# Designing for EMC

It is extremely difficult to design for Electromagnetic Compatibility (EMC) compliance, as many dynamic variables must interact to provide a “clean”, up front design. There are, however, a number of good EMC design practices that can dramatically reduce the level of pain associated with EMC compliance. A key consideration for cost effective EMC compliance is for manufacturers to adopt an approach similar to safety compliance, and allow for EMC consideration during product design and development. It is often expensive to leave EMC as the last task to be preformed before a product is introduced to the market.

While safety standards delineate a clear set of rules that provide design criteria to assure product safety conformance, EMC standards do not provide guidelines for compliance. Rather, they are a set of rules for EMC testing.

The EMC Directive 89/336/EEC, adopted in 1989, amended in 1992 and mandated from January 1, 1996, is one of the most complex of the European Union (EU) new-approach directives. The directive applies to every apparatus liable to cause or be affected by electromagnetic disturbances. It is also one of the most difficult directives to comply with and it affects all sectors of industry which supply electrical or electronic apparatus to the EU.

**The Costs of Incorporating EMC**

The EMC development cycle is somewhat iterative in that solutions for conducted emissions usually influence the radiated emissions and frequencies. Since EMI compliance is not exactly a product feature and has little perceived value, it is not always established initially as an essential design criterion.

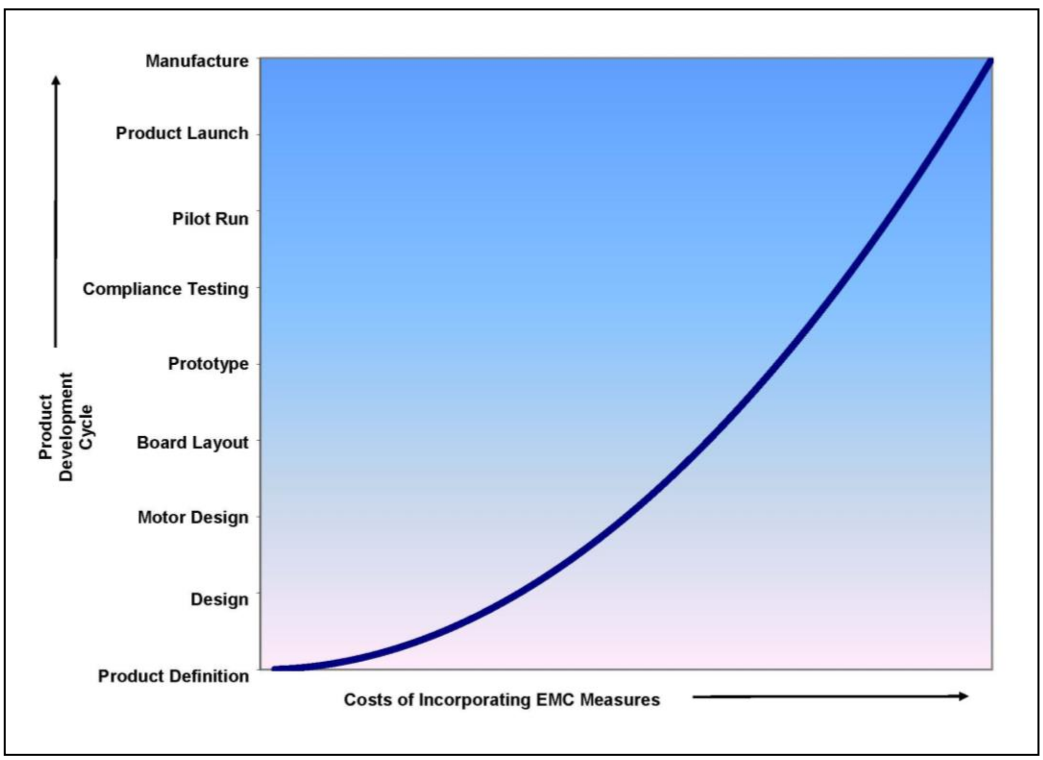


**FIGURE 1: Parabolic curve illustrating the relationship between the cost of incorporating EMC and the product development cycle.**

The curve illustrated above shows that the earlier EMC is incorporated into the product development cycle, the lower the cost impact. Laying out a printed circuit board and designing a motor with good EMC characteristics is far less costly than trying to find an EMC solution when the product is ready for launch and has failed its compliance tests. In order to successfully design an EMC solution during the development cycle of the product, there are a few different approaches that should be considered.

