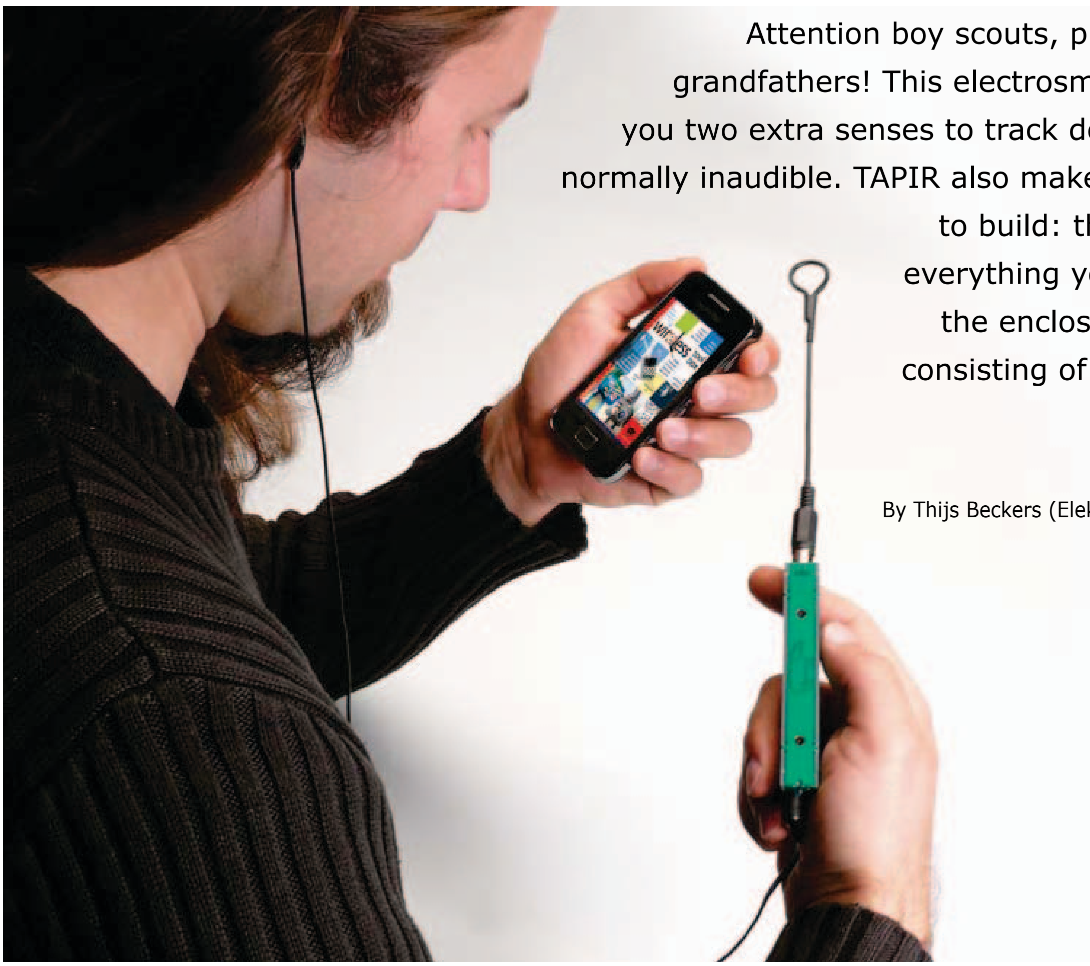
TAPIR Sniffs it Out!

Ultrasensitive wideband E-smog detector



Attention boy scouts, professionals and grandfathers! This electrosmog sleuth offers you two extra senses to track down noise that's normally inaudible. TAPIR also makes a nice project to build: the kit comprises everything you need — even the enclosure, ingeniously consisting of the PCB proper.

