

Ground and (safety) Earth

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Grounding and Earthing is wide problem on audio devices. Currents flow across ground, chassis and audio cables. Some currents are normal operation, others are parasitic.

Is this unwanted current circulation degrading audio signal?

Common user only care about parasitic current when hum or noise problem occur. At this point, audio signal is highly degraded. Even at very low level, parasitic currents dramatically damage sound performance, particularly today where DAC must maintain more than 120db resolution.

Electric plugging, let's have a look on basis.

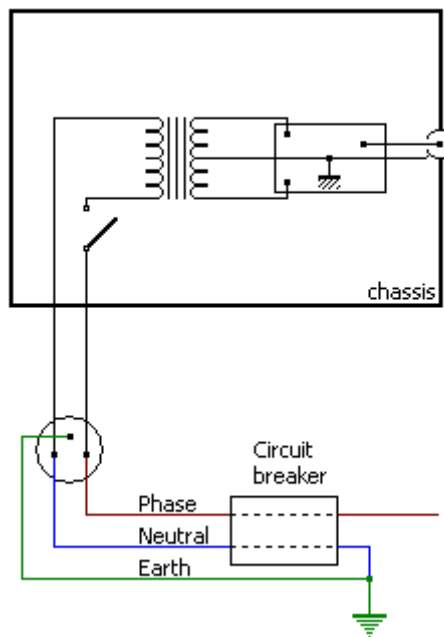


Figure 1

Figure 1 show conventional audio device plugged on main sector. Phase conductor transports main tension (220V 50Hz / 120V 60Hz) and current. Neutral conductor is normal return line current. Safety earth ground (not used on this sample) returns abnormal current to earth. Safety earth ground and neutral were link before security circuit breaker.

Where does perturbation come from?

Most of parasitic current come from main and power transformer. Figure 2 show source device and parasitic capacitors introducing unwanted currents.

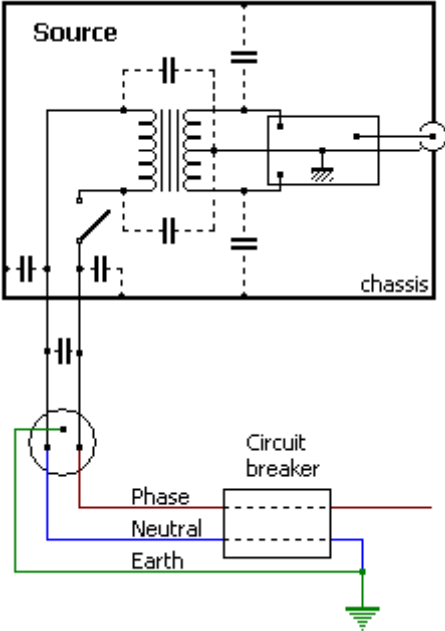


Figure 2

Measuring parasitic current and tension

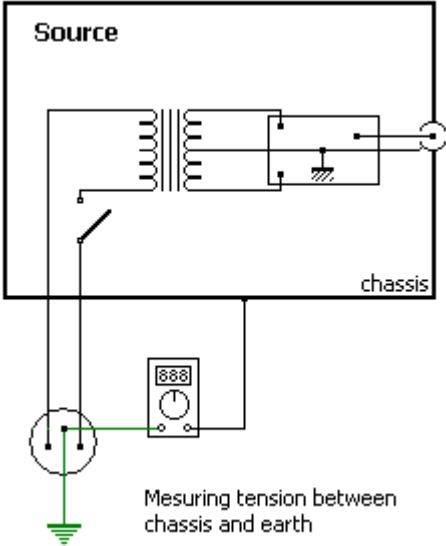


Figure 3

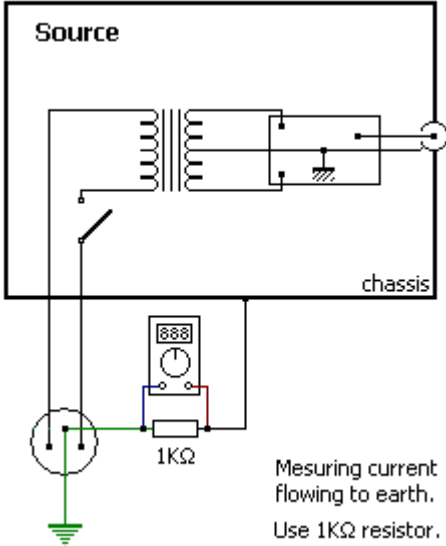


Figure 4

Figure 3 show method to measure tension between chassis and safety ground earth. Figure 4, show method to measure current flowing chassis to safety ground earth. Use 1KΩ resistor.

Table 1 gives test measure on three preamplifiers.

	Optimal phase*	Reverse phase*
Device 1	30.8 μ A	99.3 μ A
Device 2	10.9 μ A	38.2 μ A
Device 3	13.8 μ A	51.7 μ A
Device 3	9.5V @ 220V-50Hz	43.3V @ 220V-50Hz

* See later in the text

Negative effect of parasitic current

When linking two devices (source and amplifier for example), parasitic currents flows across audio cable's ground shield. This flow creates perturbation in audio signal and can generate hum and noise.

