mos clock 5314

The 'brain' in the digital clock described in this article is the clock-IC MM5314, which needs only a few external components. The time of day is indicated by seven-segment Ga-As displays, which are now offered at quite agreeable prices.
Another attractive feature is that if no seconds reading is included in the design, a considerable saving can be made, whilst seconds indication can always be added at a later stage.

The clock-IC

The clock integrated circuit type MM5314 is designed to indicate the time in hours, minutes and seconds with the aid of seven-segment displays. In contrast to the MM5313 it has no BCD output. Consequently, it is smaller (DIL 24 pins), has a simpler construction, and, what is perhaps even more important, is a lot cheaper. However, as appears from the circuit diagram of the MM5314 (figure 1), all the components needed for building a clock are available.
The IC receives its clock pulse from the mains, and can be used for 50 Hz or 60 Hz drive. The supply voltage may vary from 8 V to 17 V and need not be stabilized. If not connected, all drive inputs are at '1' level because resistors are incorporated which connect them to the plus pole of the supply voltage.
As regards the clock design, the IC offers the choice of various possibilities that depend only on a certain logic state of the drive input concerned.
It is possible, for instance, to choose between a 24-hour and a 12-hour cycle. With the 12-hour cycle the leading zero indication is automatically suppressed, which saves a lot of power. If in addition no seconds reading is required, two seven-segment displays and two transistors can be omitted, which gives a considerable saving. By means of the input 'strobe', read-out can be suppressed, and there are, of course, control inputs for retarding or advancing the clock. The clock can also be stopped for correct time setting. The table gives all possible settings of the control inputs. Figure 2a shows a top view of the pins of the MM5314 integrated circuit.

Operation

In the overall circuit of the IC two main sections can be distinguished:
a. the counter with corresponding circuits
b. the circuits for decoding and driving the displays (surrounded by the dashed line in figure 1).

Pulses to drive the counter are obtained from half cycles of the mains supply. The pulse shaper at the input of the counter changes the sine-waves into square waves by means of a Schmitt trigger. This trigger has a hysteresis of about 5 V. Depending on the logic state at pin 11 of the IC, the pulse signal is divided by 50 or 60, so that a signal of 1 Hz becomes available for the next divider. In the next three stages of the counter the pulse signal is divided into minutes and 12 or 24 hours, depending on the cycle chosen, and determined by the logic state of pin 10.
Via the gates of the individual stages of the counter the clock can be set correctly. If pin 14 of the IC is at '0', the clock will run at the rate of 1 minute per second. If pin 15 is at '0', the hours will run at the rate of 1 hour per second. When pin 13 is at '0', the clock is stopped. If a 12-hour cycle is chosen, the leading zero is suppressed by a special circuit in the IC.
Counter read-out and display drive are achieved with a multiplex technique. The multiplexer senses the various counter positions successively in the rhythm of a multiplex frequency, and passes the value found to a decoder, and from there to an output memory (ROM-Read Only Memory). The multiplex frequency can be varied by means of a simple RC network connected to pin 23.
The multiplex oscillator is followed by a divider that, depending on the logic state of pin 24, produces four- or six-digit drive pulses (with or without seconds, respectively). Using the multiplex technique implies that the displays are not driven in parallel, but in series. Parallel drive means that all counter positions can be read out simultaneously. To that end the counter reading of each decade is, at a certain moment, fed to a memory corresponding to each decade. The information thus stored drives the displays of the counter readings via a decoder. This happens simultaneously for all decades; hence the term parallel drive. Multiplex technique, however, means that all counter readings are scanned quickly in successive order and are fed in the same order to an output memory (ROM), which for this IC is programmed for seven-segment displays. At the same time that the counters are read, each corresponding display receives the supply voltage via the drive logic of the block marked 'Digit Enable'. This means that, with this clock, the counters can be read 1 out of 4 if a four-digit display is used, or 1 out of 6 for a six-digit display; the logic state of pin 24 determines the display mode. If, for instance, the one-second counter is read, the one-second display receives supply voltage via 'Digit Enable', and the reading of this decade becomes visible. Corresponding segments of each display are interconnected, but only the particular segments of a display that receive a voltage will light up. In spite of the fact that series drive is used, visual read-out remains constant, provided the multiplex frequency is higher than about 100 Hz. In the MM5314 the multiplex frequency can be chosen up to 60 kHz. If the read-out is suppressed via pin 1 ('strobe') of the IC, the clock will continue to run normally. Thanks to this feature it is quite easy to build an emergency supply.

The circuit

The complete circuit in figure 3 shows that apart from the MM5314 only few components are needed to build a complete clock. Perhaps somewhat unusually, the circuit description starts with the supply, because it is from there that the counter pulses are derived. Since the supply voltage for the IC need not be stabilized, the source has been kept as simple as possible. The d.c. supply voltage may be anything between 8 V and 17 V.
The half cycles of the 50 Hz mains are fed to the pulse input via a decoupling network R_{22}/C_3. This input is protected against overloading by means of diode D_1.
The RC network (R_{23}/C_4), connected to pin 23 of the IC, determines the multiplex frequency which, for the given values, is about 10 kHz. Because the integrated circuit cannot provide sufficient current to drive the seven-segment

Figure 1. Block diagram of the MM5314 integrated circuit. From this it is clear that the entire clock, except the supply and drive for the displays, is incorporated in this IC.

