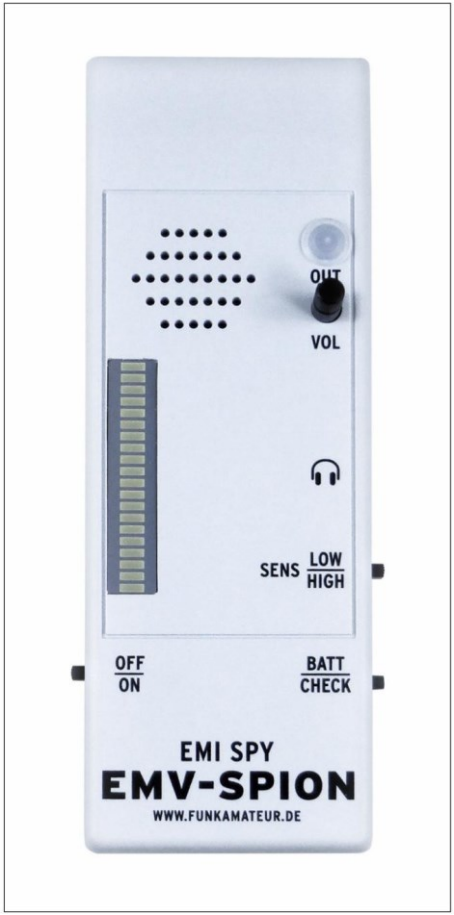
FUNK AMATEUR

EMI locator
>EMI Spy 2<

Complete kit for a
handy, battery-operated
Near location device for locating
sources of Electro Magnetic
Interference

Assembly instructions



building instructions for this
EMI locator
›EMI Spy 2‹

FA Reader Service

Radio amateurs are increasingly affected by interference from cheap electronics, switched-mode power supplies, energy-saving lights, etc. when practicing their hobby.
A simple locating device – such as the EMI Spy available here as a kit – can help to locate such sources of interference and check the effectiveness of interference suppression measures. With the help of the built-in miniature speaker, headphones or by connecting an optional analysis device, conclusions can be made about the type of polluter. In addition, the device can also be used as an AF signal tracer when repairing electronic devices.

Designed by Michael Lass, DJ3VY, and Dr. Jochen Jirmann, DB1NV, this device for locating spurious emissions was first presented in [1]. This concept resulted in the complete kit, which is now available as a new upgraded version, which, in addition to the SMD pre-assembled main board, contains all the necessary components, and includes a ready made enclosure with four different, pluggable search antennas (probes).

Image 1: Fully assembled EMI Spy without attached probe

Required Tools

This kit can be assembled by anyone in a relatively short time as the main board is supplied largely pre-assembled, therefore no SMD parts need to be soldered. For the few components that still have to be soldered, only thru-hole components are used. Therefore, the kit is easy to assemble for users with limited soldering skills.

The following tools are required for assembly:

– temperature-controlled soldering iron 60W to 80W with pencil solder tip
– Solder 0.5 mm to 1 mm with flux core
– Electronic side cutters,
– Flat nose pliers,
– Screwdrivers of different sizes
– A Multimeter

Assembly

If you have limited experience with kits, you should work through the following instructions step by step. Experienced electronics hobbyists do not have to stick to the specified order of assembly. Above all, it is important that all components are correctly positioned and that switches and sockets are pushed flat on the circuit board prior to soldering.

