EMC Testing Plan and Key Success Factors

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Electromagnetic compatibility (EMC) can prove difficult for developers and project managers. In-house testing results are rarely as good as expected, and additional obstacles may arise during development. These unexpected changes can result in shifted schedules, increased development costs, and external post-testing costs.

EMC At A Glance

EMC is the ability for electrical equipment to function properly in its electromagnetic environment without introducing intolerable disturbances to other equipment. However, few topics are as difficult to grasp as EMC. You cannot see, hear or feel electromagnetic waves, which makes it difficult to determine influencing factors and structures.

Engineers today face roadblocks of greater complexity, as smaller package sizes often conflict with the economic goal of reducing cost and development time. Because of this, compromises must often be made.

This intense pressure to deliver quickly often leads to EMC issues that only come to light during a project's final phase. MPS's goal is to offer technical support to customers and prepare them for future technical challenges. With a clearly-structured EMC development process, these issues are easily avoided (see Figure 1).

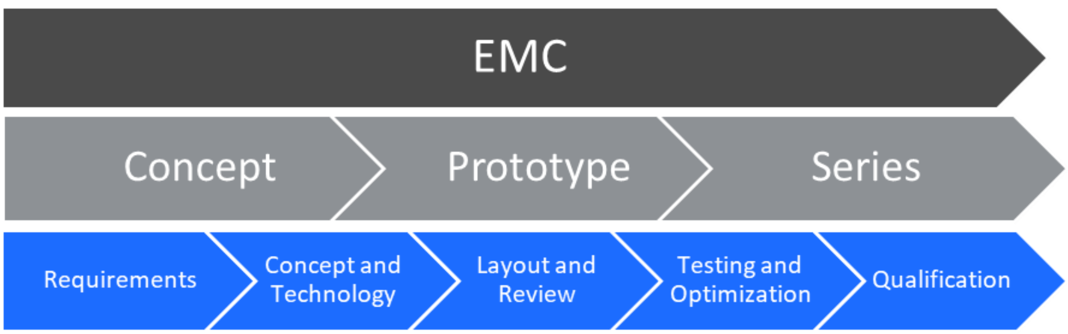

Figure 1: Structured EMC Development Process

Requirements and Testing Plan

Requirements and Testing Plan

The is the early phase of the EMC development process, during the product definition. In this stage:

- Obtain the requirements for the product
- Define supplier requirements
- Define a test plan for the product and subassemblies

Begin with the project schedule. A schedule ensures everyone involved knows the goals and requirements to sell a product to the end customer. Depending on the product and industry, different requirements must be fulfilled. On top of various regulations, international standards and national standards must be met (see Figure 2).

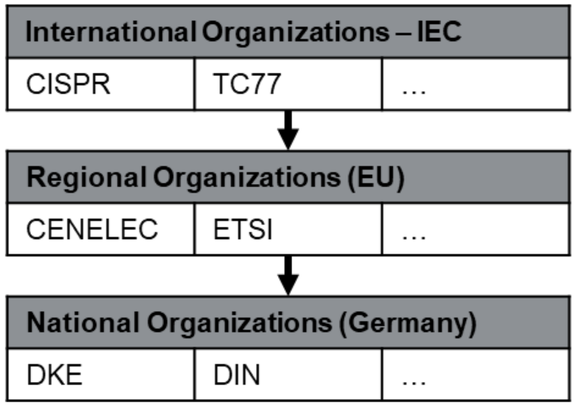

Figure 2: Example of Commercial Standardization

An example of this is the automobile industry, where the complexity of vehicle development involves additional requirements that ensures appropriate component interactions. The automobile industry spent years defining the requirements for electronic components and subassemblies. Limits and test levels have become standardized, and risk assessments can be made based on component measurements alone.

However, meeting the legal requirements is not enough. Nearly every car manufacturer has their own EMC requirements with higher test levels and lower emission limits. Strict compliance with these requirements ensures that communication services (broadcast and mobile) and high-power electronics (e.g. e-boosters, e-trains, onboard chargers) work in parallel.

This planning process also benefits other industries, where products consist of subassemblies — some of which are not even developed in-house. While there is no guarantee that all limits and test levels will be met when the module is interconnected, defining requirements in advance significantly reduces this risk.

A unique testing plan should be integrated into the development schedule. This plan is a working document to be updated during the first phase of the development, and acting as a central document for the testing and documentation phase of the project.

A good test plan defines and documents all relevant information about the equipment under test (EUT). This document should allow an engineer to run their tests without additional documents and background knowledge. Defining operation modes during testing is as important as the test set-up (grounding, wiring harness, load box, and software configurations). Companies who work with external suppliers and multiple customers should document all mutually understood requirements in the test plan. Requirements should be tracked throughout the process, especially for purchased parts.

Concept and Technology for an EMC Testing Plan

Concept and Technology

In this stage:

- Combine the mechanical and electrical concepts to determine the best overall concept
- Conduct pretests by evaluating components to find the appropriate functional, thermal, and EMI viewpoints

PCB size and connector positions for the cables are usually pre-defined by mechanical limitations. The housing is based on cost structure, weight, and thermal concept.

Mechanical designs require great attention be paid to EMC. Decisions made in this stage can result in later problems that can only be solved through extensive efforts in redesigning the layout or conducting additional EMC measurements.

