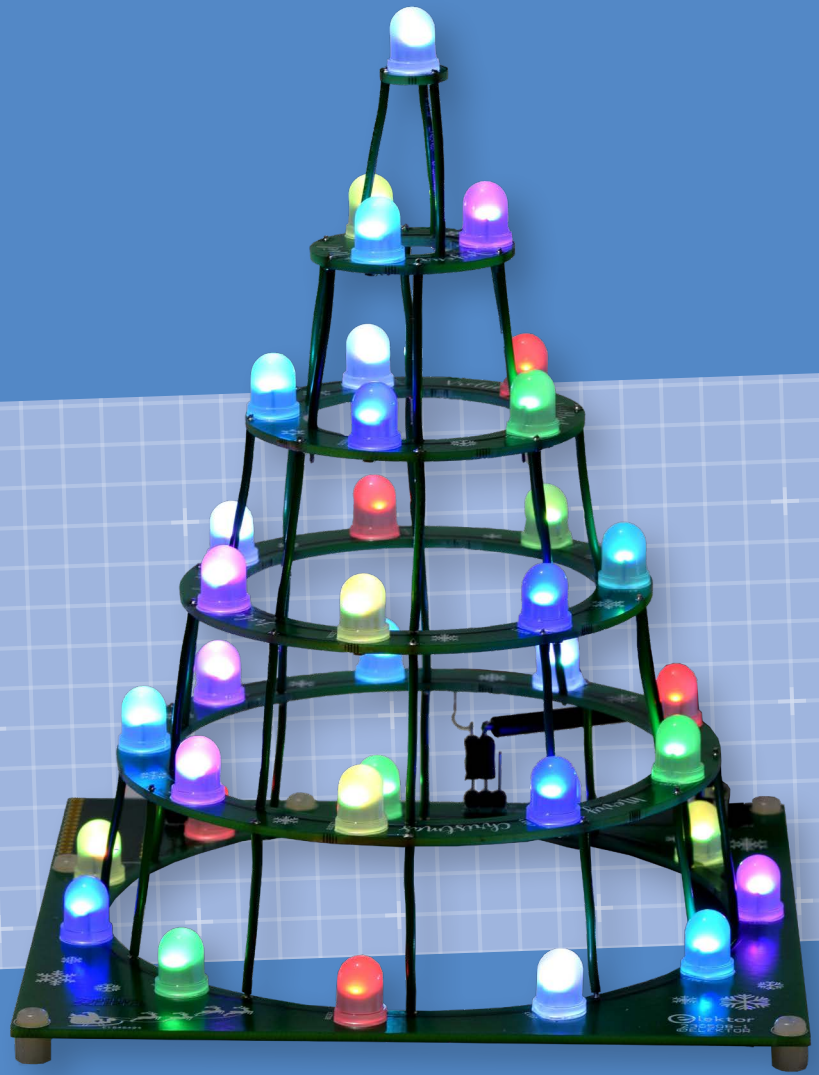
Elektor Circular Christmas Tree Kit

Construction Manual



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Construction Manual

V1.0 – November 1, 2023

This Christmas Tree is an assembly of 6 PCBs supplied in a single panel.

5 PCBs are circular while the base PCB is square (136 x 136 mm).

The PCBs are mounted on top of each other by pieces of stiff wire creating a 3D Christmas Tree.

In the prototype, the distance between the PCBs was 30 mm. A little higher may be preferred.

Notice: an external processor/microcontroller/module must be used, or an optional onboard Arduino Nano ESP32 module (not included).

The digital RGB LEDs can be addressed as a NeoPixel LED strip.

Publishers' Notice: The latest version of this *Construction Manual* for the Elektor Circular Christmas Tree Kit supplied by Elektor is available as a pdf file at: www.elektor.com/20672.

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1 – Kit Contents

One panel comprising 6 PCBs (PCB shown is v1.0)

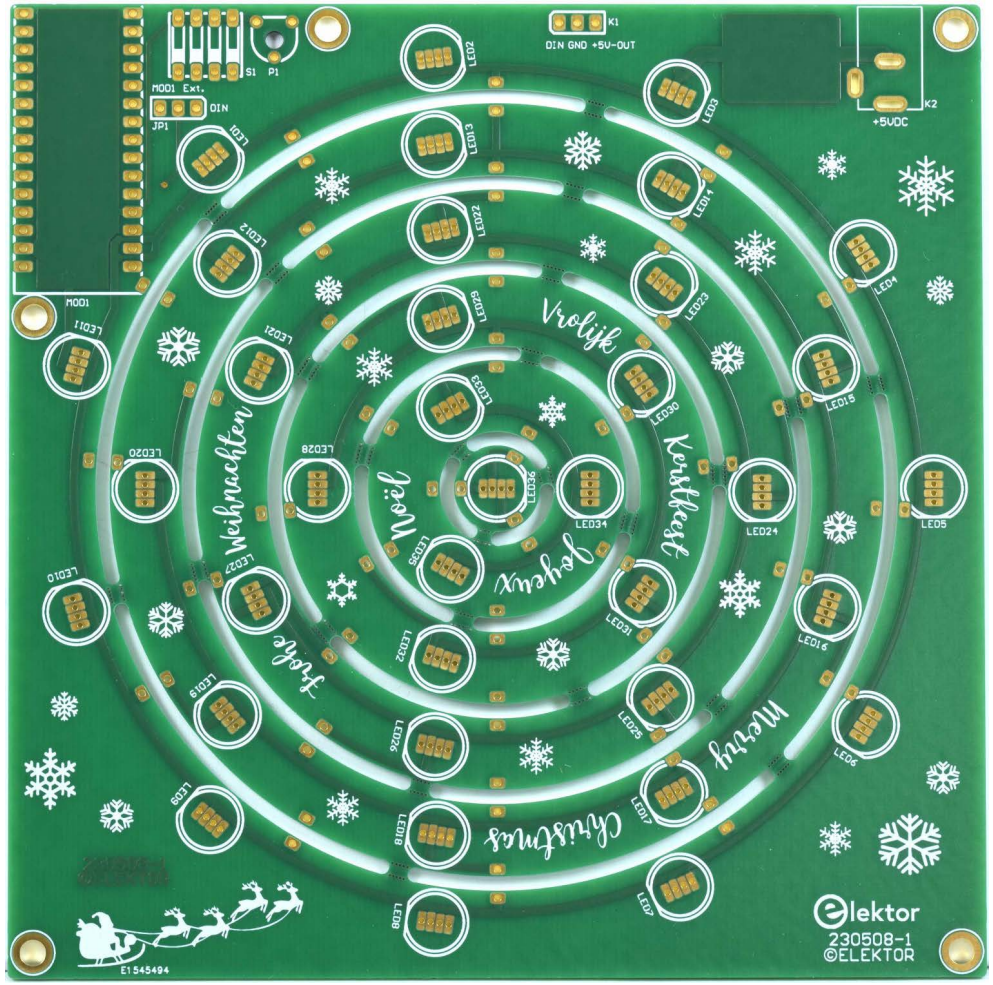

Figure 1: Top view of the PCB breakout panel for the Circular Christmas Tree2023, no. 230508-1 (v1.0).

