mos-clock (2)

The mos-clock described in Elektor 1 has been extended with a crystal time base and an emergency supply. These extensions do make the clock a bit more expensive, but they are at the same time elements changing the clock into a highly-accurate and universal instrument. Furthermore, the total extra current consumed by these extensions is practically negligible. Both the emergency supply and the crystal time-base are mounted on one printed circuit board.

In recent years especially, the mains voltage has been liable to cut out momentarily (or even for quite some time!). Depending on the capacitance of the electrolytic in the power supply, the d.c. voltage driving the clock will have disappeared after about 200 ms. The clock will then forget what time it is, so that it must be reset. This is in itself not such an enormous problem, but a number of brief failures in one day could be annoying!
The emergency supply circuit described here uses a 9-volt battery. This provides an emergency drive for about 20 hours; a period within which even the most serious mains breakdown will have been repaired. The emergency drive also offers the possibility of moving the clock from one room to another without it stopping.

Design

As the clock-IC MM5314 consists of one monolithic MOS circuit, its current consumption can be neglected in comparison with that of the displays. At 15 V the total current consumption of the clock is about 250 mA, 240 mA of which is drawn by the displays. This is one of the reasons why the clock-IC is provided with a so-called strobe input (pin 1 of the IC) which is '1' when the clock is running normally. If, however, the strobe input is made '0', the display is suppressed, and only the divider circuits and the memory still draw current.
These circuits still function satisfactorily at a supply voltage of 7 V.
So for an effective emergency supply from a small battery it is essential that as soon as the normal supply cuts out, the strobe input becomes '0' so that current consumption drops to about 8 mA. Of course, it must be possible to switch on the display circuits now and again on the emergency supply. A circuit which provides for this is given in figure 1.
If the mains voltage is available, the circuit is driven via point BS from the secondary of the transformer. This point is indicated on the clock P.C. board. The transformer secondary voltage on BS is rectified via D1, so that capacitor C1 is charged. Then transistor T1 is driven into saturation via resistor R1. The collector voltage of this transistor is then so low that transistor T2 is not driven. Via resistor R4 and push-button S1 the collector of T2 is connected to the strobe input of the clock-IC. This point (SB) is also indicated on the clock p.c.b. When transistor T2 is off, the strobe input of the clock-IC is connected to a relatively high-impedance load so that it 'sees' a '1', causing the displays to light up.
If, however, the mains voltage cuts out, point BS in figure 1 no longer carries a voltage, and C1 discharges so rapidly that transistor T1 is cut off within 5 ms. Now the base of T2 is driven via resistors R2 and R3, so that its collector-to-emitter resistance drops to about 200 ohms. As a result point SB becomes '0' via resistor R4 and the supply for the display circuits is cut off inside the clock-IC.

Parts list for figures 1, 2, 5, and 7.

resistors:
R1,R3 = 100 k
R2,R7 = 27 k
R4 = 10 k
R5 = 120 Ω
R6 = 15 k
R8 = 47 k

capacitors:
C1 = 0.1 μ
C2 = 5 . . . 30 p trimmer
C3 = 15 p
C4 = 220 μ, 10 V

semiconductors:
T1,T2,T3 = BC 107 B or equ.
D1 = BAY 61, BA 127
D2,D3,D4,D5,D6 = DUS
IC1 = ICM 7038 A (intersil)

miscellaneous
S1 = push button with break contact
X-tal = 3.2768 MHz crystal; parallel resonance with external 12 p
8-pin DIL IC-base for IC1

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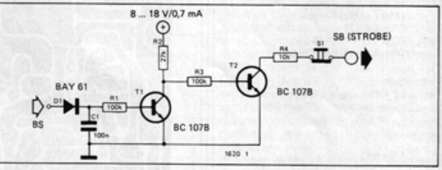

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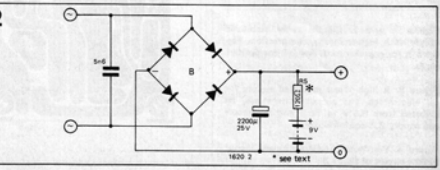

