Super Awesome Test Box 2000

Assembly and User's Guide

1 Introduction

When building circuits for guitar and synth, a test box is an invaluable tool to help with troubleshooting before boxing your newly soldered up circuit. When I first started, I would frequently box up an untested circuit, only to find that there was some kind of problem that needed to be fixed. A test box helps avoid that frustration.

There are several ways of doing a circuit test box, including in/out jacks, bypass switch, power, and some alligator clips in a failed enclosure. After using a very basic test box for the last 20+ projects designed for the DIY community, I decided I needed something a little nicer. So what does the Super Awesome Test Box 2000 (SATB2k) offer? Well, the key features include:

- True stereo in/out support as well as mono in/stereo out and mono in/mono out.
  - Stereo in via TRS jack
  - Stereo out via TRS jack or dual TS jacks
- Switchable audio probe for debugging
- Test tone generation with volume control

- Onboard preamp/cab sim/headphone amplifier
  - Can be configured as mono or stereo out

This document serves as both assembly and user's guide. If you have a kit, please proceed to Section 3. If you have a fully assembled box, please proceed to Section 4.

2 Populated PCB Assembly

2-1 Additional Components

In addition to the board, the following parts/materials will be needed. I have listed values, quantities, and Tayda part numbers for easy ordering. Please note that any deviations from the parts listed below may result in incorrect hole sizes/placement in the enclosure.

Component	Value	Qty	Tayda Part #	Board Part #
1/4" Stereo Jacks		3	A-3575	
DC Power Jack		1	A-2237	
2 way speaker terminal		1	A-5095	
4 way speaker terminal		1	A-5105	
Binding Post		1	A-861	
3.5mm stereo jack		1	A-4855	
SPDT Toggle Switch		1	A-3186	
3PDT Toggle Switch		2	A-5486	TONE, PROBE_SW
4PDT Toggle Switch		1	A-6195	BYPASS
3mm LED Bezel		3	A-661	
Bypass LED	Diff. Blue	1	A-3004	D3
Tone LED	Diff. Green	1	A-262	D1
Probe LED	Diff. Red	1	A-261	D4
16mm PC Pot	100kA	1	A-2417	TONE_VOL
Test Tone Knob		1	A-5965	
Enclosure		1	A-2392	
Electrolytic Capacitor	100u, 16V	3	A-972	C38,C39,C40
Electrolytic Capacitor	>=100u, 16V	2	A-4553	C9,C10
Electrolytic Capacitor	4u7, 16V	1	A-975	C17
3362P Trimmer	100k	2	A-605	HPVOL_R,HPVOL_L
3362P Trimmer	10k	1	A-604	FREQ

BoM for additional components

In addition to the components above, hookup wire and solder will be required. I recommend having an assortment of wire colors to keep track of the various

connections.