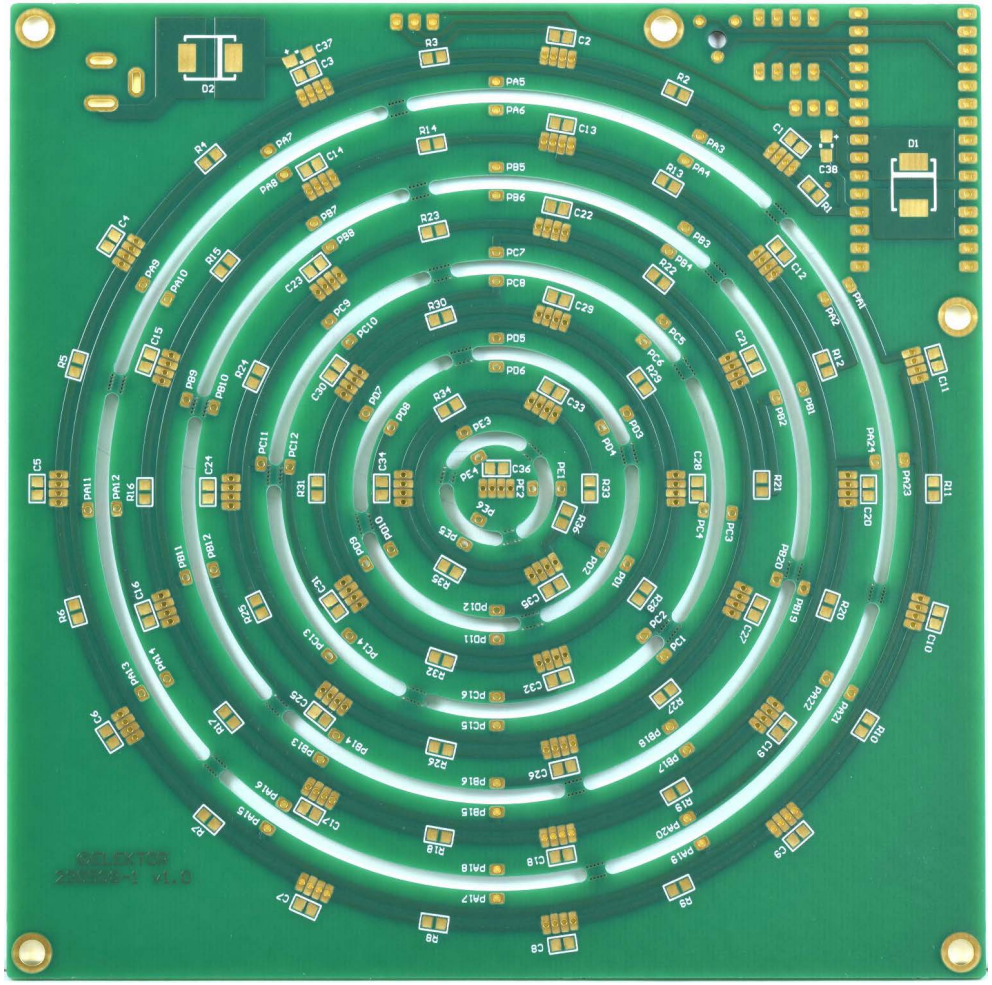

Figure 2. Bottom view of the PCB breakout panel for the Circular Christmas Tree2023, no. 230508-1 (v1.0).

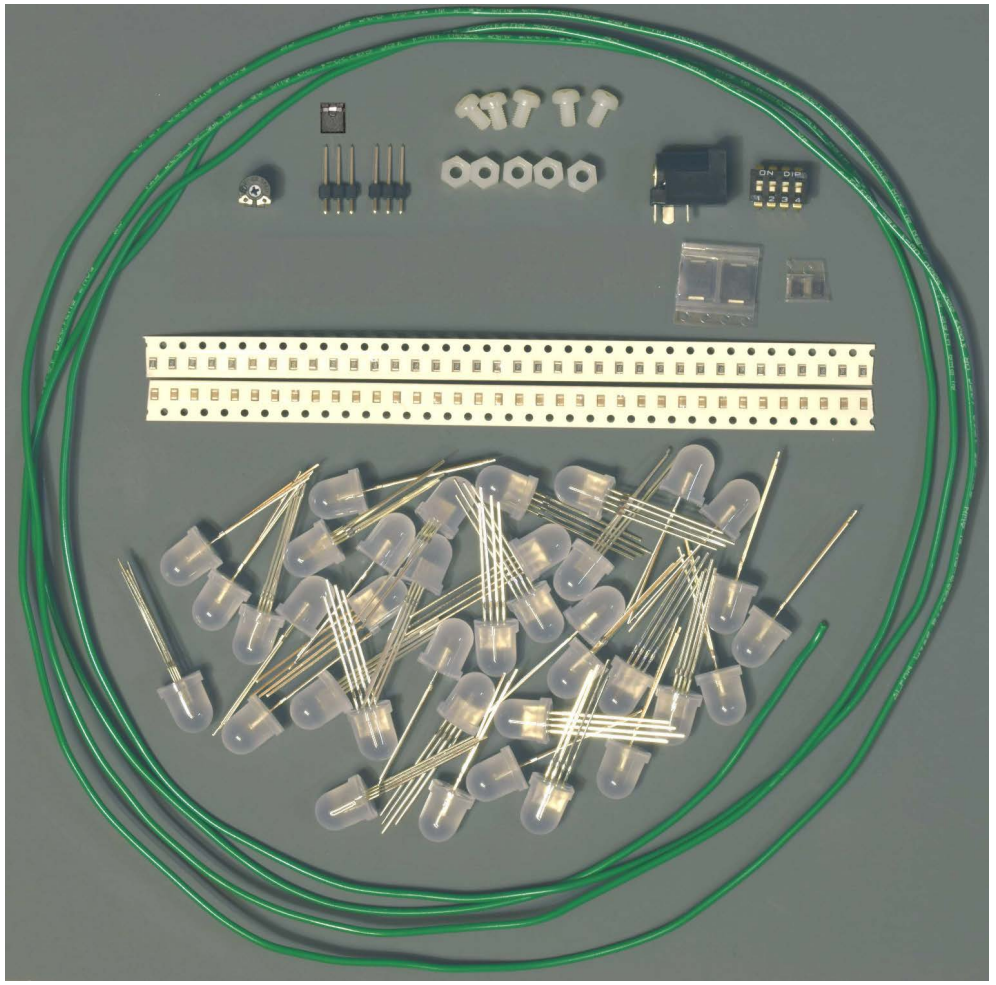

Figure 3. Components according to the bill of materials.

