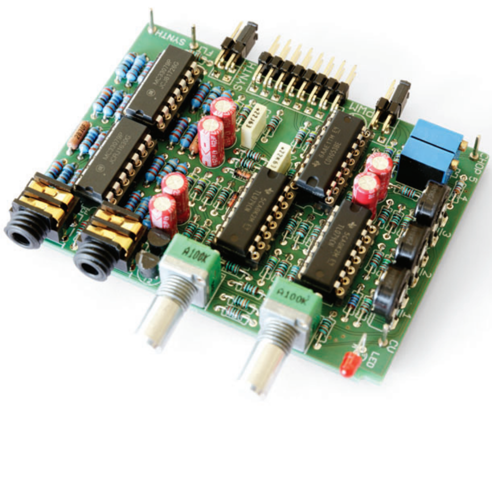
# — VoIS —

## An 18-Channel Analog Stereo Vocoder and Formant System

### Assembly and Tuning Guide

## READ THIS FIRST!
## DISCLAIMER

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Your comments are welcome. If you have suggestions or believe something requires to be corrected, please contact the author at `vocoder@hoerold.com`.

# Contents

# 1 Expected Level of Experience

This assembly guide is a step–by–step description for building the VoIS, an 18-Channel Analog Stereo Vocoder and Formant System. It is targeted at the ambitious electronics enthusiast as an advanced do–it–yourself project.

Building the vocoder requires a high level of experience. Read through the entire document and familiarize yourself with the bill of materials before deciding whether you really want to tackle this project. Building this vocoder requires dedication and many hours of work. You should not proceed if you have little or no experience with this type of do–it–yourself electronics project. However, If you decide to go ahead, I have high confidence you will be proud of your accomplishment. Have fun and enjoy this project.

# 2 Test Equipment, Custom Tools, and Recommended Tools for Assembly

The following test and calibration equipment is required:

- **Oscilloscope**
- **Multimeter**
- **A sine wave signal generator** with a frequency range from ~100 Hz to ~8 kHz.
- **A tuner** for the 1 V/Oct. calibration of the internal excitation boards.

Instead of a stand–alone sine wave signal generator, a function generator app for a smartphone or tablet device can be used, too. A version that is available free of charge is sufficient. Using an online tone generator to send a sine wave through a computer's sound card will work as well. Generally, the quality of the sine wave is not critical. There is no need for low THD or any particular signal fidelity. However, fine control over the frequency for testing and calibrating the 18 channel filter boards is needed.

As a tuner, a smartphone app that is free of charge is sufficient.

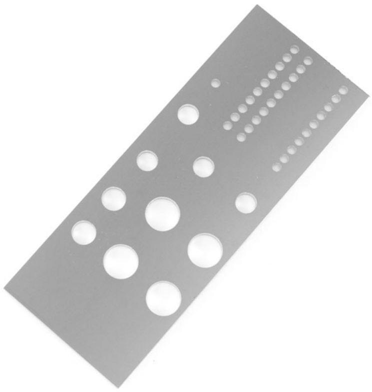
Note that a bench power supply is not required for this project. The first PCB to be built is the power supply board. Once assembled, it will be used throughout the remainder of this project to power the other boards during testing and calibration.

There are two custom tools available for assembly purposes (Fig. 1):

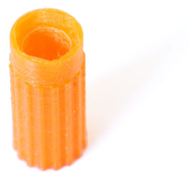
- A **metal template** for easier assembly of the preamplifier boards and the 18 channel filter boards (alignment of jacks, potentiometers, and LEDs)
- A **custom socket** for the tightening of the potentiometers. This socket is only required for the front panel that has cavities for recessed nuts

Furthermore the following equipment and tools are needed:

- **A temperature controlled soldering station** with a soldering tip that is fine enough for soldering SMD capacitors of sizes 0805 and 1206
- **Soldering wire, ⌀ 0.5 mm.** Use solder wire with silver content, such as Sn95Ag4Cu1, for ease of solderability
- **Safety goggles** for protecting your eyes during soldering, cutting wires, etc.
- **Precision side cutters** for pinching off component leads



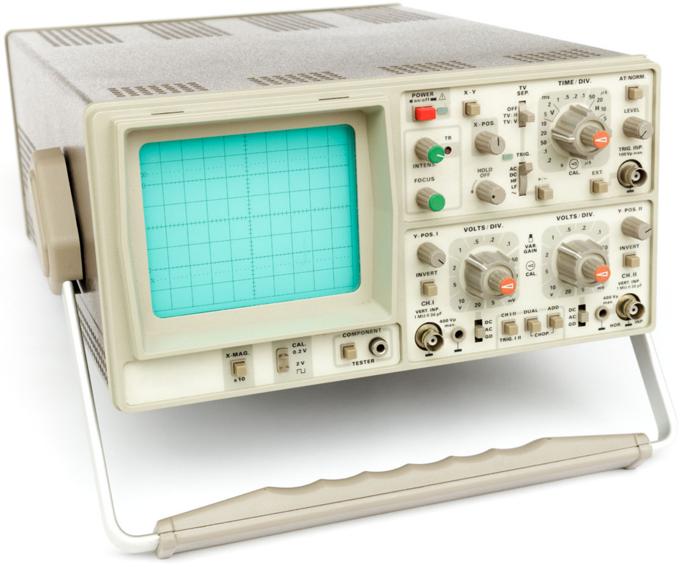
*Metal template*



*3D–printed socket*

Fig. 1: *Custom tools for easier assembly.*

- **Needle–nose pliers**
- **A lead forming tool** for bending resistor and diode leads accurately for the given lead spacing of 7.62 mm (0.3 in)
- **An anti–static wrist strap** and an **ESD mat** for handling ESD–sensitive devices
- **Test leads with small crocodile clips**
- **An adjustable wire stripper** for stripping wires between size AWG20 and AWG30 (e.g. C.K Tools 330013)
- **Sockets:**
  - 10 mm socket for the potentiometers, unless the front panel with cavities was supplied
  - 11 mm socket for the 3.5 mm jacks (CL13845G)
  - 14 mm socket for the 6.35 mm jacks (ACJS-MHDR)
- **Desoldering wick**
- **An assortment of small flat–head and Phillips–head screwdrivers** for calibration purposes, enclosure assembly, tightening knobs, etc.
- **A try square** for ensuring that the boards are perpendicular to the front panel during the soldering of the potentiometers and the jacks
- **Magnifier** to check the solder joints, particularly around the SMD capacitors and the transistors
- **Pincers** for SMD soldering. With a tightened rubber band around the pincers, the SMD components can be pressed onto the board so that you have both hands available for soldering.

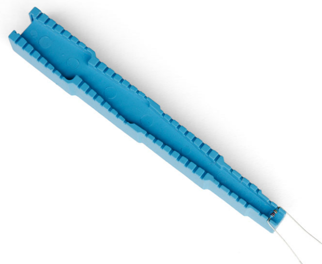


*Oscilloscope*

*Soldering station*

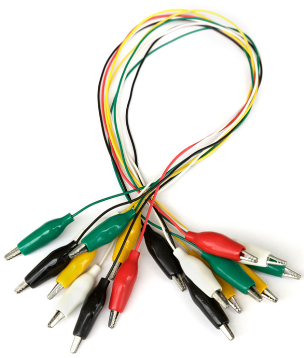
*Digital multimeter*

*Pliers and side cutter*



*Lead forming tool*

*Adjustable wire stripper*



*Test leads with crocodile clips*

*Anti–static wrist strap*

Fig. 2: *Test equipment and assembly tools.*

# 3 General Information and Instructions

## 3.1 Text Style Convention

The following stylistic elements are used throughout this document:

- Designators found in schematics are shown as R1, IC1, C1.
- Test pins found on the PCBs are set apart like GND, CV.
- Product names are accentuated like TL074, LM13700.
- The potentiometers as marked on the front panel are underlined, e.g. Osc. Level.
- Cables found in the table in Section 20 are emphasized in a brownish color like cable #1.

If you read this document in an appropriate document reader, clickable links are marked by text in blue, like shown in the table of contents.

## 3.2 Soldering

Many electronics do–it–yourself projects are hard to debug because poor soldering practices cause intermittently working gear or results that fail to work entirely. It is expected that you are highly skilled in the art of soldering. Do not rush the soldering job. This project is not about winning a race. Stop at the onset of fatigue and take breaks.

Remember:

- Do not overheat components or keep them heated up for too long. This is particularly important for LEDs as the plastic lenses tend to soften up quickly.
- The insertion of components with polarity or specific orientation (such as transistors) into the boards should be checked twice or more before soldering.
- Always be sure to insert the components into the correct locations. Desoldering is a major effort, especially when board space is tight. It takes considerable time and effort, and may lead to a less professional looking board.
  - The resistors, if size 0207, are particularly hard to desolder because they are often placed in densely populated areas, yet they are typically the easiest to be inserted in the wrong places.
  - Always use a multimeter to confirm that the correct resistor has been selected before soldering it into the board. This is particularly important for the E48 resistors used on the 18 channel filter boards.
  - If you want to be perfectionist, orient the resistors all in the same direction so that the ring codes can be read from left to right (or top to bottom). This is a good habit to establish and it will pay off once a board needs to be troubleshooted. Similarly, you may want to insert the film capacitors in such way that the printed texts for the capacitor values are all oriented the same way.

## 3.3 Test and Calibration

For all the test and calibration procedures, dedicated test pins are placed on the boards.

For convenience, have a set of test leads with small crocodile clips handy. Over time, the braided wiring tends to break at the clips, so make sure the test leads are all in good order to avoid intermittent, false or no reading at all during testing and calibration.

Due to tight board space, test pins are often placed close to each other. Pay attention when connecting the oscilloscope's ground connection and the probe to prevent shorts.

There is no need for special calibration tools. All trimmers can be adjusted using a conventional screwdriver.

## 3.4 Component Insertion Sequence

When soldering the components into the boards, start out with the flattest components and continue with increasing height above the board:

1. SMD capacitors
2. Diodes
3. Resistors
4. IC sockets
5. Transistors
6. Solder pins
7. Film capacitors
8. Electrolytic capacitors
9. Jacks, potentiometers and other peripherals

## 3.5 Polarity Checks

- Always double and triple check that the electrolytic capacitors have been soldered with proper orientation.
- The same goes for the diodes, the LEDs (the side with the flat spot is the cathode) and the transistors.
- Solder the IC sockets properly oriented into their designated locations.
- Later, when putting the ICs into the sockets, be certain to insert them correctly by observing the right orientation and preventing shifted placement. Insert the ICs completely into the sockets and check for bent pins.

## 3.6 ESD Considerations

Do not touch IC or JFET pins. Familiarize yourself with the proper use of an anti–static wrist strap connected to an ESD mat to ensure that ESD–sensitive devices do not get partially or fully damaged by electrostatic discharge. Partially damaged devices could work for a while but eventually may start malfunctioning unexpectedly or work intermittently. The LEDs or the BJTs (2N3904 and 2N3906) do not need this special handling.

## 3.7 Cable Color Coding

The following color coding is suggested for cable assembly:

- For the 3-wire power cables, use
  - **black** for ground
  - **red** for +12 V
  - **yellow** for −12 V
- For any other cables, use other colors than red, black and yellow to avoid a mix–up unless a wire is either ground, +12 V or −12 V.

## 3.8 Early Supply Short Circuit Check

Before inserting the ICs, the boards should be powered up for a voltage check. This will help detecting early if there is a short among the board supply wiring.

Many parts of the design with distinct functionality are isolated from each other via 47 Ω resistors accompanied by corresponding electrolytic capacitors, usually 47 µF. If there is a supply short on a board, a corresponding resistor will probably warm up, start to smell and eventually release smoke because there is about 3 W of power being dissipated.

With no ICs inserted, the multimeter should always read about ±12 V at the corresponding IC socket pins for the IC supplies, such as pins 4 and 11 of a `TL074` operational amplifier. One way is to verify the voltage between pins 4 and 11 which should read about 24 V but it is more prudent to check each pin individually against the GND test pin available on each board.

# 4 Cable Assembly

As you incrementally build the boards, you will also need to establish board–to–board connections for testing and calibration purposes. Refer to the table in Section 20 to identify the required cables, their suggested lengths, and whether they need to be shielded.

The cables can be built as and when they are required during the course of this project. Once a cable is needed, it is referred to by its cable number, like in a statement such as cable #1.

## 4.1 Power Cables

For the power cabling, use stranded AWG23 or AWG22 wires. Fig. 4 on page 13 illustrates the assembly procedure for a power cable with focus on the wire–to–terminal connection and insertion into the connector housing.

CAUTION: it is absolutely critical that you pay special attention to the order in which you insert the terminals into the connector housing. If the polarity of the supply to a board is reversed, it will lead to a disaster as it will destroy all ICs and electrolytic capacitors on that PCB! This is particularly disastrous if connected to the output board as the 18 channel filter boards are supplied by the output board via the ribbon cable!

Fig. 3: *Vocoder power distribution cable.*

With the connectors placed as shown in Fig. 3 (terminal openings at the bottom),

- +12 V is always on the left side (red wire),
- ground is always in the middle (black wire), and
- −12 V is always on the right side (yellow wire).

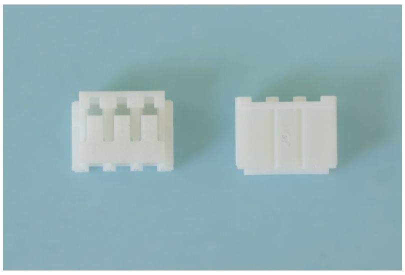
In general, for a clean looking vocoder interior, braid the wires.

## 4.2 Unshielded Cables

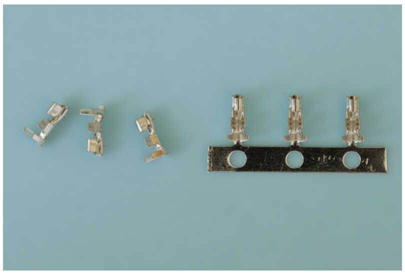
For the unshielded signal cabling, use stranded wires in the range of AWG26 to AWG24. Follow the same assembly procedure as illustrated in Fig. 4 on page 13.

## 4.3 Shielded Cables

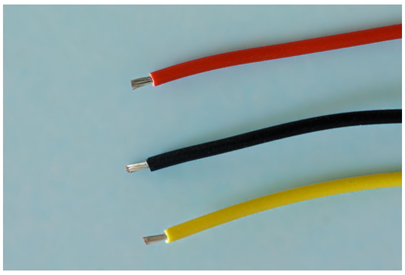
For shielded cabling, use a thin, flexible coax cable. The shield has to be connected to ground on both cable ends to ensure the shortest return path for the signal current. Fig. 5 on page 14 illustrates the assembly procedure for a shielded cable.



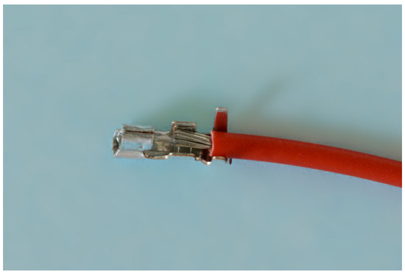
*This is the top side (shown on the left) and the bottom side (shown on the right) of an* EHR-3 *connector housing.*



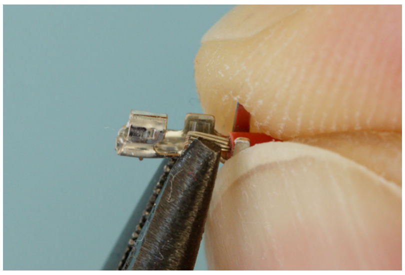
STEP 1: *Snap the terminals* SEH-001T-P0.6 *off the strip (shown on the right) with a side cutter.*



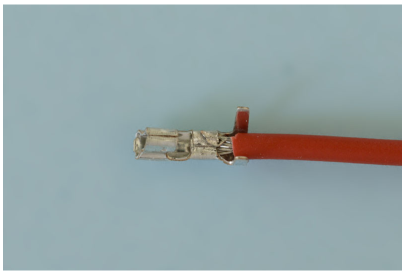
STEP 2: *Prepare the wires and dismantle them for a length of about 2 mm.*



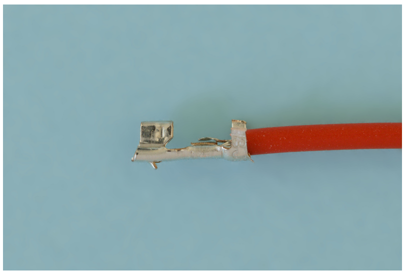
STEP 3: *Insert the wire as shown. The middle wings will later cover the bare wire, the wings on the right will later be squeezed onto the insulation.*



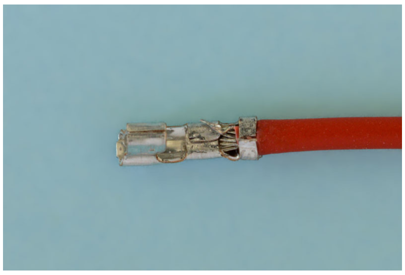
STEP 4: *Take needle–nose pliers and bend one of the two middle wings tight over the bare wire. Repeat the same with the opposite middle wing.*



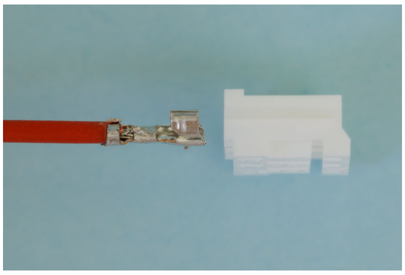
*The two middle wings clenching the wire. The wings on the right need to be shortened.*



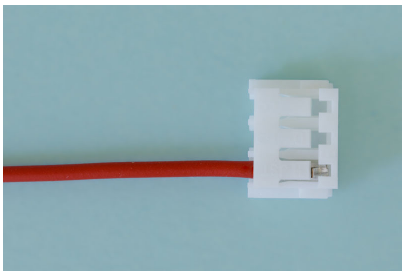
*The same cable turned 90°for a side view.* STEP 5: *Shorten the wings on the right to a length as shown here.*



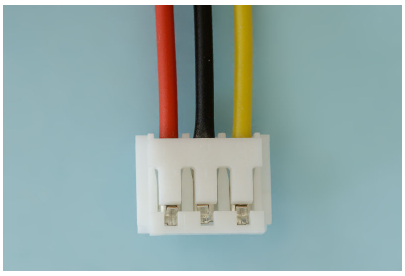
STEP 6: *Like in* STEP 4, *bend the right wings over the insulation to get the result as shown in this picture.*



STEP 7: *Orient the wire as shown here. There is a tiny hook on the bottom of the terminal that will prevent the cable from coming loose once inserted in the connector housing.*

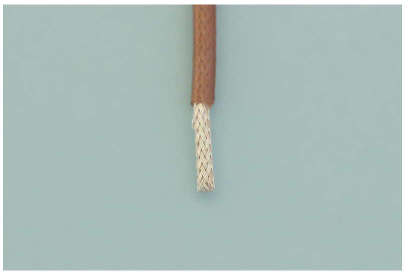


STEP 8: *Insert the cable. Notice the tiny hook keeping hold of the wire inside the connector housing.*



*The final power cable. The way this connector is oriented, +12 V is always on the left, ground is in the middle, and −12 V is on the right.*

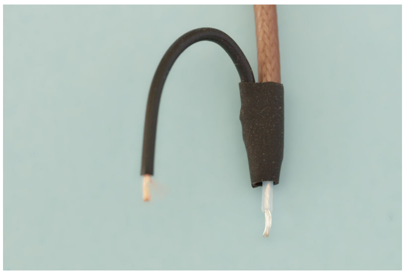
Fig. 4: *Assembly procedure for an unshielded cable, building a power cable as an example.*



STEP 1: *Strip off the outer mantle by 7 mm.*

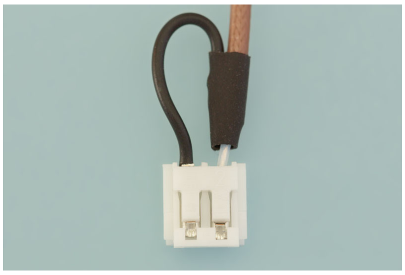
STEP 2: *Strip down the shield to lay bare the second mantle. Pinch off about half to two thirds of the shield, twist it and shorten it. Strip off the inner mantle by 2 mm.*

STEP 3: *Solder a 2.5 cm long black wire, sized about AWG26 to AWG24, onto the shielding.*



STEP 4: *Put shrink tubing around the bare shielding and heat it up so that it sits tight on the cable.*

f STEP 5: *Put on the terminals as described in Steps 3 to 6 in Fig. 4.*



STEP 6: *Insert the terminals into the connector housing as described in Steps 7 and 8 in Fig. 4. The way this connector is oriented, the black ground wire is always on the left side for all shielded cables.*

Fig. 5: *Assembly procedure for a shielded cable.*

### 4.4 Ribbon Cable Assembly

Before assembling the channel filter boards, the 16-wire ribbon cable needs to be prepared in order to allow the connection of the filter boards to the output board. You can choose to do this now or anytime before testing and calibrating the first channel filter board described in Section 11.2.

Accuracy and a clean workflow are important to avoid the ribbon cable applying sideways force when later installed onto the 18 channel filter boards. 18 connectors are placed at a pitch of 17 mm. The pitch between the 18th and the 19th connector is 45 mm.

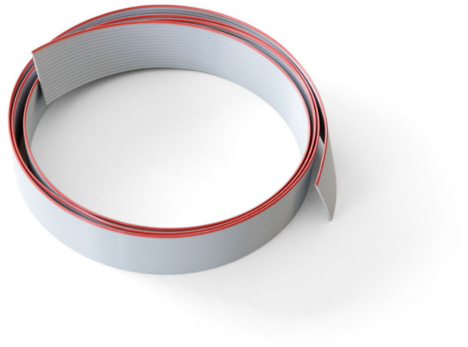


Fig. 6: *16-wire ribbon cable.*

In the first step, lines need to be drawn to mark the cable as shown in Fig. 9. Use a try square to draw the lines perpendicular to the cable's edge. Use a ruler and start out drawing the first line at 0 mm (the reference line), the second line at 17 mm, the third line at 34 mm, and so on. Do **not** measure 17 mm going from line to line as otherwise you will likely end up with a skewed cable assembly that you will not be able to use. In other words, always use the first line as a reference for all other lines. Do **not** start measuring in a relative manner by going successively from line to line. Use the following pitch table as a reference:

reference line
↓

| line 1 | line 2 | line 3 | line 4 | line 5 | line 6 | line 7 | line 8 | line 9 | line 10 | line 11 | line 12 | line 13 | line 14 | line 15 | line 16 | line 17 | line 18 | line 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 mm | 17 mm | 34 mm | 51 mm | 68 mm | 85 mm | 102 mm | 119 mm | 136 mm | 153 mm | 170 mm | 187 mm | 204 mm | 221 mm | 238 mm | 255 mm | 272 mm | 289 mm | 334 mm |

Next, install the wire–to–board connectors one by one to build the cable assembly as shown in Fig. 10. Align one of the connector's edges with the corresponding marker. While it is not crucial, all connectors should be oriented with their notches the same way. Place the connector along the marker so it is placed perpendicular to the cable's edge. To squeeze the head of each connector onto its receptacle, place the receptacle onto a flat surface and press the head down evenly. The clamps on the side easily break off if you press the head down slanted. For best control over the pressure applied on the head, use something like a small wooden block like shown in Fig. 8. Press down the head firmly until you hear a faint click. That way you know the clamps have locked onto the receptacle. Note that there is no need to install the strain relief.