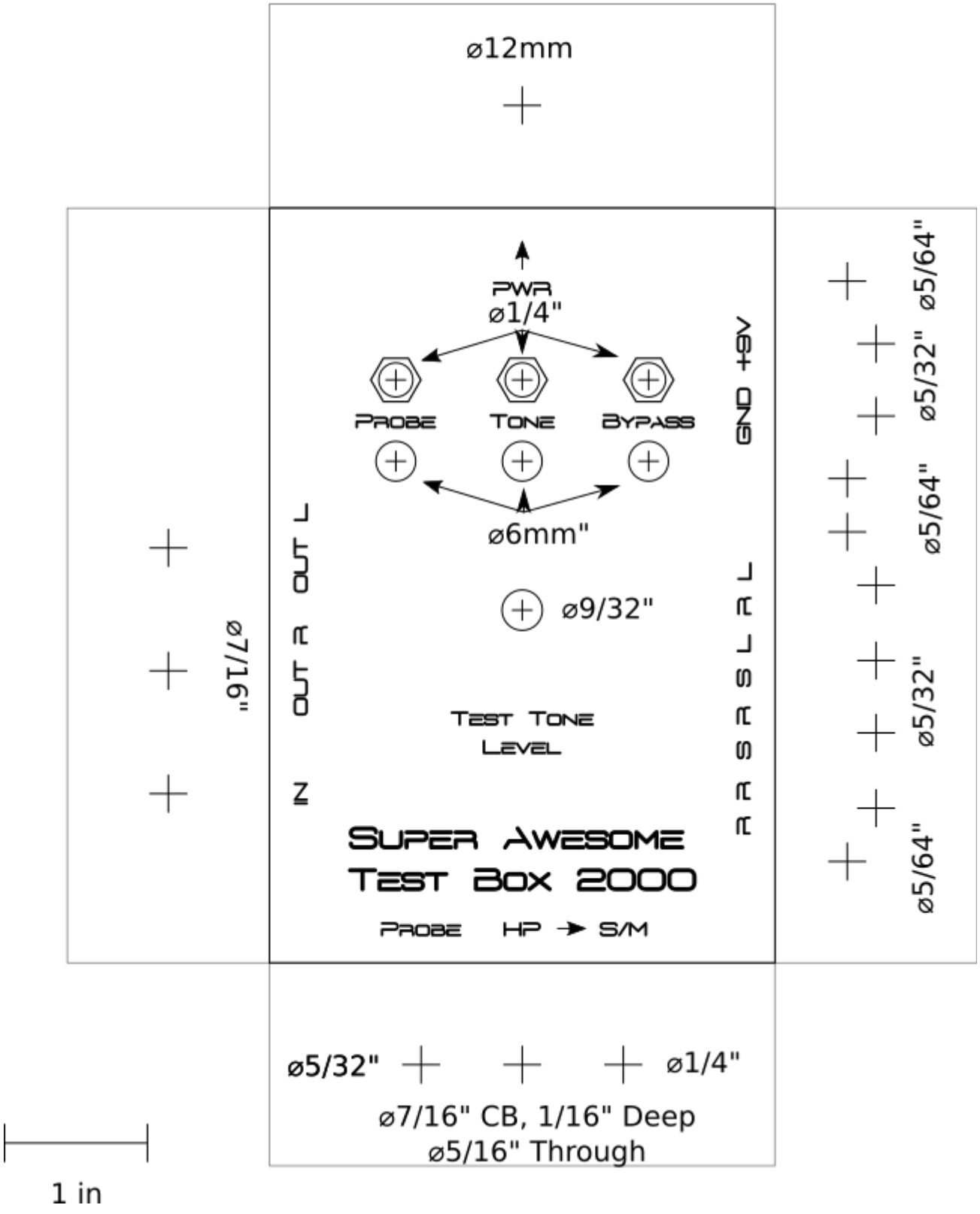
2-2 Enclosure Preparation

To prepare the enclosure, first remove the integrated plastic standoffs indicated in the figure below. If not removed, they will interfere with mounting the PCB. I find that a Dremel with a cutoff wheel makes super quick work of this. While it doesn't need to be perfect, getting a reasonably close cut will make the fitting process work better.

Integrated standoffs to be removed

Next, drill the enclosure using the drill template below. Cut along the gray lines and fold along the dark black lines and it will fit nicely over the enclosure. Use a punch to mark the holes and then drill larger holes with a step drill. The 1/8” jack for headphones is a little tricky because the threads aren't long enough to go all the way through. I use a 7/16” Forstner to counterbore about 1/16” deep and then a 5/16” Forstner to drill through and it works like a charm. Make sure to deburr the holes after drilling for proper fitting of parts.

SATB2k Drill Template



Drill template in place over enclosure

Below is a picture of what the fully prepared enclosure looks like from the inside.

Fully prepared enclosure

At this point, I highly recommend labeling the box using your method of choice. With a lot of features comes the possibility of getting them mixed up at times. You can use the artwork from the drill template (see end) if you like. If not, just don't make it boring!

3 Full Unit/Kit Assembly

3-1 Board Mounted Components

Finish populating the board by soldering in the electrolytic capacitors, trimmers, and toggle switches. At this point, put the LED's in their respective holes with the long leg in the square solder pad, but DO NOT solder the LED's into place yet. We will solder them into place after the board is mounted in the box.

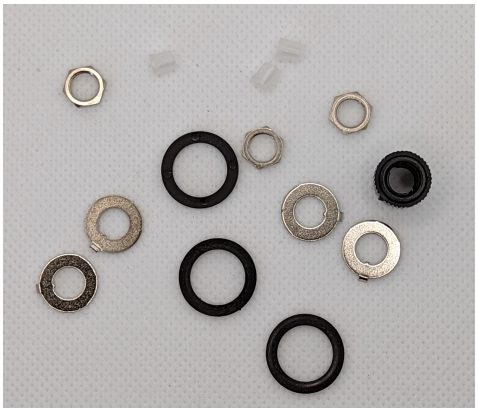
Also note that the LED colors and their current limiting resistors have been chosen to correspond with each other. Thus, the blue LED is meant for the Bypass switch, green LED for the Tone switch, and red LED for the Probe switch. You may use other colors, but the brightness might be higher or lower than expected.

