Completing the "TINY TIM" Stereo Amplifier

Part 3 – By Nicholas Vinen

In this final instalment we finish building the Tiny Tim amplifier by fitting all the modules into the case and wiring it up. We'll also look at testing the unit, its final performance and some other useful tidbits.

At this stage, you will have finished building the main amplifier PCB and power supply and you should also have prepared the case, including drilling holes in the base for mounting the modules.

But before we screw them in, it's easiest to do some of the wiring first.

Start with the wiring between the two chassis-mount RCA sockets, the slide switch, the RCA plugs for the DAC and the leads to connect to the amplifier PCB. This wiring is shown in the upper-left corner of Fig.6 on page 82 of the December 2013 issue.

Strip and tin the wires to go to the PCB but leave these loose; the rest of the wiring can be completed in-place.

Note that depending on how close you have mounted the RCA sockets to the slide switch, it may be impractical to use shielded cable for these connections, in which case you will have to use ordinary hook-up wire instead. In this case, keep the wires as short as possible and run the two signal wires close to the ground wire(s) to minimise hum pick-up.

Fitting the DAC

With that done you can then mount the DAC board. As explained last month, to save space we fitted ours directly above the RCA sockets and slide switch and we used a combination of various Nylon tapped spacers, nuts and screws to support it.

Essentially, what you need to do is fit the DAC connectors and switch through the rear panel holes you made earlier and measure how high it sits above the bottom of the case, then pick the next shortest tapped M3 spacers you can get.

Experiment with how many M3 nuts or washers you need to fit to the screws before attaching the spacers so that the DAC board naturally rests on these spacers when it is in place.

It's then just a matter of using a few more Nylon M3 screws to hold it in place on the top. The holes on the DAC board are a bit bigger than usual for M3 screws but the screw heads should be sufficiently large to hold it down. Otherwise, use Nylon washers under the screw heads. You can then plug the two RCA cables you soldered earlier into the DAC outputs.

Output & pot wiring

The next step is to fit the front panel components and connect wires in preparation for the final assembly. This wiring consists of the following runs; again, refer to Fig.6 in the December 2013 article:

1) Two red wires from the left and right channel pins on the headphone socket, long enough to reach the amplifier board, plus a black ground wire of a similar length.

2) Two long red wires from the switched left and right channels pins on the headphone socket to run along the bottom of the case and back to the two red binding posts. Remember to slip a couple of pieces of heatshrink tubing over each wire before soldering them to the binding posts and it's also a good idea to wrap the exposed copper strands securely around the binding post pin before soldering it (which will require a hot iron).

That done, slide the heatshrink over the solder joint and shrink it down, then repeat for a double insulating layer (see photos). We attached several adhesive plastic wire clips to the bottom of the case to hold these wires in place, roughly along the paths shown in Fig.6.

3) Two black wires from the black binding posts, long enough to reach the rear of the amplifier board and connect to the ground plane. These should also have two layers of heatshrink insulation over the solder joints.

4) Two stereo shielded wires soldered to the volume control pot, long enough to reach to the pot connections on the amplifier board. Wire these as per Fig.6 last month.

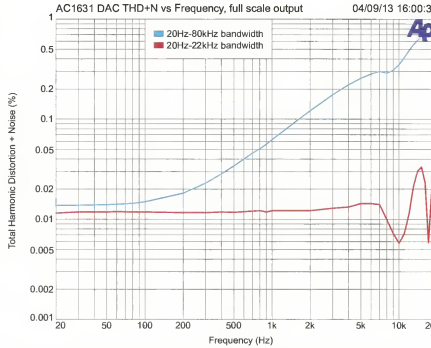
Mounting modules & testing

First, fit the power supply module in place by screwing its four tapped spacers into the bottom of the case. Use three short steel M3 machine screws and a Nylon M3 machine screw for the right-rear corner, ie, the mounting posts which already has a Nylon screw in the top.

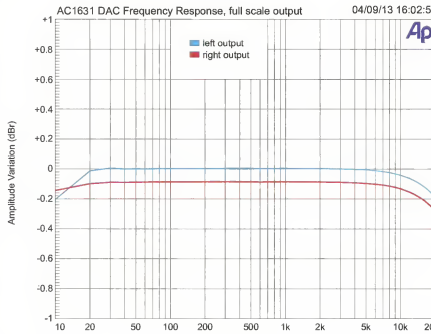
Cut a 60 x 40mm piece of fibre insulation (eg, Presspahn) and then score and fold it 45mm from one end. Drill two holes in this to correspond to the two holes in the bottom of the case, near, the power supply board and attach it using M3 Nylon machine screws and nuts, as shown in the photos. This prevents any wires which may come loose from contacting any of the mains-potential components on the PCB.

