2020 EUROPE EMC GUIDE

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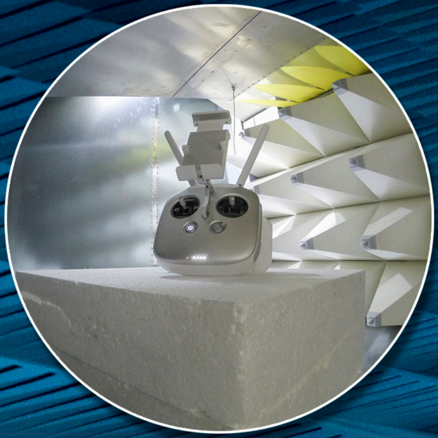

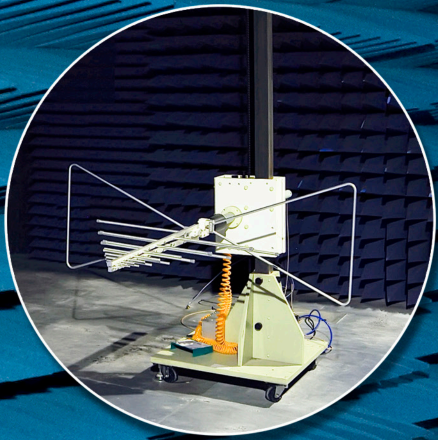

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TABLE OF CONTENTS

2020 Europe EMC Guide

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TABLE OF CONTENTS

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EDITORIAL

Hello! Welcome to the 2020 Europe EMC Guide from Interference Technology.

We hope you enjoy the articles and information we have to offer. This year, the guide underwent a bit of a makeover and we've included reference materials, a company directory, and a products and services list for more than 10 countries, into one guide.

This guide also includes articles that touch on automotive and testing concerns for EMC. Our first article, "Avoid Rogue Waves by Finding the Worst-Case Load in Power Distribution Networks," by Heidi Barnes, focuses on the "always on" electronics that now exist in most modern vehicles and how important it is to predict areas that might be susceptible to interference. The author stresses that EMI should be considered very early in the design phase.

The articles continue with "Basics of Passive Filters for EMC Compliance," by Don MacArthur, who explores the difference factors to consider when selecting a passive filter for EMC. Additionally, we have "What Is the Most Important EMC Design Guideline?" by Marcel van Doorn, which centers on how the partial inductance of the ground return conductor is key when designing for EMC.

We round out this guide with a list of major EMC standards as well as a reference section listing seminars, trade shows and standards working groups.

Finally, I wanted to note the new downloadable EMC guides we've produced this past year. If you visit our homepage, you'll see the list of guides. Some of the more popular ones include Military/Aerospace, Automotive, Wireless & IoT, Components, and EMC Fundamentals.

Cheers,

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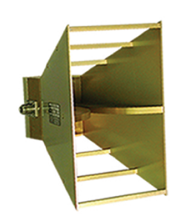

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AVOID ROGUE WAVES BY FINDING THE WORST-CASE LOAD IN POWER DISTRIBUTION NETWORKS

Heidi Barnes
SI/PI Engineer, Keysight Technologies

Multifunction, always-on connected devices and systems dominate today's high-speed digital (HSD) design trends. New smart devices feature increasing levels of complexity and lower consumption of power in smaller rugged packages. For example, smart cars combine sensors with a powerful onboard computer and complex communication systems that connect to the internet, GPS, other cars, and traffic lights (*Figure 1*).

In addition to complexity, power, and space constraints, the race continues for faster data transmission. The most common consumer products already provide gigabit data speeds. Cloud data is driving the need for server farms with 400 Gb Ethernet communications and ever-higher bandwidth.

Figure 1: Autonomous vehicles generate huge amounts of data from HSD subsystems (Source: Intel).

Exponential growth of design and test requirements is one consequence of increasing electronic complexity. Take, for example, 5G wireless, which requires 20x the number of conformance tests as its LTE predecessor. Add technologies such as Wi-Fi, Bluetooth, multiple radios, digital memory, and high-speed input/output into the mix, and the resulting mountains of data clearly strain current capabilities to manage design and test configurations. Further complicating the matter are local standards that electronic designers must pass in more than 20 world geographies.

