More Guidelines for Minimizing Amplifier Hum

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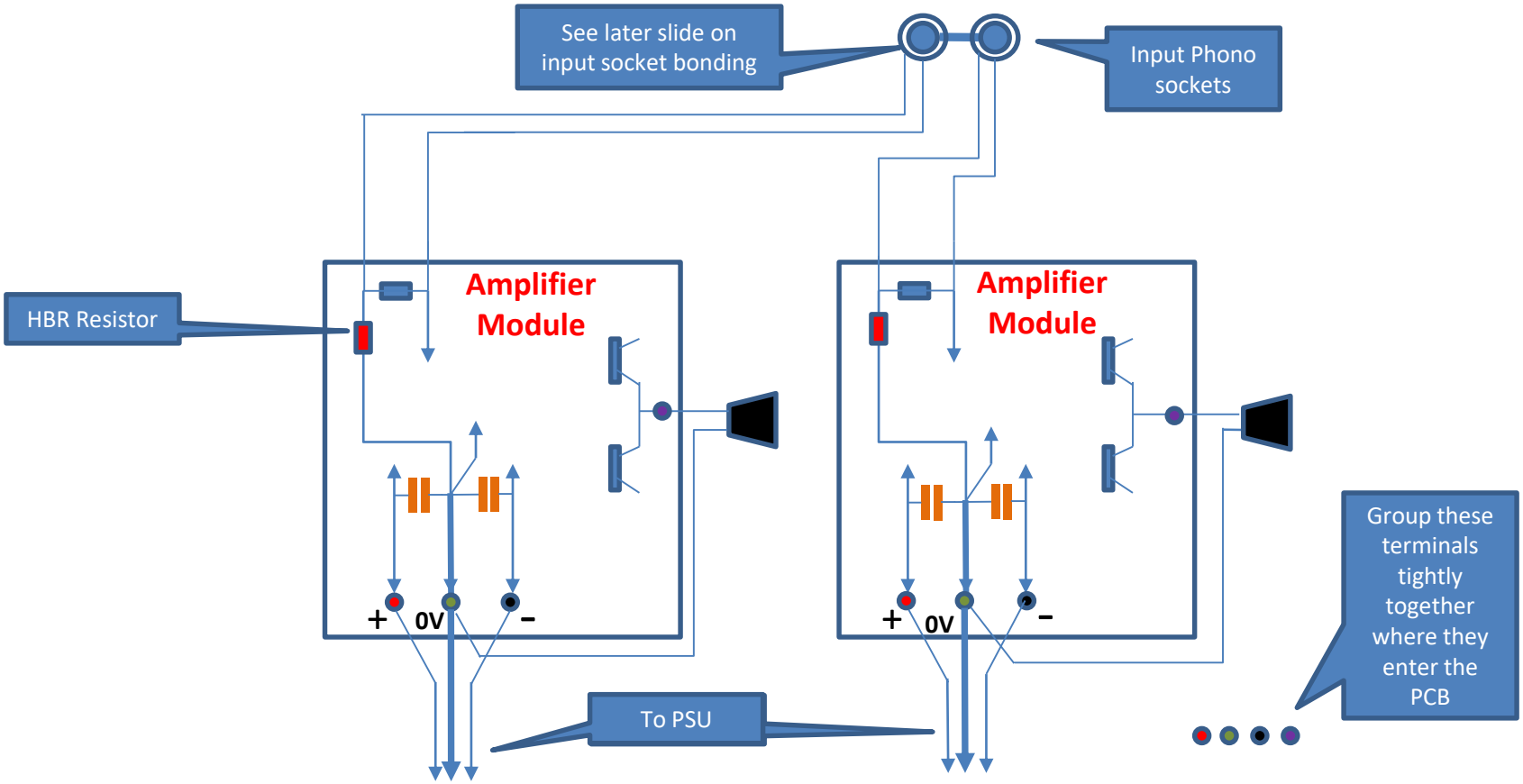
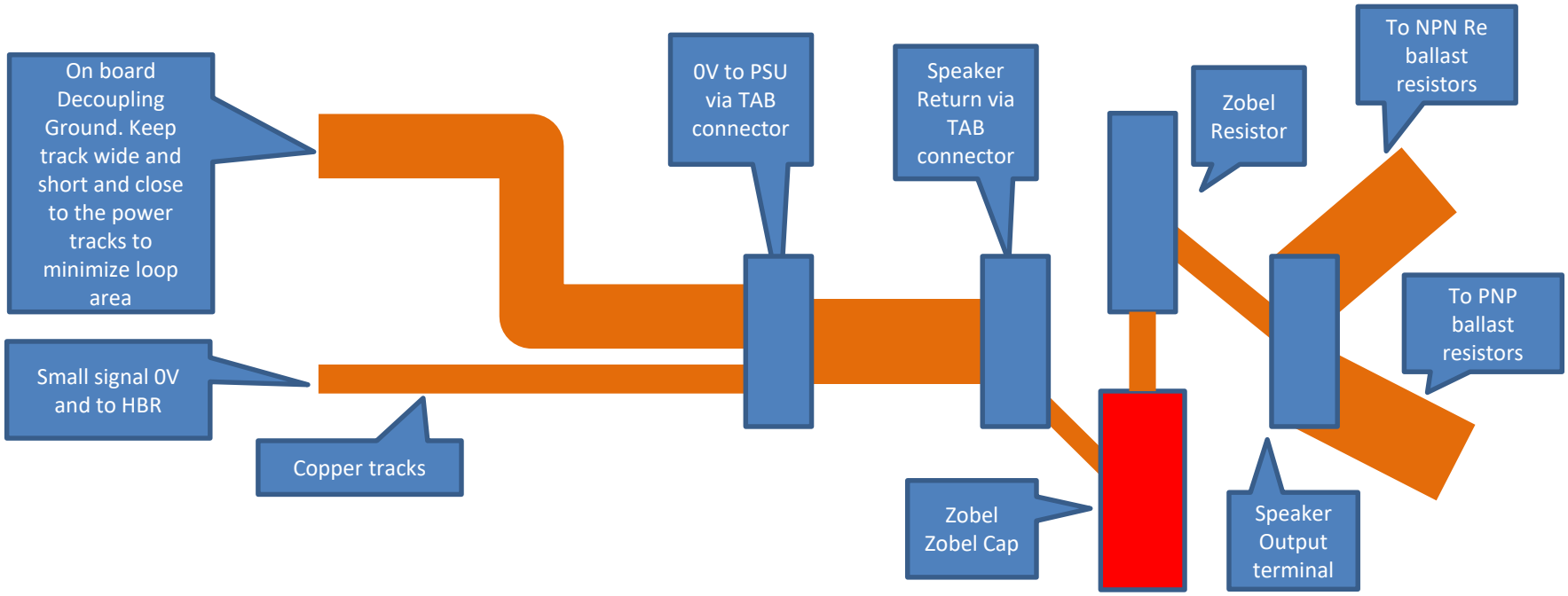


