Microwaves&RF

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Understanding and Guarding Against EMI

EMI protection is a fundamental element of system design, but poor prioritization, unexpected sources of interference, or a lack of in-house answers can leave designers stumped for solutions.

System engineers, across a multitude of applications, occasionally overlook the impact of electromagnetic interference (EMI), making it a secondary consideration in design. This oversight can lead to development delays and additional costs.

Still, even the most cunning engineer who has considered EMI from the outset encounters unexpected interference or interference from an unknown source. This article examines options to eliminate EMI—both mid-stream and at the outset of system development—and the cost constraints of those options.

Systems Change, But EMI Remains

EMI protection—for the most part—is either insufficiently covered in the engineering education system or its impacts are improperly prioritized. Thus, it often is relegated to an afterthought or a low-priority consideration during design.

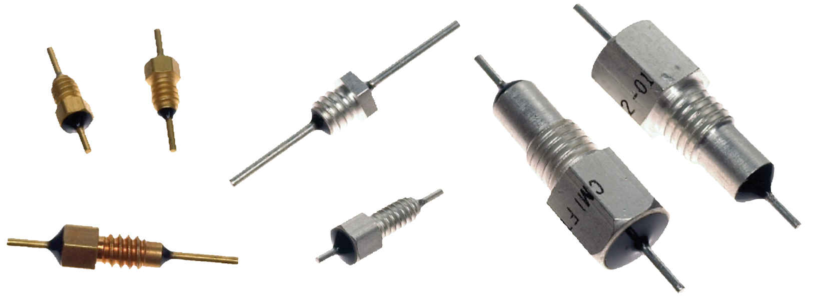
Rather than help this situation, the advent of digital technology seems to have exacerbated it. As interference on a digital circuit is minimized, compared to an analog circuit, EMI can erroneously be assumed to be a non-issue. It may also have a negligible impact on a system when, in fact, its effects compromise the system in some way.

Furthermore, analog circuitry remains a vital component even in digital systems—significant both in volume and function—because even a digital signal must be transferred from one box out to another through wires or over-the-air (OTA) transmission.

A good illustration of this is a laptop computer. All of the laptop's digital workings are under the keyboard, inside the case. But, to scan something, print something, or move files to an external hard drive, your laptop must connect to another system.

This transmission of a signal from point A to point B is where EMI protection becomes critical. Externally powered devices (those plugged into wall sockets), as well as those connected to peripheral devices—anything with an input/output (I/O)—are susceptible to EMI because those wires can act as an antenna that will allow EMI to be received (coupled onto them) and enter the device. In addition, completely isolating a system from EMI becomes more difficult

1. A single multiple-line connector, such as the filtered terminal blocks pictured here, can mitigate EMI problems in designs that might seem to not be susceptible to EMI, but in fact contains signals at various frequencies that interfere with each other.



2. Feedthrough filters incorporate a wire that goes all the way through the part. More current demands a larger wire, and the whole component must be upsized to surround it.

as the system grows in complexity, such as when the system involves multiple lines or multiple signals.

A scenario with multiple lines might involve a company that has come out with an impressive overall design, but one that suffers an EMI problem across the power supply. For instance, the bus driver and the I/O lines operate at different frequencies. The company can install one feedthrough filter each for the power supply, the I/O lines, and the bus driver, or they can choose to combine them into a single multiple-line connector *(Fig. 1)*.

A scenario involving grappling with multiple signals could be applied to the laptop example. You may use a USB cable to connect to a printer, and that cable is completely shielded (encased in a metal shield connected to the system ground on both ends).

However, what happens when you need a 100-foot cable or a one-mile-long cable? The cable may be shielded, but it also could be running a multitude of signals along the same line (such as the cable line that comes into your house), introducing considerations about signal cross-contamination and (frequency-based) microwave filtering to your design.

Note that a digital system that stays "inside the box" may appear to have little need or requirement for EMI protection. Nonetheless, EMI shielding from unexpected sources should remain a principal consideration.

First Things First

When reviewing the use of feedthrough filters to prevent EMI, basic requirements common to all applications include:

• **Cutoff frequency:** This is the frequency at which the filter starts eliminating the unwanted EMI.

• **Insertion loss:** This refers to the filtering capabilities of the feedthrough filter at a given frequency.

• **Power requirements (voltage and current):** The feedthrough filter must be capable of operating at the device's input voltage for power connections or the signal voltage for signal lines.

While off-the-shelf and custom solutions exist for these filters, proper customization goes beyond simple performance and considers the "how" and "where" of system implementation. For example, consider a system with 50 lines. Adding 50 screw-in type filters will take a lot of space. Connectorized multiline solutions consume less space, are easier to implement, and (usually) cost less.

In terms of direct EMI protection cost, the biggest contributing factor to the price tag is power. How much power do you need to run? Power breaks down into voltage and current, with current representing the more significant factor.