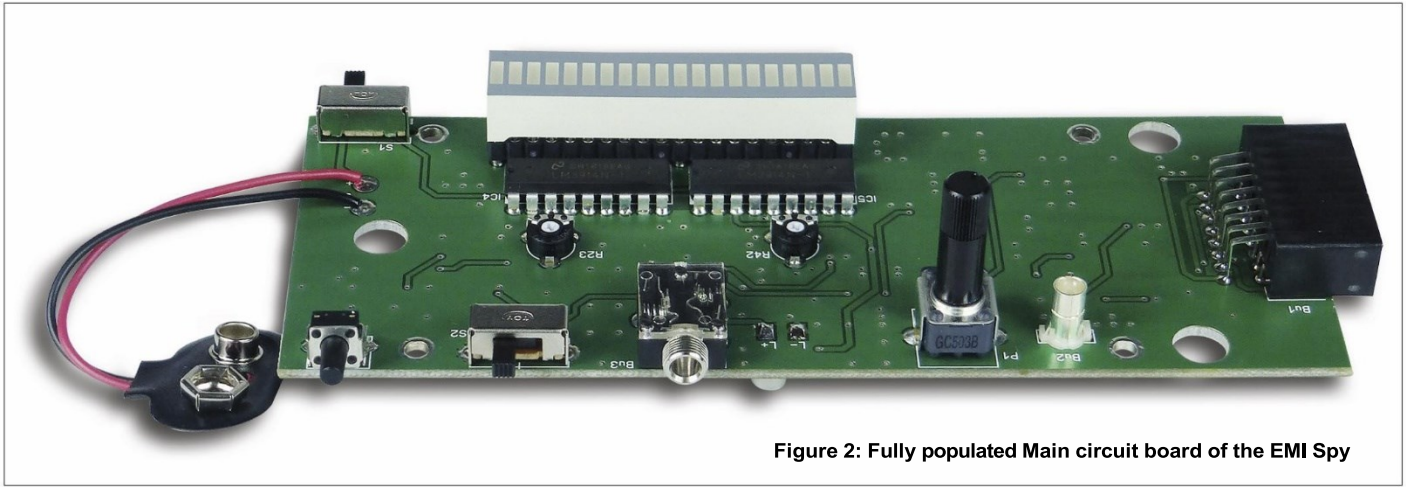


Figure 2: Fully populated Main circuit board of the EMI Spy

Table 1: Parts list of the kit

Designation	Value/Type	Quantity	Remarks
R23	10 kOhm	1	Adjustable resistor
R42	2.5 kOhm	1	Adjustable resistor
P1	50 kOhm	1	Potentiometer, vertical
IC4, IC5	LM3914	2	DIL-18
LED BAR	SRBG2000	1	Kingbright
Bu1	probe socket	1	16 pin
Bu2	coaxial Socket	1	miniature version
Bu3	jack socket	1	3.5mm, stereo, horizontal
S1, S2	slide switch	2	
S3	button switch	1	push button switch
socket strip	20-way	2	Socket for LED Bar
battery clip	T shape	1	for 9V block battery
stranded wire		2	7cm, Isolated, Red and Black
cover plug	7.5mm	1	for coaxial socket -
Screw	M2 x 6mm	4	to fasten PCB to Enclosure
Washer	for M2	4	
foam rubber strips		1	self-adhesive, battery compartment
PCB circuit board		1	with fitted SMD components
Probe PCBs		4	
Audio Probe PCB		1	Audio signal tracer PCB
RCA jack		1	to fit on Audio Probe PCB
Enclosure		1	2 parts including 3 screws

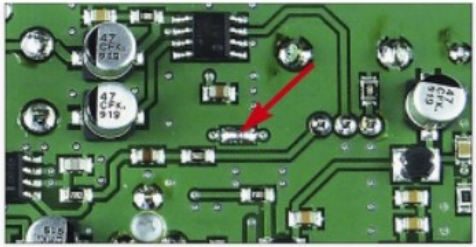


Figure 3: Solder bridge to be closed on the underside of the board

Solder bridge

First the solder bridge on the underside must be closed (Figure 3). It enables a signal path to be created for measurement purposes, eg during repairs.
If you forget to close the bridge, the device will not function.

Assembly of the main circuit board
All the components included in the kit are **inserted** on the **upper side** of the circuit board and **soldered** on the **underside**. The circuit board is printed on both sides and plated through. This provides for a compact, RF-capable layout, but makes de-soldering more difficult in the event of an accidental fault during assembly of any components.

There is a risk of destroying the circuit board by lifting soldering pads or tracks. For this reason, **great care and prudence** must be exercised when placing and soldering any components

If in doubt, the fully assembled circuit board shown in **Figure 2** can serve as a guide during the assembly work.

Adjustable Resistors

Next start the assembly with two of the flat components. In this case, these are the two variable resistors R23 (10kOhm) and R42 (2.5kOhm).

The assembly plan is on page 12. The plan is also printed on the top of the circuit board. It shows the location of the components and their correct installation position.

Integrated Circuits

IC4 and IC5 are then fitted. Their position can be seen on top of the IC body, the indentation or marking on the narrow side of the relevant circuit housing must point in the specified direction (Figure 4).

The following procedure is recommended for soldering: First, the component with solder pins is plugged into the corresponding holes on the circuit board. On the solder side, solder one of the pins to the board using a little solder.

Then the correct position and alignment of the IC are checked again and a second connection pin is soldered.
If necessary, you can now readjust or desolder the component relatively easily. If everything is correct, all connection pins must be soldered.

LED socket

The LED socket consists of two separate 20-pin precision socket strips. These are for ensuring that the 20-digit LED line later achieves the required height in the enclosure. Note Red Arrow in (Figure 7). for correct position. To ensure the two socket strips are soldered correctly they are attached to the LED during soldering.

After soldering, the sockets should sit exactly straight and flat in the holes of the circuit board.

When the two socket strips are soldered in, the LED bar may be unplugged if desired so that it does not interfere with the following steps or is accidentally damaged.

Slide switch

Now the two identical slide switches S1 and S2 are fitted. Each must have its underside pushed fully onto the board.
The toggles should then be horizontal in relation to the board surface (Figure 5).
The easiest way to do this is to provisionally solder one of the soldering pins of the respective switch first. The switch can then be easily aligned while the soldering point is heated at the same time. When the switch is finally in the correct installation position, all the soldering pins and the two housing lugs are soldered.

