Perfect Signal Supplier

HQ Stereo VHF Test Generator SUP3

The SUP3 generates a high-quality FM signal including an individually configurable RDS signal. In addition to the analogue audio feed, a USB interface also allows digital audio data to be fed in. The operation is clearly arranged via a practical combination of rotary encoder and OLED display; in addition, PC software allows easy control of the SUP3 from a PC.

Versatile

After the great response to the predecessor models SUP1 and SUP2, we present the successor, SUP3, which has numerous new features. First of all, there is now a digital signal feed via USB. This allows you to use a PC or other device with USB sound output directly as a signal source. And since the VHF test generator can also be operated with batteries and an RDS signal to be output can be stored in its EEPROM, you can, for example, use the mobile combination of test generator and smartphone to put the coveted radio treasure through its paces before buying it, even if, for example, VHF reception is not possible in a particular space. Such a generator is also excellently suited for demonstrating radios, whether in the showroom or in a museum, as it makes the radio independent of antenna reception and also offers the possibility of outputting your own content, such as explanations in an exhibition.

However, the main purpose of use is probably the repair and restoration of VHF radio receivers. An exact calibration is only possible with a test signal that conforms to standards. The use as a VHF transmitter, however, even if it is only for short distances, is prohibited!

Technical data

Device short description:	SUP3
Power supply:	2x 1,5 V LR6/Mignon/AA
Current consumption:	250 mA max.
Standby current:	10 µA
Frequency range:	87,5–108 MHz
HF-output:	88–118 dBµV/75 Ω/IEC
Audio-inputs:	Audio-/Stereo-audio-jack
Display:	OLED-colour-display with 128 x 128 pixel
Other:	Audio optional analog (audio jack) or digital (USB) Station name (2x 8 characters) RDS-text (64 characters) Operation and audio data (digital) via USB
Ambient temperature:	5 bis 35 °C
Dimensions (W x H x D):	63 x 142 x 25 mm
Weight (with/without batteries):	184/135 g

The operation of the SUP3 has also changed. A colour OLED display is now available. It is operated comfortably with a rotary wheel (rotary encoder).

A very special feature, as already mentioned, is the USB connection. This makes it possible to transfer digital audio data from the PC to the SUP3. The SUP3 functions as an external sound card. Remote control is also possible via the USB connection.

Change of Function

Fig. 1 shows the connection diagram for the SUP3 with all connection variants. The device under test is shown here as a vintage radio. Please note that a shielded cable must always be used as the connecting cable to the device under test and must be connected directly to the antenna input of the device. As already mentioned, the SUP3 is a test generator and not a VHF transmitter in the conventional sense. Therefore, HF radiation must be avoided at all costs.