START EARLY TO PREDICT ELECTROMAGNETIC INTERFERENCE AND COMPLIANCE

Failing a compliance test, such as the conducted emission compliance tests, at the end of the product design cycle is expensive. Old electromagnetic interference reduction approaches based on adding components or re-spinning designs are costly and time-consuming. Retrofits with added filters and capacitors increase manufacturing costs, while design re-spins to fix electromagnetic interference/compliance (EMI/EMC) problems result in product delays and lost revenue.

It is more effective to start early in the design phase to understand and mitigate potential EMI noise sources. Power delivery is the one network that connects to everything in a design, providing a path for conducted EMI noise to propagate through a system. The fast-changing di/dt transients of the switching converters or load demand can easily interact with parasitic inductances to cause excessive power rail noise.

This specialized power delivery for HSD has evolved into the field of power integrity (PI) engineering. Modern design tool suites and methodology enable PI engineers to simulate potential EMI sources and predict compliance up front. Whether parasitic effects impact a design depends upon the desired specification compliance, the performance margin built into the design, and the manufacturing and process tolerances.

DO NOT COUNT ON DATA SHEETS TO REVEAL WORST-CASE VOLTAGE NOISE RIPPLE

In a world of increasing power distribution network (PDN) complexity, as in autonomous vehicles, power delivery is no longer a DC problem. HSD data requires fast delivery of power at microwave frequencies. An autonomous vehicle PDN serves data collected from cameras, radar, sonar, GPS, and lidar subsystems that can easily reach 4 Terabits per day (*Figures 1* and *2*). The vehicle processes data locally and requires processors, DDR memory, serializer/de-serializer, and Tx/Rx devices, each with its own point-of-load (POL) power supply. Fast di/dt switching loads from these subsystems can react with any inductance in the power delivery path to create voltage noise ripple. The amount of allowable ripple continues to decrease as power rail voltages drop below 1 V to meet low power demands and faster data rates.

Note: A POL power supply is typically a switched mode power supply with a buck regulator DC-DC converter design. The microprocessor printed circuit board world calls that a voltage regulator module. All these terms are interchangeable and refer to the source of power.

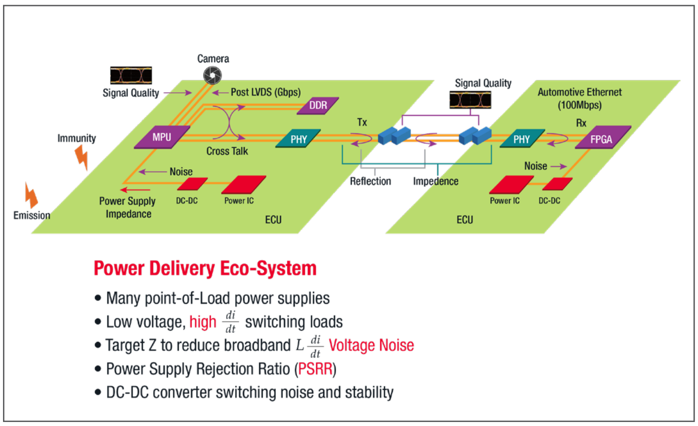

Figure 2: In this autonomous vehicle PDN exemplary of today's complex power delivery ecosystem, power integrity is no longer about DC but fast delivery of power at microwave frequencies.

PDNs must provide clean power to the load. Electronic devices have maximum voltages and ripple specifications to avoid damage, lost data, and EMI/EMC failures. The goal of the power rail is to provide a constant voltage even when the current load is switched on and off with high-frequency di/dt transients. Traditional methods of measuring noise on a power rail often fail to detect worst-case voltage ripple.

To test the power rail, PI engineers typically use the classic step load excitation taken from most data sheets. When a step load change in current is applied to the voltage rail, engineers refer to the corresponding response on the power rail as the natural response. The natural response will often have some ringing, but it decays exponentially. The small voltage ripple the step load generates could easily pass specifications.

