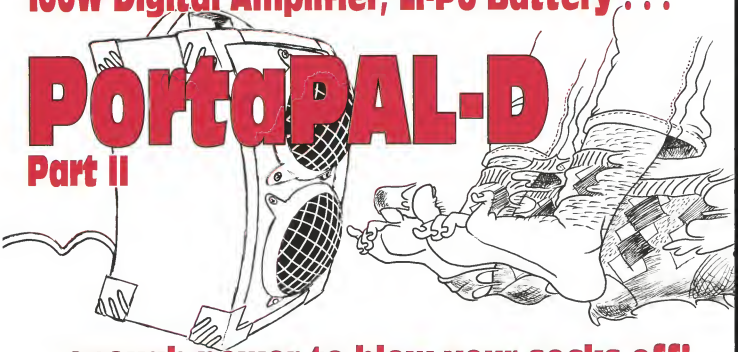
100W Digital Amplifier, Li-Po Battery . . .

PortaPAL-D

Part II



. . . enough power to blow your socks off!

In the second part of our new go-anywhere Portable PA system, we put together all the electronics. There's a lot to it, but we've separated out each section to simplify matters. So let's get stuck into it!

As described last month, we use the CLASSiC-D Amplifier module and its matching speaker protector from the November and December 2012 issues, along with the DC-DC Converter from May 2013 which allows the CLASSiC-D amplifier to run from a 12V supply.

Both the CLASSiC-D Amplifier and the speaker protector need to be set up for the ±35V supply option as detailed in their construction. But more on this later.

Firstly, we will describe the building of the main PortaPAL-D mixer and input PCBs. There are three PCBs for these: the largest is the main PCB (Mixer and power supervision) coded 01111131 and measuring 212 x 100mm; the Guitar and Line Input/Output PCB is coded 01111132 and measures 109 x 35mm and finally the Microphone input PCB coded 01111133 and measuring 64 x 73mm.

Check each PCB carefully for any problems such as undrilled or incorrectly sized holes and for poor etching. Typically, PCBs supplied in kits or from the SILICON CHIP shop are excellent quality and should not require any repairs.

Microphone input PCB

We'll start with the smallest PCB. Follow the overlay diagram in Fig.7. The resistors are installed first, but note that the four 1kΩ resistors each have a ferrite bead placed over the lead at one end. As well as checking each resistor against the colour code shown last month, measure each one with a multimeter to verify its value.

IC1 can be directly soldered onto the PCB or mounted using an IC socket. Either way, make sure it is oriented correctly. Similarly, electrolytic capacitors (which can be installed next) are also polarised. For the smaller capacitors, where the value is not printed on them, the codes were shown in the capacitor codes table last month.

by John Clarke

CON3 comprises a 6-way right-angle pin header. Along the longer side of the header is a thin plastic backing piece behind the pins. This needs to be cut off (using side cutters) to allow the pins to plug into the single in-line socket on the main PCB.

Two PCB-mount XLR female connectors (CON1 & CON2) are soldered onto the PCB. The connectors are ultimately secured to the front panel with self tapping screws. The central hole at the top of the PCB under the XLR connectors is for a chassis mount earth point.

This can be a 6.4mm spade terminal or a crimp eyelet that mounts on the rear of the PCB using an M3 screw and nut with star washers top and bottom of the PCB to ensure a good earth connection to the PCB copper.

Guitar and line input and output PCB

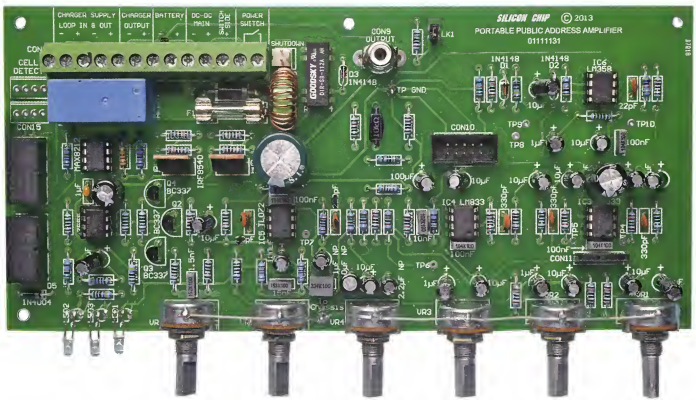
Like the first board, construction can begin with all resistors and capacitors. Again, take care with polarity of the electrolytic capacitors. Like IC1, IC2 can be either directly mounted onto the PCB or using a socket. Be sure to orient the socket and IC correctly.

