TB-O Build Guide

TB-303 Inspired Oscillator

v1.4.6 July 2022

The TB-O shares the same saw-core oscillator circuit as the Roland TB-303. It also generates the distinctive, not quite square using the same technique as the original, including using the same transistor types – afterall, the name is Transistor-Bass…

In addition, the TB-O adds pulse width variation in two forms. Manually, using the PW knob so you can dial in the PW you desire (flick the switch to the left) and using CV PWM with an attenuator knob to set the strength of your PWM signal (flick the switch to the right). Both waveforms are output from the square jack, but only one type of PW modulation can be applied via the switch.

Due to the way the TB-303 wave-shapes the saw into the square, when adjusting the PW it changes both the offset and the amplitude of the waveform. Be careful at extreme PW settings both via the knob and CV control as the signal can get quite hot – extending outside the normal 10V p2p of Eurorack.

There are two other waveforms, a very quiet (as most are) triangle and a sort of shark-tooth-saw-sine strange shape. Both are included as I stumbled on them when playing around with waveshaping the saw.

The module also includes some basic FM capability, I've found it works best with slow frequency modulations like LFOs.

The TB-O is available as a panel and pcb set, a panel and pcb set with partial kit (transistors) or in very limited numbers as a pre-built module.

The build is simple if you've built other Eurorack modules, if you know what you are doing, read the important notes below and then proceed in your preferred build order.

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!!! Important Notes !!!

During the time Roland were making 303's they basically used whatever they had in stock for the 3 pin transistors, real machines have any of 2SC536F, 2SC945P and 2SC1815G. The most common is the 536, but any ECB pinout NPN will work just fine. These aren't particularly important to the sound, I've experimented with all of these and NOS/new parts, including cheapo Aliexpress variants of the 945P (marked P331) and all of them work.

The PNP is usually a 2SA733P, which are not really made any more either, you can find some NOS ones and Q variants are fine too. There is much voodoo about high HFE values etc, but only really Q8 in the square waveshaper circuit makes much difference. If you have a tester, by all means find a high (>300) 733 and use it there.

Because the 1980's dual transistor pairs are getting harder to find, or are often fakes, the 2SC1583F/G can be replaced with a pair of matched 2SC945P (or equivalent). Again you can match these or just take a gamble and pair some up.

To make it easier I have included both a 5pin footprint (Q26) for a 1583 AND a pair of 3 pin footprints (Q26A,Q26B)where you can substitute for two matched 3pin NPNs – whatever you are using for the other NPNs will be fine.

ONLY INSTALL COMPONENTS IN ONE FOOTPRINT, i.e. either Q26, OR Q26A+Q26B

The 1583 is common emitter, so you end up with BCECB as the 5 pins, or BCEECB for the pair of 3 pins, with the middle E's connected via the board.

You can of course make a 5 pin also, and I've included some pictures of how I find it easiest to do this in the appendix.

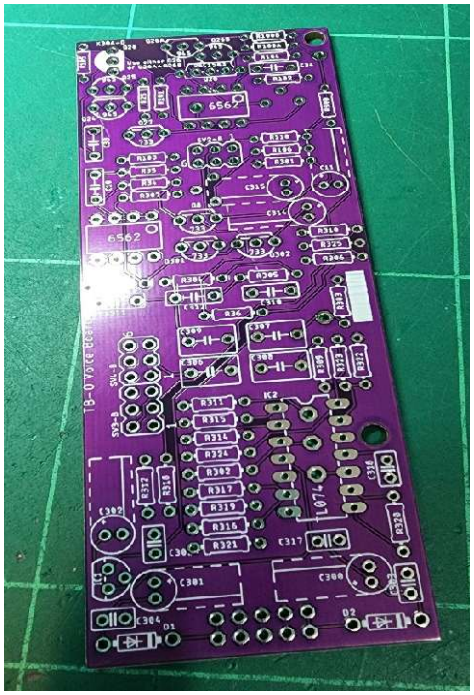
For the JFET SK30A-O, this is quite important to the base shape of the core waveforms, so best to try and find an original – the 2SK118-O is IDENTICAL just in the smaller package and can be found quite readily for reasonable cost.

Note on electrolytics. I've tried to make it possible to use normal 11mm capacitors, so you will see a marking on the silkscreen showing where you can lay the capacitor on its side. The solid white line designates the side where the -ve stripe should end up. You can of course use <11mm high caps and stand them up, but if you are like me I have loads of 11mm normally.

