Organizational EMC — Regulations and Design

Meeting the EMC Directive poses technical and administrative challenges.

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INTRODUCTION

All new electronic products must meet applicable EMC specifications, and beginning January 1, 1996, products sold in EU countries will be held to the standards of the EMC Directive 89/336/EEC. Meeting the EMC specification should be addressed while writing the product specification and during the development phase, rather than hoping for the best during the EMC test phase. This planning and other EMC related activities will involve many departments and individuals in a company. To succeed, all involved groups must cooperate.

The technical problems to be solved are complicated and multifaceted, and require competence in various mechanical and electronic areas, which are often of a high-frequency nature. The investment in, and the use of EMI measuring instruments requires special competence. Juridical aspects are important to the field of EMC; there is a need to know which EMI and other norms and regulations in the vast jungle of related documents are relevant to the actual product. Documentation of the EMC activities is also an essential and time-consuming activity. Solving EMC related problems as they evolve and deciding who should be responsible on a case-by-case basis will inevitably lead to frustrations and delays in the development process. It is therefore vital that the company has some form of organization dedicated to EMC activities.

EMC MANAGER

To succeed with various EMC activities, it is important that the company assign one person the responsibility for all related programs. The EMC manager need not necessarily be competent in every aspect of EMC, nor should that person perform all the relevant work. Rather, the manager should ensure that this work is done, and perform central parts of the work.

The EMC activities manager will have a function similar to that of the quality control manager. The EMC activities may be defined as a part of the quality work, and the two job functions may, especially in small companies, be performed by the same person. It is also the manager's responsibility to make the whole company aware of the EMC issue.

It is important that the person responsible for EMC and the job function itself be backed by a mandate that guarantees that EMC is considered integral to all products that are designed and manufactured by the company. It is likewise important that all EMC activities are documented, and that the documents — especially the test documents — are filed and stored in a safe manner and for the length of time dictated by the EMC Directive.

It is difficult to measure or to document the cost-effectiveness of the work of the EMC manager. It is therefore very important that corporate management has an accurate understanding of the necessity of the EMC work, and that it supports the efforts. The work load of the EMC manager will require a full-time commitment rather than being assigned as extra tasks for an employee already occupied with other duties.

The person appointed to manage EMC should accept the following responsibilities:

- Stay abreast of EMC norms and regulations.
- Know which literature to recommend.
- Know the best consultants.
- Know and recommend the best test laboratories for specific cases.
- Organize the EMC training of the employees.
- Gather and promulgate information on relevant EMC courses and seminars.
- Confirm that the functional specification of a new product incorporates the correct EMC specification.
- Check that the EMC demands of the clients are incorporated into the functional specification.
- Check that the choice of components and the hardware design principles are in accordance with the system EMC specification.
- Check that the placement of components on the printed circuit board and the layout of the signal and ground return tracks are in accordance with the EMC specification.
- Check that the mechanical design is in accordance with the EMC specification.
- Determine that EMC issues are discussed during all design reviews.
- Determine that all work performed by consultants takes EMC into account.

- Check that all purchased sub-units have applicable EMC certificates.
- Check that the product is tested according to relevant EMC norms.
- Prepare cost analyses, evaluate usefulness, and oversee the purchase of EMC test instruments.
- Write the supplier's Declaration of Conformity for all EMC products.
- Oversee EMC testing and revision of the relevant EMC documentation when a product is altered or upgraded.
- Oversee the CE-marking of the products.
- Oversee archiving of EMC documents for all products.

PRODUCT APPROVAL

Product approval may lead to different interpretations. The word "approval" may not be related to EMC, and sometimes the word is used to deceive potential customers. Customers may have differing definitions and some may be more or less stringent than the EMC Directive. Compliance with the EMC Directive can be documented by a supplier's "Declaration of Conformity," as defined in EN 45014 or by having the importer or manufacturer generate a "Technical Construction File."

The supplier's Declaration of Conformity route is expected to be the most common method. Preparing a supplier's Declaration of Conformity and the CE-marking demands that the product has been tested on an open area test site (OATS) as defined in EN 55022 or in a large anechoic test chamber with properly controlled and acceptable reflections and resonances. The tests may be performed by the manufacturer, provided that it has the facilities and technical competence. As only the largest companies can afford to have acceptable or accredited testing facilities, the testing will normally be performed by an external independent test house. The test house issues test result protocols, and based upon these documents, the producer will issue a supplier's Declaration of Conformity document if the test protocols show that the relevant EMC requirements are met.