The 6.35mm jack sockets (CON4 & CON7) as well as the stereo RCA sockets (CON5 & CON6) mount as far down onto the PCB as they can go before soldering the pins. Finally, insert and solder in the 10-way IDC connector with the notched section toward CON6.

Mixer and power supervision PCB

This PCB overlay is shown in Fig.8. Construction follows the same pattern: resistors first, followed by the diodes. There are three types used; 1N4148s, a 1N4004 and a 1N5404. Make sure these are inserted in their correct positions and with the correct orientation.

Two PC stakes are used on the PC board. One is for TP GND and the other for the GND pin between VR4 and VR5. The remaining test points



do not use PC stakes - their tinned pads on the PCB can be probed with an oscilloscope probe or meter lead if necessary.

ICs can be installed now – again, sockets are optional but watch polarity (and position!). Capacitors follow (watch polarity on electrolytic types) and refer to the capacitor table last month if in doubt.

The two fuse clips each have an end stop to prevent the fuse sliding out. Install each clip with the end stop facing to the outside.

Transistors are installed as shown. These are all BC337 types. LEDs are mounted by bending the leads at right angles at 15mm back from the body of the LED. The LEDs are to face forward with the anode (longer lead) to the left. The two outer LEDs are red while the middle LED is green.

Inductor L1 is wound on a 28 x 14 x 11mm iron powdered toroid with 24 turns of 1mm enamelled copper wire. After winding, the enamel needs to be scraped off the wire ends so that it can be soldered to the PCB.

The four relays can now be installed, along with the vertical RCA socket (CON9), the 6-way SIL socket (CON1) and the 10-way IDC connector (CON10). The latter needs to be installed with the notch oriented as shown.

The two-pin header CON12 is installed adjacent to L1. Although this header has a polarity key to prevent reverse connection, its orientation is not important. The two-pin header for LK1 can also be installed now.

CON14 and CON15 don't use plugs and sockets - their wires directly solder onto the PCB plugs and sockets. They are for connecting the '3S 250mm 2xJST-XH parallel balance lead'. This lead has a 4-way socket at one end that branches out to two 4-way plugs. The lead is cut to provide just one plug on a 4-way lead and one socket on a 4-way lead. Cut the leads to get the maximum lead length that you can. Then strip back the insulation on each wire by about 4mm and insert into the CON14 and CON15 holes. You can place the plug or socket lead set in either the CON14 or CON15 position.

However, it is important to insert the wires so that there is the same order between the plug lead and socket lead. We had the red lead on each lead set inserted in the outside hole followed by the black leads in the order they terminate to the plug or socket. A cable tie located close to the PCB holds all the wires together.

The 13-way screw terminals are made up using five 2-way terminals and a 3-way terminal. These terminals dovetail together first, before inserting the entire 13 terminal set into the holes on the PCB, with the wire entry toward the outside of the PCB.

Finally, the potentiometers (VR1-VR6) can be installed. Before you do so, however, a little "surgery" is needed and it's easiest to do it before the pots are soldered in.

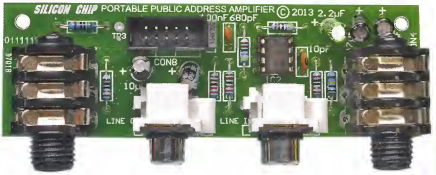
As the pot bodies need to be earthed to the GND PC stake (between VR4 & VR5), you will need to scrape a small patch of the passivated coating from each pot body, using a hobby knife, at the position where the wire is to be soldered. This will allow the solder to flow onto the steel surface below the passivated coating.

And if the pot shafts are too long, cut each pot shaft to about 12mm long to suit the knob that's used. Clean up the cut edges with a file so that the knob will push on readily. Also the locating tabs on the pots need to be snapped off using pliers. Now install each pot taking care to place the 10kΩ log pots in positions VR1-VR4 and the 100kΩ linear potentiometers in positions VR5 & VR6.

CLASSiC-D Amplifier

The CLASSiC-D Amplifier is built according to the articles in November and December 2012. There are some differences in building this for use with the PortaPAL-D.