By Thijs Beckers (Elektor UK/INT Editorial)

Why build an electrosmog ('E-smog') detector? The answer is quite simple. More and more of our everyday objects are based on some sort of electrical 'core': your toothbrush, camera, cellphone, TV set, and so on. Each and every one of these devices generates electrical radiation in some way. There are of course rules manufacturers should abide by, but that doesn't mean that devices are completely free from electrosmog. In fact, even with the widespread 'CE' certification stamped onto your device, it is not certain that a device complies with all the rules and doesn't interfere with other electronic devices. Ever tried calling someone (or, when receiving an incoming call) holding your mobile phone close to a cheap alarm clock radio, or a set of low-end PC speakers? (your guitar amp probably loves those cellphones too…)

An E-smog detector is designed to detect the 'radiant misbehaviour' of nearby electronics. The TAPIR — short for *Totally Archaic but Practical Interceptor of Radiation* — is a simple design capable of detecting, and audibly pinpoint, any source of electric or — with the appropriate antenna — magnetic field. Its application area extends from home use (*"Where can I sit without being microwaved?"*), to practical use (*"Where's that Wi-Fi-antenna aimed at?"*), to professional use (*"Who the devil is jamming me?! I'm trying to do some sensitive measurements here!"*). It's even suitable as a first SMD soldering project — with your (grand)child

— since it's so easy (and fun!) to assemble.

Different fields

TAPIR is able to detect electric as well as magnetic fields of high frequencies. Magnetic fields are mostly generated by transformers and loop antennas, while electric fields are emitted by high voltage transmission lines, EL backlights and old mopeds passing by. Electromagnetic fields are a combination of both fields, mostly occurring in the 'far field' at a larger distance from the generating object.

Two different antennas can be connected to TAPIR, each optimised for one type of field. Magnetic fields are detected with a ferrite cored coil, while electric fields are detected with a rod antenna, which can be constructed very easy from a piece of installation wire.

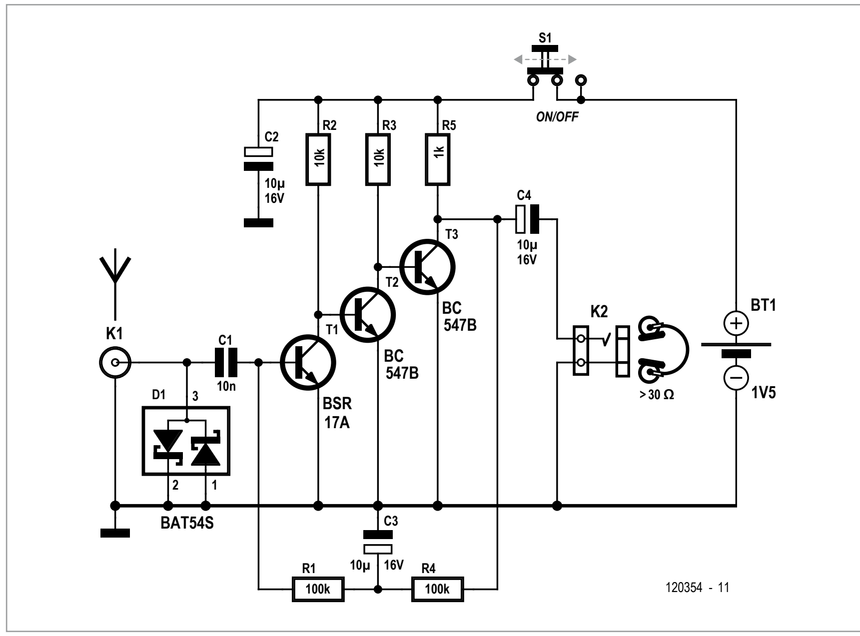
How does it work?

The schematics show the simplicity of the design and are very similar to an Elektor circuit published in 2005. Basically it consists of a three-stage low-frequency amplifier with high gain. There is no low-pass filter in the circuit, consequently high frequencies are passed on to the gain stages. This way the non-linear characteristics of the transistors have a demodulating effect on these high frequency signals, so they can also be heard via headphones.

The bias point of the gain stages is automatically adjusted via a DC feedback path from the output through R4 and R1. To suppress the AC component C3 is added, which shorts this part of the signal to ground.

The output voltage level has an offset of about 0.7 volts, hence C4 is added to remove this offset and protect any connected headphones (or other devices).