Components to match Bill of Materials.

the Arduino Nano ESP32 module (MOD1) is **not part of the kit**. This module is optional and may be purchased separately from Elektor (https://www.elektor.com/arduino-nano-esp32-with-headers). The PCB has a 3-way pinheader (K1) with a pin connected to the input of the first LED by way of a jumper (JP1) and the other two pins to the internal power supply voltage. This allows any suitable external processor/ microcontroller circuit or module to be used to control the 36 LEDs. If the onboard module is used, K1 can be omitted.

2 – Required Items

- A well illuminated and tidy work surface
- The Circular Christmas Tree 2023 Kit as supplied by Elektor
- Soldering equipment for through-hole and SMT components
- Tweezers for placing small SMDs on the board
- Resin-core solder with a maximum diameter of 0.5 mm (0.02 inch), 0.35 mm is recommended for the SMT components, or use solder paste
- Optional: narrow-tip pliers (<2 mm width)
- Fine-grade, semi-round file
- Wire stripper for thin wire (0.8 mm)

3 – The PCB Panel

Before soldering, separate all PCBs. The PCBs in the panel are secured by small bridges that must be broken, which takes some force.

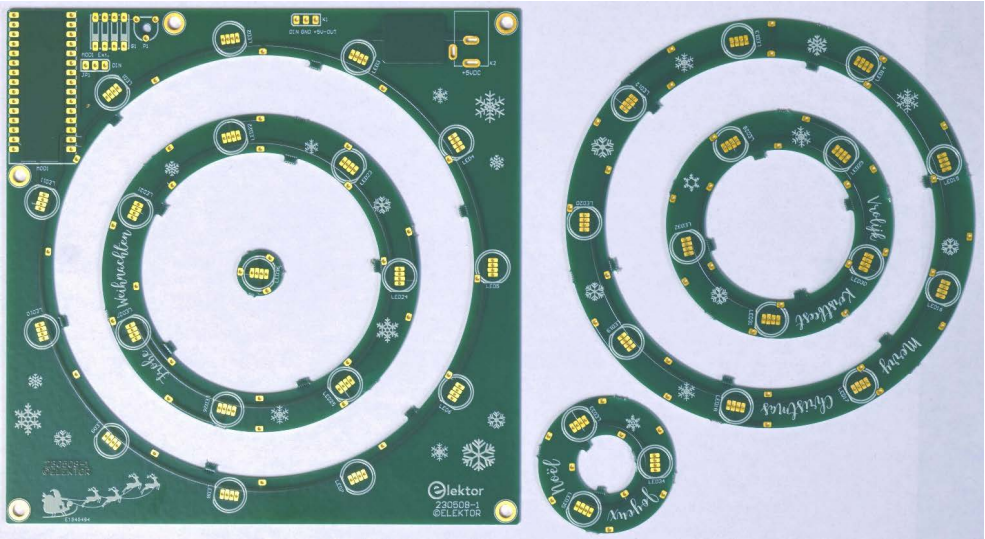

Figure 4. All PCBs separated from the panel. The bridges that one connected the 6 PCBs can now be removed.

With the PCBs separated, remove the remnants of the bridges with pliers. A fine-grade semi-round file can be used to smooth the rough edges that may remain after removing the bridges. Use the rounded side of the file for the inner side and the flat side for the outer side of the PCBs. Be careful when snapping the bridges off the PCB where these are next to a wire pad — a little damage however is inconsequential.

4 – Commence Construction

First read the entire manual before heating up the soldering iron. After separating the PCBs, start by soldering the small SMD resistors R1–R36 and capacitors C1–C38. It's best to use very thin (0.35 mm) resin-core solder. Put a very small amount of solder on one pad. Place the component in the centre of the footprint and solder that first pad with very little solder to fix the component, then and place it flat against the PCB surface. Then properly solder the other pad and the first pad. Solder all SMDs on all PCBs this way.

You can solder all SMDs on the base PCB first and then proceed to the next PCB. **Important**: the grey stripe on top of the tantalum capacitors C37 and C38 (located on the base PCB) indicates the positive terminal (+). The overlay has a small + next to the solder pad. After soldering R1–R11, C1–C11, C37 and C38, the two diodes D1 and D2 can be soldered. Next, the rest of the SMD components can be soldered on the remaining PCBs. A tip: don't squeeze the tweezers too hard when holding the small SMDs, they might fly off and disappear forever.

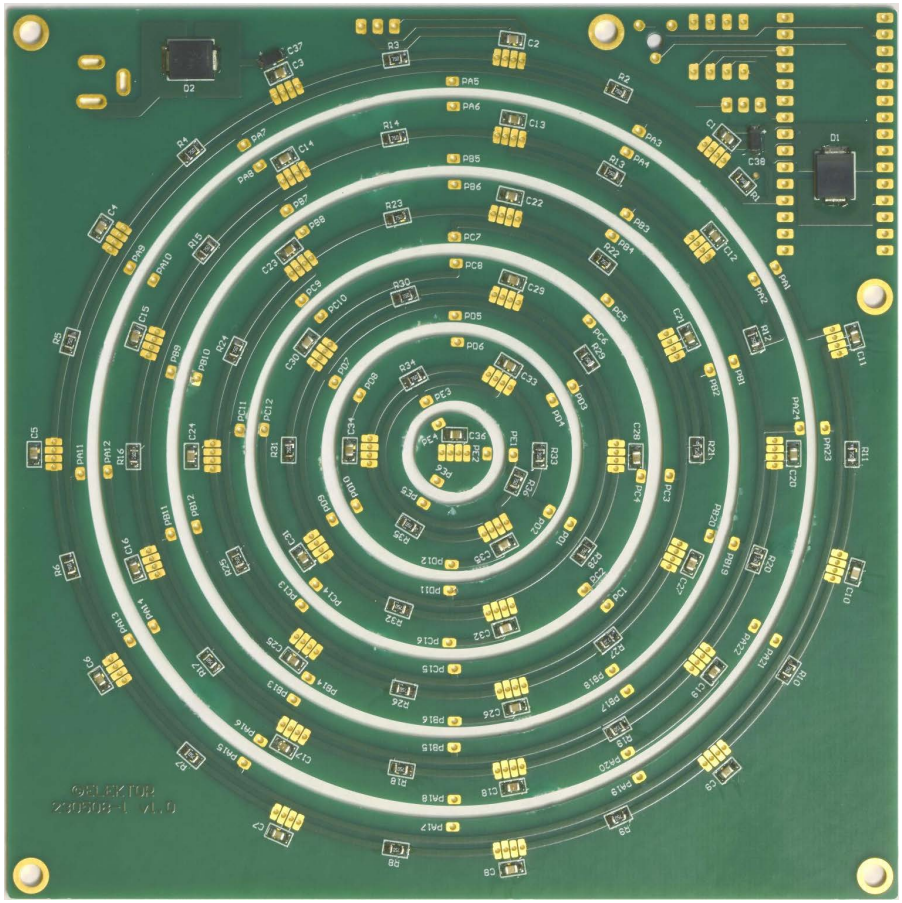

Figure 5. All SMDs soldered: R1–R36, C1–C38, and D1–D2.