First, use the Component Values vs Supply Voltages table on page 68 of the December 2012 issue to set up the amplifier for ±35V. Additionally, do



At left is the main PCB (mixer and power supervision) shown slightly less than full size. Note the wire soldered to all pot bodies thence to the PCB. Above is the guitar and line input PCB (left), shown full size, and similarly the microphone input PCB at right. The XLR (microphone) sockets on this board look slightly skewiff . . . because they are! We didn't have any PCB mounting sockets on hand and the photographer was waiting! Your board, using the right sockets, should look perfect.

not install the horizontal RCA socket (the one that protrudes past the edge of the PCB) – just install the vertical mount RCA socket.

Heatsink drilling is also changed to include the 50 degrees C thermostat that is secured to the right hand side of the heatsink (above the V_{CC} and COM PC stakes). The thermostat is attached using M3 screws that are screwed into M3 tapped holes in the heatsink. The thermostat is mounted as high on the heatsink as possible without the thermostat body showing above the heatsink edge. The screw holes are positioned to pass though the heatsink and between the fins.

The ground lift jumper shunt is installed for the PortaPAL-D. This ensures the minimum noise is produced.

Speaker protector

The CLASSIC-D Amplifier's Speaker Protector should be constructed as shown in Fig.23 of the December 2012 issue, using the values shown for use with a 35V supply. The 47µF delay capacitor is changed in value to 10µF. Being the only capacitor on the PCB, it is easy to locate. The capacitance change improves the overall response of the PortaPAL-D when switching from standby to producing an output.

DC-DC Converter

Build the DC-DC Converter as it is shown in the May 2013 issue except for two changes. First, change the 13kΩ resistor connecting to the anode of D3 to 10kΩ. On the PCB, this is located between ZD1 and diode D3. This resistance change reduces the low battery shutdown voltage of the DC-DC Converter to 10V. This is more suiting to the LiPO battery used in the PortaPAL-D. The second change is not to connect the earth wire from the TP GND terminal to the chassis. Instead, the DC-DC Converter case is earthed directly to the PortaPAL-D chassis once it is secured in place.

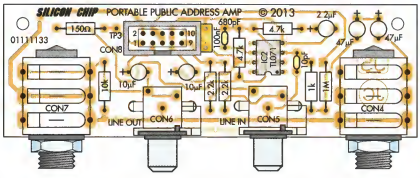
Chassis

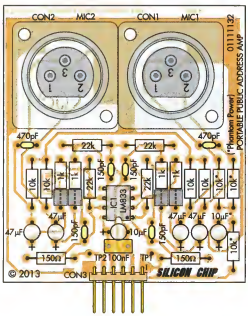
As shown in our photos, the PortaPAL-D is built on two L-shaped aluminium chassis panels which screw together into an open-ended box. Each of these panels is bent from a 300 x 300mm x 1mm aluminium sheet.

Fig.10 and 11 show the folding and drill layout for these two panels which can be made using basic hand tools. Some of the holes are countersunk, as shown in Fig.11.

For the cutouts, we drilled a series of holes around the inside perimeter of the cutout, then filed the it to shape.

In the absence of a metal bender, the 90° bends can be folded over the edge of a bench with the sheeting held in place with a timber block and clamps. A rubber mallet can be used to finish folding the aluminium flat along the bend crease.





Figs.6&7: component overlays for the guitar and line input PCB (above) and the microphone input PCB (right). The two boards mate to the main PCB via CON8 to CON10 and CON3 to CON11, respectively.

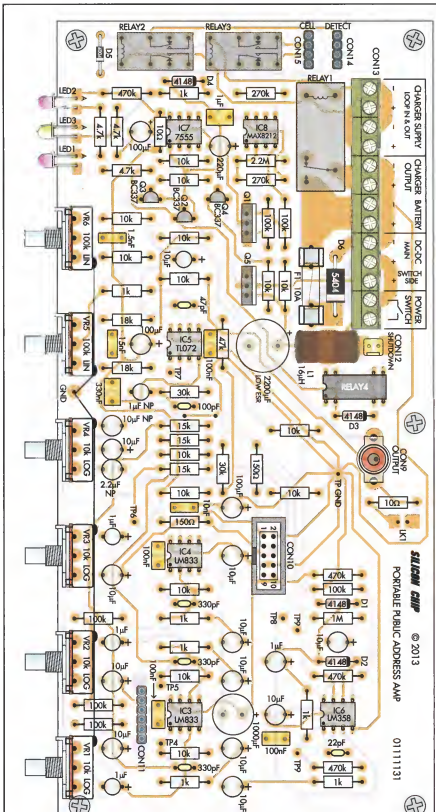


Fig.8: this board contains all of the mixing and audio signal control circuitry before it is passed off to the CLASSiC-D amplifier module from CON9. But it also contains the important power monitoring and processing circuitry to prevent damage to the Li-Po battery. These batteries, while light and powerful, are not quite as forgiving as other types if mishandled in the charging/discharging department.

