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with kind permission

Grounding 101:

I like to think of all electrical currents as water flow in pipes. Easier to visualize.

If you have a sink... and a tub and they both drain into the Atlantic (ok you California boys...) ... PACIFIC ocean, there is little chance that they will interact

The tub cannot back into the sink, nor the sink into the tub.

If you join them with a 1/4" pipe... it is a sure thing they will interact.

If you run two separate pipes, all the way to the ocean... they may drain slow but will NOT interact.

If you consider TOILET and DRINKING WATER together, you can see how important the planning is.

QUESTION : If you drop a jigger of Vermouth into Gin to fill the North Atlantic Ocean... what do you get ?

ANSWER : A VERY dry martini :^P

If you add one ounce of water to the ocean... the level rises. Probably you will say "who the fvck cares" and you're probably right. The question becomes... do I notice the change in water level, and do I care ???

NOW Grounding... There are several techniques.

1) Make ONE ground, really BIG and hope that all the current you can dump into it does not cause circuits to interact.
2) Make several grounds and run them separately all the way to the ocean (power supply)

Plan two is MUCH harder to pull off... you need to design that right from the beginning or it is nearly impossible. So most people use plan one. Plan one is CHEAPER, and might be all you need.

Harry's theorem of circuit equivalents.

Low level audio is like the "Drinking Water"

Most CVs are like the "Tub" Circuits that drive obnoxious loads like LED displays and Relays are the "Toilet" :^P

You need to take special precautions for the drinking water. That could be things like separate power traces ALL the way back to the power supply, or extra decoupling caps etc.

The same is true for the obnoxious loads... you don't want to pollute the power system.

PARASITIC inductance and capacitance... friend or foe ???

Every circuit has parasitic elements... they are there without your intentional design. The power supply traces have some inductance in series with them and capacitance between them. Inductance will cause the current to rise slowly when there is a power demand... so there will be a voltage drop at the load. Capacitance can cause fast rising signals on one wire to be coupled into another.

In general, for a power supply bus the parasitic capacitance is not a problem and could even help you. Likely you don't notice... its a few pF in parallel with many uF(s) of filter capacitors. Inductance DOES hurt you. You minimize inductance by running the power feed and return very close together. Often, twisted pairs work well for this (in wires) and double sided or multilayer boards work for PCBs.

The idea is to minimize the area of the loop made as the current flows in the circuit. The smaller the loop, the lower the parasitic inductance.

HOW to achieve all this is a system design nightmare. If the maker of the modules did not plan ahead there is little you can do to improve on their design. The best route would be BIG power supply traces with lots of decoupling caps to provide local power storage... this will feed the circuit until the current can reach from the main supply.

You could make a distribution board and run all the wires back to it, using twisted pairs. That would be good as well.

It is good to have a single point ground (the 'ocean' would be ideal :^). This is often not possible. Some chips like A/D converters have both Digital and Analog signals (like DIRTY and CLEAN...) and the best technique in that case is to run things so that the digital currents have an easier path back to digital ground, and the analog currents have an easier path to analog ground. Usually it is nice to tie the analog and digital grounds together RIGHT AT that chip, so that they are at the same voltage and no errors are introduced...

But what if there are TWO A/D converters, or a bunch of sensitive preamps etc... then you are back to the drawing board.

Grounding is as much art as science. How you do it drastically effects the performance, but there is no one technique that is perfect for all situations. I usually (by design) try and run power to my dirty loads separate from the clean ones... make the grounds BIG and low inductance... use a lot of decoupling caps (right Mr. Patchell ???)...

...and pray often

H^) harry