This digital clock makes use of the giant displays published in the August/September 1985 issue of *Elektor India*. It has a face of 720 mm wide by 280 mm high, which makes it readable at distances of up to 100 m. The display alternately shows the time and the ambient temperature.

JUMBO CLOCK

by A Sevriens

The circuit diagram in Fig. 1 shows that the clock is designed around well-tried ICs. The clocking frequency is derived from the mains: T_1 is provided with part of the secondary voltage of Tr_1 and converts this into a suitable rectangular signal. Low-pass filter R_1-C_9 and monostable IC_{21} ensure a noise-free 50 Hz signal. This signal is divided by 6 in IC_4, then by 5 and 10 in IC_5, and finally by 10 in IC_6. The signal at pin 12 of IC_6 is, therefore, 1/60 Hz, which is 1 pulse per minute.

Circuit IC_7 functions as a frequency converter: signals of 8⅓ Hz, 1⅓ Hz, and 1/60 Hz are applied to its D_4, D_2, and D_0 inputs respectively. When S_3 is in the centre — NORM — position, control inputs A, B, and C of the IC are logic low, and D_0 is then connected to output W. The clock is then supplied with normal minute pulses and operates normally. The clock may be set by switching S_3 to FAST or SLOW as the case may be.

Clockwork

The clockwork is formed by the chain consisting of four-bit synchronous counters IC_{11} to IC_{13}. The Q-outputs of these circuits give the counter position in 11-bit digital code, where Q_A of IC_{11} has the lowest value bit. Connections between the outputs and gate N_7 are so arranged that when the counter position reads 1Ø111111111 (decimal 1439), the three ICs are reset to Ø. This counter position corresponds to 23 hours 59 minutes. The clock can also manually be set to 00 hours 00 minutes with the aid of reset button S_2.

Thermometer

Circuit IC_{18} is the temperature sensor. Its temperature-dependent current causes a voltage drop across R_{31}, which, after amplification in A_1, is supplied to digitizer IC_{14}. Provided P_1 and P_2 are adjusted correctly, the Q-outputs of IC_{14} have logic levels corresponding to the temperature. The digitizer is clocked via gate N_4.

Decoding

The 11-bit digital information as to time and the 8-bit data on temperature are applied to the A and B outputs of multiplexers $IC_8 \ldots IC_{10}$ respectively. The signals at the $\overline{A}$/B input of these three ICs determine whether the time or temperature information is provided to their outputs. The signals at the $\overline{A}$/B inputs are derived from the clock oscillator, and arrange for a regular change-over at three-second intervals.

The output signals of the multiplexers are simply used as addresses for EPROMs IC_{15} and IC_{16}. Two EPROMs provide 16-bit data, and, since four digits are used for the clock, these are divided into four groups of four bits. At each address in the EPROMs now exists the relevant BCD code for controlling each of the four clock digits.

Display

How the outputs of the EPROMs control the individual display boards is shown in Fig. 2. Each of the display boards has a BCD to seven-segment decoder — see Fig. 4. This decoder converts the BCD codes into control voltages for each individual LED element of the display in accordance with Fig.3. The $\overline{RBI}$ input of the left-hand display board is connected to the D_6 output of IC_{15}: if this is logic low, the display cannot light (so that zeros are not shown in this position). The colon required for time indication is switched off by T_2 when temperature is displayed.

The degree symbol is obtained by making the B-inputs of IC_{10} logic high. This results in segments *b*, *f*, and *g* of the right-hand display board being activated via the BCD code, and segment *a* via T_3 and the Z terminal. Connections to the collectors of T_2 and T_3 must still be made, because they were not provided for in the *jumbo displays* article in the August/September issue.

These displays have a number of advantages:

- they are entirely solid state, which prevents segment failure since the life of LEDs is much longer than, for instance, that of incandescent lamps;
- they do not need intricate reflector constructions;
- if any one LED fails, they remain fully legible by virtue of the speciaal segment construction;
- they are easily arranged in a variety of colours — red, green, blue, yellow, orange;
- they work from 24 V with relative high efficiency, which keeps heat dissipation low.