Buttons and sockets

Next, the miniature button S3 with the soldering pins is plugged into the corresponding holes on the circuit board. The button must also be fully pushed down into the circuit board.

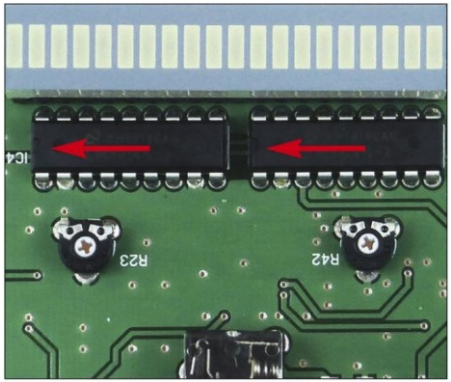


Figure 4: Positioning of the two ICs

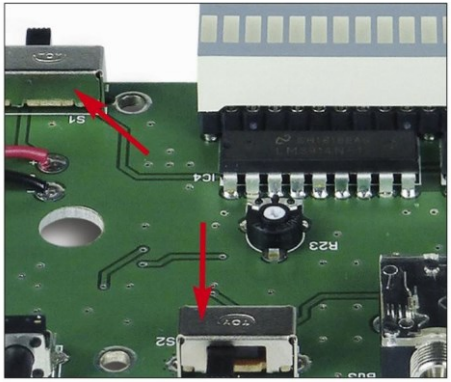


Figure 5: Sliding switches, buttons and sockets must lie flat on the circuit board and be correctly aligned.

Check the button is vertical otherwise there is a risk later that it will jam after the housing cover has been put on.
Align the 3.5 mm jack socket Bu3 when soldering in such a way that its long side is exactly perpendicular to the edge of the circuit board. The lines of the assembly imprint for Bu3 can serve as a guide.
The miniature coaxial socket Bu2 should be seated in an upright position with connection pins into the circuit board before it is soldered.
Next the 16-pin plug Bu1 connector serving as the probe socket should be fitted. It must lie straight and flat with its housing against the circuit board.

Potentiometer

Finally, the potentiometer P1 with its connections and the housing contacts must be plugged into the corresponding holes on the circuit board, aligned to a vertically position and then soldered.

This completes the assembly of the main board.

First functional test

Before the battery is connected for the first functional test, you should use an ohmmeter to check whether a short circuit on the circuit
board's power supply line may be present due to an assembly or soldering error.

You should connect an ohmmeter to the pads marked + and - and measure "into the circuit board". The value displayed should be a few kiloOhms. S1 must be set to *On* (slider towards the battery compartment). If you measure a short circuit or only a few ohms, the cause of this error must be found and eliminated first.
If everything is in order, the black battery connection wire is soldered to the soldering pin on the circuit board marked with –. Connect the multimeter, set as a current meter between the end of the red plus line and the + solder pin on the circuit board.

After switching on S1, a current of about 40 mA should be measured. Minor deviations are permissible due to tolerances.
The bottom segment of the LED line must flash. The power consumption fluctuates accordingly in the flashing rhythm. If everything is in order, remove the

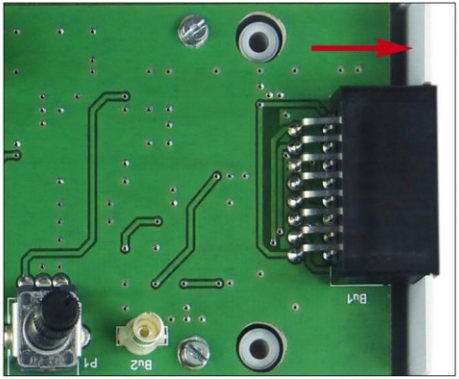


Figure 6: The gray front plate (arrow) must be pushed into the housing in such a way that the cutout for the probe connector points upwards.