- ***Bond the input phono connectors grounds together at the point of entry into the amplifier chassis*** but do not let them make contact with the chassis metalwork. Connect a 1~2nF cap from the phono socket ground to the metal chassis right at the point of entry.
- Locate the input connectors for each channel ***NEXT TO EACH OTHER***
- Use a screen cable from the phono connectors to the amplifier module PCB's – best way to minimize internal interconnect loop area – or use tightly twisted wires
- Note the position of the Hum Breaking Resistor (Red) aka HBR
- The orange capacitors are the local on-board filter capacitors (typically 100uF to 1000uF). Note how the HBR connects directly to the star ground.
- Tap off decoupling and 0V reference directly from the on board star ground.
- The speaker return comes back to the 0V entry point on the PCB module. Twist the speaker wires from the amplifier to the speaker output terminals on the amplifier (see later slides for alternative wiring though)
- Use a THICK wire for the 0V return to the PSU and keep it SHORT
- Twist the +, - and 0V wires between the PSU and the amplifier modules

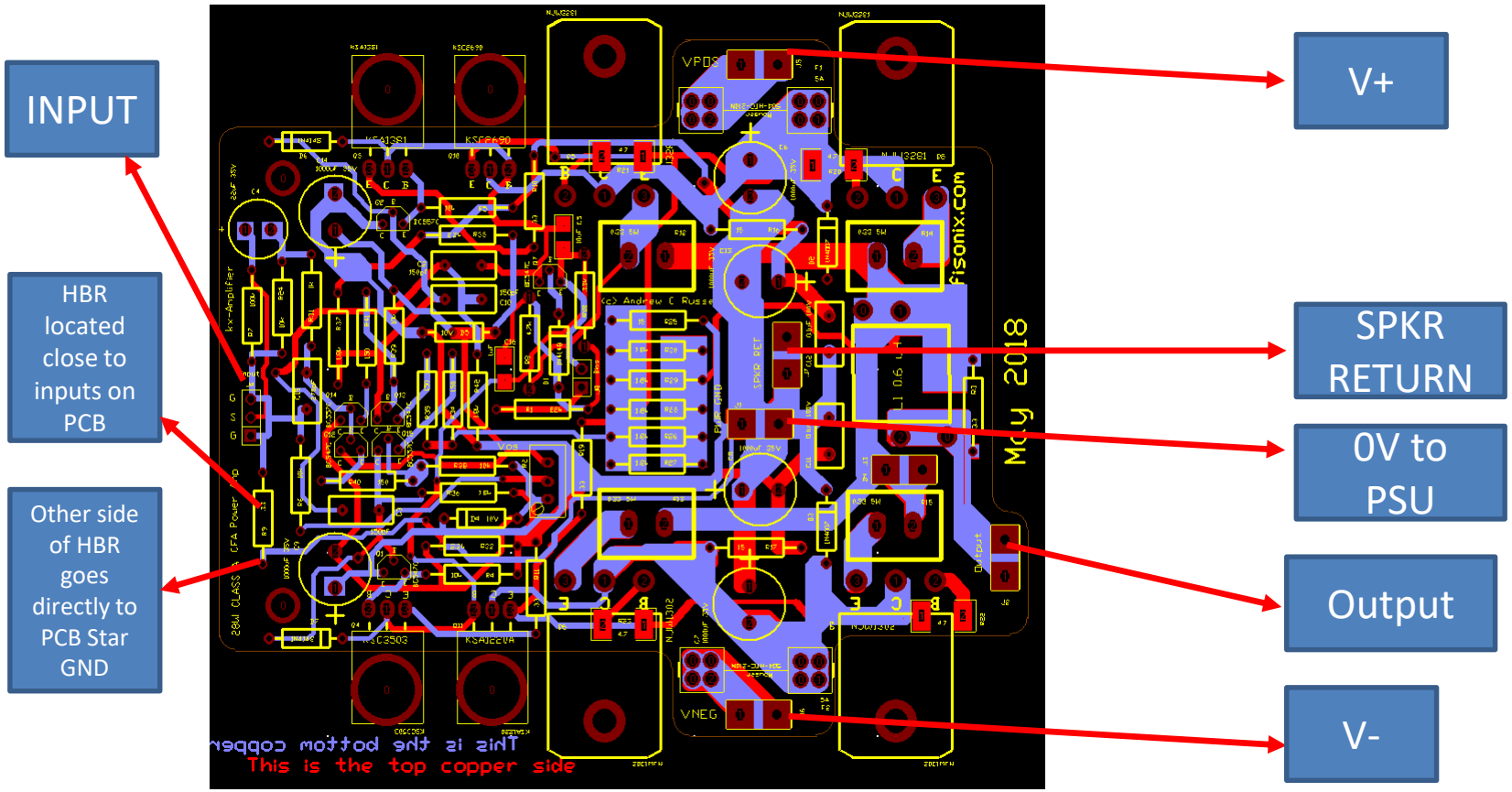
General arrangement for PCB 'STAR' ground