The Technical Construction File route specifies a description of the product, a description of the procedures used to warrant the relevant safety requirements, and a technical report or certificate issued by a Competent Body stating that the relevant EMC requirements are met. The use of a Competent Body may imply that no tests will be performed. Both the supplier's Declaration of Conformity and the Technical Construction File route qualify products for the CE Mark. The EMC manager will be responsible for the supplier's Declaration of Conformity, or for administering the Technical Construction File route, and for the CE-marking.

EMC SPECIFICATIONS

The possibility of successfully marketing a product may be calculated before the product is produced by reading its system specification. This document is, however, often incomplete and erroneous. It is the responsibility of the project manager and the EMC manager to check that the EMC requirements are detailed in the product specification before the start of the design phase. Failure to do this will inevitably result in costly consequences later.

The product specification has two main parts: the functional specification and the EMC specification. Both will affect the logic design and the types and number of components that will be used. The product specification will also incorporate the safety and environmental specifications relating to mechanical and climatic endurance to stresses such as vibration, bumps, temperature and humidity. The manufacturer and the client should agree on the product specification before the start of the development process.

International standardization work aiming to assign different electronic equipment to different product categories, each with a specific set of EMC requirements, is ongoing. When developing a new product, one must first decide to which product category it belongs. The requirements applicable to EMI control and to electromagnetic susceptibility (EMS) are given in the applicable norms. The aim should always be CE marking of the product, which implies not only that the EMC specification is met, but also that it meets other relevant Directives and norms. A typical example is that a product cannot be CE-marked without meeting the safety norm EN 50950.

Issuing a supplier's Declaration of Conformity document and CE-marking a product without having the relevant confirmation documents are criminal offenses. The documents must clearly show that the product meets the relevant specifications. One should note that an outside EMC test laboratory does not normally issue any kind of certificate, just a measuring protocol. The laboratory is therefore not responsible for issuing documents that imply that the relevant specifications are met. It is responsible for performing the ordered tests correctly. Responsibility for the content and the writing of the supplier's Declaration of Conformity document lies with the producer, as does ultimate responsibility for the correct performance of the tests. The EMC documentation shall be available for ten years after the last sample of the product was manufactured.

EQUIPMENT COMPONENTS

STANDARDIZATION

In the past few years there has been a radical increase in the number of new component types, despite some

experts' belief that this evolution should have come to an end some years ago, as more and more logic hardware was supposed to be hidden in very large scale integration (VLSI) components. The new components, both active and passive types, are changed in their internal technology as well as in their physical size.

Most, though not all, new component types have better EMC qualities than former versions. However, the process of choosing the right component types has recently tended to be increasingly difficult. The reason for this is the increased and vast diversity of component types, and a seemingly decreasing interest in component technology among hardware designers.

One new problem is the decreasing likelihood of procuring components with equal function and quality from more than one vendor. This is referred to as the "second source" issue. Vendors increasingly prefer to give versions of standard function components unique properties to increase sales. Thus, there may be no competitors in the market. Even if there are functional second sources in the market, their EMC properties may be different. This can cause products that meet the EMC requirements to fail the same requirements if second source components are used.

Components with superior EMC properties are often higher priced and not cost-effective when used in low-cost products. Their availability may also be a problem, and the lead times can often be counted in months rather than days or weeks. The standardization of components must always take their EMC properties into account. In these matters, the person charged with responsibility for EMC may be more competent than the component manager.

DESIGN REVIEW

Design review of a circuit diagram and its accompanying parts list has been shown to be a very efficient means to reveal design errors, both functional and economic. Design review is also very useful for determining design principles; choice of components; placement and orientation of components on the circuit board; and design of the printed circuits such that the generation of radiation will be sufficiently low, and such that the product will be sufficiently immune to incoming radiation and overvoltages, all at the lowest possible cost. Design reviews should be performed using documented guidelines, in which EMC is a main topic. Design review is a part of the quality standard EN 29001, and the review procedure is documented in the standard IEC 1160, Formal Design Review.