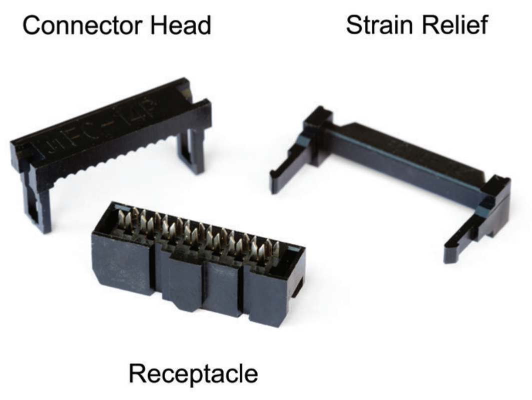



Fig. 7: *A 16-pin header taken apart. The two clamps on either end of the connector head easily break off if not carefully inserted into the receptacle.*

Fig. 8: *Apply pressure evenly on each wire–to–board connector.*

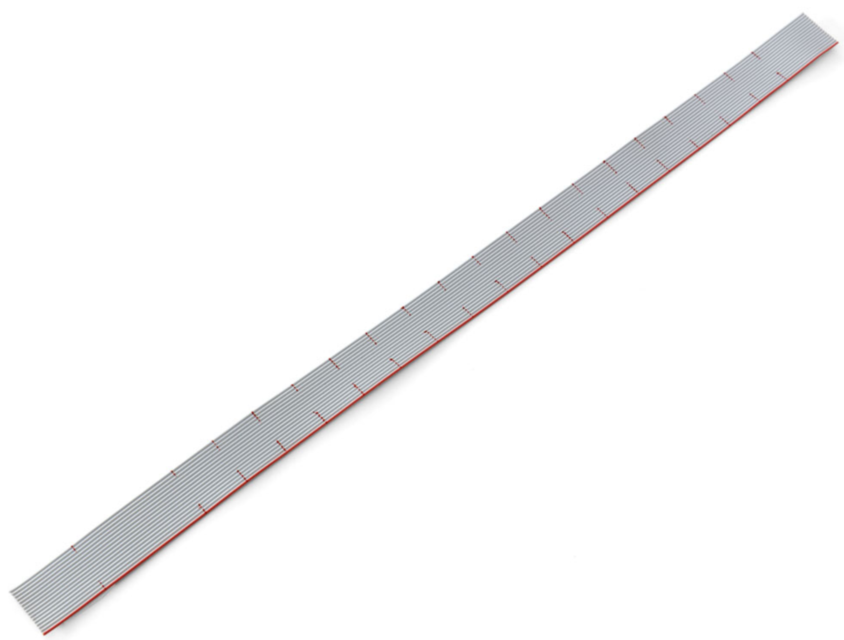


Fig. 9: *Ribbon cable marked with red lines for the placement of the wire–to–board connectors.*

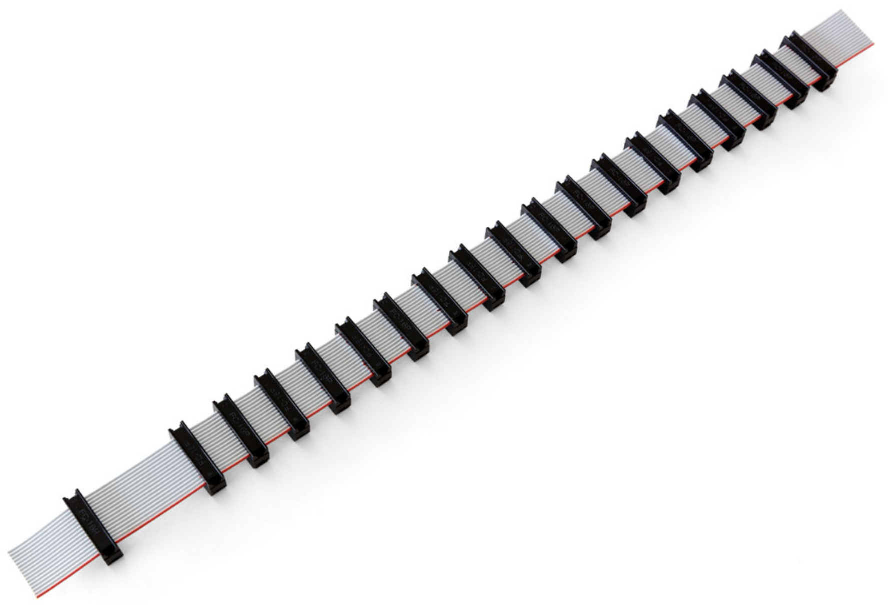


Fig. 10: *Final ribbon cable assembly.*

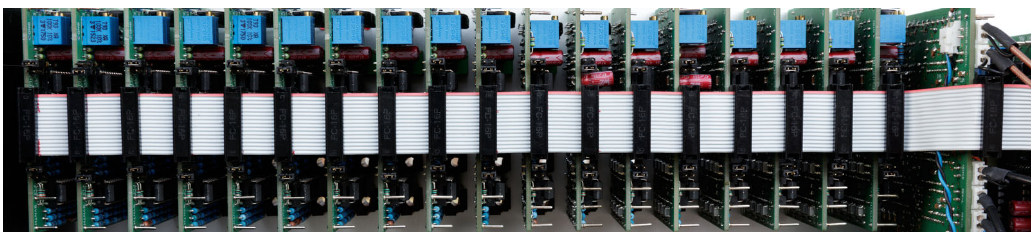


Fig. 11: *Installation of the ribbon cable on all assembled channel filter boards. The output board sits on the right.*

## 4.5 Front Panel LED Assembly

At various stages during the vocoder build, LEDs have to be installed on the front panel. See Fig. 12 for an example of an LED assembly. To prepare for the insertion into the front panel, follow these guidelines:

- When facing the sockets as shown in Fig. 13, always connect the anode with the left entry.
- Shorten the leads of the LED to about 7.5 mm (0.3 in). Do not forget which lead is the anode.
- Solder wires in the range of AWG26 to AWG24 onto the leads. Be careful not to overheat the leads as the plastic lens of an LED will soften up quickly and become useless.
- Use shrink tubing (about 1.5 mm unshrunk) to isolate the soldered leads and to prevent shorts.
- When inserting an LED into the front panel use hot glue or superglue to attach the LED in the panel. Use superglue sparingly to prevent it from creeping to the facing side of the panel.

Fig. 12: *Front panel LED assembly, on the right with the shrink tubing added.*

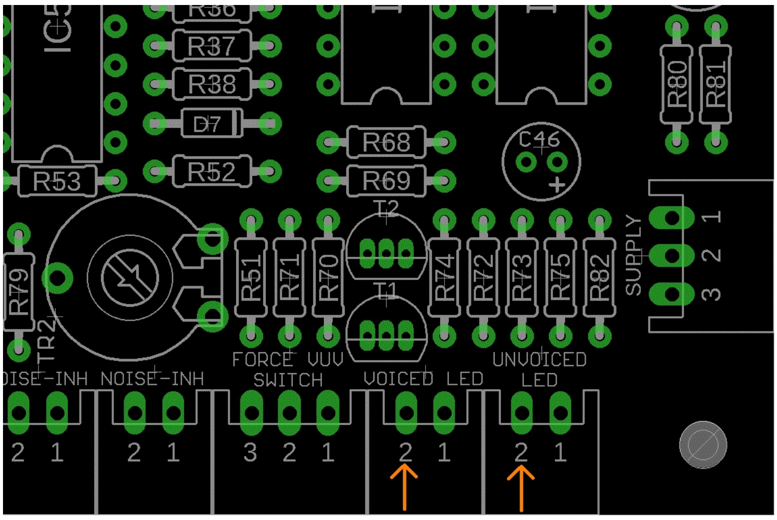



Fig. 13: *Always connect the LED anode with the left socket entry as shown here on the voiced/unvoiced detector board.*

## 4.6 Front Panel Switch Assembly

At various stages during the vocoder build, switches will be installed on the front panel. See Fig. 14 for a sample of a switch assembly, prepared for the insertion into the front panel. Follow these guidelines:

- Solder wires in the range of AWG26 to AWG24 onto the leads. Be careful not to overheat the leads as they will come loose otherwise.
- Use shrink tubing (about 5 mm unshrunk) to isolate the leads of the switch.
- All switches are active on, except for the attack switch. That means to turn on a functionality, the corresponding wires have to be interconnected. For a mono/stereo switch, mono corresponds to active on.
- When inserting a switch into the front panel, remember that it interconnects the leads on the opposite side. In the switch setting shown in Fig. 14, the two cables are bridged. Consequently, if the other side was depressed, the cables would no more be interconnected. Remember that when inserting the switch into the panel.

Fig. 14: *Front panel switch assembly. Unlike shown here, you should also isolate the unused lead. If a cable ever comes loose somewhere in the build, it helps avoid inadvertent contact to an unused lead.*

# 5 Vocoder Build Sequence

The vocoder is built step by step in the following order:

1. Power supply (Section 7)
2. Voice preamplifier (Section 8)
3. Carrier preamplifier (Section 9)
4. Output, PWM and silence bridging (Section 10)
5. 18 channel filter (Section 11)
6. Left nn (Section 12)
7. Right internal excitation (Section 13)
8. Voiced/unvoiced (V/UV) detector (Section 14)
9. Slew/freeze (Section 15)
10. Back panel mounting (Section 16)
11. Remaining vocoder calibration and fine–tuning (Section 17)
12. Final Assembly (Section 18)

The sequence above allows incremental testing and calibration of the individual boards. For this purpose, the power supply board is built first so that all the subsequent boards can be powered up. Once you arrive at assembling the first of the 18 channel filter boards, the main functionality of the vocoder can already be checked. As you progress building the remaining channel filters, the vocoding results become incrementally more intelligible. After all filters are finished, the focus is on the internal excitation boards. They are required for supplying the noise to the subsequently built V/UV detector. The slew/freeze board completes the feature set of the vocoder. The project concludes with the back panel mounting, the calibration of the remaining features and fine–tuning, and finalizing the assembly.

# 6 Initial Vocoder Enclosure Setup

Before starting to build the first board, mount the front panel onto the two side panels of the enclosure and add the bottom plate. This is a stable framework for incremental board assembly, calibration and testing. As the PCB's are successively built in the upcoming sections, the boards are mounted onto the front panel. The power supply board is an exception because even though it is built first, it will not be mounted until all other boards are in place.

# 7 Power Supply

## 7.1 Board Assembly

Start out with soldering the power MOSFETs (`IC1`) and then follow the component order shown in Section 3.4. Check the solder quality around `IC1` and the transistors using a magnifier to make sure that the leads are properly soldered and that there are no shorts. There are capacitors to be placed on both sides of the PCB.

The DC/DC converter module is to be placed on the backside of the PCB. This allows screwing the board onto the back plane with the module touching the metal for cooling purposes.

Do not forget to insert an 8 A fuse into the fuse holder.

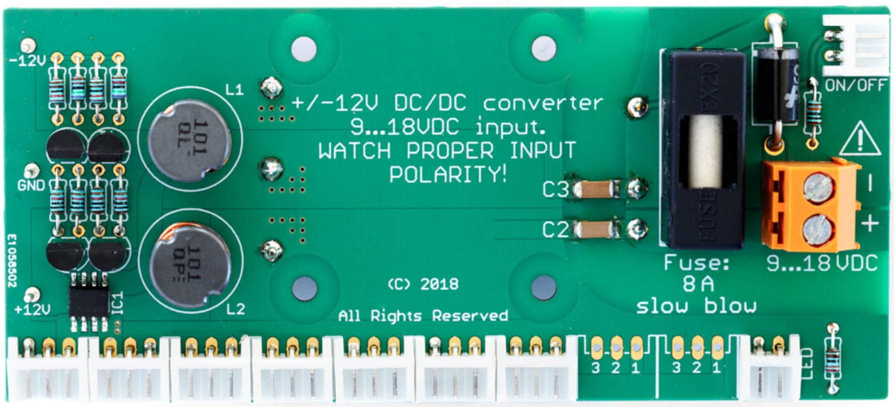



Fig. 15: *Power supply viewed from the top. Some parts are soldered from the other side, e.g. the DC/DC converter module.*

## 7.2 Connection to External Power Supply

The connection to an external power supply is done via a 2.1 × 5.5 mm power jack that is later to be inserted into the back panel (Fig. 16).

Following the color coding as described in Section 3.7, prepare a red and a black cable sized about AWG20, each about 25 cm (10 in) long. This will be the cable configuration for the power supply setup until later when the wires will be shortened during the back panel mounting procedure (Section 16).

Though there is a diode built into the power supply, avoid reversing the polarity:

- Solder the red and black wires onto the correct lugs. To determine the polarity, plug the external power supply into the power jack, connect the external power supply to the mains and use a multimeter to find out which of the two lugs is +12 V and which one is ground. If you use the suggested power jack, the shorter lug should be +12 V, the longer one should be ground. Use properly sized shrink tubing to cover the exposed lugs in order to reduce the risk of a power short.

- Next, the cables will be connected to the power supply board. Desolder the wire ends for about 3 mm and screw the red cable into the plus terminal and the black cable into the minus terminal of the power terminal block. Both the plus (+) and the minus (–) signs are clearly marked on the power supply PCB (Fig. 17).

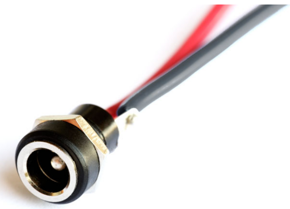


Fig. 16: *Isolated 2.1 × 5.5 mm power jack with cables soldered to the lugs (no shrink tubing).*

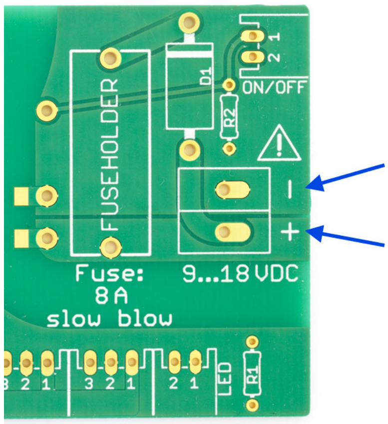



Fig. 17: *Plus and minus signs for the connection to the external 12 VDC supply.*

Fig. 18: *Wire–wound resistor assembly for power supply load testing.*

## 7.3 Power Supply Performance Check

The power supply requires no calibration. It should, however, be tested for performance to be sure it maintains the specified voltage under full load. Two 10 Ω, 17 W wire–wound resistors will serve to verify that.

### 7.3.1 Preparation

One resistor is used for loading the +12 V output, the other one for loading the −12 V output. Solder SEH-001T-P0.6 contacts onto each lead. For each resistor, use one wire–to–board connector EHR-3. The center contact is ground, so the leads of one resistor have to be inserted into the center and the left contact of one EHR-3, the other one into the center and the right contact of another EHR-3. Fig. 18 shows the assembly of one of the two resistors. Insert each resistor into any of the eight supply headers. Do not operate the power supply board with only one resistor inserted as it will otherwise not provide the right voltages at its outputs.

### 7.3.2 Load Test

> *Warning: the resistors get very hot quite quickly, so before you power up the supply board, take the necessary precautions not to get burned and make sure the resistors do not touch anything that cannot withstand the heat.*

Plug the ON/OFF header on the board with a bridged connector EHR-2 (Fig. 64). Power up the supply board with an external power supply (12 VDC). With a multimeter, check the voltages between the GND and +12V, and the GND and −12V test pins, respectively. They should read roughly 200 mV less than +12 V and −12 V (±11.8 V). With the oscilloscope in AC mode, Volt/Div set to 10 mV and Time/Div set to 2 µs, check the quality of the supplied voltage between GND and +12V on the power supply board. You should observe some ripple at a frequency of about 320 kHz with an amplitude of less than 20 mV with the oscilloscope bandwidth limited to 20 MHz (Fig. 19).

The amplitudes of the high–frequency peaks actually depend on the quality of the external switched–mode 12 VDC power supply. The high–frequency content has not been observed to have a detrimental effect on the quality of the vocoder.

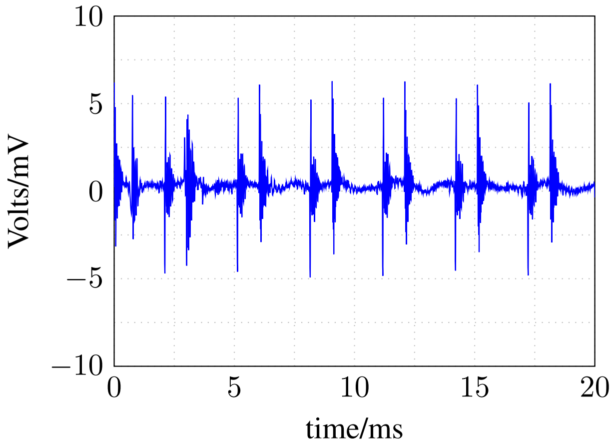



Fig. 19: *Typical power supply ripple with the oscilloscope bandwidth limited to 20 MHz.*

## 7.4 Final Remarks

From this point forward, the power supply board will serve as supply for all the upcoming boards during testing and calibration. Keep the ON/OFF header plugged in for this purpose. Keep the oscilloscope bandwidth limited to 20 MHz when performing calibration and testing to prevent from high–frequency ripple distorting the results. There is no need to mount the power supply board onto the back panel until the last assembly steps described in Section 16.

# 8 Voice Preamplifier

The PCBs for the voice preamplifier and for the carrier preamplifier are identical. The voice preamplifier board will only be partially populated according to the voice preamplifier BOM.

## 8.1 Board Assembly

Follow the component order shown in Section 3.4 and solder all components, except for the jacks, the potentiometer and the LEDs. Only solder the connectors required for the voice preamplifier (`AUDIO-L/VUV`, `AGC-L/OUTPUT`, `EXC-L/SLEW`, `EXP-L` and the power connector).

Do not put solder pins into A, B and C. Instead connect A with C via a wire and leave B open.

The header `EXP-L` needs to be plugged by a bridged connector EHR-2 as shown in Fig. 64.

Next snap off the anti–rotation tag from the potentiometer. Insert the two jacks and the potentiometer into the PCB and insert that assembly into the metal template. Fasten the jacks and the potentiometer onto the template using their corresponding nuts and take care of proper alignment. The edge of the PCB should be parallel to the template's edge to ensure the LEDs that are going to be inserted later will line up nicely and not be slanted. Use the try square to verify that the PCB's surface is perpendicular to the template (Fig. 20). The bottom side of the potentiometer should sit firmly on the PCB surface. Now solder the jacks and the potentiometer.

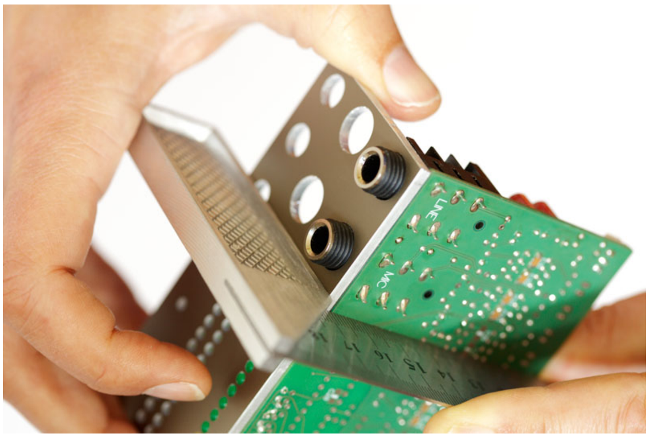


Fig. 20: *Use of a try square for the proper perpendicular alignment of the preamplifier PCB with the metal template.*

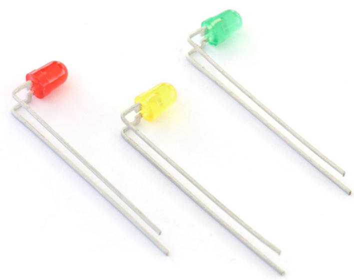
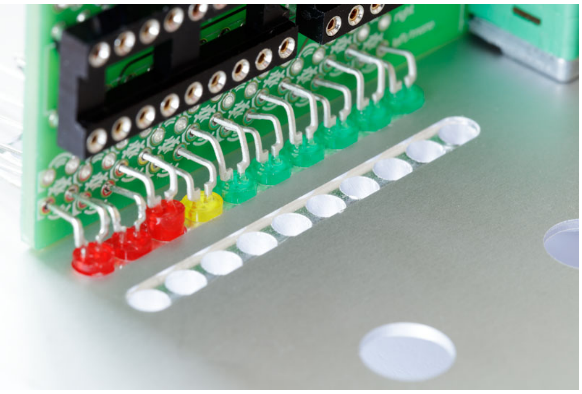


Fig. 21: *Bent LED leads for preamplifier board assembly.*

The last assembly step focuses on the LEDs. Bend the LED leads as shown in Fig. 21, then insert all the LEDs into the PCB using the correct color order. Use the template and masking tape over the LEDs for accurate LED alignment before soldering (Fig. 22). Pay special attention to the soldering. The LED placement is very tight. Do not overheat the LEDs. Pinch off one soldered lead at a time to get better access to the next lead to be soldered.

## 8.2 Front Panel Mounting

Mount the board onto the front panel using the appropriate screws and the corresponding tools. This will likely be the part of the project where you need to have the most patience as you insert the LEDs into the panel. The



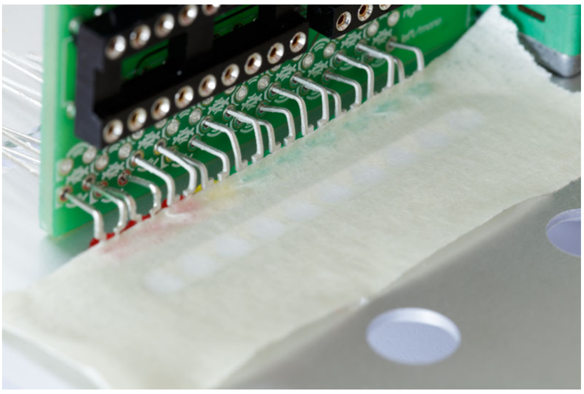


Fig. 22: *Insertion of LEDs in template shown on the left, covered by masking tape shown on the right.*

board is held onto the front panel by the corresponding potentiometer and jack nuts.

## 8.3 Test and Calibration

**Trimmer Description:**

Left Channel VU (TR1): Signal level adjustment on Left Ampl

**Preparation:**

1. If not already done so, plug EXP-L with a bridged connector EHR-2 (Fig. 64).
2. Connect the voice preamplifier supply header to the power supply board. Turn on the power supply board.
3. Connect the sine wave signal generator to the 6.35 mm Line–in jack. Note that the jack receives stereo plugs. Both channels are mixed on the board.
4. Switch the oscilloscope to AC mode.
5. Connect the oscilloscope's ground to GND and the probe to Left Ampl.
6. Set the oscilloscope to be triggered by the input signal.

