

Elektor "TAPIR" E-Smog Detector Kit Construction Manual



SKU 20579

Elektor

"TAPIR" E-Smog Detector Kit

Construction Manual

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The TAPIR is a three-dimensional assembly with PCBs for the 6 enclosure sides. To ensure easy access to all solder points during assembly, be sure to assemble the kit exactly according to the sequence described.

Publishers' Notice: The latest version of the Construction Manual of the "TAPIR" E-Smog Detector Kit supplied by Elektor is available as a pdf file at: www.elektor.com/.....

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Notice

This document is complementary to the information contained in:

1. the article "TAPIR Sniffs it Out!" published in *Elektor Magazine* edition 7&8 2012;
2. the engineering background, reader queries, and related discussions posted on the *Elektor Labs* website.

Web Links to these publications may be found in Section 8.

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www.elektor.com; www.elektormagazine.com.

1 – Kit Contents

Figure 1 below shows the components that should be present in the kit upon opening the box.



Figure 1. Kit contents, as received.

Check for the contents to consist of:

- › 1 PCB panel
- › 1 headset (ear buds)
- › 1 wire piece (length approx. 50 cm)
- › 1 piece heat shrink tubing (length approx. 10 cm)

- › 1 coil (inductor)
- › 2 Cinch (RCA) plugs
- › 1 Cinch (RCA) PCB-mount connector

- › 1 resistor, 1 k Ω (R5)
- › 2 resistors, 10 k Ω (R2, R3)
- › 1 transistor, MMBT3904LT3G (T1)
- › 2 transistors, BC847B (T2, T3)
- › 1 capacitor, 10 nF (C1)
- › 2 standoffs, M2x6
- › 2 screws, M2x6

- › 2 resistors, 100 k Ω (R1, R4)
- › 3 capacitors, 10 μ F (C2, C3, C4)
- › 1 diode, BAT54S (D1)
- › 1 switch
- › 1 3.5-mm audio jack
- › 1 spring for battery

2 – Required Items



Figure 2. Some of the items and tools required to assemble the TAPIR kit.

The following items are required for the proper assembly of this kit:

- › A well lit and tidy work surface
- › The TAPIR kit as supplied by Elektor
- › A soldering iron or soldering station with a fine tip
- › 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 recommended
- › Hand-operated countersink or a small drill bit for countersinking the cover screws
- › One 1.5 V AAA-size battery
- › If necessary, a magnifying glass for checking component markings and solder joints
- › A coping saw and a file or Dremel tool as necessary
- › Clamping tweezers as necessary

3 – Tips

- › When breaking the individual PCBs free from the supplied panel, be careful to avoid damage to the tabs intended for fitting PCBs 1, 3, 5, 6 and 7 to the component PCB. We recommend using a coping saw to cut these PCBs free from the panel. PCBs 2 and 4 can be broken free by hand. The tabs on these PCBs must be removed (e.g., by filing them off). However, do not do this until instructed to do so.
- › There are several solder connections between the various PCBs. Be sure to make these connections during assembly.
- › Apply solder sparingly, especially on the board fitted with the headset connector. Proper assembly of the PCBs may be difficult if the solder layer is too thick.
- › The antenna is electrically connected to the circuit. To avoid the risk of electrical shock, always ensure that the antenna is properly insulated.

Soldering SMDs

We recommend soldering the SMD components in the TAPIR kit one at a time. Due to their small size, they are easily mixed up, mislaid, or even lost when "strewn" on the work surface. Start by tinning one of the solder pads. Hold the solder against the pad and briefly touch it with the tip of the soldering iron as close as possible to the pad, so that the pad is covered by a thin layer of solder. Then place the component in position. This is best done with tweezers. Secure the component with the tweezers if necessary, and then briefly touch the tinned solder pad with the tip of the soldering iron. The solder will reflow and form a bond between the component and the solder pad. If the component is properly positioned, the rest of the component leads can be then soldered by holding the solder against the solder pad and the component lead and briefly heating the joint. In general, short soldering times produce clean and tidy joints.

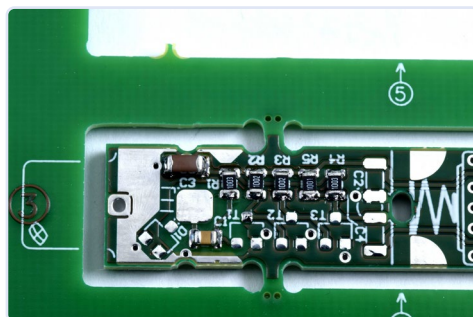


Figure 3. Example: one pad of SMD transistor T1 soldered.

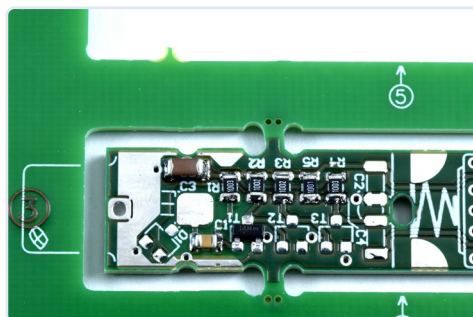


Figure 4. One lead of T1 soldered to the PCB.