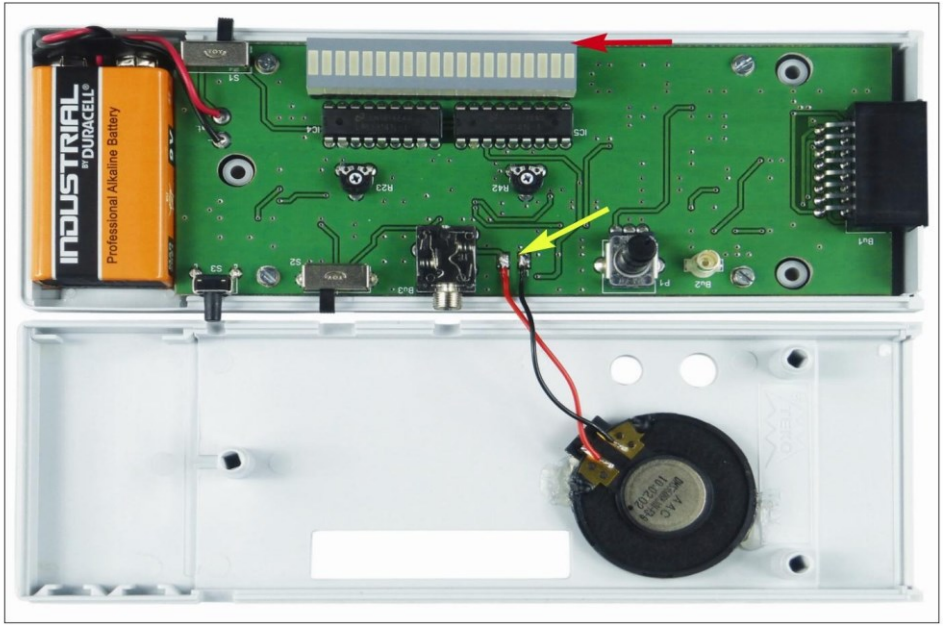


Figure 7: EMI Spy after wiring the speaker and before closing the housing cover; the red arrow indicates the position of the chamfer on the housing of the LED row, the yellow arrow points to the two connection pads for the speaker cable.

multimeter cable and solder the red plus cable of the battery clip to the + solder pin on the circuit board.

Note: The length of the two cables of the battery clip is very generous.
If it seems too long, you can shorten the connection cable accordingly.

Final Assembly

First, the front panel must be pushed into the bottom shell of the housing. The cutout for the probe connector must face upwards (Figure 6).

Next the main circuit board is then carefully placed in the lower shell of the housing and aligned. It is fastened with four M2x6mm screws and washers.

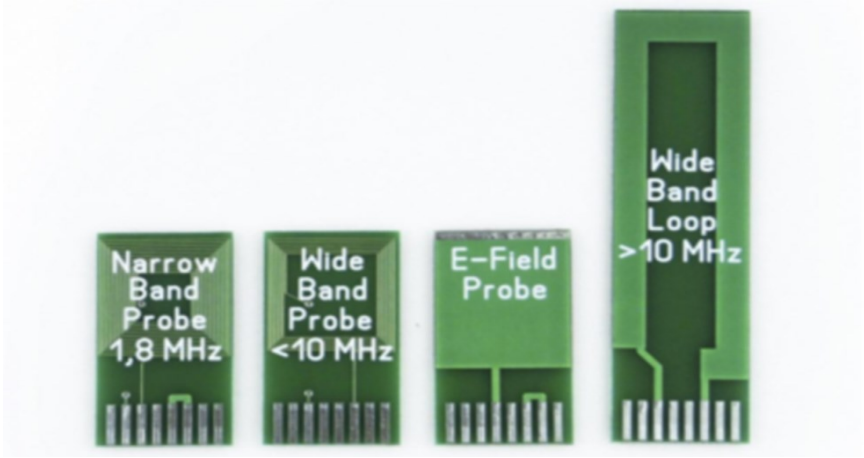


Figure 8: Four search antennas (probes) are included in the kit.

Table 2: Search Antennas (Probes)	
Label	**Application**
Narrow Band Probe	Narrow band Probe Resonant freq 1.8 MHz
Wide Band Loop >10 MHz	Basic Wide band Loop 10...50 MHz
E-Field Probe	E-Field Probe also usable as RF Probe
Wide Band Probe <10 MHz	Wide band probe 100 kHz ... 2 MHz

The 20-pin LED Bar can be plugged into the socket if it was previously removed so that the slightly rounded corner corresponds with the marking on the circuit board or red arrow (Figure 7). The two Loudspeaker connections in the enclosure cover are to be connected to the corresponding soldering pads L+ and L- on the circuit board using the two pieces of wire supplied (Figure 7). The enclosure cover is fitted on the other enclosure half and screwed together.

After inserting the 9 V battery, the EMI Spy is ready for use. Note: A self-adhesive foam rubber strip is included in the kit. Glued to the inside of the battery compartment cover it prevents the battery from rattling inside the enclosure.

Probes and Probe board

The kit contains four different search antennas (probes) (Table 2 and Figure 8). Each has different characteristics and are therefore dependent on the type of interference and frequency range. The coils are designed as conductor tracks. There are no other probe components on the boards.

The probes can be plugged into the socket on the main circuit board either way and will function in any position.
An adapter board labeled *Audio Probe* is included (Figure 9). Fitted with a 3.5mm jack it functions as an AF input when the EMI Spy is used as a signal tracer when repairing an AF circuit

Commissioning and operation

For commissioning, the broadband antenna for low frequencies *(wide band probe <10MHz) is connected* to the EMI spy.

It doesn't matter which side of the probe is on top, as the probe socket is wired in such a way that all probes can be inserted in any position

After switching on using S1, the bottom segment of the LED line must flash as a switch-on indicator. The response threshold of the internal comparators of IC4 and IC5 can be varied with the adjustment of resistor R23. Accordingly, the display of the LED line shifts by a few segments. This setting can be customized later depending on the preferred probe and desired display sensitivity. At full sensitivity the noise of the preamplifier is readily displayed, so R23 is set in such a way that without a connected probe, the lowest segment just stops from lighting up but only flashes instead. If you press the push button S3, the LED line shows the current level of the battery voltage. The higher the illuminated segment moves on the line, the better the condition of the battery.