The total gain is high enough to be able to 'hear' the intrinsic noise of transistor



Listen in on electromagnetic pollution

T1, so it's best to pick a low noise transistor for this. We went for the BSR17A, which has far better noise figures at high frequencies than a BC847B. Signals of mere microvolts are audible via headphones connected to the output.

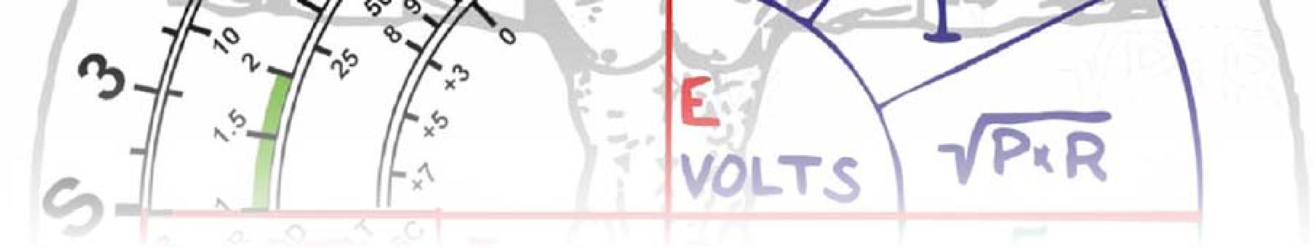
The whole circuit starts to operate from 1.2 to 1.5 V, so a single AAA cell can be used as its power source. The low supply voltage also acts as a kind of limiter; even if strong signals drive the amplifier into saturation, the output levels and thus the headphone levels never become excessive.

Don't flee 4 the SM-Dee

This E-smog detector is available as a low-cost kit [1] with the PCB and all the components included (except the batteries). Worried about soldering those tiny SMD components? No need! Even though there are some components with the '0805' shape, it can all be done with your standard tools, provided you have a reasonably small soldering tip at hand for your soldering iron, and a pair of precision tweezers.

First, clean up your desk! You might drop an SMD component from your tweezers in which case you want to be able to find it again... Assuming the light conditions on your desk are optimal, you may begin with opening the first bag and sorting the components, with or without the help of our online assembly manual [1]. Now you're ready to start soldering.

To get the hang of it, start with some larger components, switch (S1) and the headphones jack (K2). Be frugal with the solder on K2, otherwise you may have some trouble assembling the PCBs together into the housing. When finished, remove PCB #2 and #4 from the panel and flatten the sides where it used to be held into place. Now you're



ready to start with the 'real deal'.

A convenient way to solder SMDs is to 'wet' *one* pad first. Hold the end of the solder wire (thin wire is preferred) onto the pad and *shortly* touch it with the solder tip. A thin layer of solder should now cover the pad with some flux from the core still active. Now use tweezers to align the component onto the PCB, holding it down while you gently touch the lightly tinned soldering pad with your soldering iron again, reflowing the solder. The flux now helps the tin to flow, creating a solid connection between the component and the pad. You may even reheat the pad to position the component better.

When the component is in position, solder the other pad by pushing the solder wire onto the pad and shortly touching it with your soldering iron. The flux should work its magic and evenly spread out the solder onto the pad and the solder connection of the component.

Short soldering actions create the tidiest connections. But do make sure you're actually soldering and not only wetting the pad or the component. Adding some fresh solder to the first pad while shortly reheating it can tidy it up if you made it a little messy.

Now you're ready to proceed with the rest of the components.

Cubism, it's a work of art

When finished, remove PCB #3 from the panel using a fretsaw. Make sure there's a small ridge left. This is needed to put the PCBs together forming its housing. Solder the RCA connector (K1) onto the PCB.

Now we're going to solder PCBs #5, 6 and 7 onto PCB#3. Remove the PCBs from the panel, leaving a short pin in place where it used to be connected to the panel. Place PCB #3 in front of you with K1 pointing away. Now put PCB #5 in its place, making sure it's perpendicular and the soldering pad for the PCB pillar is at the RCA connector side pointing upwards. Solder the pad on the right corner only, so adjustments are easier later on.

Put PCB #6 in place, again making sure it's perpendicular. The PCB pillar pad should be pointing upwards and away from the RCA connector. Solder the right corner pad only. Finally put PCB #7 in its place and solder all three pads.

