Design Ideas

Use Layout to Reduce Radiated Emissions

By Gary A. Breed
Publisher

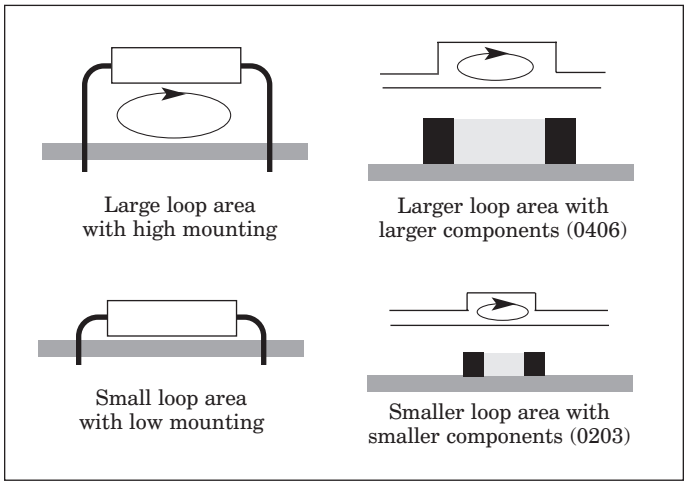
All electronic products must comply with U.S., European or other international regulations for electromagnetic compatibility (EMC). These regulations have either specified limits for the field strength of unwanted radiated emissions, or a requirement that those emissions do not cause interference. European Union (EU) regulations also include standards for immunity to outside fields, surges and discharges.

Many design engineers will attest to the fact that modifying a circuit to achieve EMC compliance often takes more time and effort than the original functional design! This note covers one way to reduce radiated emissions — controlling the size of loops formed when the circuit is laid out on a p.c. board or installed in an enclosure.

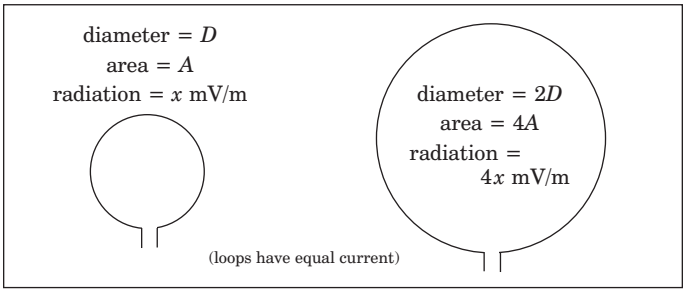
Loop characteristics

Loop radiation has two main characteristics to remember. First, radiated field strength is proportional to the current (RF current) flowing in the loop. This means that loops in large signal portions of the circuit have greater contribution to overall radiation than those where RF levels are minimal. Second, loop radiation is proportional to the area enclosed by the loop, as illustrated in Figure 1. Radiation can be reduced significantly with a modest decrease in loop size.

We'll take a brief look at three areas where loops occur in p.c. boards and finished equipment. These areas include component mounting, power supply traces and internal wiring practices.



■ **Figure 2. Component mounting affects loop size.**



■ **Figure 1. Radiation from loops is proportional to loop size.**

Component mounting

In the "old" technology of through-hole construction, it is very easy to get large loops. Not only is the overall size much larger than SMT construction, it is possible to get unwanted loops when components are not installed properly, as shown in Figure 2. Make sure that components are mounted flat against the p.c. board. If the board is two-sided instead of multilayer, make sure the ground plane is as extensive as possible, reducing the overall path of the loop.

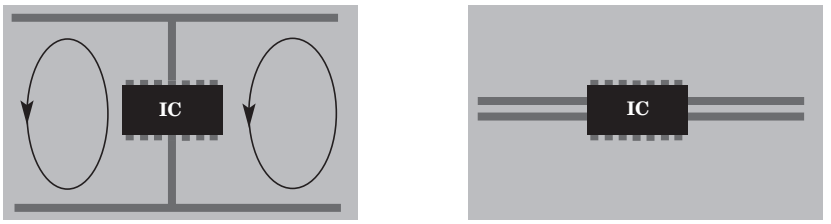
SMT boards can also be improved regarding radiating loops. The right side of Figure 2 shown why smaller components are better from a radiated emissions standpoint. The loop created by the component and the underlying substrate will be substantially reduced when smaller components are used.

Power supply routing

Although the magnitude of the RF current may be small, the DC power connection can create a very large loop if the designer is unaware of its radiation potential. From an immunity standpoint, the extensive size of the overall power bus can create an effective "antenna" that intercepts energy from outside sources. Reducing the efficiency of that antenna is a worthy goal.

In the days of slow logic families and kHz or low MHz device speeds, p.c. boards were often laid out with DC power distributed far from the devices (Figure 3, left). It is obvious that the loop created is very large. If the circuit uses analog parts with dual supply voltage, there might even be two loops per device.

A better power distribution scheme is illustrated in the right hand sketch of Figure 3. DC power and its return (ground or dual polarity) are routed in side-by-side traces. The enclosed loop has a very small area,



Large loops with wide trace spacing.

Loops are minimal with this method.

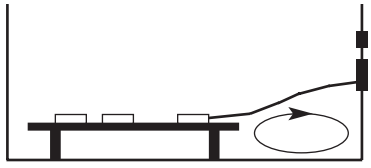
■ **Figure 3. Keep power conductors from creating large loops.**

looking much like a transmission line. This arrangement will minimize radiation and improve immunity of the circuit.

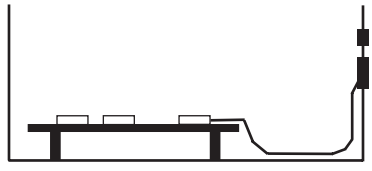
Internal interconnections

Most products still require connections to switches, controls, connectors and other circuit boards inside the enclosure. If we can keep the radiation from these interconnections to a minimum, we might save money on the enclosure. The cost of an electronic enclosure always increases when special materials, coatings or foils are added to improve shielding.

Figure 4 illustrates internal loops. Loop size is reduced when wires are routed close to the conductive ground plane. This ground plane may be the case itself, internal shielding material, or part of a shielded cable assembly. Like a transmission line, fields are largely contained between the conductor and the underlying ground plane.



Direct wiring can create large loops that include the walls of the enclosure



Routing wiring along enclosure walls minimizes loop size

■ **Figure 4. Loop size can be controlled by routing internal lines.**

Conclusion

While these concepts will not solve all radiated emissions problems, knowing them will help you design circuits that will meet EMC requirements with less rework. ■