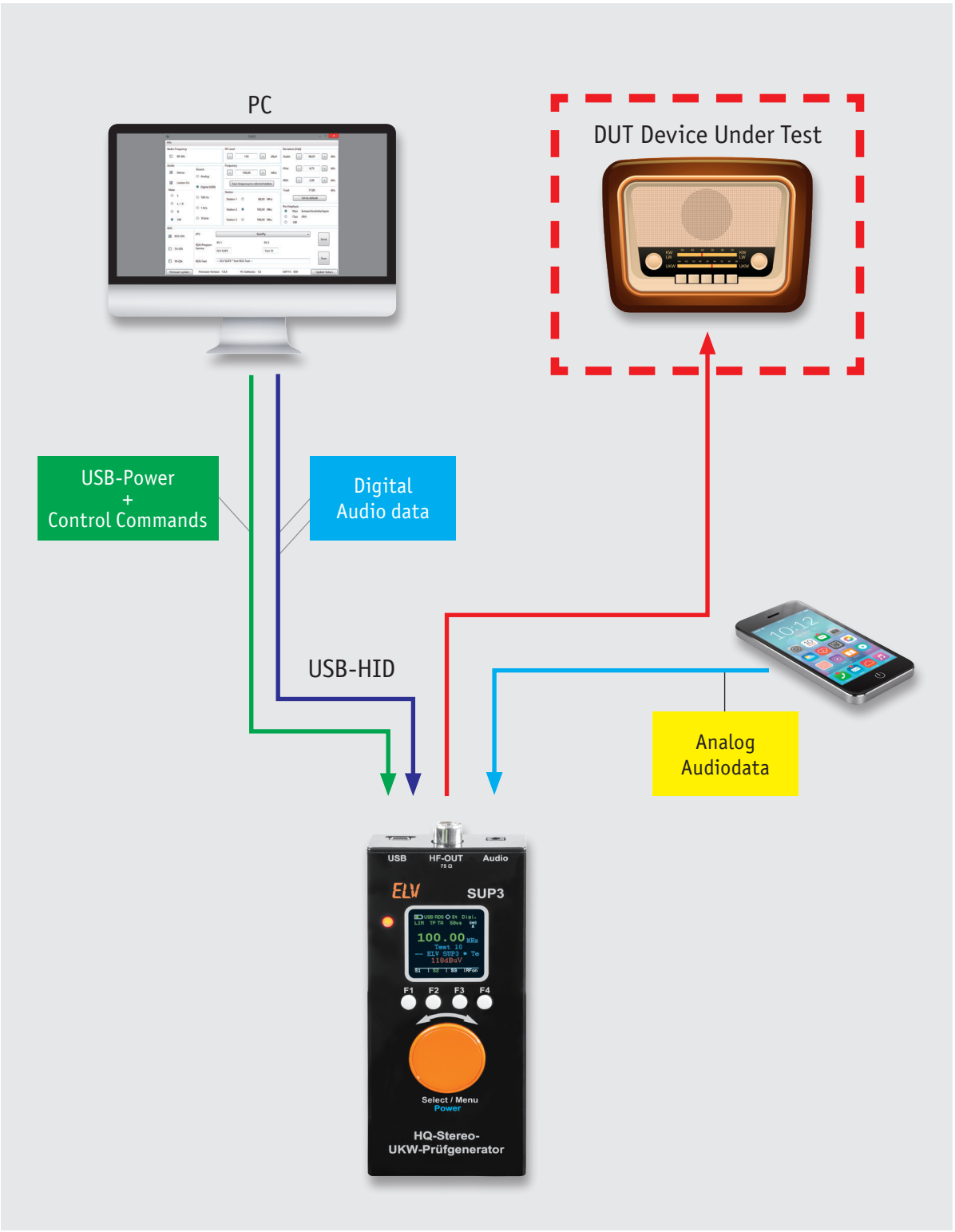


Figure 1: Connection diagram of SUP3

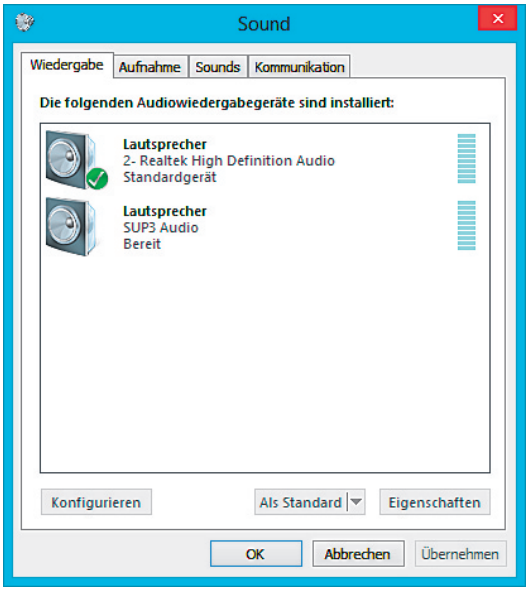


Figure 2: Menu Sound under system settings

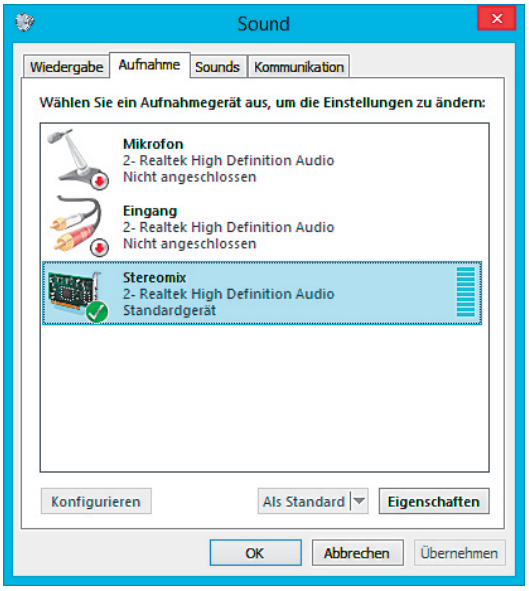


Figure 3: Under Recording you will find the stereo mixer

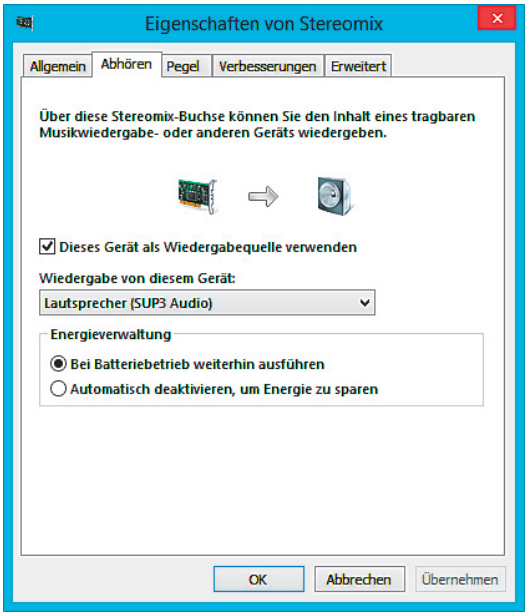


Figure 4: Set the checkmark to Use this device as playback source

A smartphone, for example, can be used as an analogue audio source. For the internal generation of test signals, the internal oscillator with fixed frequencies of 100 Hz, 1 kHz or 10 kHz can also be used for modulation (see Operation). Furthermore, it is possible to connect the SUP3 to a PC via a USB connection. Two channels are used here. On the one hand, the SUP3 can be conveniently controlled remotely via PC software and, at the same time, a digital audio signal can be transmitted from the PC to the SUP3. In this case, the SUP3 registers as an external sound card.

Setting up SUP3 on the PC

After the SUP3 has been connected via the USB port, it is automatically recognised by the PC. For remote control, the SUP3 registers as an HID device, so no driver is needed.

At the same time, an external sound card is recognised. The SUP3 can now be selected as the output device under Speaker Properties. Please note that Windows can only manage one sound card as an output source. There is a little trick that allows you to listen to the audio signal on the PC, namely „Stereo Mixer":

To do this, go to *Control Panel* → *Sound* (Fig. 2) and under the *Playback tab* the PC sound card and the SUP3 should be listed. Select the sound card as the default device.

Under *Recording* you will find the Stereo Mixer (Fig. 3, if not: *right click* and *show deactivated devices* and *activate the stereo mixer*). In the stereo mixer settings in the *Listening tab* (Fig. 4), set the checkmark to *Use this device as playback source* and select the SUP3 in the drop-down menu. Then finish the setting with *OK*. Now the playback should take place on both devices. Sometimes a restart of the computer is necessary.

During playback, latencies occur between the sound card and the output on the device under test connected to the SUP3. This is due to the different transmission paths.

PC-Software

The operating options, as shown in Fig. 5, are self-explanatory and correspond to the operation on the unit, with the exception of the RDS function. Here it is possible to change the RDS text and the text for the RDS programme service directly. Pressing the Send key transmits the RDS data to the SUP3. If you want to save the texts directly in the SUP3, this is done by pressing the *Save to EEprom SUP3* button.

Another special feature is the update function. A firmware update is provided on the product page in the ELVshop (https://de.elv.com) if re-

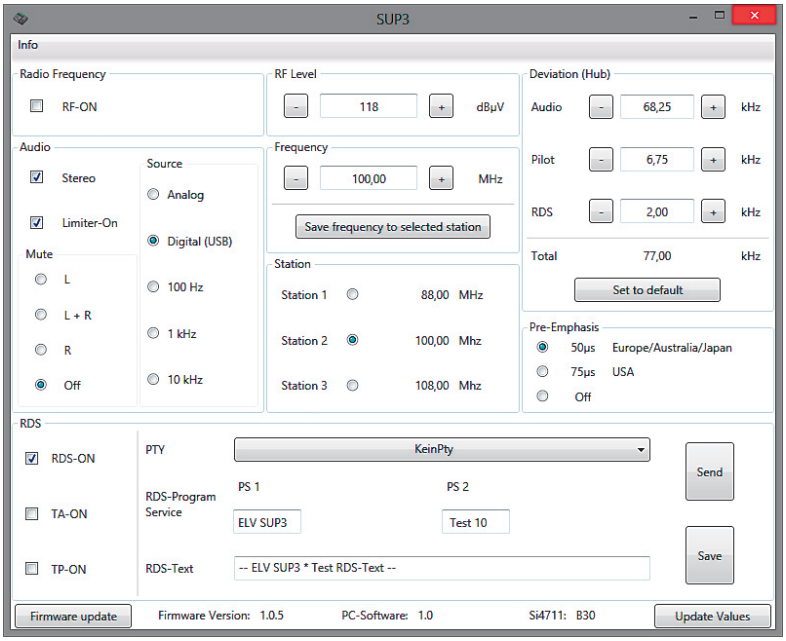


Figure 5: You can adjust all settings via the PC software

quired. This may be the case if, for example, a firmware bug or the like is corrected. The FW file must first be downloaded. Then select the downloaded file and start the FW update. This process should not be interrupted, otherwise a malfunction may occur.

Operation

The unit is operated via a rotary wheel (rotary encoder) and four function keys that perform different functions depending on the menu. The unit is switched on by pressing the rotary encoder. The Firmware version first appears in the display. Then the main screen appears. All the symbols are shown and explained in Fig. 6. In the main screen, you can use the function keys (F1 to F4) and the rotary encoder to carry out the functions described below.

The function keys F1 to F3 can be used to call up previously previously programmed frequencies (S1 to S3). The fourth function key F4 is used to switch the RF output (RFon) on and off. The active RF output is indicated by an antenna symbol. The frequency can be changed manually by turning the rotary encoder.