The polybox caps also need to be 10mm high or less. The BOM includes an example Mouser part that works, make sure you fit flush to the board, and if you have taller ones, you may be able to lean over at 90 degreees, in particular there is plenty of space on the control board.

Enjoy!

Lower – Voice Board



Start with the board marked as the voice board.

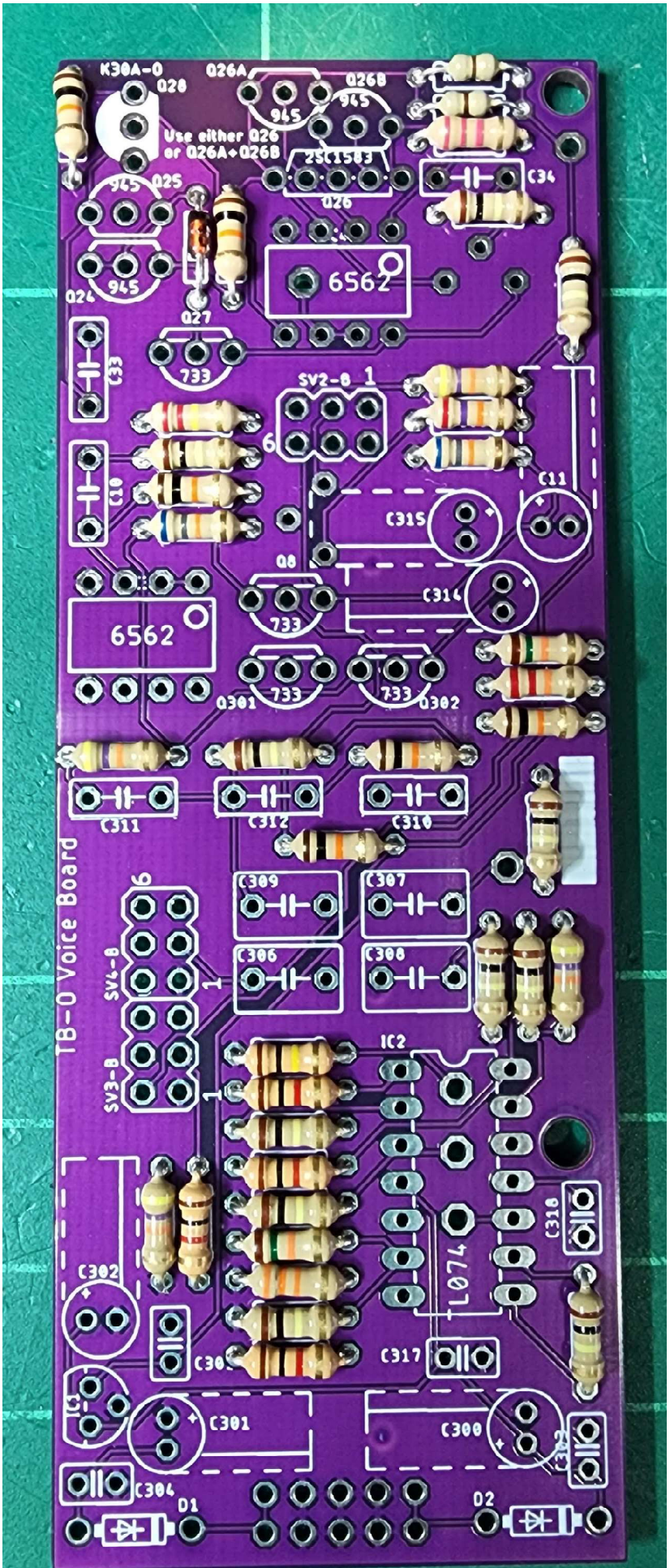
1. Solder the single 1N4148 diode.
2. Solder all the resistors, don't forget to two 1K tempco.

   Note that there is some method in the madness that is the component numbering. Where the analogue voice parts are directly corresponding with the TB-303 circuit, they maintain the original machine part numbers, typically diodes, resistors, capacitors and transistors.

   Where the parts are specific to this module, on the lower board they are numbered starting at 300 and 400 for the upper board.

   For now, just look for and solder all the resistors that are numbered <400.