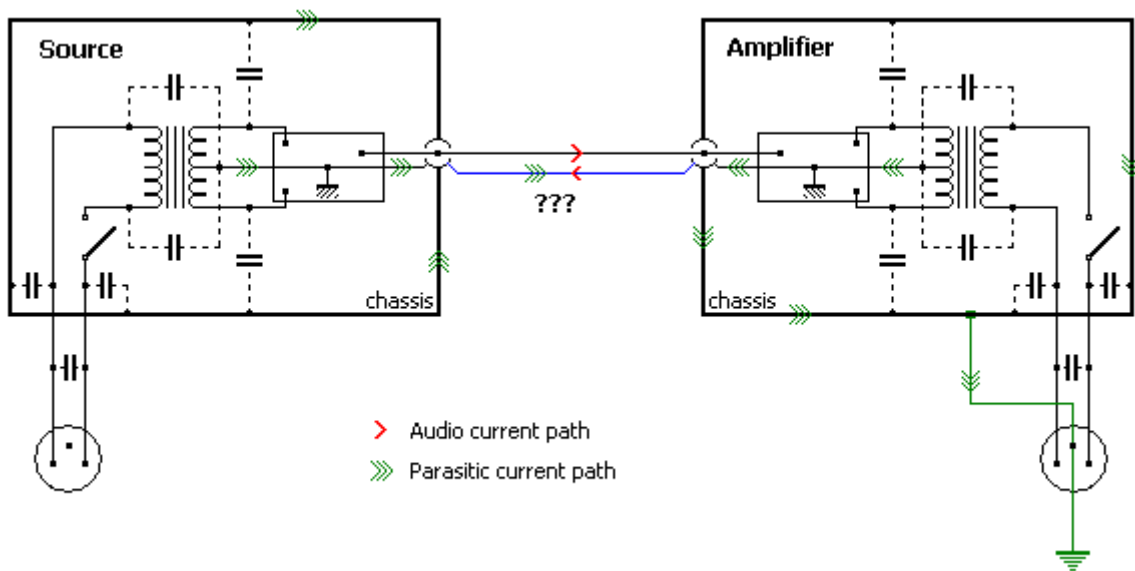


Figure 5

To return to Earth, parasitic current from source must flow across audio cable. The direction of this flow is opposite to audio current. This creates sound degradation.

Audio signal flowing across audio cable is about 6 μ A (280mV output tension on 47K Ω input impedance). See table 1, even low measured parasitic current is greater than audio current. **In audio cable's ground, parasitic current is directly mixed with audio current.**

Minimizing parasitic 50/60Hz current

Table 1 gives measured values from three different preamplifiers. **You can minimize parasitic current by inverting main plug** as show as figure 6. You can determine normal and reverse position by listening comparison, without unplugging Earth cable.

Warning: Cutting-off safety earth could be dangerous. Reserve this operation only for measuring test. Take great attention during operation, prefer listening comparison.

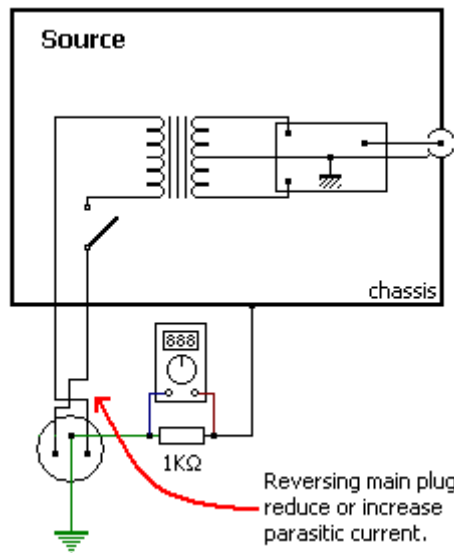


Figure 6

To minimize parasitic currents flowing across audio cable, link all devices to the Earth as shown in figure 7.

