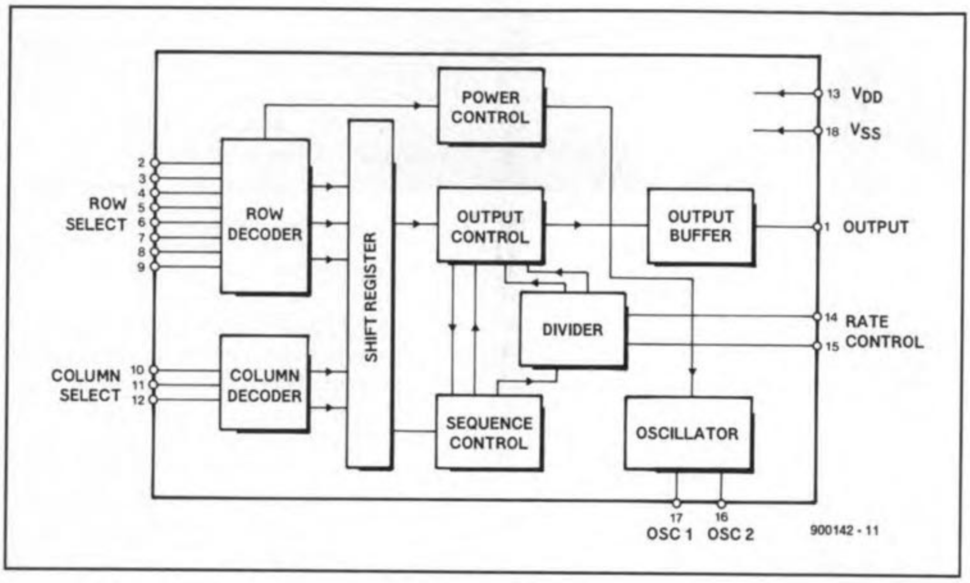


Fig. 1. Block diagram of Plessey's Type MV500 integrated circuit.

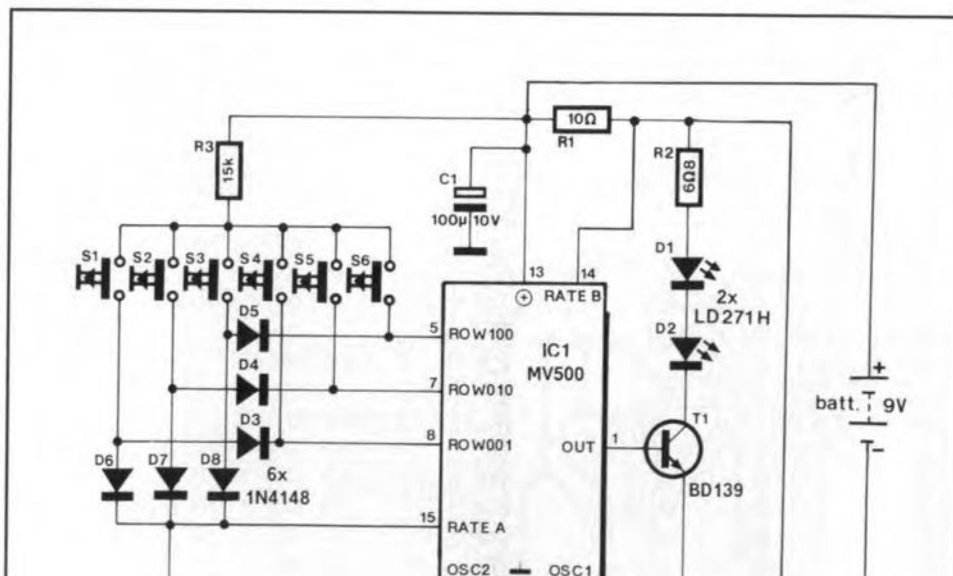
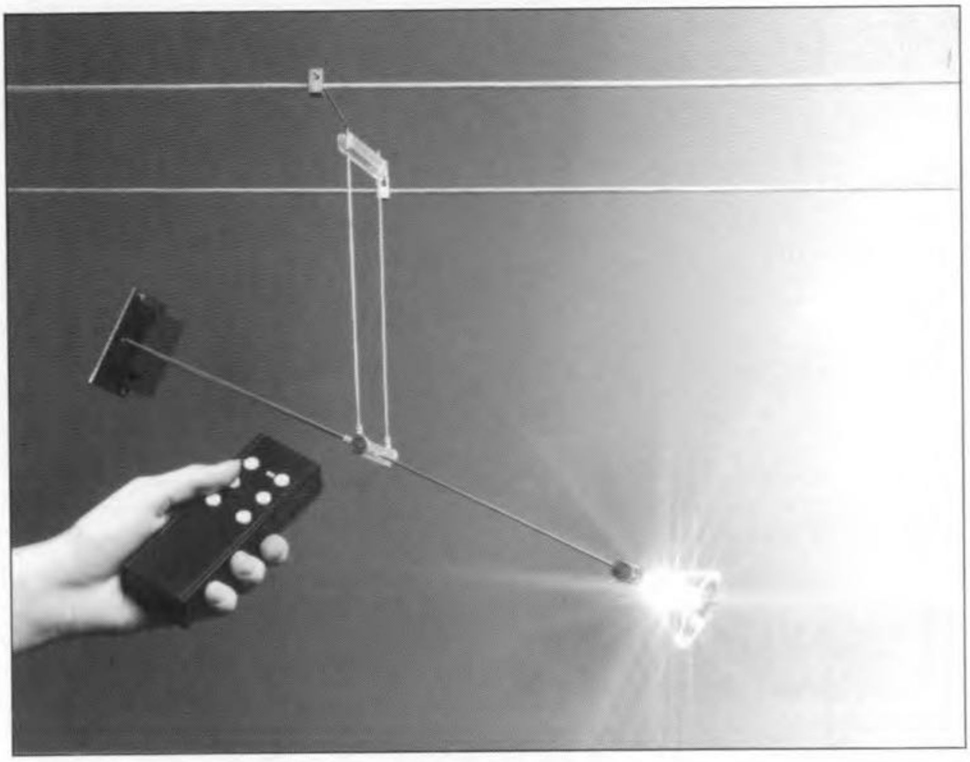


Fig. 2. Circuit diagram of the remote control transmitter.



current through the infra-red diodes is of the order of amperes. However, the duration of the current pulses, because of the pulse-spacing modulation, is only about 15 µs. Moreover, the transmitter remains operational even when the battery voltage has dropped to just below 4 V.

During quiescent operation, the greater part of the MV500 is switched off. When one of the keys is depressed, the power control switches the supply voltage to all stages of the IC that were off before then. This causes the oscillator, consisting of crystal X_1 and capacitors C_3 and C_4, to generate a 455 kHz signal.

The voltage from the keyboard is applied as a five-bit signal to the row and column decoders. In these, it is converted into a serial signal which, after being pulse-spacing modulated, is available at the output, pin 1. From there, it is applied to T_1, amplified, converted to an infra-red signal by diodes D_1 and D_2 and then transmitted in the direction of a receiver.

In pulse-spacing modulation, also called pulse-interval modulation, the spacing between the pulses, rather than the pulses themselves, is modulated. This type of modulation ensures low current drain from the battery and also greater invulnerability to noise and hum.

The 455 kHz signal from the oscillator is converted to 17 µs long needle pulses. The spacing between the pulses varies according to the modulating information. The divider in the MMV500 arranges for a logic 1 to be given a duration of 9 ms, and a logic 0, a duration of 13.5 ms. The intervals are thus relatively long compared with the pulses. The data stream continues for as long as the key is pressed. When it is released, the power control removes the power supply from most of the IC again.