   The board should look something like this;


K30A-O
Q28
Q26A
Q26B
945
945
Use either Q26
or Q26A+Q26B
2SC1583
Q26
C34
945
Q25
945
Q24
Q27
6562
733
SV2-B
1
6
C33
C10
C11
C315
Q8
C314
733
6562
733
733
Q301
Q302
C311
C312
C310
C309
C307
C306
C308
SV4-B
SV3-B
6
1
1
IC2
TB-O Voice Board
C316
L074
C302
C303
C317
C5
C301
C300
C304
D1
D2

3. Solder the two 1N5817 diodes.
4. I like to add the IC sockets next, so if you are using them, place the two 8pin DIP and single 14 pin DIP sockets.
5. Next comes the capacitors, again my routine is usually;

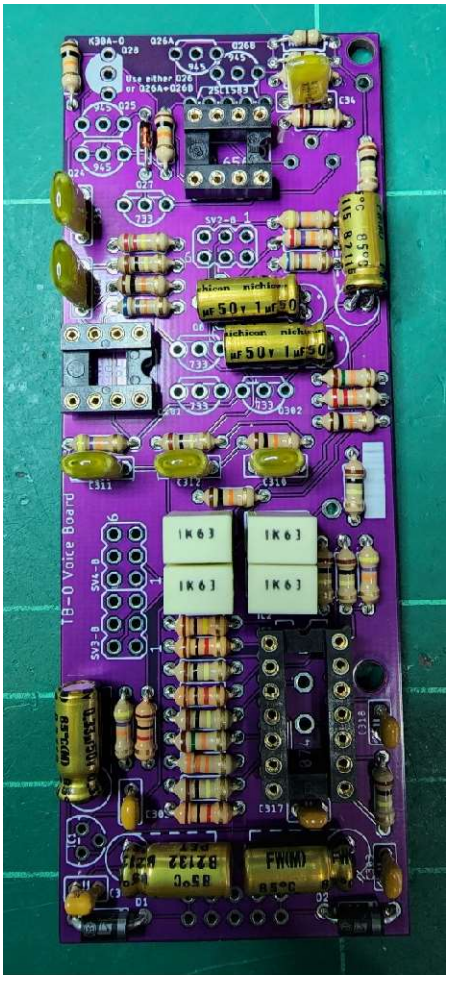
    a. MLCC small ceramics
    b. Polyester/polypropylene yellow/greenies and the poly box ones – try to get the 1uF polybox as flush with the PCB as possible and note the warning in the BOM 10mm maximum height. See mouser part in BOM for reference.
    c. Finally, the electrolytics.

    Due to the stacking of the boards and the normal 11mm clearance between them, you cannot stand up the electrolytics if the are standard 11mm themselves. If you have low profile electrolytics, all good, but otherwise insert the caps and bend them over to sit parallel to the board in the space marked in the silkscreen.

    The solid white line marks the side where the -ve marking should end up.

    With C315, it may be easier to solder TM5 on the reverse before fitting C315.

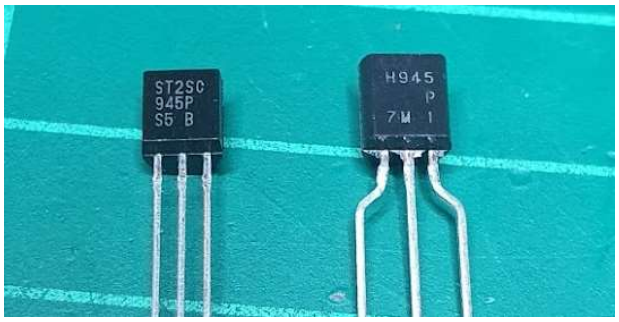
    Make sure C300 and C301 are not touching.



6. Now we can add the transistors.

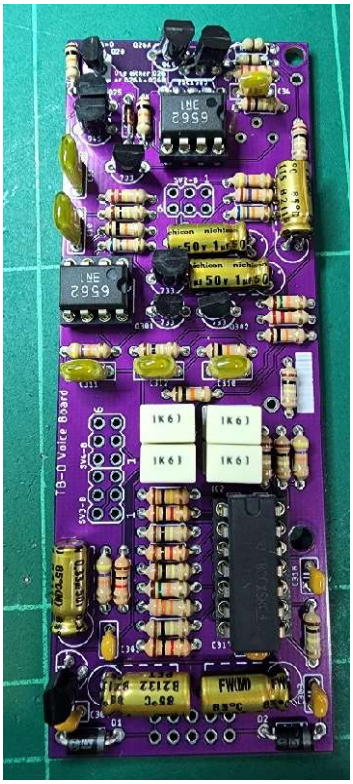
   Q26 – here you will either have a 5pin 2SC1583 – in which case install in Q26 (orientation does not matter) – or if you are using 2x 3pin NPN such as 2SC945P then install two in Q26A and Q26B