Connect the mains cable to the leftmost pin header terminal and feed it through its grommet at the rear of the case (ie, the one that it went through originally).

At this point, with the power supply in the case, it's probably a good idea to check that it is working properly so plug the switch in and check that it is properly isolated. To do this, set your



Distortion vs frequency at full scale output for the AC1631 DAC module. It's an oversampling type DAC, rather than delta-sigma, hence the rather steep rise in distortion with increasing frequency. But when the output is filtered with the 20Hz-22kHz bandpass filter (red trace, simulating human ear response), most of the distortion harmonics are eliminated. Comparing this graph to the others shows that when using a digital input, the DAC is generally the limiting factor in performance.



The frequency response of the AC1631 DAC is pretty flat, being down by only 0.2dB at the high end (20kHz) and virtually flat to 20Hz at the low end. Note that it does not handle Dolby Digital, DTS or other compressed audio streams so if connected to a TV set or disc player, the unit should be configured to output a linear PCM stereo digital signal. Most disc players and many TV sets offer a "down-mixing" option, specifically to allow the digital audio output to be connected to devices like this.

Reproduced from last month, this photo shows the placement and interconnection of the PCBs within the Tiny Tim amplifier.

DMM to high ohms range (ie, megohms) and connect one probe to the mains plug Active pin and one to an exposed piece of metal on the chassis. Check that there is no connection (it should read "oL" or similar).

Repeat the same test with the Neutral pin. Then check, with the power switch on, that there is no connection from the mains Active pin to any of the three terminal block outputs on the power supply PCB. This verifies that the transformer insulation is intact. Assuming that's all OK, switch the DMM to DC voltage measurement mode and check that the power supply fuse cover and adjacent Presspahn shield are in place, plug in the mains cord and turn it on.

Without touching the mains section of the power supply board, measure between the middle pin of the terminal block and either side. You should get readings of approximately ±20V (likely a bit higher). Switch off and check that these drop to near 0V within about 30 seconds. This confirms that the power supply board is working and you can then switch off and unplug the mains and then the mains switch from the power supply board.

Note that with some terminal blocks, there may not be a good connection to the screw on top when there is no wire inserted so it's best to probe the wire openings if possible.

Amplifier module installation

Before fitting the amplifier module to the case, make sure you have soldered the three power supply wires as shown in Fig.6 last month and that they are long enough to reach the power supply output terminals when it is in the case. A 2-wire cable should also be attached for the 12V DC output as described last month. If you fitted sockets to the amplifier board, plug in the ICs now but make sure their pin 1 dot lines up with the notch on the socket.

You can now mount the amplifier module using four tapped spacers and eight short M3 machine screws. The MiniReg board is mounted in a similar manner (note that no heatsinking or regulator tab connection is required) and the two-pin header you wired to the amplifier board's 12V rail earlier can now be plugged into the MiniReg's input. Check the polarity, ie, ensure the grounds of the two boards are continuous, eg, from the OUTPUT - pin of CON4 on the Minireg to the tinplate shield on the amplifier board.

You can also plug in the power LED into the MiniReg now. But we don't want to connect the power supply directly to the amplifier PCB just yet, with the exception of the 0V (black) wire which can go to the central output on the power supply board. Leave the other two (red and blue) loose for now.

Now solder the remaining wires to the PC pins on the amplifier board, specifically the six from the pot, three from the headphone socket, four for the inputs (from the chassis-mount slide switch) and two from the black binding posts.

It's a good idea to slip a short length

of heatshrink tubing over each wire before soldering (slide it far along enough the wire that it doesn't shrink from the heat) and then shrink it down over the solder joint when it's cooled to provide some strain relief.

More testing

We now want to check whether the amplifier module is working and the best way to do this is to temporarily connect a couple of 100Ω 5W safety resistors in series with the supply leads so that if something is wrong, you will have time to switch power off before any damage occurs. This also reduces the chance of a problem when adjusting the amplifier's quiescent current.

If you have enough room, you can insert one lead of each safety resistor into one of the terminal block outputs on the power supply board, screw it down and bend it up so that the resistors stick up vertically. It's then just a matter of running a clip lead from the other end of each resistor to the appropriate power supply wire for the amplifier module.