**Calibration Procedure:**

1. Set the frequency of the sine wave signal generator to roughly 440 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer (P1) on the board until the oscilloscope shows a sine wave with an amplitude of 1 V. Make sure the displayed waveform is a proper sine wave that is clipped neither at the top nor at the bottom (Figs. 24 and 25).
2. Turn TR1 until the yellow LED is illuminating. It should be set halfway between the illuminating green LED and the red LED that is not illuminating.

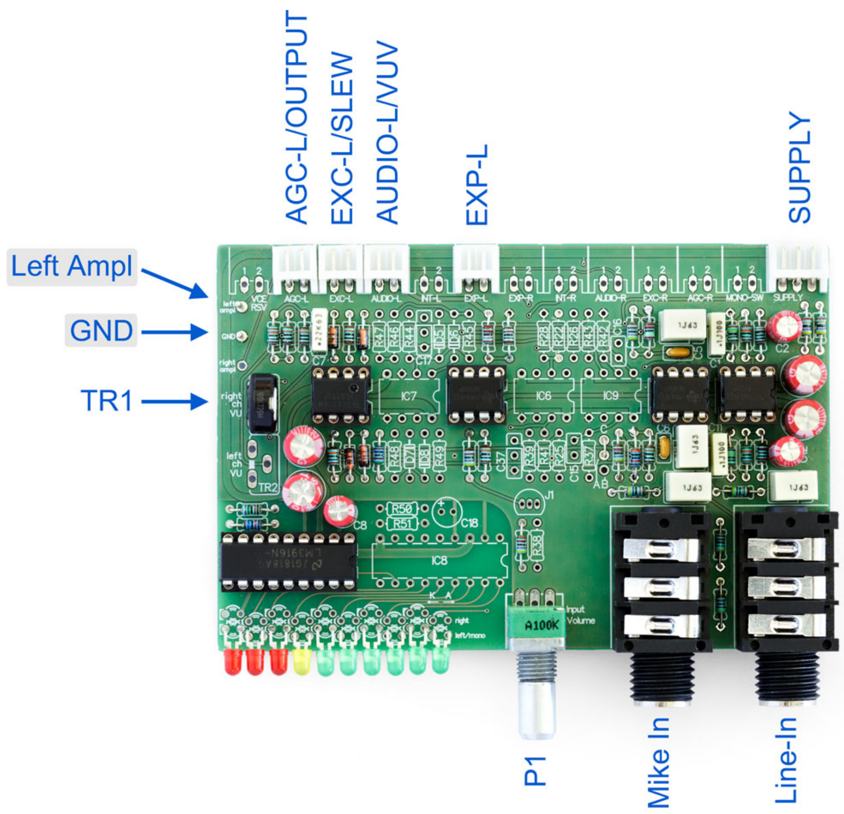



Fig. 23: *Voice preamplifier headers, trimmers and test pins.*

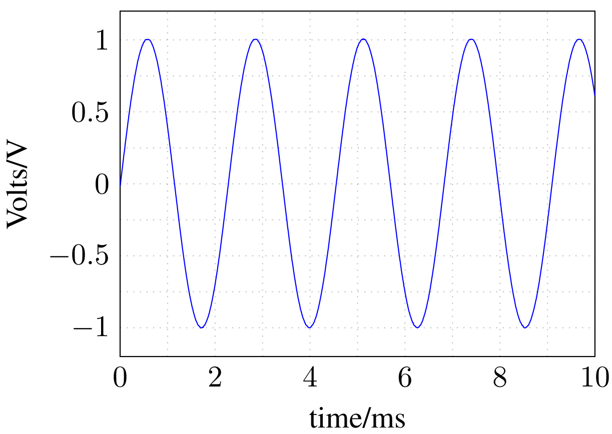



Fig. 24: *Sine wave generator set to 440 Hz, amplitude set to 1 V measured between* GND *and* Left Ampl.

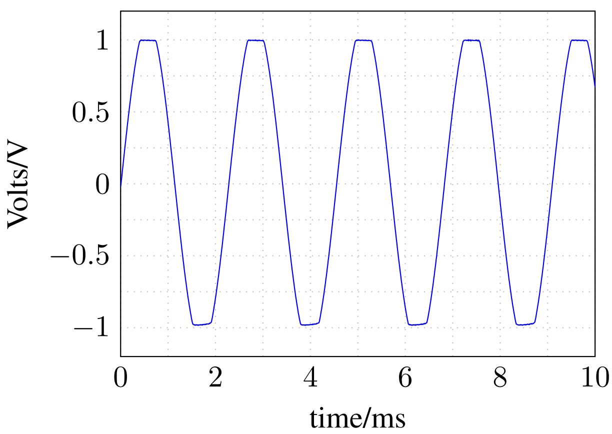



Fig. 25: *Poor setup leading to a clipped waveform. This may be caused by an input signal which comes at a too high amplitude causing it to be clipped by the preamplifier, subsequently set to 1 V amplitude on the Level potentiometer* `P1`.

# 9 Carrier Preamplifier

The assembly and calibration of the carrier preamplifier board is similar to the voice preamplifier board.

## 9.1 Board Assembly

Follow the component order shown in Section 3.4 and solder all components, except for the jacks, the potentiometer and the LEDs. Only solder the connectors required for the carrier preamplifier (EXC-L/SLEW, EXC-R, AUDIO-L/VUV, AUDIO-R, INT-L, INT-R, AGC-L/OUTPUT, AGC-R, EXP-L, EXP-R, MONO-SW and the power connector).

Do not put solder pins into A, B and C. Instead connect A to B via a wire and leave C open.

Each of the two connectors EXP-L and EPX-R need to be plugged by a bridged connector EHR-2 as shown in Fig. 64.

For the remaining assembly of the board, follow the description for the board assembly of the voice preamplifier.

## 9.2 Front Panel Mounting

Mount the board onto the front panel. Once again, be patient while inserting the 20 LEDs into their corresponding front panel holes.

## 9.3 Test and Calibration

**Trimmer Description:**

| | |
|---|---|
| Left Channel VU (TR1): | Signal level adjustment on Left Ampl |
| Right Channel VU (TR2): | Signal level adjustment on Right Ampl |

**Preparation:**

1. If not already done so, plug EXP-L and EXP-R each with a bridged connector EHR-2 (Fig. 64).
2. Connect the voice preamplifier supply header to the power supply board. Turn on the power supply board.
3. Connect the sine wave signal generator to the 6.35 mm Line–in jack and make sure both audio channels are supplied with the signal.
4. Switch the oscilloscope to AC mode.

**Calibration Procedure:**

Left channel:

1. Connect the oscilloscope's ground to GND and the probe to Left Ampl.
2. Set the oscilloscope to be triggered by the input signal.

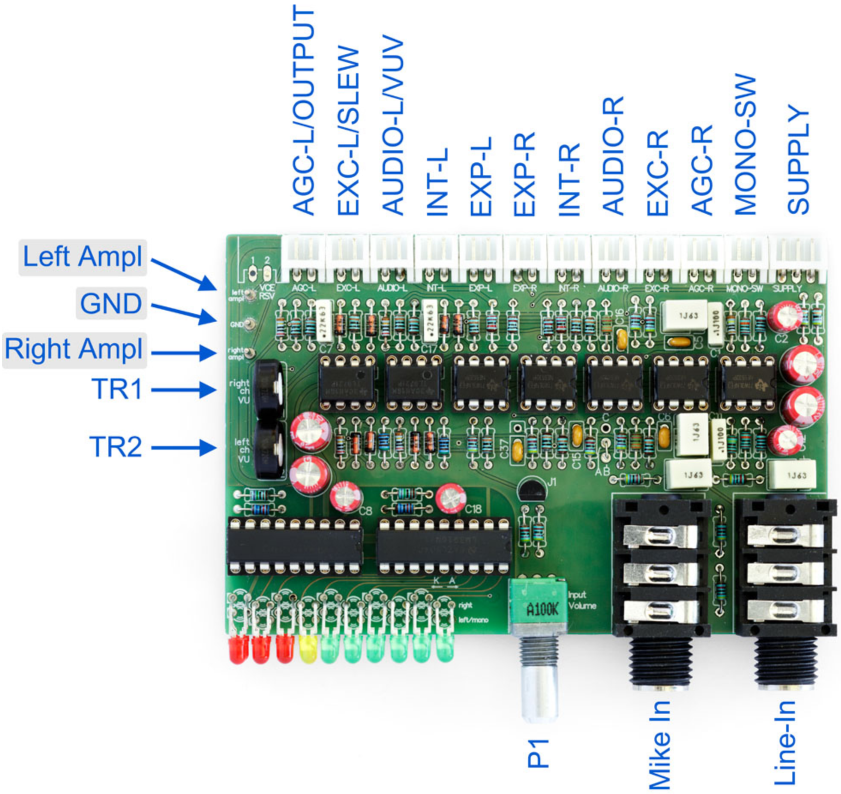



Fig. 26: *Carrier preamplifier headers, trimmers and test pins.*

3. Set the frequency of the sine wave signal generator to roughly 440 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer on the board until the waveform on the oscilloscope shows an amplitude of 1 V. Make sure the displayed waveform is a proper sine wave that is clipped neither at the top nor at the bottom (Figs. 24 and 25).

4. Turn `TR1` until the yellow LED is illuminating. It should be set halfway between the illuminating green LED and the red LED that is not illuminating.

Right channel:

1. Connect the oscilloscope's ground to GND and the probe to Right Ampl.

2. Set the oscilloscope to be triggered by the input signal.

3. Set the frequency of the sine wave signal generator to roughly 440 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer on the board until the waveform on the oscilloscope shows an amplitude of 1 V. Make sure the displayed waveform is a proper sine wave that is clipped neither at the top nor at the bottom (Figs. 24 and 25).

4. Turn `TR2` until the yellow LED is illuminating. It should be set halfway between the illuminating green LED and the red LED that is not illuminating.

# 10 Output, PWM and Silence Bridging

## 10.1 Board Assembly

In the following description, the "output, PWM and silence bridging board" is mostly referred to simply as "output board".

Follow the component order shown in Section 3.4 and solder all components. Resistor R73 is to be bridged by a wire. Snap the anti–rotation tags off the potentiometers. For soldering well aligned jacks, potentiometers and the LEDs, use the front panel as a template. When soldering the silence bridging indicator LED, align it with the designated opening of the front panel.

Do not forget to place the headers for EXP-L, EXP-R and NOISE-INH onto the backside of the PCB.

Solder the 16-pin header in a straight angle so that the protruding pins are parallel to the surface of the PCB.

## 10.2 Front Panel Mounting

After board assembly, mount the PCB onto the front panel using the appropriate nuts. The board is held onto the front panel by the corresponding potentiometer and jack nuts.

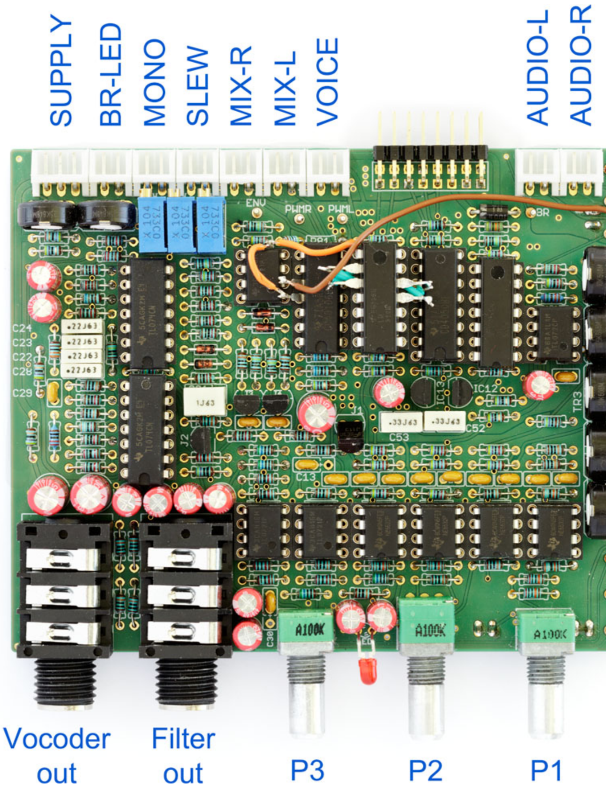
## 10.3 Test and Calibration

**Trimmer Description:**

| | |
|---|---|
| SYNTH-L (TR1): | Vocoder left channel amplitude adjust for output level on VC-L |
| SYNTH-R (TR2): | Vocoder right channel amplitude adjust for output level on VC-R |
| FILTER (TR3): | Filter amplitude adjust for output level on FLTR |
| AMPLITUDE (TR4): | Triangular waveform generator amplitude adjust on TRI |
| OFFSET (TR5): | Triangular waveform generator offset adjust on TRI |
| TR6: | Silence bridging envelope adjust on ENV |
| TR7: | Silence bridging level adjust on BR |
| TR8: | Silence bridging offset adjust on BR |
| TR9: | Silence bridging inhibit threshold |
| TR10: | Silence bridging channel filter activation on SBSW |

**Preparation:**

1. Switch the oscilloscope to DC mode for the observation of absolute voltages and offsets. With the probe connected to ground of the oscilloscope, the oscilloscope should be calibrated for a reading of 0 V.
2. Connect ground of the oscilloscope to GND of the output board.
3. Set the oscilloscope to be triggered by the input signal.
4. Connect the output board supply header to the power supply. Leave all other headers open.



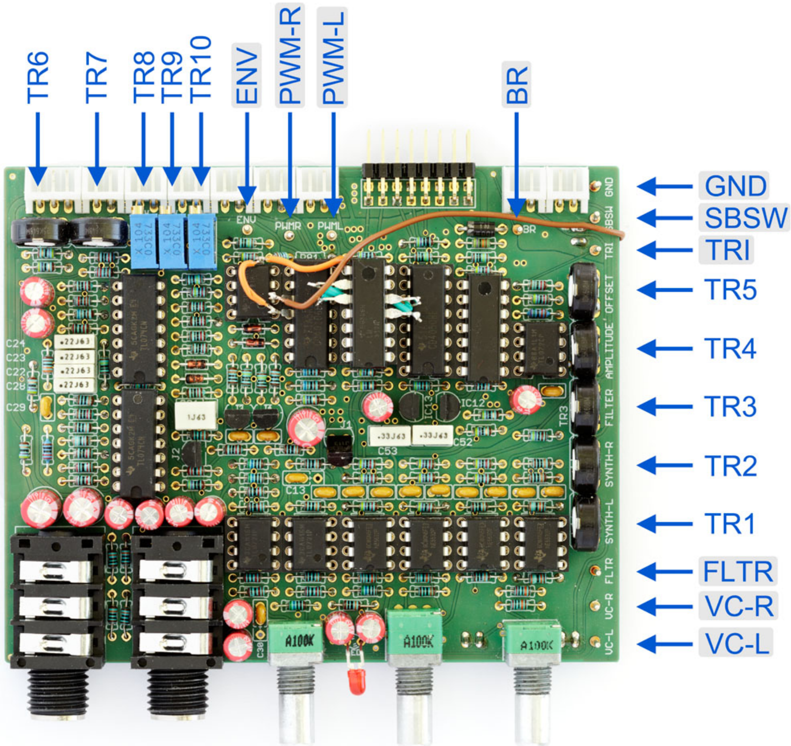




Fig. 27: *Output board with the connectors shown at the top and the trimmers and test pins shown at the bottom. Note that this photo shows the prototype with minor last–minute tweaks. These tweaks are fully integrated in the final version of the PCB.*

**Calibration Procedure:**

PWM generator calibration:

1. Connect the oscilloscope probe to TRI. A triangular waveform should be observed with an amplitude of roughly 2 V and a frequency of roughly 80 kHz.
2. Adjust trimmer `OFFSET` (`TR5`) until the waveform is vertically centered.
3. Adjust trimmer `AMPLITUDE` (`TR4`) until the amplitude of the triangular waveform shows 2 V.

The observed signal should look like Fig. 28.

PWM generator test and fine–tuning:

1. Plug header `MIX-L` with a bridged connector (Fig. 64).
2. Connect the oscilloscope probe to PWM-L. A rectangular waveform between 0 V and ~12 V at a frequency of ~80 kHz should be observed with a duty cycle of about 50% (Fig. 29).
3. Unplug header `MIX-L`.
4. Plug header `MIX-R` with a bridged connector (Fig. 64).
5. Connect the oscilloscope probe to PWM-R. A rectangular waveform between 0 V and ~12 V at a frequency of ~80 kHz should be observed with a duty cycle of ~50%.
6. If needed, use trimmer `OFFSET` (`TR5`) for fine–tuning to get as close to a 50% duty cycle as possible.
7. Unplug header `MIX-R`.

Further PWM generator testing:

1. Connect the voice preamplifier board supply to the power supply board.
2. Connect the oscilloscope probe to PWM-L.
3. Connect `AGC-L/OUTPUT` of the voice preamplifier board to `MIX-L` of the output board. Use cable #2 to do this temporarily just for these testing purposes.
4. Connect the sine wave signal generator to the 6.35 mm Line–In jack. Set the frequency to roughly 500 Hz and adjust the amplitude to 0 dB (the yellow LED illuminating, none of the red LEDs illuminating).
5. Observe the signal on the oscilloscope. If triggered properly, you should observe a steady rising edge of the rectangular signal and a wobbling falling edge.
6. As you keep observing the signal, keep playing with the signal generator frequency and the signal amplitude. Set at a very low frequency (10 Hz or less), you should be able to visually follow the wobble of the falling edge. The wobble range depends on the signal generator amplitude.
7. You may want to play around with other signal types.
8. Once done experimenting, remove cable #2 between the voice preamplifier and the output board.

Repeat the above test using headers `AGC-L/OUTPUT` and `MIX-R` by using cable #2 temporarily and observe the signal on PWM-R.

Silence bridging calibration — envelope follower:

1. Connect `AGC-L/OUTPUT` of the voice preamplifier board to `VOICE` of the output board using cable #2. This cable will now remain permanently installed.
2. Switch the oscilloscope to AC mode.
3. Connect the oscilloscope ground to GND and the probe to Left Ampl of the voice preamplifier board.
4. Connect the sine wave signal generator to the 6.35 mm Line–In jack. Set the frequency to roughly 500 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer on the board until the waveform on the oscilloscope shows an amplitude of 1 V.
5. Set the oscilloscope to DC mode.
6. Connect the oscilloscope ground to GND and the probe to ENV of the output board.
7. Adjust trimmer `TR6` until the signal observed on the oscilloscope reads −5 V (Fig. 30).

Silence bridging calibration — inhibitor setting:

1. Turn the volume on the voice preamplifier board completely off (fully counter–clockwise).
2. Turn the silence bridging level on `P3` completely off (fully counter–clockwise).
3. Unless the LED next to the S. Bridging potentiometer `P3` is not already illuminating, turn `TR9` counter–clockwise until the LED is illuminating.
4. Slowly adjust `TR9` until the bridging LED has just about turned off.
5. Switch the oscilloscope to AC mode.
6. Connect oscilloscope ground to GND and the probe to Left Ampl of the voice preamplifier board.
7. Connect the sine wave signal generator to the 6.35 mm Line–In jack. Set the frequency to roughly 500 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer on the board until the waveform on the oscilloscope shows an amplitude of 1 V.
8. Turn the silence bridging level on `P3` fully clockwise and turn the level on the preamplifier fully counter–clockwise (off). Turn the silence bridging level on `P3` completely off. Unless the LED has turned off, slowly adjust `TR9` until it has just turned off.

Silence bridging calibration — channel filter activation:

1. Switch the oscilloscope to DC mode.
2. Turn the silence bridging level on `P3` completely off (fully counter–clockwise).
3. Connect the oscilloscope's ground to GND and the probe to SBSW of the output board.
4. Unless the reading on SBSW is not already at about 12 V, turn trimmer `TR10` counter–clockwise until the oscilloscope reading shows about 12 V.

5. Slowly turn trimmer TR10 clockwise until the voltage on SBSW has just dropped to a solid 0 V.

The remaining calibration is covered at a later stage (Section 17.1).

For calibrating the upcoming boards, keep silence bridging completely switched off (LED non–illuminating) by turning the S. Bridging potentiometer fully counter–clockwise.

## 10.4 Board Interconnects

Cable #2 has already been installed for calibration purposes. Build and install cable #6 and cable #7. Until the V/UV board has been assembled, build cable #4 and cable #5 but instead of installing it on the sockets according to table in Section 20, connect EXC-L/SLEW on the carrier preamplifier board to MIX-L on the output board. Do the same for EXC-R with MIX-R.

Follow the description of Section 4.6 and build and install cable #31.

It's time to review the installation of cables. The table below gives an overview. Cables that have been installed so far are shown in green. The hatched cells for cable #4 and cable #5 indicate that these two cables have not yet been installed according to their final placement. Cable #21 is the bridged connector that was installed permanently during the voice preamplifier build. Cable #22 and cable #23 are bridged connectors that were installed during the carrier preamplifier build. Cable #24 and cable #25 are bridged connectors that were installed during the output board build.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| cable #1 | **cable #2** | cable #3 | **cable #4** | **cable #5** | **cable #6** | **cable #7** | cable #8 | cable #9 | cable #10 |
| cable #11 | cable #12 | cable #13 | cable #14 | cable #15 | cable #16 | cable #17 | cable #18 | cable #19 | cable #20 |
| **cable #21** | **cable #22** | **cable #23** | **cable #24** | **cable #25** | cable #26 | cable #27 | cable #28 | cable #29 | cable #30 |
| **cable #31** | cable #32 | cable #33 | cable #34 | cable #35 | cable #36 | cable #37 | | | |

The current setup is all that is needed for the upcoming channel filter board calibration and testing.

With these cables installed, audio signals connected to the Line–In jacks on both the voice and carrier preamplifiers can be monitored at the vocoder output jack via the corresponding level controls Voice Mix and Carrier Mix.

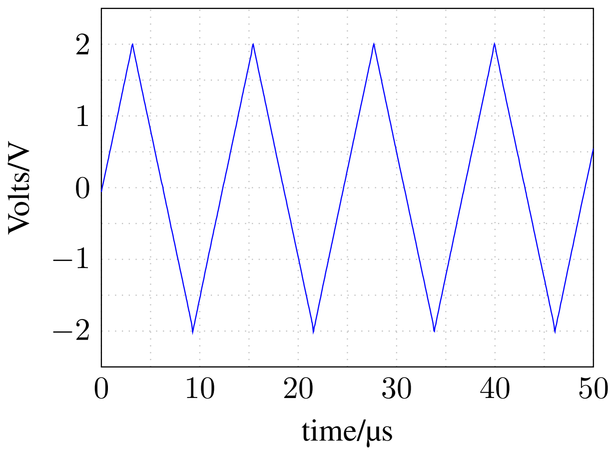



Fig. 28: *Signal with an amplitude of 2 V, corrected for offset on* TRI.