After bending, you will have two L-shaped chassis pieces. One includes the front panel and onto this attaches the mixer, microphone and guitar PCBs and the charger. The second piece is for mounting the CLASSiC-D amplifier, the speaker protector, the DC-DC Converter, the fan and the battery.

We attached two small cabinet handles 45mm long x 15mm high x 6mm wide to the edges of the front panel. This is to allow the panel to be more easily removed from the loudspeaker cabinet. Our handles were fashioned by cutting the corner pillar sections from the base of a UB5 blue translucent box but small drawer or cabinet handles, available from any hardware store, would be even better.

Brackets

Four Aluminium brackets are required. These are made using 12 x 3mm aluminium bar.

Both the charger bracket and battery bracket have a heatshrink tubing covering to protect the charger and battery from direct contact with the aluminium that may otherwise short to the battery or damage the charger case.

Fig.12 shows the 110mm-long charger bracket. 3mm diameter holes are drilled 104mm apart with one hole being countersunk for the right-angle bracket. The aluminium is covered with a 95mm length of 10mm diameter heatshrink tubing, shrunk down using a heat gun.

Fig.12 also shows how the Charger Bracket is used with one end having two 12mm lengths of M3 tapped spacers supported with an M3 x 20mm screw. This is held in the front panel with an M3 x 10mm screw. At the other end of the bracket, a right angle bracket is attached using a countersunk screw. The right angle section then mounts to the horizontal panel of the L-shaped panel that also holds the CLASSiC-D amplifier.

Fig.13 shows the two frame brackets. These support the chassis junction between the top two mounting holes of the CLASSiC-D amplifier PCB and two of the main mixer PCB mountings that are directly opposite from the amplifier. With good fortune, the same spacings are between the standoffs in the CLASSiC-D amplifier and the main mixer. As shown in Fig.13, the brackets are 65mm long with 3mm diameter holes 55mm apart with a right angle bracket attached at one end.

For the battery bracket, the arrangement is shown in Fig.14. The bracket is 83mm long with holes 73mm apart. The bracket is covered with an 87mm long length of 10mm heatshrink tubing. Two stacked 12mm, M3 tapped spacers are held at each end with M3 x 20mm screws. The bracket holds the battery in place with M3 countersunk screws into the CLASSiC-D chassis along the horizontal panel.

Chassis assembly

For the front panel L-shaped chassis section, check that the mixer PCB fits correctly with the potentiometer and LEDs fitting into their allocated holes. The Preamp mounts on 15mm tapped standoffs that are attached using six M3 x 6mm screws. These are only used along the rear of the PCB. The potentiometers support the PCB at the front.

We placed a potentiometer nut on each potentiometer before securing with another nut on the outside of the panel. This spaces the PCB back a little from the front panel.

Also check that the microphone input PCB and the Guitar and line input PCBs fit correctly onto the front panel. The microphone PCB is plugged into the 6-way socket on the main mixer PCB and the XLR sockets fit into the holes in the panel. The PCB is supported in place using M3 screws or self tapping screws into the XLR socket mounts.

The guitar PCB is held in place via the 6.35mm jack sockets that are secured to the panel with a nut. The RCA sockets are secured with self tapping screws. Check also that the charger fits into its cut out.

Front panel

Once these fit correctly, the PCBs should be removed so that the front panel label can be attached. The front panel can be printed out from the file on www.siliconchip.com.au. We used A4 photo paper and adhered the printout to the panel with Silicone sealant. The panel was then sprayed with a

Here are the completed PortaPAL-D PCBs mounted on their respective L-shaped panels. All the wiring remains connected (to make it easier to follow) with the exception of the main DC connector from the LiPo battery (the red and black cables which go off the bottom of the page) and the 5-wire balance connector which connects to each of the cells in the battery (the loose white plug and socket). Compare this to the layout diagram overleaf. With the two panels folded and screwed together, the module is complete – all it needs is to be inserted into its possie in the speaker box and the two speakers connected.