When all SMDs are soldered, proceed with the 36 LEDs. Depending on production tolerances on the LED leads and those of the PCB, it's best is to cut the LED leads right above the small widening located approximately 3 mm from the body. This also makes soldering a little easier (no long leads sticking out) and the leads need not be cut after soldering. Without cutting the leads first, chances are high they won't fit all the way through the PCB holes without using significant force, potentially damaging the metallization. But if you think the tree looks better with the LEDs bodies mounted a little above the PCB surfaces, don't cut the leads yet — do so after soldering.

Figure 6. The leads of RGB LED WS2812D-F8 cut just above the widening.

After cutting the LED leads, you can do one LED at the time. Insert it into the PCB, and first only solder one lead. When alle LEDs are fitted on a PCB, place a piece of cardboard or similar hard and flat surface that doesn't bend on top of the LEDs and turn the PCB around. Be sure to check the orientation of the LEDs again before doing so! Now solder one lead of each LED. Before soldering the other leads, check the orientation of the LEDs again and also check they are flush against the PCB surface. Better safe than sorry. The flattened part of the bottom edge of the WS2812D-F8 LED is clearly indicated on the PCBs.

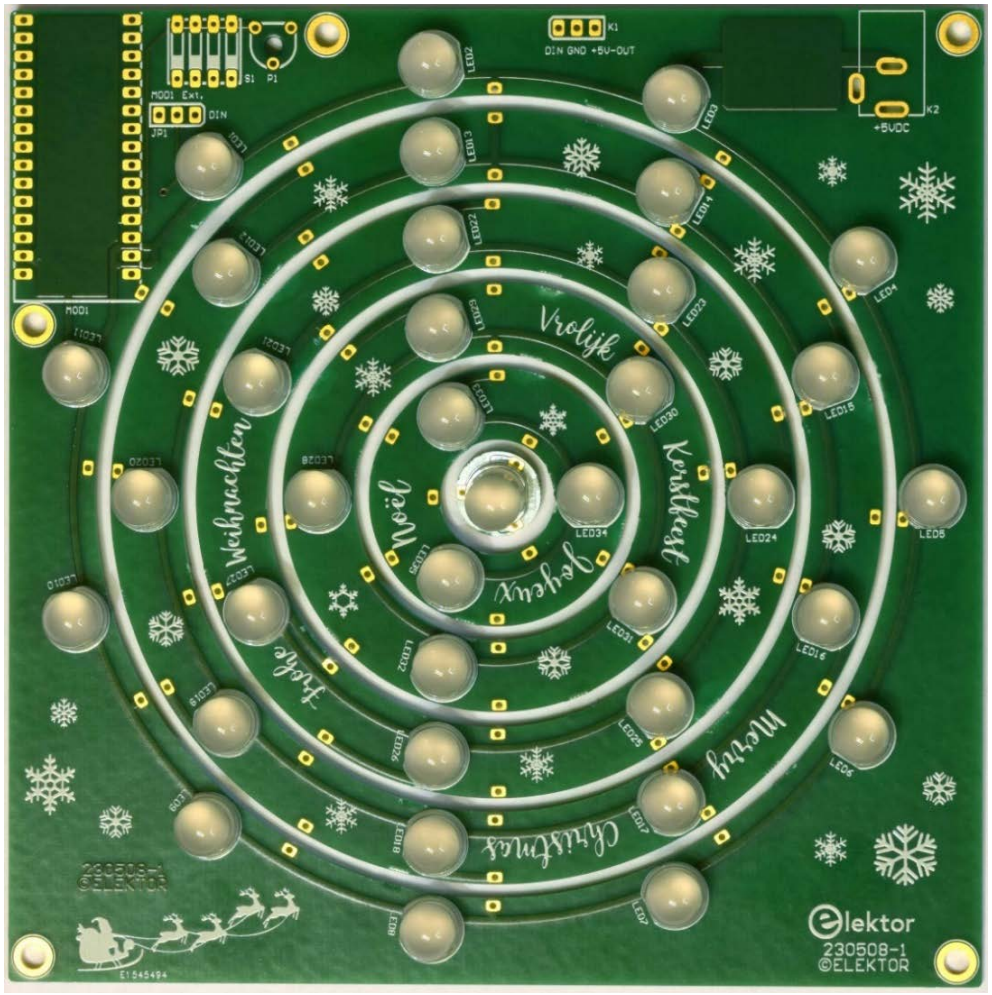

Figure 7. All LEDs soldered.

After soldering the LEDs on the base PCB, pinheaders K1 and JP1 as well as power connector K2 can be soldered.

Figure 8. Detail of the base PCB: K1, JP1, and K2 added.

At this stage of the construction, it's assumed that the Christmas Tree is controlled by an **external circuit**. Without module MOD1, DIP switch S1 and trimmer P1 need not be fitted. These three components can always be added later, even if the rest of the construction is finished.

5 – Cutting, Stripping, and Soldering Wires

39 pieces of stiff wire of equal length, approximately 4 cm long, must be cut and stripped. The exact length of the wire doesn't need to be that accurate. However, the length of the insulation left after stripping both ends of each wire should be as accurate as possible. The length of the insulation, 3 cm, determines the distance between the two PCBs that are connected and if they are placed exactly parallel to each other. Alternatively, use 3 cm high spacers, like precisely cut pieces of rigid cardboard.

Figure 9. One wire marked and another one stripped. The insulation left should be 3 cm long.

Connections between the individual PCBs:

- 12 wires from the 1st (base) PCB to the 2nd PCB
- 10 wires from the 2nd PCB to the 3rd PCB
- 8 wires from the 3rd PCB to the 4th PCB
- 6 wires from the 4th PCB to the 5th PCB
- 3 wires from the 5th PCB to the 6th PCB (top PCB).

Place the stripped wires in the lower PCB and position the next PCB on top of the wires by tilting it slightly and pushing the wires one by one through the pad holes. Don't push the PCB all the way over the first wire, as this will limit the room for the next two wires, and so on.

After placing the PCB on the wires and before soldering, check if the correct pads of the two PCBs are connected by turning the whole assembly upside down while keeping the PCBs together. For example, PA5 on the base PCB must be connected to PA6 of the 2nd PCB etc. The pad of the upper PCB is always one number higher. So: PB17 goes to PB18, PC5 goes to PC6, etc. With the PCBs still upside down, you can solder the wires in the lower (larger) PCB. Place the two PCBs upright again while keeping them together. The wires in the upper PCBs can now be soldered on the top side; the PCB is double-sided. The wires for the third PCB can be soldered from the side or from within. When soldering from the side, make sure not to touch the LEDs with the soldering iron! Proceed in this way with the other PCBs as well.

