Electromagnetic Interference: a Radiant Future!

Frank Leferink
University of Twente, Enschede, The Netherlands, and
THALES, Hengelo, The Netherlands

***Abstract*—Although Electromagnetic Interference and Electromagnetic Compatibility are well established domains, the introduction of new technologies results in new challenges. Changes in both measurement techniques, and technological trends resulting in new types of interference are described. These are the Smart Grid and conducted interference, generally below 150 kHz, while the use of the radio spectrum pose challenges at high frequencies.**

I. INTRODUCTION

Electromagnetic interference (EMI) was a subject for specialist only, and large industries employed EMI specialists, or hired EMI consultants, to make sure that equipment fulfilled contractual or legal EMC (electromagnetic compatibility) requirements. Most activities were often carried out by older experienced engineers during the testing phase. If equipment failed during the EMC test costly retrofits or redesigns, causing delay in time-to-market, were needed. This post-design approach is changing rapidly, supported by many young engineers educated at universities where EMC is a mandatory part in the curriculum. Post-design analysis and testing is changing towards concurrent EMC analysis and design, using modern EMI modelling and simulation tools and new test techniques.

Will this solve all EMI issues? No. Every introduction of a new technology will bring novel EMI challenges. For example, the use of mobile phones in cars with air bag systems caused exploding airbags. Pacemakers should not be near to strong electromagnetic fields. Power line telecommunication is causing electronic light switches to operate at most strange moments day and night, 4G mobile base stations are interfering with air traffic control radars, and photo-voltaic power converters are causing runaway electronic energy meters.

II. INNOVATION IN MEASUREMENT TECHNIQUES

CISPR developed EMI test techniques in the 1930's, like an Open Area Test Site, with the objective to resemble the effect of interfering equipment on radio reception, as shown in Figure 1. The basic test environment which resembles such an OATS is the semi-anechoic chamber, which is a shielded (Faraday) chamber lined with absorbers.

Modern environments are reflecting and energy can come from all directions. Furthermore, sources far beyond the 1 GHz range are used. New test environments like the reverberation chamber are much more suited to mimic these electromagnetic environments. A reverberation chamber operates like a microwave oven: the field is uniform distributed over the whole volume of the chamber. An object will be illuminated with the same amount of energy from every direction, or reverse, any energy emitted by an object from whatever angle, will be measured. This is much faster, and better reproducible than tests in a semi-anechoic chamber.

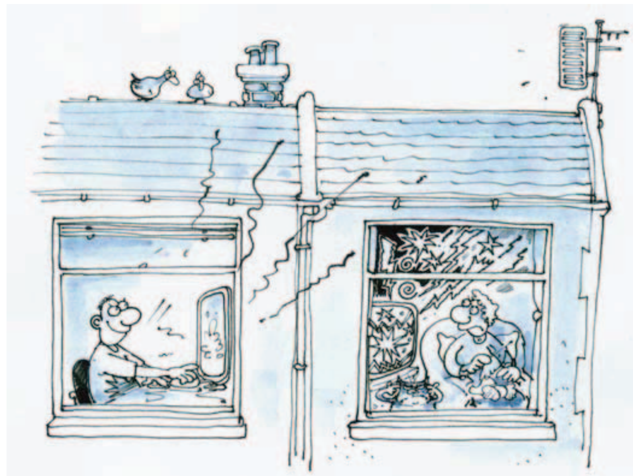

Fig. 1: Classic interference case, from neighbor to your aerial [1]. Cartoon by Rupert Besley

Another major step forward is the use of time-domain EMI meters, or so-called real-time spectrum analysers. By sampling a large part of the frequency band at once using fast fourier transform processors, the measurement time for EMI measurements is reduced drastically.

A third innovation is near-field scanning. By using highly sensitive electric and magnetic field sensors combined with highly accurate scanners the near field of an object can be measured very accurately. Again, because of the available computing power, the far field electromagnetic field pattern can be calculated from the near field patterns.

These three examples are part of a whole series of innovations in EMI measurement techniques.

III. TECHNOLOGICAL TRENDS

Many people consider EMI as radio frequency interference (RFI) only. But EMI is from DC to light, and includes conducted as well as radiated interference. The conducted part at low frequencies has been neglected for many years and switched mode power supplies, frequency converters and photo-voltaic converters, as well as modern energy-efficient lighting, are causing conducted interference [2]. As an example, the voltage waveform in a new building at our

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university, with only energy-efficient equipment connected, is shown in Figure 2. As can be seen, the waveform is distorted and this can result in problems for sensitive equipment connected to this voltage supply.

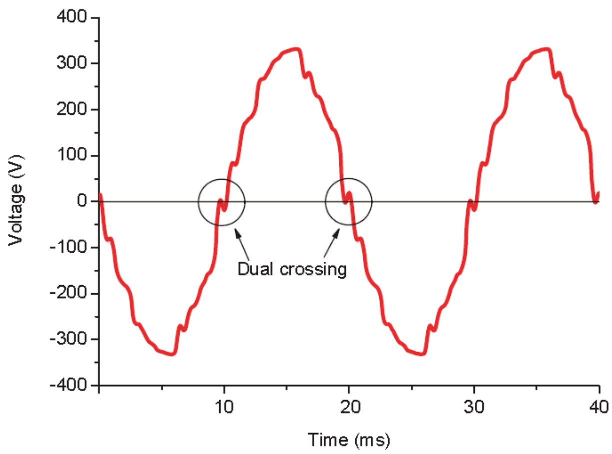

Fig. 1: Voltage waveform in a new building [3]

The Smart Grid is possible only when proper communication between equipment, smart meters and the grid managers is possible. Because of the high conducted interference, the power line communication, operating between 2-150 kHz, is disturbed [4]. In [5] it is reported that most of the complaints about interference are caused by conducted EMI. Sometimes the conducted interference is high enough to cause large misreading of electronic energy meters, of over 250%.

At the other side of the EMC spectrum, in the frequency range around 1 GHz and above, we observe a rapid increase of co-site interference. As an example, the introduction of mobile services in the 2500-2690 MHz caused large interference in the 2700-2900 MHz radar band [6]. Air traffic control radars have been modified in many countries, while base stations have been equipped with low-pass filters. This is just one example, but we can expect many more interference cases when more and more systems are using the congested electromagnetic spectrum. The key problem is often the limited performance of the radio-frequency (RF) front-end of the wireless receiver. If all systems would fulfill the ITU regulations [7], [8], in emission and also in immunity, then many co-site interference problems can be prevented.

Low-cost electronics, and lack of RF front-end filtering and selectivity, allow criminals to exploit the inherent vulnerability. In [9] it is shown that remote keyless entry systems are very vulnerable to intentional EMI resulting in car thefts [10].

IV. Conclusion

Electromagnetic compatibility is nowadays part of the conceptual and detailed design phase, with the objective to achieve first-time-right, and less re-designs. This effort will reduce cost, but will not prevent all interference issues; because the introduction of new technologies will result in new types of interference. New test techniques like reverberation chambers, time-domain EMI meters and near field scanners are briefly introduced. Low-frequency (conducted) interference, as well as high-frequency and intentional interference, are described.

To conclude: electromagnetic interference: a radiant future!

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