Pressing the push-button (rotary encoder) allows you to enter the menu, which offers the following setting options and can be seen in the overview in Fig. 7:

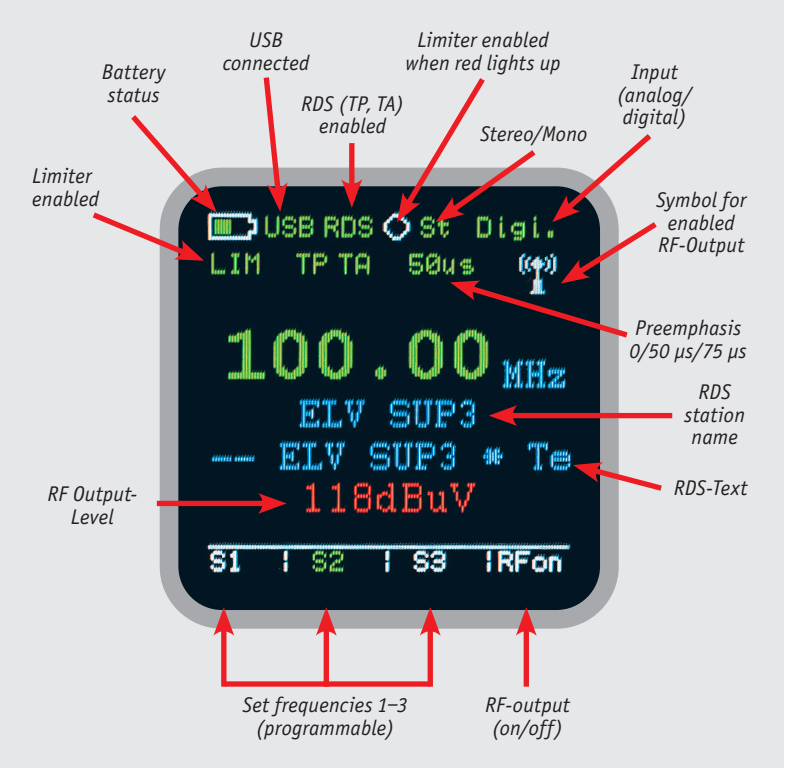


Figure 6: All possible elements of the display

RF Level (RF Power) and Pre-emphasis

Here, the output level can be changed in a range from 88 to 118 dBµV.

The function keys can be used to set the pre-emphasis. In Europe, a pre-emphasis of 50 µs is used [1]. The pre-emphasis is a transmitter-side treble boost that is compensated by de-emphasis in the receiver. This procedure is used to improve the signal-to-noise ratio.

Deviation

The deviation depends on the modulation depth. In FM modulation, the deviation indicates the volume of the modulation signal. The greater the deviation, the higher the volume [2]. The change in carrier frequency Δfr is called frequency deviation. The deviation can be set separately for themain carrier, RDS carrier and pilot tone. According to the standard, the total deviation must notexceed 77 kHz, because the carriers can interfere with each other. For this reason, the total deviation is displayed as a sum.

The function keys can be used to directly select between the setting options, or the rotary encoder can be used to advance. The respective value is changed with the rotary wheel. The menu can be exited with the function key F4.

With *Default*, the basic settings for the deviation can be restored. To do this, select this menu item by pressing the rotary encoder and turn it to *YES*, then press the encoder again to restore the default settings.

Under *NO*, the menu is closed without restoring the basic settings.

„Audio“ Menu

In this menu you can select three submenus and activate or deactivate the limiter. The limiter can also be switched with the function key F4.

Input Mode

Here you can select the source for the FM modulation. You can choose between analogue input (jack socket), digital input (USB) or fixed frequencies. By turning the rotary knob or using the function keys, you can directly select between the inputs. To leave this menu, press the function key F4.

Note: No external analogue signal may be present during internal modulation, as both signals mayoverlap.

Modulation

The functions can be activated using the rotary wheel. In addition, the stereo, mono and mute functions can be activated directly via the function keys F1 to F3. Press the F4 key to leave this menu.

RDS

Press the F1 key to activate or deactivate the RDS function. Key F2 activates the TA (Traffic Announcement) function. This causes a volume increase on the receiver side if TP is also active.

When the function is activated, the corresponding circle next to the function is filled in green.

The TP (Traffic Programme) function is activated with the F3 key. TP identifies a station that offers traffic radio. Further information is available at [3].

Menu Settings

With *Display Timeout* you can set the time after which the display switches off (1–10 min). The set functions remain active. *Disable* activates the display permanently, but this is not recommended, as switching it on permanently can lead to premature failure at the end of the limited service life of OLED displays.

Auto Power Off

This setting only applies to battery operation.

With *Auto Power Off* you can set a time after which the unit switches off after the last operation (1–10 min). With Disable or when supplied via USB, the unit does not switch off automatically.

Factory Reset

Due to the large number of setting options, various setting parameters can be changed. To return to the delivery status, there is the so-called *factory reset*. If you select this option, all parameters are reset to the factory settings.

Circuitry

The circuit diagram of the SUP3 (Fig. 8 and 8a) is divided into the following circuit sections: analogue input circuit, FM transmitter, controller with OLED display and power supply.

Let's look at the input circuit first, which is shown in the upper part of the circuit diagram. The analogue audio signal (stereo) is fed to the circuit via the socket BU11, which first reaches a limiter. The diodes D25 to D27 are Transient Voltage Suppressor diodes which protect against overvoltage or voltage peaks. The limiter IC14 of the type NJM2761 ensures that a certain audio level cannot be exceeded; the limiter function can also be deactivated via the menu. The output level is determined by the resistor R3, which is 0.6 Vpp in this configuration. This means that the maximum permissible level for the FM transmitter is not exceeded. C7 sets the time constant for the control.

From the limiter output, the two stereo signals are fed to a 2nd order low-pass filter with a cut-off frequency of 15 kHz, which consists of the