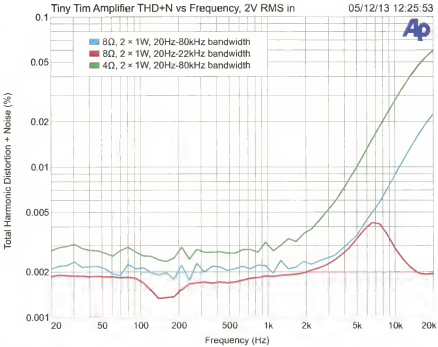
Make sure that the clip lead from the red wire goes to the safety resistor at the positive output terminal on the power supply, which is furthest from the corner of the board. If necessary, use clip leads at both ends of the safety resistors and they can sit outside the case. But regardless, make sure that the exposed metal of the alligator clips can not make contact with anything else – a good way to ensure this is to temporarily wrap them in electrical tape.

For now, do not connect the DC output from the MiniReg board to the DAC's power supply input socket. Re-connect the mains power switch, do a final check to make sure there are no stray wires that could short to anything (especially near the power supply board!) and turn trimpots VR2 and VR3 on the amplifier board fully anti-clockwise.

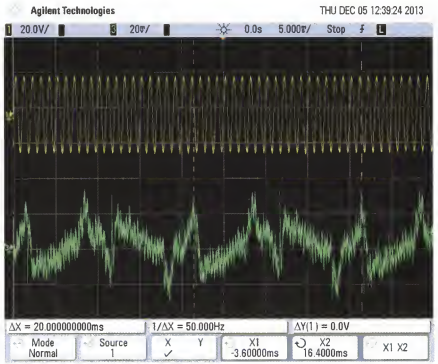
You can now plug the unit back into mains, switch it on and check the voltage across each safety resistor using a DMM set to DC volts mode.

Don't go near the mains side of the power supply. You should get a reading below 10V in each case (typically around 8-9V); if not switch off immediately and check for faults in the wiring.

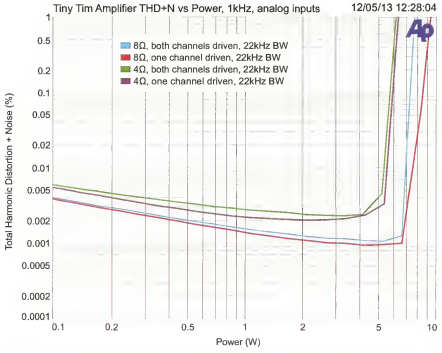
If the wiring looks OK but the voltages are too high, there is likely a problem with the component installa-



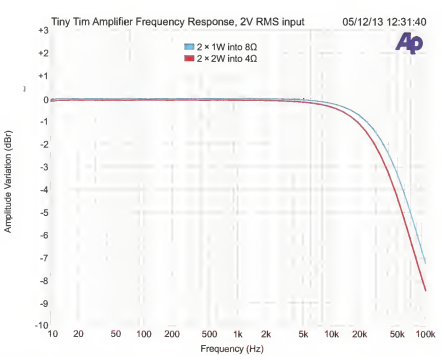
Distortion versus frequency from the completed amplifier under a variety of conditions. This is somewhat higher than what was shown for the amplifier module/power supply combination in the October 2013 issue. This is almost entirely due to increased hum and rectifier buzz pick-up now that the boards are mounted close together in the case. If we measure the distortion with a 400Hz high-pass filter to eliminate mains 50Hz hum and its immediate harmonics, the readings drop substantially, to around 0.0006%.



The distortion residual of the amplifier output at 1W with both channels driven into an 8Ω load (green) compared to the output itself (yellow). As you can see, it is mainly a combination of 50Hz, 100Hz and even order harmonics of these frequencies, indicating that it's due to hum pick-up from the power supply. The actual distortion products at 2kHz and above can be seen superimposed on this waveform at a much lower level.



Distortion versus power for a 1kHz signal under various conditions. As is typical, distortion is lower into 8Ω loads than 4Ω due to the lower output current for the same power level. Continuous power output is below 10W but music power (ie, the power available for short bursts) is higher than this, at about 10W for both 4Ω and 8Ω speakers with both channels driven. Note that despite the level of hum measured, even with the volume turned up and our ear very close to the speaker we could barely make it out (inputs must be terminated for this test).