1

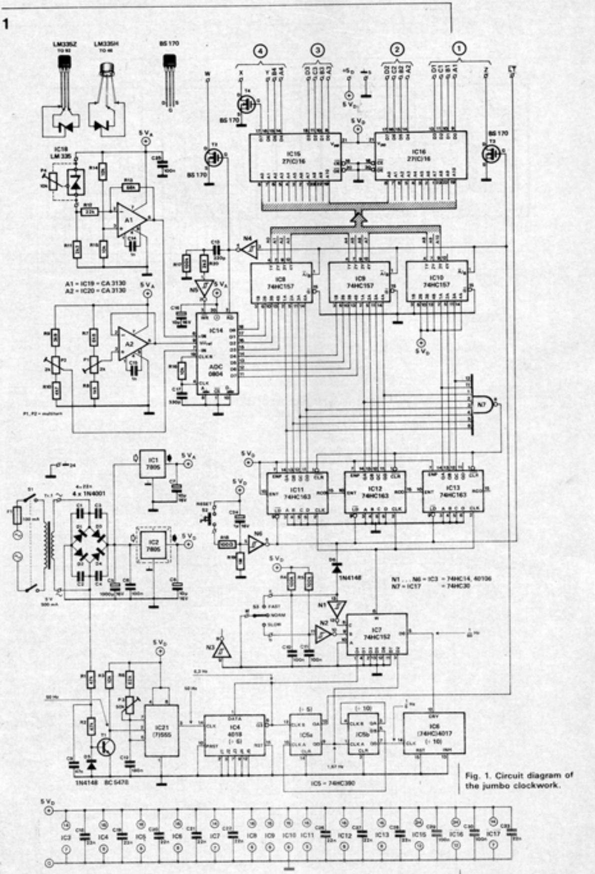

Fig. 1. Circuit diagram of the jumbo clockwork.

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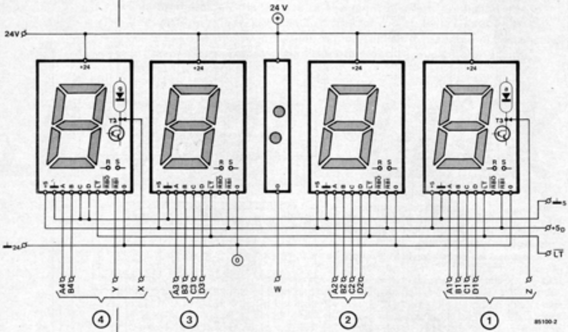

Fig. 2. Connections between the display and control boards.

It may be said that the large number of LEDs required is a disadvantage, but, in our opinion, this is largely negated by the advantages.

The seven-segment display, shown in Figure 4, is based on a type 74LS248 decoder, which has the same features as the well-known type 74LS47/247, but has in addition internal pull-up resistors and inverted output signals, so that external transistors can be used to cope with the large currents drawn by the segments. The inputs and outputs to the decoder, the read-outs, and the additional functions are correlated in Figure 3.

All input and output controls have been arranged external to the decoder, so that they can be used in the same way as with normal displays. Wire link R-S serves to interconnect the earths of the +5 V and +24 V supplies.

At the output of the decoder there is a switching stage for each segment that switches the relevant segment on or off.

Each segment consists of four parallel groups of eight or nine LEDs in series with

3

Fig. 3. The BCD-to-seven-segment decoders on the display boards function according to this table.

number or function	inputs						RBO/BI	outputs						
	LT	RBI	D	C	B	A		a	b	c	d	e	f	g
0	H	H	L	L	L	L	H	H	H	H	H	H	H	L
1	H	X	L	L	L	H	H	L	H	H	L	L	L	L
2	H	X	L	L	H	L	H	H	H	L	H	H	L	H
3	H	X	L	L	H	H	H	H	H	H	H	L	L	H
4	H	X	L	H	L	L	H	L	H	H	L	L	H	H
5	H	X	L	H	L	H	H	H	L	H	H	L	H	H
6	H	X	L	H	H	L	H	H	L	H	H	H	H	H
7	H	X	L	H	H	H	H	H	H	H	L	L	L	L
8	H	X	H	L	L	L	H	H	H	H	H	H	H	H
9	H	X	H	L	L	H	H	H	H	H	H	L	H	H
10	H	X	H	L	H	L	H	L	L	L	H	H	L	H
11	H	X	H	L	H	H	H	L	L	H	H	L	L	H
12	H	X	H	H	L	L	H	L	H	L	L	L	H	H
13	H	X	H	H	L	H	H	H	L	L	H	L	H	H
14	H	X	H	H	H	L	H	L	L	L	H	H	H	H
15	H	X	H	H	H	H	H	L	L	L	L	L	L	L
BI	X	X	X	X	X	X	L	L	L	L	L	L	L	L
RBI	H	L	L	L	L	L	L	L	L	L	L	L	L	L
LT	L	X	X	X	X	X	H	H	H	H	H	H	H	H