Continue sliding PCB #4 into its place. K2 should be right through the hole in PCB #7. The small ridges on PCB #5 and 6 should enter the cut-outs on PCB #4. Now solder the 'lower' PCB pads of PCB #4 to PCBs #3, 5 and 6, starting from the middle, pressing the PCBs together tightly. Don't forget to solder the 'normal' pads between PCB #3 and 4 next to K2. Put PCB #4 down and solder the RCA connector onto PBC #4. Also solder the 'upper' PCB pads to the rest of the PCBs.

Put PCB #2 in place and solder it to the rest of the PCBs, making sure it all stays nice and square. Make sure all pads are soldered! Solder the two M2×6 PCB pillars in place. They should be flat on the PCB and right in the middle. Bracket tweezers can be helpful with this. Use a sharp drill to countersink the screws into PCB #1 and check if the last PCB (#1) fits nicely. If needed, correct the position of the PCB pillars. Place the spring and a battery (AAA type) and close the lid. Your TAPIR is now ready for use.

Constructing antennas

To detect electric fields, a simple rod antenna can be constructed using an RCA connector and 20 cm (8 inches) of electrical installation wire (or any type of wire, but installation wire is quite stiff and can be bent the way you like). Strip 3 mm (0.1 inch) off the isolation and solder the wire to the centre pin of the RCA plug. When locating interference on circuit boards a small loop at the end of the rod could prove useful.

Magnetic fields are picked up by an inductor-based antenna. This antenna is constructed using a piece of installation wire as a frame to hold the coil,

while one end of the coil is connected to the centre pin of the RCA plug and the other to the outer connection. Make sure the 'ground' (outer connection) is securely connected to the TAPIR, otherwise the inductor acts as an electric field antenna. More detailed information about the construction can be found on our website [1].

TAPIR in use

Using the TAPIR is dead easy. Connect the headphones and an antenna and switch it on. Move it around any electrical device and you'll hear different noises with each device, depending on the type and frequency of the emitted field. Give these a try: a TFT PC dis-

COMPONENT LIST

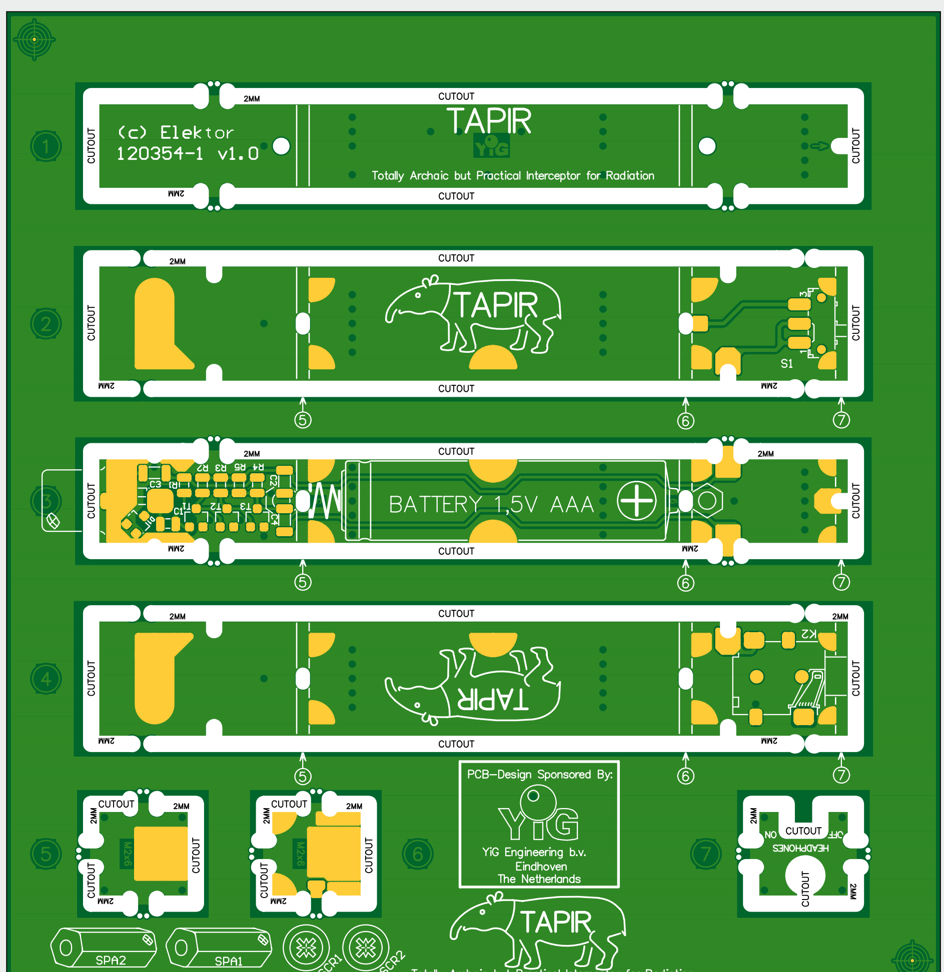
Resistors (SMD 0805)
R1,R4 = 100kΩ
R2,R3 = 10kΩ
R5 = 1kΩ