The kit contains a 2 m length of green insulated stiff wire. It's of course possible to make the PCB spacer wires a little longer if you like. However, since 39 wires have to be stripped, a few may not pass close scrutiny. Hence there's some room for error when stripping the insulation to 3 cm. In theory, you need 1.56 m for 39 pieces of 4 cm long wires. Then another 11 extra pieces can be stripped. By placing all stripped wires alongside of each other, those with roughly the same insulation lengths can be sorted out to make sure the PCBs are completely level, i.e. parallel to each other. Alternatively, use 3 cm spacers as mentioned earlier.

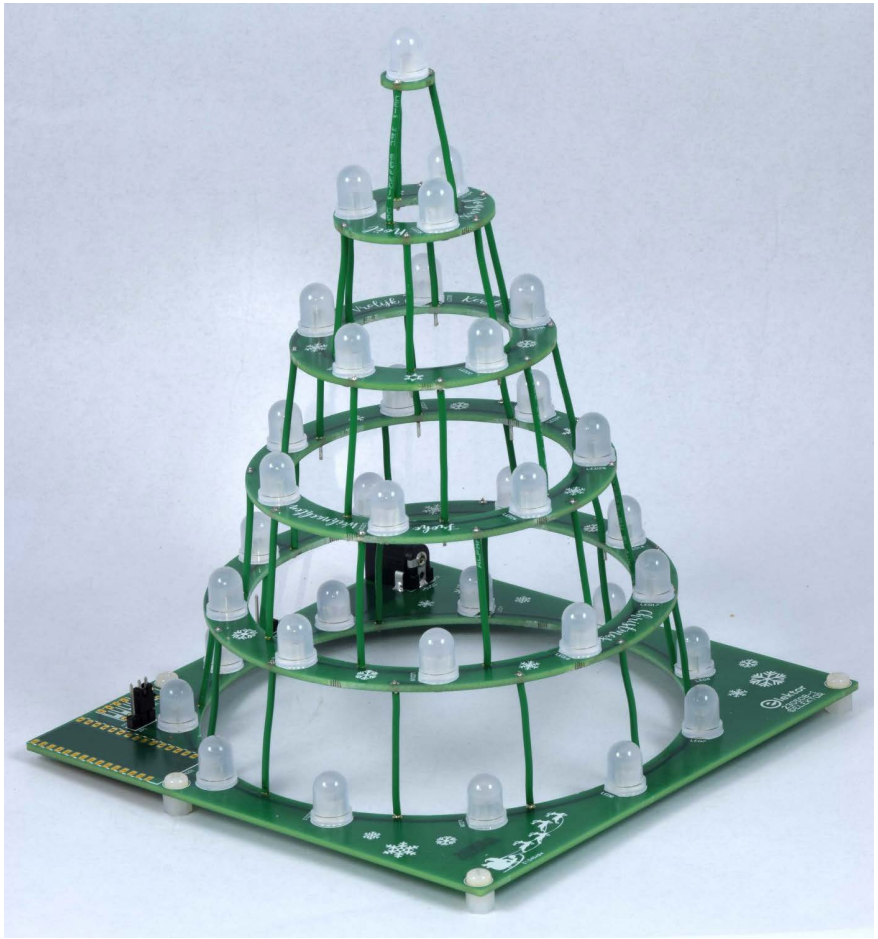

Figure 10. Side view of the finished Circular Christmas Tree, with all 39 wires soldered.

Figure 11. Another side view of the Circular Christmas Tree 2023 (PCB 230508-1 v1.0).

6 – Controlling the LEDs

At this stage, the LEDs can be controlled by an external module or a microcontroller/microprocessor circuit of your own choice. The 5 V power supply for the LEDs is connected to K2 through a diode, D2, on the bottom PCB. As a result, the actual voltage on K1 will be lower at around 4.3 V or even lower at high LED current/brightness settings. Most microcontrollers or modules have no problem with this lower supply voltage but keep it in mind! The input voltage of the LEDs is specified in the datasheet as VDD + 0.5 V maximum. It's best is to use the supply voltage available on K1 to power your external circuit.

The 36 digital LEDs type WS2812D-F8 are connected in series and the input of the first LED is connected to K1 (contact labelled: DIN) through resistor R1 and jumper JP1. The jumper should be placed on pins Ext. and DIN.

The LEDs can be addressed as NeoPixel strips. Information how to do this can be found on the web. Most projects use NeoPixel strips with multiple LEDs. An observation: sometimes the software assumes red is the first colour to be addressed. However, with the WS2812D-F8 this is green.

Figure 12. All LEDs on. The photo doesn't do the justice to the actual colours.

7 – Specifications

Power supply voltage K2	+4.5 V to +5.5 V
Max. supply current (all LEDs and all colours set to maximum)	1.2 A (theoretically, 36x3x0.012 = 1.3 A)
Min. supply current (all LEDs and all colours off)	18 mA

8 – Optional: Arduino Nano ESP32 Module

To make this Christmas Tree work independently of an external circuit, an Arduino Nano ESP32 module can be placed on the base PCB along with a small trimmer (P1) and a DIP-switch (S1). MOD1 should be purchased separately. P1 and S1 (contained in the kit) can be used to adjust brightness and set different patterns/modes, for instance. Programming the module is up to the user and can be done with the latest version the Arduino IDE and the C programming language. If you are looking for a MicroPython project, this Christmas Tree is also a good choice. A dedicated IDE for MicroPython called *Arduino Lab for MicroPython* can be downloaded from the Arduino website (through Github), as well as the required MicroPython Installer (see section 9, Web Links). It's all well documented and should even provide beginners good resources to get it working. On the ElektorLabs website, the MicroPython program main.py can be downloaded. Feel free to change and/or augment it.

Aside from DC power connector K2, the LEDs can also be powered by the VBUS pin of MOD1. This module is not powered by connector K2 but through its USB-C connector. An AC adapter with a USB-C connector supplying at least 1.5 A is required. A separate AC adapter for K2 is not needed then. Two diodes (D1 and D2) prevent connecting the power supplies directly to each other. Since the USB connector of the module is of type C, the VBUS pin of MOD1 can source enough current for even

the highest brightness setting. In the kit are no sockets (female headers). Using sockets for the module would put the module rather high over the PCB and will make it too conspicuous. The module with headers already attached (pay attention to this when purchasing the Arduino Nano ESP32) is soldered directly to the PCB. Removing it after mishap, with the module won't be easy. If you still want to use sockets, the type BL1.36Z from Fischer Elektronik is a good choice or use an equivalent.

