An Introduction to EMC Standards and Design

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Attention to EMC standards and careful design are essential to achieving EMC certification.

INTRODUCTION

EMC standards have proliferated over the years as governing bodies worldwide have imposed their own sets of requirements to ensure that electronic equipment will function in its intended environment. Standards are generated by U.S. government and military agencies, professional societies, industry consortiums and international organizations. While most standards carry the force of law, voluntary standards have also been generated to meet the common needs of various industries. In fact, well prepared and pertinent standards have been adopted by governments to replace their own aging standards. One example is the aged MIL-STD-285 on measuring the effectiveness of shielded enclosures, which has been replaced by the less ambiguously worded IEEE 299 for U.S. military use. In the nonmilitary realm, the Federal Communications Commission has adopted ANSI C63.4 to replace its earlier EMC test procedures for digital devices.

MARKETING CONSIDERATIONS

Some manufacturers and marketing professionals see the bewildering array of worldwide standards as an impediment to free trade. To overcome this obstacle, a group of European nations, known as the European Community (EC), has endeavored to establish common EMC and electrical safety requirements for products marketed in their nations. The resulting standards are said to be "harmonized." A list of key standards (including some that are not harmonized but are commonly used) is given in Table 1.

In spite of concerted efforts to develop comprehensive and precise standards, technology continues to advance and standards may not be directly applicable to the latest innovations. The EC has allowed for this situation, and in some cases only requires evidence that the new technical "widget" complies, not with the inapplicable details of the standards, but with their basic intent. Such evidence (largely design and test data) is gathered into what is termed a "technical construction file" (similar to a report) and then submitted to an officially recognized Competent Body to determine by analysis if compliance with the intent of a directive or standard has been achieved. That body can then issue a certificate or other notification of official acceptance to permit sales of the product. The advantages to the manufacturer of having approval of a technical construction file are its flexibility and continuity. After standards are revised or new standards are created, they can be applied to the existing data to obtain approval without retesting. Also, new variations of a product that meets the same technical requirements need not be retested. This is a tremendous advantage to manufacturers continually marketing new products.

What is the significance of this arrangement to a U.S. manufacturer? It means that a limited amount of rigorously conducted testing can assure that a product can be sold in world markets. The disadvantage is that under some circumstances such testing in the U.S. is only recognized as valid in EC countries provided that it is performed in laboratories deemed qualified by the EC.

DESIGN CONSIDERATIONS

It cannot be guaranteed that any cost-effective product will pass the qualification tests. However, the chances for success are greatly enhanced by following good EMC/ESD design and manufacturing practices. An understanding of design aspects, including basic electronic functions, physical layout, cables and cable connectors, and standard EMC components such as filters, absorbers, and electromagnetic shielding is essential.

The basic electronic considerations relative to EMC fall into two broad classifications: emissions and immunity. RF emissions are caused primarily by internal signal sources, which can be either sinusoidal or digital. An upper limit on the sinusoidal

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HARMONIZED STANDARDS FOR EMC REQUIREMENTS

CISPR Publication 22, Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment, First Edition 1985, IEC

Publication IEC 1000-4-2, Electromagnetic Compatibility for Industrial-process Measurement and Control Equipment--Part 2: Electrostatic Discharge Requirements, First Edition 1984

Publication IEC 1000-4-3, Electromagnetic Compatibility for Industrial-process Measurement and Control Equipment--Part 3: Radiated Electromagnetic Field Requirements, First Edition, 1984

Publication IEC-1000-4-4, Electromagnetic Compatibility for Industrial-process Measurement and Control Equipment--Part 4: Electrical Fast Transient/burst Requirements, First Edition, 1988

EN 55022, Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment, April 1987

EN 50082-1, Electromagnetic Compatibility - Generic Immunity Standard--Part 1: Residential, Commercial and Light Industry, January 1992

NON-HARMONIZED STANDARDS FOR EMC REQUIREMENTS

U.S. Code of Federal Regulations (CFR) Title 47, Part 15, Radio Frequency Devices, Subpart B, Unintentional Radiators, October 1, 1991

MIL-STD-461C, Electromagnetic Emissions and Susceptibility Requirements for the Control of Electromagnetic Interference, August 1986 (military applications)

NON-HARMONIZED STANDARDS FOR MEASUREMENT METHODS AND/OR EQUIPMENT

ANSI C63.4 - 1992, Methods of Measurement of Radio-noise Emissions from Low-voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

CISPR Publication 16, Second Edition, CISPR Specification for Radio Interference Measuring Apparatus and Measurement methods, IEC, 1987

MIL-STD-462D, Measurement of Electromagnetic Interference Characteristics (military applications)