Figure 2a. The pins of the IC seen from the top.

Figure 2b. Pin details of the Opcoa red GaP seven-segment display type SLA 1. With most other types of seven-segment displays separate anodes are also connected to pins 3 and 9; hence, an extra connection is needed between these pins and pin 14.

Table

function	state *	pin
stop	'0'	13
slow adjustment	'0'	14
quick adjustment	'0'	15
mains frequency 50 Hz	'1'	11
mains frequency 60 Hz	'0'	11
12-hour cycle	'0'	10
24-hour cycle	'1'	10
with seconds	'0'	24
without seconds	'1'	24
strobe	'0'	1

*) An unconnected input is at state '1' because within the IC these inputs are connected to the plus of the supply voltage via resistors.

display simple buffer stages are required. These use normal TUN's and are connected between pins 3 to 9 and the display segments. The collector resistors provide current limiting for the segments, so their values determine the luminous intensity of the displays. The minimum permissible value for these resistors is 330 Ω (+V_b = 17 V); in practice 470 Ω gave satisfactory results for all supply voltages. A lower value produced no noticeable increase in luminous intensity, so that in fact only the life of the display is then unnecessarily shortened.

Buffer transistors, acting as switches, are also connected between the 'Digit-Enable' outputs and the anodes of the displays. These switches connect the second-, minute- and hour displays to the

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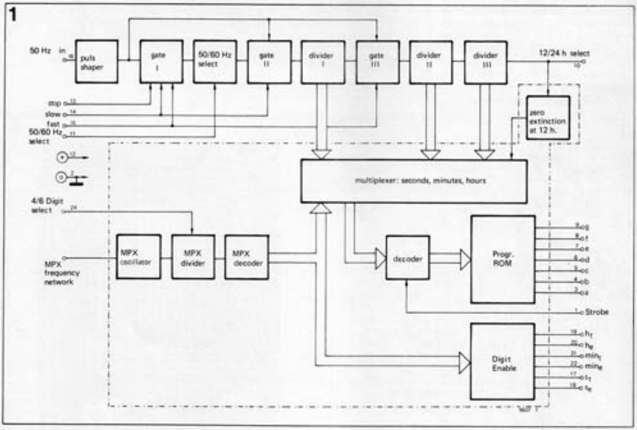

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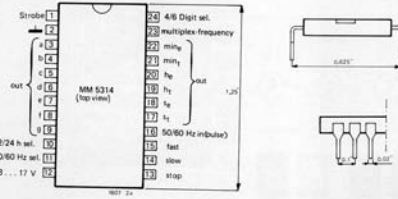

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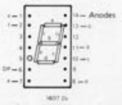


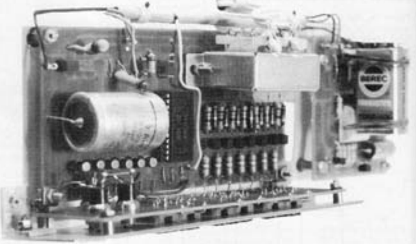
supply voltage at the correct moment. The switching transistors used here are TUPs.
The circuit is mounted on two printed circuit boards: one for the displays, and one for the actual clock circuit with mains supply.

Printed circuit boards

Figure 4 shows the printed circuit board, and figure 5 the component layout for the mains-fed clock circuit. The boards are quite small, so that the whole unit can be housed in a small attractive cabinet. So much space has been reserved on the board for the supply transformer and electrolytic capacitor C_2 that, if necessary, fairly large types can be used. All terminals and controls (50/60 Hz selection, strobe, etc.) are placed in a row on one side of the board, directly opposite the terminals they are connected to on the display board, which is shown in figure 6. This display board holds the displays and small push buttons for 'stop', 'slow' and 'fast'.

Displays

The display board (figure 6) is mounted



3

Parts list

Resistors:
$R_1 \ldots R_7$ = 10 k
$R_8 \ldots R_{14}$ = 100 k
$R_{15} \ldots R_{21}$ = 470 Ω
R_{22}, R_{23} = 100 k

Capacitors:
C_1 = 5n6
C_2 = 2200 µ/25 V
C_3 = 10 n
C_4 = 22 n
C_5 = 47 n

Various:
Tr = mains trafo, 8 ... 12 V/250 mA
$S_1 \ldots S_3$ = miniature push-button, SPST
IC-socket (24 pin DIL)

Semiconductors:
IC = MM5314
$T_1 \ldots T_7$ = TUN
$T_8 \ldots T_{13}$ = TUP
D_1 = DUS
B = bridge rectifier B30C500, BY 164 etc.
Displays = Opcoa SLA 1, Monsanto MAN 1, MAN 7 and MAN 10, Texas T 6302, Hewlett Packard 5082 and 7730, Litronix Data Lit