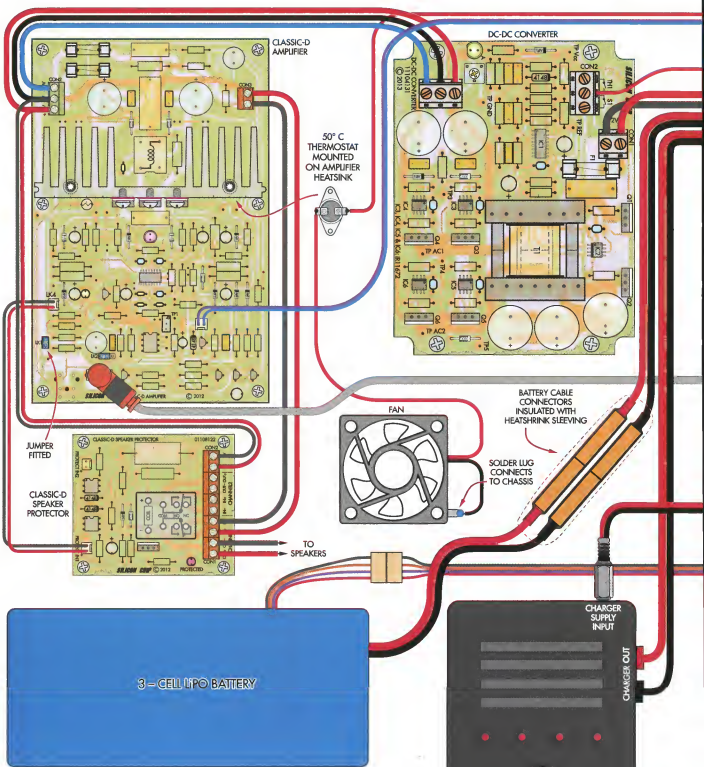
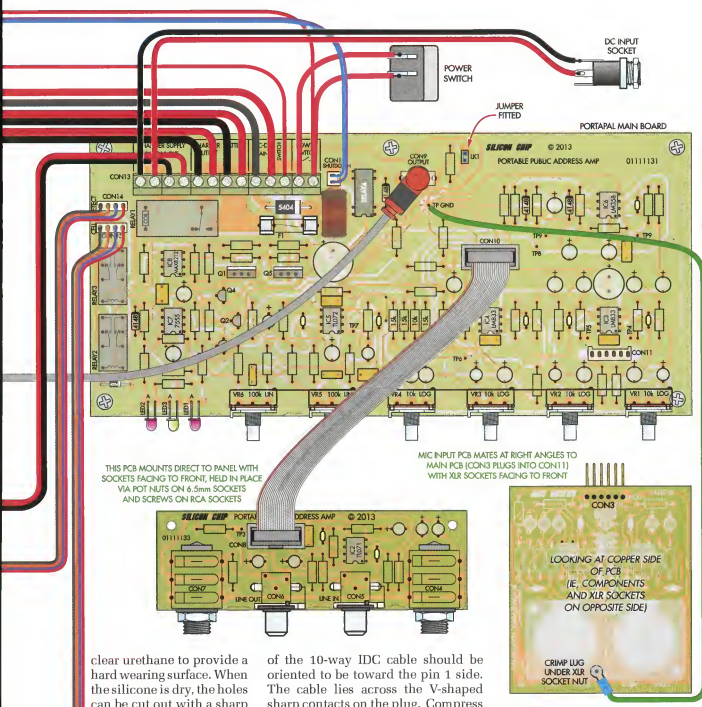


Fig.9: here's the complete wiring diagram of the PortaPAL-D, including the commercial LiPo Balance Battery Charger. While this diagram is not meant to be a layout, the DIY modules do follow the construction nicely: the Classic-D amplifier, its DC-DC converter and speaker protector, the fan and the LiPo battery all mount on one L-shaped panel, while the PCBs on the opposite page – microphone input board, guitar/aux input board and the main mixer/power monitoring board, along with the commercial battery charger, all mount on the other L-shaped panel. Screw those two panels together and you have the complete PortaPAL-D module as shown on page 31, ready to mount in the speaker box. Did we forget to mention you have to build that too?



clear urethane to provide a hard wearing surface. When the silicone is dry, the holes can be cut out with a sharp hobby knife.

