ZD-11E Quasi Analog Clockwork Kit

elektor ZD-11E Quasi Analog Clockwork Kit Instruction Manual

Contents

elektor ZD-11E Quasi Analog Clockwork Kit

Product Specifications

- **Brand:** Elektor
- **Product:** Quasi Analog Clockwork Kit
- **Model:** 20944
- **Components:** PCB and all parts listed in the Bill of Materials

Product Usage Instructions

Tools Required

- Soldering iron with a relatively small tip
- Cutting pliers
- Flat-jaw pliers
- Flat and clean surface to place the PCB on during soldering

Component Placement and Soldering Order:

1. Solder Trimmer C7
2. Solder Transistors T1 and T2
3. Place Terminal block K1 on the bottom side (refer to Fig. 5)
4. Solder Crystal X1

Soldering Process:

- Follow the instructions provided in the manual to solder all components in the correct order.
- Ensure components are fitted and soldered properly as shown in the images.

FAQ

- **Q:** Where can I find the complete construction manual?
  - **A:** The complete construction manual is available as a downloadable PDF at **www.elektor.com/20944**.
- **Q:** What components are included in the Elektor Quasi Analog Clockwork Kit?
  - **A:** The kit includes a PCB and all parts listed in the Bill of Materials section.
- **Q:** What tools do I need for soldering the components?
  - **A:** You will need a soldering iron with a small tip, cutting pliers, flat-jaw pliers, and a flat, clean surface to work on.

Kit Contents

The kit supplied by Elektor contains the PCB and all parts stated in the Bill of Materials found in section 5. The next photo shows the components in the kit.
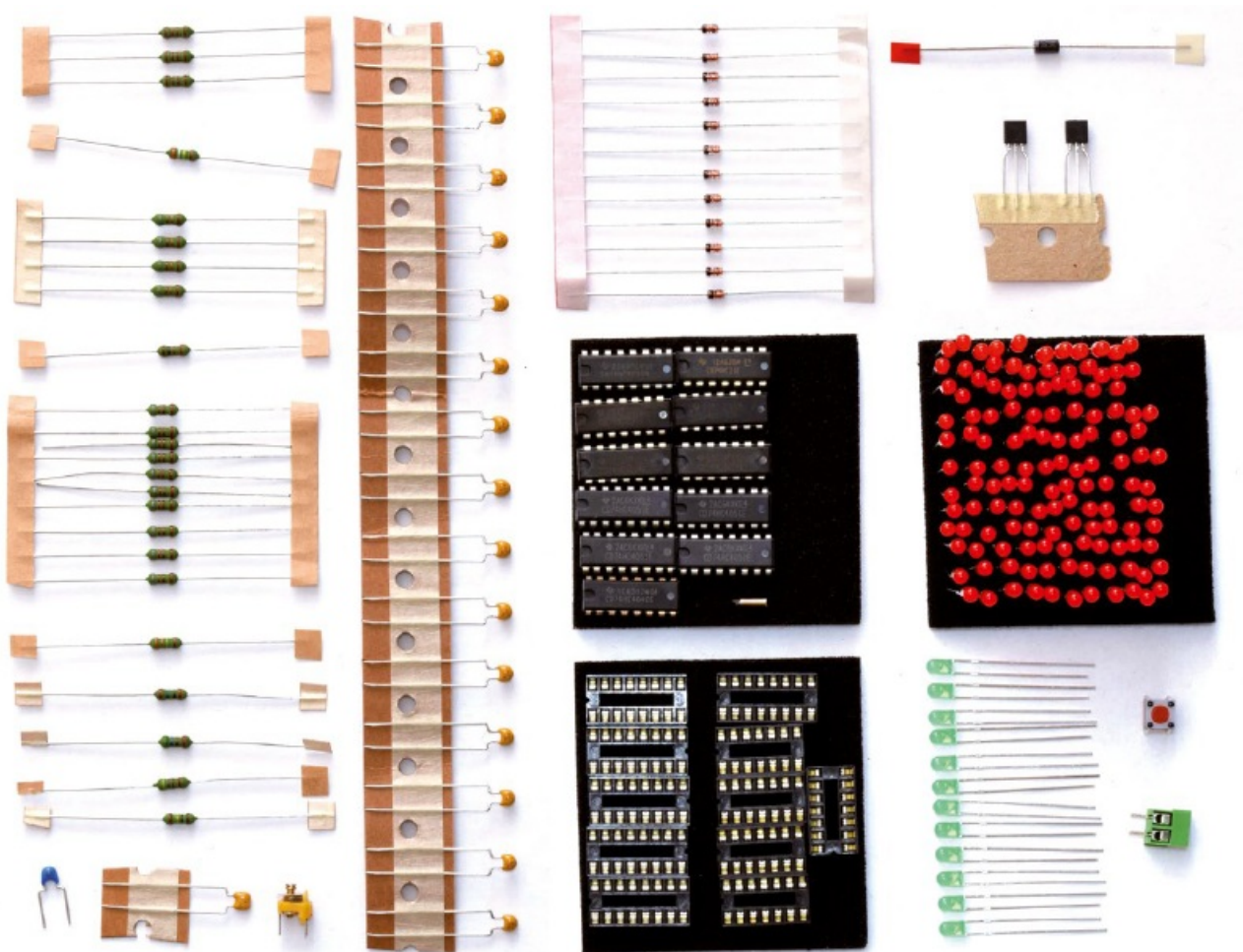

Figure 1: Components contained in the Elektor Quasi-Analog Clockwork kit.