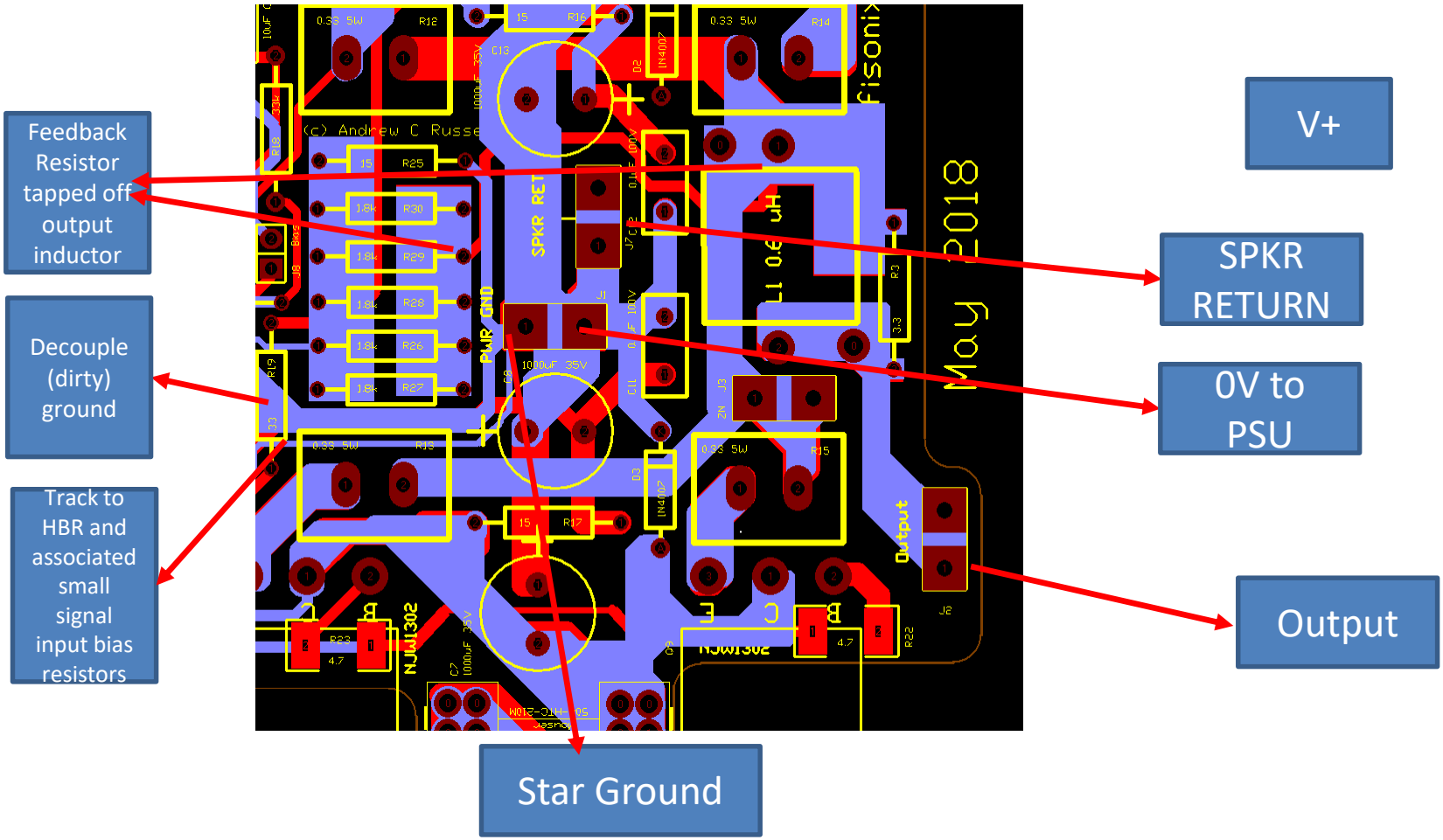
This graphic gives you an idea on how to layout the ground, speaker return and output on your PCB. The 0V to the PSU is in the middle and the speaker return top the right. This ensures that the local on board decoupling and small signal ground, which are on the left, are not contaminated by any large speaker related currents generating common impedance voltage drops. Since the small signal 0V is the system reference, the volt drops across the cable from the 0V Return to the PSU do not appear in series with any input or reference points and therefore do not contribute any common impedance distortion. ***However the 0V connection to the PSU must be short and low resistance/impedance***.

You can take the speaker return straight back to the PSU 0V, but to minimize loop area (and thus magnetic radiation), you should run it along side the output from the speaker terminal to the board, and then from the board alongside the power and 0V return to the PSU. This approach will in almost all cases be sub-optimal in terms of radiated magnetic fields compared to running the speaker return back to the amplifier PCB, but it still works quite well.