When the load excites the power rail at that ripple frequency, it is known as the forced response (*Figure 3*). The forced response is much larger and represents the worst-case ripple on the power rail. The forced response grows exponentially to a steady-state value. It can be large enough to cause a device damaging over voltage, a failure in data transmission, and EMI noise. Normal operation of the load may never excite this resonant frequency, but digital systems are wideband and difficult to test for all combinations of operating scenarios. For example, power-saving modes that turn on and off and data bursts can easily create HSD load transients that extend from kilohertz to gigahertz.

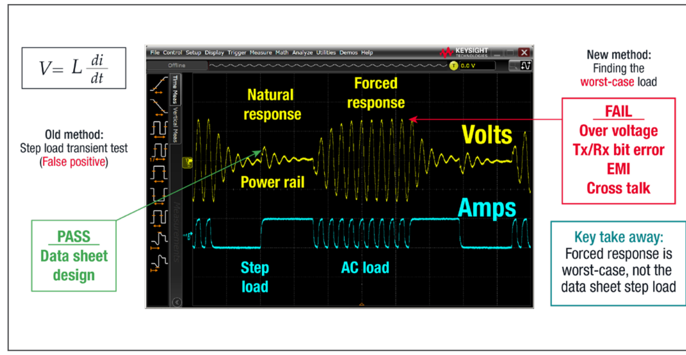

Figure 3: In this power rail measurement made on Keysight's Infiniium oscilloscope, the yellow trace shows the power rail voltage amplitude vs. time, and below that is the corresponding load current amplitude vs. time.

The new way of testing for the worst-case voltage ripple is to look at the impedance peaks in the frequency domain (*Figure 4*). PI engineers must identify the power rail impedance peaks where the di/dt at those frequencies, multiplied by the impedance, results in a maximum ripple. If the peaks are below a target impedance (flat green dashed line), the voltage ripple at that peak frequency will be within acceptable limits.

However, what happens if the second impedance peak frequency is excited at the maximum of the forced response of the first frequency, and the third impedance peak frequency is excited at the maximum of the first two? Just like two ocean waves lining up to create one large rogue wave, multiple resonances can line up to create a rogue voltage wave on the power rail.[1] Although their probability is low, rogue voltage waves do exist. Passengers in the next generation of autonomous vehicles should not have to take a chance on rogue voltage waves.

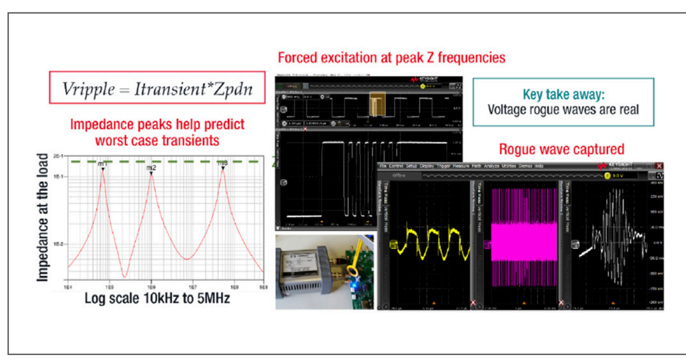

Figure 4: Multiple impedance peaks in the frequency domain result in power rail ripple and can be a source of rogue voltage waves.

The better design is one with flat impedance, with no resonant peaks. This requires an understanding of how parallel inductance and capacitance can resonate and the need for optimizing the selection of decoupling capacitors to compensate for this distributed inductance in the path. Achieving the flat impedance design provides matched impedance across the required operating frequencies and no possibility of rogue waves. In this special case, the maximum ripple voltage is the same whether excited by a simple step load or a forced frequency excitation. Predicting worst case ripple and potential EMI with the traditional step load can be done, but only if the design has been optimized for flat impedance.