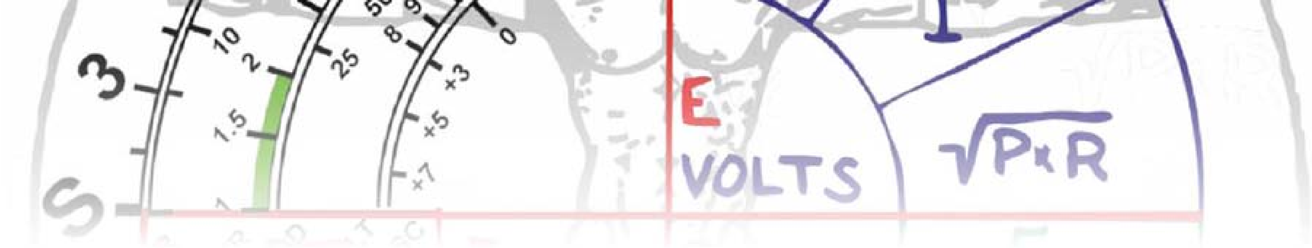
Capacitors
C1 = 10nF 50V, SMD 0805
C2,C3,C4 = 10µF 25V, SMD 1206

Semiconductors
D1 = BAT54S
T1 = BSR17A
T2,T3 = BC847B

Miscellaneous
K1 = RCA socket, SMT
K2 = mini jack SMT, CIU
S1 = switch, JS102011SAQN
PCB #120354-1, see [1]
Battery spring
Two PCB pillars, M2×6
Two Phillips screws, M2×6
Two RCA connectors
Two pieces of installation wire, approx. 20 cm (8 inch)
One inductor coil (H-field antenna)