**Misconceptions**

Many manufacturers are passing the EMC European Conformity (CE) compliance responsibilities to their component suppliers, believing that if all the components meet the EMC directive, the end product will be compliant. Some also believe this relieves the final product manufacturer of its responsibilities while reducing costs.

It's not always true that if only pre-tested CE compliant components are used, that the end product will automatically comply. In other words CE + CE + CE does not always equal CE, and even when it does, this approach is not the most cost effective and efficient way of demonstrating compliance with the EMC directive.

**Case Study 1**

LCR was approached by a lamp manufacturer to test and design an EMI filter for a fluorescent lamp using standard Off-The-Shelf electronic ballast, with the product needing to meet a stringent EMI requirement imposed by the end user. After designing a filter to work with the electronic ballast, the system worked efficiently and met the required EMI standards, so the manufacturer began sales with the product.

Within a few months the customer, exercising good business practices, sent their product to a lab to have it re-tested. During this standard re-test, the product failed to meet the initial EMI requirements. Surprised by this result, both teams went to work trying to uncover the source of the problem by starting with the first question – had anything changed? After an extensive review of all of the components and the wiring configuration it was discovered that the electronic ballast supplier had changed one of the main components in the ballast PC board assembly with an equivalent part more readily available in the market. Because the electronic ballast was a standard part, it was at the supplier's discretion to replace any component as long as it still met the original specification without notifying their customers. The EMI test results revealed that the emissions generated by the ballast with the replacement part were far higher than the previous EMC compliant one. To prevent this problem from happening again in the future, LCR proposed a new solution in which they would design an integrated electronic ballast and EMI filter in one package. This design approach ensured that if LCR controlled the electronic ballast and filter, they could be solely responsible for the EMI performance of the whole assembly. The new integrated EMC filter and electronic ballast design resulted in a smaller more compact product, generating less production time and more cost savings. This solution proved to be an excellent investment for the company and their product.

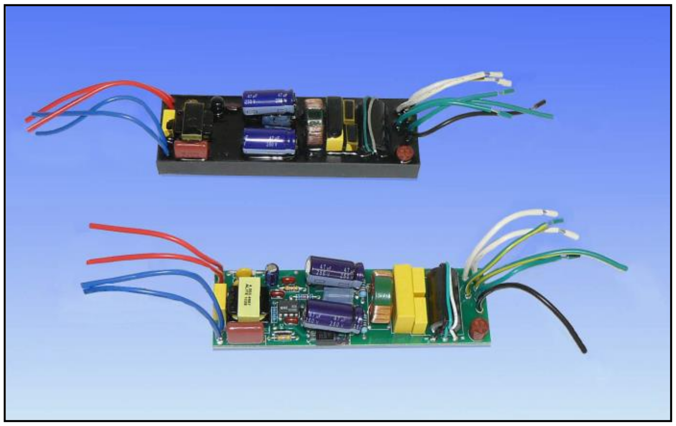

**FIGURE 2: Electronic ballast with EMI filter**

**Case Study 2**

LCR was approached by an industrial equipment manufacturer in the beginning of their product development for help in developing an EMI compliant speed control for a portable motorized vibration tool. The requirements for the control were

- Single board solution
- Regulate speed of a 3hp universal motor to 10,000 RPM
- Maintain control under any input voltage from 90Vac to 250Vac
- Comply with safety standards for UL, cUL and IEC

The combined requirements necessitated that an EMI filter be designed directly into the control board. In order to keep costs as low as possible, LCR chose a microcontroller-based triac phase cut drive. To make the project especially challenging, the board had to fit into an unusual space in the product enclosure. By being brought in on the front-end of this product's design, LCR was able to make a board that fit the space allowed, and its design has been highly successful. The best and most cost effective approach for component manufacturers is to apply good EMC practices in the initial design and development of their products. This will ultimately assist the end product manufacturers in obtaining final EMC compliance in the most economical manner.