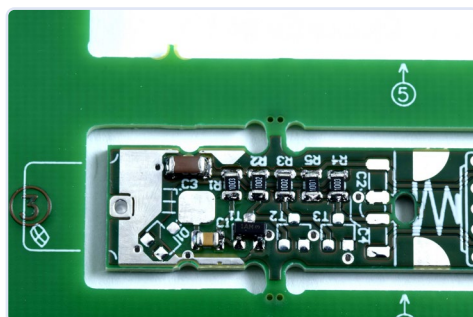


Figure 5. All three leads of T1 soldered.

4 – The Panel

Top view and bottom view of the breakout panel holding the 7 PCBs.

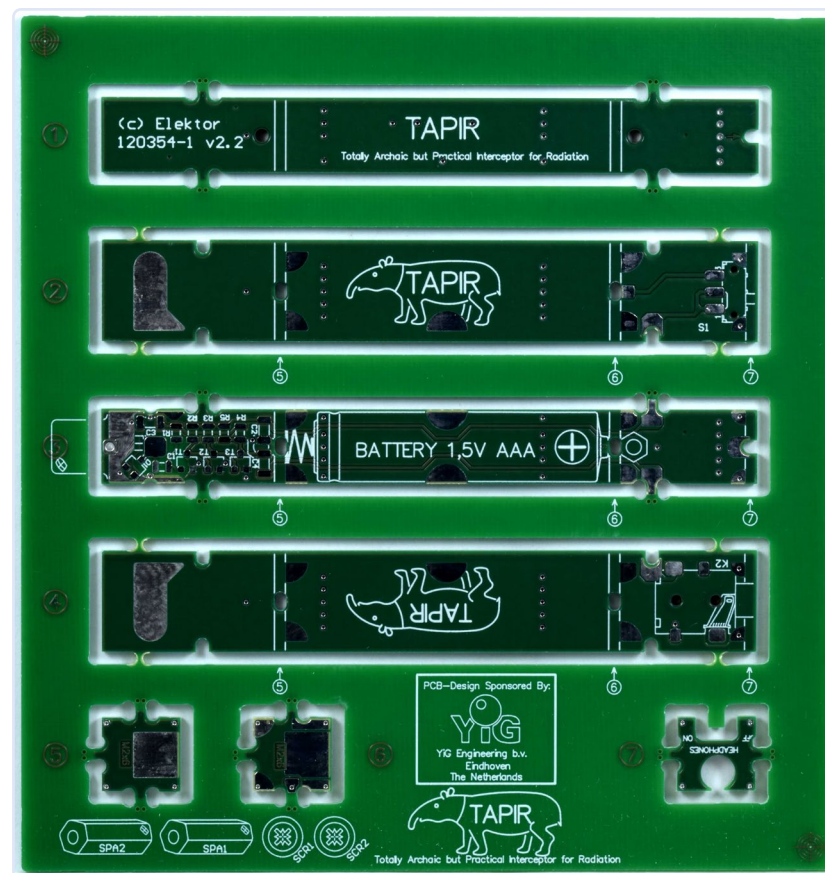


Figure 6. Top view of PCB breakout Panel 120354 v2.2 for the TAPIR E-Smog Detector.



Figure 7. Bottom view of PCB breakout Panel 120354-1 v2.2 for the TAPIR E-Smog Detector.

5 – Assembly

Start by soldering the switch onto PCB 2 and the panel mount connector for the headset onto PCB 4. Apply solder sparingly. Then remove these two PCBs from the PCB panel and file off the tabs.