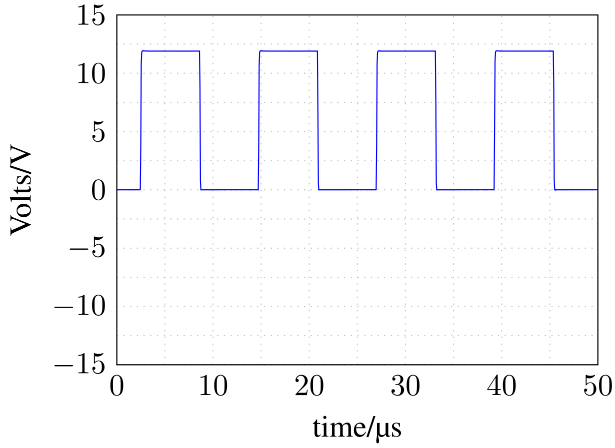



Fig. 29: *PWM signal observed on* PWM-L *with header* `MIX-L` *bridged. The duty cycle should be close to 50%.*

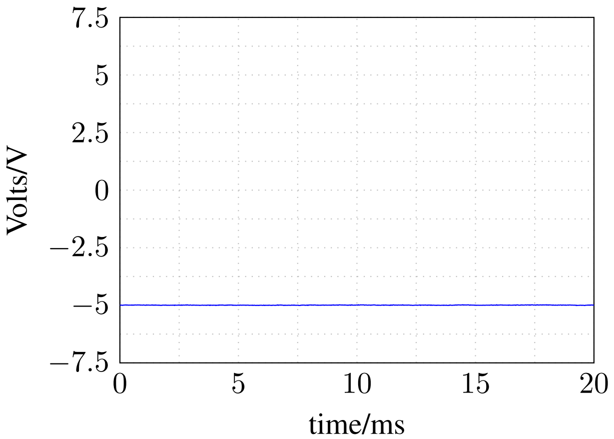



Fig. 30: *Expected signal on* ENV *of the output board with an audio signal at 500 Hz and an amplitude of 1 V on the Line–In jack of the voice preamplifier.*

# 11 18 Channel Filters

A total of 18 channel filter boards are to be assembled. Most components are identical among all the boards.[1] The resistors R1 to R24, R37 to R39, and the capacitors C1 to C16, however, depend on the frequency for which a board is to be built.[2] Pay special attention to these components to avoid lengthy troubleshooting and desoldering.

Before starting to assemble any of the 18 channel filter boards, familiarize yourself with the capacitors C1 to C16 used in the 8-pole filters. These are dedicated capacitors with COG/NP0 dielectric for better matching and temperature stability. The values used depend on the frequency for the given channel filter board and are either 10 nF, 33 nF or 100 nF. You may want to color code the tape in which each capacitor value was delivered to prevent from getting them mixed up. This is particularly critical for the 100 nF capacitors as this project uses X7R as blocking capacitors and C0G/NP0 types for the six channel filter boards with frequencies ranging from 500 to 1660 Hz. The locations for the 8-pole filter capacitors are specifically marked on the PCB as shown in Fig. 31. All other SMD capacitors on this board that do not have this dedicated marking are regular 100 nF X7R blocking capacitors.

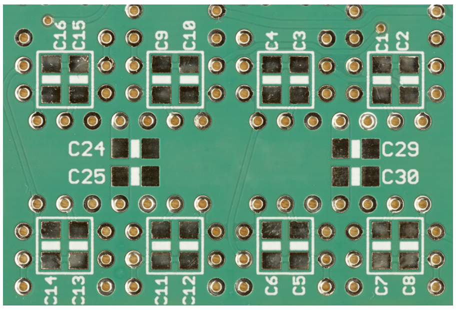



Fig. 31: *The 16 locations of the capacitors dedicated to the channel filters are surrounded by white squares. The four capacitors in the center are regular* 100 nF *blocking capacitors.*

For best matching between the analysis section filter and the synthesis section filter, take out one capacitor at a time from one end of the tape and solder them according to the following sequence from left to right:

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cap #1 | cap #2 | cap #3 | cap #4 | cap #5 | cap #6 | cap #7 | cap #8 | cap #9 | cap #10 | cap #11 | cap #12 | cap #13 | cap #14 | cap #15 | cap #16 |
| C1 | C9 | C2 | C10 | C3 | C11 | C4 | C12 | C5 | C13 | C6 | C14 | C7 | C15 | C8 | C16 |

Similarly, when soldering the resistors R27 to R34, use adjacent 10 kΩ resistors from the tape. The resistors R29 to R32 are part of a precision rectifier.

## 11.1 Board Assembly

Follow the component order shown in Section 3.4 and solder all components, except for the jacks, the potentiometers and the LED.

Avoid soldering the 16-pin header and the two 4-pin headers in an angled way. The protruding pins should be parallel to the surface of the PCB.

Next snap off the anti–rotation tags from the potentiometers. Insert the two jacks and the two potentiometers into the PCB and insert that assembly into the metal template. Fasten the 3.5 mm jacks and the potentiometers onto the template using their corresponding nuts and take care of proper alignment. Notice that the 3.5 mm jacks should not be fully inserted into the PCB. Instead the pins should barely stick out from the solder side (bottom side) of the PCB. The bottom surface of the PCB should be flush with the edge of the template (Fig. 33). Use the try square to verify that the PCB's surface is perpendicular

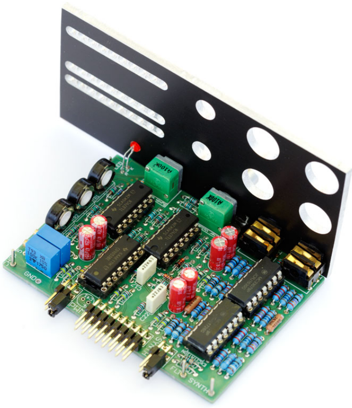
Fig. 32: *Bent LED leads.*

[1] see Assembly Table "Common materials for the 18 channel filter boards" in the Bill of Materials document

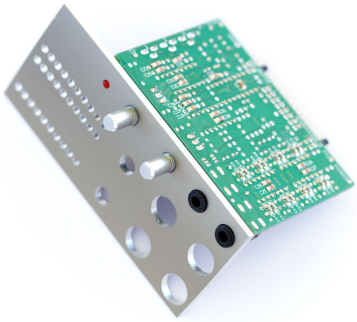
[2] see Assembly Table "Frequency–specific materials for the 18 channel filter boards" in the Bill of Materials document

to the template. The bottom side of the potentiometer should sit firmly on the PCB surface. Now solder the jacks and the potentiometers.

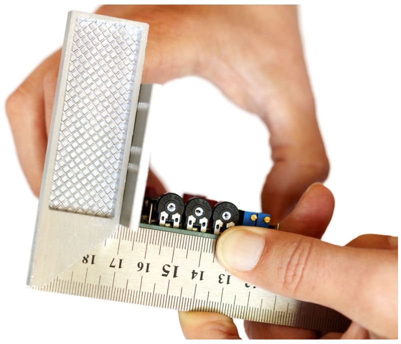
The final assembly step focuses on the LED. Choose an appropriate length of the lead section coming out of the LED lens when bending the LED as shown in Fig. 32. Insert the LED into the template and the board and check for proper alignment, then solder the LED.



*Channel filter board inserted in the metal template.*



*The PCB surface must be flush with the edge of the template. The 3.5 mm jacks will not be fully inserted but instead stick out by roughly 1 mm.*



*Use of a try square for accurate perpendicular alignment.*

Fig. 33: *The metal template used for the channel filter board assembly.*

## 11.2 Test and Calibration

**Trimmer Description:**

`TR1`: Output amplitude of synthesized signal on SYNTH
`TR2`: Envelope level on CV
`TR3`: Filter output amplitude on FLT
`TR4`: Excitation bleedthrough elimination on CHOP (post–CV control)
`TR5`: Excitation bleedthrough elimination on CHOP (pre–CV control)

**Preparation:**

1. The CV–IN and CV–OUT jacks need to stay unplugged during calibration to ensure internal connection between both jacks.
2. Insert a jumper to bridge `PWM-L`. Insert a jumper to bridge `SYNTH-L`.
3. Turn the S. Bridging potentiometer `P3` on the output board completely off (fully counter–clockwise).

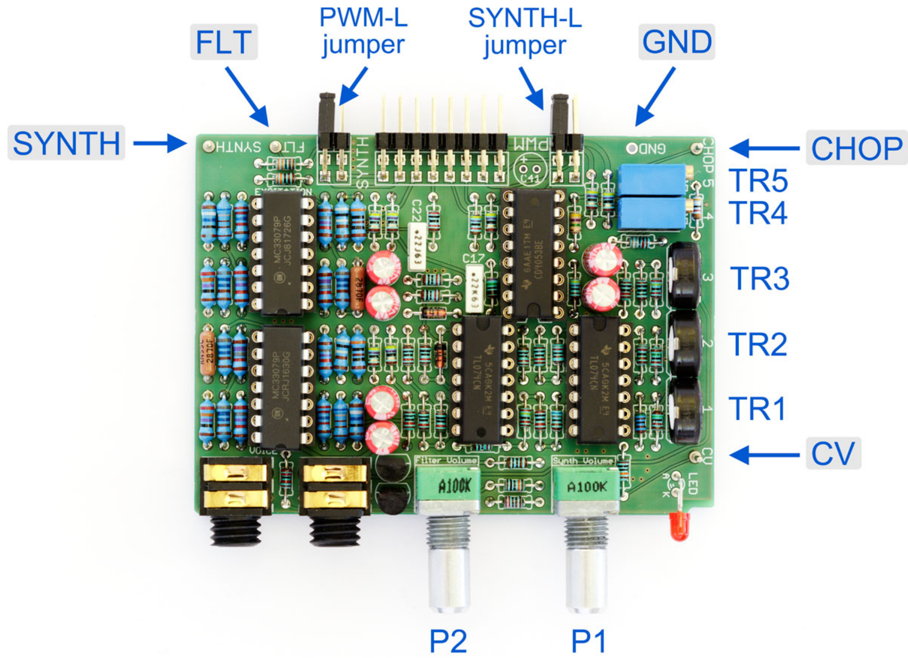



Fig. 34: *Channel filter trimmers and test pins.*

**Calibration Procedure:**

1. Connect one end of the 16-wire ribbon cable to the output board. Connect the other end to the filter channel board. Make sure the board header is inserted into the ribbon cable with proper orientation (Fig. 35).
2. Connect the sine wave signal generator to both the voice preamplifier and the left channel of the carrier preamplifier via their respective 6.35 mm jacks.
3. Set the signal generator frequency to the channel filter board frequency.
4. Switch the oscilloscope to AC mode.
5. Connect oscilloscope ground to GND of the voice preamplifier board and the probe to Left Ampl. Adjust the voice preamplifier volume control for an amplitude of 400 mV (Fig. 36).
6. Connect oscilloscope ground to GND of the carrier preamplifier board and the probe to Left Ampl. Adjust the carrier preamplifier volume control for an amplitude of 400 mV (Fig. 36).
7. For the remainder of this calibration procedure, connect oscilloscope ground to GND of the channel filter board.
8. Turn the Filter Level potentiometer `P2` full clockwise. Connect the oscilloscope probe to FLT of the channel filter board and fine–tune the sine wave signal generator frequency for peak amplitude.
9. Adjust `TR3` for a 400 mV signal amplitude on FLT (Fig. 37).
10. Switch the oscilloscope to DC mode. Correct the oscilloscope reading to 0 V with the probe grounded to the oscilloscope ground.

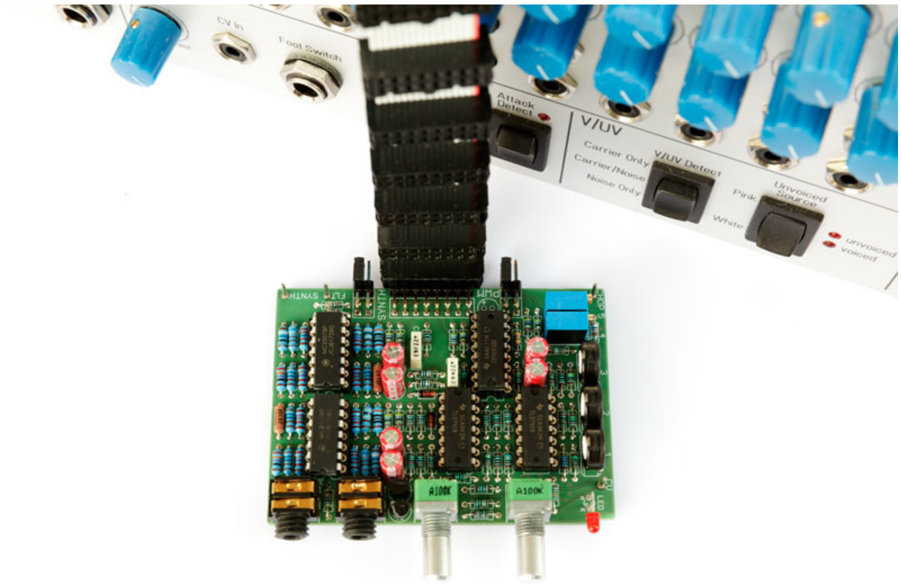


Fig. 35: *Temporary setup of the channel filter board for calibration purposes.*

11. Connect the oscilloscope probe to CV and adjust TR2 for 5 V (Fig. 38).
12. Switch the oscilloscope into AC mode. Turn the Channel Level potentiometer P1 fully clockwise and adjust TR1 for a signal amplitude of 800 mV on SYNTH (Fig. 39).

**Excitation signal bleedthrough reduction:**

1. Turn the voice preamplifier volume off (fully counter–clockwise).
2. Turn the carrier preamplifier volume to 0 dB (yellow LED illuminating). An exact setting to 0 dB is not needed.
3. Switch the oscilloscope to AC mode and connect the probe to CHOP. Set Time/Div. to 5 µs and Volts/Div. to 10 mV or lower.
4. Turn the Channel Level potentiometer P1 off (fully counter–clockwise) and adjust TR4 for no signal bleedthrough on CHOP by looking for best possible alignment of the horizontal part of the signal. See Fig. 40 and Fig. 41 for an illustration of the calibration procedure.
5. Turn the Channel Level potentiometer P1 fully clockwise and adjust TR5 for no signal bleedthrough on CHOP and follow the procedure as described in the previous step.

Once calibration of the board is done, disconnect the 16-wire ribbon cable from the filter channel board.

## 11.3 Stereo Setup and Front Panel Mounting

To establish the stereo functionality, a channel filter board needs to be assigned either to the left or the right vocoder audio output channel. This is accomplished via jumpers that are inserted in an alternating fashion going from one channel board to the next. To assign a board to the left audio channel, insert two jumpers to bridge PWM-L and SYNTH-L, respectively. Accordingly, to assign a board to the right audio channel, insert jumpers to bridge PWM-R and SYNTH-R.

Insert the channel filter board into its designated spot with the corresponding frequency shown on the front side of the panel and fasten it with the corresponding nuts for the potentiometers and the jacks.

Continue with the next filter board until all 18 boards are done. See the next section if you would like to check interim results.

## 11.4 Interim Vocoder Testing

To test the vocoder with whatever many channel boards have been built, install the ribbon cable on the output board and all the available channel filter boards and leave the remaining headers on the ribbon cable disconnected. Supply Line–In on the voice preamplifier and Line–In on the carrier preamplifier with appropriate signals and connect Vocoder Out to an amplifier. Turn on the vocoder and start vocoding. If the output signal is too weak, turn up `TR1` and `TR2` on the output board. The final calibration of these trimmers will take place in Section 17.1.

Once all 18 boards are done, install the ribbon cable permanently as shown in Fig. 11.

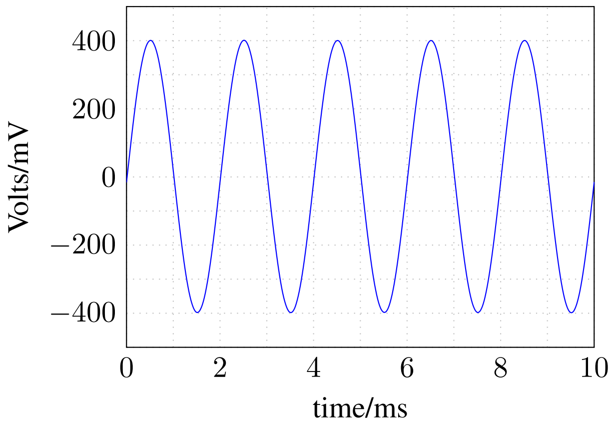



Fig. 36: *Sine wave generator set to the 500 Hz channel filter board frequency. Set input volumes for a 400 mV amplitude reading on* Left Ampl*, both for the voice and carrier preamplifiers.*

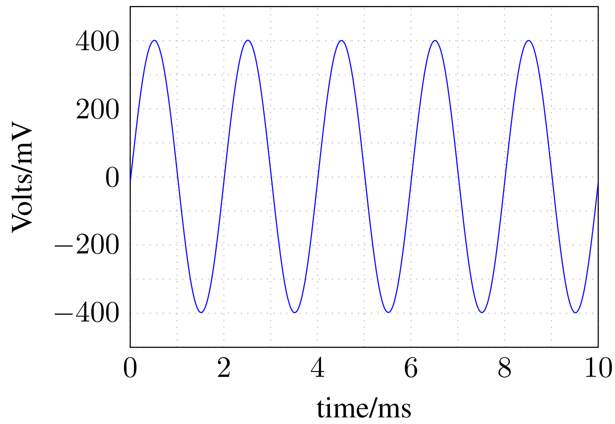



Fig. 37: *400 mV amplitude on* FLT *of the channel filter board.*

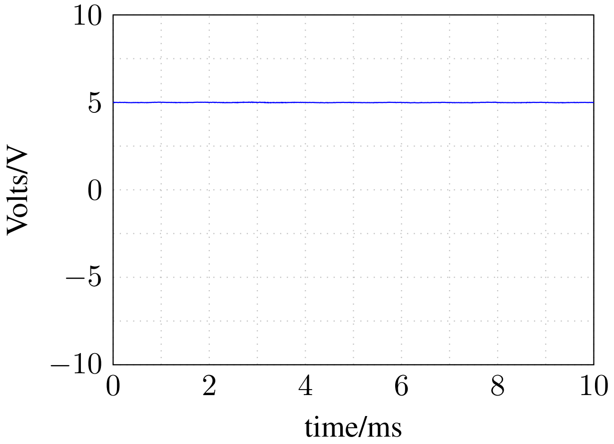



Fig. 38: *Oscilloscope in DC mode for 5 V calibration on* CV *of the channel filter board.*

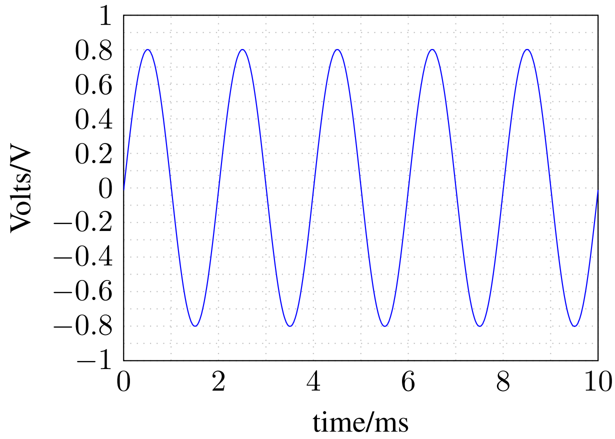



Fig. 39: *800 mV amplitude on* SYNTH *of the channel filter board. This is the synthesized output signal.*

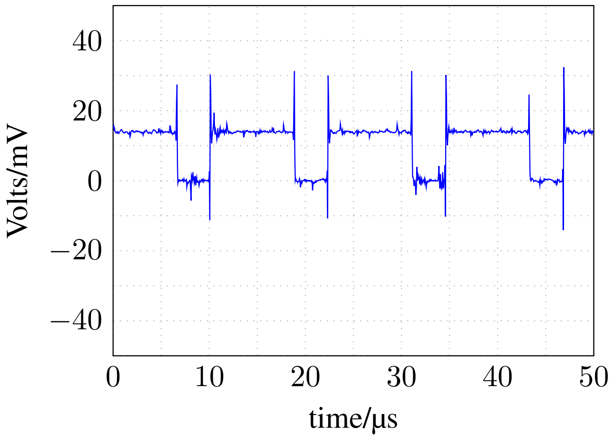



Fig. 40: *Oscilloscope in DC mode, connected to* CHOP*, set to 5 µs Time/Div. and 10 mV Volts/Div. With the horizontal signal sections not in line, the signal is uncalibrated.*

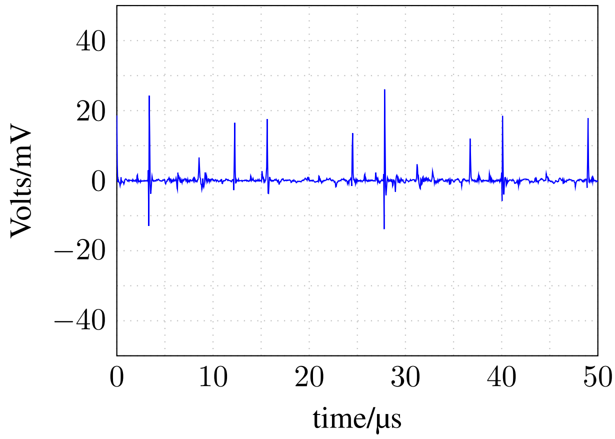



Fig. 41: *Well–adjusted signal on* CHOP*. The vertical spikes are harmless. They are the result of switching activities of the PWM–based multiplier.*

# 12 Internal Excitation (Left)

## 12.1 Board Assembly

Follow the component order shown in Section 3.4 and solder all components. Pay close attention to the BOM as the material used is almost identical to that for the right internal excitation board.

Snap off the anti–rotation tags from the potentiometers. For soldering the 3.5 mm jack and potentiometers, use the front panel as a template. The pots should sit firmly on the PCB surface. Similar to the channel filter board, the 3.5 mm jack will stick out by about 1 mm.

Assemble the tempco R7 (2 kΩ, 3300 ppm/°C) over the center of IC2 as shown in Fig. 42. You may want to put some thermal paste underneath the tempco for improved thermal conductance.

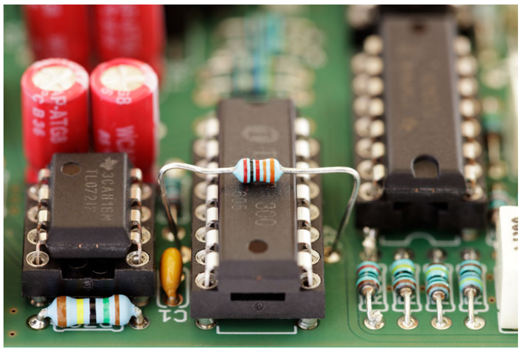


Fig. 42: *Tempco closeup view over* IC2 *on the excitation board.*

## 12.2 Front Panel Mounting

Mount the board onto the front panel. The board is held onto the panel by the corresponding nuts of the potentiometers and the 3.5 mm jack.