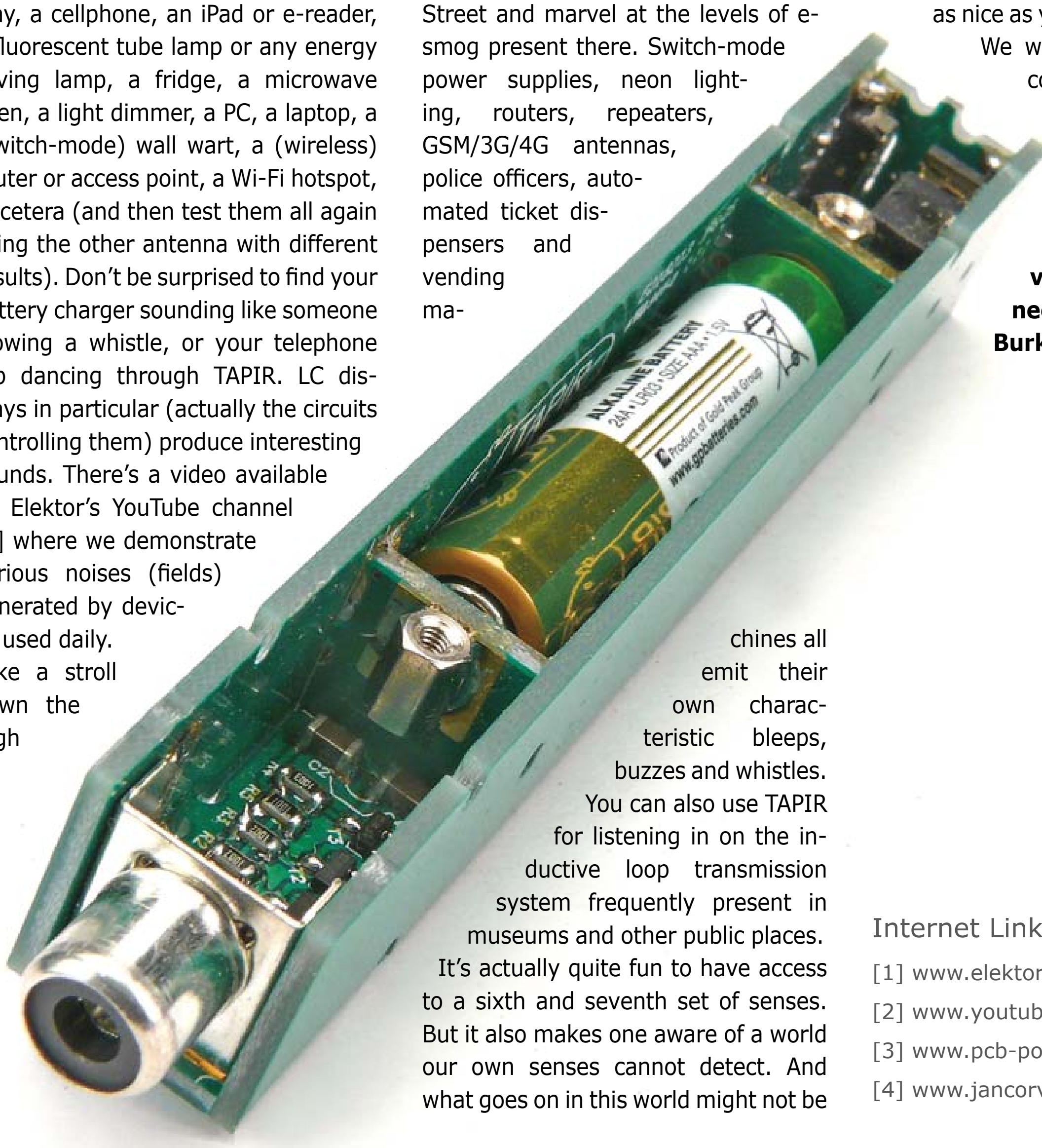
A kit consisting of the PCB and all the needed parts (AAA cell excluded) is available from Elektor [1] order no. 120354-71.





play, a cellphone, an iPad or e-reader, a fluorescent tube lamp or any energy saving lamp, a fridge, a microwave oven, a light dimmer, a PC, a laptop, a (switch-mode) wall wart, a (wireless) router or access point, a Wi-Fi hotspot, et cetera (and then test them all again using the other antenna with different results). Don't be surprised to find your battery charger sounding like someone blowing a whistle, or your telephone tap dancing through TAPIR. LC displays in particular (actually the circuits controlling them) produce interesting sounds. There's a video available on Elektor's YouTube channel [2] where we demonstrate various noises (fields) generated by devices used daily.

Take a stroll down the High Street and marvel at the levels of e-smog present there. Switch-mode power supplies, neon lighting, routers, repeaters, GSM/3G/4G antennas, police officers, automated ticket dispensers and vending machines all emit their own characteristic bleeps, buzzes and whistles.



You can also use TAPIR for listening in on the inductive loop transmission system frequently present in museums and other public places.

It's actually quite fun to have access to a sixth and seventh set of senses. But it also makes one aware of a world our own senses cannot detect. And what goes on in this world might not be as nice as you'd hope it would be.

We would like to thank all contributing partners for making this project possible: PCB production: **PCB-Pool** [3]; design: **Museum Jan Corver** [4] and **YiG Engineering**; original design: **Burkhard Kainka**.

(120354)

Internet Links

[1] www.elektor.com/120354

[2] www.youtube.com/ElektorIM

[3] www.pcb-pool.com

[4] www.jancorver.org/en/index.htm

Partners