For PCB terminals, I like to use 6.35mm push on tabs (available from Mouser, RS components etc). These solder directly in to the PCB and accept push-on female tab receptacles which are available in fully insulated versions. The crimped connections are neat, very low resistance and very reliable – much more so than screw terminals which can loosen over time, and the crimp terminal/tab solution is cheaper although you will have to invest in a crimp tool (circa £15/US$20).

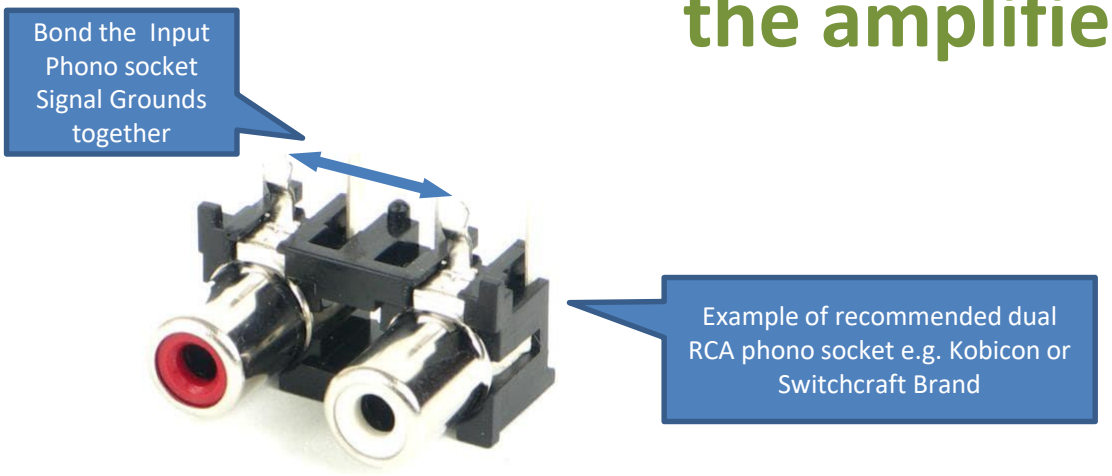


The V+, V-, 0V, speaker return and output are all located on one side and are close together. This allows the wiring to be tightly bundled to the power supply and out to the speaker cables, minimizing loop area. Note the speaker return and 0V connectors are mounted closely to each other and the small signal/local decoupling is taken off from the OPPOSITE side of the 0V connector to prevent common impedance coupling on the board. There are no other connections between the Speaker return and the main 0V terminal – this is to avoid any common impedance coupling.