   *** If you purchased the partial kit, there will be one 733 marked with Q8 on the cardboard, use this in Q8 as it has the higher hfe needed. For the 1583, there will be two 945 transistors in the smaller bag, either marked “ST2SC945P” or “H945P” use these as they are already matched for Q26A/B. The other 945/1815/536 in the larger bag should be used in the other positions. ***

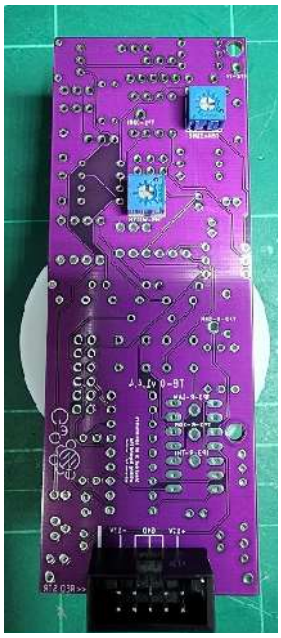


   DO NOT POPULATE ALL 3, if Q26 is used Q26A+Q26B should be empty, and vice versa.

7. Add the ICs, the VR IC2, TL074 and the two op-amps into the sockets.



8. Add the Euro 10pin header and the two 3pin trimmers **on the reverse side of the board.**

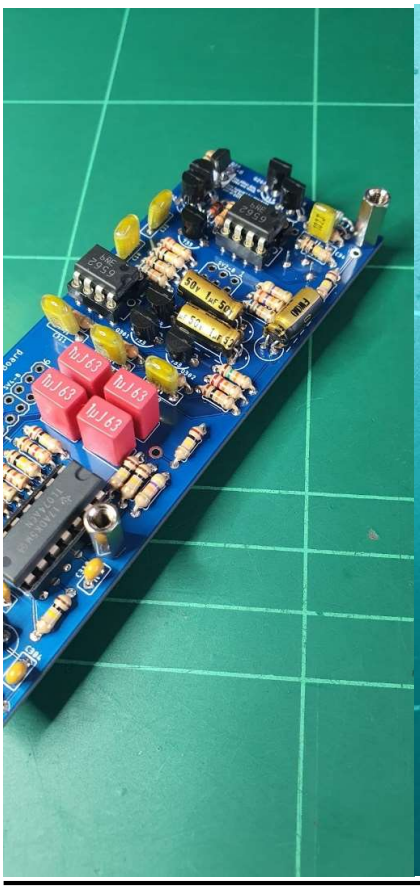


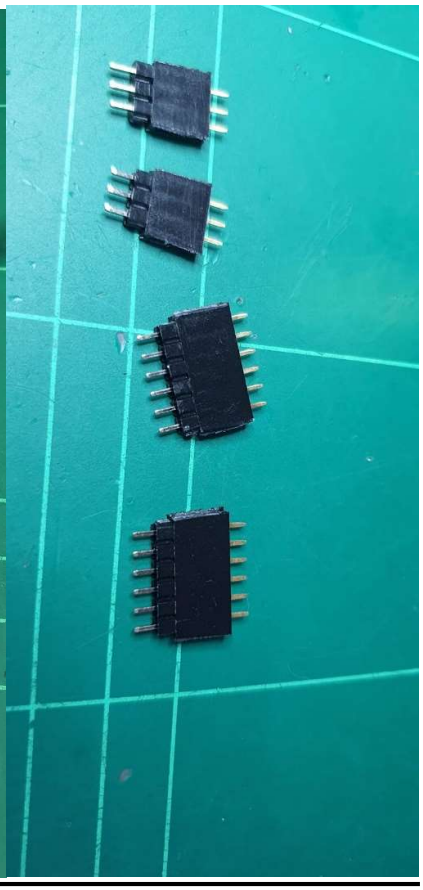
9. Finally, the headers to join the two boards. (Pictures in this section for example only, not actual production level PCBs)