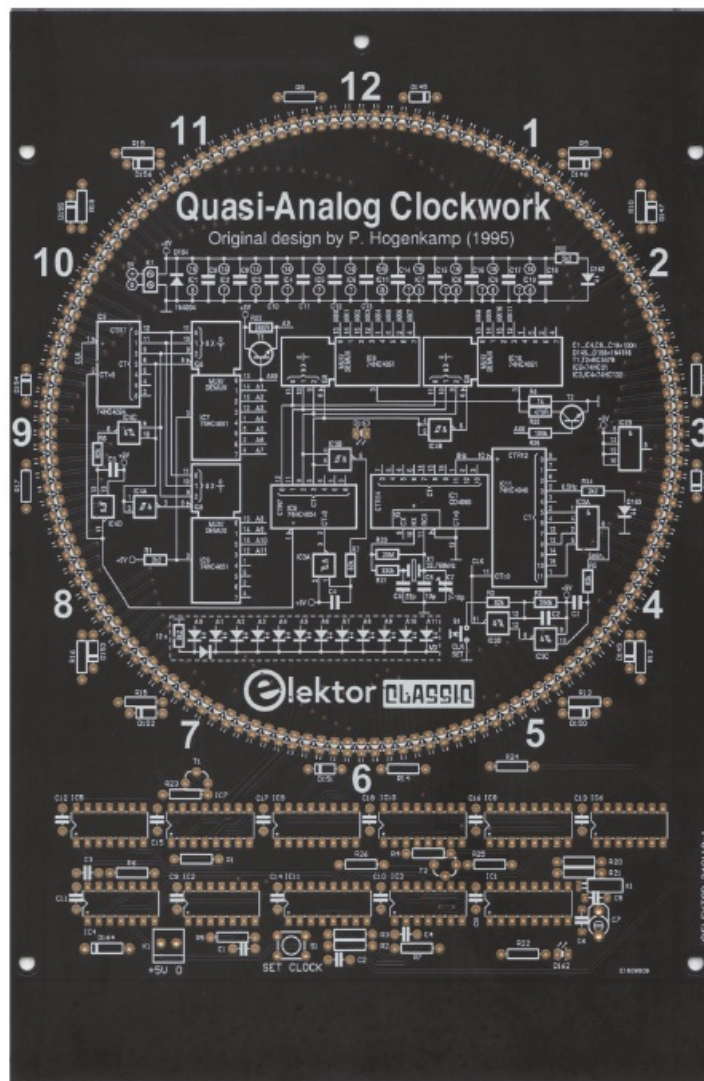The following images show the top and bottom side of the PCB contained in the kit.

Figure 2: Top view of supplied PCB 240118-1 v1.1.

Figure 3: Bottom view of supplied PCB 240118-1 v1.1.

Tools Needed

- Soldering equipment for through-hole components. Soldering iron with a relatively small tip.
- Cutting pliers
- Flat-jaw pliers
- Flat and clean surface to place the PCB on when soldering the components

Assembling the PCB

Start by placing the lowest components first and solder them. The quartz crystal, X1, is the smallest and most fragile component and best fitted when the rest of the components are placed and soldered. In case of the diodes, pay attention to the cathode marking. First solder one lead and check polarity again — it's easier to remove a diode with just one lead soldered. When turning over the PCB to solder the leads, make sure the surface is perfectly flat. After soldering the first leads — also applicable to the resistors — check if the body of every component is level and flush on the PCB surface. Then solder the second lead of each component.

Place the following components and solder them in this order:

- **1.** Diodes D145 – D156
- **2.** Resistors R1 – R26
- **3.** Diode D164

- **4.** Tactile switch S1
- **5.** All IC sockets: first solder 2 pins in opposite corners of each IC socket and check they are all fitted correctly; then solder the rest
- **6.** Capacitors C5 (22 pF) and C6 (10 pF)
- **7.** Capacitors C1 – C4, C8 – C18
- **8.** LEDs D1 – D144, D162, D163

The short leads (i.e. cathodes) of the LEDs in the circle are on the outside. When soldering, pay close attention to this! Place one LED at a time and solder one lead of each LED only and check if it's placed perpendicular with the PCB surface and if the last LED soldered lines up perfectly with the previously soldered ones. Check if this is the case, with every LED, every time! Also place the green LEDs in the correct position.

Between two green LEDs go 11 red LEDs. If everything looks good it's safe to solder the second lead of each LED. Before soldering, make 12 stacks of 12 LEDs, 11 red and 1 green. This is to remind you that after 11 red LEDs one green LED must be soldered. Placing all 144 LEDs in the circle first and soldering them all at once will not work since the transparent plastic of the LEDs is subject to tolerances too much, and the holes in the pads are larger than the LED wire diameter.