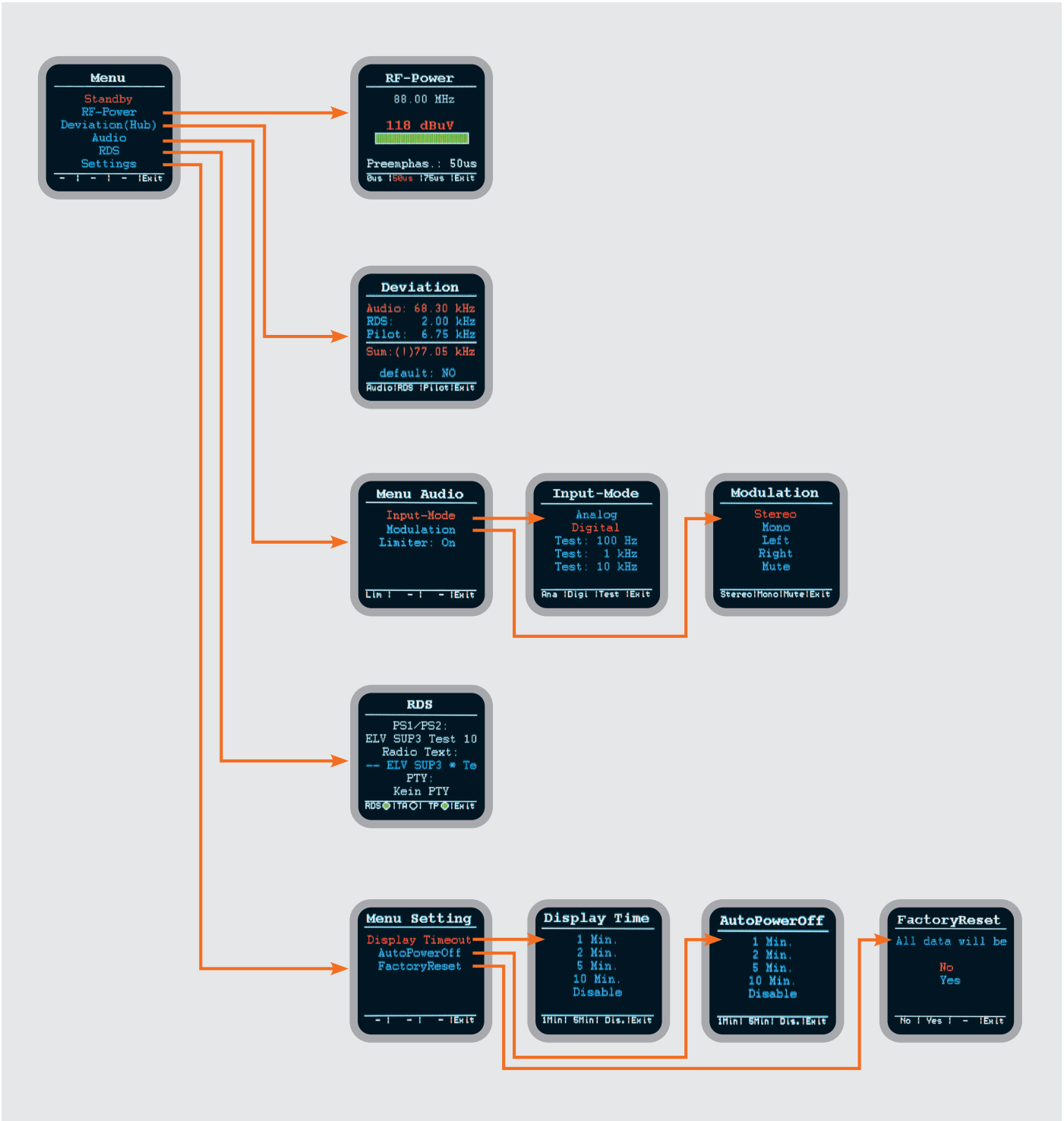


Figure 7: Menu diagram of SUP3

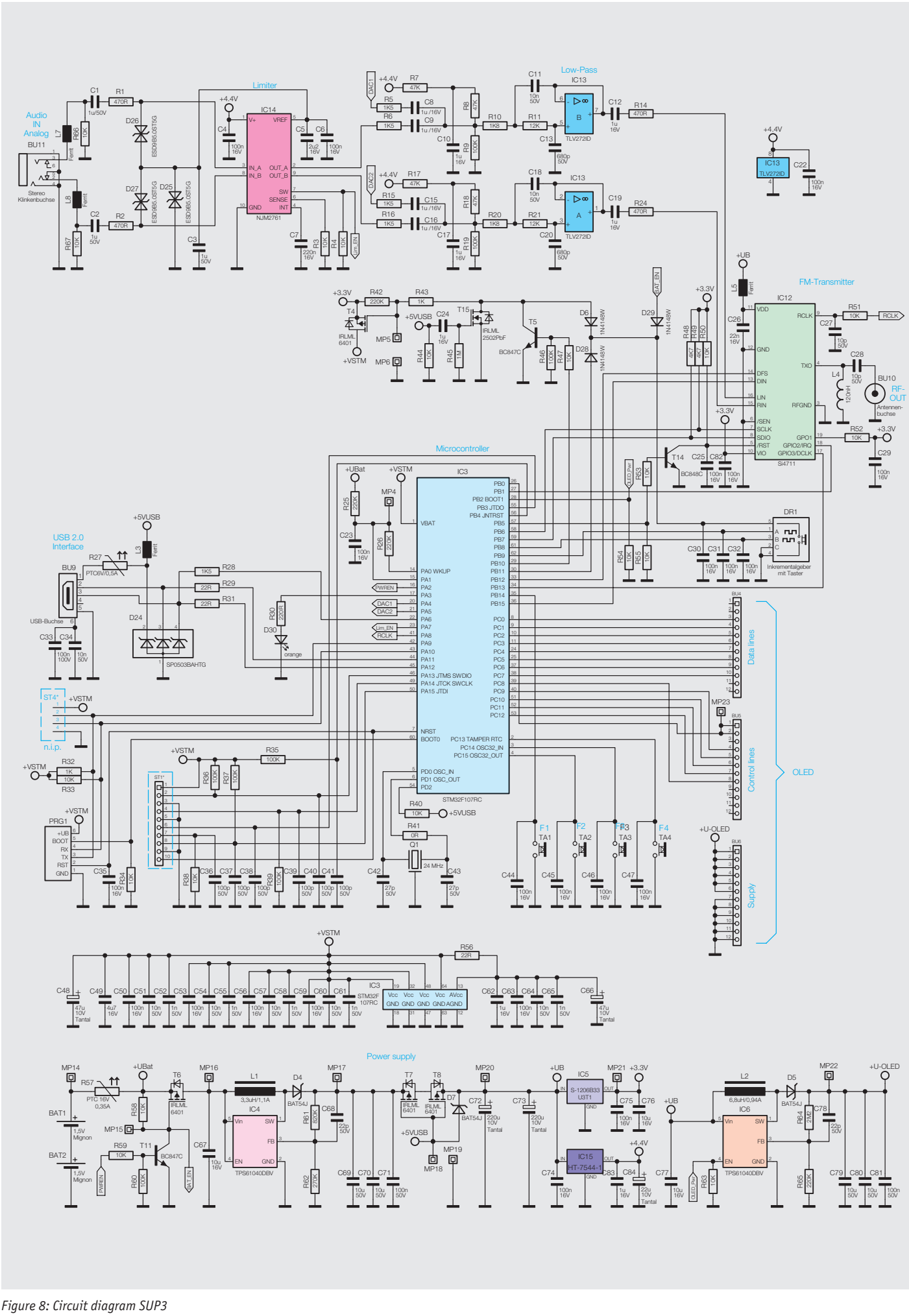


Figure 8: Circuit diagram SUP3

two amplifiers IC13A and IC13B. Audio frequencies above this cut-off frequency would be outside the specification for the FM signal and would negatively influence the frequency spectrum. The audio signal processed in this way now reaches the inputs (LIN and RIN) of the FM transmitter IC12 of type Si4711. This component contains all the components that are necessary to generate a standard FM signal. IC12 is a DSP (Digital Signal Processor) from Silicon Labs. The digital processing results in excellent technical data that cannot be realised with reasonable analogue circuit technology. The modulated RF signal is decoupled at the output TXO (pin 4) and reaches the output socket BU10 via the capacitor C28. The Si4711 can process both analogue and digital audio signals. We have just described the analogue signal path. The digital audio data is fed via the pins DFS (pin 14) and DIN (pin 13). Furthermore, the Si4711 can be controlled via an IC interface. The Si4711 is configured via the lines SCLK (pin 7) and SDIO (pin 8) with the help of the micro-controller IC3. Special registers are used to set the transmission frequency and the output level, for example.

The afore-mentioned micro-controller IC3 of the type STM 32F107RC, is the main control element of the switch control. With the help of the OLED display, the rotary encoder DR1 and the four function keys (TA1 to TA4), a convenient operating unit is created. The Si4711 is programmed via the IC bus according to the desired function. A special feature is the USB interface, which fulfils two functions: control, i.e. remote operation from a PC, and the transmission of digital audio data. When connected to a PC, an HID device and an external sound card are recognised. The SUP3 then works as a sound card, while at the same time being operated via USB. The audio data is converted by the micro-controller IC3 into a format required for the FM transmitter.