When the battery is full, the top segment should be lit. If the battery voltage has dropped to just under 6 V, only one of the middle segments will light up and you should think about changing the battery soon.

The full deflection of the LED line can be set with R42. R42 is set in such a way that the top LED lights up when the battery is full and S3 is actuated.

The setting resistors influence each other in terms of their effect.

The slide switch S2 is used to switch to the output of the differential amplifier and thus causes a higher sensitivity *(HIGH/ LOW)* and thus a wider *(HIGH)* or narrower *(LOW)* display of the interference signal on the LED Bar.

A commercially available headphone or earphone with a 3.5mm stereo jack plug can be connected to Bu3. This allows you to listen to the amplified and demodulated signal received from the probe. The internal loudspeaker is switched off when the stereo jack is use. Note that the loudspeaker should only be used for initial acoustic orientation due to limited low frequency response.

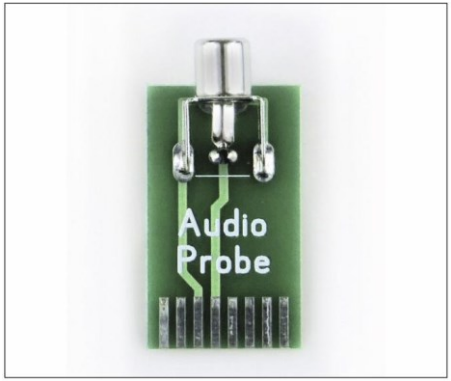


Figure 9: Adapter board for the AF probe

The headphones deliver a much broader acoustic spectrum. With a little experience you can draw conclusions about the type of interference source. Bu2 is an HF output for connecting external devices, eg a spectrum analyzer. A suitable connection cable with BNC plug is available under the designation *MAK-1* at www.box73.de [2].

When not in use, the opening in the enclosure should be sealed with the supplied plastic cap to prevent dirt from entering the enclosure.
Plugging in the *audio probe* circuit board turns the EMI Spy into an AF signal tracer. The EMI Spy in this mode can be used to isolate errors in the AF section of electronic devices. An inline diode rectifier or HF probe [3] would even make the AF signal tracer suitable for HF for AM signals.

The E-field probe can also be used for this purpose if a short piece of wire is soldered to the top edge pad of the circuit board as a testing tip.

Which probe to use in practice depends on the interference to be detected. For example the broad band probe is suitable for pinpoint localization of Low Frequencies. You can even use it to check for a break in stranded lengths of telephone and unshielded network cables by moving the probe along the cable.
If in doubt, try it out and select the probe that best receives the fault. The experience gained is then useful in the next case of a fault. With headphones connected, interference can already be heard when the LED bar graph does not respond due to the low level.

The acoustic differences between the sources of interference is an important aspect of the search anyway. Depending on the type of source of interference, you will be able to tell the most common of them apart after a relatively short time. Testing the directivity with the connected probe is also an interesting field of activity, which provides essential information for isolating sources of interference.

Notes
Questions from users or other interested parties that are of general relevance in the product-FAQs are answered on www.box73.de . In the future there will also be videos available showing the practical use of the EMI Spy.
Anyone who fears that the printed text on the probes will wear off over time due to frequent use or careless storage is advised to slide a length of transparent shrink tubing with a suitable cross-section over the probes as protection.

If the device is not used for a long length of time, then the battery should be removed to prevent damage from leaking electrolyte liquid.

shop@funkamateur.de

literature

[1] Lass, M., DJ3VY,Jirmann,J., DB1NV: The EMV Spion – ein Ortungsgeraet fuer Stoeremissionen und mehr. FUNKMATEUR 61 (2012) H. 7, pp. 706-709 German Text edition Juli 2012 page 706-709

[2] Online shop of the FUNKAMATEUR reader service www.box73.de

[3] Editor FA: Minimalistischer HF-Tastkopf FUNKMATEUR 62 (2013) German text Funk Amateur February 2013 Page 165.