The rate control outputs enable the frequency of the transmission to be altered. This is effected by a logic 1 at either of these pins, which results in transmission rate A at

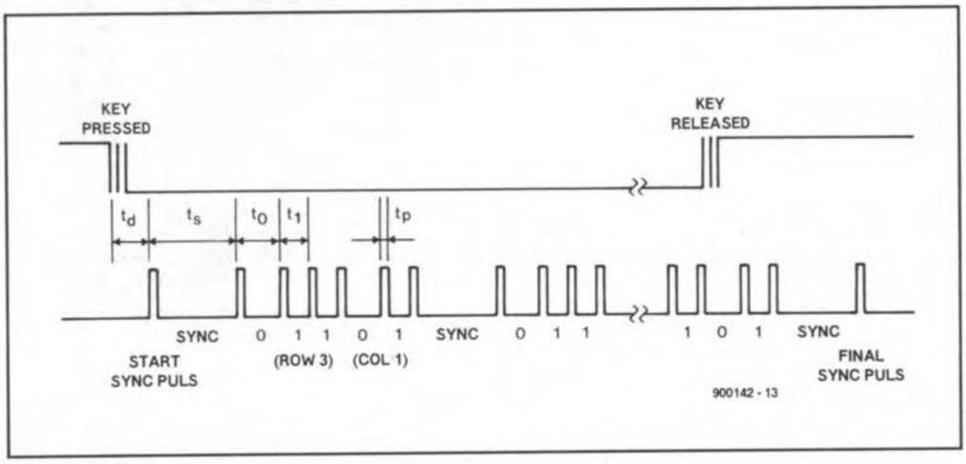


Fig. 3. Transmission of the infra-red signal begins 2.2 ms after a key is pressed with a 27 ms long synchronization interval, followed by the actual 5-bit data stream.

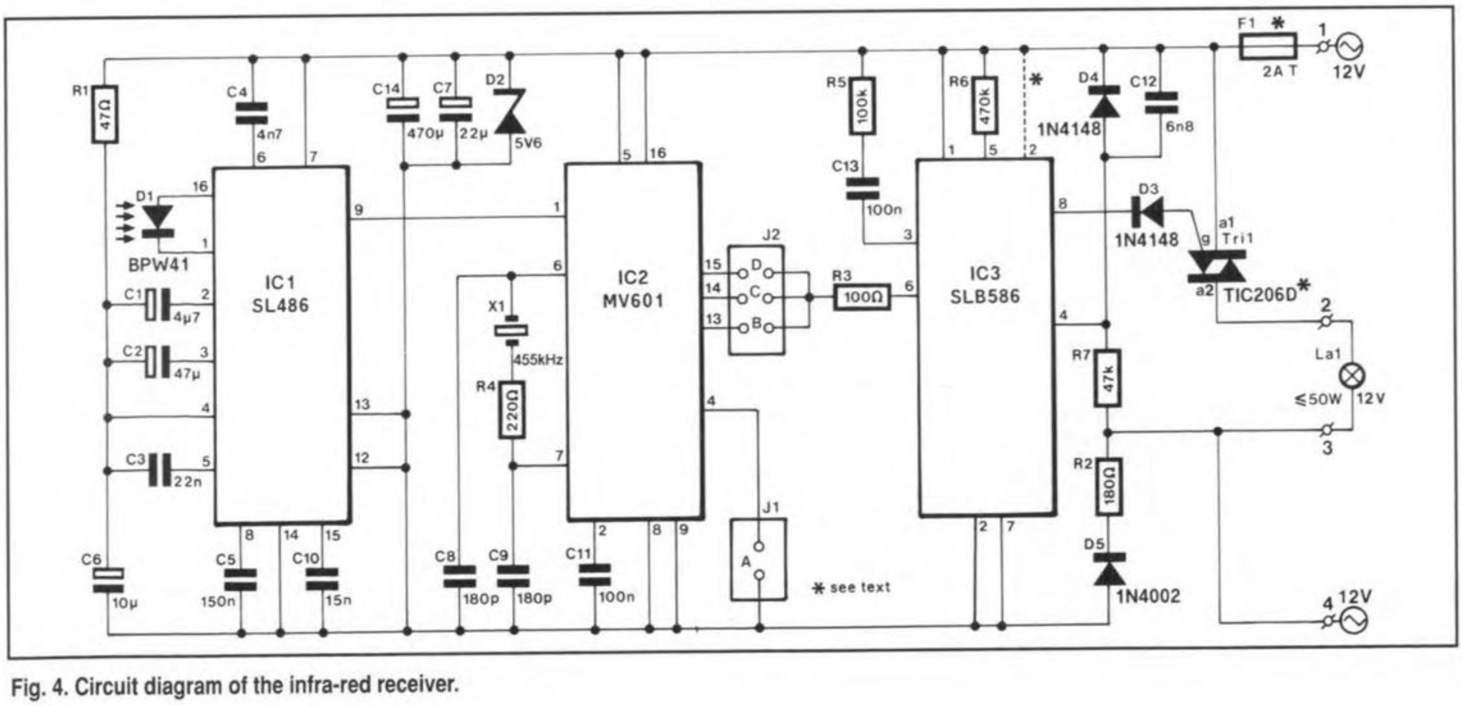


Fig. 4. Circuit diagram of the infra-red receiver.

Table 1
Correlation between transmit keys, data bits, wire link positions and transmission rates

Key	Bit	J_1	J_2	Rate
1	A	Yes	A	A+B
2	B	Yes	B	A+B
3	C	Yes	C	A+B
4	A	No	A	B
5	B	No	B	B
6	C	No	C	B

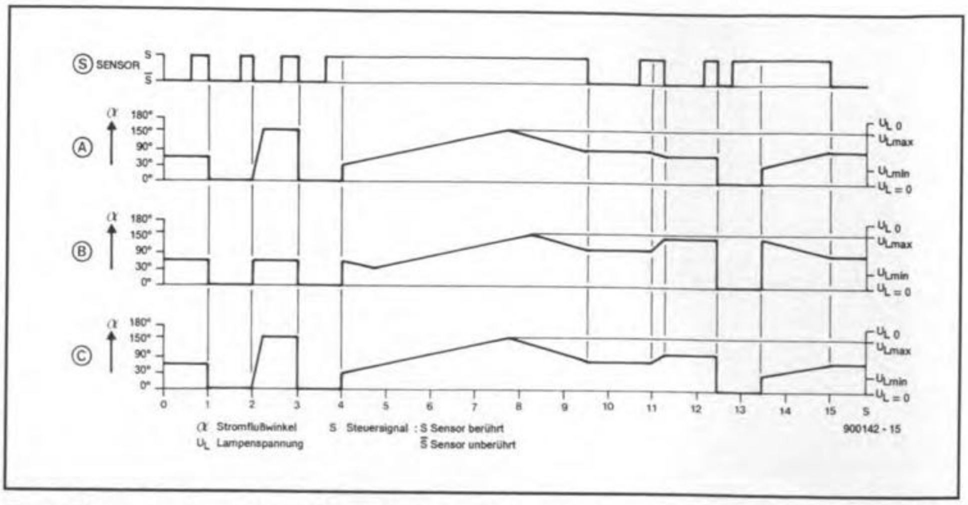


Fig. 5. The mode of operation of IC_3 is determined by the level at pin 2. In the figure, α is the phase gating angle; U_L is the lamp voltage and S is the control signal: S = logic 1 and $\bar{S}$ = logic 0.

pin 15 or transmission rate B at pin 14. The pulse-pause ratio remains unchanged, however. The durations stated earlier pertain to rate A; they are halved with rate B. Note that the transmitter and receiver(s) must be set to the same transmission rate. There is the possibility of a third rate (A+B), which is obtained when a logic high is applied to pins 14 and 15 simultaneously.

Keys S_1–S_6 provide the channel information to the row decoder; the column decoder is not used. This atypical configuration was chosen because the channel information is not decoded in the receiver(s) owing to space considerations.

The present system uses rate B and rate A+B. Pin 14 is permanently connected to the positive supply line via R_1. Pin 15 is kept low via R_4 as long as no key is pressed. When one of the keys S_1–S_3 is pressed, pin 15 also goes high via the OR gate formed by D_6–D_8. The transmitter then operateas at rate A+B. When, however, one of keys S_4–S_6 is pressed, pin 15 remains low and the transmit rate is B. In this way, it is possible by adding six inexpensive diodes to obtain operation in 2×3 channels without it being necessary for any decoding in the receiver(s).