The USB interface is located at socket BU9. At the same time power can also be supplied via the USB interface. The 5 V supply voltage from the USB socket is fed to the circuit via the fusible resistor R27. The diode array D24 protects the data lines of the USB connection from overvoltage peaks.

Let's now take a look at the power supply, which is shown in the lower part of the diagram. The circuit can be powered either by two non-rechargeable batteries or by the USB port. To make effective use of the battery voltage, a step-up converter is used to generate a constant voltage of 5 V. This step-up converter is formed by IC4. The peripherals include the storage coil L1 and the diode D4. The output voltage is set with the voltage divider R61/R62. We do not want to explain the functioning of a switching regulator in detail here. The battery voltage is switched with transistor T6. In order to be able to switch the circuit on and off with the integrated push-button of the rotary encoder, there is a network of swit-

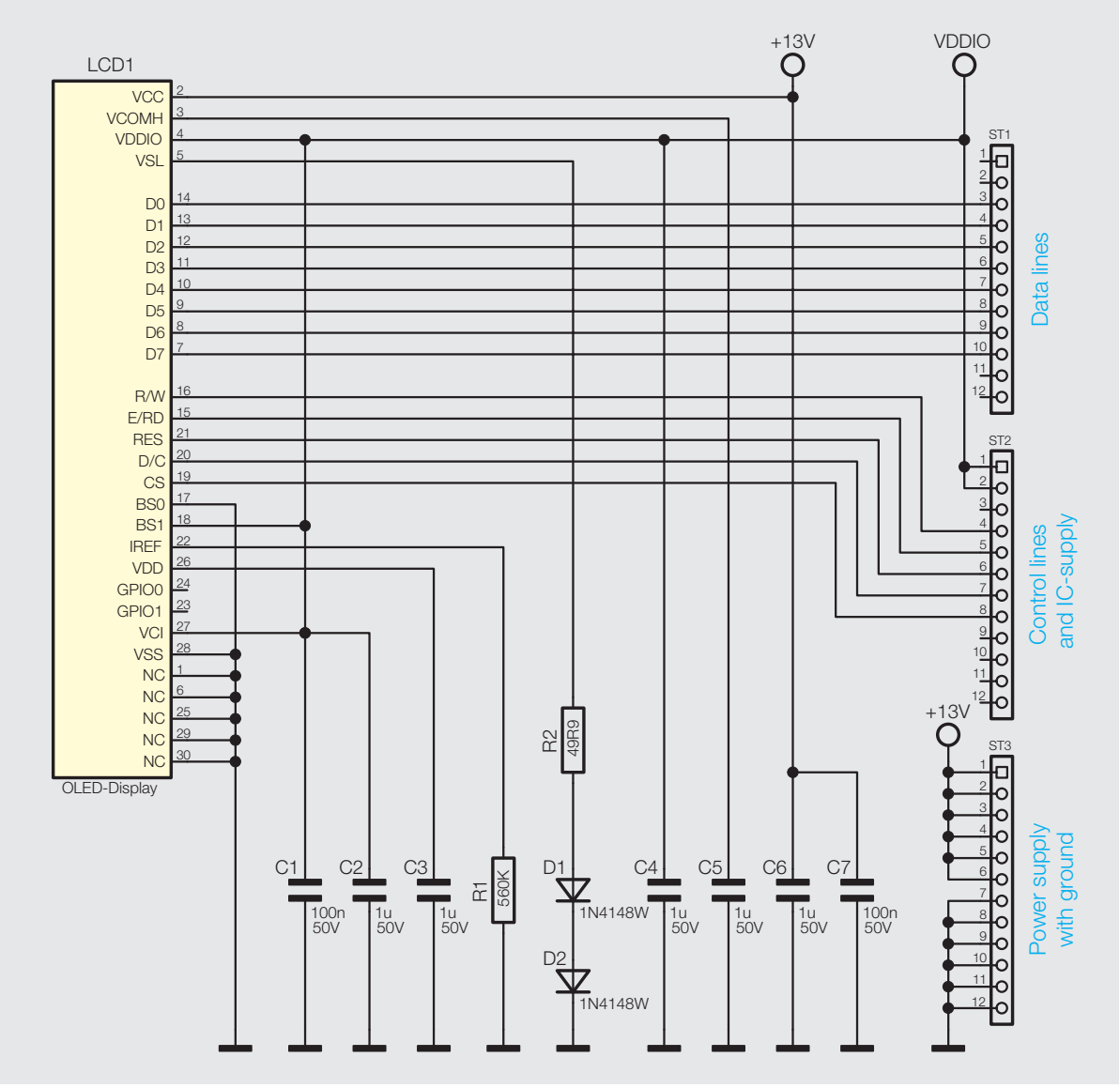


Figure 8A. Circuit diagram OLED-display

ching transistors, the function of which is not easy to recognise at first glance. When switched off, i. e. when transistor T6 is blocked, the battery voltage (+UBat) is applied to the button of rotary encoder DR1 via resistor R58 and diode D29. When the button is pressed, T6 becomes conductive and the controller is supplied with voltage. The controller then outputs a voltage at the „PWREN“ port, which puts transistor T11 into the conductive state. This activates a latch that switches transistor T6 through. Now let's look at the further voltage path from the output of the step-up converter. The two transistors T7 and T8 serve as switches to interrupt the voltage supply of the step-up converter when it is supplied via the USB connection. This happens automatically as soon as the voltage (+5VUSB) is applied to the gate of the two transistors. The 5V voltage thus comes either from the USB socket or from the step-up converter. The USB voltage always has the highest priority. The following voltage regulator IC5 generates a stable voltage of 3.3 V to supply the controller. The second voltage regulator IC15 provides a voltage of 4.4 V for the analogue input circuit. For the OLED display a voltage of 13 V is required. The voltage is generated with another step-up converter (IC6). The structure is similar to that of IC4 with the difference that the output voltage is higher here (13 V).

A colour OLED display is provided for visualisation. Via the BU4 to BU6, data and the required voltages of 3.3 and 13 V (U_{OLED}) are supplied. Figure 8a shows the circuit of the OLED display module. In addition to the 3.3 V for the display controller, which are supplied via pins 1 and 2 of the socket connector BU5, the OLED display requires an additional 13 V voltage for the panel. This „panel voltage“ is made available to the display via pins 1 to 6 of the socket connector BU6. On the display board there are only the components needed to operate the OLED and the three pins that connect to the base board.

Build

The circuit of the SUP3 is placed on a multilayer board with 4 layers. One inner layer contains a complete ground plane, which is the only way to avoid undesired interference.

The board is pre-assembled with SMD components so that only a few wired components have to be assembled. The wired components are assembled in the usual way using the parts list and the assembly plan, but the board photos shown (Fig. 9) also provide helpful additional information.