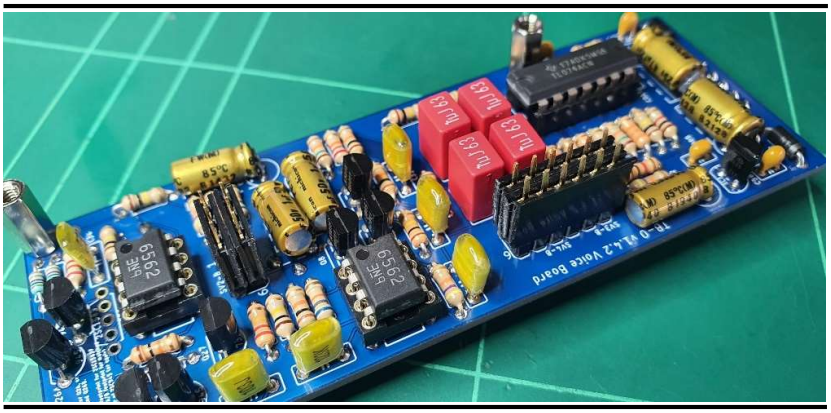
   Use your usual technique for this but I find the following makes it easy.

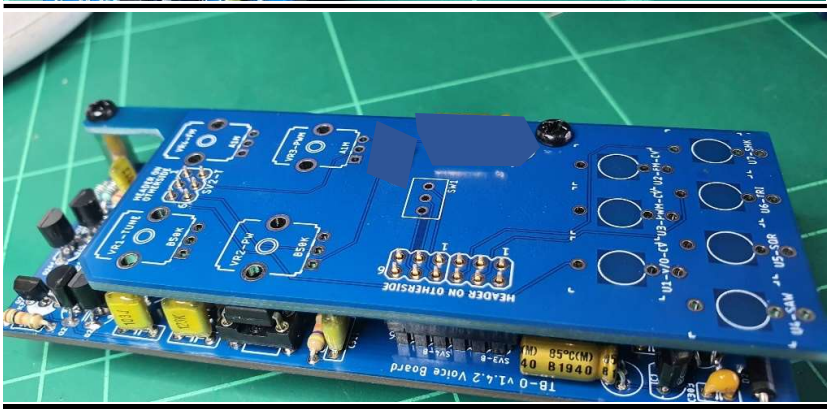
   a. Screw the three 11mm standoffs to the voice board. The standoff should be on the same side as the components, so screw from the underside.
   b. Cut / prepare both the male and female connectors and join them together.
   c. Place all 3 (SV2-SV3-SV4) (or 2 if you are using 6x2 pin for SV3-SV4 combined) into the voice board sticking up the same way as the standoffs. **Don't solder yet.**
   d. Bring the control board to the stack and place it carefully so the standoffs line up with the holes and most importantly so that all the connector pins go through the corresponding holes in the control board.
   e. Screw the control board to the standoffs and you should now have a nice, neat sandwich and you can simple solder all the connector pins from the top and bottom.
   f. Unscrew one of the boards from the standoffs and carefully pull apart the connectors. Perfectly lined up every time!

      (NB: I usually leave the standoffs attached to the upper board, so unscrew the bottom board. This is because I am lazy and if they are already attached to the upper board, you can fit the panel later and not have to worry about access to the screw holes!)






TB-0 V1.1.2 Voice Board


HEADER ON OTHERSIDE
TB-0 V1.1.2 Voice Board

Upper - Control Board

Not much to do here, solder the single resistor and capacitor. Again, make sure the polybox capacitor is as flush to the PCB as possible, the panel will sit right ontop of a 10mm polybox cap only if it is flush and level.

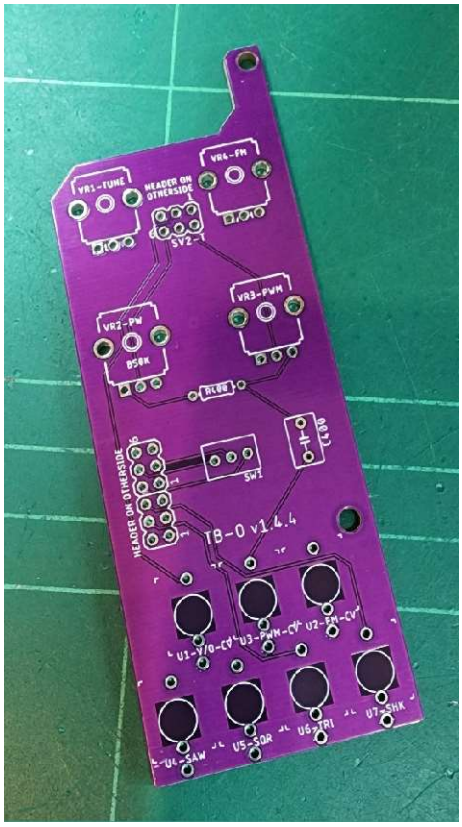
Insert the 4 pots, the switch and the 7 jack sockets and place the front panel over them so you can ensure they line up with the holes **before you solder them!**