Infra-red receiver

Circuit IC_1 in Fig. 4 prepares the received signals, IC_2 decodes them, and IC_3 undertakes the dim function.

Circuit IC_1 is an infra-red preamplifier, which is quite complex, because it must provide a clean, usable electrical signal from a light signal that is full of spikes and constantly varies in intensity. A number of automatically operating amplifier stages raise the current of the receive diode from as low as just below 1 μA by 68 dB. A clean PPM (pulse period modulated) signal is provided at the output, pin 9.

Circuit IC_2 decodes the serial information into the same five-bit data word that was coded in the transmitter. Since all signals must be processed at the transmit frequency, the oscillator based on X_1 is identical to that used in the transmitter. Resistor R_4 ensures that the crystal oscillates at its fundamental frequency. The decoded data is available at pin 13 (bit A), pin 14 (bit B) and pin 15 (bit C).

PARTS LIST
(Transmitter)

Resistors:
R_1 = 10 Ω
R_2 = 6.8 Ω
R_3 = 15 kΩ
R_4 = 100 kΩ

Capacitors:
C_1, C_2 = 100 μF, 10 V
C_3, C_4 = 100 pF

Semiconductors:
IC_1 = MV500
T_1 = BD139/10
D_1, D_2 = LD271H
D_3–D_8 = 1N4148

Miscellaneous:
X_1 = crystal 455 kHz (e.g. Murata Type CSB455E or Toko Type CRK455A)
6 push-button keys
2 reflectors for D_1 and D_2
1 plastic enclosure 61×26×101 mm with (PP3) battery compartment
1 battery (e.g. 9-V PP3)
PCB Type 910032-1

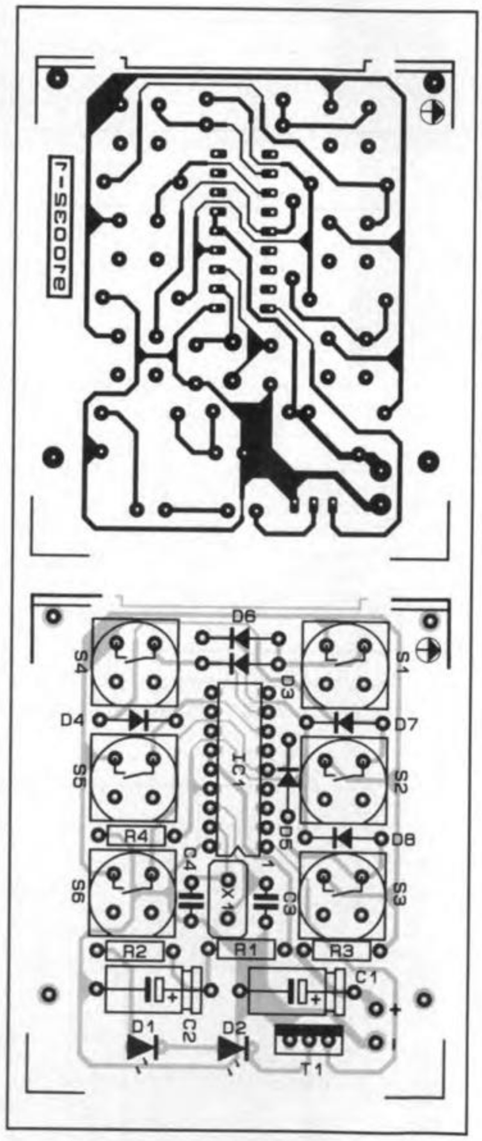


Fig. 6. Printed-circuit board for the transmitter.

It is, of course, imperative that each receiver responds only to the corresponding transmit key. The selection of the appropriate signal is effected by wire links J_1 and J_2. When J_1 is used, the transmission rate is A+B, when it is omitted, the rate is B. The transmit keys, data bits, use or omission of J_1, and position of J_2, are correlated in Table 1.

The on/off cum brightness control circuit is based on IC_3. Since this circuit has only one input, pin 6, the four functions must be derived from the duration of the input signal. If the pulse width is in the range of 50–400 ms, the circuit arranges on/off switching. When the pulse width is greater (0.5 s to 7.6 s) the IC continuously varies the phase gating angle until the control signal becomes zero.

The mode of operation of the circuit is determined by the level at pin 2—see Fig. 5.

Level = 0 (variant A). In this mode, the brightness is maximum when the light is switched on. Dimming takes place from minimum brightness; renewed dimming continues towards maximum.

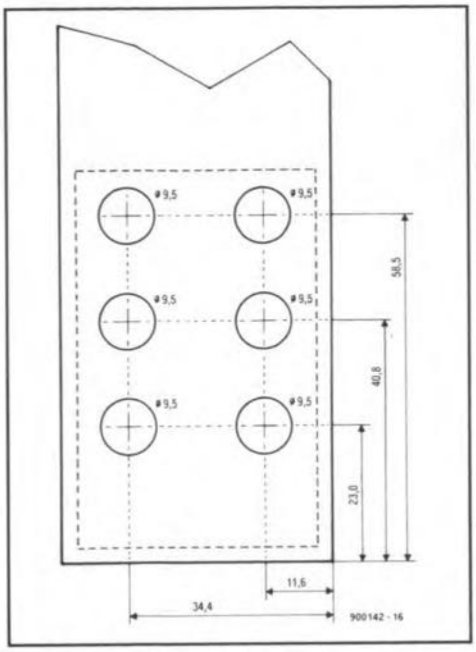


Fig. 7. Drilling template for transmitter case.

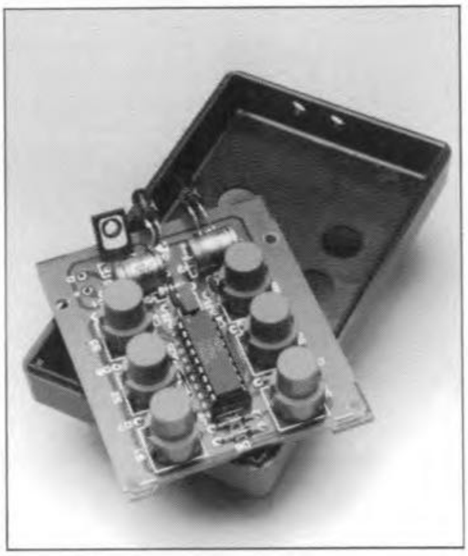


Fig. 8. Completed infra-red transmitter.

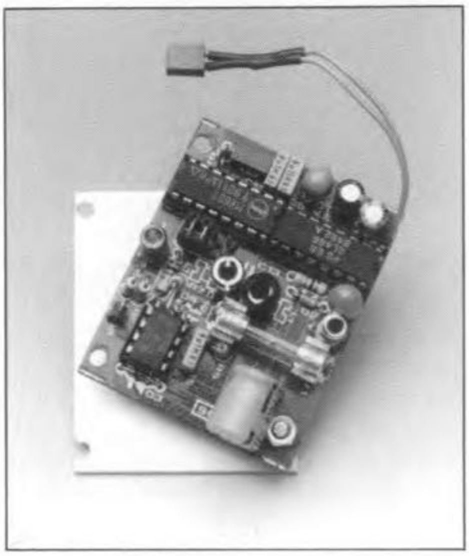


Fig. 9. Completed infra-red receiver.

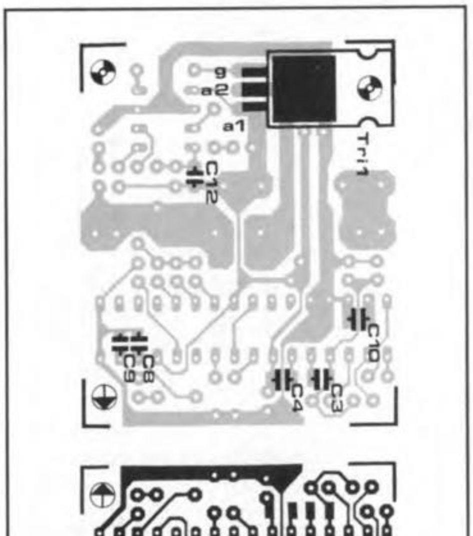


Fig. 10. PCB for the infra-red receiver(s).