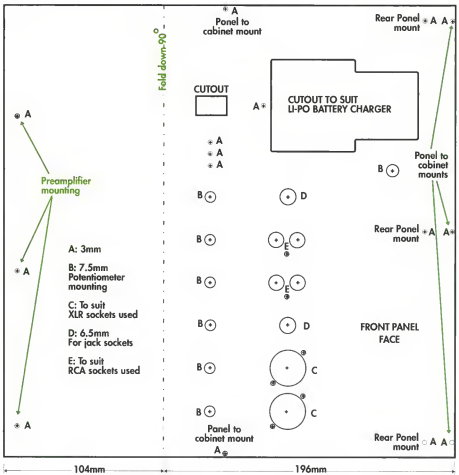
Reinstall the PCBs onto the panel. Take care not to damage the front panel while you are completing the wiring and chassis assembly.

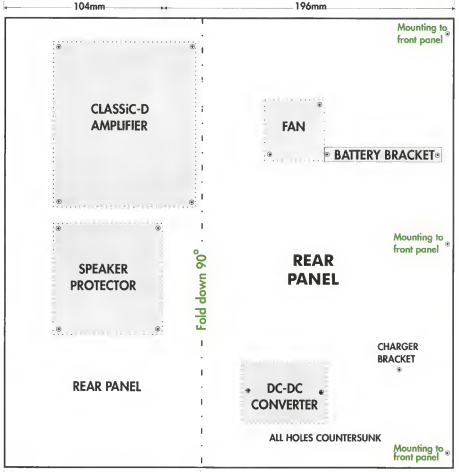
Make up the lead to connect the main mixer PCB to the guitar input PCB. This comprises two 10-way IDC line plugs and a 100mm length of 10-way IDC cable. The polarity indicator arrow on each plug is pin 1 and the red stripe side of the 10-way IDC cable should be oriented to be toward the pin 1 side. The cable lies across the V-shaped sharp contacts on the plug. Compress down the plug so the wires are pushed into these contacts. This cable can now be plugged into the sockets on the two PCBs.

The power switch, DC socket and charger unit can be installed now. Note that the charger can be partially held in place with the 24mm spacer end of the charger bracket attached to the front panel with an M3 screw. The other end of the bracket attaches to the CLASSiC-D amplifier L-shaped chassis later on.

The CLASSiC-D amplifier L-shaped chassis can be assembled now. The CLASSiC-D amplifier and the speaker protector are each mounted on four M3 x 9mm standoffs using M3 x 10mm screws. Only the lower four mounts are used with the CLASSiC-D amplifier PCB, with the two mounting holes above the heatsink (where the power in and speaker terminals are located) are free from the chassis and attach to the chassis brackets.

The fan mounts onto two 12mm tapped spacers positioned diagonally





Figs. 10&11 (left) show the sizes and drilling details for the two panels. These are reproduced at 40% life size. Figs. 12,13&14 (below and right) are details of the four brackets required. Much larger versions of these drawings, with more detail can be downloaded from www.siliconchip.com.au

from each other using two M3 x 10mm countersunk screws on the underside of the chassis. Two M3 x 15mm screws are used to secure the fan to the spacers.

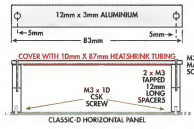
The DC-DC Converter mounts onto the chassis using two M3 x 6mm countersunk screws. Position the DC-DC Converter box over the two mounting holes and mark out on the box where the holes are to be drilled. Drill the two holes at 2.5mm (3/32") in the box before tapping the thread with an M3 tap. Be sure to clean out any metal shavings from within the DC-DC Converter box.

The battery is secured in place using the battery clamp. Use M3 x 20mm screws to secure the two 12mm spacers to the bracket and M3 x 10mm countersunk screws to attach the spacers to the panel.

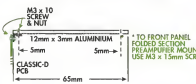
Wiring

Before assembling the two L-shaped chassis panels together, some of the wiring can be completed. For the CLASSiC-D amplifier chassis, that means that wiring can be done between the DC-DC Converter +/- 35V supply outputs and the CLASSiC-D amplifier and speaker protector plus interconnecting wires between the amplifier and the speaker protector. Fig.13 shows the wiring diagram.