Here again as I don't want to have to take all the nuts off, again I make sure I have the standoffs attached to the upper control board, fit all the 7 jack nuts, 4 washers and nuts to the pots and check the sub-mini switch. If you screw it too high to the panel it may not make good contact with the board. If it has two nuts, often leaving one on the switch thread all the way down will help with the height under the panel.

Once you are happy everything fits, is lined up solder them all from the underside.

You may need to trim the underside of the switch pins if they foul on the four 1uF polybox caps on the voice board.

Connect the two boards, check everything over and time to power on.



Simple Checks - optional

If you want to check everything is OK, you can check the power rails before fitting the ICs on the lower board. You should get a nice steady +12 and -12 on the middle pins of the TL074 socket. Anything close to 12v is correct the main thing is the polarity – with pin 4 +ve and pin 11 -ve.

The board has simple reverse polarity protection, if you see only around 1 to 2v on either, check the cable orientation. The board is clearly marked for -12 (red stripe)

You should get +5, +12 and GND on the 3 pins of IC2, this generates the 5v supply.

If you have a scope, you can check the waveforms :

TP1-CORE – a SAW wave with an offset of 5v and amplitude of 7-8v

TP3-R-xxx – these are the 4 output waveforms in raw form, before they are sent to the TL074 for voltage normalising. They mostly low voltage amplitude here, around 2-3v peak to peak but you can see the different waveforms.

Calibration

The calibration process is the same as described in the TB-303 service notes – (google) – but basically you are wanting to adjust both the width and the tune trimpots.

The width defines the gap between octaves and the tune sets the base tune.

Make sure the TUNE pot on the panel is in the middle.

Standard analog 1V/Oct tuning technique, so play C1 and C2 and adjust width so you get a doubling of frequency between the two etc. Adjust tune to get ~~32.7Hz on C1, 65.41Hz on C2~~ etc etc – as with all analog tuning, it's a pain, but keep going and eventually you find the right place for both trimmers.

Process

Set the front "Tune" pot to center position.

Then I usually set tune trimpot so C1 is 65,41Hz

Play C2 and adjust width trimpot until I get 130.8Hz. This will have moved the tune out for C1, so go back and adjust it back to 65.41Hz, and …

Repeat, repeat, repeat!!!

Get pissed off, decide this is impossible, randomly turn one of them, try again, want to throw the module across the room, calm down, have a beer, start again but this time go the other way… repeat… repeat… get super excited when its finally done, go tell your better half who couldn't care less…

UPDATE 29th July 22 **-** Depending on where you look, there is much debate about what frequency equates to what octave range, I had been using an old reference that suggested that C1 for example should be 32.7hz – and that is what I've been calibrating the pre-built modules to, and the build guide up until now has suggested.

After some analysis and testing with various sequencers it would seem that C1 at 65.41hz makes more sense and in reality matches the usable range of the oscillator (for example when driven by the MSW Choronovore – which btw is an excellent choice for getting the 303 slides and accents)

You may be able to adjust your TB-O by simply turning the TM4-TUNE trimmer on the rear counter-clockwise to increase the pitch – you should not need to change the TM5-WIDTH if you have already set it.

However, you may find you can't quite get enough range to get to 65.41Hz (without moving the TUNE POT on the front away from its center position) – if this bugs you, as it did me, then you can either replace R102 with a 47K ohm resistor, or add a second 100K ohm resistor in parallel to R102. ***Note that the BOM v1.4.6 onwards has adjusted this and calls for a 47K at R102 so you don't need to do this tweak.*** This should extend the range of the tune trimmer to allow you to set the correct value. See picture here of "quick" fix.