PARTS LIST
(Receiver)

Resistors:
R_1 = 47 Ω
R_2 = 180 Ω
R_3 = 100 Ω
R_4 = 220 Ω
R_5 = 100 kΩ
R_6 = 470 kΩ
R_7 = 47 kΩ

Capacitors:
C_1 = 4.7 μF, 16 V, radial
C_2 = 47 μF, 16 V, radial
C_3 = 22 nF, surface-mount
C_4 = 4.7 nF, surface-mount
C_5 = 150 nF
C_6 = 10 μF, 25 V, tantalum
C_7 = 22 μF, 16 V, tantalum
C_8, C_9 = 180 pF, surface-mount
C_{10} = 15 nF, surface-mount
C_{11}, C_{13} = 100 nF
C_{12} = 6.8 nF, surface-mount
C_{14} = 470 μF, 10 V

Semiconductors:
D_1 = BPW41N (Motorola)
D_2 = zener, 5.6 V, 400 mW
D_3, D_4 = 1N4148
D_5 = 1N4002
IC_1 = SL486 (Plessey)
IC_2 = MV601 (Plessey)
IC_3 = SLB586 (Siemens)
Tri = TIC206D (Texas Instruments)

Miscellaneous:
X_1 = crystal, 455 kHz
F_1 = fuse, 2 A, slow blow
2 PCB-type screw terminals
J_1, J_2 = PCB pin strip header, double row, 4-way, with jumper sockets
Heatsink for triac (see text on p. 58)
Plastic enclosure 80×26×45.4 mm
La_1 = halogen lamp, 12 V, 50 W

Level = 1 (variant C). In this mode, operation is similar to variant A, but renewed dimming reverses towards minimum.
Level = three-state (variant B). In this mode, the phase angle at switching off is stored and the next switch-on occurs at the same angle. Renewed dimming reverses direction with respect to the previous dimming.

On the printed-circuit board, pin 2 is connected to earth, that is, the circuit is set for variant A. If one of the other variants is wanted, break the track to obtain variant B, or break the track and solder pin 2 to pin 1 to obtain variant C.

Resistor R_7 and capacitor C_{12} filter the a.c. supply, which is then used for synchronizing the internal PLL (phase-locked loop) time base. Resistor R_5 and capacitor C_{15} form the integrating network for the time base.

Diode D_3 reduces to safe values the positive voltages that ensue at the gate of many triacs when they are fired. The TIC206D enables lamps rated at up to 20 W to be controlled; for higher rated lamps, a TIC226D should be used (see also under 'Receiver' on page 58).

Direct voltage is provided by rectifier D_5, regulated by R_2 and D_2, and smoothed by C_{14}. Note that IC_3 requires a negative supply.

Construction

TRANSMITTER

Populating the printed-circuit board for the transmitter—see Fig. 6 and Fig. 8—is straightforward.

A drilling template for the top of the enclosure (where the six holes that will give access to the push-button switches will be located) is given in Fig. 7. The switches are not seated on the PCB, but about 11.5 mm above it. Three spacers under the board ensure that the push-buttons protrude through the top of the case.

Furthermore, two small holes must be drilled in the front of the enclosure through which the infra-red diodes will transmit.

After the board has been completed, test its operation with the aid of an oscilloscope connected between the collector of T1 and earth.

The MV500 is very sensitive to electrostatic charges. It may well operate almost normally after having been subjected to such a charge, but chances are that its power-down facility does not function properly any more. This causes a current of more than 1 mA to flow even during quiescent operation and this does of course shorten the life of the battery quite considerably.

A chromium reflector placed behind each of the infra-red diodes increases its operating range by 40–50 per cent. If that is still not sufficient, resistor R_2 may be short-circuited. This increases the current through the diodes, however, and thus shortens the life of the battery.

RECEIVER

The completion of the receiver printed-circuit board—see Fig. 9 and Fig. 10—is not so straightforward. Because of lack of space, five surface-mount capacitors are fitted at the track side of the board. Great care must be exercised during the soldering of these components to make sure that no tracks are short-circuited.

Resistor R3 should be shrouded in insulating tape or inserted into a length of insulating sleeve to prevent its connecting wire touching the adjacent a.c. supply terminal.

The triac is soldered at the underside of the board in such a way that its inscription points towards the board: this makes it possible to fit the heatsink as shown in Fig. 11. A template for the heatsink is shown in Fig. 12. The heatsink is made from 2 mm thick aluminium sheet. Note that this suffices for lamps rated at up to 20 W only. If lamps of up to 40 W are to be used, a more substantial heatsink is required, for instance, a 50 mm long Type SK59 (5 K/W). Lamps of 50 W require a 75 mm long Type SK59 (6 K/W). Furthermore, it is advisable to use a Type TIC226D triac (which can handle currents of up to 8 A) instead of the TIC206D (which can handle up to 4 A only). Lastly, the printed-circuit board can cope with the temperature of lamps rated up to 20 W; higher rated lamps must be fitted externally, for instance, as shown in the photograph on page 55.

Do not yet fit any of the ICs or halogen lamps. When an alternating voltage of 12 V is connected across the supply terminals marked ~, there should be a direct voltage of about 5.5 V across C14. If this is so, disconnect the 12 V supply, discharge C14, and insert IC1 into its socket.

An oscilloscope connected between pin 9 of IC1 and earth should show the PPM signals whenever one of the push-buttons on the transmitter is pressed

Next, insert IC2 into its socket. A high logic level should appear at its pins 13 and 15 when the corresponding button on the transmitter is pressed. When this test is successful, insert IC3 into its socket and fit the lamps on to the board. When then the corresponding button on the transmitter is pressed, the lamps should light. ■

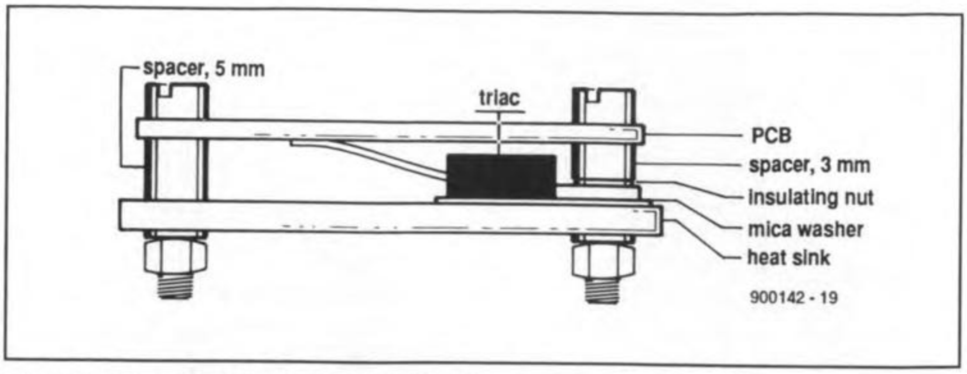


Fig. 11. Construction of the triac and its heat sink to the underside of the PCB.

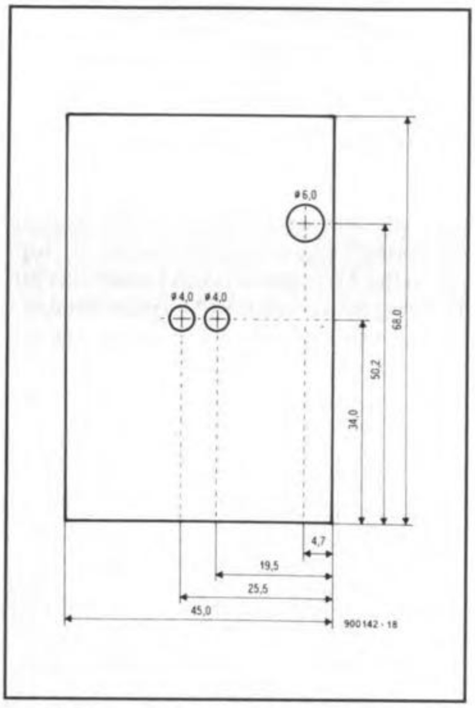


Fig. 12 Template for the heatsink for the triac.