Steve Sandler, *President and Founder of Picotest, first published his simulation and measurement of rogue voltage waves at DesignCon 2015. He made the challenging statement that "designing for a target impedance may not be the right approach, as it can't protect you from rogue waves." The topic was controversial and led to a panel of experts at DesignCon 2016 "Target impedance, rogue waves: tales from the experts" debating the existence of rogue voltage waves. The conclusion was that they are real. The probability is small, but not impossible, with dynamic power delivery to high speed digital systems.*

In summary, PI engineers can no longer afford to wait until after layout to perform measurements that find EMI on the PDN. The cost associated with failing electromagnetic compliance late in the design cycle is too high. Moving from a traditional data sheet-based approach to a modern simulation and measurement-based workflow early in the product design cycle enables PI engineers to design resonant free power delivery and avoid rogue voltage waves.

REFERENCES

[1] Steve Sandler, "Target Impedance Limitations and Rogue Wave Assessments on PDN Performance" Signal Integrity Journal, March 19, 2018.

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BASICS OF PASSIVE FILTERS FOR EMC COMPLIANCE

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One of the roles of the practicing EMC engineer or product designer is to be able to design filters to add to circuits in order to get them to pass various EMC immunity and emissions standards such as IEC 61000-4-2 for ESD immunity, IEC 61000-4-3 for Radiated RF immunity and IEC 61000-4-4 for Electrical Fast Transient/Burst immunity and other various international standards covering Radiated Emissions (RE) or Conducted Emissions (CE).

EMI filters are often used along with proper shielding in order to achieve EMC compliance. The purpose of a filter is to establish either a low-impedance path for RF current to return back to the local source of energy, and/or to provide a high impedance to prevent RF currents from flowing on a cable. However, selecting the proper filter for a given situation may be confusing to some, especially if they are new to the EMC field or have not dealt with the subject in some time.

EMC practitioners may be asking themselves what filter configuration is the best one to use for any given application or how to correctly choose the values of components given the frequency, circuit impedance, and other parameters of the circuit. They may also want to know how they can get more attenuation out of their filter design in order to pass an emissions or immunity test. The time to learn how to properly design filters for EMC compliance is not when schedules are tight, and the product's ship date is rapidly approaching.

If you find yourself stuck in any of the above situations, this article on passive filter basics for EMC compliance should help remove the mystery, and allow you to quickly find the best passive component filter solution that allows product to ship on time.

PASSIVE LOW-PASS FILTERS

Fortunately, designing filters for EMC compliance is not as difficult as it may seem. For most cases, in order to achieve EMC compliance, we really only need to know how to apply passive low-pass filter types to our circuits. The other types of passive filters, such as high-pass, band-pass, and band-reject are not as common as the low-pass filter is for EMC work and will not be covered in this paper. Consult the references for more information on these other filter types.

Unfortunately, circuit impedances are not always well understood or impossible to know, making it more difficult to determine which values of passive low-pass filter components to choose from in order to pass the EMC compliance tests. This is the situation with common mode emissions emanating off of a cable during a RE test where the impedance of the cable changes as it is rearranged in order to maximize emissions.[1]

It is impossible to model the filter exactly if the load impedance is not known. The only way to know if a low-pass filter design is adequate or not is by trial and error experiments performed during EMC compliance testing, or more preferably, by trying out different low-pass filter component values very early in the product development cycle. In order to be most effective, this experimental work should occur during pre-compliance testing performed in your own test facility prior to going out of house for full-compliance testing. See *Reference [3]* for a detailed description on how to setup an in-house pre-compliance EMC test facility.

A low-pass filter is one in which the frequencies below a certain significant frequency are easily let-through and those above this same significant frequency are heavily attenuated. A passive low-pass filter is a simple voltage divider; non-amplifying device composed of a combination of resistors and capacitors, inductors (or ferrites) and capacitors or in some instances, may be composed of just one of these components. For instance, a single capacitor placed across a line to reference ground without the resistor or inductor installed may be all that is required in order to suppress an unwanted signal.

The benefit to using a single component filter is that only one physical device is required which in turn requires less board space and also helps keep parts costs down. Multi-element filters are useful in situations where the range of frequencies involved is too large and impossible for a one component filter to fully attenuate.