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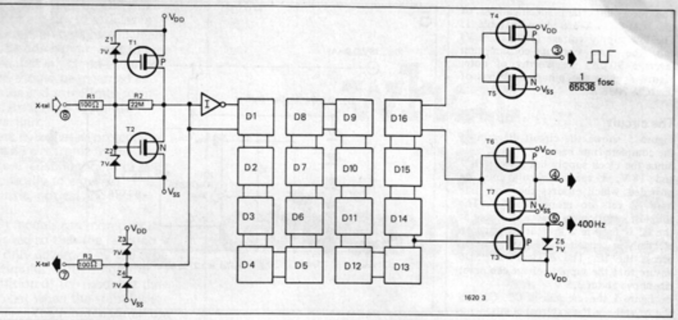

When button S1 in figure 1 is depressed, the strobe input of the clock-IC becomes '1' again and the displays light up. Instead of a push button, a single-pole switch can be used for S1.

Practical version

For the emergency supply, only a battery with a series resistor need be connected across the supply electrolytic capacitor of the clock proper. Figure 2 shows the relevant detail of the clock supply: the extra battery and the series resistor R5 are in parallel with the supply elco. A so-called minipower pack will do as the battery. The design of the p.c.b. is based on this type of battery.

Two alternative arrangements are also possible. The first is to replace R5 by a diode, with the anode connected to the battery and the cathode connected to the supply rail. This has the advantage that the full battery voltage is available to drive the displays for short periods on emergency drive. However, it also means that no 'refresher' current runs through the battery when the mains is on.

Perhaps the best arrangement of all is to replace R5 by a diode, as above, and add an extra resistor of 100 k in parallel to the diode. This will trickle-charge the battery.

In all cases it is advisable to check the battery condition occasionally (by disconnecting the mains). This is particularly important when 'dry' batteries are used – they sometimes become very wet after a period of time, as many owners of portable radios and torches have discovered to their cost!

Crystal timebase

Although the standby supply will maintain the information in the memory of the clock in the event of a mains failure, the counting circuits will not operate in the absence of a 50 Hz signal. This is where the crystal timebase comes in. It ensures good timekeeping accuracy (approx. 10 seconds per month) and makes the drive to the clock independent of the mains.

Table 1. Some specifications of the Intersil IC type ICM 7038 A.

supply voltage	: 1.6 V . . . 4 V (max. 5 V)
current consumption	: 60 µA (V_b = 2.2 V); 130 µA (V_b = 3.6 V)
output resistance	: 230 Ω both for p- and n-output condition (I_o = 3 mA)
minimum oscillator frequency	: 0.2 MHz (V_b = 1.6 V)
maximum oscillator frequency	: 10 MHz
power dissipation	: 300 mW maximum
input voltage oscillator	: $\leq V_b$
case temperature	: −30° C . . . +125° C maximum
ambient temperature	: −20° C . . . +70° C maximum
output voltage	: $\approx V_b$ at all outputs
output current at $V_o = 0$	: 80 mA maximum
$V_o \approx V_b$	: 18 mA maximum
400 Hz output current ($V_a \approx V_b$)	: 30 mA maximum
400 Hz output resistance	: 200 Ω (I_a = 3 mA)

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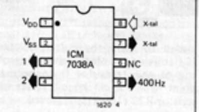

Figure 1. With the mos-clock, the displays draw most of the current. If the clock is provided with a circuit that drives the 'strobe' when the mains cuts out, the emergency battery will keep the clock itself running for about one day.

Figure 2. The mos-clock can easily be provided with an emergency supply. A 9-volt battery and a series resistance of 120 Ω will do.

Figure 3. The intersil IC type ICM 7038 A comprises a.o. a 16-stage divider and a crystal oscillator. For the oscillator only the crystal and two capacitors need be connected externally. The IC is built up from complementary MOS-circuits, so that the power dissipation is extremely low.

Figure 4. The external connections of the ICM 7038 A. Owing to the COS/MOS properties, it is always advisable to use a base or socket for this IC.

For this crystal time base use is made of a complementary MOS IC which, besides an oscillator, also comprises the dividers necessary for obtaining the 50 Hz square-wave voltage with which the clock is driven.