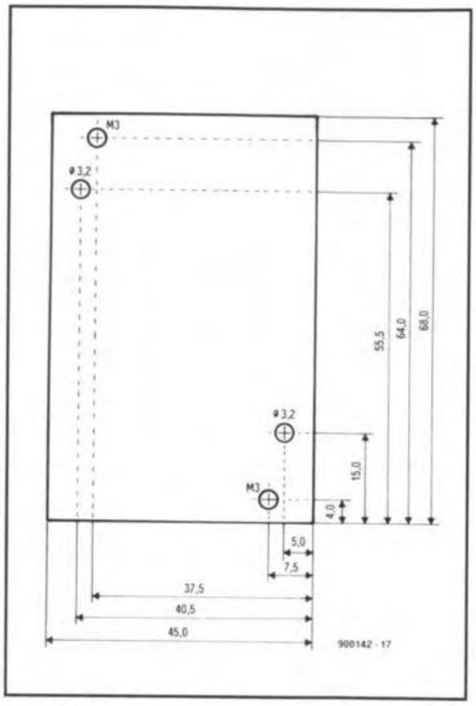
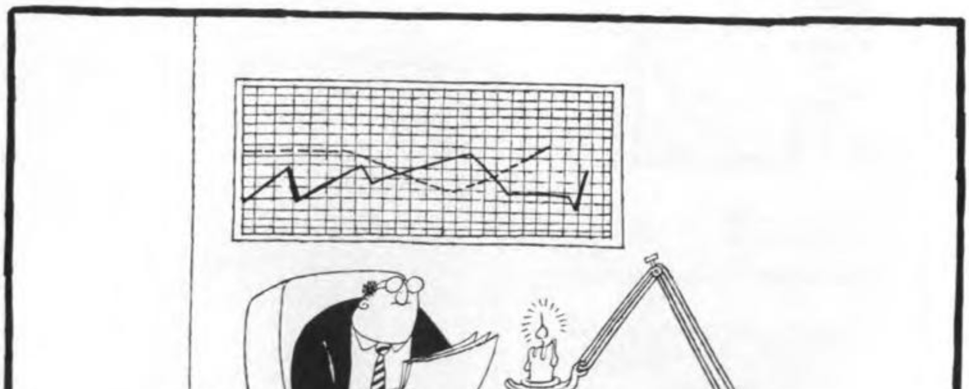
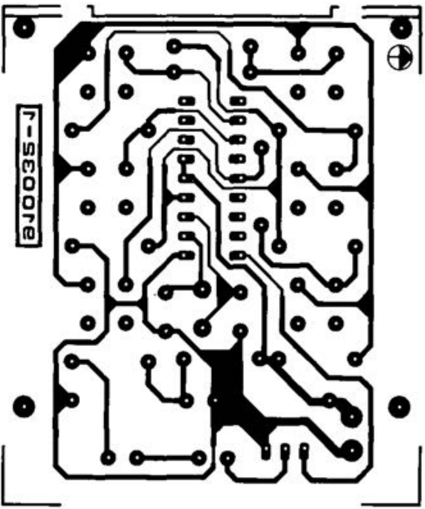
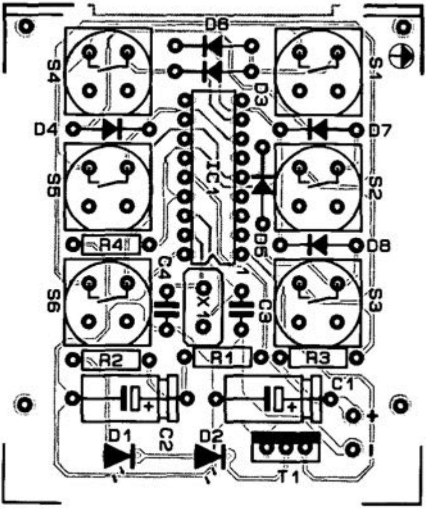


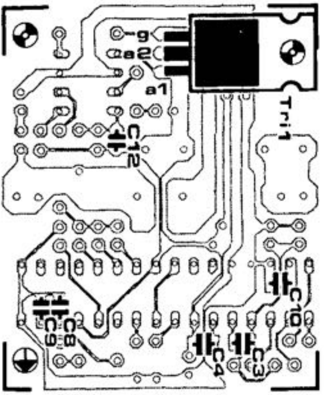
Fig. 13. Template for drilling the top of the receiver enclosure.



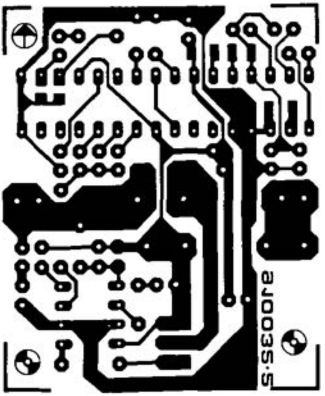


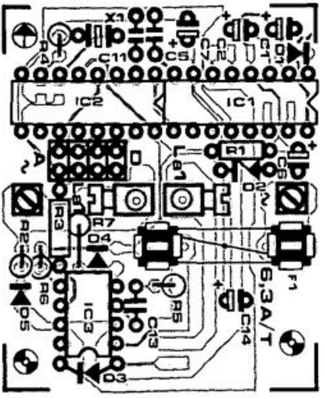


D6
D3
S4
S1
D4
D7
IC1
S5
S2
R4
D5
D8
C4
S6
S3
C3
R2
R1
R3
C1
+
D1
C2
D2
T1



Tri1
g
a2
a1
C12
C10
C9
C8
C4
C3





X1
R4
C11
C5
C7
C2
C1
D1
IC2
IC1
R1
C6
D2
La1
R8
R3
R7
D4
R2
R6
D5
IC3
R5
C13
C14
6,3A/T
F1
D3

CORRECTIONS

6-metre band converter

April 1991, p. 38-43

The components list and the inductor overview in the top left hand corner of the circuit diagram should be corrected to read:

L_1, L_2 = 301KN0800.

Capacitor C_{16} (4.7 pF) must not be fitted on the board.

Finally, a few constructional tips:

- Fit a 10 nF ceramic decoupling capacitor at junction L_7-R_{36}.
- Fit a 18 kΩ resistor between the base of T_3 and ground. This reduces the Q factor of L_2, and prevents too high signal levels at the base of T_3.
- For improved tuning, inductor L_9 may be replaced by a Toko Type 113KN2K1026HM.

Multifunction measurement card for PCs

January and February 1991

We understand that the 79L08 (IC_{17}) is no longer manufactured and, therefore, difficult to obtain. Here, the IC may be replaced by a 7908, which, although physically larger than the 79L08, is pin-compatible, and should fit on the PCB.

Dimmer for halogen lights

April 1991, p. 54-58

In the circuit diagram of the transmitter, Fig. 2, pin 14 of the MV500 should be shown connected to pin 13, not to junction R1-R_2-C_2. The relevant printed-circuit board (Fig. 6) is all right.

RDS decoder

February 1991, p. 59

Line A0 between the 80C32 control board and the LC display is not used to reset the display, but to select between registers and data.

We understand that the SAF7579T and the associated 4.332 MHz quartz crystal are difficult to obtain through Philips Components distributors. These parts are available from C-I Electronics, P.O. Box 22089, 6360 AB Nuth, Holland. For prices and ordering information see C-I's advertisement on page 6 of the May 1991 issue.