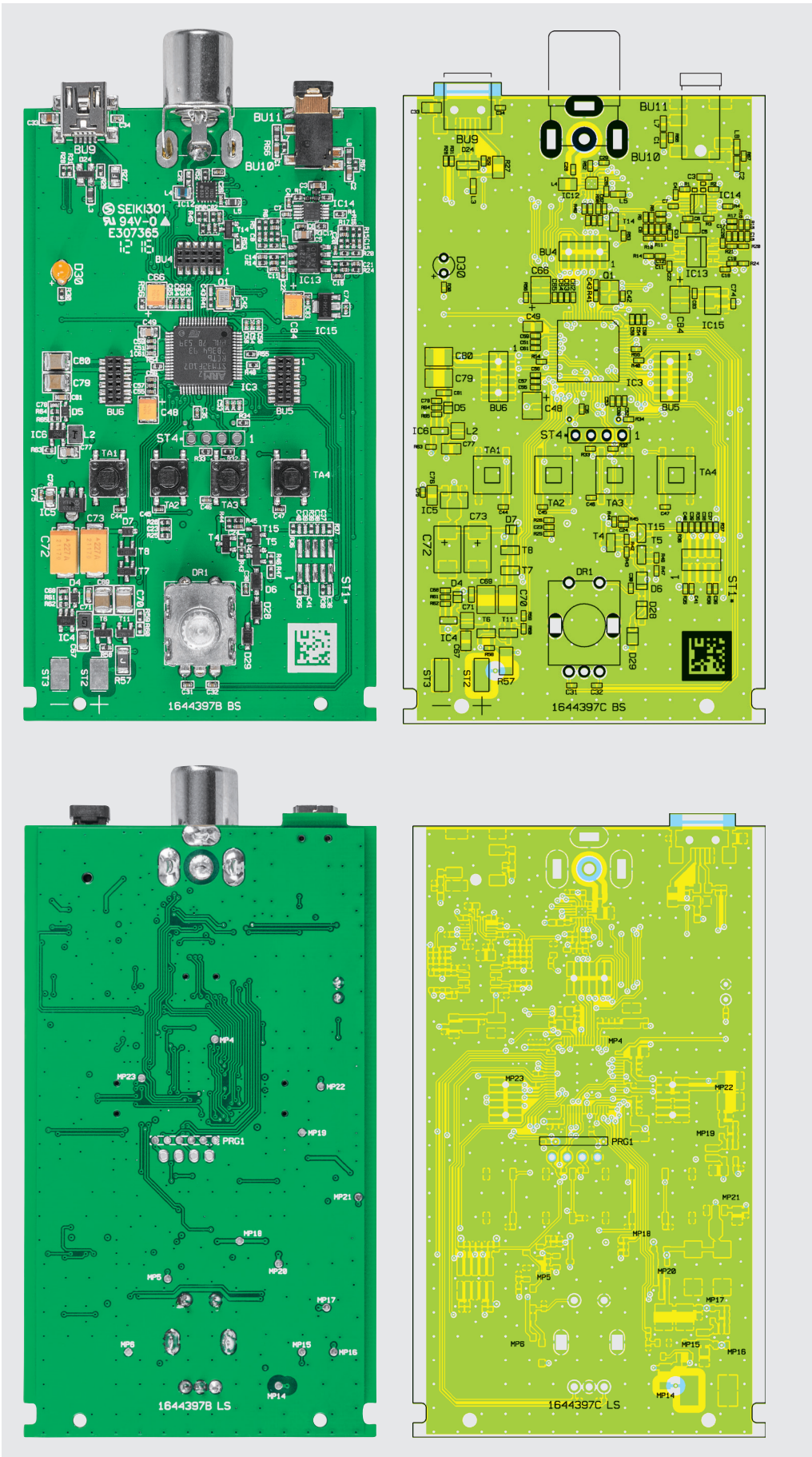


Figure 9: Board photos and placement information of SUP3 (Top/ Bottom)

We start the assembly work by inserting the socket BU10, which is inserted into the board from above and soldered to the underside of the board. The rotary encoder DR1 is then inserted and soldered in the same way.

Make sure that the socket lies flat on the board and is exactly aligned. Only then will the sockets fit through the recesses in the housing. All connecting wires of this and the following components must be shortened to a maximum length of about 3 mm, if necessary.

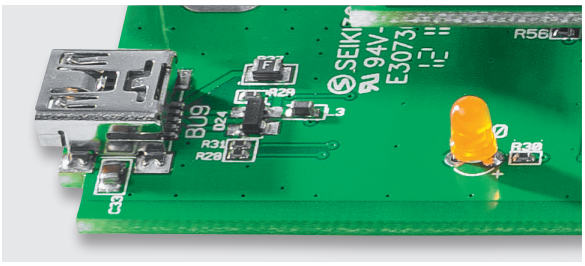
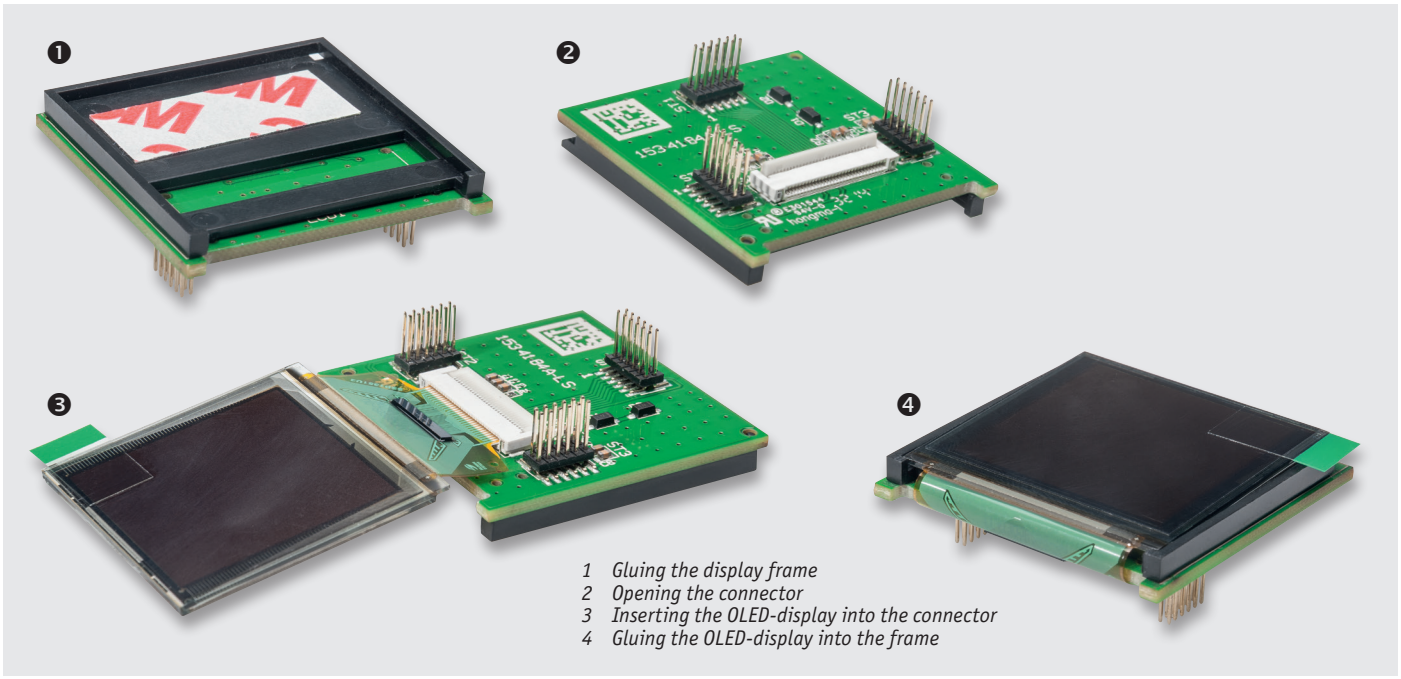


Figure 10: The LED is soldered directly and with no distance to the pcb

Next, the light emitting diode D30 is installed. Make sure that the polarity is correct. The slightly longer connection is the anode (+) of the LED. The anode connection is also marked „+“ on the PCB. The LED can rest directly on the PCB without any gap (see Fig. 10). This completes the assembly of the main board.