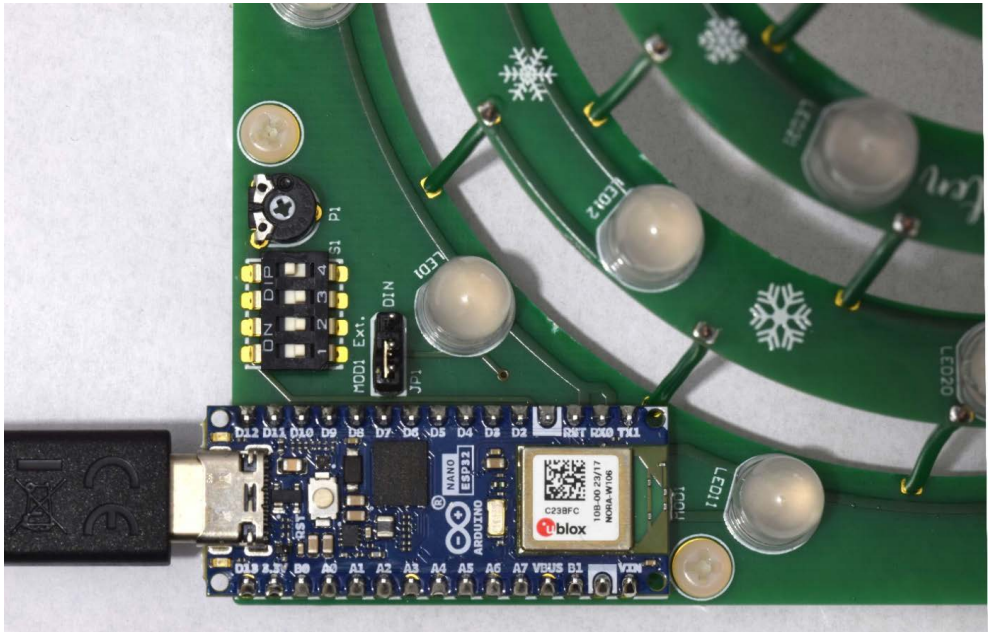

Figure 13. Detail of MOD1, S1 and P1 mounted on the base PCB (MOD1 not in included in kit).

9 – Web Links

Project on the Elektor Labs website
https://www.elektormagazine.com/labs/circular-christmas-tree-2023-230508

Arduino Nano ESP32 with headers
https://www.elektor.com/arduino-nano-esp32-with-headers

Documentation about the Arduino Nano ESP32
https://docs.arduino.cc/hardware/nano-esp32

MicroPython course MicroPython 101 by Arduino
https://docs.arduino.cc/micropython-course/

Arduino Lab for Windows
https://github.com/arduino/lab-micropython-editor/releases/download/0.8.0/Arduino.Lab.for.Micropython-win_x64.zip

Arduino MicroPython Installer
https://github.com/arduino/lab-micropython-installer/releases/tag/v1.2.1

10 – Bill of Materials

Resistors
R1-R36 = 75 Ω, 0.125 W, 5%, SMD 0805
P1 = 10 kΩ, 0.1 W, 20%, trimmer, top adjust, 6 mm, round (Piher PT6KV-103A2020)

Capacitors
C1-C36 = 100 nF, 50 V, 5%, X7R, SMD 0805
C37, C38 = 47µF, 6V3, 10%, tantalum, Case Size A (1206)

Semiconductors
D1, D2 = S5J-E3/57T, SMD Case Size SMC
LED1-LED36 = WS2812D-F8, 8 mm, THT (Worldsemi Co., Limited)

Miscellaneous
K1, JP1 = pinheader, 3x1, vertical, 0.1" pitch (2.54 mm)
JP1 = shunt jumper, 2.54 mm spacing
K2 = MJ-179PH Multicomp Pro, DC Power Connector, 4 A, pin diam. 1.95 mm
S1 = DIP switch, 4-way
PA1-PE6 = 2 m wire, 0.81 mm solid, 0.52 mm² / 20AWG, insulated, green (Alpha Wire 3053/1 GR005)
H1-H5 = Nylon standoff, female-female, M3, 5 mm
H1-H5 = Nylon screw, M3, 5 mm
PCB 230508-1 v1.1

Optional, not included in kit:
MOD1 = Arduino Nano ESP32 with headers

11 – Schematic and PCB Layout (Breakout Panel)