S-VHS-to-RGB converter

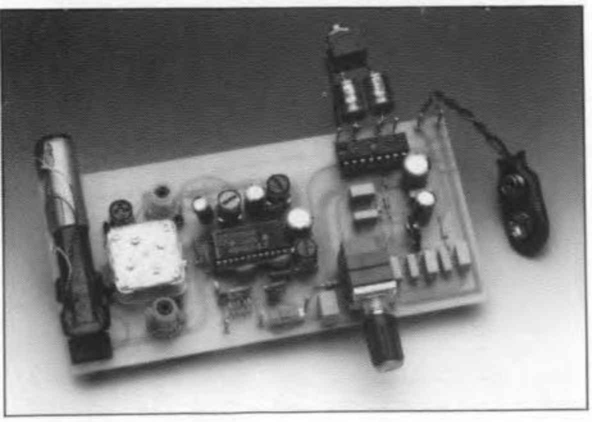
October 1990, p. 35-40

Relays Re_1 and Re_2 must be types with a coil voltage of 5 V, not 12 V as indicated in the components list. Constructors who have already used 12-V relays may connect the coils in parallel rather than in series.

Suitable 5-V relays for this project are the 3573-1231.051 from Günther, and the V23100-V4305-C000 from Siemens.

The components list should me modified to read:

6	33nF	C57-C62



AM-FM RECEIVER

The Type TEA5591A IC from Philips contains virtually all the electronics for an AM/FM tuner: all that needs to be added are a few tuned circuits. Moreover, adding a stereo decoder and an output amplifier results in a compact, state-of-the-art radio receiver.

TO KEEP the AM/FM tuner as small as possible, Philips have housed the TEA5591A not in a standard DIL package, but in a so-called shrink-DIP, of which the pins are not on a 0.1 in. but on a 0.07 in. grid. Consequently, the device is no longer than a standard 16 pin DIP circuit, but it is 0.1 in. wider.

Inside the TEA5591A

From the block diagram in Fig. 1 it is seen that the TEA5591A contains two separate receivers, both superhets. The FM section receives the incoming signal via a wideband antenna circuit and pin 2. From there, the signal is amplified and then applied to a mixer via a parallel-tuned circuit.

In the mixer, the signal is mixed with an oscillator signal, which is also controlled by a parallel-tuned circuit. The oscillator is combined with an automatic frequency control circuit—AFC—which only needs an external buffer capacitor.

The output of the mixer is applied to an external filter and from there to the first (internal) IF amplifier. From there, it is again filtered externally and then applied to the second IF amplifier.

Finally, the signal is demodulated in an FM discriminator. The resulting audio frequency signal is output via pin 11.

To prevent the AM receiver simultaneously delivering a signal to pin 11, the power supply to the AF stages is taken to earth via pin 14 during the reception of FM signals. Similarly, during AM operation, the supply to the FM IF stages is earthed via pin 5.

Broadly speaking, the AM section is similar to the FM section. There is, however, a difference in the input circuits: instead of a wideband antenna circuit, the AM section has a tuned antenna circuit, the inductor of which is formed by a ferrite antenna.

The amplified RF signal is applied to a mixer together with the output of an appropriate oscillator.

The mixer is followed by IF filters and an IF amplifier. The output of the IF amplifier controls the automatic gain control—AGC—circuit. The AGC holds the outputs of the IF amplifier and mixer substantially constant in spite of variations in the RF signal.

The output of the IF amplifier is demodulated by a suitable detector and the consequent audio signal is applied to pin 11.

Circuit description

The diagram in Fig. 2 shows the receiver complete with stereo decoder, IC_2, and a stereo output amplifier, IC_3, which can deliver about 2×1 W into 8 Ω.

Inductor L_1 and capacitor C_1 form the wideband input circuit for the FM receiver. The tuned circuit for the RF amplifier is formed by L_7 and one section of a 20 pF tuning ca-

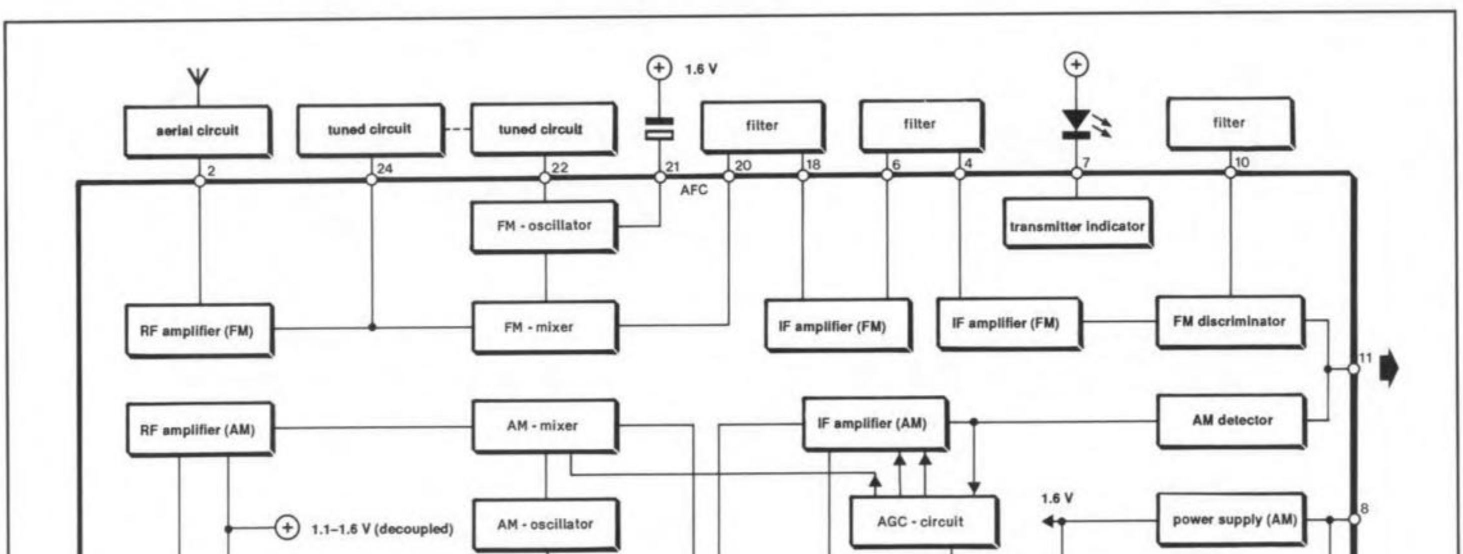


Fig. 1. Block diagram of the Type TEA5591A single-chip AF/AM receiver from Philips.

pacitor.

The oscillator for the FM section is tuned by L_6 and a second section of the tuning capacitor.

The first FM IF filter is formed by L_5 and C_{12}, while the second FM IF filter, K_1, is a ceramic type.

A second ceramic filter, K_2, ensures correct operation of the FM discriminator.

The 50 µs time constant for the correct de-emphasis is provided by the internal resistance at the AF output pin 11 (2.4 kΩ) and capacitor C_5.

The antenna tuning for the AM section is carried out by L_8 and the 140 pF section of the tuning capacitor, while the oscillator is tuned by L_4 and the 82 pF section of the tuning capacitor. Since the AM sections and the FM sections of the tuning capacitor are electrically interlinked, L_4 and L_8 form a transformer. In that way, the AM section remains electronically separated from the FM section.

The AM section contains two IF filters formed by L_2-C_{11} and L_3-C_6 respectively.

Switch S_1 selects either AM or FM. When it is in the FM position, the power supply to the AM section is earthed, whereas when AM operation is selected, most of the FM section is without power.

The AF signal at pin 11 of IC_1 is applied to stereo decoder IC_2, a Type TDA7040T (Ref. 1). This chip occupies only 0.25 cm² of space. It may be switched to mono operation by connecting pin 7 to the positive supply line via a 4.7 kΩ resistor. The same pin may be used to drive a stereo indicator via a transistor stage (mono is logic high; stereo is logic low).