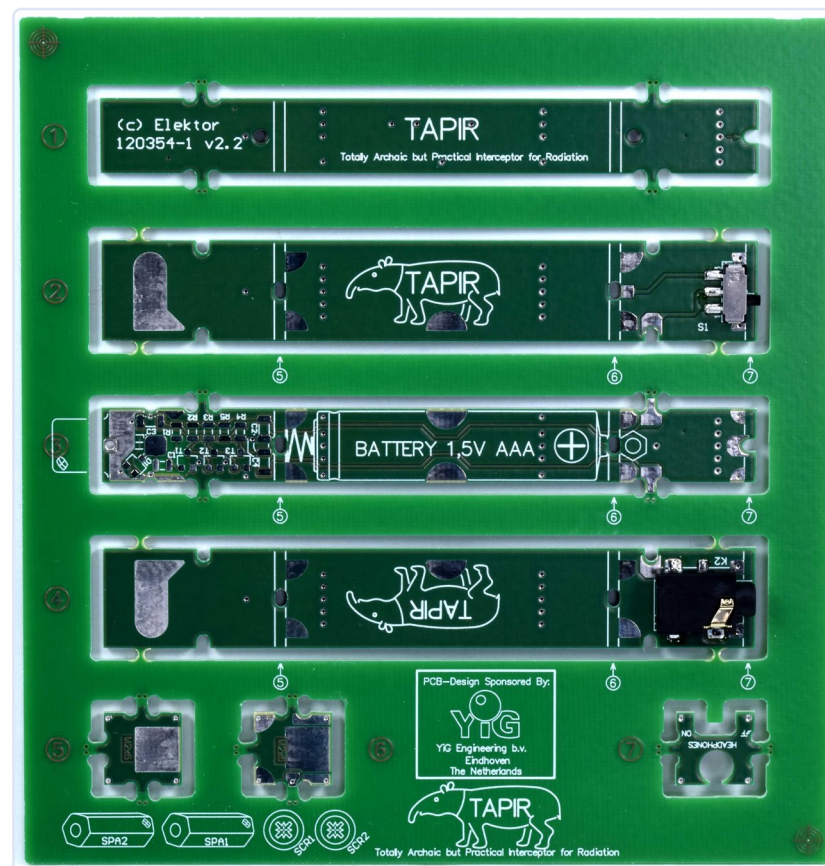


Figure 8. Slide switch S1 and headphones connector K2 soldered.

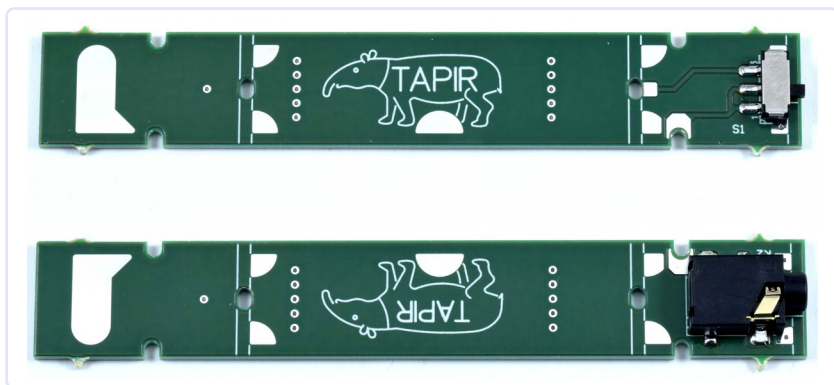


Figure 9. PCB 2 and PCB 4 removed from the panel.

Next, fit the following components on PCB 3 using the previously described soldering method:

1. C3 (10 μ F; no marking, large SMD)
2. R1 & R4 (100 k Ω ; marking: 1003)
3. R2 & R3 (10 k Ω ; marking: 1002)
4. R5 (1 k Ω ; marking: 1001)
5. C1 (10 nF; no marking, small SMD)
6. T1 (MMBT3904; marking: 1AM)
7. T2 & T3 (BC847, marking: 1F or 1FW)

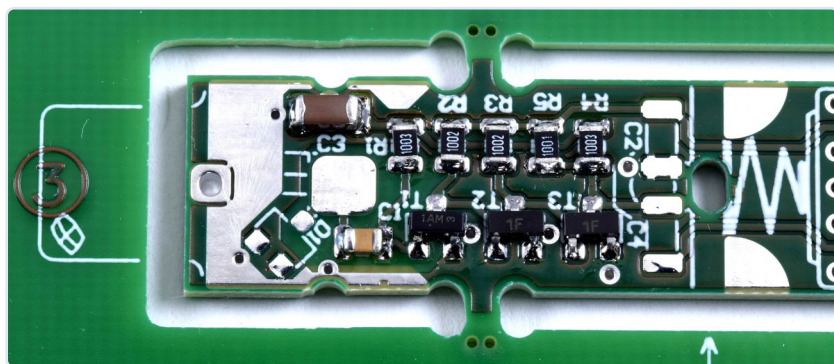


Figure 10. Detail of PCB 3 with C1, C3, R1-R5, T1-T3 fitted.

Temporarily connect a 1.5-V supply voltage to the points indicated in Figure 11 below.

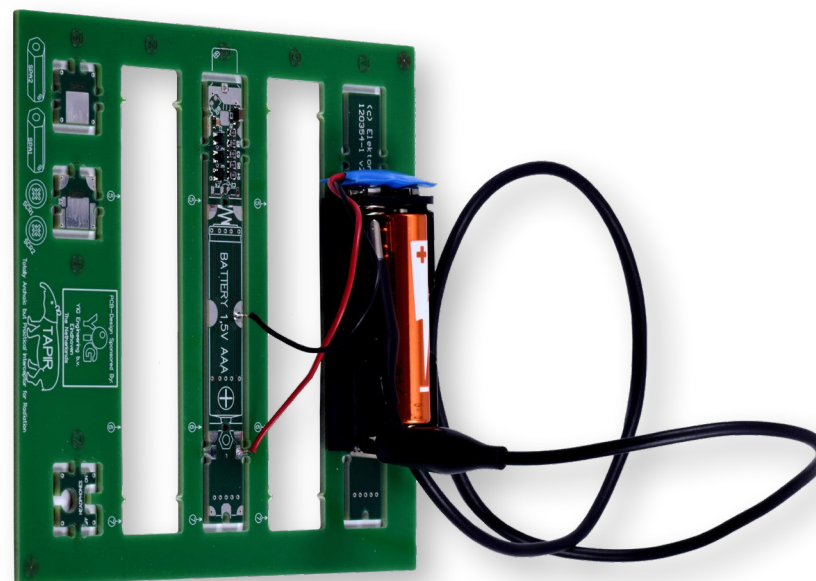


Figure 11. AA battery connected as a temporary 1.5 V power supply. Note polarity!