## 12.3 Test and Calibration

**Trimmer Description:**

TR1: 1V/Oct. adjust
TR2: 1V/Oct. high frequency compensation
TR3: Automatic gain control (AGC) output centering on AGC
TR4: AGC bleedthrough reduction on AGC
TR5: AGC gain on AGC
TR6: White noise amplitude on WHT
TR7: Pink noise amplitude on PNK
TR8: Sawtooth amplitude on SAW
TR9: Sawtooth centering on SAW
TR10: Square wave amplitude on SQR

**Preparation:**

- Connect the excitation board supply header to the power supply.
- Leave the CV-IN 3.5 mm jack unplugged.
- Leave the headers for NOISE TYPE and WAVEFORM disconnected (no jumpers).

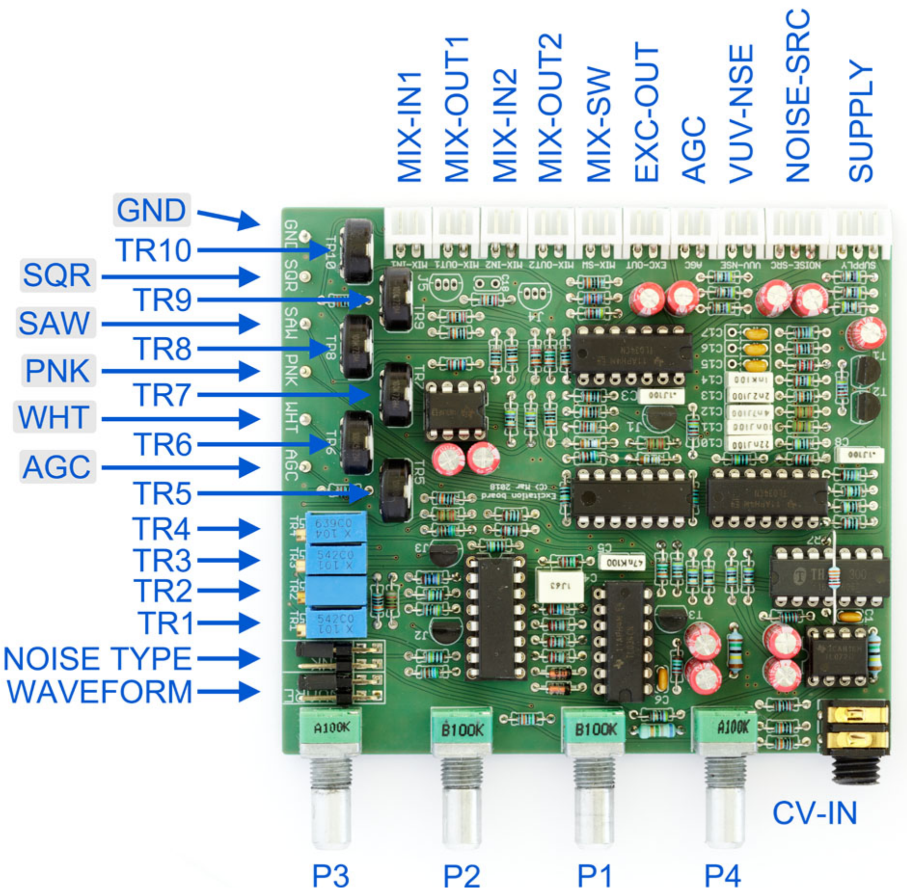



Fig. 43: *Internal excitation board headers, trimmers and test pins.*

**Calibration Procedure:**

Sawtooth generator calibration:

1. Switch the oscilloscope to DC mode for the observation of absolute voltages and offsets. With the probe connected to ground of the oscilloscope, the oscilloscope should be calibrated for a reading of 0 V.
2. Set the oscilloscope to be triggered by the input signal.
3. Connect the oscilloscope's ground to GND and the probe to SAW of the excitation board. Set Time/Div. to 500 µs. The amplitude should read roughly 1 V.
4. Adjust the Coarse Freq. potentiometer P2 to a frequency of roughly 500 Hz (2 ms per period of the sawtooth).
5. Adjust TR8 and TR9 for a symmetrical sawtooth signal with an amplitude of 1 V (Fig. 44).

Square wave calibration:

1. Insert a jumper for SQUARE on the WAVEFORM header.
2. Connect the probe of the oscilloscope to SQR.
3. Adjust the amplitude of the square wave to 1 V on TR10 (Fig. 45).
4. Remove the jumper from SQUARE and move it to SAW on the WAVEFORM header.

White noise calibration:

1. Insert a jumper to bridge WHITE on the NOISE TYPE header.
2. If the left excitation board is to be calibrated, add cable #10. If the right excitation board is to be calibrated, add cable #11.
3. Switch the oscilloscope to AC mode.
4. Turn Osc. Level (P3) fully counter–clockwise (off). Turn Noise Level (P4) fully clockwise (on).
5. Connect the oscilloscope ground to GND and the probe to WHT.
6. Adjust TR6 for a solid illumination of the yellow LED on the VU meter. The red LED might flicker up once in a while. The oscilloscope will indicate white noise (Fig. 46).

Pink noise calibration:

1. Remove the jumper from WHITE and use it instead to bridge PINK on the NOISE TYPE header.
2. Connect the oscilloscope ground to GND and the probe to PNK.
3. Adjust TR7 for a solid illumination of the yellow LED on the VU meter. The red LED might flicker up once in a while. The oscilloscope will indicate pink noise (Fig. 47).

Keep the jumpers permanently inserted for SAW on the WAVEFORM header and for PINK on the NOISE TYPE header.

Automatic gain control and 1 V/Oct. calibration are covered at later stages.

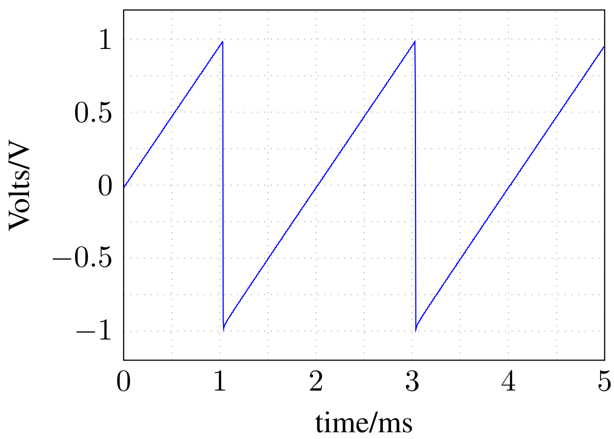



Fig. 44: *Centered sawtooth at a frequency of 500 Hz with a 1 V amplitude observed on* SAW *after tuning* `TR8` *(amplitude) and* `TR9` *(offset).*

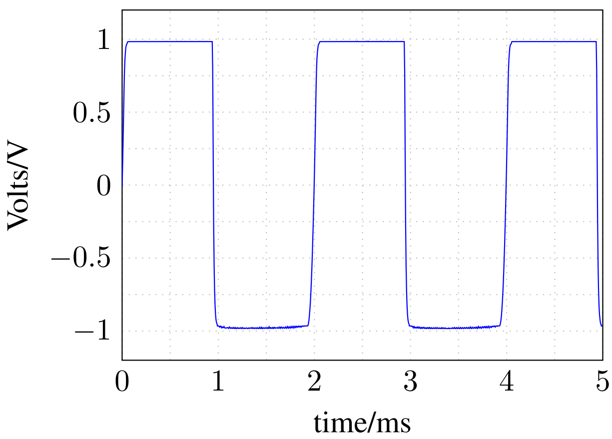



Fig. 45: *Square wave observed on* SQR*, adjusted for a 1 V amplitude on* `TR10`.

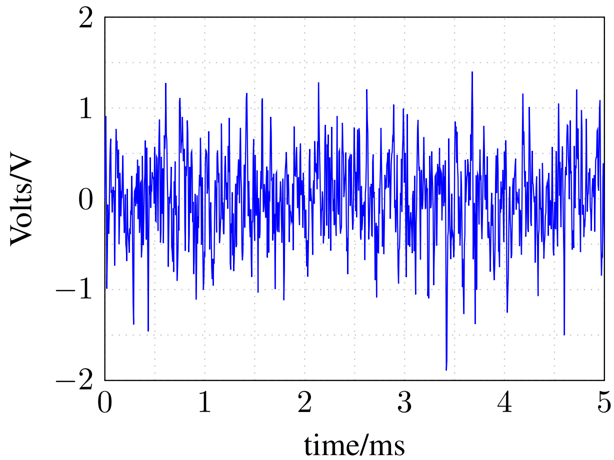



Fig. 46: *White noise observed on* WHT*. The signal amplitude was adjusted on* `TR6` *while utilizing the VU meter.*

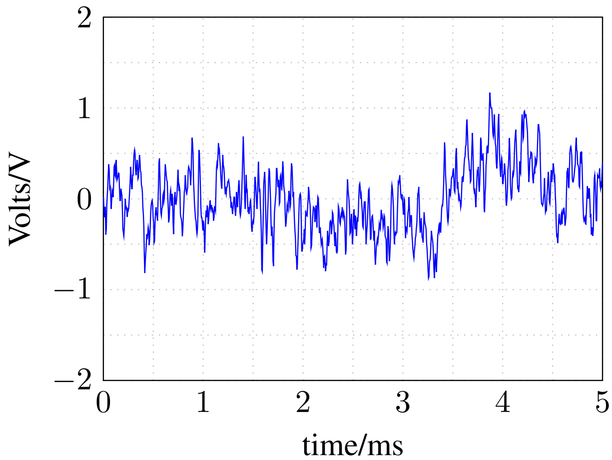



Fig. 47: *Pink noise observed on* PNK*. The signal amplitude was adjusted on* `TR7` *while utilizing the VU meter.*

# 13 Internal Excitation (Right)

## 13.1 Board Assembly

Follow the description for the assembly of the right internal excitation board as described in Section 12. Pay close attention to the bill of materials as this board contains the additional material needed for handling the stereo–to–mono down–mixing.

Follow the calibration procedure described in Section 12.

## 13.2 Board Interconnects

Cable #10 and cable #11 were installed during calibration. Assemble and install cable #14 and cable #15. Follow the description of Section 4.6 and build and install cable #26 and cable #27.

Review the cable installations shown in the table below. The lighter green entries show the cables that were already reviewed previously. The darker green entries are the new additions.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| cable #1 | cable #2 | cable #3 | cable #4 | cable #5 | cable #6 | cable #7 | cable #8 | cable #9 | **cable #10** |
| **cable #11** | cable #12 | cable #13 | **cable #14** | **cable #15** | cable #16 | cable #17 | cable #18 | cable #19 | cable #20 |
| cable #21 | cable #22 | cable #23 | cable #24 | cable #25 | **cable #26** | **cable #27** | cable #28 | cable #29 | cable #30 |
| cable #31 | cable #32 | cable #33 | cable #34 | cable #35 | cable #36 | cable #37 | | | |

Internal excitation is now ready to be used in addition to external excitation fed into Line–In of the carrier preamplifier.

# 14 Voiced/Unvoiced Detector

## 14.1 Board Assembly

Follow the component order shown in Section 3.4 and solder all components.

## 14.2 Mounting

The V/UV detection board is mounted onto the bottom enclosure cover. The four holes on the PCB are sized to fit 3 mm screws. Create the holes according to the template in Fig. 48.

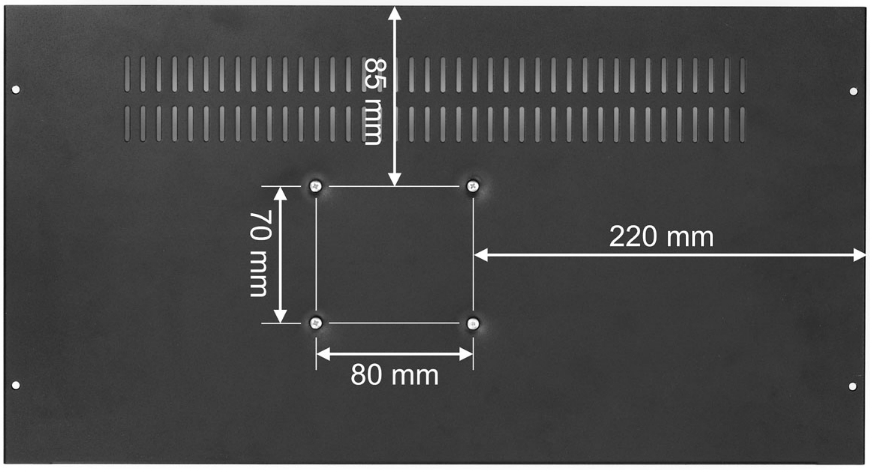



Fig. 48: *Drill hole positions for the V/UV detection board on the enclosure bottom cover. This is the view from the outside face of the cover (the V/UV detection board is later to be placed on the opposite side).*

Once the holes have been drilled, indent the area around the holes to prevent the screws from scratching whatever surface the vocoder is placed on (Fig. 49).

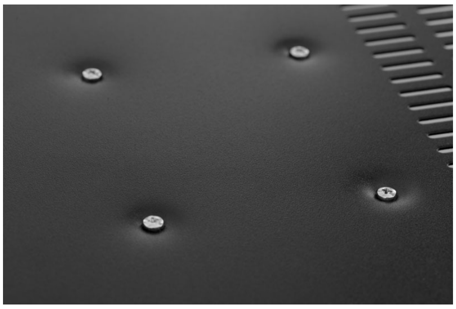


Fig. 49: *3 mm screws embedded in the indented holes. This prevents scratching the surface on which the vocoder is placed. When creating these indentations, avoid warping the steel enclosure cover.*

In the next step, mount the V/UV detection board onto the bottom cover using appropriate plastic spacers that provide enough clearance between the board and the bottom cover. Then use 3 mm screws to fasten the V/UV detection board onto the cover (Fig. 50).

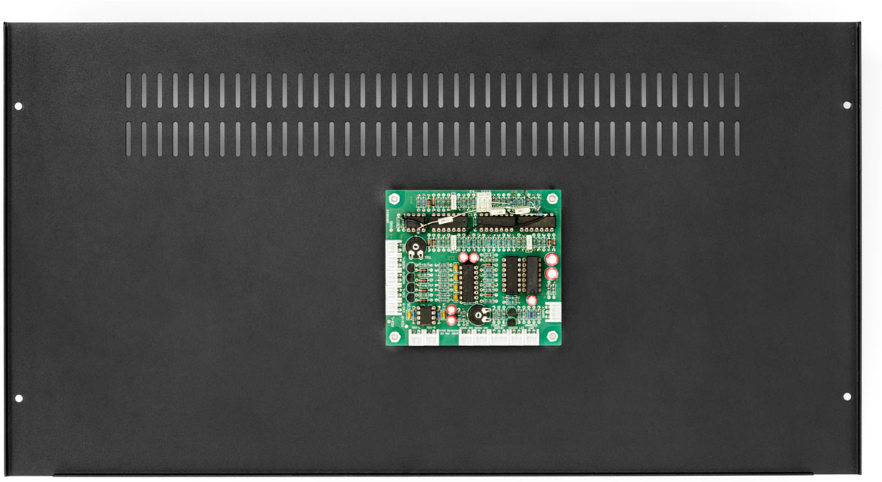


Fig. 50: *The V/UV detection board mounted onto the inside face of the bottom cover.*

## 14.3 Board Interconnects

Now that the V/UV detection board has been built, the carrier preamplifier signals no more need to be fed directly into the output board. These signals have to be routed through the V/UV detection board instead: disconnect cable #4 from header MIX-L on the output board and connect it instead to EXC-L of the V/UV detection board. Similarly, disconnect cable #5 from header MIX-R on the output board and connect it instead to EXC-R of the V/UV detection board. The connections of these two cables should now match the corresponding entry of the table in Section 20.

Continue with the installation of the following cables: cable #1, cable #8, cable #9, cable #12, cable #13, cable #16, cable #17 and cable #19.

For the LEDs and the front panel switch, follow the descriptions in Sections 4.5 and 4.6 and build and install cable #28, cable #32, cable #36 and cable #37.

It is time for a another review of the cables that have been installed so far. The cables highlighted in dark green are the new ones:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **cable #1** | cable #2 | cable #3 | **cable #4** | **cable #5** | cable #6 | cable #7 | **cable #8** | **cable #9** | cable #10 |
| cable #11 | **cable #12** | **cable #13** | cable #14 | cable #15 | **cable #16** | **cable #17** | cable #18 | **cable #19** | cable #20 |
| cable #21 | cable #22 | cable #23 | cable #24 | cable #25 | cable #26 | cable #27 | **cable #28** | cable #29 | cable #30 |
| cable #31 | **cable #32** | cable #33 | cable #34 | cable #35 | **cable #36** | **cable #37** | | | |

## 14.4 Test and Calibration

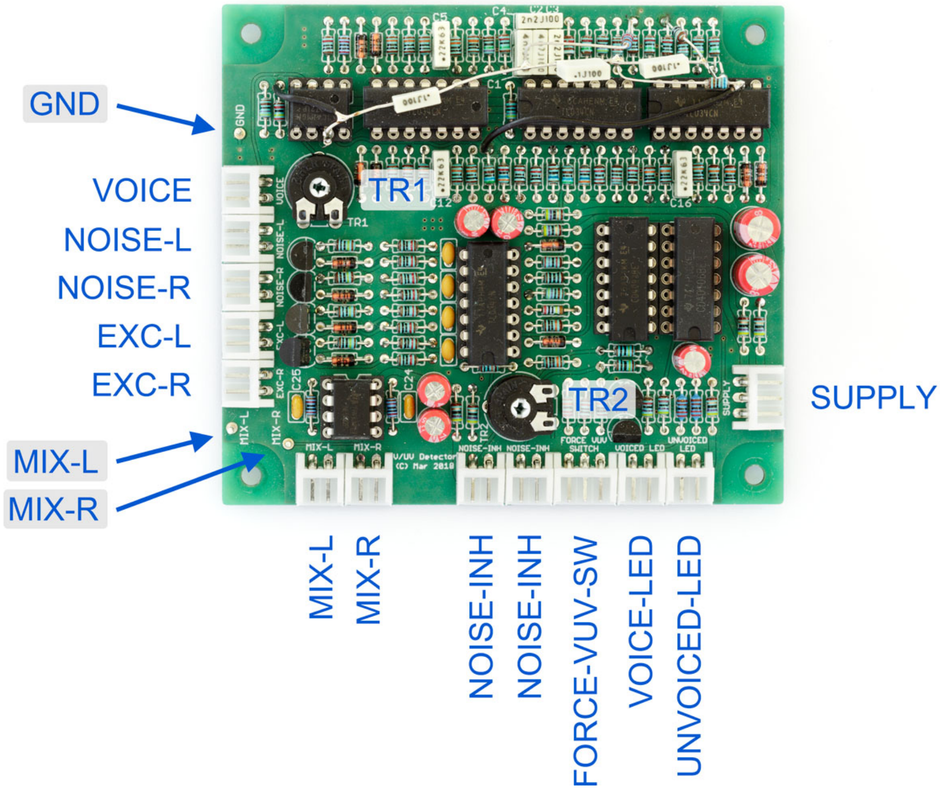



Fig. 51: *Voiced/unvoiced board with headers, trimmers and test pins. Note that this photo shows the prototype with minor last–minute tweaks. These tweaks are fully integrated in the final version of the PCB.*

**Trimmer Description:**

| |
|---|
| `TR1`: Voiced/unvoiced separation<br>`TR2`: Detection trigger adjust |

**Automatic Gain Control Calibration:** For test pins and trimmers related to automatic gain control, refer to Fig. 43 on Page 42.

Perform the following procedure on both internal excitation boards. Changes in the procedure during the second round are shown in square brackets.

1. On the front panel, switch Unvoiced Source to Pink (Fig. 52).
2. Set the three switches in the Mix section on the front panel to Stereo (Carrier, Internal Excitation and Vocoder Output; see Fig. 52).
3. Switch the oscilloscope to AC mode and turn off triggering for the observation of continuous signals.

4. Turn the Level potentiometer of the carrier preamplifier off (fully counter–clockwise). Turn the Osc. Level potentiometers of both internal excitation boards off. Turn the Noise Level potentiometers of both internal excitation boards off.
5. Connect the oscilloscope's ground to GND and the probe to AGC of the left [right] internal excitation board.
6. Turn TR4 on the left [right] internal excitation board fully clockwise.
7. Turn TR4 counter–clockwise and watch the output signal amplitude getting smaller. Continue turning until just to the point where the amplitude does not get any smaller (Figs. 53 and 54).
8. Set the oscilloscope to be triggered by the input signal.
9. Connect the sine wave signal generator to the 6.35 mm Line–In jack of the carrier preamplifier and make sure both audio channels are supplied with the signal.
10. Two oscilloscope channels will be used for the next steps.
11. Connect the oscilloscope's ground to GND and the first probe to Left Ampl [Right Ampl] of the carrier preamplifier board.
12. Set the frequency of the sine wave signal generator to roughly 440 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer on the carrier preamplifier board until the waveform on the oscilloscope shows an amplitude of 1 V. Both yellow LEDs of the carrier preamplifier should be illuminating.
13. Connect the oscilloscope ground to GND of the left [right] internal excitation board.
14. Connect the first probe to PNK of the left [right] internal excitation board. Connect the second probe to AGC of the left [right] internal excitation board. Set the same Volts/Div. on both oscilloscope channels.
15. Adjust TR5 until both signals lie on top of each other (see Figs. 55 and 56).

The AGC control is now tuned to ensure that the volume of unvoiced signals is controlled by the envelope of the corresponding excitation signals, thereby ensuring unvoiced signals aren't much louder or quieter than the voiced signals.

**Signal Path Check:**

Keep the setup established from the previous process for AGC calibration. Perform the following procedure on both internal excitation boards:

1. Connect the power supply header of the V/UV detection board with the power supply.
2. Connect the oscilloscope's ground to GND and the probe to MIX-L [MIX-R] of the V/UV detection board.
3. On the front panel, switch V/UV Detect to Carrier Only.
4. The signal on the oscilloscope should show the sine wave with an amplitude of 1 V.
5. On the front panel, switch V/UV Detect to Noise Only.
6. The signal on the oscilloscope should show pink noise.

Disconnect the sine wave signal generator.

**V/UV Detection Calibration:**

To prepare for the calibration of voice/unvoiced detection, the vocoder will be set up for actual vocoding purposes.