Proceed with soldering:

- **9.** Trimmer C7
- **10.** Transistors T1 and T2
- **11.** Terminal block K1 (place it on the bottom side, see Fig. 5)
- **12.** Crystal X1

Adjusting Trimmer Capacitor C7

Adjusting C7 requires a frequency counter with at least a 7 digits. Many modern multimeters with an graphical display also are able to measure frequency but not that accurately. The latter can be used to get an indication whether or not the 8 Hz deviates too much. Measure at pin 1 of IC1. If an accurate frequency measurement isn't possible, adjust the trimmer halfway. A quote from the datasheet published for the trimmer used (BFC280823109): "Life of trimmer is specified as 10 cycles maximum, rotation in 180° only (is the effective angle of rotation). The electrical and mechanical performance is not guaranteed if rotated beyond 10 cycles." Also solder the trimmer as close as possible to the board!
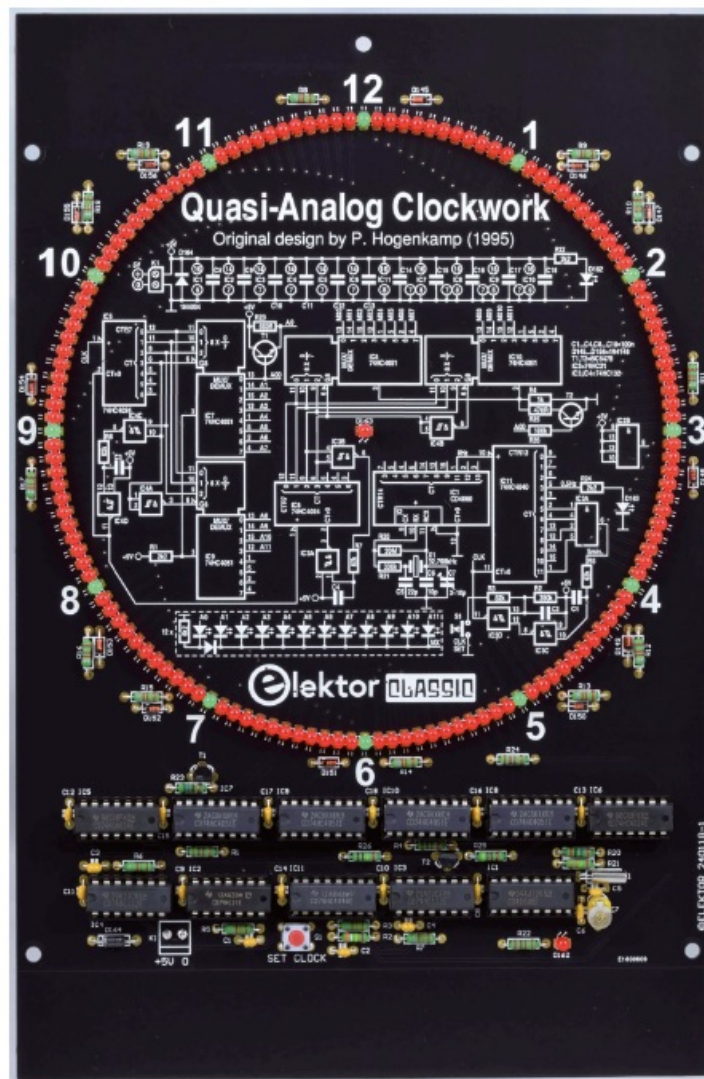
Figure 4: Front view on PCB 240118-1 v1.1. All parts are fitted and soldered.