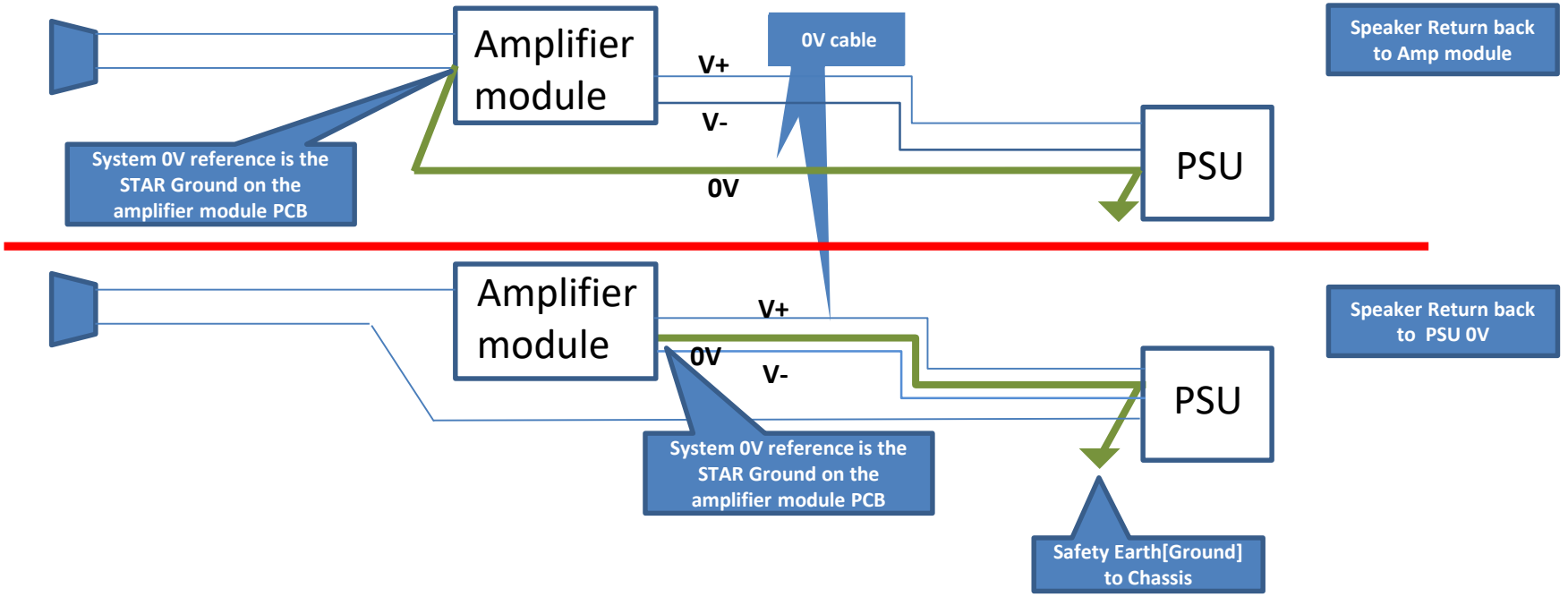
Here is a close up of the connections around the STAR GROUND on the PCB. The small signal ground connects directly to the 0V terminal and the decouple grounds connect at that point as well. The speaker return joins at the 0V and there are no other connections between it and the 0V terminal. ***The STAR ground on the PCB is the ground reference point for the whole amplifier***

Bond the phono input socket signal grounds together to trap cross channel ground loops within the amplifier



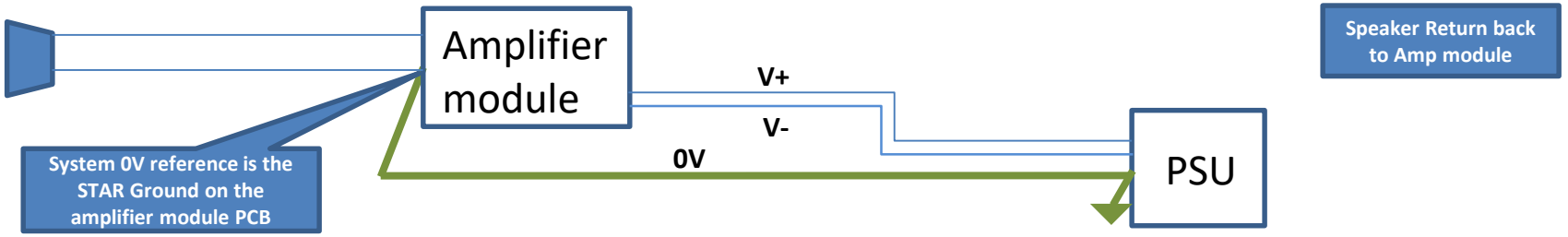
- If you bond the input signal grounds together at the input sockets, the total loop area is split into two smaller loops (external loop meeting at the input and internal loop meeting at the input) whose total area taken together remains the same. Any loop currents intersecting either of the loops will still give rise to their associated loop currents
- However, the benefit of bonding the phono sockets signal grounds together at the amplifier (same for preamplifiers as well) inputs is that loop currents arising ***internally in the amplifier*** do not flow out through the interconnect shield and its associated resistances to the source and back again to the other channel input, but ***remain trapped within the amplifier***.
- This reduces noise voltages arising across the interconnect shield (unwanted) resistances due to loop currents generated inside the receiving amplifier and therefore improves the amplifier noise performance.
- Same rationale applied to preamplifier outputs: keep them next to each other and bond them together at the output.
- Remember that the Hum Breaking Resistor inside the amplifier will act to reduce the loop currents and divide any internally arising noise voltage down – so always make sure this is fitted.