Now we come to the preparation of the display board. The individual steps are summarised in Fig. 11. Here, too, all SMD components are preassembled. The frame has some catches that fit into the corresponding openings of the display board to prevent it from being mounted incorrectly. This should be tested in advance, as it is very difficult to remove a sticky display frame afterwards. So that the display frame can be mounted on the display board, the protective film on the underside must first be removed and the frame must then be pressed onto the top of the module with the aid of the latching lugs.

The next step is to attach the actual OLED display to the frame. First, the contact connection on the underside of the module is opened by moving the small lever, which is then perpendicular to the board. Now the



1 *Gluing the display frame*
2 *Opening the connector*
3 *Inserting the OLED-display into the connector*
4 *Gluing the OLED-display into the frame*

Figure 11: The individual steps to build the OLED-display

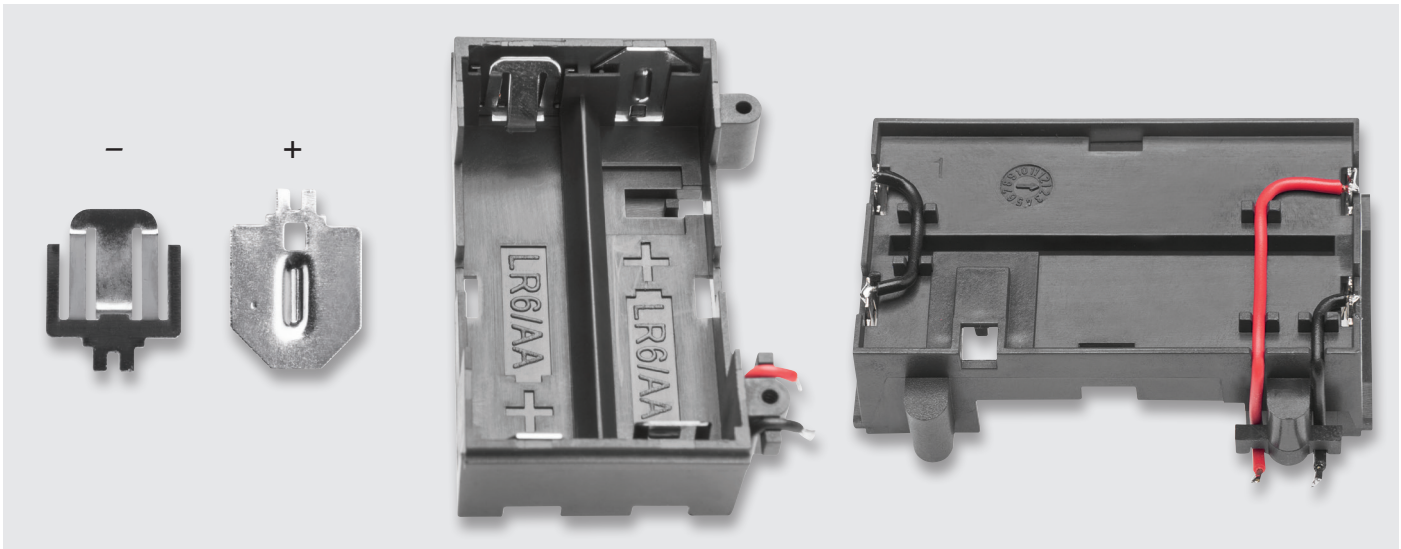


Figure 12: The battery holder ist to be equipped with the battery contacts and the connecting wires

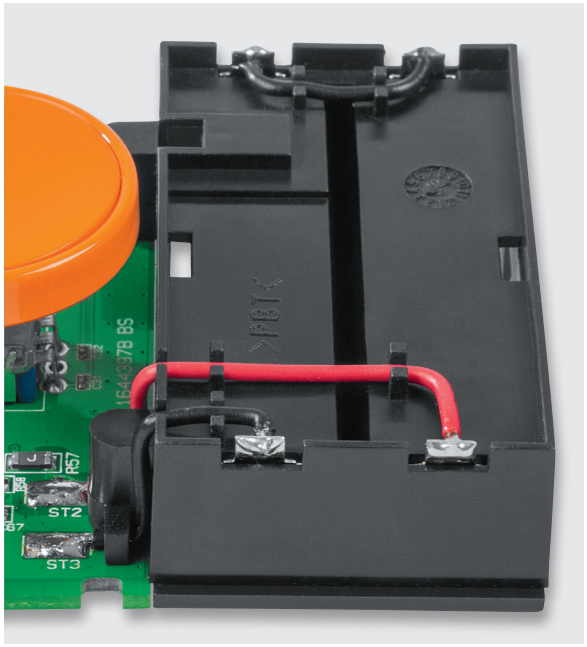


Figure 13: Detail of assembly and connections for mounting the battery compartment on the pcb

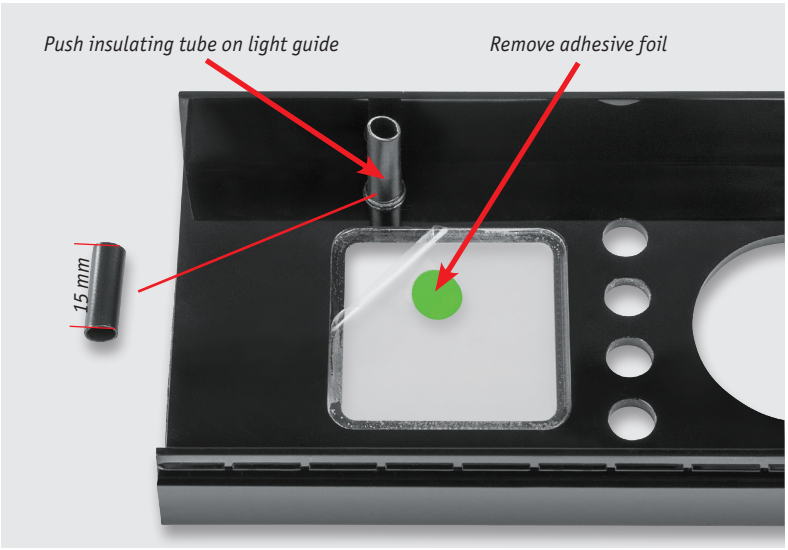


Figure 14: The insulating tube has to be pushed over the light guide to avoid any light scattering

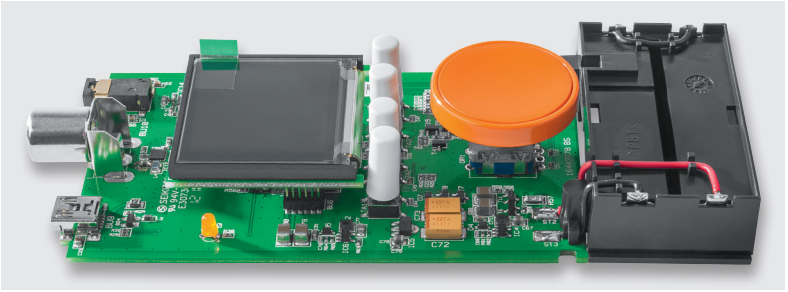


Figure 15: Fully assembled pcb of SUP3

contact foil of the display can be inserted into the connection and the lever pressed down again. In this step it is important to ensure that the display is not inserted the wrong way round. You can check the correct installation with the help of Fig. 11. Finally, the protective film of the second adhesive strip is removed and the glass body of the OLED is glued into the frame with light pressure.