Figure 5: View of back of PCB 240118-1 v1.1. All parts are fitted and soldered.
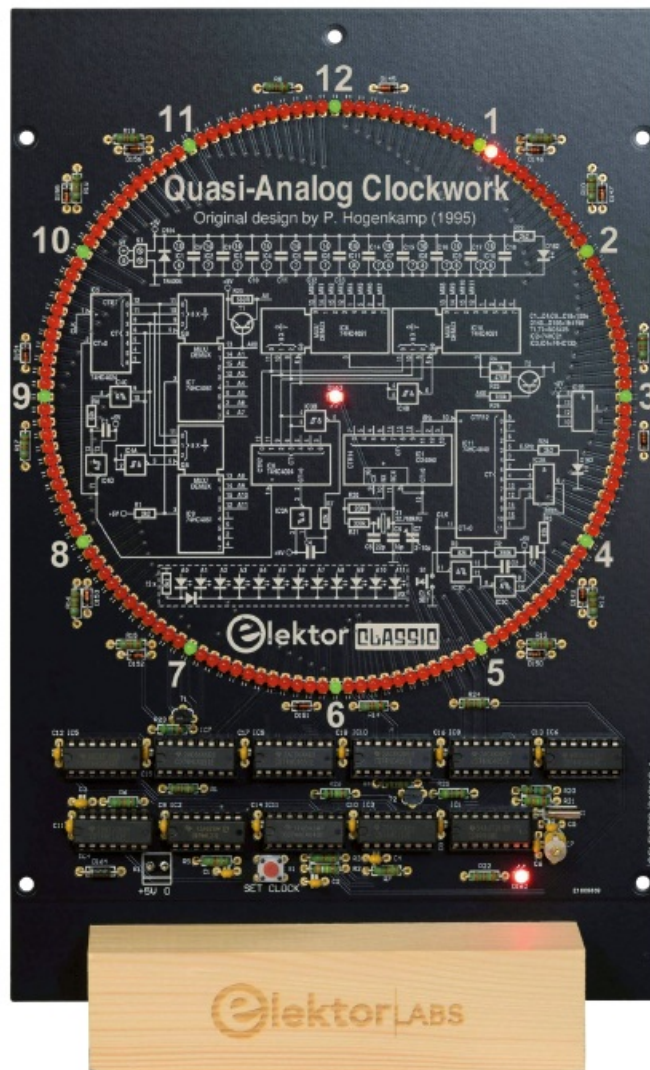
Figure 6: PCB powered and secured in wooden stand.
Time indicated is between 5 and 10 minutes past 1.
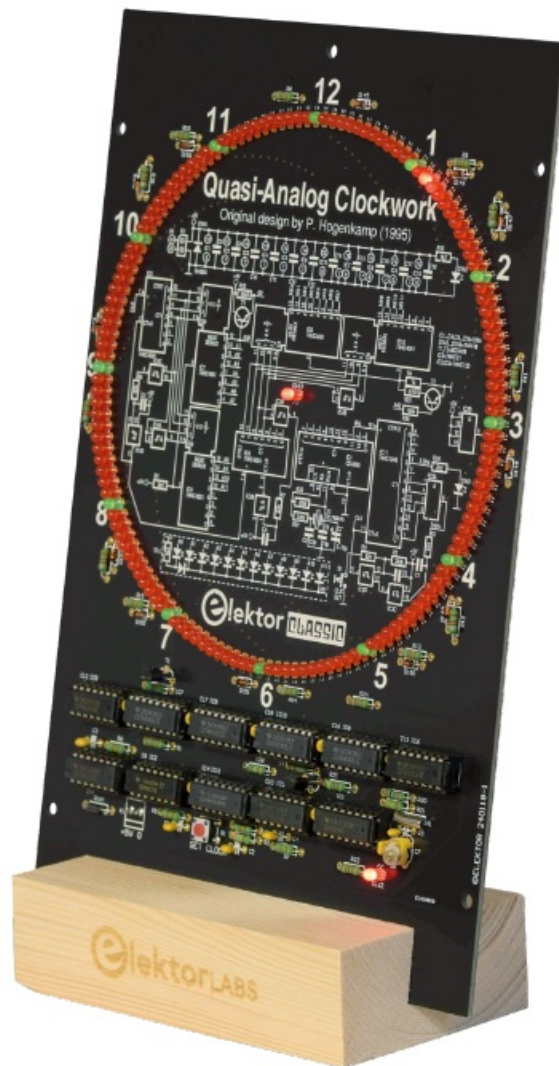
Figure 7. Another view of the clock in the wooden stand. Time indicated is between 10 and 15 minutes past 1.
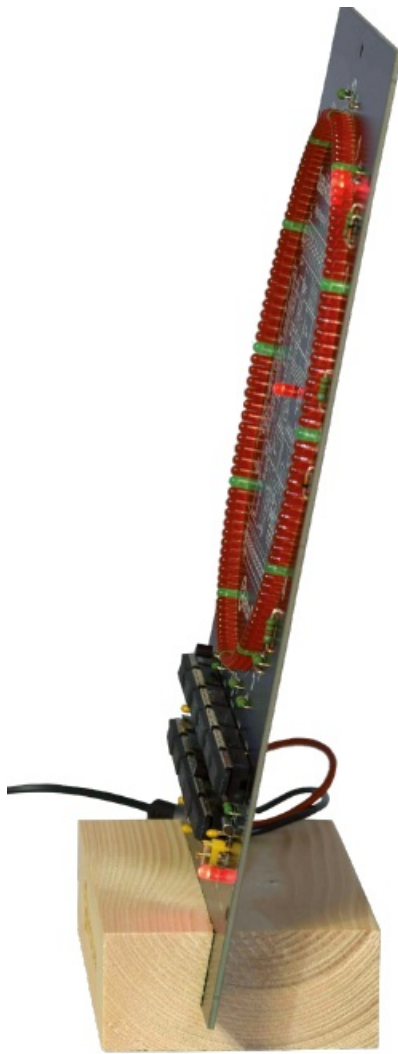
Figure 8. Side view on the clock in the wooden stand.
Time indicated is between 10 and 15 minutes past 1.

Bill of Materials

Resistors
(body 2.5 x 6.8mm, 250mW)

- R1, R22, R24 = 2.2kΩ
- R2 = 390kΩ
- R3, R5, R6, R7 = 82kΩ
- R4 = 1kΩ
- R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19 = 8.2kΩ
- R20 = 20MΩ
- R21 = 330kΩ
- R23 = 560Ω
- R25 = 470Ω
- R26 = 100kΩ

Capacitors

- C1, C2, C3, C4, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18 = 100nF, 50V, ceramic X7R, lead spacing 5mm

- C5 = 22pF, 50V, 5 %, ceramic C0G/NP0,lead spacing 5mm
- C6 = 10pF, 50V, 5 %, ceramic C0G/NP0, lead spacing 5mm
- C7 = 3~10 pF, trimmer capacitor, 150V, through hole (BFC280823109 Vishay BCcomponents)

Semiconductors

- D1, D13, D25, D37, D49, D61, D73, D85, D97, D109, D121, D133 = LED green, 3mm (T1), flat side, no ledge
- D2-D12, D14-D24, D26-D36, D50-D60, D62-D72, D74-D84, D86-D96, D98-D108, D110-D120, D122-D132, D134-D144, D162, D163 = LED red, 3 mm (T1), flat side, no ledge
- D145, D146, D147, D148, D149, D150, D151, D152, D153, D154, D155,
- D156 = 1N4148, DO-35
- D164 = 1N4004, DO-41
- T1, T2 = BC547B, TO-92
- IC1 = CD4060, DIP-16
- IC2 = 74HC21, DIP-14
- IC3, IC4 = 74HC132, DIP-14
- IC5, IC6 = 74HC4024, DIP-14
- IC7, IC8, IC9, IC10 = 74HC4051, DIP-16
- IC11 = 74HC4040, DIP-16

