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Concerns Related to EMC Compliance

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There are international regulatory compliance requirements for electrical and electronic products to achieve electromagnetic compatibility (EMC). The definition of EMC is "The ability of a device, equipment, or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in the environment" [1]. There are two parts to EMC: emissions (preventing radio frequency (RF) energy generated within an electrical device from causing harmful electromagnetic interference), and immunity (protecting an electrical device against RF signals within the electromagnetic spectrum that may cause functional disruption).

Herein, we highlight problems that engineers face not only with products of today, but about the reliability of electrical systems used within a variety of applications.

With advances in semiconductor technology, systems are not only becoming smaller in size with greater functionality, but are being operated within environments containing a significant amount of RF energy throughout the frequency spectrum. Engineers must anticipate future technological applications that users want, and extrapolate these needs with strategic planning to achieve EMC.

An example of the need to ensure EMC is to highlight the numerous electronic assemblies within an automobile. We must ensure these systems are reliable under all operating conditions, both environmental and mechanical. Some vehicles have up to 26 microprocessors that control engine operation, pollution control, breaking, collision avoidance, global positioning, entertainment systems, and others. What could happen should one drive near an antenna farm transmitting high levels of RF power, such as airport radar, military installations and their communication networks, or high-power commercial radio and television stations? What is the potential harm to the brakes or engine controllers when we drive by power lines that are carrying Ethernet signals, known as Broadband over Power Lines (BPL)?

We must minimize RF energy from causing harm to electrical products. How is this undesired RF energy developed by electrical circuits and propagated into free space or through metallic interconnects (i.e., cables)? We cannot see electromagnetic interference (EMI) which propagates as radio signals but can easily measure it with receivers and spectrum analyzers. The field of EMC engineering is essentially everything that is not on a schematic or assembly drawing. How much field strength intensity does it take to cause harm; and conversely, how much RF energy present within the environment or atmosphere will cause disruption? How does EMC relate to the field of reliability? We must ensure electrical products will work as designed under all abnormal conditions that the system may be subjected to.

The concern for having a reliable system is high. What should we focus our design efforts on first, emissions or immunity protection? Examine our environment, and not just device-to-device interference. The type of RF energy that causes harm is a narrowband spike. Due to the sensitivity of our ears to hear an acoustic wave, we are generally only able to hear narrowband signals. A broadband signal is one that has a much larger spectral bandwidth.

To illustrate the difference between narrowband and broadband, assume we are in a room full of people, all talking in a normal voice and you are on a balcony listening to the crowd. It is impossible to hear a single person as the ambient noise level is high. All of a sudden, someone yells as loud as they can. This high-pitched squeal can be heard by everyone in the room, as well as those upstairs. This example illustrates a narrowband spike within a broadband environment. We call this narrowband signal a nuisance. Now take this noisy spike, and repeat this sound every millisecond, forever. Will any of us have sanity after the party?

Almost everyone has a cell phone, personal computer, wireless device, or similar product for access to local area networks. If everyone used their wireless tools at the same time within close distance to each other, all we would see is broadband noise. It is thus impossible to locate a narrowband spike within a large spectrum of RF energy at a distance of three or more meters from the generating source. With only broadband noise present, should we be concerned about the amount of radiated emissions present from our low-power wireless systems? Extrapolate this scenario to the center of a major metropolitan city. With thousands of wireless networks, the RF environment appears broadband to everyone. Under this condition, should we worry about the radiated emission aspect EMC, or will all RF energy in the vicinity of our wireless device cause functional disruption and interference?

Systems in the future will include advanced technology for use in medical and lighting products, telecommunication networks, automotive and transmission systems, aerospace and avionics, home entertainment systems, as well as military applications. All devices identified are used in a noisy electromagnetic environment, and must be EMC complaint, as well as have a high level of reliability. What then is the real threat: emissions or immunity?

The field of EMC is changing from not just meeting regulatory compliance requirement but to ensuring reliable products exist. External threats include electrostatic discharge, radiated, conducted and magnetic field immunity, electrical fast transients/bursts, surge, power line harmonics, and flicker.

Why is immunity a greater concern today versus product design of years past? Semiconductor devices such as processors, memory, field programmable gate arrays (FPGA), and interface controllers are operating on lower voltage levels which make them more susceptible to switching noise within their internal power distribution network due to smaller physical distances between transistor gates. These components are now unable to withstand higher levels of transient current surges. In addition, more products are packaged in lightweight plastic enclosures which permit external radiated RF threats to cause disruption. Remember, narrowband spikes are the primary cause of an EMC failure. However, most systems are operated in an environment containing many broadband signals.

All electrical products must have a high level of reliability. With reliability a primary concern, just think about the functional safety of a medical product when exposed to a high intensity RF signal, such as a wireless phone or personal device assistant (PDA) used in close proximity to a life-saving device; i.e., a heart-lung machine, a fusion pump, or ventilator. A narrowband spike from the phone in close proximity to the device could cause sensitive low-voltage digital components to become non-functional, which may result in a change of data in memory, or a system reset. Any failure of a life saving medical device could be fatal to the patient. This risk of death due to functional disruption of electrical equipment is the primary reason why wireless devices, which include cell phones, are not permitted in hospitals.

What about avionics, especially for smaller size aircraft? We must ensure complete reliability of all onboard systems, yet when the plane flies over a city with numerous wireless networks and high-power communication systems, everything must work perfectly without causing a disaster. There is documented proof from NASA that personal electrical devices used by passengers do cause abnormal operation of flight control systems, and that is the reason why we are told to turn off electrical products during takeoff and landing. You may not believe this, but a portable computer or even an iPod can generate enough unintentional RF energy to be noticed in the cockpit.

Consider a scenario on what may occur in a location with heavy industrial robots, all automated, such as in an automobile factory. How reliable do we want these robots to be, especially when someone with a hand held radio commonly used by police, firefighters, or facility managers walk down the aisle? The RF signal from the radio may have enough field strength intensity to disrupt the control circuits or computers that monitors all aspects of robotic operation. Components susceptible to electromagnetic disturbance may change operating states which in turn may disrupt the safety protocols defined within the software. Under this condition, we may now have a serious situation that may cause harm to operators. At what point in the automated process do we learn that our robotic system has lost memory and safety protocols? When and how do we even find out that a problem exists? Can reliability be ensured if we have no knowledge that an RF event has affected the intended operating function of the robot?

The examples given above are concerns that EMC and reliability engineers must consider during design and deployment. We must guarantee products are safe and reliable for the duration of their operating life.

Reference

[1] ANSI C63.12-1999. *American National Standard Recommended Practice for Electromagnetic Compatibility Limits*.