X = irrelevant

4

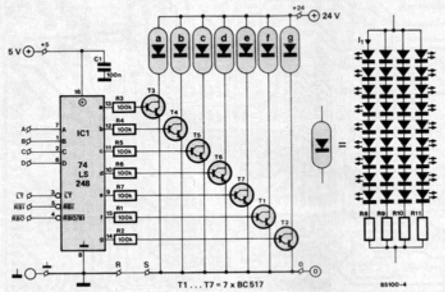

Fig. 4. Circuit diagram of a seven-segment display board.

a current limiting resistor.

The displays can be powered from a non-stabilized 20...24 V supply. The current drawn per segment varies from 50 mA to 100 mA.

Figures lb and lc give the diagrams for displays with a "1" and a ":" respectively. Both can be used for a 12-hour clock. The "1" display has provision for a lamp test (LT); open inputs are considered active, i.e., the display lights. This is in contrast to the seven-segment display which treats inputs that are not connected as logic high, that is, inactive.

As mentioned earlier, read-out boards consisting of several figures may be composed by mounting a number of displays side by side on a flat base. The whole may be protected by translucent red perspex: this also acts as a light filter, which improves the legibility considerably.

As you need a large number of LEDs, shop around for these because many dealers are prepared to allow a quantity discount. Uniformity of brightness of these diodes is not so important for this application, because at the distances for which these displays are intended, differences in brightness do not shown up.

Power supplies

Fig. 1 shows that the temperature processing circuits have their separate power supply, +5 A, provided by an additional voltage regulator Type 7805. This arrangement is necessary to prevent the analogue circuits being affected by the digital pulses in the remainder of the unit.

The displays have their own power supply — see Fig. 5, which is not regulated. The secondary voltage of Tr_2 was chosen at 2×18 V

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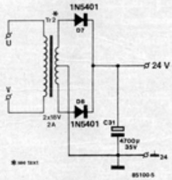


Fig. 5. The power supply that enables the 946 LEDs to glow brightly.

for red LEDs and good brightness. If green or yellow LEDs are used, or the displays need not be so bright, a secondary output of 2×15 V at 1.5 A will suffice.

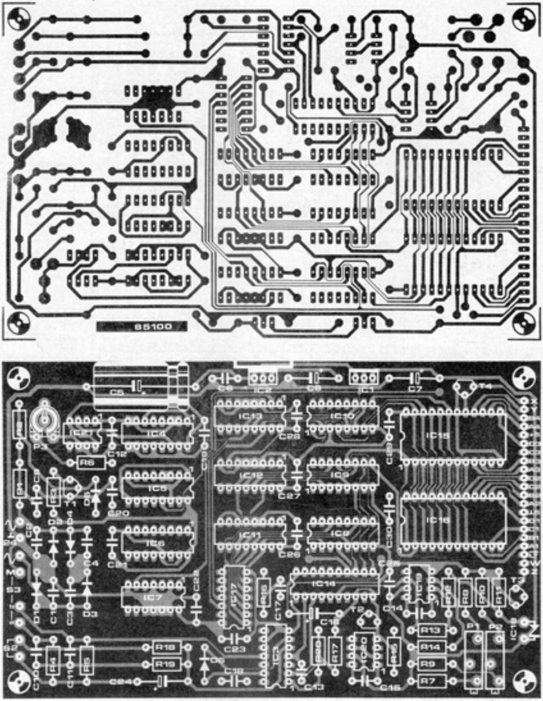
Construction and setting up

The only problem in the construction is likely to be a wandering of concentration, since there are no fewer than some 2500 soldering joints to be made. It is, therefore, all too easy to make a dry joint.

The clock itself needs no adjustments, but the temperature circuits need to be set up as indicated below.

The temperature sensor is not yet fitted at this stage: in its place, connect a variable power supply (+ to the cathode terminal). The output voltage of the supply should be monitored with a digital voltmeter. As the LM335 provides a voltage of 10 mV/K, the voltage should be set to 2.53 V to simulate a temperature of −20 °C.