Miscellaneous:

- K1 = 2-way wire-to-board terminal block, 3.5mm pitch
- S1 = 6mm tactile push button
- X1 = 32.768kHz crystal, 20ppm, Cload 12.5pF, 8x3mm cylinder package
- IC2, IC3, IC4, IC5, IC6 = IC socket, DIP, 14 contacts
- IC1, IC7, IC8, IC9, IC10, IC11 = IC socket, DIP, 16 contacts
- PCB no. 240118-1 v1.1

Specifications

- **Supply voltage** 5 V
- **Supply current** 11 mA max.
- **Power supply indicator** 1 LED
- **Time display** 12 hours in a circle
- **Display** 144 LEDs
- **LED circle** 132 red LEDs, 12 green LEDs
- **Resolution (display)** 5 minutes
- **Seconds indication** 1 LED in center of circle, blinking at 0.5 Hz
- **Technology** 10 pcs HC-logic series ICs, 1 pc. 4000-logic series IC
- **Reference signal** 32 kHz quartz oscillator, adjustable
- **Set clock** 1 pushbutton, 5 minutes step
- **Programming needed** no

- Project as published on Elektor Labs: **https://www.elektormagazine.com/labs/quasi-analog-clockwork-an-elektor-classic-a-remake**
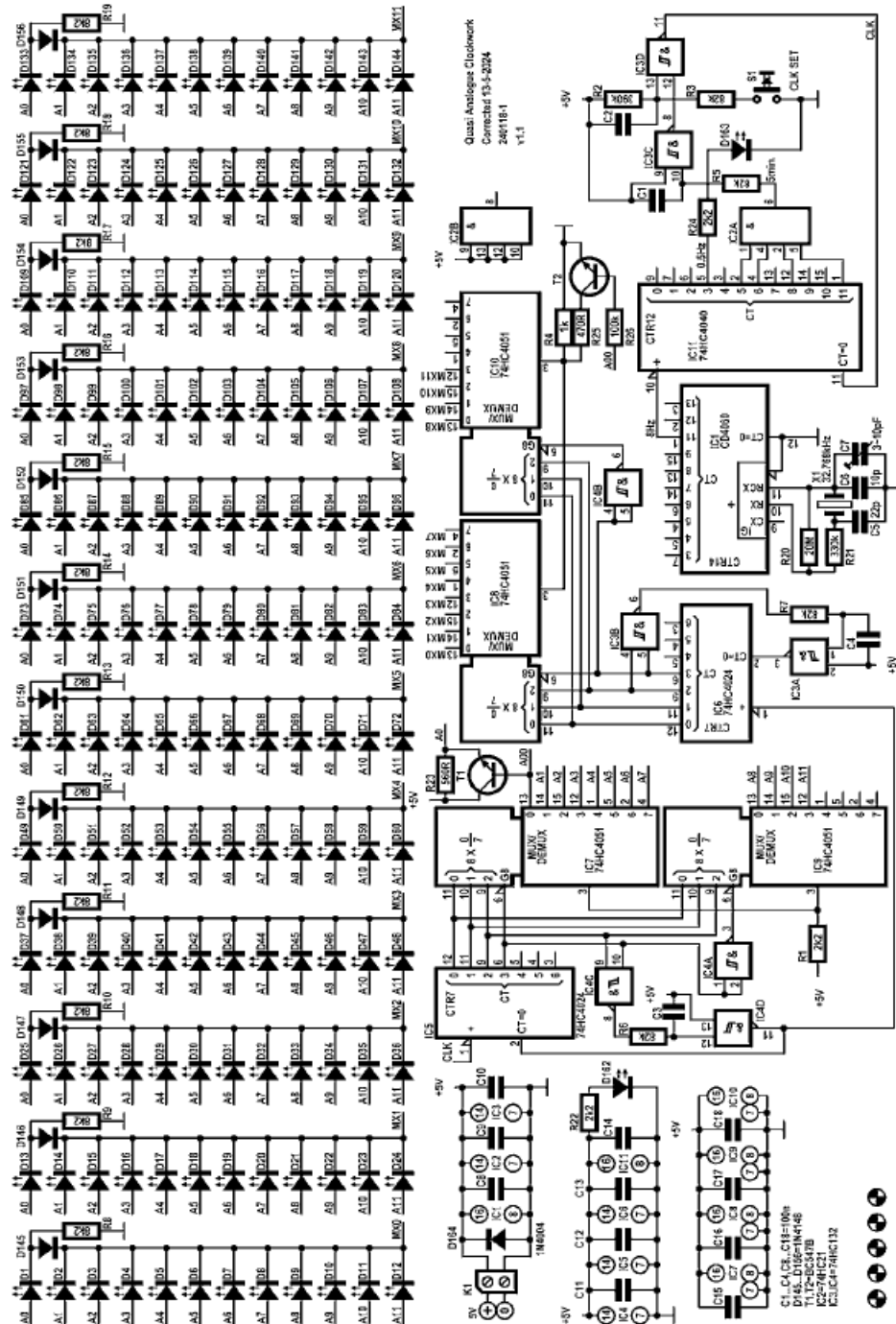
Schematic and PCB Layout