Solder the test tone potentiometer to the board. Make sure that you remove any protruding tab that might be on the potentiometer so that it mounts securely to the box.

3-2 Box Mounted Hardware

Next we will attach all the hardware that mounts to the box. This includes input/output jack, power connector, speaker terminals, headphone jack, probe binding post, headphone mode switch, and LED bezels.

When mounting the input/output jacks, the flat plastic washer that comes with them will be unused. This is because the enclosure side is sufficiently thick that they are not needed. Additionally, I do not use the flat washers and only use one nut for the toggle switches and I don't use the plastic LED retainers that come with the bezels. With the board footprint, the plastic LED retainers are useless as there is no way to fit them in after the board is in place. The screw on cap of the binding post will also be discarded. The leftover hardware is shown in the picture below.



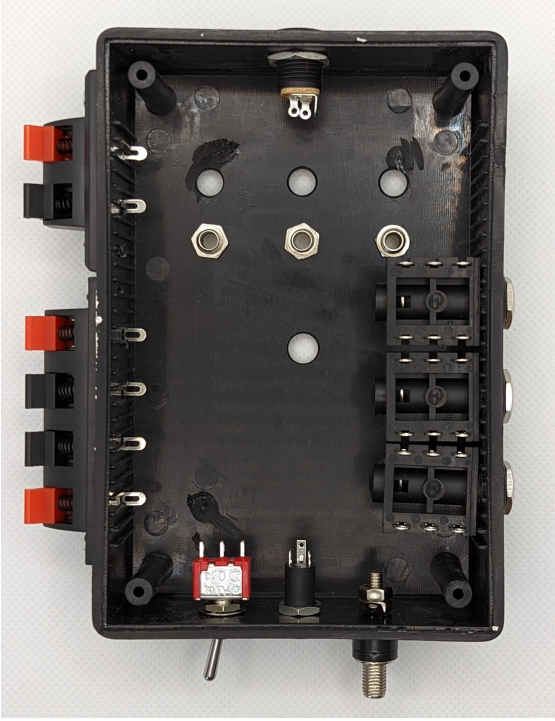
Unused hardware from enclosure-mounted components

The enclosure comes with 8 screws: 4 long and 4 short. The 4 long screws are for attaching the back cover. The 4 short will be used for mounting the speaker terminals. The holes in the enclosure are sized that the short screws will cut threads into the plastic for a firm hold.

Note that the 3.5mm headphone jack is a TRRS jack. The long tab is ground and the tab directly across from it is the unused connection. A picture shows this below. I just bent the unwanted tab back and forth a couple of times until it broke off. I also used a multimeter to determine which tab is left (T) and which is right (R).

TRRS jack with unused tab shown bent

The inside of the box with all hardware mounted is shown in the photo below.

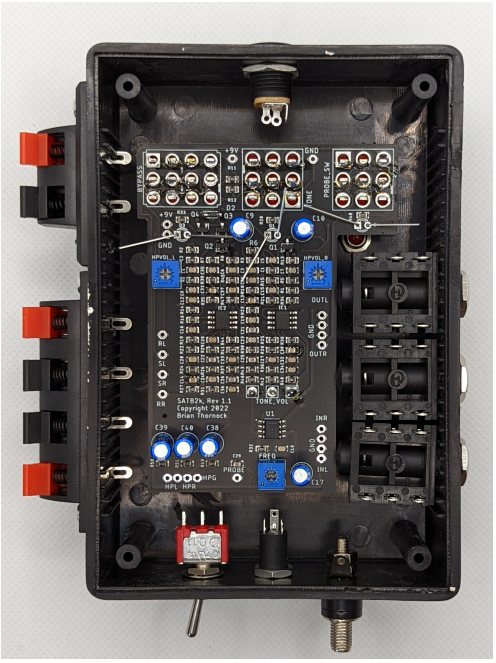


Box with all hardware mounted

3-3 PCB Fitting

We are now ready to fit the PCB to the box. I recommend turning the box over onto the board so that the loose LED's don't fall out. The board is a relatively precise fit, so take your time getting the switches and potentiometer through the holes. Secure the PCB to the enclosure using the nuts for the toggle switches and potentiometer.