Q26
C34
Q27

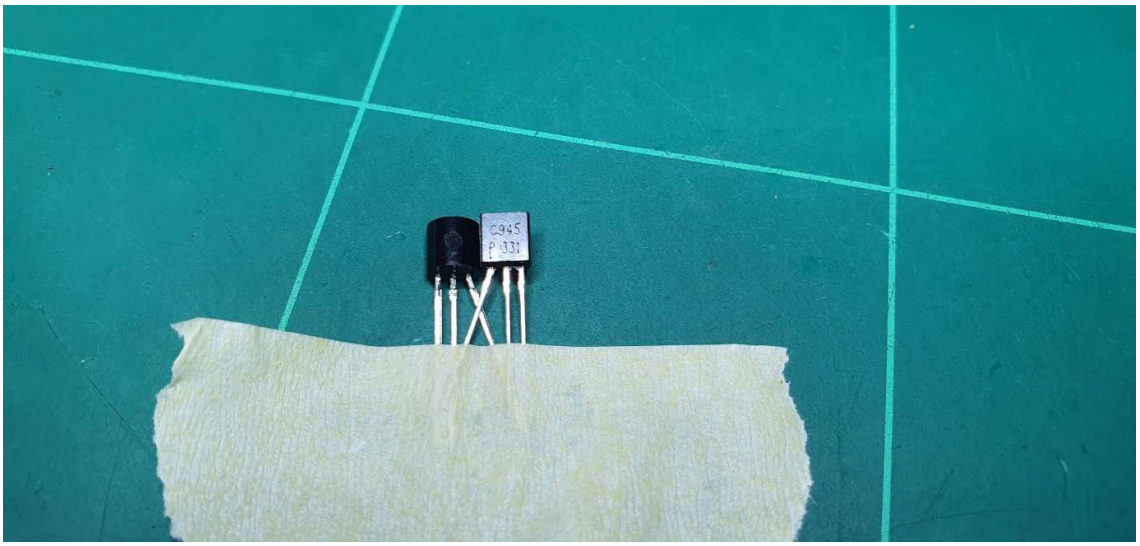
Appendix A : Making the Dual Transisors

Easy way to build a common emitter dual transistor.

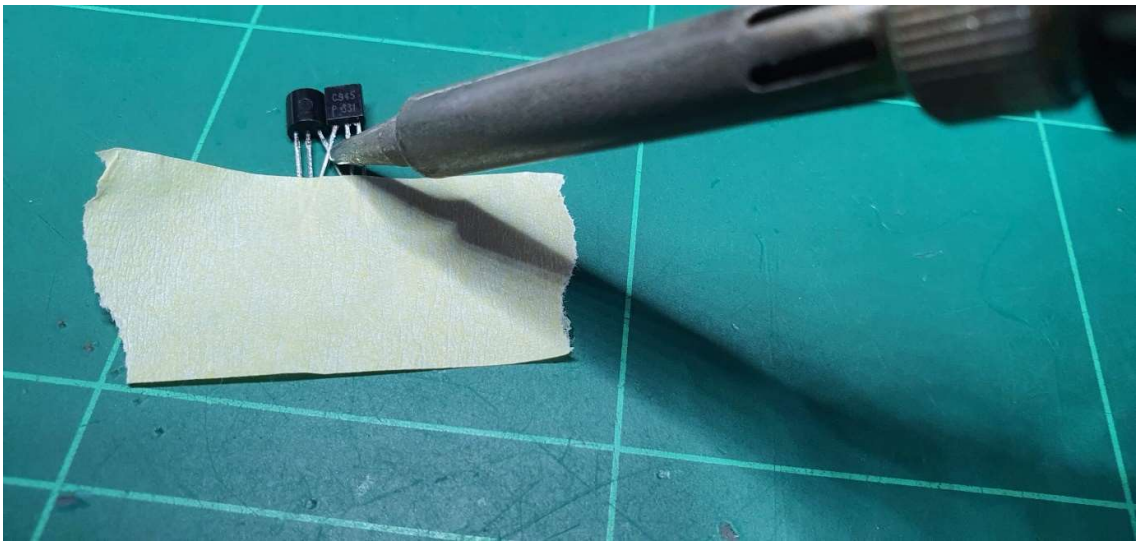
The board has footprints to install two 3 pin, so this is only needed if you want to use the 5 pin footprint – there will be no sonic difference.

Start with your two NPN transistors, left hand one facing down, right hand one facing up and gently bend the emitter legs at an angle as shown.