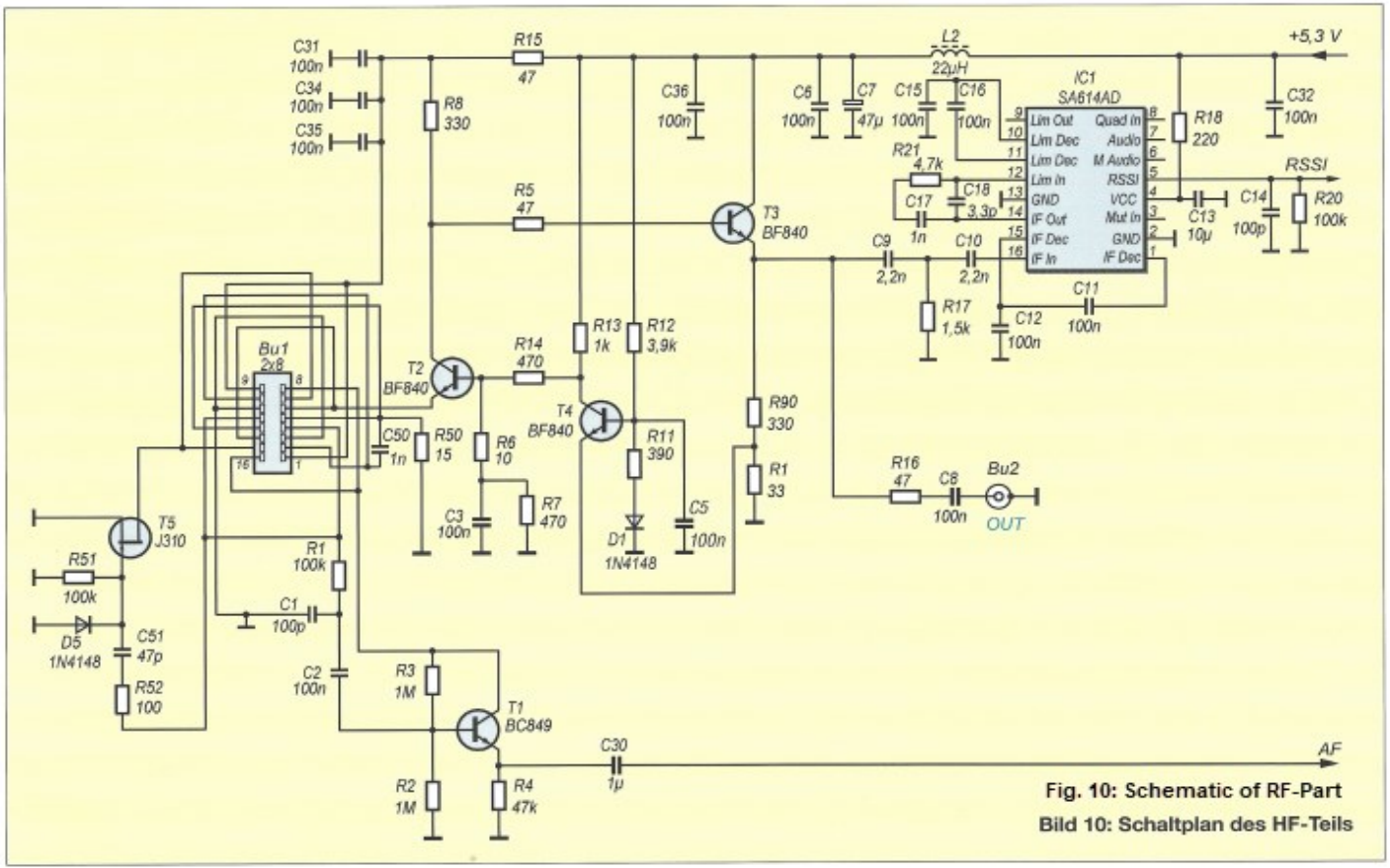