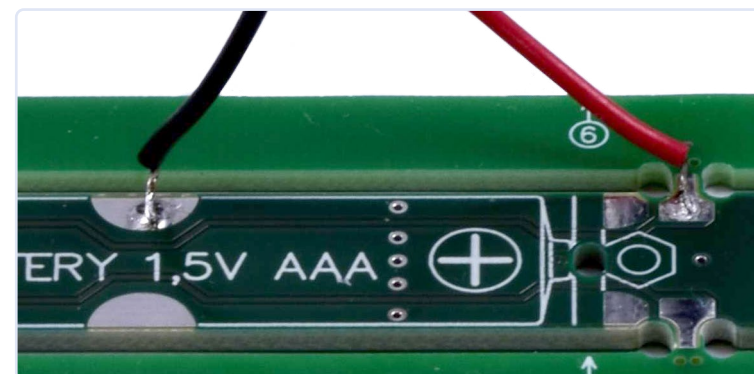


Figure 12. Detail of the temporary battery connection.

Measure the DC voltage at the upper solder pad of C4 (next to C2, which is connected to T3 and R4). The reading should be between 0.5 V and 1.0 V. If not, check all solder joints for proper contact and check that all components have been fitted in the right places.

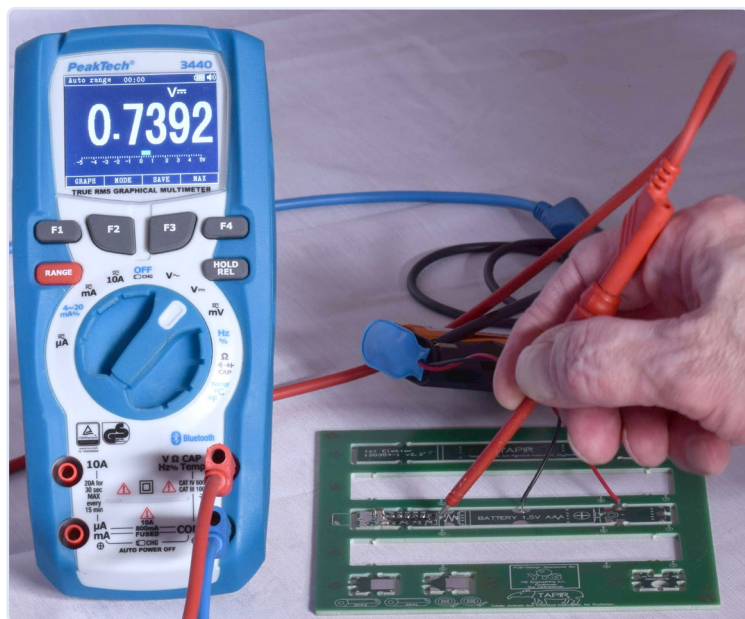


Figure 13. Measurement of the DC level at the output.

If everything is okay, the final three components can be fitted:

8. D1 (BAT54S; marking: LD3 or WV4 depending on manufacturer)
9. C2 and C4 (10 μ F; no marking, large SMD)

Now release PCB 3 from the panel, taking care to avoid damage to the tabs.



Figure 14. PCB 3 removed from the panel.

Then solder the Cinch panel-mount connector onto the PCB. First, straighten the two ground tabs.

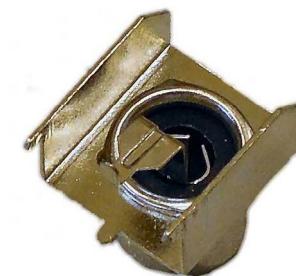


Figure 15. The RCA phono connector with two ground tabs straightened.

Remove PCB 5 from the panel and lay PCB 3 on the work surface with the Cinch connector facing away from you. Place PCB 5 in the proper position on PCB 3 as well as perpendicular to PCB 3, with the marking "M2x6" facing the Cinch connector. For now, solder only the pad at the bottom right.

Remove PCB 6 from the panel and fit it perpendicular to PCB 3 with the marking "M2x6" facing you. For now, solder only the pad at the bottom right.

Remove PCB 7 from the panel and fit it perpendicular to PCB 3. The proper orientation is clearly indicated by the solder pads. Solder all three pads.



Figure 16. PCB 3 with PCB 5, 6 and 7 fitted.

Take PCB 4 (with the headset connector) and insert it carefully into the rear piece and down onto the bottom piece, so that the tabs of PCB 5 and PCB 6 fit into the recesses in the side pieces. Press the PCBs firmly together and solder them in place, starting at the middle. While doing this, regularly check that the PCBs fit closely together at the bottom — at this point it's still possible to make small adjustments.