RC LOW-PASS FILTER

One of the most basic forms of a low-pass filter is comprised of just one resistor and one capacitor, an RC filter. In an RC low-pass filter, the cutoff frequency occurs at resonance, where the capacitive reactance (X_c) equals the resistance (R) and where $X_c = 1/2\pi fC$.[4]

A simple RC low-pass filter and the equation for determining its cutoff frequency is shown in *Figure 1*. Note that the filter shown in *Figure 1* is also known as an L filter due to its resemblance to the letter L. It is also considered a single-pole filter because there is only one reactive component, the capacitor.

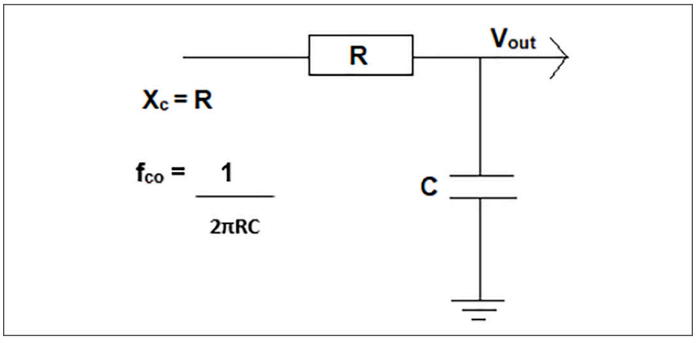

Figure 1: Basic RC low-pass filter (L Type)

A low-pass filter has an ideal, theoretical response where all signals contained below a so-called critical frequency (the 3 dB down point) are easily let-through the device and above which frequency, all signals are heavily attenuated. An ideal low-pass filter response curve is shown in *Figure 2*.

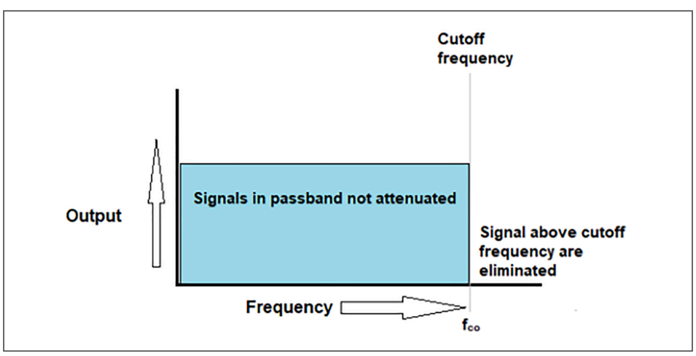

Figure 2: Ideal low-pass filter response curve

In actual practice, the output of the filter will not go to zero as abruptly as shown in the ideal curve of *Figure 2*. In actuality, the output will gradually roll off at a 6 dB/octave or 20 dB/decade rate as shown in *Figure 3*.

EMC APPLICATION OF LOW-PASS FILTERS

Reference [3] suggests applying a low-pass filter in order to fix an EMC problem such as a fast transient or ESD discharge immunity issue and that a good starting point in putting together a low-pass filter that will work for most situations is to start out by using a 47 to 100 Ω series resistor placed in the signal line, with a 1 to 10nF capacitor placed in the signal or power return line. If we take this information and select R = 100 Ω and C = 10nF as a starting point, the cut-off frequency (f_{co}) will equal approximately 159 kHz, and the low-pass filter response curve should look like that shown in *Figure 3*. Very little of the signals that are greater than 1.59 MHz will be let through the filter as they are 20 dB lower than any of the signals that at the filter's cutoff frequency of 159 kHz.

As another example, if we leave R = 100 Ω and select C = 1nF, the cutoff frequency at the 3 dB down point moves out to roughly 1.59 MHz, the 6 dB down point is at 3.2 MHz, and the signal is almost completely attenuated at 15.9 MHz. Signals greater than 15.9 MHz are heavily attenuated and not let through the filter.