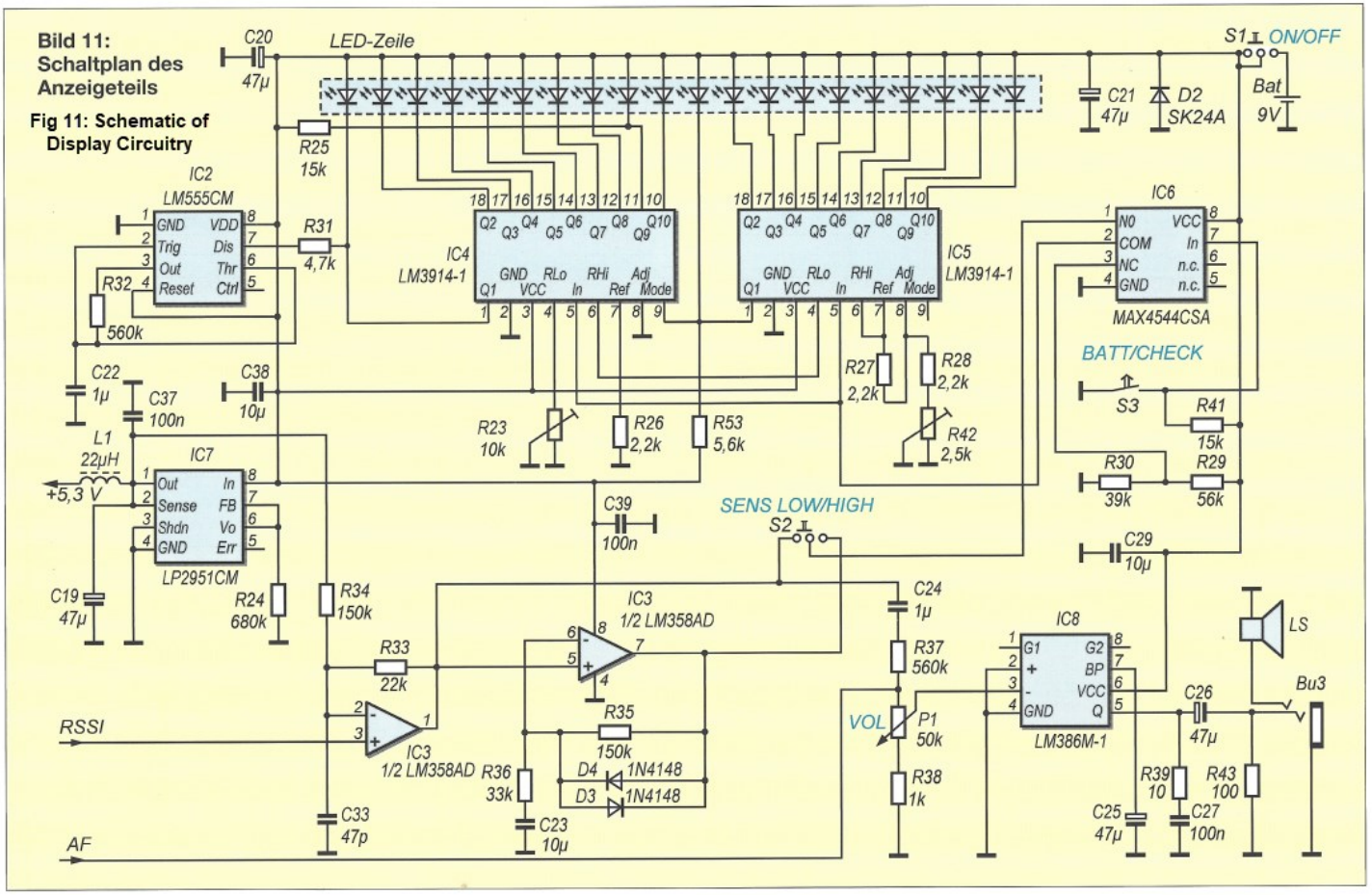