Figure 3 gives a simplified block diagram of this IC, the INTERSIL ICM 7038 A. Transistors T1 and T2 in figure 3 are a part of the crystal oscillator. Two external capacitors and the crystal are connected between points 7 and 8. The oscillator is followed by an inverter (I) which is turn is followed by 16 divider stages. The 16th divider is followed by two inverse output stages at which a relatively low-impedance square-wave voltage is available for further processing. The divider stages D1 . . . D16 are all binary so that after the 16th divider we have a frequency of:

$$f = f_o/2^{16} = f_o/65536$$

Here f_o is the oscillator frequency and f the output frequency behind the 16th divider.

It is also apparent from figure 3 that all important points are protected by means of zener diodes. This does not imply, however, that the IC can be handled as if it were TTL: due care is always recommended. Touching the connecting pins of the IC must be avoided as much as possible, whilst the IC can best be mounted on the p.c.b. by means of a socket.

The most important specifications of the ICM 7038 A are given in table 1. The low supply voltage (1.6 . . . 4 V) and the low current consumption (average 90 µA) are worthy of note. Figure 4 gives the pin connections of the ICM 7038 A.

The circuit

Figure 5 shows the circuit diagram of the complete time base.
Since the clock supply lies between 8 V and 18 V, a special circuit must be provided which ensures that the time base IC gets no more than 5 V. The simplest solution is shown in figure 5: the IC is fed via a resistor R6, and an electrolytic capacitor (C4) is connected across the IC. The diodes D2 . . . D6 ensure that the supply voltage can never rise above about 3.5 V.
In figure 5 the capacitors C2, C3 and the crystal are the external components for the oscillator. The crystal must be of a type that has been ground for parallel resonance with an external parallel capacitance of 12 pF nominal. For 50 Hz output reference the crystal frequency must be 3.2768 MHz. The oscillator can be adjusted with capacitor C2.
Transistor T3 has been included in the circuit to make the output voltage of IC1 suitable for clock drive. The collector of this transistor is connected to point X on the clock p.c.b., after which resistor R22 (100 k) is removed.

The printed circuit board

Figure 6 shows the lay-out of the printed circuit board on which the circuits of figures 1, 2 and 5 can be mounted. The component arrangement of these circuits is given in figure 7.
Figure 8 shows a photograph of the board. It can be mounted on the mains transformer on the original clock board.

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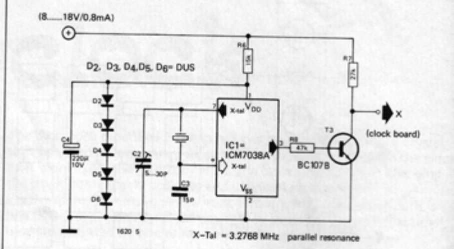

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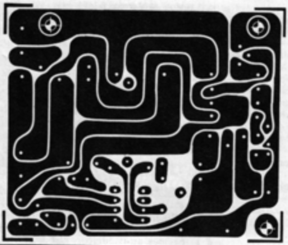

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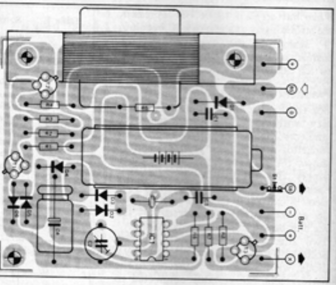

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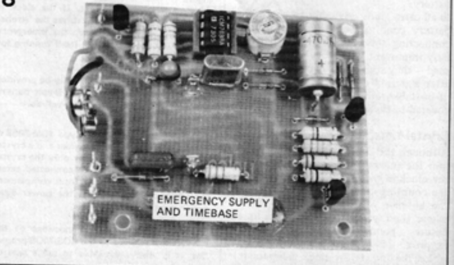

Figure 5. The complete 50-Hz reference source for the mos-clock. The diodes D2 . . . D6 are for protection and ensure that the supply voltage for the IC cannot rise above about 3.5 V. T3 is needed because the output voltage of the IC is too low to drive the clock input directly.

Figure 6. The lay-out of the printed circuit board for the circuits of figures 1, 2, and 5.

Figure 7. The component arrangement on the printed circuit board of figure 6.

Figure 8. Photograph of the complete printed circuit board with the circuits of figures 1, 2, and 5.