SOME TECHNICAL DATA

Frequency range	AM: 520–1600 kHz
	FM: 88.5–107 MHz
Sensitivity	AM: <5 µV
	FM: <2 µV
I.F.	AM: 468 kHz
	FM: 10.7 MHz
Power output	2×1 W into 8 Ω
Harmonic distortion	<2.5%
Supply voltage	3–6 V
Quiescent current	≈30 mA

Loudspeaker outputs are protected unconditionally against short circuits

Output amplifier stages switch without any audible clicks

The output of the decoder is taken to the output amplifier, IC_3, a Type TDA7053, via a stereo potentiometer, which is combined with on/off switch S_2.

Each of the two short-circuit-proof bridge amplifiers in IC_3 delivers about 1 W into an 8 Ω loudspeaker. The advantage of bridge amplifiers is that they deliver more power for a relatively low supply voltage (minimum 3 V) than most other types of amplifier.

If modern, lightweight headphones are to be used, these can only be driven by one half of each of the bridge amplifiers (since they have only three instead of four connections). They are connected to the amplifiers via 100 µF electrolytic capacitors. Their common connection is taken to earth. The capacitors are necessary because the outputs of the amplifiers have a d.c. component of some 2 V.

In spite of the excellent properties of the tuner, it is not advisable to connect it other than via a 19 kHz band-stop filter to a hi-fi installation, because the output signal (during FM reception) contains a strong 19 kHz pilot tone. When the loudspeakers are connected to the TDA7053, this tone does no harm, but if it were amplified in a hi-fi installation, the tweeters might not be able to cope with the level.

If it is intended to use the TDA7053 regularly at full volume, bear in mind that the peak current is 1 A. This requires a medium-duty power supply instead of a simple set of batteries. In portable use batteries are, of course, the only possible supply. If only headphones are used, the batteries will give a long life, since the quiescent current is only 30 mA.

Construction

The receiver is best constructed on an experimental printed-circuit board as shown in Fig. 3. Note that this board is not available ready made. When preparing the board, a number of points need to be borne in mind: for instance, L_4 must be placed very close to the tuning capacitor. Furthermore, near pin 3 of IC_1 a common earthing point must be provided for all h.f. returns. Similar multi-connection points must be provided near the neg-

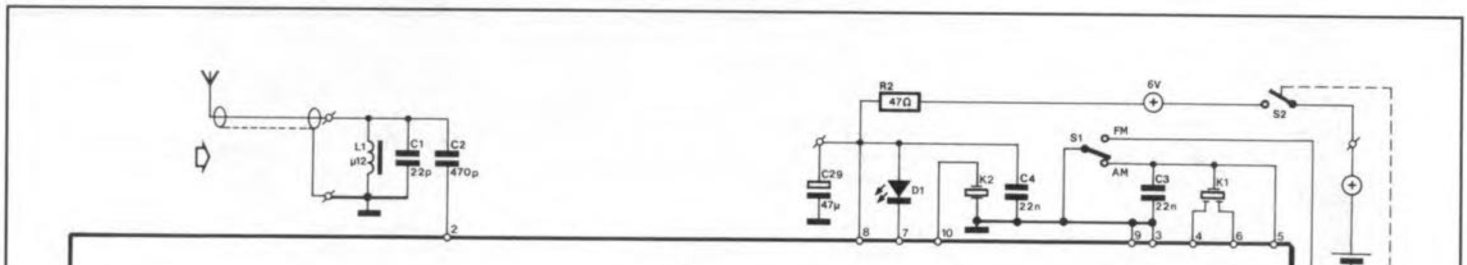


Fig. 2. Circuit diagram of the (portable) AM/FM receiver based on the TEA5591A.

ative supply input terminal (circuit earth) and near pin 14 of IC_1 (power supply to AM section).

The tracks to pins 22 and 24 must be narrow to keep parasitic capacitances low. The track to pin 24 must be very short.

To avoid feedback problems, the ferrite antenna must be as far away from the AF output (pin 11) as possible.

Inductors L_5, L_6, and L_7 are commercially available Toko types (although your dealer almost certainly will not have them in stock, but he can order them); all others must be made individually. The coil formers specified are all Toko types.

Alignment

1. Set all trimmers to their mid position.
2. Couple an RF signal generator, set to AM and tuned to 468 kHz, to the ferrite antenna via a few turns of wire around it.
3. Adjust L_2 and L_3 for maximum AF output at pin 11 of IC_1.
4. Detune the signal generator to check the symmetry of the IF filters; adjust the filter(s) if necessary.
5. Tune the signal generator to 520 kHz and set the tuning capacitor to maximum capacitance.
6. Adjust L_4 for maximum AF output.
7. Tune the signal generator to 1600 kHz and set the tuning capacitor to minimum capacitance.
8. Adjust the trimmer of the oscillator circuit for maximum AF output.
9. Repeat steps 5, 6, 7, and 8, in that order, a number of times until no more adjustments of L_4 and trimmer are necessary.
10. Tune the signal generator to 600 kHz and set the tuning capacitor to maximum capacitance.
11. Adjust L_8 (by shifting the coil on the ferrite rod) for maximum AF output.
12. Tune the signal generator to 1500 kHz and set the tuning capacitor to minimum capacitance.
13. Adjust the trimmer of the AM RF circuit for maximum AF output.
14. Repeat steps 10, 11, 12, and 13, in that order, until no more adjustments of L_8 and the trimmer are necessary.

Note that tuning the antenna circuit below the two extreme frequencies ensures optimum synchronization of that circuit and the oscillator circuit.

15. Loosely couple the signal generator to the FM antenna circuit.
16. Set the signal generator to FM and tune it to 10.7 MHz.
17. Adjust L_5 for minimum distortion on the AF output signal (either on a scope or by listening to it).
18. Tune the signal generator to 87.5 MHz and set the tuning capacitor to maximum capacitance.
19. Adjust L_6 for minimum distortion of the AF output signal.
20. Tune the signal generator to 108 MHz and set the tuning capacitor to minimum capacitance.
21. Adjust the trimmer of the oscillator circuit for minimum distortion of the AF output.
22. Repeat steps 19, 20, 21, and 22, in that order, until no further adjustments of coil and trimmer are necessary.
23. Set the signal generator to 88.5 MHz and set the tuning capacitor to maximum capacitance.
24. Adjust L_7 for minimum distortion of the AF output.
25. Tune the signal generator to 107 MHz and set the tuning capacitor to minimum capacitance.
26. Adjust the trimmer in the FM RF circuit for minimum distortion of the AF output signal.
27. Repeat steps 23, 24, 25, and 26, in that order, until no further adjustments of L_7 and the trimmer are necessary.
28. Connect pin 8 of IC_2 to earth.
29. Connect a 5.6 kΩ resistor between pin 7 of IC_2 and the positive supply line.
30. Connect a frequency counter between pin 7 of IC_2 and earth.
31. Adjust R_7 for a reading of 19 kHz on the counter. ■

Reference: "SMA FM stereo receiver", *Elektor Electronics*, September 1987, p. 51.