Frequency response of the complete amplifier. Note that this shows a much greater roll-off at the high end (down by about 1dB at 20kHz) compared to the graph published in the October 2013 issue. That's because since taking the earlier measurements, we decided to increase the input filter capacitors to 4.7nF to give better attenuation for the harmonics in the DAC output. You could lower this value slightly to give a slightly flatter high-frequency response but then it would be less effective at attenuating DAC switching noise.

tion or the modifications to the amplifier board. Assuming the voltages are OK, measure the voltage between each pair of red/black binding posts (ie, the output offset voltage). It should be below 20mV. If it's much higher than that, there is a fault so switch off and check your work carefully.

Otherwise, now is also a good time to check the output of the MiniReg board, either at CON4 or if you have plugged it in, the DC plug (with the red probe inserted through the end and the black in contact with the outside of the barrel).

Turn its adjustment trimpot and check that the output voltage varies. You can then set it to 6V±0.1V.

Next, connect the DMM between TP1 and TP2 on the amplifier board and slowly rotate VR2 clockwise. The voltage should start out low (just a few millivolts) and rise as you turn the pot. Stop once it reaches 15mV.

Note that we indicated a reading of 30mV in the circuit diagram on page 61 of the October 2013 issue but have found that the heatsinks run a bit hot at idle; 20mV is plenty of bias in practice. We're setting it to 15mV now because it will increase a bit once the safety resistors have been removed. Repeat this procedure for TP3/TP4 and trimpot VR3.

Check the voltage across the safety resistors again. It should have increased to around 12V and they will be getting a little warm.

Having passed those tests, the amplifier board is likely working but if you want to be really sure, you can do a live signal test by connecting a pair of speakers and some sort of signal source. But if you do this with the lid open, you need to be careful not to go anywhere near the power supply. In fact we would switch off and unplug the unit while connecting the speakers and signal source.

Of course with this sort of test it's always a good idea to turn the volume control right down before switching back on and advance it slowly. While the power switch is off you should also check that the input selector slide switch is in the appropriate position for the analog inputs.

With the safety resistors in place, only a small amount of power will be available but you should be able to get clean audio at a reasonable volume.

You can then switch off, unplug the mains cord and wire the amplifier

module directly to the power supply, making sure you hook up the wires to the same terminals as you used earlier. You can now also connect the output of the MiniReg to the DAC board.

That should complete the wiring. To keep it neat and safe, tie all the cables into bundles or to adjacent posts so that they can't move and break loose should the unit be subject to vibration or shock.

If in doubt, refer to our photos (including those published last month) to see how we did it. Your completed unit should look much like ours although obviously it will vary somewhat depending on which case you used.

Now is a good time to repeat the live signal test but this time without the safety resistors, you should have the full power output of up to 10W per channel available. Once it's warmed up a little bit, re-adjust VR2 and VR3 to get 20mV across the associated test posts.

Assuming it all works and sounds good, you can switch off, unplug the mains cord and attach the lid, volume knob and any other ancillaries to complete the unit such as feet. Make sure the mains cord is properly anchored using the original method once the lid is in place; in some cases the lid helps to hold the cordgrip grommet in place.

The accompanying graphs show the performance of the completed unit and the integrated DAC. These measurements include power supply noise, hum, RF pick-up in the wiring and so on so they aren't quite as good as the performance of the amplifier module itself but still pretty good and we think you will find the sound quality is "up to scratch".

Depending on what speakers you are using, you may want to consider adding a Bass Extender (described elsewhere in this issue) to your new hifi setup. SC

Modifying the DAC for more output

The pre-built DAC board we have used in this project (Jaycar AC1631) has an output of around 1V RMS while most CD/DVD/Blu-Ray players and high-end DACs have an output closer to 2V RMS. This is generally not a big problem but it does mean that if you are switching between the analog and digital inputs, you will need to adjust the volume control each time.

Reader Gavin Krautz wrote to us to explain that he has this DAC and grew tired of constantly changing volume levels when switching inputs; he came up with a simple way to increase the DAC output level to around 2V RMS. As he explains:

The DAC contains a BH3544 headphone amplifier to drive the outputs, which has a default gain of 6dB. However, its gain can be reduced by inserting resistors in series with the signal going to pins 3 and 5 of the IC. In the Jaycar DAC, these resistors (R25 and R27) are 90kΩ, which sets it gain to 0dB (ie, unity). The formula given for the gain is 6dB + 20.log10(90kΩ÷(90kΩ + R_{ip})).

This means you can increase the output gain by up to 6dB by changing these resistors. I initially considered making the output gain switchable, or shunting R25 and R27 to increase the gain, but in the end I simply shorted them out to restore the 6dB default and I have been very happy with the result.