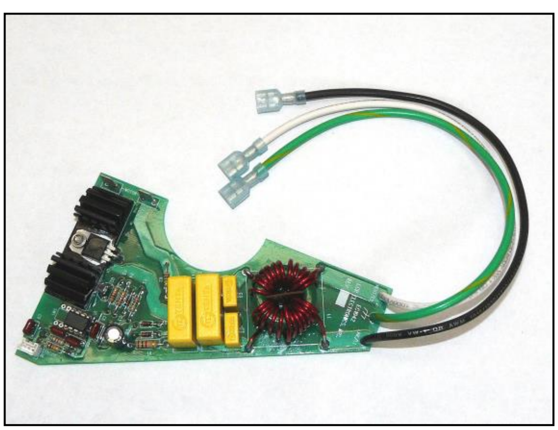

**FIGURE 3: Speed regulating motor control with integrated EMI filter**

During the development of the filter for this customer, the following knowledge was critical -

*SCR's and Triacs* are used to regulate the voltage and therefore the current flowing into a load from the AC supply. The RMS voltage supplied to the motor can be controlled by the firing angle of the triac. These devices can generate very high levels of EMI towards the line and load. The maximum level of interference is generated when the phase angle is around 90 degrees (usually around half speed) when the voltage is chopped at its peak. The interference generated is broadband and differential mode in nature with the highest levels at the low end of the frequency spectrum (from 150kHz to 750 kHz).

*Controllers containing clocks, oscillators or any electronic switching devices* will generate EMI emissions. They tend to be designed (or overdesigned) with very fast rise times. To reduce the potential for high levels of EMI radiation, the clock rise time and power level should be reduced as much as is practical. Select a clock with a fast enough rise time to do the job, not the fastest rise time available.

The traces on the *PC board* are the medium of propagation of EMI. These emissions, which radiate from the traces, are generally in the form of common mode noise. The typical trace inductance on a PC board is 7.5nH per cm. At 100 MHz this translates to an impedance of approximately 5Ω per cm. Therefore, the longer the PC board traces, the longer the antenna and the higher the potential for EMI radiation.

**Designing for EMI**

There are a number of techniques available to design engineers to reduce the potential for high levels of EMI from PC boards. The following is a brief list of good EMC practices to follow when designing PC board circuits.

- Make use of multilayer PC boards (wherever possible) with large ground planes.
- Use decoupling capacitors (disc ceramic) with short lead lengths from the IC's supply to ground, keeping the capacitor close to the IC. This provides a low impedance path for high frequency signals.
- Keep trace lengths as short as possible, this limits the trace impedance and the antenna effect for common mode signals.
- Carefully select components to minimize the potential of EMI.

**Conclusion**

Manufacturers should not expect that taking off the shelf components and pairing them with custom parts in order to provide an EMI solution is enough to ensure compliance for their product throughout the lifetime of its production. There needs to be an understanding that any change in a component, regardless of how minor, can affect the EMI performance of their product in the future.

With the end-user being responsible for the compliance of their products, it is highly recommended to have products tested regularly to account for any possible changes and to discover any potential problems as early as possible.

Lack of in-house EMC expertise makes it advisable for design engineers to confer with an EMI filter specialist who can assist with subsystem level testing and development of cost effective EMC solutions. Transient voltage suppressors (MOV's), EMI filters and careful selection of components and board layout can also help eliminate most immunity problems.

Experience indicates that for most electrical product manufacturers, EMC is not a core competency. We hope that the information in this article provides readers with the necessary EMC knowledge to make informed decisions that will help them meet the challenge of complying with EMC standards as cost effectively as possible. For more information on LCR's products and services, please contact our US office at 9 South Forest Avenue, Norristown, PA 19401 by calling (800) 527-4367 or via e-mail at sales@lcr-inc.com.

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