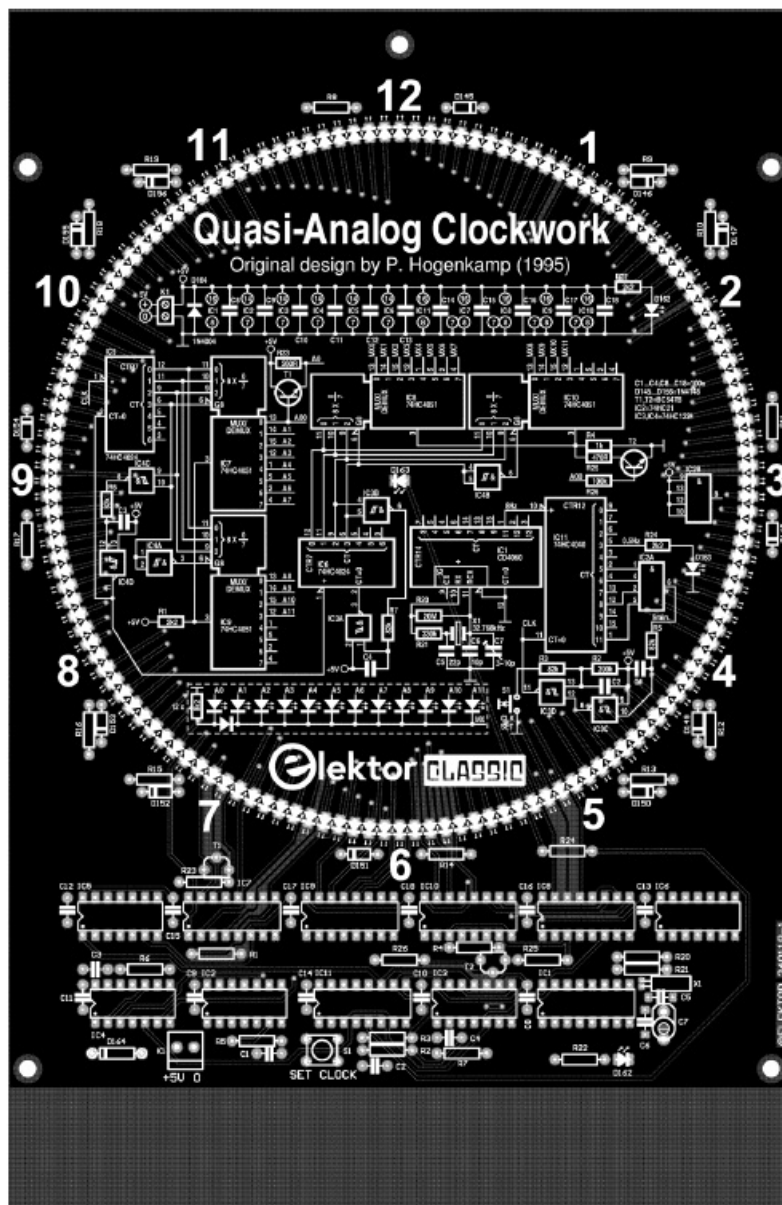Fig. 9. Schematic of the Quasi-Analog Clockwork (240118-1 v1.1).

Fig. 10. Top overlay of PCB 240118-1 v1.1 of the Quasi-Analog Clockwork.

Digital watches with displays consisting of numbers only have lost much of their popularity. They are now outnumbered by traditional glass with hour and minute hands actuated by a digitally controlled stepper motor. These watches (and clocks) are the best of both worlds because they have an analogue readout with digital control. The LED clock described here is based on the same principle — only there are no moving parts at all.

The quasi-analogue clockwork uses 144 LEDs (light emitting diodes) to indicate the time on a round quasi-analogue dial with a diameter of about 143 mm. One of twelve green LEDs lights at maximum intensity to mark the hours, while the other 11 LEDs are dimmed. Between two green LEDs sit 11 red LEDs, each representing a period of 5 minutes in the hour.