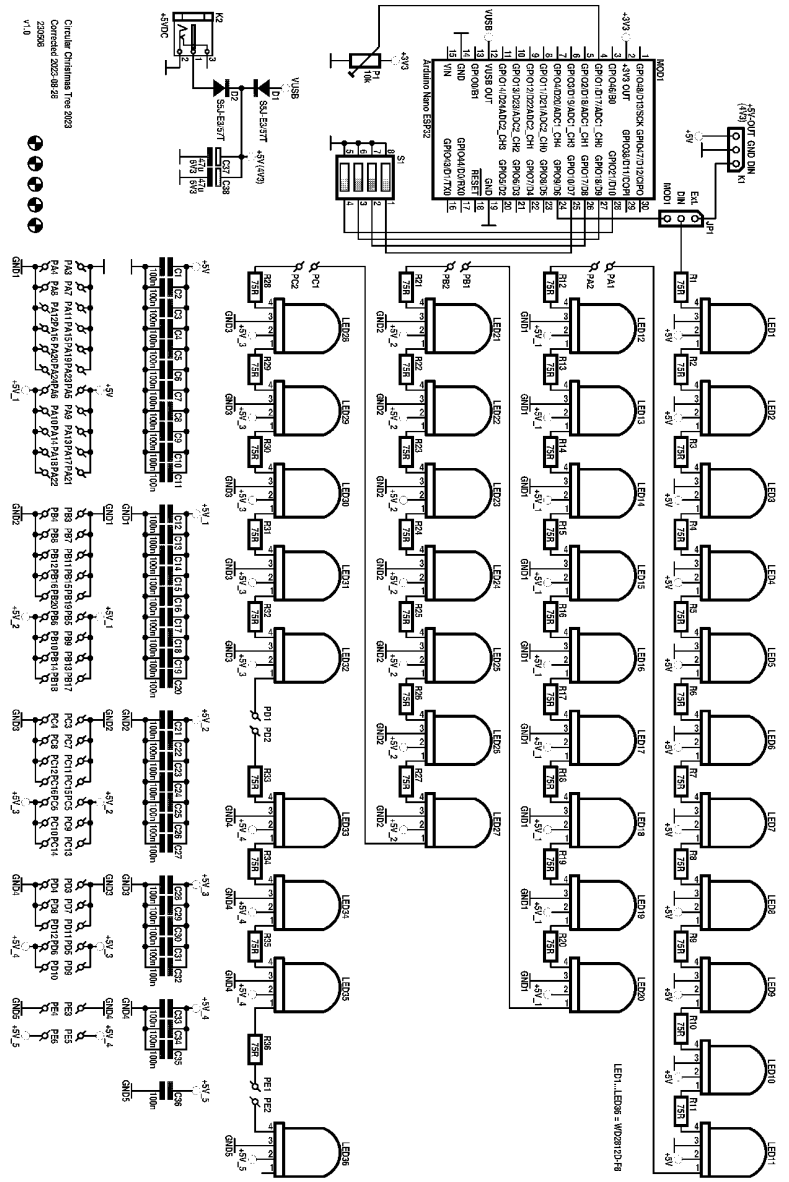

Figure 14. Schematic of the Circular Christmas Tree 2023. no. 230508-1 v1.0

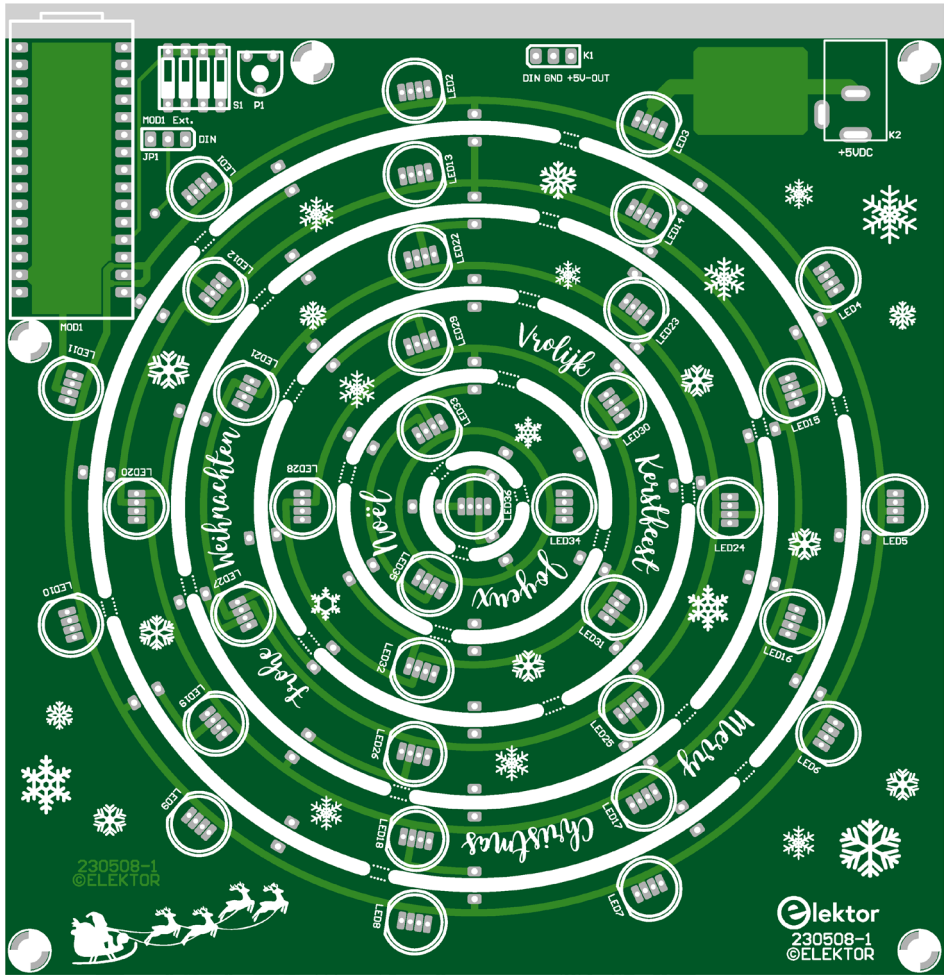

Figure 15. Top-side overlay of PCB for Circular Christmas Tree 2023. PCB no. 230508-1 v1.1.

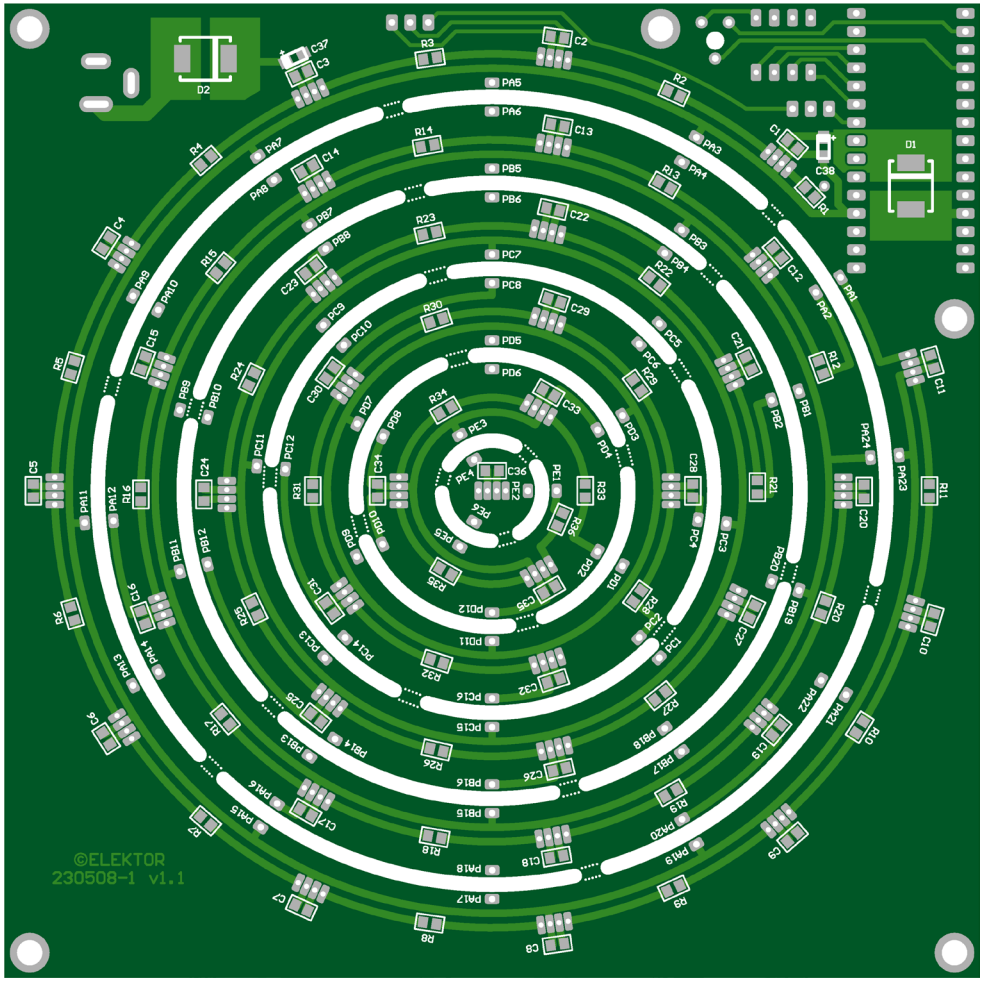

Figure 16. Bottom-side overlay of PCB for Circular Christmas Tree 2023. PCB no. 230508-1 v1.1.