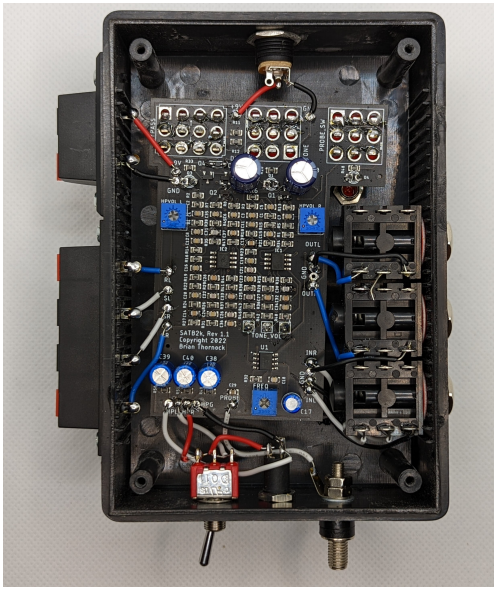
With the PCB fit into place, turn the box right side up and carefully slide the LED's into place in the bezels. Because of the board footprint, the little plastic retainers used by some bezels won't really work here. Instead, once the LED is to the desired height, bend the LED leads over on the back side of the PCB so that you will get the right depth when soldering in place. On Rev 1.1 PCB's, the probe LED is purposely offset on the board from the bezel due to a previous test box iteration's input/output jack placement. All future boards will not have this quirk. It's still relatively easy to guide the LED into the bezel. I find a toothpick or dental pick can help guide the LED into place and then press from the back side of the bezel to get it in there correctly. A correctly fitted PCB is shown in the photo below. Notice the bent LED leads since I had not yet soldered them in place.



Correctly fitted PCB/Enclosure

3-4 Soldering

Now it's time to solder all the connections from the board to the various hardware. The solder pads are placed to approximately correspond with the hardware locations to make things simpler. I also recommend using some kind of color scheme. You will see in the photo of my completed box below that I use black for ground, red for power (and the right headphone connection), white for input, and blue for output.



Fully Wired Interior

4 User's Guide

With a completed box in hand, it's time to put it to use!

4-1 Basic Operation

Basic operation refers to the most basic task of connecting a test board to the SATB2k, giving it inputs, outputs, and power. The power connection is for +9V **ONLY**. Higher voltages may damage some of the components inside, which would make for a very bad day. If your circuit requires higher than 9V, supply SATB2k with +9V and supply your circuit with the higher voltage separately.

Plug an input signal source into the IN connection. This can be a stereo TRS or mono TS connection. Send your output signal to an amplifier or computer soundcard using the OUT L for mono TS or stereo TRS out. For stereo out with two cables, connect OUT L and OUT R to their respective amplifier or soundcard inputs. For OUT L to work as TRS stereo out, OUT R needs to have no cable connected.

Connect the circuit to the speaker terminals such that the left (or mono) input to the circuit is connected to SL (send left) and the left (or mono) output of the circuit is connected to RL (return left). If the circuit has stereo inputs, connect the right input to SR (send right). If the circuit has stereo outputs, connect the right output to RR (return right). Connect the circuit's power to the box for +9V, or to a separate supply. Please note that in either case, the circuit ground MUST be connected to the GND speaker terminal.
With this configuration, you should be able to hear the unaffected signal with the bypass switch in the off position. Putting the bypass switch to the on position tests the circuit connected to the box. If you assembled the SATB2k from a board or kit, you may want to use a known working circuit to verify that the SATB2k is working correctly.

For connecting to circuits, the speaker terminals allow for use of any wire connection. I use Dupont jumper wires for breadboards and alligator clips for PCB's, though sometimes it is helpful to use clip leads, soldered test wires, or other methods. As long as it is conductive and fits in the speaker terminal, it should work, but use common sense. Don't go trying to shove a BNC connector in there or something...

4-2 Debug Features

4-2-1 Audio Probe

One of the most most useful tools for debugging a circuit is the use of an audio probe.