Table 1 contains a matrix of the various R-C low-pass filter values discussed so far plus some others that might be useful, and their low-pass filter characteristic responses at the 6 dB and 20 dB down points.

When attempting to suppress an unwanted high-frequency signal, one may find out that a filter containing only a single reactive component (i.e. one capacitor or one inductor) may not provide enough attenuation. Adding a second reactive component will increase the roll off to 12 dB/octave or 40 dB/decade.[4] These types of filters are called various names such as double-pole, two-stage, two-element, or second-order filters. Filters with three reactive components will provide 18 dB/octave or 60 dB/decade attenuation. Four reactive component filters will provide 24 dB/octave or 80 dB/decade attenuation and so on.[2]

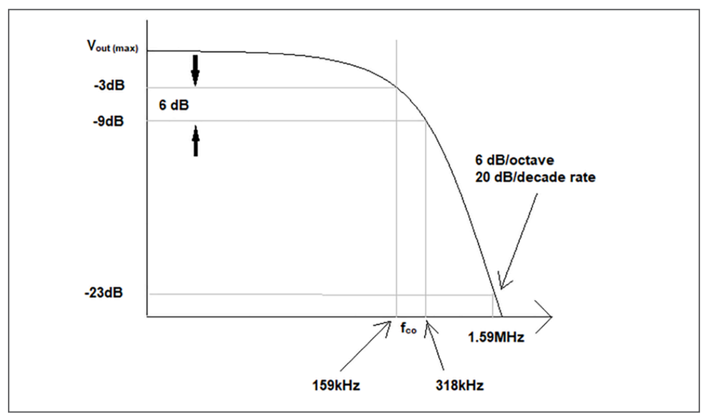

Figure 3: Realistic low-pass filter response curve

R	C	f_{co} (-3 dB Point)	-6 dB Point	-20 dB Point	
200	10nF	79.6 kHz	159.2 kHz	795.8 kHz	
100	10nF	159 kHz	318 kHz	1.59 MHz	← Plotted in Figure 3
49	10nF	325 kHz	650 kHz	3.3 MHz	
20	10nF	796 kHz	1.6 MHz	7.9 MHz	
200	1nF	796 kHz	1.6 MHz	7.9 MHz	
100	1nF	1.59MHz	3.2 MHz	15.9 MHz	
49	1nF	3.3 MHz	6.5 MHz	32.5 MHz	
20	1nF	7.9 MHz	15.9 MHz	79.6 MHz	
200	100pF	7.96 MHz	15.9 MHz	79.6 MHz	
100	100pF	15.9 MHz	31.8 MHz	159.2 MHz	
49	100pF	32.5 MHz	65 MHz	325 MHz	
20	100pF	79.6 MHz	159.2 MHz	796 MHz	

Table 1: Matrix of R-C Values and Low-Pass Filter Responses

SELECTION OF F_{CO}

When selecting a cut-off frequency for a low-pass filter, it is important to take into account the fundamental frequency of the intended data, clocks, and other purposeful signals present on the filtered line. If the cut-off frequency chosen is too low in frequency, then the intended signals will be attenuated along with the higher frequency signals that you want to suppress. Try to maintain at least the fifth harmonic of the intended signal, with the 10th harmonic being ideal.[3] Many I/O signals that are used with unshielded cables require some form of filtering in order to be in compliance with EMC standards. These signals usually have a frequency of 1 MHz or less.[1] It is important to also ensure that by adding a filter's impedance to circuit that it does not in turn create a signal integrity problem.

Once the filter's component values are chosen, carefully consider where it is going to be placed in the circuit or system. The most benefit is obtained when the filter is placed as close to the item to be protected as possible, one centimeter is ideal for most designs.[1] In order to keep any extra unwanted inductance from affecting performance of the filter, be sure to keep lead lengths as short as possible. Additional layout and placement concerns will be covered later in this article.