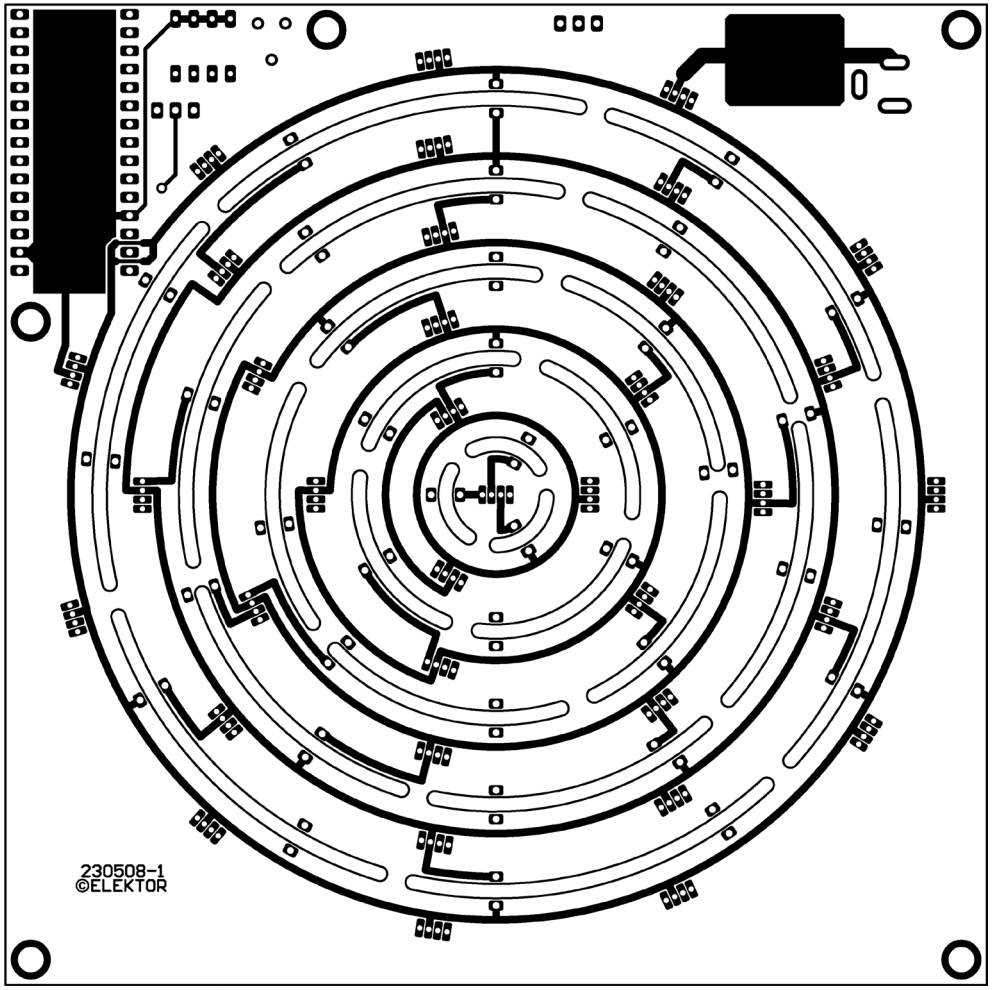

Figure 17. Copper layout, PCB top side, Circular Christmas Tree 2023. PCB no. 230508-1 v1.1.

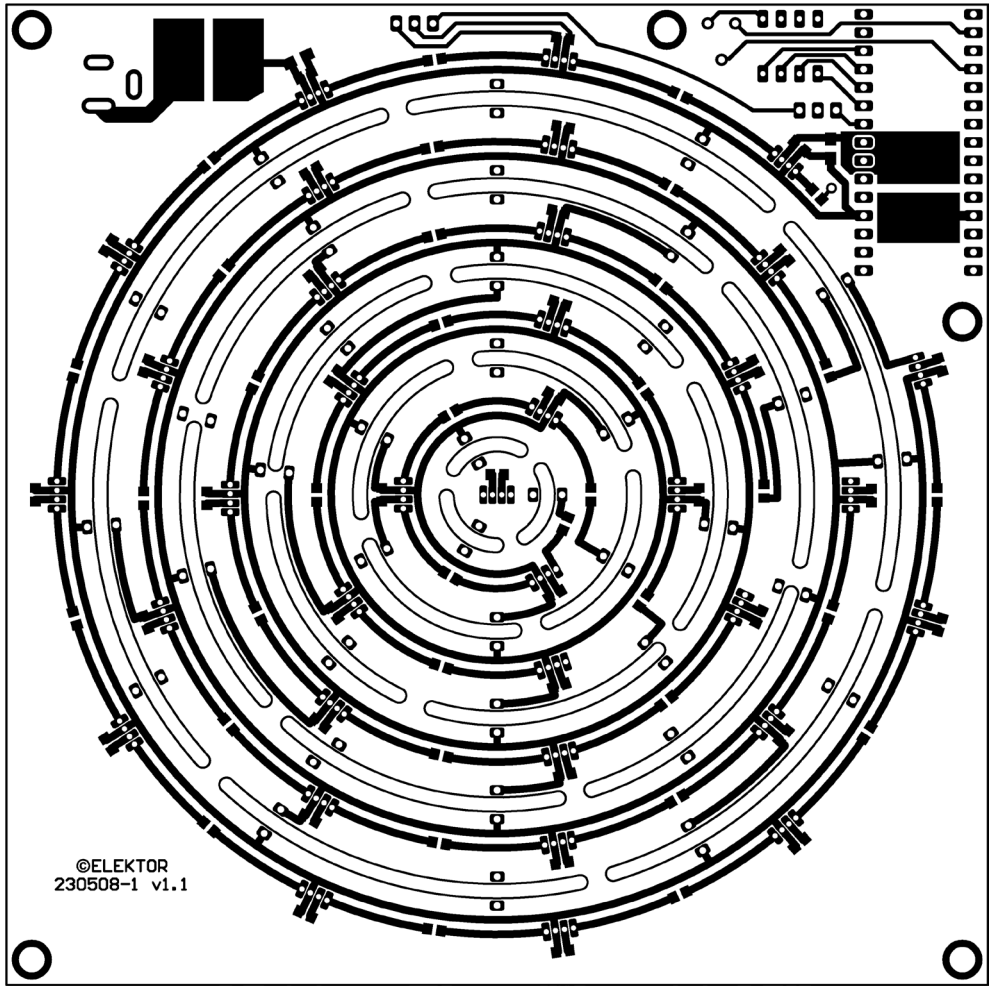

Figure 18. Copper layout, PCB bottom side, Circular Christmas Tree. 2023. PCB no. 230508-1 v1.1.