Wires connecting to the power input of the CLASSiC-D amplifier are held against the heatsink with a "P" clamp. This helps to keep the wires away from internal cleats when the chassis is inserted in the speaker box. Most wiring is done using 7.5A rated wire. Typically the 0V wiring would be in black, positive wiring in red and earthing wiring in green. Using colour



BATTERY BRACKET – 1 REQUIRED



FRAME BRACKET – 2 REQUIRED

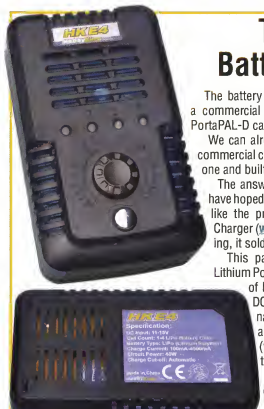
conventions helps to ensure the correct power polarity is connected.

The protect lead, comprising a 2-way lead with 2-pin header sockets on each end, plugs into the Protect IN1 plug on the speaker protector and LK4 on the CLASSiC-D amplifier.

Wiring of the fan to the thermostat can also be done. Fan wiring involves securing a solder lug under one of the spacer supports against the chassis and soldering the black fan lead to this. The red positive lead from the fan connects to the thermostat. The second thermostat terminal is the positive supply lead for the fan. This and the supply leads for the DC-DC Converter can be prepared ready to connect to the main mixer PCB.

Two other leads can also be prepared. One is the 150mm length of single core screened cable that has an RCA line plug connected to each end: one end is plugged into the CLASSiC-D amplifier input RCA socket while the other end is ready for connection to the main mixer PCB RCA outlet. The second is a 270mm length of twin figure-8 light gauge wire with a 2-pin header socket on each end. This lead connects to the LK3 protect header on the CLASSiC-D amplifier, while the other end connects to the main mixer PCB at the shutdown connector CON12.

Front panel chassis wiring is mainly for the charger and battery plus the interconnecting wires to the other CLASSiC-D chassis. Wires connect from the power switch itself to the power switch terminals on the mixer PCB. For the charger, a 2.5mm DC line plug connects to the charger supply input on the charger and the wires



The LiPo Battery Charger

The battery charger we used for this project is a commercial unit which we mounted inside the PortaPAL-D case.

We can already hear the question: "Why buy a commercial charger when you could have designed one and built it in?"

The answer is, quite simply, that we couldn't have hoped to build a battery charger for anything like the price of the HobbyKing TE4 Balance Charger (www.hobbyking.com). At time of writing, it sold for $AU13.12.

This particular charger handles from 1-4 Lithium Polymer cells with an auto charge current of between 100mA and 4500mA from a DC input of 11-15V. Furthermore, as its name suggests, it automatically balances the charge on each of the cells (which accounts for the direct connection to those cells).

The lower photo shows the output connectors (large red and black terminals) along with the balance terminals for 2, 3 or 4 Lithium Polymer cells.

connect charger supply out terminals on the main mixer PCB.

The charger supply input terminals on the mixer PCB connect to the 2.5mm DC panel connector. Charger output terminals on the mixer PCB connect to the charger output on the charger itself using right angle banana plugs. Red is for positive and black for the negative plug.

Battery supply terminals on the mixer PCB connect to leads that are terminated into Polymax 5.5mm Gold Connectors. The negative lead is terminated into the socket and the positive lead is terminated into the plug. These are designed to plug into the plug and socket leads on the battery. Note that it is important to place heatshrink tubing over the plug and socket so that when connected to the battery terminals, there is no exposed metal. Note that the leads as supplied with the battery have their terminals excessively covered in protective heatshrink tubing. It will be necessary to remove the excess tubing covering the plug portion of the negative lead plug and directly at the end of the red positive lead socket to expose the socket. You can connect up the 4-way cell sensing plug and socket to the battery and charger but do not connect the battery terminals yet.

There are two earthing wires. One is from the battery minus terminal on the main mixer PCB to the chassis. The second is from the microphone input PCB that connects to the TP GND PC stake on the main mixer PCB.

The two L-shaped chassis sections can now be connected together. The base of the CLASSiC-D amplifier chassis piece connects to the front panel using right angle brackets. The CLASSiC-D amplifier PCB's top mounting holes are attached to the frame brackets using right angle brackets. The opposite end of the frame brackets attach to the same screws that secure the main mixer PCB to its chassis.

Connect the supply and switch wiring to the DC-DC Converter and plug the RCA plug lead into the RCA output on the mixer PCB. Also connect the 2-pin header socket lead to the CON12 shutdown header.

NEXT MONTH:

We'll build the PortaPAL-D box, cover it in speaker carpet, fit the speakers and then fit the PortaPAL-D module to the box to finish it off. In the meantime, you have plenty of work to do! SC