This allows you to listen to the audio signal at any point in the circuit. Using the probe in conjunction with the circuit schematic can help rectify the majority of common circuit issues.

To use the audio probe, switch the Probe toggle to the on position. This will send the probe output to both the left and right outputs. The probe input on the board provides the necessary DC blocking cap. The binding post for the Probe connector accepts a standard multimeter probe, which allows for connection of all the various multimeter lead types: standard probe, SMD probe, clip, etc.

4-2-2 Test Tone

The test tone feature utilizes a 555-based tone generator that is used in place of the standard signal input when the Tone switch is in the on position. The test tone level is controlled by the potentiometer and the test tone output is sent to both left and right circuit inputs.

Before first use, it is recommended that you set the tone generator frequency to your liking. The tone generator will produce tones from roughly B0 up to B2. The frequency is adjusted using the Freq trim pot on the PCB. Turning the pot clockwise results in a higher frequency. I set mine to about 82 Hz, which is a low E on standard guitar. The procedure for setting the frequency is as follows:

1. Connect SL to RL
2. Connect OUT L to sound card input
3. Turn Test Tone Level to 0
4. Turn on test tone by setting Tone switch to on position
5. Use a tuner app or plugin on the computer
6. Slowly turn up test tone level until the tuner registers the signal well
7. Adjust the Freq trim pot on the PCB until the desired frequency is achieved; rotating in the clockwise direction increases frequency while counterclockwise reduces the frequency

Once the frequency of the tone is set to the desired value, we can use the tone to inject a constant signal into the circuit. When used with the audio probe, it becomes very easy to identify where the signal is being lost.

Please Note: The tone is sort of square-ish and is not intended for tuning values of the circuit. Rather, it is intended to help identify where in a circuit the signal gets lost, quiet, etc. This is a simple debug feature, not a fine tuning one. For fine tuning purposes, a real guitar signal is recommended so as to tune to correct signal level and content.

4-2-3 Headphone Amplifier

The SATB2k has an integrated preamp/cab sim/headphone amplifier for debug purposes. This allows the user to connect headphones to the box to monitor the signal. **Please note** that this is a debug feature and is not intended for use in fine tuning of circuits. It is recommended that your actual signal flow be used for fine tuning.

When used in conjunction with the audio probe and test tone generator, the SATB2k becomes a fully self-contained circuit debugging tool. No guitar, amp, or other connections required.

The headphone amplifier can be configured in stereo or mono. In the mono case, the OUT L signal is sent to both sides of the headphones. In stereo, the OUT L is sent to headphone L and OUT R is sent to headphone R. This mode is selectable via the toggle near the headphone connector.

Please note that some higher impedance headphones may suffer from reduced output. In extreme cases, there may be insufficient output to satisfactorily monitor the signal. I have tested this headphone amplifier with impedances up to 150 Ohms without issue, but this has been a relatively small sample set. I have used Sennheiser HD600, AKG K240, and some random earbuds with it, each with success.

In the case of low headphone output, the headphone out level can be set via the HPVOL_L and HPVOL_R trimmers on the PCB. Clockwise increases volume and counterclockwise decreases volume.

*NOTE: It has been noticed on some Rev 1.1 PCB's that the headphone amp can experience some hum due to the layout and the tone generator. I have found that increasing the VREF filter capacitor (C10) and +9V filter capacitor (C9) can help mitigate this. If you are noticing this effect, you can either replace/increase those capacitor values, or solder an additional capacitor across the power connector and one across R12.

5 Final Thoughts and Recommendations

The SATB2k is a powerful tool for debugging and testing circuits prior to boxing them up. While it will not solve every situation, it does make the process much less painful.

I do have two recommendations to make using the box even more pleasant. First, put rubber feet on the bottom so that it doesn't slide around all over the place. Second, put something heavy in the bottom lid to keep it anchored. I noticed that the weight of the guitar cable connectors can cause the box to tilt or move. I ended up digging up some scrap steel and taping it into the bottom lid of the enclosure. It's ugly, but no one ever sees it. Other things that could be used include lead weights, large flat washers from the hardware store, etc. I think the total weight of the steel I used comes in about 13 oz., which gives it a very hefty feel and keeps it right where I put it.

Here is a full size printout of the artwork that I use on the boxes. Note that the perimeter is the actual out dimensions of the box. Happy bug hunting!