After the display board has been assembled, it can be plugged onto the base board. Special care should be taken here, as the pin strips are very sensitive and can bend easily. Make sure that the pin strips are not plugged in at an offset, as this could lead to a malfunction or destruction of components during testing.

Next, the battery holder must be pre-assembled. To do this, insert the four battery contacts into the battery holder with the correct polarity (Fig. 12). Make sure that the contacts engage properly. As can be seen in Fig. 12 on the right, the contacts on the left-hand side must be bridged with the enclosed stranded wire. The two remaining free contacts are provided with the enclosed stranded wire, which is laid through the cable guides, as also shown in Fig. 12 on the right. Finally, screw the battery holder to the circuit board with the enclosed screws and solder the stranded wire to the solder pads S12 (+) and ST3 (-) provided (see Fig.13).

The light guide and display screen are already pre-assembled in the upper part of the housing. Here, only a piece of insulating tubing needs to be placed on the light guide (see Fig. 14). This prevents the light from the LED from shining into the display window from the side. The insulating tube must be shortened to a length of 15 mm. The display window is covered on both sides with a protective film that still has to be removed.

Before installing the housing, caps for the buttons and the rotary encoder must be fitted. The hand-wheel for the Rotary encoder consists of two individual parts that are simply plugged together. Fig. 15 shows the completed circuit board. Now the batteries can be inserted and the board can be placed in the bottom shell of the housing.

Finally, both halves of the housing are pushed together. Fig. 16 shows the unit ready for operation.

Figure 16: SUP3 Fully assembled and ready for operation

Important notice:

For the connection between the SUP3 and the test object a shielded cable with suitable connectors must be used, to prevent any unwanted and not permitted RF radiation.

More Informations:

[1] https://en.wikipedia.org/wiki/Emphasis_(telecommunications)

[2] https://en.wikipedia.org/wiki/Frequency_modulation

[3] https://en.wikipedia.org/wiki/Radio_Data_System

Parts list

Resistors:

0 Ω/SMD/0402	R41
22 Ω/SMD/0402	R29, R31, R56
220 Ω/SMD/0402	R30
470 Ω/SMD/0402	R1, R2, R14, R24
1 kΩ/SMD/0402	R32, R43
1,5 kΩ/SMD/0402	R5, R6, R15, R16, R28
1,8 kΩ/SMD/0402	R10, R20
4,7 kΩ/SMD/0402	R48, R49
10 kΩ/SMD/0402	R3, R4, R33, R34, R38, R40, R44, R47, R50–R55, R58, R59, R63, R66, R67
12 kΩ/SMD/0402	R11, R21
47 kΩ/SMD/0402	R7, R8, R17, R18,
100 kΩ/SMD/0402	R9, R19, R35–R37, R39, R46, R60
220 kΩ/SMD/0402	R25, R26, R42, R65
270 kΩ/SMD/0402	R62
820 kΩ/SMD/0402	R61
1 MΩ/SMD/0402	R45
2,2 MΩ/SMD/0402	R64
PTC/0,5 A/6 V/SMD/0805	R27
PTC/0,35 A/16 V/SMD/1206	R57

Capacitors:

10pF/SMD/0402	C28
10 pF/50 V/SMD/0402	C27
22 pF/50 V/SMD/0402	C68, C78
27 pF/50 V/SMD/0402	C42, C43
100 pF/50 V/SMD/0402	C36–C41
680 pF/50 V/SMD/0402	C13, C20
1 nF/50 V/SMD/0402	C52, C55, C58, C61, C65
10 nF/50 V/SMD/0402	C11, C18, C34, C51, C54, C57, C60, C64
22 nF/16 V/SMD/0402	C26
100 nF/16 V/SMD/0402	C4, C6, C22, C23, C25, C29–C32, C35, C44–C47, C50, C53, C56, C59, C63, C74, C75, C82
100 nF/50 V/SMD/0603	C71, C81
100 nF/100 V/SMD/0805	C33
220 nF/16 V/SMD/0402	C7
1 µF/16 V/SMD/0402	C10, C12, C15–C17, C8, C9, C19, C24, C62, C83
1 µF/50 V/SMD/0603	C1–C3
2,2 µF/16 V/SMD/0805	C5
4,7 µF/16 V/SMD/0805	C49
10 µF/16 V/SMD/0805	C67, C76, C77
10 µF/50 V/SMD/1210	C69, C70, C79, C80
22 µF/10 V	C84
47 µF/10 V	C48, C66
220 µF/10 V	C72, C73

Semiconductors:

ELV151488/SMD	IC3
TPS61040DBV/SMD/TI	IC4, IC6
S1206B33U3T1/SOT89-3	IC5
Si4711	IC12
TLV272ID/SOIC8	IC13
NJM2761RB2/SMD	IC14
HT7544-1/SMD	IC15
IRLML6401/SMD	T4, T6–T8
BC847C/SMD	T5, T11
BC848C/SMD	T14
IRLML2502PbF/SMD	T15
BAT54J/SMD	D4, D5, D7
1N4148W/SMD	D6, D28, D29
SP0503BAHTG/SMD	D24
ESD9B5.0ST5G/SMD	D25–D27
LED/3 mm/orange	D30

Other:

storage throttle, SMD, 3,3 µH/1,1 A	L1
storage throttle, SMD, 6,8 µH/0,94 A	L2
Chip-Ferrite, 300 Ω bei 100 MHz, 0603	L3
SMD-Inductivity, 120 nH/0805	L4
Chip-Ferrite, 1000 Ω bei 100 MHz, 0603	L5, L7, L8
Quarz, 24.000 MHz, SMD	Q1
Incremental encoder with axis and pushbutton switch, 20 pulses/360°, 20 (18°) steps, print, horizontal	DR1
Mini-Pushbutton TC-06106-075C, 1x on, SMD	TA1–TA4
Socket connector, 2x 6-pole, SMD	BU4–BU6
USB socket, Mini B, SMD	BU9
Coaxial connector, right angle jack, solder	BU10
Jack socket, 3,5 mm, 4-pin, SMD	BU11
PVC insulation hose, ø 3.5 mm, black	
OLED-Display module ODM1-8.8	
Male headers, 2x 6-pin, 8.8 mm, straight, pitch = 1.27 mm, SMD	ST1–ST3
Sliding housing SG2	
Handwheel, orange	
4 key caps	
Battery holder for sliding housing SG2	
Minus battery contacts	
Plus battery contacts	
2 thread-forming screws, 1,8 x 8 mm, T6	
4 housing feet, 5 x 1,6 mm, self-adhesive, white	
8 cm flexible cable, 0,22 mm², red	
8 cm flexible cable, 0,22 mm², black	

Translation by: M. Caldeira, of "Electronics Old and New by M Caldeira", January 2021