USE OF FERRITES

If the voltage drop across the series resistor cannot be tolerated, a device such as a ferrite, which acts as a high-frequency resistor with minimal voltage drop, can be used instead of the resistor. Because the ferrite presents the circuit with high AC impedance, while also not affecting signal quality, they are most optimal for filtering at frequencies greater than 30 MHz. Carefully consider the amount of DC or low-frequency current present in the circuit when using ferrites. They can become easily saturated with too much current present in the circuit which renders them ineffective.[5]

USE OF INDUCTORS

An inductor can also be considered for the series element in a low-pass filter instead of a resistor or ferrite, particularly if dealing with a signal in the 10 to 30 MHz range. When using inductors, beware of the effect that their inductive reactance (XL = 2πfL) and parasitic capacitance will have at these higher frequencies. You may be actually creating a high-pass filter when you are attempting to create a low-pass one, and not even realize it.

BASIC FILTER TOPOLOGIES

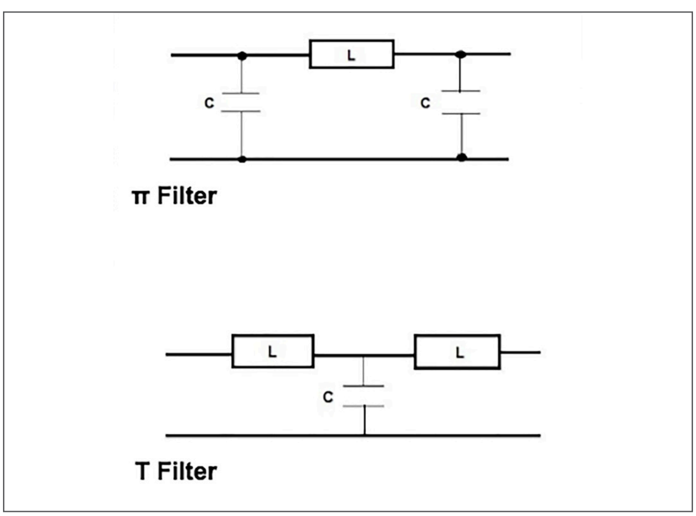

Figure 4

The above diagrams show two more of the basic filter configurations available for impedance mismatching between circuit source and load input and output impedances and filter input and output impedances. Both are named after their shapes. The first is called a π filter because it looks like the Greek letter π and the second is called the T filter because it looks like the letter T. Note that there are three reactive elements present in these filters, which means they an attenuation curve of 18 dB/octave and 60 dB/decade. They are considered third-order filters.[5]

IMPEDANCE MISMATCHING

Source and load impedances must be considered in selecting the proper filter configuration. In order to work properly, the source driving the input to the low-impedance shunt element (i.e. capacitor), should be high impedance. If the output of the source is a low-impedance, it should face the high-impedance series component. This same concept applies to load input impedances versus the filter's output impedances. In general, a source or load impedance less than 100 Ω is considered low and great than 100 Ω is considered high impedance.[5] *Table 1* provides a matrix of source versus load impedances and their associated correct filter topologies.

Source Z	Load Z	Filter Configuration	Analysis
High (>100Ω)	High (>100Ω)	Shunt Element (Capacitive) or π Filter	Use π filter if greater roll-off is required.
High (>100Ω)	Low (<100Ω)	L Filter	The shunt element should face the High Z source and this element should face the Z load.
Low (<100Ω)	Low (<100Ω)	Series Element (Inductive) or T Filter	Use T filter if greater roll-off is required.
Low (<100Ω)	High (>100Ω)	L Filter	The shunt element should face the High Z load and the series element should face the Low Z source.

Table 2

DIFFERENTIAL MODE (DM) AND COMMON MODE (CM) CURRENTS

There are two different types of current modes, and hence noise sources capable of creating interference. It is important to know which mode is prevalent so that proper filtering can be applied. The two types of signals we are referring to are differential-mode (DM) and common-mode (CM) signals.

DM signals carry useful information whereas CM currents provide no useful information what-so-ever and are the main source of RE and CE issues. A DM signal travels down one side of a circuit path, and an equal and opposite DM signal travels back on the other side of the path. If no circuit discontinues exists, then complete canceling of these two DM signals occur, and no CM current is developed. Placing capacitors across the outgoing and return lines and/or an inductor in series with either outgoing or return line is called DM filtering.