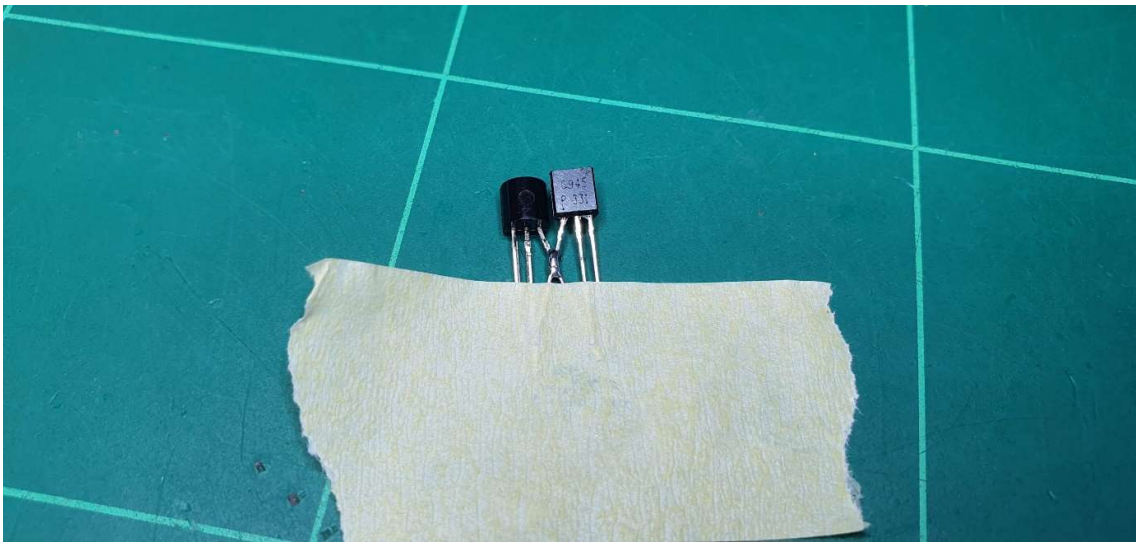
Next place the two legs across each other and tape the lower edges to hold in place while you solder.



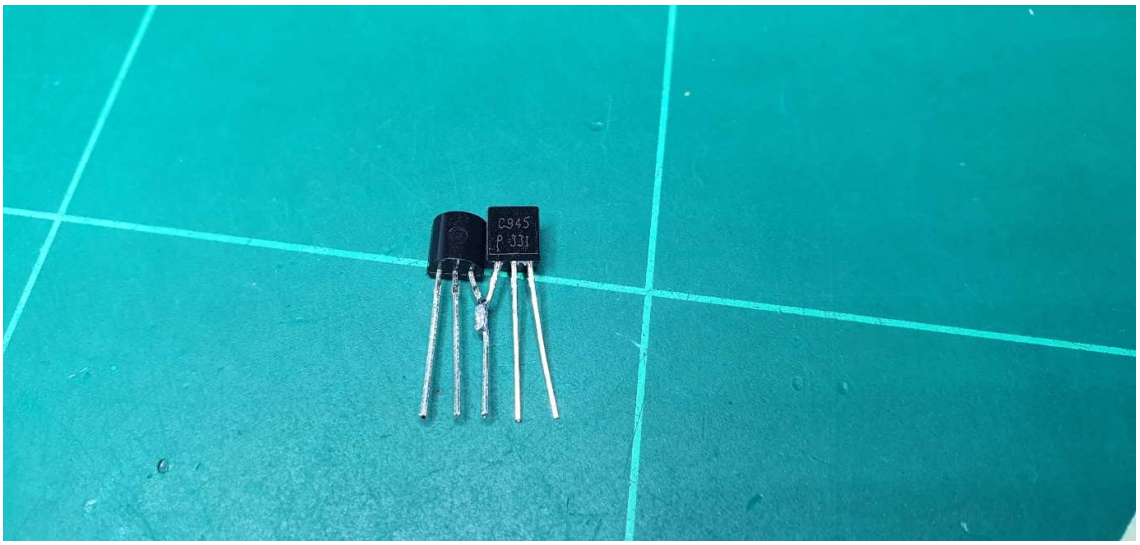
As shown there is a little ledge you can rest the soldering iron tip against to warm the legs and then dab with a small bit of solder.



The solder should flow nicely around the join and you end up with :



Finally, carefully cut off one of the legs at the join and bend the remaining leg straight.



The images show a common emitter, so a 2SC1583.

To build a common base dual transistor, such as the 2SC2291, simply reverse the two transistors before soldering, i.e. left hand faces up, right hand faces down.