Should I take the speaker return back to the PCB or directly back to the PSU 0V?



- These are the two usual methods of routing the speaker return
- Clearly in the second option above, no heavy speaker currents flow in the 0V return from the amplifier modules (thick green wire). However, the amplifier reference in both cases is the 0V on the amplifier board, so what's the best approach here and is one better than the other?

The method below minimizes loop area most effectively (assuming good amplifier PCB layout)



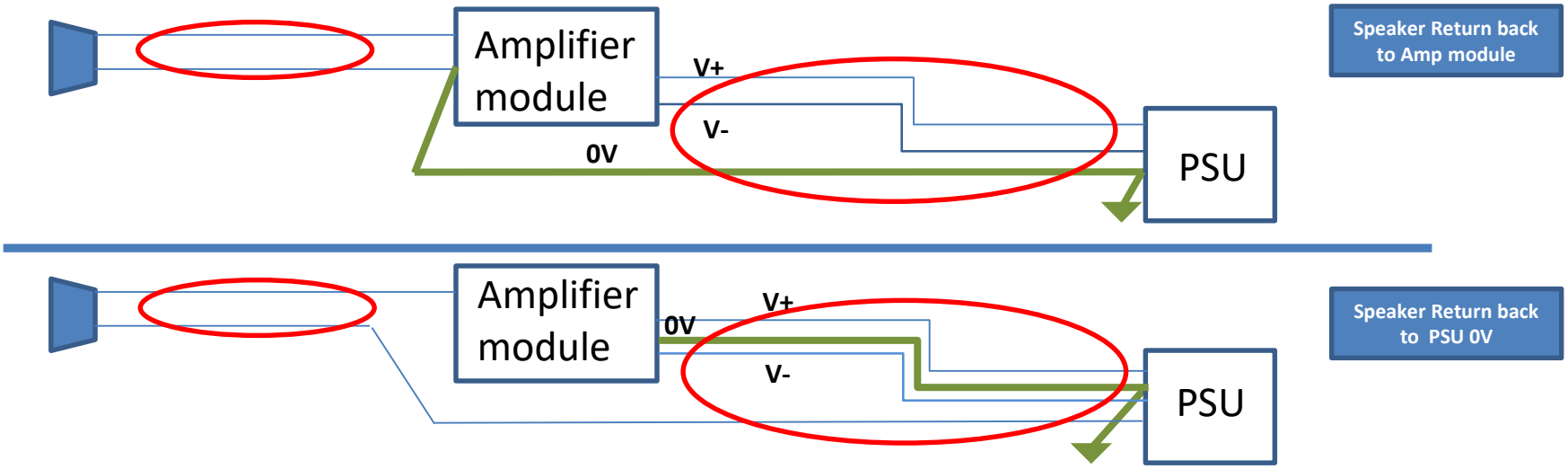
There are a number points to consider where the speaker return is taken back to the amplifier module first, and then returned to 0V on the PSU via the module 0V connection as shown above.

If the local module onboard bulk decoupling is inadequate, high HF currents will be forced to flow along the return wire (thick **GREEN**), and if this is of any appreciable length and the loop area bounded by it and the V+ and V- cables is large, its inductance will play a role and it becomes a potential magnetic radiation source inside the amplifier

So, the rules when using this approach are:

- Keep the return cable THICK and SHORT
- Ensure there is ***adequate on board decoupling*** and that it is ***wide-band*** – so use 1uF and 0.1uF localized decoupling around the output stages along with 220uF to 1000uF bulk decoupling on the amplifier module(s) near the output stage power feed. This keeps HF currents trapped on the amplifier module board and within the speaker/cabling branch and away from the return cable which then carries only LF currents.

In both approaches, twist the wiring where indicated to minimize loop area and wiring inductances



- In both approaches, tightly twist the all wires from the PSU to the amplifier module
- Tightly twist the wires from the amplifier module to the speaker terminals
- In the second approach, run the speaker return back to the PSU along with the PSU wiring. Where the return cable goes around the amplifier module, try to route it over the main 0V on the PCB module – whatever you do though, keep it well away from the small signal parts of the circuit.