All product designs, whether they are prepared by company employees or by an external consulting company, should undergo the same review procedure. The procedure should also cover the review of purchased OEM (original equipment manufacturer) products, subunits that will be incorporated into the company's own product.

PRINTED CIRCUIT BOARDS

Printed circuit boards (PCBs), their types and their number of layers are normally addressed for the first time late in the design phase, often after the logic diagrams are designed. However, it is better to consider the number of layers as early as possible when writing the product specification. This is because an unnecessarily high number of layers will be costly, and because one can never know if a lower number of layers would have been sufficient. High EMC requirements generally demand multilayer boards. Signal track routing on densely populated boards also demands the use of multilayer boards.

Design of the signal tracks and of the ground return current system without considering EMC will result in boards that have only a limited chance of meeting the EMC requirements. As a result, designers may be forced to revise the board design until tests eventually show that the EMC requirements are met. Well-screened circuit boards with moderate EMC requirements can be based on a 2-layer solution. A high-volume production series in which a high-cost signal track design may be acceptable may also be based on a 2-layer solution. Recent practice based on EMC knowledge has shown that some complicated boards with high EMC requirements may be based on only two layers, or even on just one layer.

It is essential that the printed board designer be trained in EMC circuit board design and that he or she cooperates closely with the designer of the logic circuit diagram. The designer should also work closely with the producers of PCBs, and be able to evaluate their quality profile, their punctuality, and the total price of a printed circuit board, depending on the number of layers and the pricing policy of the producer. The PCB designer must be competent to evaluate the cost effectiveness of the computer-aided design (CAD) system, and to evaluate whether a 2-layer solution can be used without resulting in both EMC problems, and whether auto-routing of the board tracks can be used. One should observe, however, that most current auto-routing systems result in rather poor EMC performance.

SOLDERING PROCESS

The change from hole-mount technology to surface-mount technology has resulted in smaller board areas, and thus, lower emissions. This change necessitates changes in soldering machines from single-wave ma-

chines to double-wave machines and to infrared soldering machines. Newer component types with smaller distances between terminals, circuit tracks with smaller insulating distances, and the mounting of components on both board sides may demand even newer soldering principles and machines, which again may demand new investments.

This escalation of investments in production machinery, partly caused by the EMC requirements, may force smaller companies to allow the mounting of components and the soldering processes to be performed by outside companies.

INSTRUMENTATION

Companies developing and producing electronic products, however small, should invest in EMC measurement instrumentation, both for measuring emissions and for testing the products' immunity to overvoltages and static electricity. The types and number of instruments may vary, depending on need and the possibility of borrowing. A useful first set of instrumentation may consist of a spectrum analyzer, including test probes, antennas, and an electrostatic discharge (ESD) gun. A TEM (transverse electromagnetic) cell, a miniature test chamber, may also prove helpful.

EMC measurements based on this instrumentation will give general measurements only, but will prove very helpful for checking EMC modifications on prototypes. Correct use of the ESD gun may give absolute-value measurements, as done in a test laboratory. To achieve absolute-value emission and susceptibility measurements, a reflection-free test must be used. This is affordable for the largest companies only, but reasonably acceptable results can be obtained in a sufficiently large empty cellar or other less valuable space. Investment in test equipment may seem expensive in itself but one should not forget the additional and necessary investments in test manpower.

COMPETENCE AND COOPERATION

It may seem that meeting the EMC Directive, both technically and administratively, may be complicated. Indeed it is, and it demands competence and means increased duties for the EMC manager and other involved employees. The keys to success are expertise, and above all, close cooperation between the client, the writer of the technical plan and the EMC specification, the EMC manager, the quality control manager, the circuit diagram designer, the circuit board designer, and the mechanical designer.

Success with EMC and the related disciplines needed to develop a new electronic product demands a very broad competence, not only in technical matters, but also in a complicated and constantly growing jungle of norms and regulations. Few small or medium-size companies can afford to have an in-house staff to handle all these questions. Specialized external EMC consultants offer one solution. While some companies see this as an unnecessary expense, it may prove to be cost-effective in the long run.

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