Now solder the joints between PCBs 3, 4, and 5 and between PCBs 3, 4, and 6. Be sure to solder the joint between PCBs 3 and 4 at the bottom near the headset connector. If the tip of your soldering iron is too thick for proper access to these joints, consider using a piece of solid wire to

'extend' the tip. Place the TAPIR on the bench with PCB 4 facing down and solder the Cinch panel mount connector and PCBs 5, 6 and 7 to PCB 4.

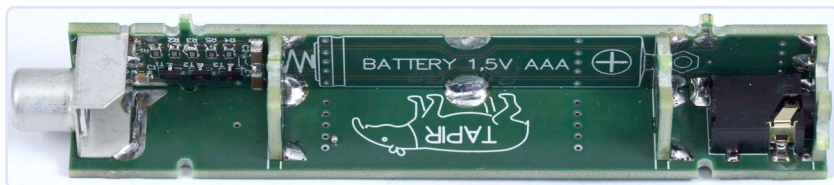


Figure 17. PCB 4 fitted to the others.

Next, fit PCB 2 in the same way as PCB 4. The tabs of PCBs 5 and 6 must fit accurately in the notches. Press everything firmly together and solder the Cinch connector end and the switch end. Check once again that everything is properly mated and correct this if necessary. If everything is as it should be, solder the seams between PCBs 2, 3 and 6, and between PCBs 2, 3 and 6. Place the TAPIR on the bench with PCB 2 facing down and solder the joints between PCBs 5, 6 and 7 and PCB 2. Check that all of the solder joints have been soldered and no short circuits are formed, especially where PCB 2 and 6 meet.

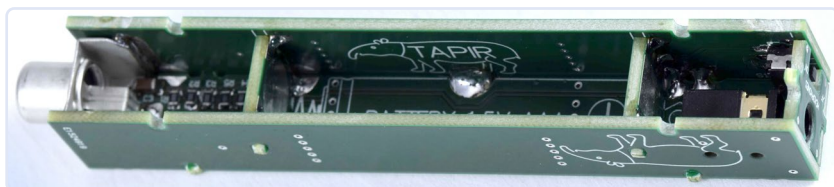


Figure 18. PCB 2 fitted and soldered to the others.



Figure 19. Don't forget to solder the positive supply rail connection from PCB2 to PCB6.

Finally, solder the two M2x6 standoffs at the indicated locations on PCBs 5 and 6. Ensure that they are flush against the board and exactly in the middle. Hold them in place with clamping tweezers if necessary. If you have a steady hand, you can also use a screw temporarily threaded into the standoff. It might help to put some solder on the side of each standoff to be placed against the PCB. It takes a little effort to get the solder flowing evenly on the standoff. Remove excess solder before soldering the standoff onto the PCB.



Figure 20. The two standoffs soldered securely.

Remove PCB 1, countersink the mounting holes with a sharp drill bit, and check that the cover fits properly and can be screwed in place. Now fit the small spring and then insert the battery as shown on the PCB. The spring can be soldered in place if necessary. Now you can place the lid on the TAPIR and screw it tight.

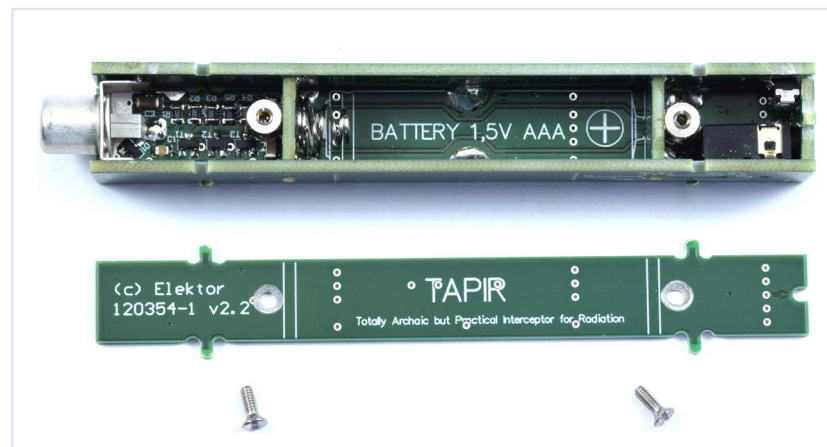


Figure 21. Showing the battery spring soldered, and the two holes countersunk to take the 2 mm screws.

Insert the AAA battery into the battery compartment, observing the polarity.



Figure 22. The AAA battery inserted. Notice polarity!

Fit PCB 1 and the screws



Figure 23. Finished assembly of the Elektor TAPIR.