The oscillator section of counter/divider IC1 is configured as a quartz oscillator with a 32.768 kHz crystal. The high value of R21, (330 kOhm) ensures the total power delivered to the crystal is well below the maximum drive level of 1 μW (more would reduce its lifespan). The total divider for the 5-minute pulse is created in two parts. The CT11 output of counter/divider IC1 (CD4060) ticks at 8 Hz and clocks the second counter/divider IC11 (74HC4040). IC11 has to divide 8 Hz by 2400 to create a 1/300 Hz pulse rate (i.e., a 5-minute pulse). A total divisor of 9,830,400 is achieved by detecting the binary code '2400' with the aid of IC2A. In numbers, 2400 = 2^11 + 2^8 +2^6 + 2^5. When the value 2400 is reached, a CLK pulse is generated via R5, C1, IC3C, and IC3D, resetting IC11 (CT=0). The CLK pulse also increments the count of IC5 by 1. The other input of IC3D is connected to pushbutton S1 and serves to adjust the clock. The pulse supplied by the pushbutton is debounced by network R3—R2—C2 and IC3D. Every time the button is pressed, the readout advances by one LED position. Counter/divider IC5 (74HC4024) operates as a five-minutes counter and has 12 states corresponding to 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 and 55 minutes. The outputs of IC5 determine which channel of multiplexers IC7 and IC9 (both 74HC4051) is actuated. The multiplexers' Common pins are connected. For example, when all multiplexer Select inputs and the active-low Enable (pins 11, 10, 9 and 6) are held at 0, the anode terminals of the LEDs connected to output A0 (D1, D13, D25, D37, D49, D61, D73, D85, D97, D109, D121, and D133) are connected to the +5 V supply rail via a 2.2 kOhm resistor, R1. IC4A inverts the fourth bit of counter IC5 to enable IC9 when IC7 is disabled and vice versa. To make an LED light, however, its cathode must be pulled to Ground. That is done by multiplexers IC8 and IC10 (both 74HC4051), which have their Common pins tied to Ground via R4 (1 kOhm). The binary pattern of counter/divider IC6 (74HC4024) is applied to the Select and Enable inputs (IC10 through IC4B; same function as IC4A) and determines which LEDs have their cathode connected to Ground, via the MX0 through MX11 signal lines. As soon as IC5 reaches state '12' (corresponding to 0 minutes), the counter is reset via IC4C and IC4D. Also, IC6 receives a clock pulse which marks the start of a new hour. Incrementing the counter in IC6 results in the next output of IC8 or IC10 becoming active. The multiplexers ensure that the cathodes of the selected LEDs are connected to R4. As soon as IC6 supplies the binary code '12', a reset pulse is generated via IC3B, R7, C4 and IC3A. This pulse resets IC6 to state '0', enabling the counter can start to count another 12 hours. As already mentioned, the display has 132 red and 12 green LEDs. The green LEDs light continuously at low intensity. This is achieved by connecting their cathodes to Ground via 8.2 kOhm resistors (R8—R19). Since the anodes of the green LEDs are connected to R23, a constant current of about 0.2 mA flows through each LED. At the full hour, the relevant green LED must light at maximum intensity. That is achieved by connecting—in R4 (via MX0—MX4), through a diode (1N4148; D145—D156). This trick explains why the LEDs connected to line A0 are wired differently in the matrix. The current is also stepped up by connecting R25 in parallel with R4 via T2. R26 is connected to virtually +5 V through IC7 and R1. Due to buffer T1, the voltage drop across R1 is only 0.1 V. LED D162 lights as soon as the supply voltage is present. The last LED on the clock face, D163, is located in the center and flashes slowly at 0.6 Hz to indicate that the clock is "ticking". 5 VDC from an adapter is connected to K1. D164, a 1N4004, protects against wrong polarity.

