Summary of Research

Electromagnetic compatibility (EMC) problems related to the printed circuit board (PCB) and EMC measurement and instrumentation technologies

Alongside the progressive miniaturization of electronic devices in recent years, the PCB has continued to grow smaller and more highly integrated. Inevitably, the integration of multiple lines within the limited space available on the PCB forces lines close together, raising the potential for electromagnetic interference between adjacent lines and product malfunctions. However, these electromagnetic effects are difficult to detect. Once a product has been assembled, it can be nearly impossible to identify electromagnetic interference on the PCB as the cause of a specific malfunction. For many products, the effects of electromagnetic interference are given inadequate attention at the design stage.

Our laboratory pursues research on EMC, a field in which many issues remain unresolved. Of these various issues, we focus on the following three:

- The EMC problem in PCB, in particular, studies of signal integrity (SI), which represents signal distortion during transmission/reception, and power integrity (PI), a measure of the stability of the power supply voltage throughout the board.

- Studies of instrumentation technologies for EMC: In this area, we tackle the latest issues in EMC research, performing measurements of electromagnetic radiation generated (for example) by PC CPUs, as well as the electromagnetic immunity of electronic devices and equipment.

- Research related to electromagnetic field analysis especially in the area of developing a system to visualize the three-dimensional electromagnetic field based on limited measurements and post-analysis.

In PCB-related areas, we are studying the mechanisms of the crosstalk, an interference effect between transmission lines. Since nearly all modern electronic devices are multi-layered, we are currently investigating the effects of the length or configuration of lines on crosstalk and the effects of defected ground structures. Generalized guidelines from this research should allow the manufacture to design and develop high-EMC-performance PCBs and products.

In our study of EMC instrumentation technologies, we use a device called the transverse electromagnetic (TEM) cell. Electronic devices are placed inside the cell and exposed to powerful electromagnetic field to study their immunity or susceptibility. In conventional TEM cells, the electromagnetic field is applied to the device under test (DUT) in only one direction. Called as the 4-septum TEM cell, the TEM cell developed in our laboratory will make it possible to slowly rotate the direction of the electromagnetic field.

Keywords

Environmental electromagnetic engineering, electromagnetic compatibility (EMC), printed circuit board (PCB), electromagnetic immunity, crosstalk, TEM cell, 4-septum TEM cell, microwave, microwave imaging

Affiliations

Institute of Electronics, Information and Communication Engineers (senior member), Institute of Electrical and Electronics Engineers (IEEE) (senior member)

Member

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Unprecedented PCB Guidelines for High EMC Performance PCB Design

Having yet to establish a firm footing, the academic discipline of environmental electromagnetic engineering remains in its developing stages. To the best of our knowledge, our laboratory is the first to estimate the electric fields and the power flow by measuring only the magnetic files, which can be further applied to investigate the mechanism of electromagnetic emissions in a comprehensive manner. One result of our numerous joint researches is the successful development of EMC guidelines for PCB design. In general, current computer-aided PCB design focuses only on maximizing performance. But neglecting to account for EMC at the design stage can prove costly if countermeasures are needed to correct problems due to electromagnetic interference. Our EMC guidelines make it possible to design PCBs with robust EMC and have drawn interest from companies around the world.

Constructing EMC Instrumentation Technologies

The 4-septum TEM cells designed and assembled by our laboratory electronically control the directions of the electromagnetic fields, resulting in short measurement times. In ordinary TEM cells, the field is applied in just one direction; to obtain measured data for another direction, the DUT must be reset within the TEM cell. Our TEM cell makes it possible to take measurements for electromagnetic fields applied from all directions, resulting in significantly more reliable data, a dramatic advantage over existing TEM cells. Our goal for the future is to commercialize our 4-septum TEM cell through joint research efforts.

Advantages

Future Prospects

Contributing to the Field of EMC Research

Despite the many difficult problems associated with EMC research, an understanding of the mechanism of radiation should enable a suitable countermeasure to protect devices against electromagnetic interference. We intend to persevere in our EMC research and contribute to solve such tricky issues based on our research results.

Advancing into the Automotive Field

Electronic devices in the automobile industry represent one of our new areas of interest. In addition to radios and CD players, most cars these days are equipped with car navigation units and ETC units. Having all of these electronic devices coexist inside one automobile poses significant challenges. For example, the electromagnetic waves emitted from long harnesses can generate audible noise on the radio. The automobile industry today is moving towards the design of automobiles that rely more and more on electronic parts, leaving little doubt that the problem of EMC will become significant. In light of current trends, our laboratory hopes to play an active role in the area of EMC technologies related to the automobile industry.