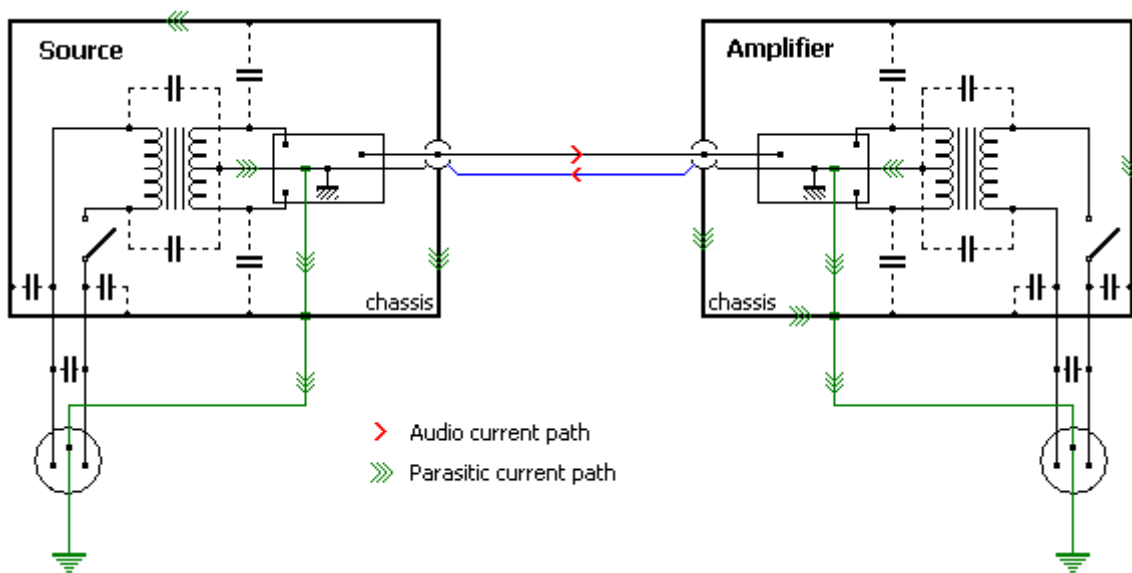


Figure 7

Figure 7 show optimum wiring to reduce or cancel parasitic current flowing across audio cable. All devices are linked to the Earth and optimal point on ground pin is linked to chassis.

Is there any risk of ground loop?

Ground loop, well known problem, can highly degrade audio signal by creating hum and buzz. Ground loop occurs when parasitic current flow across audio cable's ground. Linking ALL devices to the Earth shunts parasitic directly to Earth. It cancels or reduces parasitic current flowing in audio cable. It acts like ground plane. **Linking ALL devices to Earth minimize hum and buzz problem.**

One step further

Parasitic is not only 50/60Hz current; it's a wide band signal. Keeping low impedance on Earth is very important. For this goal I use multiple cords and connections. One cord is main sector Earth wire; second one is a 6mm² wire linked to *ideal ground point*. Ideal ground point is silent ground pin. This point is after regulators. Avoid errors on connecting on noisy point as show on many devices!

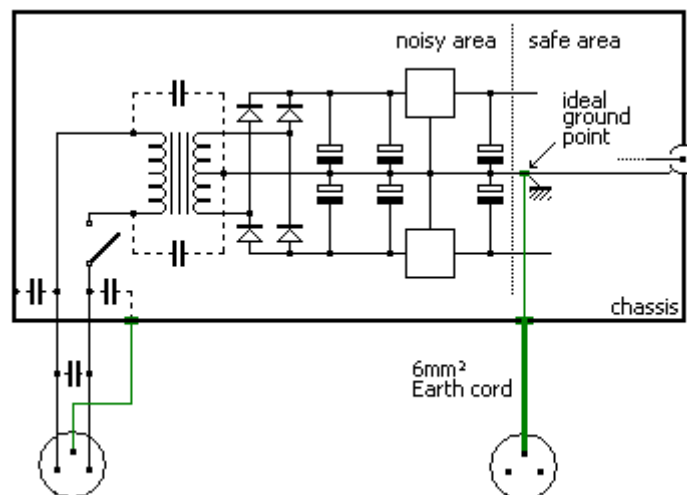


Figure 8

Figure 8 show device with two Earth wires. Second (and optimal) Earth wire is connected to chassis and ideal ground point. Ideal ground point is in the safe area. Keep (main) cables as short as possible to reduce impedance.

Warning: Only change internal wiring on your personal designs. Wiring error can dramatically damage device.

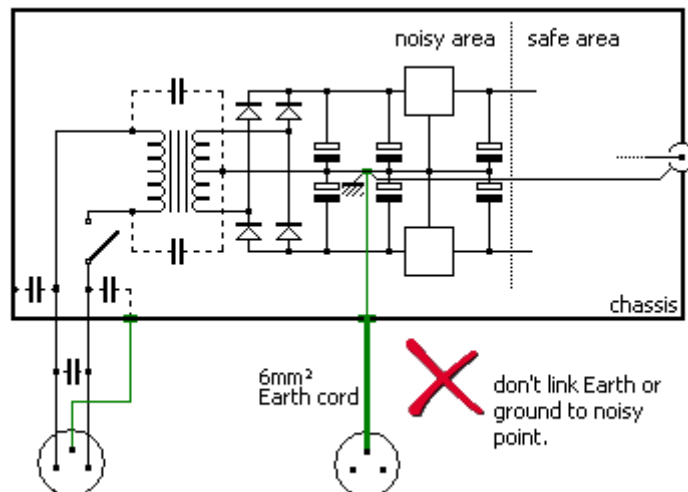


Figure 9

Figure 9, avoid ground and Earth connection on noisy area.

Sonic benefit

Linking all analog and digital audio device to Earth greatly enhance sonic perception. This reduces artificial harmonic and brightness, increase bass and depth level, greatly improve dynamic. Music is steadier, less foggy; everything seems so natural and easy, very sweet and detailed.

References

Jensen AN-004 "Hum & buzz in unbalanced interconnect systems" by Bill Whitlock
<http://www.jensen-transformers.com/>

"Supply Decoupling" by Guido Tent
<http://www.tentlabs.com/>

« Mechanical Grounding » by Goldmund
<http://www.goldmund.com/>