Table 1*. EMC Standards.*

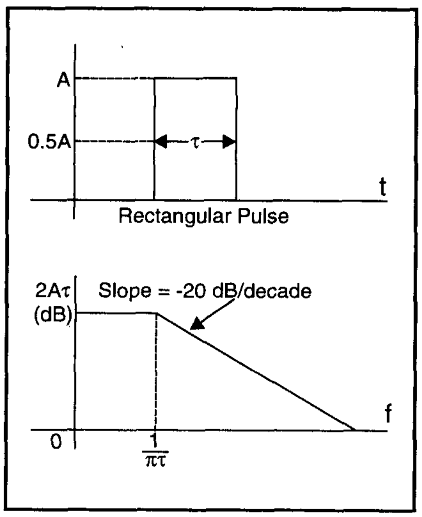

Figure 1*. Fourier Spectrum Amplitude Approximation of Time-Domain Pulse-Type Wave Shape.*

components for an ideal rectangular pulse in the time domain is illustrated in Figure 1. In the time domain t, A is the pulse amplitude, and τ is the pulse duration (at the half-amplitude point if the pulse were not ideal); the corresponding upper bound in the frequency domain f is shown using the same parameters. It is readily apparent that the shorter the pulse, the higher the frequencies generated, and generally, the greater the radiation because associated conductors become more efficient radiators at higher frequencies. As a result, the digital designer and the EMC engineer are often at loggerheads, since good EMC design necessitates use of the longest pulses that are acceptable to satisfy the functional design, whereas the digital designer normally desires the shortest pulses possible. The two should coordinate efforts at this point so that the digital designer is aware of the increased costs of product EMC design resulting from functionally unnecessary high pulse rates.

PHYSICAL LAYOUT

The physical layout of a circuit board influences both emissions and immunity. Optimum positioning of a digital clock is a fine

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art of compromise. The clock cannot be located so close to input/output (I/O) connectors that coupling occurs, nor so far away that lengthy signal leads couple to other circuits. The latter problem can be mitigated with the use of multilayer boards having ground-plane layers (or even ground traces) sandwiched between the circuits involved. The layout should include distributed capacitors connected between the power lead and ground at each active element. Such grounds should not be attached to case shielding at more than one point in an entire system (which might be comprised of multiple cases) for protection from electrostatic discharge.

CABLES AND CONNECTORS

In many systems, cables carry digital information from one piece of equipment to another. Cables of conducting wires act as antennas to radiate and/or receive such signals and can cause electrical disturbances in circuits to which they are connected or to other nearby equipment. Inexpensive techniques for overcoming such difficulties include separating circuit cables widely to reduce coupling, and the use of shielded cables. Connectors must be of the screw-on type; twist and snap-on connectors can permit signal leakage (both in and out) at their relatively poor electrical shell contacts.

At somewhat greater initial expense (but reduced EMC expense), fiber-optic cables can be used to carry digital information. One of their major advantages is that they are completely compatible with EMC requirements because they do not carry electrical currents.

FILTERING

For EMC purposes, filters are normally used at two types of locations. One type of filter is a feed-through capacitor on the power supply lead of each active element. The other kind is low-pass filters which are placed in series with electrical power input leads. Filters are normally not usable at I/O ports because in these positions they can distort data.

Ferrites are essentially a special form of filtering. They are used to encircle leads and cables, generally within an equipment case. They can also be integrated with I/O connectors or used on external cables. Functionally, they introduce losses into circuits to dissipate RF energy at the higher frequencies which cause emission problems, and generally do not introduce significant losses at lower frequencies. Hence, with proper selection of materials, they do not degrade desired signals. Standard ferrites are available in a wide variety of shapes and absorption characteristics. They also have the advantage of flexible designs because they can be readily manufactured in specialized shapes for given applications.

SHIELDING

Shielding equipment boxes or cabinets is frequently necessary to mitigate emissions from contained radiators, to decrease traces on PC boards and internal wiring, and to isolate them from external fields. Equipment cases often pose a challenging problem in terms of balancing the requirements for adequate shielding performance with case style and economics. A wide variety of possibilities exists for shielding cases, with corresponding differences in shielding effectiveness, appearance, and cost. The situation is further complicated by trade-offs between the required degree of case shielding and internal shielding of selected circuits. The most effective shielding is obtained with metal cases, which are often undesirable for sales appeal. A second choice is electrodeposited or metallic-sprayed plastic; the highest quality materials combine effective shielding performance with attractive appearance. If a lesser degree of shielding performance is needed, a number of other techniques may be used, including conductive plastic (plastic loaded with conducting particles) or metallic paint on plastic.

RECOMMENDATIONS

The following steps are advisable for expedient, cost-efficient production of electronic products:

- Coordinate the activities required for functional design and EMC design before the functional design is far advanced.
- Coordinate both activities with manufacturing design.
- Perform preliminary EMC testing to determine and correct major EMC problems.
- For the first production configuration, have formal EMC testing performed at an authorized or accredited EMC laboratory by qualified EMC engineers and technicians.

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