Fig. 11. Bottom overlay of PCB 240118-1 v1.1 of the Quasi-Analog Clockwork.
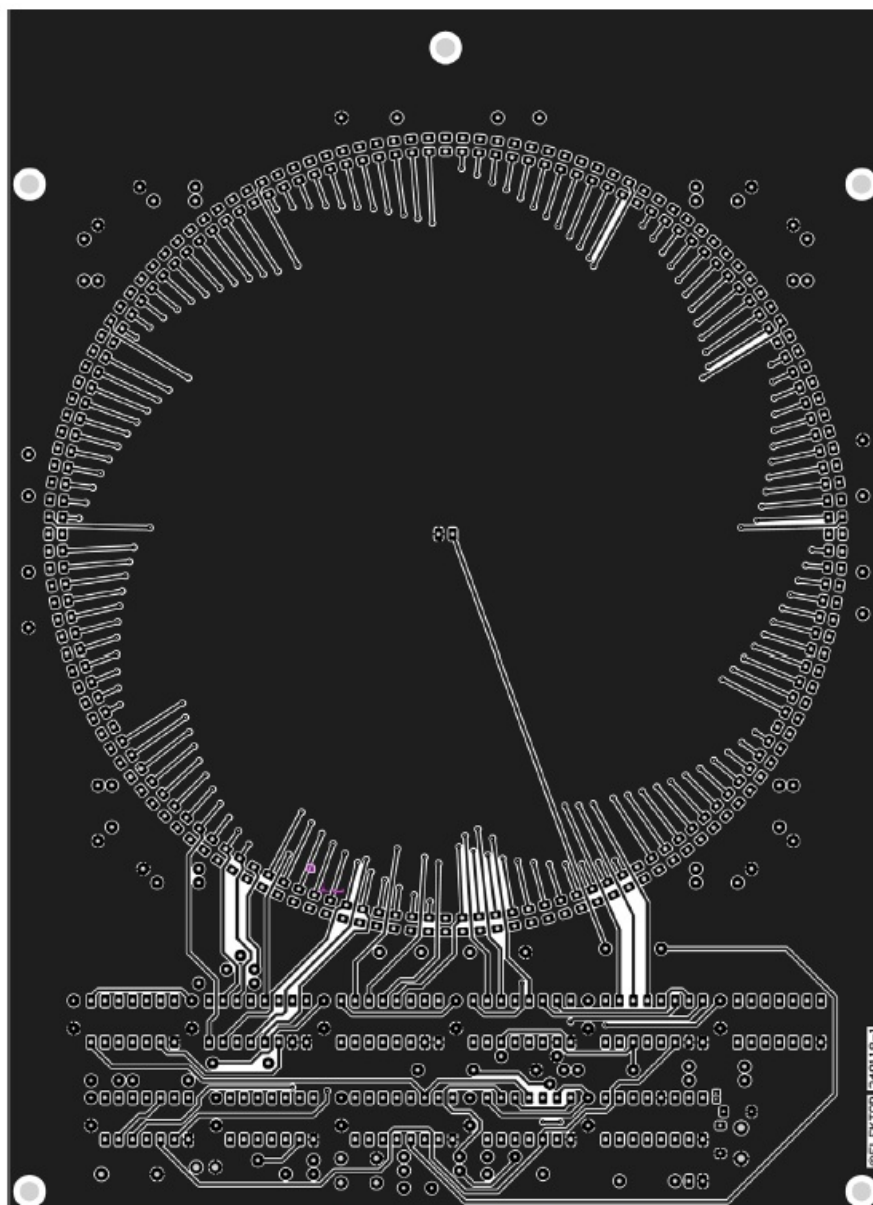
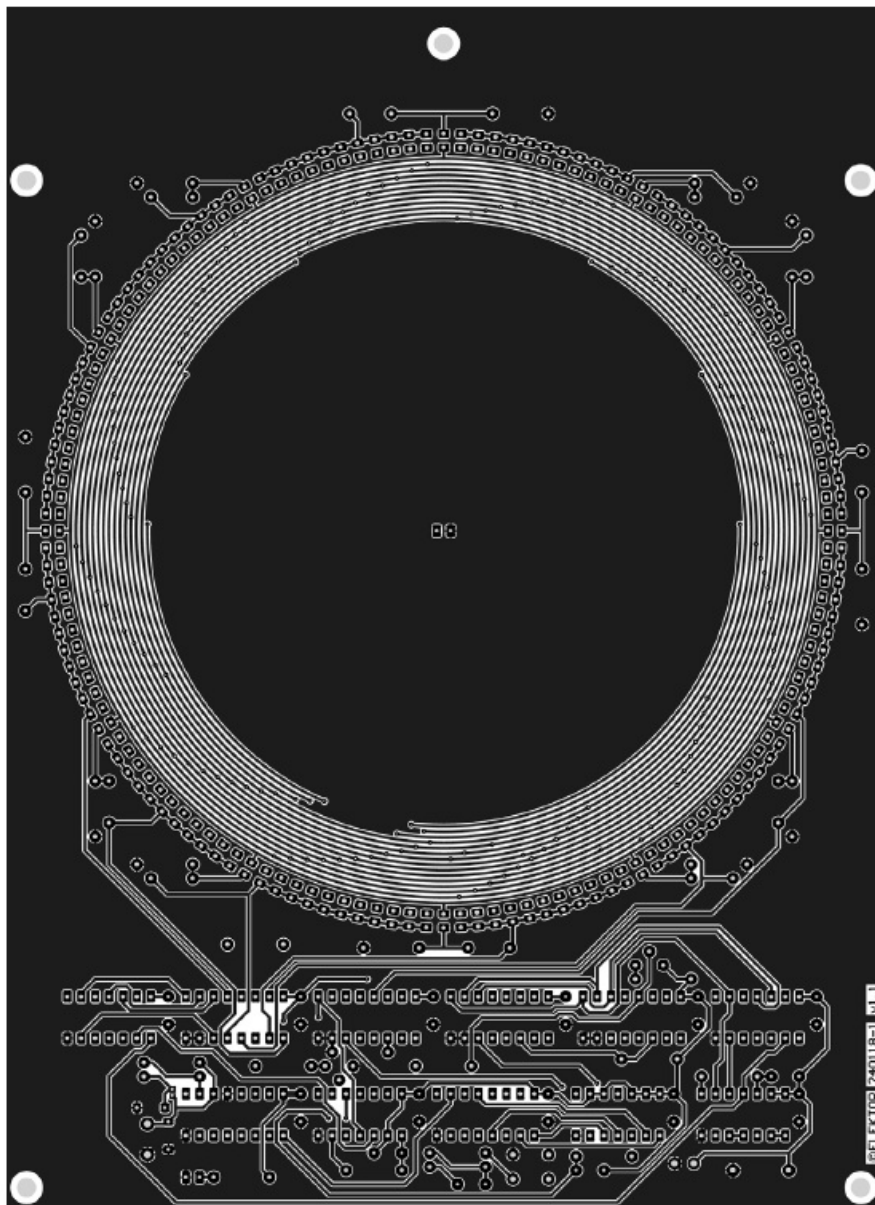Fig. 12. Copper top of PCB 240118-1 v1.1 of the Quasi-Analog Clockwork.

Fig. 13. Copper bottom of PCB 240118-1 v1.1 of the Quasi-Analog Clockwork.

Notice

This document is complementary to the information contained in the engineering background and discussions posted on the Elektor Labs website.

Disclaimer

This manual is available as a downloadable PDF.
You can find this essential document at the following address: www.elektor.com/20944

Documents / Resources

	elektor ZD-11E Quasi Analog Clockwork Kit [pdf] Instruction Manual ZD-11E, SKU 20944, PCB 240118-1 v1.1, ZD-11E Quasi Analog Clockwork Kit, ZD-11E, Quasi Analog Clockwork Kit, Analog Clockwork Kit, Clockwork Kit, Kit

References

- **Elektor Magazine: Your Electronics Community > Design Share Earn | Elektor Magazine**
- **Elektor - Learn, Design & Share electronics | Elektor Magazine**
- **User Manual**