- Plug an audio amplifier in the Vocoder Out jack so you can listen to the vocoding results.
- On the front panel, set the V/UV Detect switch to Carrier/Noise. On the front panel, set the Unvoiced Source switch to Pink (Fig. 52).
- Turn `TR2` on the V/UV detection board fully counter–clockwise.
- Use spoken text to feed Line–In of the voice preamplifier and tune Level to reasonably high audio levels by using the VU meter as a reference. Listen to the voice preamplifier input by turning Voice Mix temporarily up to make sure the spoken text is fed through to the Vocoder Out jack.
- The signal fed into the voice amplifier needs to be free of noise such as background music. An appropriate talk radio station is a good source.
- Turn Voice Mix off.
- Turn the Level potentiometers of both internal excitation boards up (fully clockwise) and turn the Coarse Freq. potentiometers for appropriate frequencies as carrier input for good vocoding results. The VU meter should show both yellow LEDs illuminating.
- You should hear regular vocoding, probably with incorrect detection of voiced and unvoiced sounds. If you do not hear a vocoded signal, check that the Channel Level potentiometers for the 18 channel filters are turned clockwise.
- Adjust `TR1` of the V/UV detection board for a proper distinction of voiced and unvoiced sounds. Listen to the results and watch the voiced and unvoiced LEDs.
- Turn the Level potentiometer of the voice preamplifier off (fully counter–clockwise).
- Slowly turn `TR2` clockwise until the voiced LED turns off.

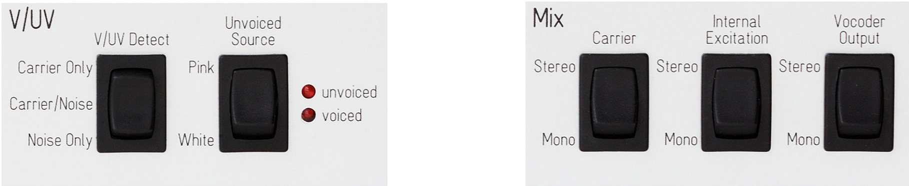



Fig. 52: *Initial switch settings for AGC and V/UV detection calibration.*

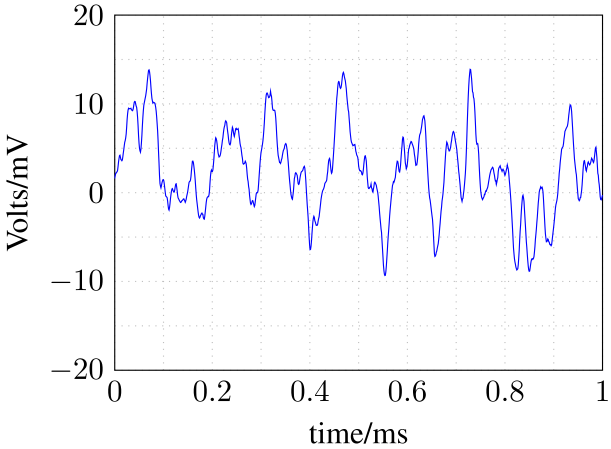



Fig. 53: *Noise breakthrough before a well–adjusted AGC level.*

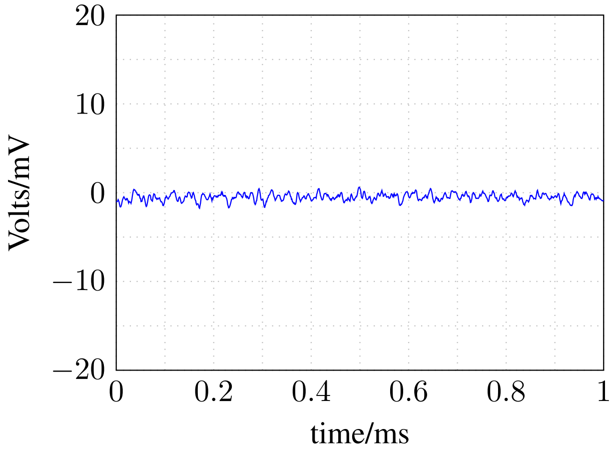



Fig. 54: *Minimized noise after* `TR4` *was turned just to the point where no further reduction is observed.*

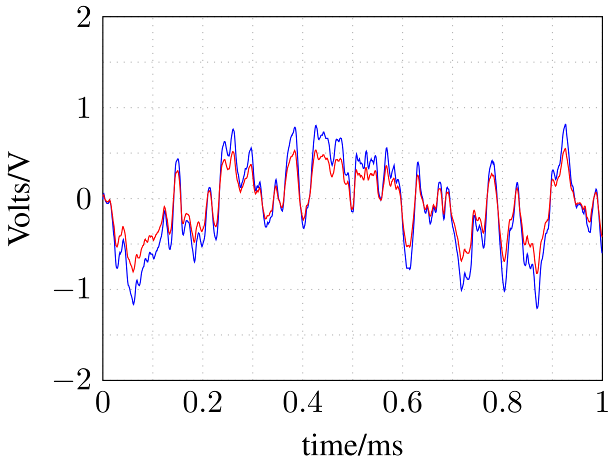



Fig. 55: *Poorly tuned AGC level. The signals of the two channels do not lie on top of each other.*

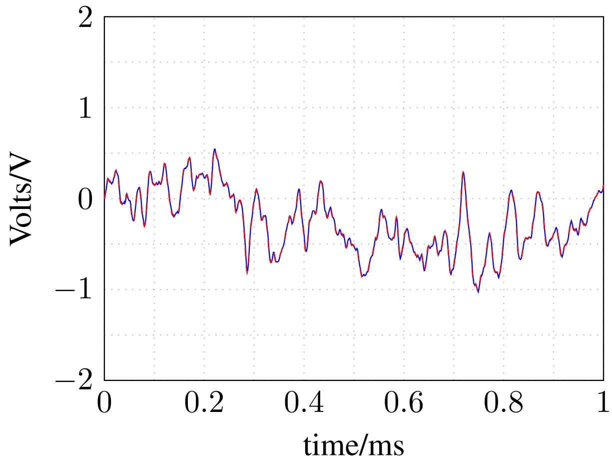



Fig. 56: *Well tuned AGC level.*

# 15 Slew/Freeze Control

## 15.1 Board Assembly

Follow the component order shown in Section 3.4 and solder all components.

Snap the anti–rotation tags off the potentiometers. For soldering the jacks and the potentiometer, use the front panel as a template. The pot and the 6.35 mm jacks should sit firmly on the PCB surface. Similar to the channel filter board, the 3.5 mm jack will stick out by about 1 mm.

Assemble the tempco R7 (2 kΩ, 3300 ppm/°C) in a way that the two transistors T1 and T2 touch the tempco as shown in Fig. 57. You may want to put some thermal paste between the tempco and the two transistors for improved thermal conductance.

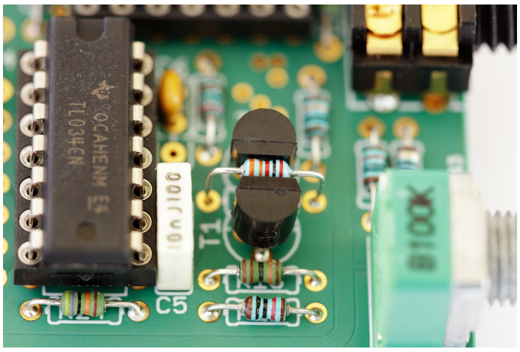



Fig. 57: *Closeup view of the tempco sandwiched between transistors* T1 *and* T2.

## 15.2 Front Panel Mounting

Once the board is assembled, mount the PCB onto the front panel using the appropriate nuts. The board is held onto the front panel by the corresponding potentiometer and jack nuts. In addition, place appropriate spacers underneath the 3 mm holes. Glue them onto the PCB but do not fasten them onto the bottom enclosure cover.

The attack switch, unlike all other switches, is active off (see also Section 4.6).

## 15.3 Board Interconnects

Assemble and install the following cables: cable #3, cable #18, cable #20, cable #29, cable #30, cable #33 and cable #34. For the LED and switch assembly, refer to Sections 4.5 and 4.6.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| cable #1 | cable #2 | **cable #3** | cable #4 | cable #5 | cable #6 | cable #7 | cable #8 | cable #9 | cable #10 |
| cable #11 | cable #12 | cable #13 | cable #14 | cable #15 | cable #16 | cable #17 | **cable #18** | cable #19 | **cable #20** |
| cable #21 | cable #22 | cable #23 | cable #24 | cable #25 | cable #26 | cable #27 | cable #28 | **cable #29** | **cable #30** |
| cable #31 | cable #32 | **cable #33** | **cable #34** | cable #35 | cable #36 | cable #37 | | | |

Cable assembly and installation is now completed. Cable #35 will not be built. The corresponding socket was initially reserved for an LED to indicate silence bridging somewhere on the front panel but this LED was later integrated into the output board.

## 15.4 Test and Calibration

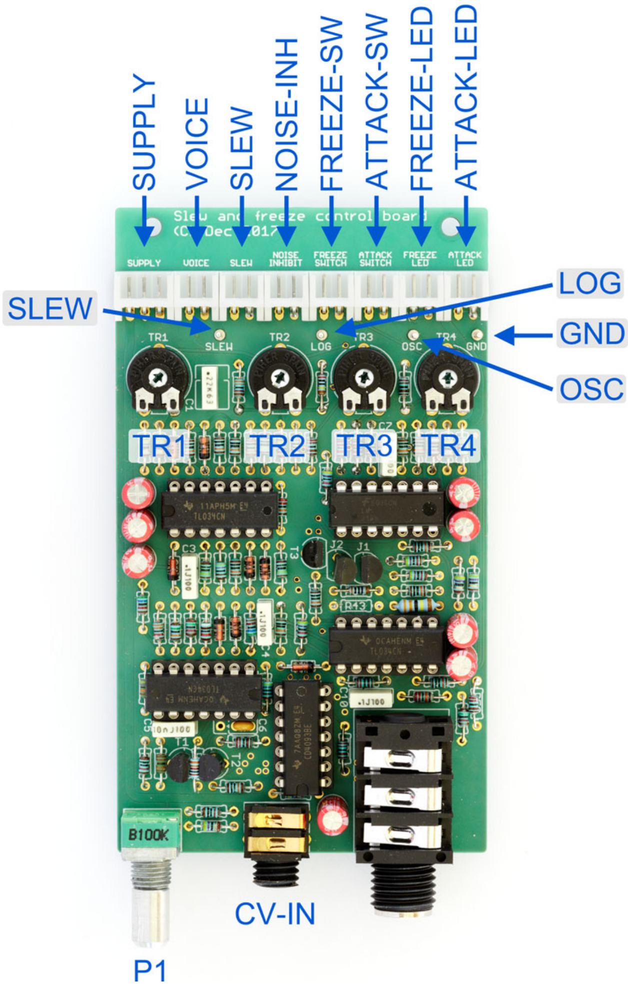



Fig. 58: *Slew/freeze board with headers, trimmers and test pins.*

**Trimmer Description:**

TR1: Logarithmic converter output amplitude on LOG
TR2: Slew off threshold
TR3: Freeze detect threshold
TR4: Oscillator level adjust on OSC

NOTE: For the slew and freeze board calibration, make sure the vocoder is completely cooled off. If the vocoder is turned on, turn it off and wait for a least one hour for the vocoder to cool down.

**Freeze Detection:**

1. Unplug all cables from the front panel.
2. Turn the Level potentiometer on the voice preamplifier off (fully counter–clockwise).

3. On the front panel in the V/UV section, switch V/UV Detect to Carrier Only.
4. On the front panel in the Slew section, switch Attack Detect off and turn Rate to slow (fully counter–clockwise).
5. If the Freeze LED on the front panel is illuminating, turn TR3 on the slew/freeze board clockwise until the LED is off.
6. Slowly turn TR3 counter–clockwise until the Freeze LED is illuminating.
7. When turning Rate slowly clockwise, the LED should turn off. Once off, hit the momentary Freeze switch and confirm that the Freeze LED turns on.

**Slew–Off Detection:**

1. Switch the oscilloscope to DC mode for the observation of absolute voltages and offsets, and turn off triggering. With the probe connected to oscilloscope ground, it should be calibrated for a reading of 0 V.
2. Set Time/Div. to 1 ms on the oscilloscope.
3. Connect oscilloscope ground to GND and the probe to SLEW of the slew/freeze board.
4. Turn Rate to Slow (fully counter–clockwise). The Freeze LED should be on. The signal on SLEW should read 0 V.
5. Turn Rate to Fast.
6. If the DC signal on SLEW is showing roughly 12 V, turn `TR2` clockwise until either 0 V or needle pulses are observed.
7. Slowly turn `TR2` counter–clockwise until SLEW shows a DC level of 12 V.

**Oscillator Check:**

1. Connect the probe to OSC. The signal as shown in Fig. 59 should be observed. The bottom of the signal should be near 0 V.

**Needle Pulse Calibration (near freeze):**

1. Connect the probe to SLEW.
2. Turn Rate off and slowly turn it clockwise until the Freeze LED has just turned off.
3. Turn `TR4` fully counter–clockwise. The signal observed on the oscilloscope should be 0 V.
4. Slowly turn `TR4` clockwise until the onset of needle pulses is observed.

**Needle Pulse Calibration (near fast):**

1. Turn Rate fully clockwise. The signal observed on SLEW should be constant 12 V. Slowly turn Rate counter–clockwise until the signal on SLEW starts showing needle pulses.
2. Turn `TR1` for a pulse width of about 40 µs (Fig. 61).

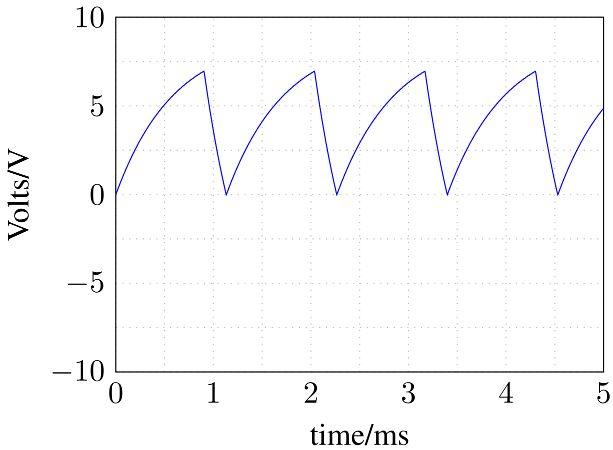



Fig. 59: *Sawtooth observed on* OSC *of the slew/freeze board.*

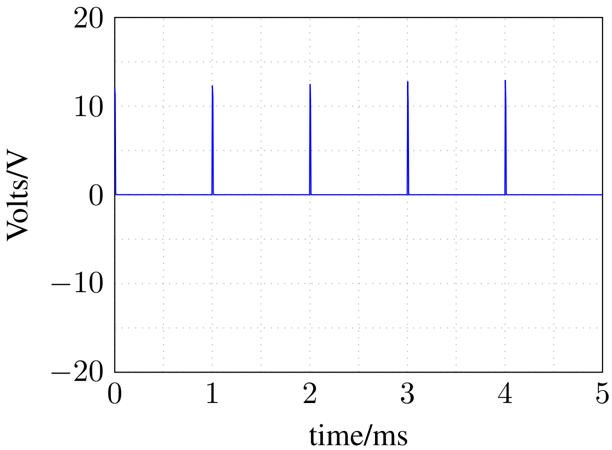



Fig. 60: *Fine needle pulses observed on* SLEW.

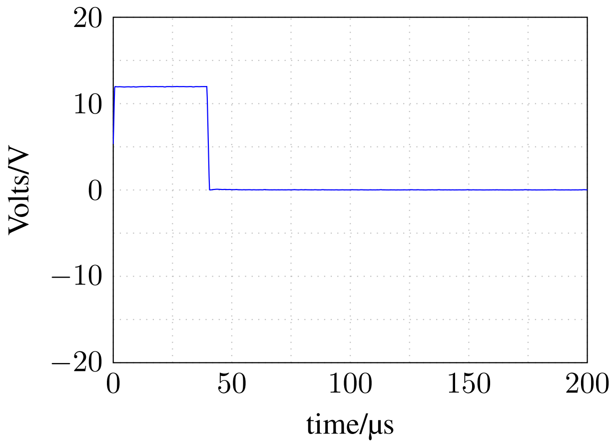



Fig. 61: *Pulse length observed on* SLEW *for fast slew rate setting.*

# 16 Back Panel Mounting

Prepare the back panel with mounting holes as shown in Fig. 62. The four holes in the square pattern should each have a diameter of 3.1 mm. The hole for the power jack should be sized 5.1 mm.

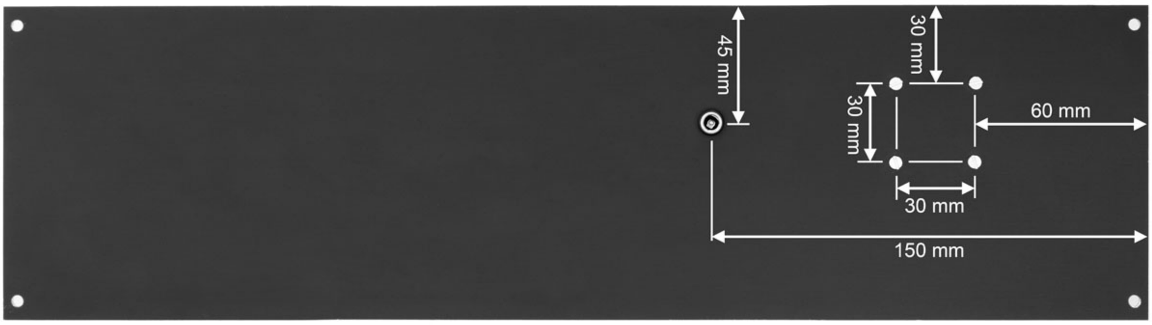



Fig. 62: *Drill hole positions for the power supply board on the back panel. This is the view from the outside face of the cover (the power supply board is later to be placed on the opposite side).*

Mount the power supply using 3.0 mm screws with a length of about 25 mm as shown in Fig. 63. Do not tighten the screws too much to prevent bending the PCB. Insert and fasten the power jack. Shorten the supply cables to a reasonable length and screw them into the power block while observing the proper polarity.

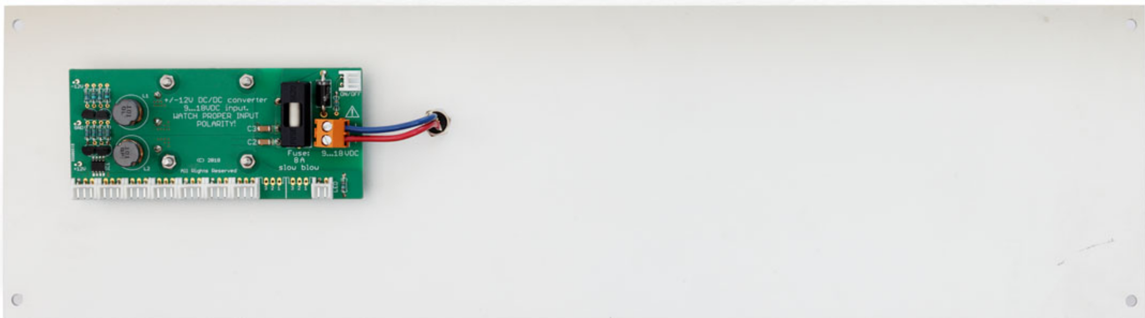


Fig. 63: *The power supply mounted onto the inward facing side of the back panel.*

Connect all the individual boards with the power supply.

Connect ground of the power supply to the vocoder enclosure by connecting the ground test pin to one of the screws holding the power supply board.

Mount the pack panel onto the vocoder enclosure.

# 17 Remaining Vocoder Calibration and Fine–Tuning

## 17.1 Final Output Board Calibration

Throughout the final output board calibration, on the front panel in the Slew section, Rate must be turned to Fast (fully clockwise). For test pins and trimmers, refer to Fig. 27 on Page 30.

### 17.1.1 Vocoder Filter Level Calibration

- On the front panel, turn the Filter Level potentiometer of the 500 Hz channel filter completely on (fully clockwise).
- Switch the oscilloscope to AC mode.
- Connect the oscilloscope's ground to GND and the probe to Left Ampl. of the voice preamplifier board.
- Set the frequency of the sine wave signal generator to 500 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer (`P1`) on the board until the oscilloscope shows a sine wave with an amplitude of 1 V. Make sure the displayed waveform is a proper sine wave that is clipped neither at the top nor at the bottom.
- the LED of the 500 Hz channel filter board should be illuminating.
- Connect the oscilloscope's ground to GND and the probe to FLTR of the output board.
- Adjust `TR3` (`FILTER`) until the signal amplitude is at 3.5 V. This is the amplitude for studio output levels. If you prefer consumer output levels, adjust `TR3` for 1 V amplitude instead.

### 17.1.2 Vocoder Output Level Calibration

Perform the process described below for both audio channels. Changes in the procedure during the second round are shown in square brackets. For the calibration it is expected that the 500 Hz channel board is configured for the left audio channel and the 640 Hz channel board is configured for the right audio channel. Otherwise select appropriate frequencies for the two audio channels in the description below.

- On the front panel in the Mix section, set the three switches to Stereo (Carrier, Internal Excitation and Vocoder Output).
- On the front panel in the V/UV section, switch V/UV Detect to Carrier Only.
- On the front panel in the Internal Excitation section, turn both the Osc. Level potentiometers off (fully counter–clockwise). Also turn both the Noise Level potentiometers off.
- On the front panel in the Channel Filter Control section, turn the Channel Level potentiometer of the 500 Hz [640 Hz] Channel Filter completely on (fully clockwise).
- Switch the oscilloscope to AC mode.
- Connect the sine wave signal generator to the 6.35 mm Line–In jack of the voice preamplifier.
- Connect the oscilloscope's ground to GND and the probe to Left Ampl. of the voice preamplifier board.

- Set the frequency of the sine wave signal generator to 500 Hz [640 Hz]. Adjust the volume of the sine wave signal generator and/or the Level potentiometer (P1) of the voice preamplifier until the oscilloscope shows a sine wave with an amplitude of 400 mV. Make sure the displayed waveform is a proper sine wave that is clipped neither at the top nor at the bottom (Fig. 24).
- The LED of the 500 Hz [640 Hz] channel filter board should be illuminating.
- In **addition** to the voice preamplifier, connect the sine wave generator to the 6.35 mm Line–In jack of the carrier preamplifier.
- Connect the oscilloscope's ground to GND and the probe to Left Ampl. [Right Ampl.] of the carrier preamplifier board.
- Adjust the volume of the sine wave signal generator and/or the Level potentiometer (P1) of the carrier preamplifier until the oscilloscope shows a sine wave with an amplitude of 400 mV.
- Connect the oscilloscope's ground to GND and the probe to VC-L [VC-R] of the output board.
- Adjust TR1 (SYNTH-L) [TR2 (SYNTH-R)] until the signal amplitude is at 3.5 V. This is the amplitude for studio output levels. If you prefer consumer output levels, adjust TR1 (SYNTH-L) [TR2 (SYNTH-R)] for a 1 V amplitude instead.

### 17.1.3 Silence Bridging Level Calibration

**Envelope Follower:**

1. Connect the sine wave signal generator to the 6.35 mm Line–In jack of the voice preamplifier.
2. Switch the oscilloscope to DC mode for the observation of absolute voltages and offsets, and turn off triggering. With the probe connected to oscilloscope ground, it should be calibrated for a reading of 0 V.
3. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
4. Set the frequency of the sine wave signal generator to roughly 440 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer for an amplitude of 1 V of a proper, unclipped waveform.
5. The yellow LED of the voice preamplifier VU meter should be illuminating.
6. Switch the oscilloscope to DC mode for the observation of absolute voltages and offsets, and turn off triggering. With the probe connected to oscilloscope ground, it should be calibrated for a reading of 0 V.
7. Connect ground of the oscilloscope to GND and the probe to ENV of the output board.
8. Adjust trimmer TR6 on the output board for a level of −5 V.

