



# Understanding And Guarding Against Electromagnetic Interference



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.

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# CONTENTS

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Systems Change, But EMI Remains	01
First Things First	02
Fixes Don't Have To Be Expensive	03
Collaborative Efforts Filter Out Problems	04
Conclusions	05
About The Author	05

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 education system or its impacts are improperly prioritized. Thus, it often ends up as 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 nonissue. It may also have a negligible impact on a system when, in fact, its effects compromise the system in some way.

Further, analog circuitry remains a vital component even in digital systems — significant both in volume and function — because even a digital signal has to 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 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 (ones that use a plug), 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.

Additionally, completely isolating a system from EMI becomes more difficult as the system becomes more complicated, such as when the system involves multiple lines or multiple signals.

For example, 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 operate at different frequencies. The company can install one feedthrough filter each for the power supply, the I/O and the bus driver, or they can choose to combine them into a single multiple-line connector.

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 (i.e., encased in a metal shield that is tied to the system ground

on both ends). But, what happens when you need a 100-foot cable or a one-mile-long cable? The cable may be shielded, but it could also be running a multitude of signals along the same line (e.g., the cable line that comes into your house), introducing consideration 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, but EMI shielding from unexpected sources should remain a principal consideration.

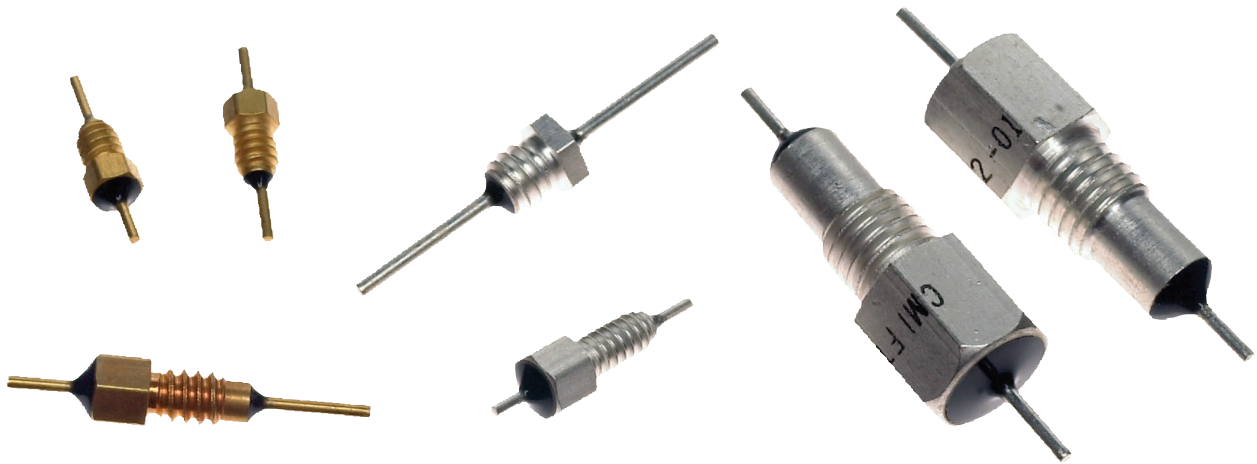
## First Things First

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 input voltage of the device for power connections or the signal voltage for signal lines.

Off-the-shelf and custom solutions exist for these filters. Though 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 take up 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 is broken 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. More current demands a larger wire, and the whole component must get bigger to surround it. Hence, filter cases get bigger, require more material, and take more machining, driving up their cost as current increases. 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 Don't Have to be Expensive

Whatever the technology or reason, many systems reach an advanced point in their design cycle — all the math and simulations appear on the level, and it's time to create the first prototype — before an EMI problem is detected.

Since 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 re-engineered? And, sometimes, even when an engineer needs a fix and a solution is apparent, program management may push back.

That said, EMI resolutions do not have to be expensive to fix, even if caught later in development. While the company creating the unit may not have specific EMI expertise in-house — 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 a fairly inexpensive component and little to no engineering cost.

It's also worth noting that "expensive" can be a relative term. Sometimes, a company's sales personnel will sell a product before it's finished, based upon an estimated production cost and profit margin. Say a unit was estimated at \$10 a unit for production and sold at \$15 per unit. Then, an EMI fix raises the production price to \$12. That fix took 40 percent 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 EMI protection support (the amount of help a client needs):

1. Top companies, such as Fortune-100 companies, that have staff specifically assigned to EMI protection generally just submit part inquiries to vendors. The supplier simply responds with confirmation that the unit can be constructed as specified, as well as a price quote. This tier represents about 10 to 15 percent of the customers CMI encounters.
2. Other companies discover an EMI problem, but internal staff cannot locate its source and have no idea how to solve the issue. They represent about 25 percent of CMI's business in this area.
3. The majority of 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, maybe the customer is at a point where they know they have 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 these potential customers have. This would include, for example, a description of the potential customer's device (its size, material composition, etc) as well as any test lab data if the failure occurred during certification. About 80 percent 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 percent of interactions represent more difficult scenarios. For example, a company has 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 is routing 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 a lot of 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.

## About The Author

Robert Meilleur has a BSEE degree from the University of Arizona. From 1987 to 2002, he was a Design Engineer and Engineering Manager for Tusonix, Inc. In this role, he specialized in EMI/RFI filtering products and solutions. In 2002, he joined the Quantic Corry team, where he became the VP of Operations.