Feedthrough filters have a wire that goes all the way through the part *(Fig. 2)*. More current demands a larger wire, and the whole component must grow larger to surround it. Hence, filter cases get bigger, require more material, and take more machining, driving up their cost due to increasing current. Digital circuits generally draw less power, so you can stick with smaller filter units. For this reason, power is less of a cost driver on the digital side than on the analog side.

Fixes Needn't Be Expensive

Whatever the technology or reason, many systems reach an advanced point in their design cycle at which all of the math and simulations appear to check out. And, as a result, it's time to create the first prototype—before an EMI problem is detected.

Because afterthoughts nearly always have consequences, tackling EMI protection midstream can be burdensome in terms of time, cost, and aggravation. In the case of midstream EMI mediation, those consequences generally are relative to the size and the complexity of the unit being designed. For example, with smaller units, available space for new components is a principal concern.

Next, the manufacturing process must be considered. Has tooling been completed, stamping ironed out, and machining set up?

Cost is the main issue designers usually fight. Can the redesign be addressed by creating a new tool? Or is a whole subsystem affected, creating a domino effect where other subsystems need to be reengineered? And, sometimes, even when an engineer needs a fix and a solution is apparent, program management may push back.

That said, EMI resolutions don't have to be expensive to fix, even if caught later in development. While the company creating the unit may not have specific EMI expertise inhouse—or perhaps those individuals have encountered a problem that's foreign to them—third-party experts may be familiar with the issue, and they can address it with an inexpensive component and with little to no engineering cost.

It's also worth noting that "expensive" is a relative term. Sometimes, a company's sales personnel will sell a product before it's finished, based on an estimated production cost and profit margin. Say a unit was estimated to cost $10 to produce and sell for $15 each. Then, an EMI fix raises the production price to $12. That fix took 40% out of the company's margin. In short, sometimes the cart is placed ahead of the horse, and designers must fight an uphill battle.

Finally, the level of support can affect cost. There are three main tiers of support regarding EMI protection (the amount of help a client needs):

1. Top companies, such as Fortune 100 companies, often have staff specifically assigned to EMI protection. Such organizations will simply submit part inquiries to vendors. The supplier responds with confirmation that the unit can be constructed as specified, as well as a price quote. This tier represents about 10% to 15% of the customers encountered by Corry Micronics (CMI).

2. Other companies discover an EMI problem, but internal staff can't locate its source and have no idea how to solve the issue. They represent about 25% of CMI's business in this area.

3. Most EMI filter customers fall into a middle grouping. Some are previous customers for whom CMI solved a midstream issue in the past, and they have returned to collaborate at the start of a new system's development. Or perhaps the customer is at a point where they know there's a problem, and rather than try to tackle it in-house, they welcome CMI to be involved in creating a solution.

Collaborative Efforts Filter Out Problems

When a customer approaches CMI with an EMI issue, a lot of the initial legwork can be completed online via a simple message: "I have this problem, and I'd like to talk to you about it."

At that point, a more detailed phone conversation—and, in some cases, an on-site visit—is needed to glean whatever data is possessed by these potential customers. This would include, for example, a description of the potential customer's device (its size, material composition, and so on) as well as any test lab data if the failure occurred during certification.

About 80% of the time, remote contact is sufficient to get the CMI team started. Pictures, video, and data files can all be transferred online, allowing CMI experts to quickly determine the issue, consider space or other requirements, and suggest a solution. In some cases, supplying solution samples may be appropriate.

The other 20% of interactions present more difficult scenarios. For instance, a company designed a system, performed some internal testing, and found a problem. But they haven't been able to properly define the issue and haven't made it to a test lab to gather a formal data package.

In such cases where the base information/data is insufficient to ask relevant questions, a customer visit to CMI or dispatching CMI experts to the customer's site may be warranted. This is because the best tool for solving an EMI issue is your eyes. Everything else is data or a reaction to the data. By observing the unit, seeing how the customer routes things, how they're moving signals, and what they have between signal areas, CMI often can diagnose the problem just by looking at it.

Consider an automobile engine with a power loss. A diagnostic computer hooked up to the OBD II port may show a lot of data and error codes. However, it might not provide any concrete answers. In this instance, an experienced mechanic could look under the hood and quickly spot fluid leaks, frayed wiring, or a punctured vacuum hose.

Conclusions

EMI protection is a fundamental element of system design. However, poor prioritization, unexpected sources of interference, or a lack of in-house answers can leave companies in need of a third-party consultation.

Consultant experience goes a long way toward mitigating the cost impacts during both initial design and after-the-fact fixes. If they've seen it before, they've solved it before. It's been said that businesses exert the tightest controls over the easiest thing to control, rather than the most critical. Thus, ask yourself these questions: Where does EMI protection fall on my priority list? How am I addressing any issues?

If you can't come up with a clear answer, or you're not comfortable with the answer you produced, reach out to us.

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