**Channel Filter Activation:**

1. On the front panel, turn the Level potentiometer of the voice preamplifier off (fully counter–clockwise).
2. Turn the S. Bridging potentiometer off.
3. Connect the probe to SBSW.

4. If the reading on the oscilloscope is not already roughly 11 V, turn TR10 counter–clockwise until this is the case.
5. Slowly turn TR10 clockwise until the reading on SBSW is 0 V.

**Silence Bridging Activation:**

1. On the front panel, turn the Level potentiometer of the voice preamplifier off (fully counter–clockwise).
2. Turn the S. Bridging potentiometer off.
3. If the silence bridging LED is off, turn TR9 counter–clockwise until it is illuminating.
4. Turn TR9 slowly clockwise until the LED is no more illuminating.
5. If you turn the S. Bridging potentiometer slightly clockwise, the LED will illuminate and SBSW will jump from 0 V to roughly 11 V.
6. Turn the S. Bridging potentiometer off again.
7. With the signal generator still connected to the voice preamplifier, if you turn up the volume with the first three or four green LEDs illuminating, SBSW will stay at 0 V and the silence bridging LED is still off. Now turn the S. Bridging potentiometer slowly clockwise. The voltage on SBSW will jump to roughly 11 V early and the silence bridging LED will turn on at a later threshold depending on the amplitude of the signal on the voice preamplifier input.

**Silence Bridging Offset Cancellation:**

1. Connect the oscilloscope probe with BR of the output board.
2. Turn the S. Bridging potentiometer off (fully counter–clockwise). The silence bridging LED should be off.
3. Set Volts/Div. very low, such as 10 mV/Div.
4. Adjust TR8 until the DC voltage reading on the oscilloscope is 0 V.

**Silence Bridging Volume Adjustment:**

1. On the front panel in the Output section, turn Voice Mix and Carrier Mix off (fully counter–clockwise).
2. Turn the Level potentiometer of the carrier preamplifier off.
3. Leave the oscilloscope probe on BR.
4. Turn the S. Bridging off (fully counter–clockwise). The silence bridging LED should be off.
5. Set the vocoder up for regular vocoding:
   (a) Plug an audio amplifier in the Vocoder Out jack so you can listen to the vocoding results.
   (b) On the front panel, set the V/UV Detect switch to Carrier/Noise and set the Unvoiced Source switch to Pink.

   (c) Use spoken text to feed Line–In of the voice preamplifier and tune Level to reasonably high audio levels by using the VU meter as a reference.
   (d) The signal fed into the voice amplifier needs to be free of noise such as background music. An appropriate talk radio station is a good source.
   (e) Turn the Level potentiometers of both internal excitation boards up (fully clockwise) and turn the Coarse Freq. potentiometers for appropriate frequencies as carrier input for good vocoding results. The VU meter should show both yellow LEDs illuminating.

6. As a starting point, turn TR7 for a DC reading of about -1.5 V.
7. Turn the S. Bridging potentiometer on (fully clockwise). The silence bridging LED should be illuminating.
8. Listen to the vocoder and adjust TR7 for a smooth transition between silent and busy periods.

## 17.2 Channel Filter Fine–Tuning

For test pins and trimmers on the channel filter boards, refer to Fig. 34 on Page 37.

**Preparation:**

1. Power up the vocoder and let it warm up for a minimum of 30 minutes.
2. On the front panel:
   - In the Mix section, set the three switches to Stereo (Carrier, Internal Excitation and Vocoder Output).
   - In the V/UV section, set Unvoiced Source to Pink and V/UV Detect to Carrier Only.
   - In the Slew section, switch Attack Detect off.
3. Turn the following potentiometers off (fully counter–clockwise):
   - In the Output section: Voice Mix, Carrier Mix, S. Bridging
   - In the Internal Excitation section: Osc. Level and Noise Level on both internal excitation boards.
   - In the Carrier section: Level.
4. In the Slew section, turn Rate to Fast (fully clockwise).
5. In the Channel Filter Control section, turn the Filter Level on all 18 channel filters completely on (fully clockwise).
6. Unplug all cables from the front panel.

#### 17.2.1 Channel Filter Recalibration

1. The frequencies on the front panel are rounded values. For the more accurate frequency setting of the sine wave signal generator, use the following table during the upcoming calibration description:

| Panel frequency (Hz): | 120 | 150 | 190 | 240 | 310 | 390 | 500 | 640 | 810 |
|---|---|---|---|---|---|---|---|---|---|
| Test frequency (Hz): | 119 | 151 | 192 | 243 | 309 | 393 | 500 | 636 | 808 |
| Panel frequency (Hz): | 1000 | 1300 | 1700 | 2100 | 2700 | 3400 | 4300 | 5500 | 7000 |
| Test frequency (Hz): | 1030 | 1310 | 1660 | 2110 | 2680 | 3410 | 4330 | 5500 | 7000 |

2. Switch the oscilloscope to AC mode. Set the oscilloscope to be triggered by the input signal.
3. Connect the sine wave signal generator to the 6.35 mm Line–In jack of the voice preamplifier.
4. If a sine wave function generator is available that holds output levels stable at the required frequency range of 120 Hz to 7 kHz (usually given with the use of a smartphone app), continue with the description of "Calibration procedure: stable sine wave generator amplitude".
5. If the sine wave generator output amplitude across frequencies is uncertain, continue with the description "Calibration procedure: unknown sine wave generator amplitude stability".

**Calibration procedure: stable sine wave generator amplitude**

1. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
2. Set the frequency of the sine wave signal generator to 500 Hz. Adjust the volume of the sine wave signal generator and/or the Level potentiometer for an amplitude of 1 V of a proper, unclipped waveform.
3. The yellow LED of the voice preamplifier VU meter should be illuminating.
4. Connect the ground clip of the oscilloscope to GND and the probe to FLTR of the output board (**not** the filter board).
5. For each frequency shown on the front panel do the following:
   (a) Select the test frequency from the table above and set the sine wave generator frequency accordingly.
   (b) The LED of the corresponding channel filter board should be illuminating.
   (c) Adjust `TR3` on this board for an amplitude of 3.5 V (or 1 V if consumer output levels are preferred).

**Calibration procedure: unknown sine wave generator amplitude stability**

If an oscilloscope is available that allows the proper determination of amplitudes (or peak–to–peak values) of two channels simultaneously, set up the probes for two channels for Steps 1 and 5 below to speed up recalibration.

For each frequency shown on the front panel do the following:

1. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
2. Set the frequency of the sine wave signal generator to the test frequency selected from the table above. Adjust the volume of the sine wave signal generator and/or the Level potentiometer for an amplitude of 1 V of a proper, unclipped waveform.
3. The yellow LED of the voice preamplifier VU meter should be illuminating.
4. The LED of the corresponding channel filter board should be illuminating.
5. Connect the ground clip of the oscilloscope to GND and the probe to FLTR of the output board.
6. Adjust `TR3` on this board for an amplitude of 3.5 V (or 1 V if consumer output levels are preferred).

### 17.2.2 Control Voltage Level Recalibration

1. The frequencies on the front panel are rounded values. For the more accurate frequency setting of the sine wave signal generator, use the following table during the upcoming calibration description:

| Panel frequency (Hz): | 120 | 150 | 190 | 240 | 310 | 390 | 500 | 640 | 810 |
|---|---|---|---|---|---|---|---|---|---|
| Test frequency (Hz): | 119 | 151 | 192 | 243 | 309 | 393 | 500 | 636 | 808 |

| Panel frequency (Hz): | 1000 | 1300 | 1700 | 2100 | 2700 | 3400 | 4300 | 5500 | 7000 |
|---|---|---|---|---|---|---|---|---|---|
| Test frequency (Hz): | 1030 | 1310 | 1660 | 2110 | 2680 | 3410 | 4330 | 5500 | 7000 |

2. Turn the Channel Level potentiometers of all 18 channels completely on (fully clockwise).
3. Switch the oscilloscope to DC mode for the observation of absolute voltages and offsets, and turn off triggering. With the probe connected to oscilloscope ground, it should be calibrated for a reading of 0 V.
4. Connect the sine wave signal generator to the 6.35 mm Line–In jack of the voice preamplifier.
5. If a sine wave function generator is available that holds output levels stable at the required frequency range of 120 Hz to 7 kHz (usually given with the use of a smartphone app), continue with the description of "Calibration procedure: stable sine wave generator amplitude".
6. If the sine wave generator output amplitude across frequencies is uncertain, continue with the description "Calibration procedure: unknown sine wave generator amplitude stability".

**Calibration procedure: stable sine wave generator amplitude**

1. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
2. Set the frequency of the signal generator to 500 Hz. Adjust the volume of the sine wave generator and/or the Level potentiometer for an amplitude of 400 mV (**not** 1 V) of a proper, unclipped waveform.
3. For each frequency shown on the front panel do the following:
   (a) Select the test frequency from the table above and set the sine wave generator frequency accordingly.
   (b) The LED of the channel filter board should be illuminating.
   (c) Connect the ground clip of the oscilloscope to GND and the probe to CV of the channel filter board under test.
   (d) Adjust `TR2` for a signal level of +5 V.

**Calibration procedure: unknown sine wave generator amplitude stability**

For each frequency shown on the front panel do the following:

1. Connect the ground clip of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
2. Set the frequency of the sine wave signal generator to the test frequency selected from the table above. Adjust the volume of the sine wave generator and/or the Level potentiometer for an amplitude of 400 mV (**not** 1 V) of a proper, unclipped waveform.
3. The LED of the channel filter board should be illuminating.
4. Connect the ground clip of the oscilloscope to GND and the probe to CV of the channel filter board.
5. Adjust `TR2` for a signal level of +5 V.

### 17.2.3 Synthesis Output Recalibration

1. In the Channel Filter Control section, turn the Channel Level potentiometers on all 18 channels completely on (fully clockwise).
2. Switch the oscilloscope to AC mode. Set the oscilloscope to be triggered by the input signal.
3. Connect the sine wave signal generator to the 6.35 mm Line–In jacks of both the voice preamplifier and the carrier preamplifier.
4. The frequencies on the front panel are rounded values. For the more accurate frequency setting of the sine wave signal generator, use the following table:

| Panel frequency (Hz): | 120 | 150 | 190 | 240 | 310 | 390 | 500 | 640 | 810 |
|---|---|---|---|---|---|---|---|---|---|
| Test frequency (Hz): | 119 | 151 | 192 | 243 | 309 | 393 | 500 | 636 | 808 |

| Panel frequency (Hz): | 1000 | 1300 | 1700 | 2100 | 2700 | 3400 | 4300 | 5500 | 7000 |
|---|---|---|---|---|---|---|---|---|---|
| Test frequency (Hz): | 1030 | 1310 | 1660 | 2110 | 2680 | 3410 | 4330 | 5500 | 7000 |

5. If a sine wave function generator is available that holds output levels stable at the required frequency range of 120 Hz to 7 kHz (usually given with the use of a smartphone app), continue with the description of "Calibration procedure: stable sine wave generator amplitude".
6. If the sine wave generator output amplitude across frequencies is uncertain, continue with the description "Calibration procedure: unknown sine wave generator amplitude stability".

*Calibration procedure: stable sine wave generator amplitude*

1. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
2. Set the frequency of the signal generator to 500 Hz. Adjust the volume of the sine wave generator and/or the Level potentiometer for an amplitude of 400 mV (**not** 1 V) of a proper, unclipped waveform.
3. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the carrier preamplifier board.
4. Keep the volume and the frequency of the signal generator unchanged. Adjust the volume on the Level potentiometer for an amplitude of 400 mV (**not** 1 V) of a proper, unclipped waveform.
5. For each frequency shown on the front panel do the following:
   (a) Set the frequency of the sine wave signal generator to the test frequency selected from the table above.
   (b) The LED of the corresponding channel filter board should be illuminating.
   (c) Connect ground of the oscilloscope to GND and the probe either to VC-L or VC-R of the output board, depending for which audio channel the board was configured.
   (d) Adjust `TR1` on the channel board for an amplitude of 3.5 V (or 1 V if consumer output levels are preferred).

*Calibration procedure: unknown sine wave generator amplitude stability*

For each frequency shown on the front panel do the following:

1. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the voice preamplifier board.
2. Set the frequency of the sine wave signal generator to the test frequency selected from the table above. Adjust the volume of the sine wave generator and/or the Level potentiometer for an amplitude of 400 mV (**not** 1 V) of a proper, unclipped waveform.
3. The LED of the corresponding channel filter board should be illuminating.
4. Connect ground of the oscilloscope to GND and the probe to Left Ampl. of the carrier preamplifier board.
5. Keep the volume and the frequency of the signal generator unchanged. Adjust the volume on the Level potentiometer for an amplitude of 400 mV (**not** 1 V) of a proper, unclipped waveform.
6. Connect ground of the oscilloscope to GND and the probe either to VC-L or VC-R of the output board, depending for which audio channel the board was configured.
7. Adjust `TR1` on the channel board for an amplitude of 3.5 V (or 1 V if consumer output levels are preferred).

#### 17.2.4 Excitation Bleedthrough Recalibration

1. Turn the Level potentiometer of the voice preamplifier completely off (fully counter–clockwise).
2. Switch the oscilloscope to AC mode. Set Time/Div. to 5 µs and Volts/Div. to 10 mV or lower.
3. Connect the sine wave signal generator to the 6.35 mm Line–In jack of the carrier preamplifier. For each frequency shown on the front panel do the following:
   (a) Set the sine wave generator frequency to the channel filter frequency shown on the front panel. High accuracy is not required.
   (b) Turn the carrier preamplifier volume to 0 dB (both yellow LEDs illuminating). An exact setting of 0 dB is not crucial.
   (c) Connect ground of the oscilloscope to GND and the probe to CHOP of the channel filter board.
   (d) Turn the Channel Level potentiometer off (fully counter–clockwise) and adjust `TR4` for no signal bleedthrough on CHOP by looking for best possible alignment of the horizontal part of the signal. See Fig. 40 and Fig. 41 for an illustration of the calibration procedure.
   (e) Turn the Channel Level potentiometer `P1` fully clockwise and adjust `TR5` for no signal bleedthrough on CHOP and follow the procedure as described in the previous step.

## 17.3 1 V/Oct. Calibration

For test pins and trimmers, refer to Fig. 43 on Page 42.

**Preparation:**

1. Power on the vocoder and let it warm up for a minimum of 30 minutes. During calibration, avoid air blowing past the boards as the tempcos will react faster than the silicon hidden inside the IC packages.
2. Disconnect any cable from the front panel.
3. On the front panel in the Output section, turn Voice Mix and Carrier Mix off (fully counter–clockwise).
4. On the front panel in the Internal Excitation section, turn both Osc. Level potentiometers off.
5. Use an electronic keyboard with MIDI output and connect it via a MIDI cable to a MIDI–to–CV converter.
6. Connect the 6.35 mm Vocoder Out jack to an audio amplifier. Position your smartphone close to the loudspeakers driven by the audio amplifier. Start the tuning app and set it to listen via the smartphone's microphone.

**Calibration Procedure:**

Perform the following procedure on both internal excitation boards. Changes in the procedure during the second round are shown in square brackets.

1. Connect the CV output of the MIDI–to–CV converter to the left [right] 3.5 mm CV jack on the excitation board.
2. Turn up Osc. Level on the left [right] excitation board until the yellow LED on the corresponding VU meter is illuminating.
3. Turn up the Carrier Mix to a reasonable volume for the smartphone to solidly pick up the tone generated by the vocoder's built–in excitation.
4. Turn `TR2` (high frequency compensation) fully counter–clockwise. Turn Coarse Freq. fully counter–clockwise. Turn Fine Freq. roughly to the center.
5. Play note A2 (110 Hz) on the keyboard. Turn Coarse Freq. until the tuner reads roughly 110 Hz and tune Fine Freq. to get as close to the 110 Hz as possible. If Coarse Freq. was too far off from the 110 Hz, continue adjusting the frequency by using Coarse Freq. and Fine Freq. until 110 Hz have been reached within ±0.1 Hz.
6. Play note A5 (880 Hz). Adjust `TR1` to get to 880 Hz as close as possible.
7. Play note A2 (110 Hz). Readjust Fine Freq. to 110 Hz and use Coarse Freq. in case the limits with Fine Freq. have been reached.
8. Repeat steps 6 and 7 until a good correspondence of the two frequencies 110 Hz and 880 Hz has been reached.
9. Play through A2 (110 Hz), A3 (220 Hz), A4 (440 Hz) and A5 (880 Hz) and check how well the frequencies match. You may have to go back to steps 6 and 7 and use your best judgment to get as close as possible to all frequencies.

10. Next hit key A7 (3520 Hz) and adjust `TR2`. Check A1 through A6. If the frequencies are satisfactory for the notes A1 through A7, the 1 V/Oct. calibration is done. Otherwise repeat from step 6. It may not be necessary to go all the way to A7 as high frequencies are not conducive to intelligible vocoding anyway.

# 18 Final Assembly

Put the top enclosure cover on the enclosure and fasten the screws. Be careful when positioning the top cover as it is hitched into the notches of the 18 channel filter boards. This ensures rigidity of the vocoder build and prevents bending the front panel when the various plugs are removed.

In case the vocoder enclosure is to be reopened later, it is important that the cover is lifted straight up so as not to exert stress onto the channel filter boards. You may want to place a corresponding label as a reminder on the top cover.

# 19 Addendum: Alternative Power Supply

## 19.1 A Word of Caution

If you have the competence and the license for constructing and assembling power supply systems, you may prefer this power supply board over the one shown in Section 7. **If you choose to assemble the alternative power supply, you must read and agree to the disclaimer at the beginning of this document!**

Specific instructions on laying out an appropriate system based on this power supply are intentionally omitted. This is your responsibility. If you build the system around this power supply, take all necessary precautions and consider the following:

- Proper earthing of metal parts.
- Isolating exposed metal parts.
- Preventing exposure of persons to lethal electricity.
- Using properly sized and isolated wiring.
- Running mains power safely through a metal enclosure while keeping in mind
  - Potential shorting or loosening of wires
  - Mechanical impact
  - Humidity and entry of water
  - Thermal aspects such as heat dissipation and overheating
  - Flame retardant
  - Vibration
  - Wear and tear
- Adding an easily accessible mains fuse for the power entering the enclosure, e.g. using a power entry connector such as the Schurter 6200.2100 in combination with an externally accessible fuse drawer such as the Schurter 4301.1405.
- Using an appropriate power switch that is properly sized for voltage and current.
- Preventing from loosening of parts or shorting of parts inside the device against the power supply system.
- Proper installing and connecting of an appropriately dimensioned transformer.
- Preventing from electric shock and fire hazards.
- Adding visible information, such as a safety sticker, on the outside of the enclosure to warn the user about potential electric shock and other hazards, and the proper use and handling of the device.

The list above must not be construed as comprehensive. It should only be interpreted as a rough guideline. Follow all rules and regulations of the applicable country.

For your safety, as you incrementally build all the other boards during the course of this project, power this power supply board from a bench power supply for all testing, calibration or other activities that require powering up the boards. Only at the very end during final vocoder assembly use the system built around the mains power.

## 19.2 Remarks

This ±12 VDC power supply was specifically designed for supplying the vocoder with the necessary power while keeping heat dissipation at a minimum. The vocoder draws a current of roughly 2 × 1.2 A.

While this power supply can handle higher input voltages, it is crucial that it is not supplied with more than 2 × 12 VAC as you may otherwise run into cooling problems with the power supply located inside the enclosure. It is also important that the heat sink of the power supply is well connected to the vocoder's enclosure back panel during final assembly of the vocoder to ensure appropriate heat propagation under full load.

Do **not** use a 3-wire output AC transformer with ground center tap. The two AC inputs need to be supplied by two independent secondary–side transformer outputs.

The AC input side of the power supply board should be supplied with a minimum current of 2 × 2 A.

The power supply was not tested with higher ESR electrolytic capacitors than shown in the bill of materials. In case you decide to use other capacitors, the no–load peak voltage of the transformer must not exceed the maximum voltage of the capacitors. Choose electrolytic capacitors with the highest permissible ripple current. At the value of 3300 µF shown in the schematic, a peak current of about 5 A will flow through the capacitors, assuming an ideal transformer with a series resistance of 0.2 Ω.

It is recommended to use a toroidal transformer with an automatically resetting temperature switch such as the Sedlbauer 825014.

## 19.3 Board Assembly

Use thermally conductive foil like the product suggested in the BOM (WLFT 404 24.5 X 27.7) to electrically isolate the voltage regulators MIC29300-12WT from the heat sink. The foil needs to be cut for the use on both voltage regulators.

Note the capacitors `C4A` and `C4B`, `C5A` and `C5B`, `C9A` and `C9B`, as well as `C10A` and `C10B`. Install only those ending either in `A` or in `B`, with preference on the `A` designators as the SMD capacitors are located more closely to the LDO leads.

The use of an LED as a power indicator along with its series resistors `R1` is optional.

## 19.4 Test

The power supply requires no calibration. It should, however, be tested for performance to be sure it maintains the specified voltage under full load. Two 10 Ω, 17 W wire–wound resistors will serve to verify that.

### 19.4.1 Preparation

One resistor is used for loading the +12 V output, the other one for loading the −12 V output. Solder SEH-001T-P0.6 contacts onto each lead. For each resistor, use one wire–to–board connector EHR-3. The center contact is ground, so the leads of one resistor have to be inserted into the center and the left contact of one EHR-3, the other one into the center and the right contact of another EHR-3. Fig. 18 shows the assembly of one of the two resistors. Insert each resistor into any of the nine supply headers.

### 19.4.2 Load Test

> *Warning: the resistors get very hot quite quickly, so before you power up the supply board, take the necessary precautions not to get burned and make sure the resistors do not touch anything that cannot withstand the heat.*

Plug the PWR SW header on the board with a bridged connector EHR-2 (Fig. 64). Connected to the transformer, power up the supply board. With a multimeter, check the voltages between the GND and +12V, and the GND and −12V test pins, respectively. In case you test the supply first without the power resistors installed, be aware that a different minimum load to the output of the supply needs to be applied as otherwise the output voltage will read too high.

## 19.5 Back Panel Mounting

*TBD*

# 20 Board–to–Board, Switch and LED Wiring Reference Table

The following table shows all the required board–to–board interconnects, both shielded and unshielded, as well as cabling to the switches and LEDs on the front panel. Each row represents an interconnect, established via a cable. Excluded from the table is the power wiring as well as the interconnect of the 18 channel filter boards with the output board. Details about these cables are given in Sec. 4.1 and Sec. 4.4.