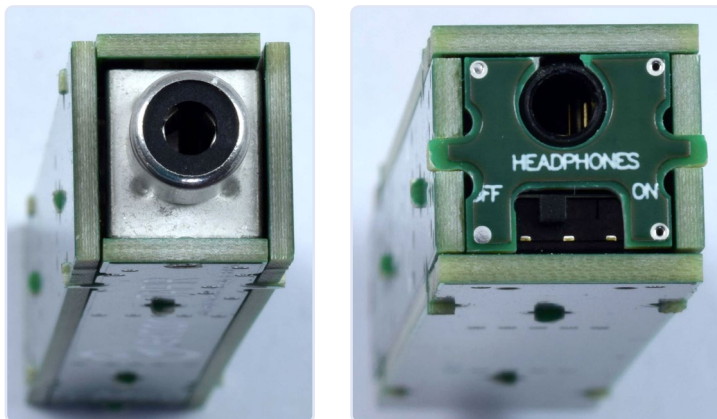


Figure 24. Looking at the RCA connector and the 3.5-mm stereo jack and power switch.

6 – The Antennas

Now you need to make two antennas, each of which is suitable for a particular type of field: an E-field antenna for sensing electrical fields and an H-field antenna for sensing magnetic fields.

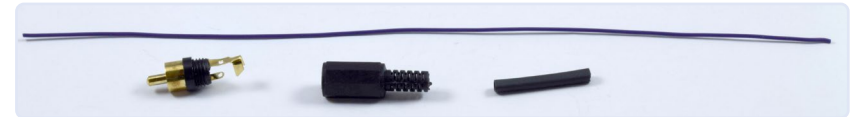


Figure 25. A piece of 25 mm stiff wire, an RCA plug, and a piece of heat-shrink tubing.

The E-field antenna

Start with the E-field antenna. All you need for this is a length of solid, insulated wire. Cut the wire included in the kit in the centre to obtain two pieces approximately 25 cm long. Take one of these and form a loop at one end. Cover the tip of the wire at this point with a piece of heat-shrink tubing or electrical tape (see photo). This electrically insulates the antenna and allows the loop to be used for “sniffing out” electrical noise on, say, a circuit board, but carefully!

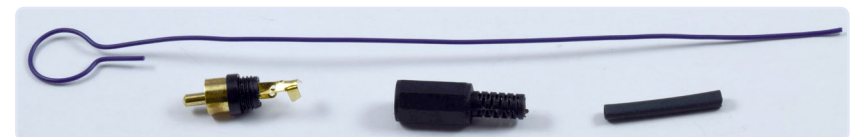


Figure 26. Loop at one end of the wire.

At the other end of the wire, strip off approximately 3 mm of the insulation and slide the Cinch connector shell over the wire. Solder the wire to the centre pin of the Cinch connector. Screw the connector together and straighten the antenna. This antenna is now finished.



Figure 27. The E-field antenna is almost ready.



Figure 28. The E-field antenna is ready.

The H-field antenna

Next comes the H-field antenna. For this you will use the supplied coil (plastic-wrapped inductor). Trim the coil leads to approx. 4 mm. Cut two lengths of stiff wire approx. 5 cm long and strip their ends.

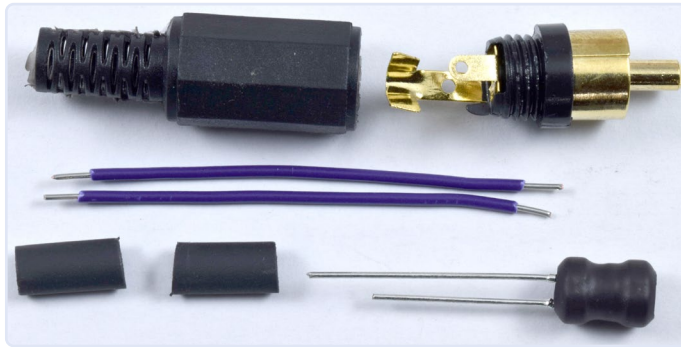


Figure 29. The parts for the H-field antenna. The two 5-cm wire pieces are already stripped.

Solder one end of each wire to the Cinch connector ("signal" and "shield") and screw the connector together.

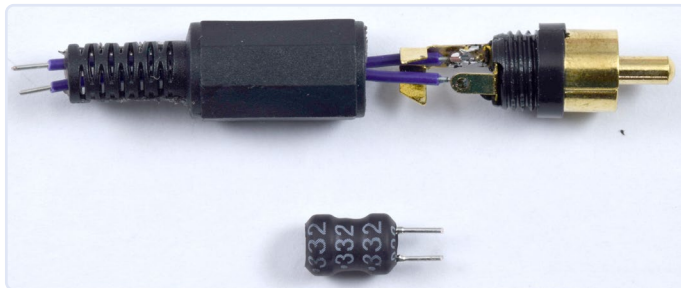


Figure 30. Wires connected to RCA plug and coil leads trimmed.

If you are using heat-shrink tubing, slide a piece of tubing over each wire. Then solder the wires to the coil leads (the polarity does not matter) and insulate the bare wire ends and coil leads. The H-field antenna is now ready for use.