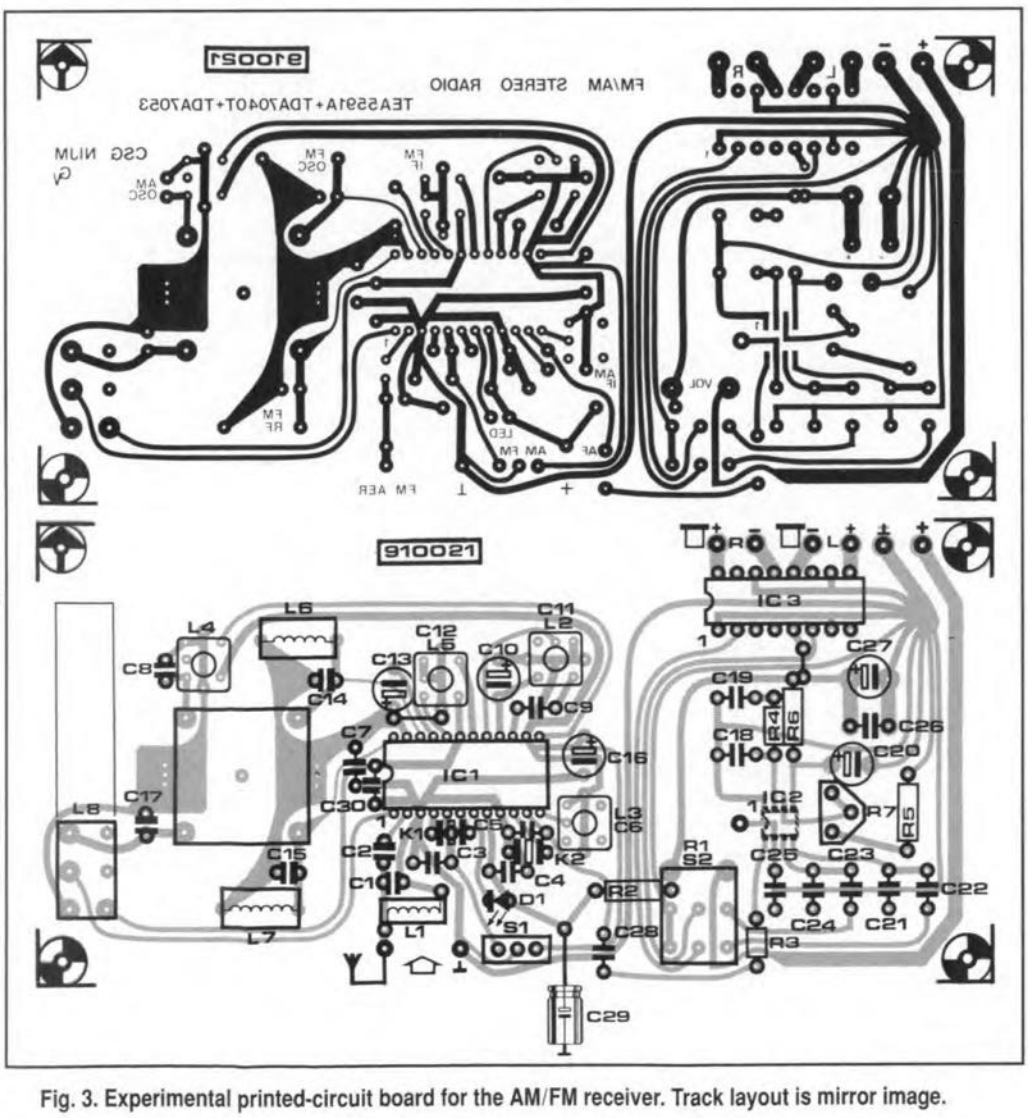


Fig. 3. Experimental printed-circuit board for the AM/FM receiver. Track layout is mirror image.

INDUCTOR DATA

L_1 = air-cored, 12 μH, inside diameter 4.5 mm; 4.5 turns of 0.8 mm dia. e.c.w.

L_2 = 665 μH; former 7MCS; n_{1-2} = 14 turns, n_{2-3} = 132 turns, n_{4-6} = 7 turns 0.07 mm dia. e.c.w.

L_3 = 665 μH; former 7MCS; n_{1-2} = 33 turns, n_{2-3} = 133 turns, 0.07 mm dia. e.c.w.

L_4 = 270 μH; former 7BRS; n_{1-3} = 86 turns, n_{4-6} = 4 turns, 0.07 mm dia. e.c.w.

L_5 = 119ACS/30120N

L_6 = 301SN0100

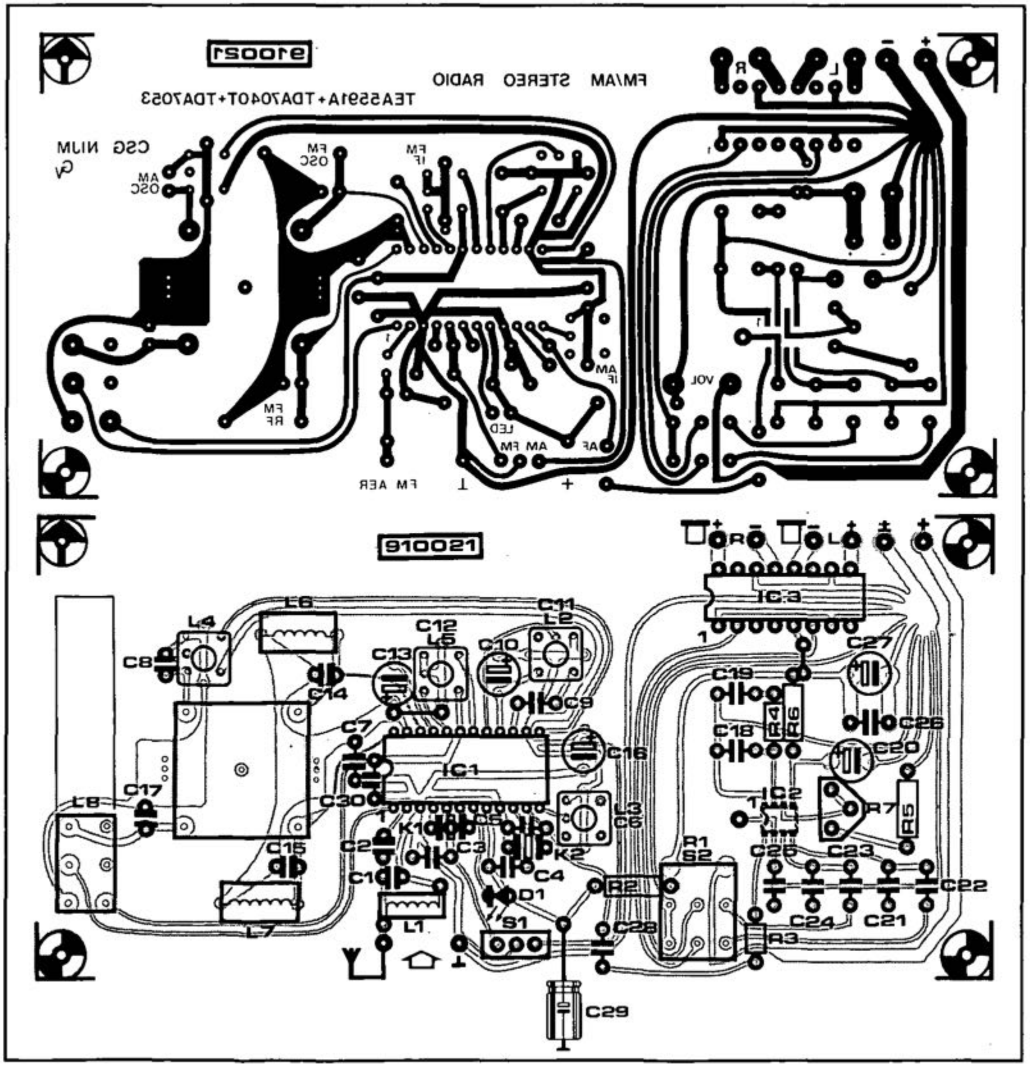
L_7 = 301SN0200

L_8 = ferrite rod 10×60 mm; 625 μH; n_{1-2} = 105 turns, n_{3-4} = 10 turns, 0.1 mm e.c.w.; wind coils on 10 mm outside diameter paper tube.

e.c.w. = enamelled copper wire

The **tuning capacitor** has AM sections of 140 and 82 pF, and FM sections of 2×20 pF; each section is shunted by a 5–10 pF trimmer (e.g., Toko FE22124)

Electronics, September 1987, p. 51.



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L_3 = 665 μH; former 7MCS; $n_{1\text{-}2}$ = 33 turns, $n_{2\text{-}3}$ = 133 turns, 0.07 mm dia. e.c.w.

L_4 = 270 μH; former 7BRS; $n_{1\text{-}3}$ = 86 turns, $n_{4\text{-}6}$ = 4 turns, 0.07 mm dia. e.c.w.

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