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EMC TROUBLESHOOTING TIPS

After several years of troubleshooting electronic products for various EMC issues, I've compiled a list of tips for assessing whether the issue may be due to conducted, radiated, magnetic or capacitive coupling. First, let's establish some basic facts about coupling paths:

CONDUCTED - If the coupling path is conducted, separating the source and victim will not affect the EMI. There will almost always be a shared R. Two conductors will be required to complete the path; typically, DC and return.

RADIATED - There will be a weak change with distance (1/r) between the source and victim. The coupling is more likely to occur at high frequencies (> 200 MHz). There will be a changing current, di/dt, pushing through some radiation resistance (Rrad). Physically, you need two antenna structures; one for the source and one for the victim.

INDUCTIVE - There will be a strong change with distance ($1/r^2$ or $1/r^3$). As frequency increases, the EMI will increase. You'll be looking for a di/dt in a loop. You will physically need two loops; one for the source and one for the victim.

CAPACITIVE - There will be a strong change with distance ($1/r^2$ or $1/r^3$). As frequency increases, the EMI will increase. You'll be looking for a dv/dt in a surface area. You will physically need two surface areas; one for the source and one for the victim. Typical surfaces could be circuit traces, heatsink, cables, etc.

OK, here's the list in no particular order.

1. The geometry of the system or potential coupling path doesn't always tell you whether the E or H field is dominant. However, small magnetic loops are very inefficient radiators. Initially, you need to evaluate di/dt or dv/dt. Which seems dominate?. Changing the load (up or down) will affect di/dt and is a good troubleshooting technique.

2. When evaluating the harmonics on a cable by using a current probe, if sliding the probe back and forth changes the harmonic levels, part of the coupling may be near-field, rather than conducted.

3. When using a pair of current probes; one on each of two cables, if the harmonics are the same in each, the source is in the middle. If one cable has stronger harmonics, then you'll want to work on that side first. See Figure 1 below.

4. Measuring the currents on two suspect legs of a dipole should read the same. Placing the two suspect legs through the same current probe should cause a big decrease due to current cancellation. See Figure 1 below.

5. If you have a 100 MHz clock and you have 200, 400 MHz (even) harmonics, it's probably power distribution noise. For a given square-wave clock signal (fo), the noise current spikes will be 2fo.

6. Unless your issue is with a very high harmonic (10th, for example), the use of a low-pass (R-C or ferrite-C) filter on a clock trace is probably a waste of time. However, if added, be sure to verify the signal integrity of the clock line after the addition.

7. If the noise coupling is conducted due to power bus noise currents, then use a ferrite-capacitive low-pass filter at the source IC power pin (or pins). A ferrite "T" filter is even better.

8. If the coupling is near-field (verify with a near-field probe) between a cable and IC package, use separation to resolve; i.e., reroute the cable!

9. If the coupling is near-field magnetic, then mounting the magnetic element (transformer, for example) on wires should cause the coupling to decrease. If moving the transformer around on the extension wires varies the effect, then you've verified the issue is inductive coupling.

10. If you suspect a heatsink is either acting as a radiating structure or if the IC itself may be capacitively coupling to it, try removing it temporarily. If you suspect its capacitively coupling to a cable or the IC itself, reroute the cable temporarily. If radiating, grounding the heatsink may help if done in multiple locations, but it may also form a tuned circuit and make the problem worse.

11. If you're testing contact discharge ESD and the position of the simulator causes a pass or fail, it's probably due to a near-field effect, rather than ESD. Most commercial ESD simulators produce very strong radiating fields, due to poor shielding, in addition to the ESD pulse. To reduce this effect, start charging the simulator farther away from the EUT.

12. If you find a large signal when using a loop probe on a PC board, and you don't know where the return current flows, you may have found a large loop area.

13. When measuring video cable currents and large cable movements cause big changes in amplitude, the coupling is likely inductive - otherwise, it's more likely conductive.

14. Circuits with a high-impedance load are more susceptible to inductive coupling.

15. If you suspect inductive coupling the phase at the victim will be 180-degrees from the source. This may be observed on an oscilloscope with H-field probes or current probes. Try syncing the scope trigger at the source using a scope probe.

16. If you suspect cavity resonance, try inserting some type of material, such as an anti-static bag, aluminum foil (be careful to avoid shorts), or ferrite material (a large core or plate) into the cavity to quench the resonance, or at least see a change.

17. Ferrite chokes are most effective at the current maximum, i.e., right where the cable terminates at the PC board or chassis.

Please feel free to write me to add to add your favorite troubleshooting technique to this list!

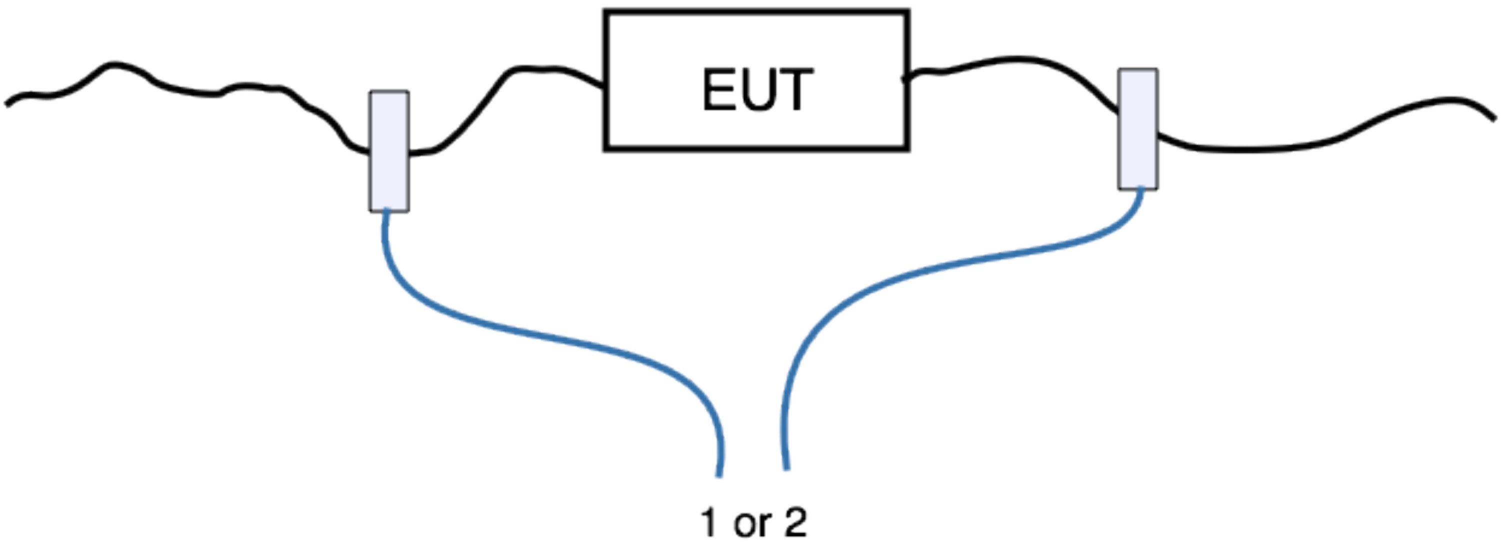

Figure 1 - When measuring two cables from a system and the harmonic currents are approximately the same (point 1 is the same as point 2), the source is at the center (the EUT) and the two cables are acting as a dipole antenna. You may notice a peak in harmonic strength at the half-have length of the two cables combined. If the harmonic currents are larger in one side or the other, then you'll want to troubleshoot just that cable.