6



Next, connect the digital voltmeter across pins 6 and 7 of IC_{14}. Set the voltmeter to its most sensitive range and adjust P_2 so that the meter reads exactly 0.000 V. Then, set the power supply to 3.230 V, and measure and note the voltage now pertaining across pins 6 and 7 of IC_{14}. Finally, connect the voltmeter between pin 9 of IC_{14} and earth and adjust P_1 so that the meter reads exactly half the voltage noted before.

Greater accuracy may be obtained by connecting P_4 as shown in dashed lines in Fig. 1, and adjust this preset with the aid of dishes of water at exactly 0 °C and +50 °C. Now, fit IC_{18} into place.

Finally, connect an analogue voltmeter between +5D and pin 3 of IC_{21}, and adjust P_3 so that the meter reads about 300 mV. The clock should then operate normally.

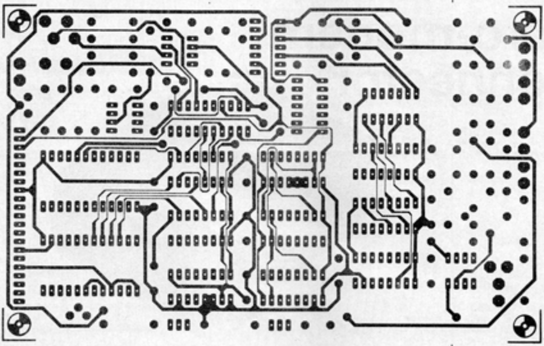


Fig. 6. The (double-sided) printed-circuit board for the control circuits.

Parts list (control board)

Resistors:

R_1;R_2 = 47 k
R_3;R_{14} . . . R_{16} = 10 k
R_4;R_5;R_{17} = 100 k
R_6 = 82 k
R_7 = 6k8
R_8 = 1k5
R_9 = 3k9
R_{10} = 4k7
R_{11};R_{20} = 2k2
R_{12} = 22 k
R_{13} = 68 k
R_{18} = 100 Ω
R_{19} = 1 M
P_1;P_2 = 2 k multiturn preset
P_3 = 50 k preset
P_4 = 10 k preset*

Capacitors:

C_1 . . . C_4;C_{18} . . . C_{23};
C_{26} . . . C_{28} = 22 n
C_5 = 1000 μ;16 V
C_6;C_{10};C_{11};C_{25};C_{29};
C_{30} = 100 n
C_7;C_8;C_{16} = 10 μ;16 V
C_9 = 47 n
C_{12} = 180 n
C_{13} = 220 p
C_{14};C_{15} = 1 n
C_{17} = 330 p
C_{24} = 1 μ;16 V
C_{31} = 4700 μ;35 V

Semiconductors:

D_1 . . . D_4 = 1N4001
D_5;D_6 = 1N4148
D_7;D_8 = 1N5401
T_1 = BC547B
T_2 . . . T_4 = BS170 or VN10KE or VN10KM
IC_1;IC_2 = 7805
IC_3 = 40106 or 74HC14
IC_4 = 4018
IC_5 = 74HC390
IC_6 = 4017 or 74HC4017
IC_7 = 74HC157
IC_{11} . . . IC_{13} = 74HC163
IC_{14} = ADC 0804
IC_{15};IC_{16} = 2716 or 27C16
IC_{17} = 74HC30
IC_{18} = LM355
IC_{19};IC_{20} = CA 3130
IC_{21} = 555 or 7555

Miscellaneous:

Tr_1 = mains transformer with 9 V, 500 mA secondary
Tr_2 = mains transformer with 2 × 18 V, 2 A or 2 × 15 V, 1.5 A secondary*
F_1 = fuse, 1 A, delayed action
S_1 = double pole mains switch
S_2 = single-pole, press to make button switch
S_3 = single-pole change-over switch with open centre rest position
heat sink for IC_2
PCB 85100

*see text

Parts list (colon display)

R_1;R_2 = 270 Ω
18 LEDs, 5 mm, colour to choice
PCB 85413-3

Parts list (display board)

NOTE: every component is required four-fold

Resistors:

R_1 . . . R_7 = 100 k
R_{8a} . . . R_{8g};R_{9c};R_{9g};R_{10b};
R_{10c};R_{10f};R_{10g};
R_{11a} . . . R_{11g} = 330 Ω
R_{9a} . . . R_{9d};R_{9f};R_{10a};R_{10d};
R_{10e} = 270 Ω

Capacitors:

C_1 = 100 n

Semiconductors:

T_1 . . . T_7 = BC517
IC_1 = 74LS248
232 LEDs, 5 mm, colour to choice
PCB 85413-1