Note that the vocoder has reserved connectors for optional processing of signals such as compression and expansion. As long as these connectors are not in use, the two pins on each connector have to be bridged by a short wire (Fig. 64). This wire may be unshielded if kept short. The corresponding connectors are called `EXP-L` and `EXP-R` (EXP = **EX**ternal **P**rocessing). They are found on the voice and carrier preamplifiers as well as on the output board.

Each designator indicated in the table has two entries if it is a shielded cable, three entries otherwise:

1. The name found on the board.
2. Information whether the signal is going into or coming out of a board, or if the cable is to be connected to a switch or an LED:
   - **(I)** – input
   - **(O)** – output
   - **(I/O)** – input/output
   - **(S)** – switch
   - **(L)** – LED
3. In case of an unshielded wire, the color coding:
   - **b** – black
   - **r** – red
   - **y** – yellow
   - $*$ – arbitrary color

Here is an example for such an entry:

| | |
|---|---|
| MONO-SW | → designator found on PCB |
| (S) | → cable information, with (S) indicating it is going to a switch |
| b, $*$ | → cable color coding, black for the first terminal and a color of choice for the second terminal |

The connectors NOISE-SRC of the two internal excitation boards are connected to each other, going to the same switch. These connectors are highlighted in pink in the table (Fig. 65).

The middle pin of connector NOISE-SRC is to be connected to the center terminal of the switch. Pin 1 is for white noise and pin 3 is for pink noise (see pin assignments of connector NOISE-SRC near the lower–left corner of the board in Fig. 70).

The middle pin of connector FORCED-VUV-SW is to be connected to the center terminal of the corresponding switch. Pin 1 is for unvoiced selection, pin 3 is for voiced selection (see pin assignments of connector FORCED-VUV-SW near the center bottom edge of the board in Fig. 71).

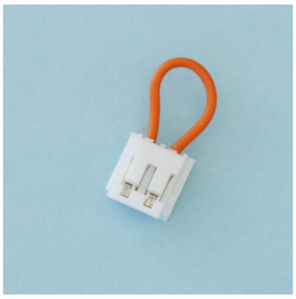


Fig. 64: *Bridged connector* `EHR-2`.

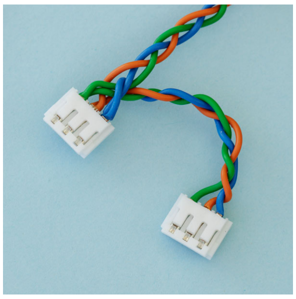


Fig. 65: *NOISE-SRC cable assembly.*

| Cable | Voice preamp | Carrier preamp | Internal excitation (left) | Internal excitation (right) | V/UV | Output, PWL, bridging | Slew/freeze | Wiring | Description |
|---|---|---|---|---|---|---|---|---|---|
| #1 | AUDIO-L/VUV (O) | | | | VOICE (I) | | | 25 cm (10 in) shielded | Voice output for VUV processing |
| #2 | AGC-L/OUTPUT (O) | | | | | VOICE (I) | | 15 cm (6 in) shielded | Voice output for channel boards, for silence bridging and for monitoring purposes on vocoder output jack |
| #3 | EXC-L/SLEW (O) | | | | | | VOICE (I) | 20 cm (8 in) shielded | Voice output for attack detection on slew/freeze board |
| #4 | | EXC-L/SLEW (O) | | | EXC-L (I) | | | 25 cm (10 in) shielded | Excitation signals for V/UV feed |
| #5 | | EXC-R (O) | | | EXC-R (I) | | | 25 cm (10 in) shielded | |
| #6 | | AUDIO-L/VUV (O) | | | | AUDIO-L (I) | | 12.5 cm (5 in) shielded | Carrier preamp signals for monitoring purposes on vocoder output jack |
| #7 | | AUDIO-R (O) | | | | AUDIO-R (I) | | 15 cm (6 in) shielded | |
| #8 | | | | | MIX-L (O) | MIX-L (I) | | 20 cm (8 in) shielded | Mixed signal output from V/UV for channel feed |
| #9 | | | | | MIX-L (O) | MIX-R (I) | | 20 cm (8 in) shielded | |
| #10 | | INT-L (I) | EXC-OUT (O) | | | | | 7.5 cm (3 in) shielded | Excitation (sawtooth and noise) from internal excitation board for mixing with external carrier signal |
| #11 | | INT-R (I) | | EXC-OUT (O) | | | | 10 cm (4 in) shielded | |
| #12 | | AGC-L/OUTPUT (O) | AGC (I) | | | | | 10 cm (4 in) shielded | Automatic gain control to control noise level in V/UV in case of unvoiced sound |
| #13 | | AGC-R (O) | | AGC (I) | | | | 10 cm (4 in) shielded | |
| #14 | | | MIX-IN1 (I) | MIX-OUT1 (O) | | | | 5 cm (2 in) shielded | Noise signal for mixing between both excitation boards |
| #15 | | | MIX-IN2 (I) | MIX-OUT2 (O) | | | | 5 cm (2 in) shielded | Sawtooth signal for mixing between both excitation boards |

| Cable | Voice preamp | Carrier preamp | Internal excitation (left) | Internal excitation (right) | V/UV | Output, PWL, bridging | Slew/freeze | Wiring | Description |
|---|---|---|---|---|---|---|---|---|---|
| #16 | | | VUV-NSE (O) | | NOISE-L (I) | | | 22.5 cm (11 in) shielded | Gain controlled noise output for V/UV usage during unvoiced signal |
| #17 | | | | VUV-NSE (O) | NOISE-R (I) | | | 22.5 cm (11 in) shielded | |
| #18 | | | | | | SLEW (I) b, ∗ | SLEW (O) b, ∗ | 10 cm (4 in) unshielded | Slew signal for channel filter boards |
| #19 | | | | | NOISE-INH (I) b, ∗ | NOISE-INH (O) b, ∗ | | 22.5 cm (11 in) unshielded | Freeze signal to stop V/UV switching activities, coming from silence bridging |
| #20 | | | | | NOISE-INH (I) b, ∗ | | NOISE-INH (O) b, ∗ | 15 cm (6 in) unshielded | Freeze signal to stop V/UV switching activities, coming from slew/freeze board |
| #21 | EXP-L (I/O) | | | | | | | shielded if used | Reserved connectors for optional processing (such as companding); to be bridged if unused with a short wire of less than 5 cm (2 in) |
| #22 | | EXP-L (I/O) | | | | | | shielded if used | |
| #23 | | EXP-R (I/O) | | | | | | shielded if used | |
| #24 | | | | | | EXP-L (I/O) | | shielded if used | |
| #25 | | | | | | EXP-R (I/O) | | shielded if used | |
| #26 | | MONO-SW (S) b, ∗ | | | | | | 40 cm (16 in), 2 wires, unshielded | Switch (SPDT ON–ON) to perform stereo–to–mono downmix in carrier preamp |
| #27 | | | | MIX-SW (S) b, ∗ | | | | 37.5 cm (15 in), 2 wires, unshielded | Switch (SPDT ON–ON) for internal excitation output signal mixing |
| #28 | | | NOISE-SRC (S) ∗, y, ∗ | NOISE-SRC (S) ∗, y, ∗ | | | | 32.5+5 cm (13+2 in), 3 wires, unshielded | Switch (SPDT ON–ON) for noise type selection (pink or white) for V/UV supply |
| #29 | | | | | | | ATTACK-SW (S) b, ∗ | 17.5 cm (7 in), 2 wires, unshielded | Switch (SPDT ON–ON) for attack turn on/off |

| Cable | Voice preamp | Carrier preamp | Internal excitation (left) | Internal excitation (right) | V/UV | Output, PWL, bridging | Slew/freeze | Wiring | Description |
|---|---|---|---|---|---|---|---|---|---|
| #30 | | | | | | | FREEZE-SW (S) b, ∗ | 17.5 cm (7 in), 2 wires, unshielded | Switch (momentary ON) for freeze toggling |
| #31 | | | | | | MONO-SW (S) b, ∗ | | 37.5 cm (15 in), 2 wires, unshielded | Switch (SPDT ON–ON) for vocoder output mono/stereo selection |
| #32 | | | | | FORCED-VUV-SW (S) b, ∗, r | | | 12.5 cm (5 in), 3 wires, unshielded | Swich (SPDT ON–OFF-ON) to select either normal operation (V/UV active), voiced only or unvoiced only |
| #33 | | | | | | | ATTACK-LED (L) ∗, ∗ | 17.5 cm (7 in), 2 wires, unshielded | Attack detect indicator LED |
| #34 | | | | | | | FREEZE-LED (L) b, ∗ | 17.5 cm (7 in), 2 wires, unshielded | Freeze indicator LED |
| #35 | | | | | | BR-LED (L) b, ∗ | | unshielded if used | Silence bridging indicator LED (optional) |
| #36 | | | | | VOICED-LED (L) ∗, ∗ | | | 12.5 cm (5 in), 2 wires, unshielded | Voiced indicator LED |
| #37 | | | | | UNVOICED-LED (L) ∗, ∗ | | | 12.5 cm (5 in), 2 wires, unshielded | Unvoiced indicator LED |

# 21 PCB Component Placement Views

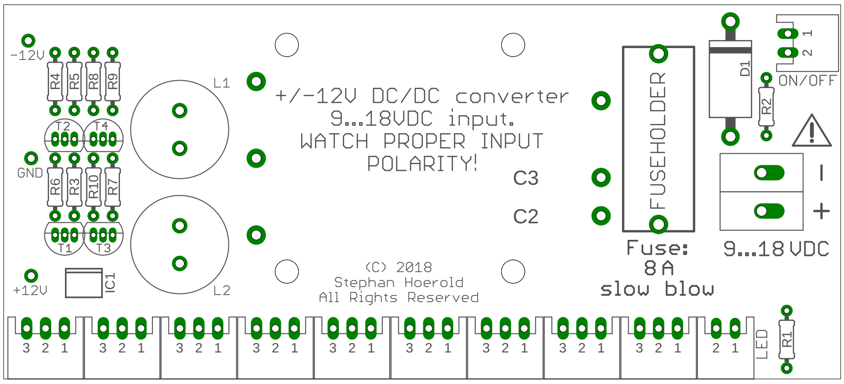



Fig. 66: *DC/DC power supply board*

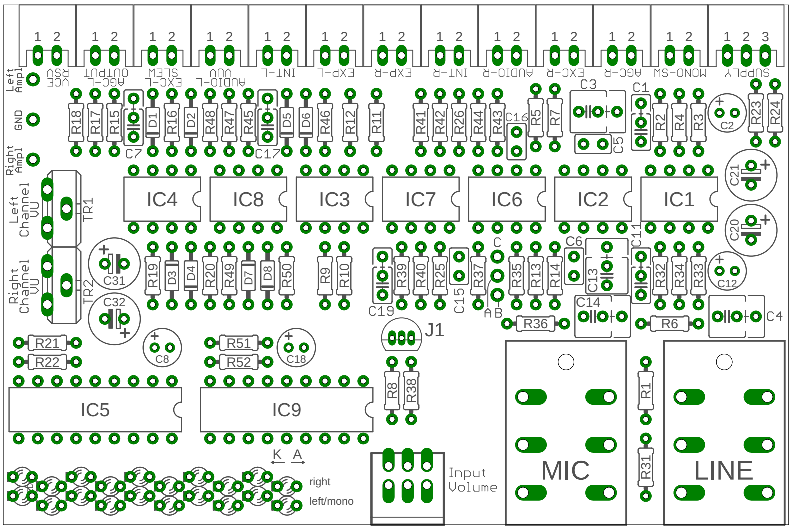



Fig. 67: *Voice and carrier preamplifier board*

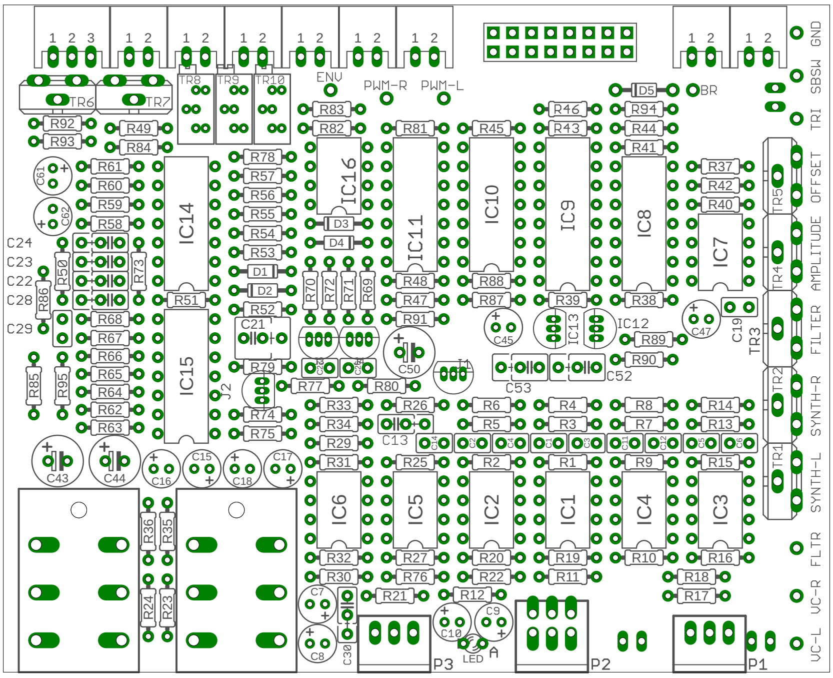



Fig. 68: *Output, PWM and silence bridging board*

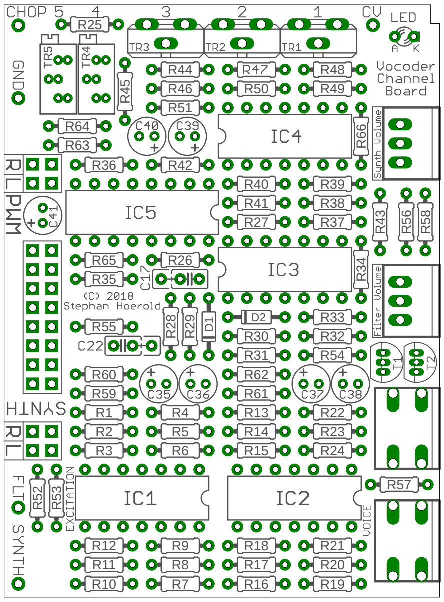



Fig. 69: *Channel filter board*

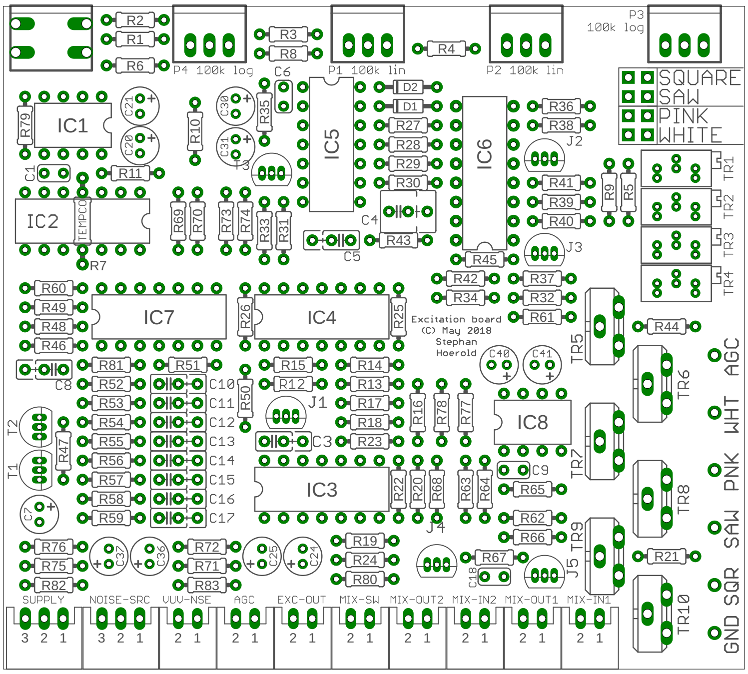



Fig. 70: *Internal excitation board*

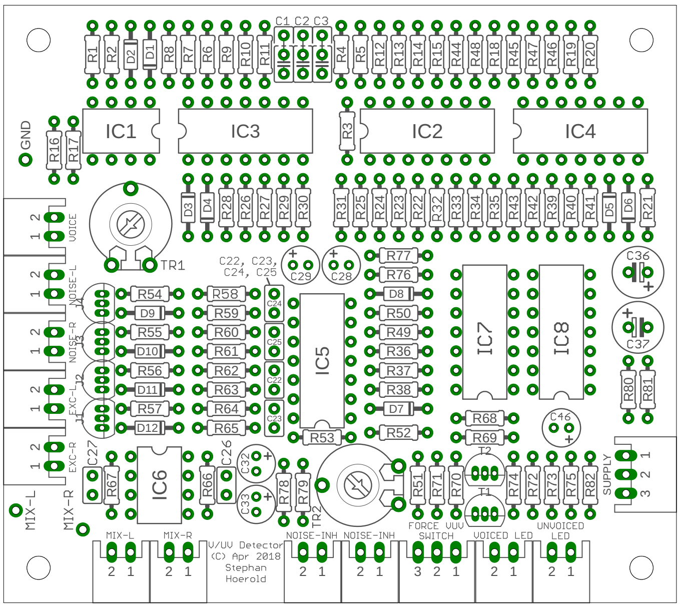



Fig. 71: *Voiced/unvoiced detector board*

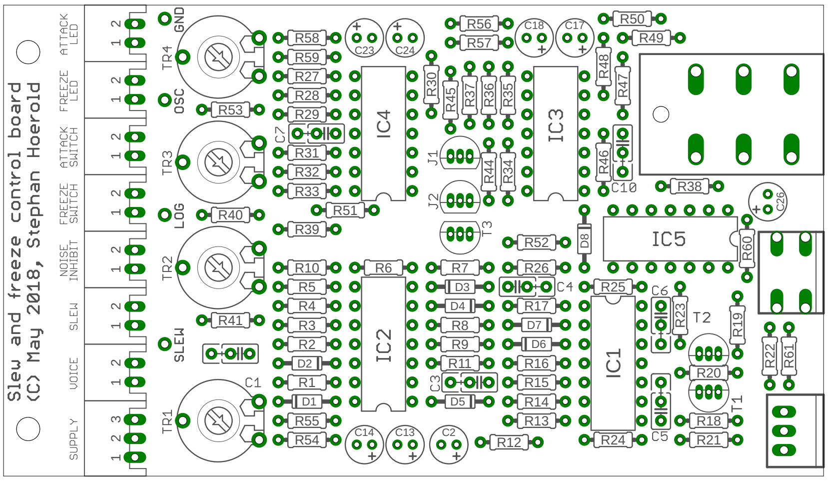



Fig. 72: *Slew/Freeze control board*

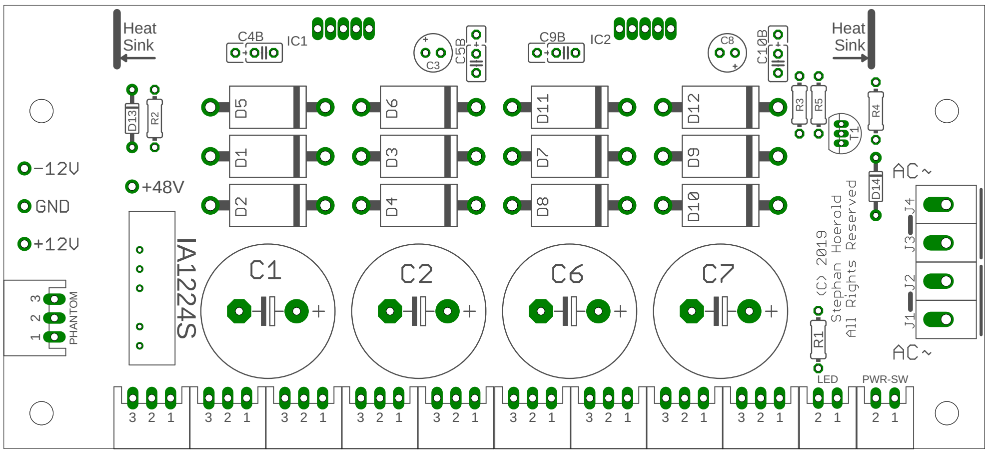



Fig. 73: *LDO power supply board*

## 22 Terms and Acronyms

**AGC:** Automatic gain control

**BJT:** Bipolar junction transistor

**BOM:** Bill of materials

**DIY:** Do–it–yourself

**ESD:** Electrostatic discharge

**IC:** Integrated circuit

**JFET:** Junction gate field–effect transistor

**LED:** Light–emitting diode

**LDO:** Low drop–out voltage regulator

**PCB:** Printed circuit board, often just called “board” in this document

**PWM:** Pulse–width modulation

**SMD:** Surface–mounted device

**THD:** Total harmonic distortion

**V/UV:** Voiced/unvoiced

# 23 Revision History

| Revision | Date | Changes |
|---|---|---|
| 1.0 | Nov 18, 2018 | Initial document release. |
| 1.01 | Dec 17, 2018 | Changed document title. Information added about enclosure. grounding (Section 16). |
| 1.02 | Feb 16, 2019 | Corrected trimmer designators `TR1/TR2` in bandpass calibration procedure (Section 11.2). |
| 1.03 | Mar 24, 2019 | Adjusted vocoder output level calibration voltages (Section 17.1.2) to lift output levels. |
| 1.04 | Mar 26, 2019 | Removed erroneous bullet point about the illuminated yellow LED of the voice preamplifier board in Section 17.2.2. Corrected CHOP to CV in the same section. Corrected first bullet from "Filter Level" to "Channel Level" in Section 17.2.3. Corrected entry about the signal generator use in the same section. Increased values to be adjusted on `TR1` for higher vocoder output levels. Added comment in Section 15.4 that the vocoder should be let cool off for tuning purposes. |
| 1.05 | Oct 26, 2019 | Corrected statement about number of wires from 3 to 2 for cables #36 and #37 at the end of the wire reference table in Section 20. |
| 1.06 | Jan 11, 2020 | A number of minor corrections. |
| 1.07 | Jul 16, 2020 | Added Section 21 to include PCB top side placement views. |
| 1.08 | Sep 7, 2020 | Clarified how to connect an LED to a socket in Section 4.5. |
| 1.09 | Sep 26, 2020 | Swapped MIX-IN/OUT connectors in the wire reference table of Section 20. |
| 1.1 | Oct 3, 2020 | Added a comment to Section 14.4 about the purpose of AGC calibration. Added comment to Section 4.6 to explain how the switches operate. |
| 1.11 | Oct 8, 2020 | Corrected `TR3` to `TR1` in the last bullet of Section 17.1.2. |
| 1.12 | Mar 14, 2021 | Added information to Section 19.4 which used to refer to Section 7.3. |
| 1.13 | Dec 29, 2021 | Added "A" to indicate the anode of the LED on the bridging board in Fig. 68. |
| 1.14 | Jan 4, 2022 | Corrected information about attack switch which is active off and about the mono/stereo switches where mono is active on (Sections 15.2 and 4.6). |
| 1.15 | Apr 18, 2023 | Clarified the connections to the dual–pole switches (noise source selection and voiced/unvoiced selection) in Section 20). |