Fig. 10: Schematic of RF-Part

Bild 10: Schaltplan des HF-Teils

Bild 11:
Schaltplan des Anzeigeteils

Fig 11: Schematic of Display Circuitry



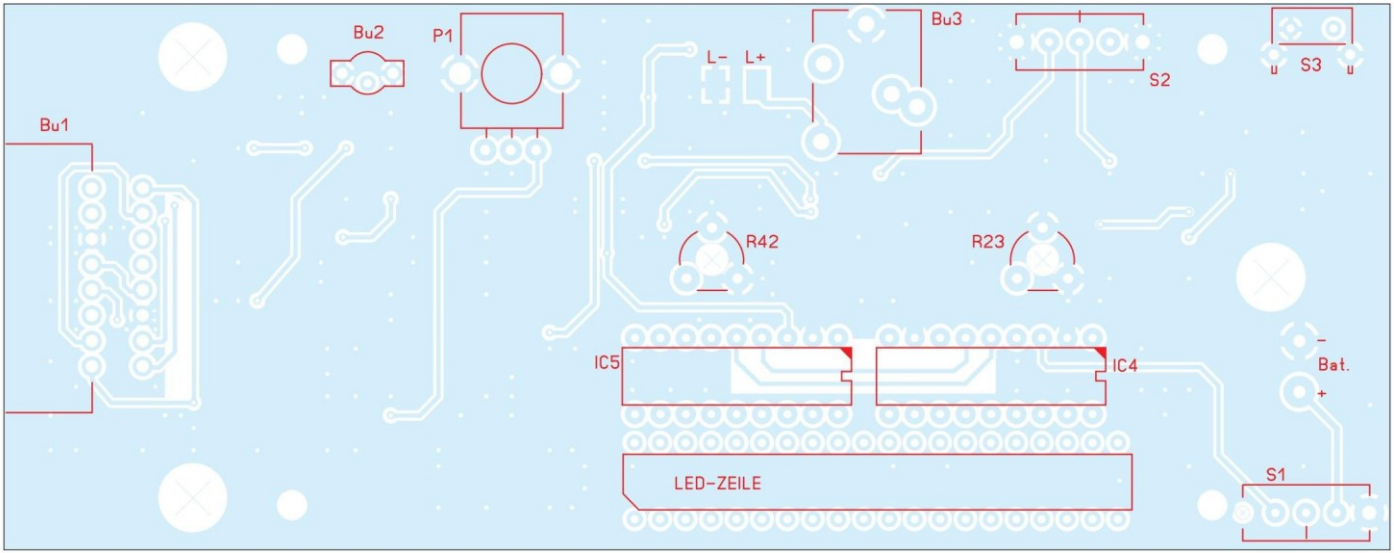
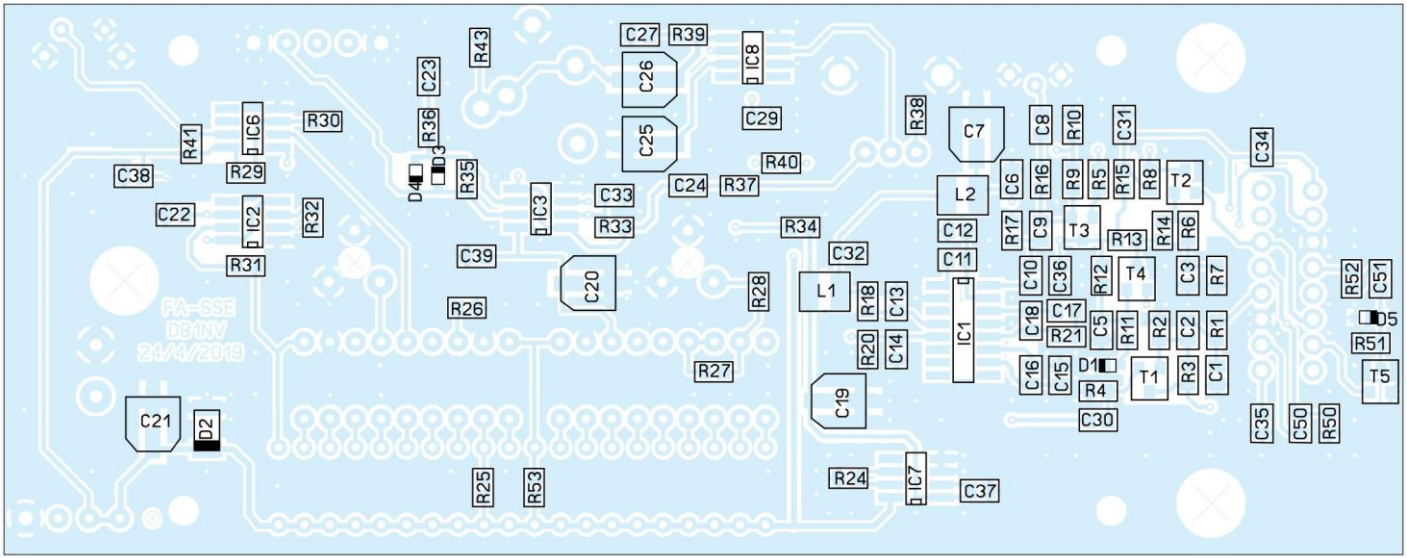
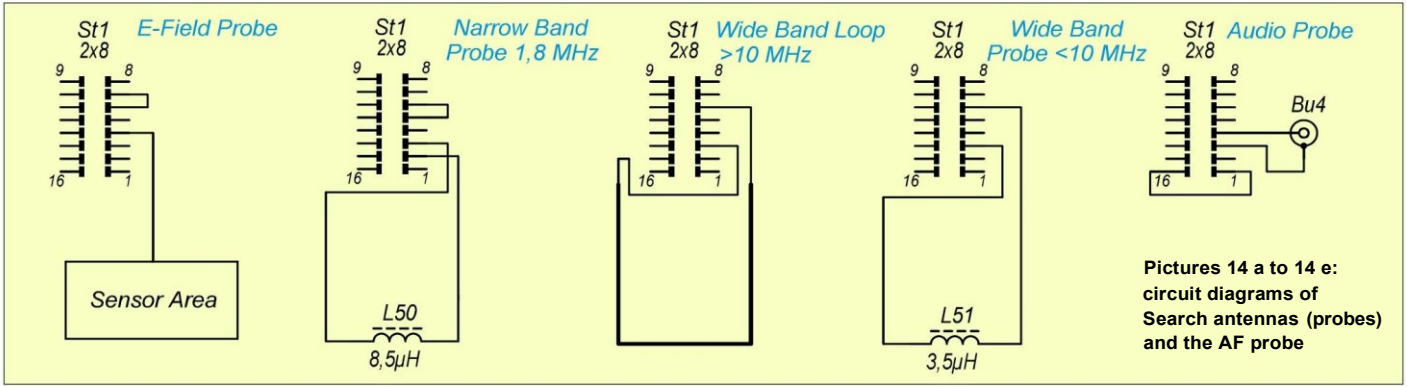


Figure 12: Assembly plan, main circuit board, top side

Figure 13: Main circuit board assembly plan, underside with SMD components (Page 13 top right)





Pictures 14 a to 14 e: circuit diagrams of Search antennas (probes) and the AF probe

Order no. BX-078 E

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please report problems to *support@funkamateur.de* .

When disposing of this product, the regulations for handling electronic waste must be observed.
Electronic devices and batteries do not belong in household waste!
WEEE registration no. UK 80777816