For example, the initial positions of plugs and function groups on the board (e.g. the switching regulator) are important, as the switching creates E and H fields. The direct field coupling is determined by the distance, design, and heights of the components (e.g. the main coil) (see Figure 3).

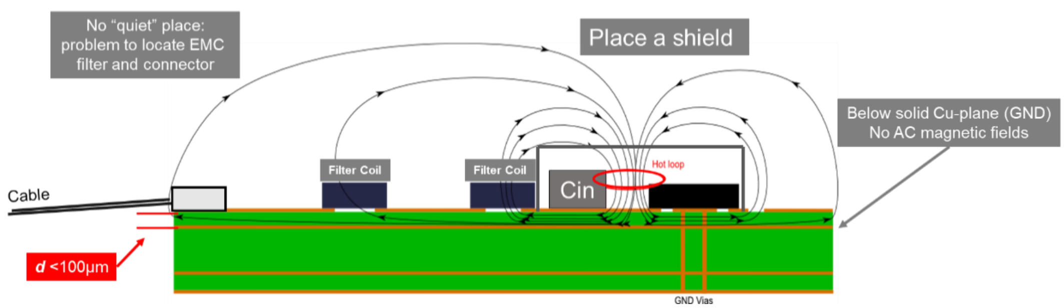

Figure 3: Field-Coupling on the PCB

Packaging, efficiency, and costs drive the development of switching regulators. Products are being delivered with higher switching frequencies, including ICs with frequency-spread spectrum and highly integrated power modules.

Consider the advantages and disadvantages of a higher or lower switching frequency when creating your design. Automotive suppliers often comply with limited AM band values at switching frequencies below 1MHz. The fundamental frequency, or the first harmonic of the fundamental frequency, lies within this band. In addition, relatively large input filters and large coils are sometimes necessary at low switching frequencies.

A switching frequency above the AM band (e.g. 2MHz) offers the advantage of the fundamental frequency and the first harmonics being outside of this band. Components such as the input filter and coil can be reduced by size, value, and cost. However, there are disadvantages like converging on switching losses, thermal rise, and EMC. Remember these tradeoffs when determining which topology and technology to use.

Table 1: Choosing the Switching Frequency (2)

Advantages of Higher Switching Frequency	Disadvantages of Higher Switching Frequency
• Smaller package based on smaller components • More cost-effective	• Higher switching losses • Higher electromagnetic noise • Higher thermal rise

Layout and Review of the EMC Test Plan

Layout and Reviews

In this stage:
- Conduct a hardware review and identify critical paths
- Leave room for additional filtering and modifications to try during a pretest
- Start looking for alternative components (e.g. main coils, capacitors and inductors for filtering) to use in EMC measurements

At this point, conduct a risk assessment based on empirical values, the analysis of possible technologies, and the evaluation of purchased parts and suppliers. Begin working on potential sources of interference and the product's weak points, since the layout consists of compromises (mechanical, thermal, functional and EMC-technical). Before the first board is produced, an internal or external layout review helps to find and implement the best compromise.

In the first layout, additional pads and components can allow you to try different tactics during EMC measurement. You could also create variations of boards and assembly options during the first measurements at an EMC lab, since several simultaneous tests will allow you to gather results quickly, such as information regarding complex coupling. No matter how you plan in advance, optimal results are difficult to define without testing.

EMC Testing and Optimization

Testing and Optimization

In this stage:
- Request subassembly test reports
- EMC tests during development (early state) and planning loops
- Define actions, and focus on optimizing the layout

Before testing your system, consider the test results from possible assemblies and components. These previous steps dealt intensively with the product itself, and they offer a good overview that will help you determine which topics to focus on in the pretests. With every test, the project becomes more transparent, and project risk is reduced.

The first tests with a real-world application should take place next. Pretests are key to finding weak spots early on. Based on the test plan and experiences with similar products, filter out individual test methods and check them in advance. It is recommended to conduct a combination of interference emission measurements and immunity measurements. A solid overview and quick feedback is important. The test plan is particularly helpful in preparing the EMC measurement for coordination with an EMC lab. There are two possible results to obtain from the EMC lab:

Result 1: EUT does not pass the requirements

In this case, the sources of interference must be identified, and optimization measurements should be obtained. If appropriate assembly options have been provided at critical points, and alternative components are included, you can start optimizing right away. Measurement time is limited. Even if you do not have your own equipment for an EMC analysis, gather as much information from the test session as possible.

Result 2: EUT passes the requirements

If the product fulfills the EMC requirements, you will have opportunities for optimization. The ideal scenario between costs and results can often only be determined by multiple measurements.

MPS has been building our experience on EMC-related topics to solve these problems during early design stages. Starting with the IC Development, the customer specific design for the application and during the validation, MPS is a viable partner in the power solution market.

References

- Learn about MPS EMC Testing Labs
- Automotive EMI Demystified Webinar - Part 2: Pursuing An Ideal Power Supply Layout
- Automotive EMI Webinar: Benefits of Spread Spectrum
- 5G Base Station Complexity Drives the Need for Low-EMI DC/DC Module Solutions
- Automotive LED Driver Design: Good Practices to Ensure EMC Compliance