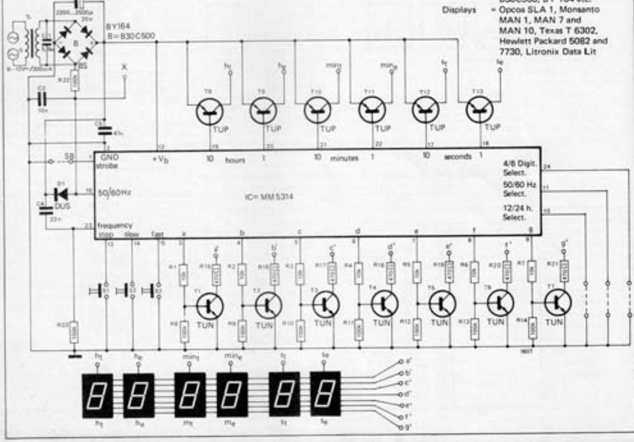


Figure 3. The total circuit complete with mains supply. If instead of TUNs, quality transistors are used for T_1.....T_7 (e.g. BC107), the resistors R_8.....R_{14} can be omitted

Figure 4. The printed circuit board of the clock circuit with mains supply. The pins are positioned so that only very short connections are needed between clock and display circuit boards.

Figure 5. Component lay-out for the clock circuit. There is sufficient space for almost any type of transformer. Even a 40V electrolytic capacitor could be accommodated on the circuit board.

behind the front plate of the cabinet. Instead of the seven-segment LED displays used here (the Opcoa SLA1), types MAN1, MAN7 and MAN10 of Monsanto, T6302 of Texas, 5082 and 7730 of Hewlett Packard or Data Lit of Litronix can be used. Some of these even have two LEDs per segment, which gives a greater intensity at a slightly lower current consumption. Unfortunately, there are many displays where not all anodes are connected to pin 14, but have separate anodes connected to pins 3 and 9. The pins 3 and 9 (at the bottom of the displays concerned) must then be bent completely inward and connected to pin 14.

With or without seconds

If the 'seconds' indication is not used the expense of two displays, two sockets and two transistors can be saved. In this case there is no connection between pin 24 and earth. Since the board is designed for six displays, two more can always be added at a later time without much trouble.

Connection between the boards

In total (including the seconds) there are 13 control connections between the clock and the display circuit boards. The six pins of Digit Enable (h_t, h_e, m_t, m_e, s_t, s_e) are connected to the corresponding terminals on the display board. Furthermore, the terminals a to g of the clock circuit are connected to the same terminals on the display board. Three other connections run to the three small push-buttons for setting the clock. One side of each button is connected to the supply common.

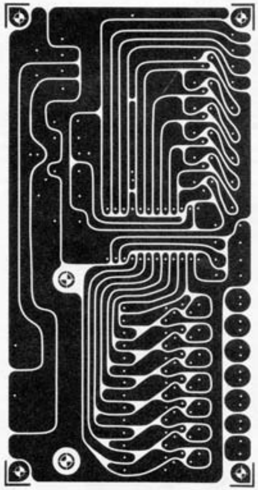
By means of time signals on the radio, TV, or telephone service, the clock can be started properly and quite accurately. With the buttons "fast" and "slow" the clock is pre-set before the time signal comes, and the button "stop" is released the moment the signal sounds. The front of the cabinet must have openings for the four or six displays which can be mounted behind perspex, for instance.

Further developments

In Elektor laboratories the following additional units have been developed for the clock:

– crystal-controlled time base with only one IC; current consumption complete with oscillator: about 90 μA.

4



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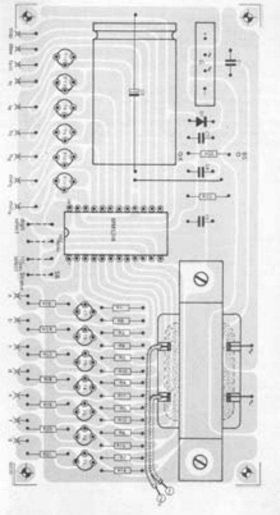

- emergency supply in case the mains supply fails.

These extensions will be discussed in a following issue. The points marked SB, BX and X in figure 3 and in the component lay-out are for use with these units.

6

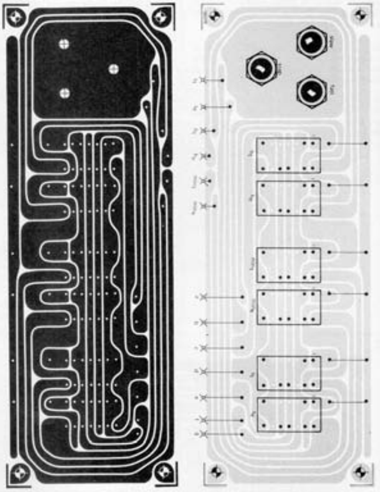

Figure 6. The display circuit board. The small buttons for setting the clock are at the front.

Figure 7. A complete digital clock! The photograph shows the simplicity of design and the limited number of components needed.

7