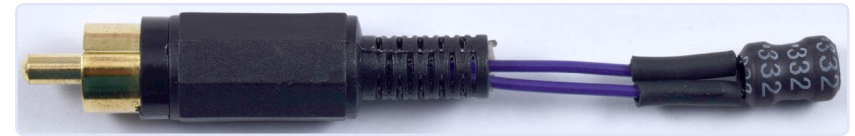


Figure 31. Finished H-field antenna.

Bear in mind that when you hold the TAPIR in your hand, your body is part of the antenna, which may increase the audible hum level.

7 – Bill of Materials

Resistors

R1,R4 = 100 k Ω , 1%, 250 mW, SMD 0805

R2,R3 = 10 k Ω , 1%, 125 mW, SMD 0805

R5 = 1 k Ω , 1%, 250 mW, SMD 0805

Capacitors

C1 = 10 nF, 10%, 50 V , X7R, SMD 0805

C2, C3, C4 = 10 μ F, 10%, 16V, X7R, SMD 1206

Inductor (for external antenna)

L1 = 3.3 mH, unshielded, Bourns RLB0812-332KL

Semiconductors

D1 = BAT54S, SMD SOT-23

T1 = MMBT3904LT3G, SMD SOT-23

T2, T3 = BC847B, SMD SOT-23

Miscellaneous

K1 = Cinch (RCA) socket, SMD, CUI Devices RCJ-011-SMT-TR

2 x Cinch (RCA) plug

K2 = 3.5mm stereo jack socket, SMD, CUI Devices SJ1-3514-SMT-TR

S1 = slide switch, SPDT, right angle, C&K JS102011SAQN

BT1 = AAA battery spring, Keystone 211

SPA1, SPA2 = spacer M2x6, female-female

SCR1, SCR2 = screw M2x6, countersunk

1 mm wire, 50 cm, black

10 cm heat shrink tubing, black, diam. 4 mm, 4:1 shrink ratio

Headphones, cabled, with standard 3.5-mm plug

PCB (panel with 7 PCBs), Elektor 120354-1 v2.2

8 – Web Links

TAPIR Kit:

www.elektor.com/20579



TAPIR project on Elektor Labs Website:

www.elektormagazine.com/labs/

tapir-ultraensitive-wideband-magneticelectromagnetic-field-detector



Original TAPIR Elektor magazine article:

www.elektormagazine.com/magazine/elektor-201207/19936#



TAPIR news on Elektor magazine website:

www.elektormagazine.com/news/week-45



9 – Schematic and PCB Layout

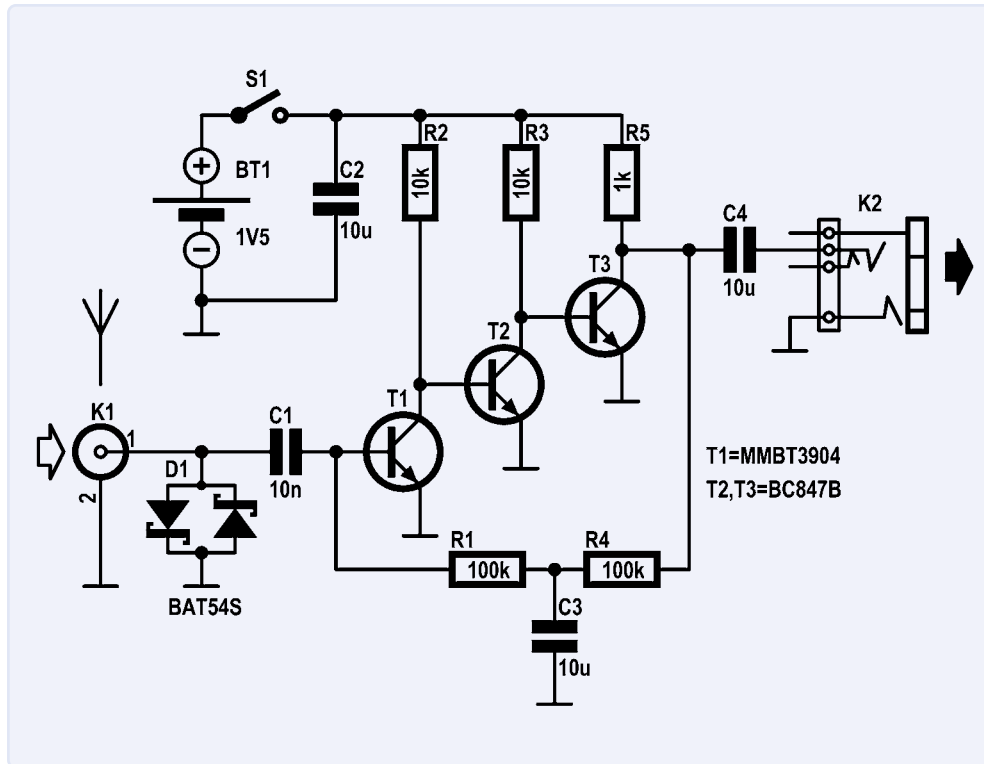


Figure 32. Schematic of the Elektor "TAPIR" E-Smog Detector (120354-1 v2.2)

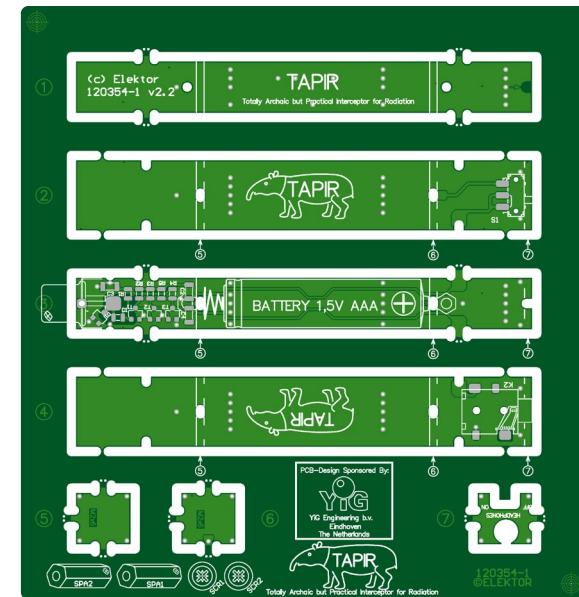


Figure 33. Top overlay of PCB Panel 120354-1 v2.2

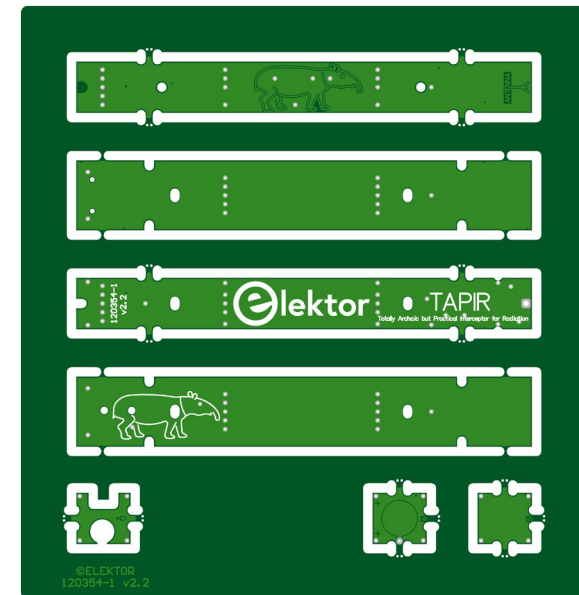


Figure 34. Bottom overlay of PCB Panel 120354-1 v2.2

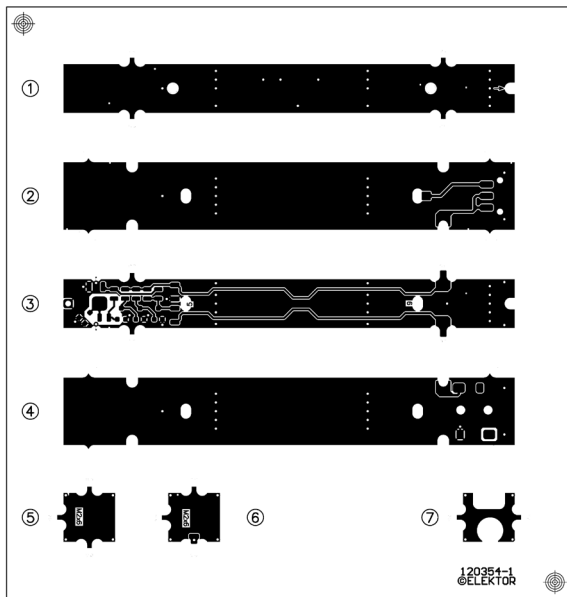


Figure 35. Copper on top of PCB Panel 120354-1 v2.2.

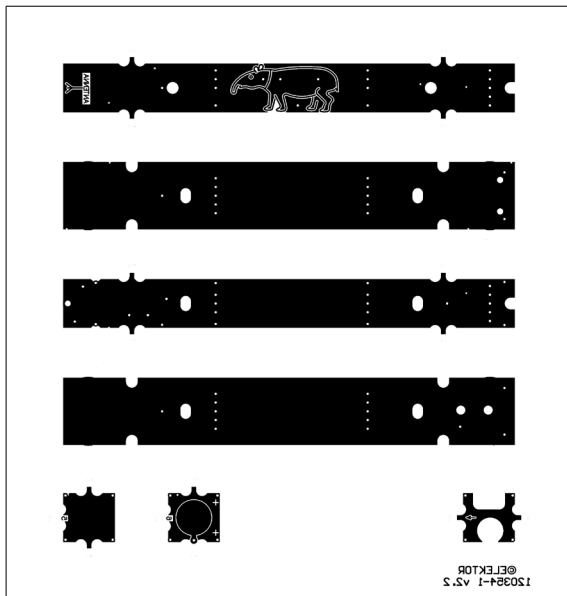


Figure 36. Copper on bottom of PCB Panel 120354-1 v2.2.