CM signals are in-phase signals present in both outgoing and return lines of a circuit. They do not cancel each other out but add up, often to a level substantial enough to cause EMI issues. CM filtering involves placing capacitors across each signal line to ground reference and sometimes also using a CM inductor in the circuit. The CM inductor only acts on the CM signals that are present. It does not affect the DM signals.

PARASITICS

The non-ideal behavior of the elements that make up our filter must be addressed. Unexpectedly, we will find that real capacitors and inductors possess both capacitance and inductance which limits the bandwidth that they are useful over. The amount of parasitics present in a circuit can be reduced through proper component selection and layout techniques, but cannot be eliminated entirely. As frequency increases, the reactance of a capacitor decreases until it reaches its self-resonant frequency. Up to this point, the capacitor is behaving as it should—it behaves like a resistor. Above its self-resonant frequency point the capacitor becomes inductive and it acts like an inductor because of the parasitic inductance found in its metal plates. This parasitic effect is greater in leaded types of capacitors than it is with the surface mount technology (SMT) types that have almost no lead length.

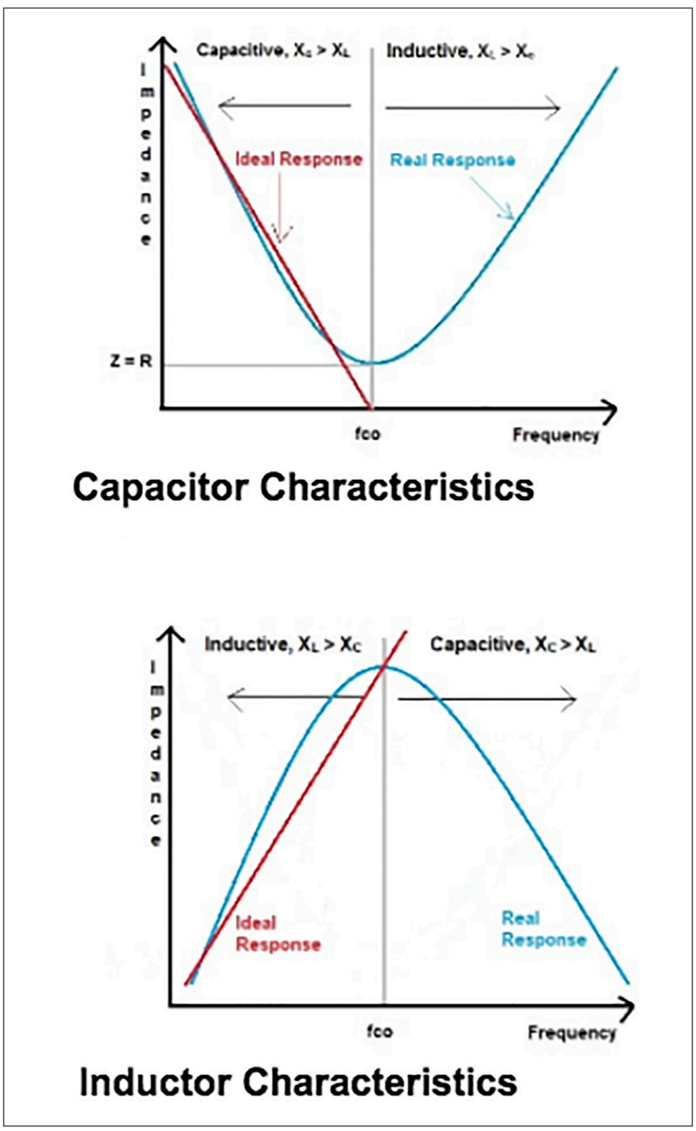

Figure 5

The opposite effect occurs with an inductor where its reactance becomes capacitive above its self-resonant frequency point, and where the inductor now acts like a capacitor. At the self-resonant frequency, capacitors are intended to provide a very low impedance and inductors should provide a high impedance. For inductors, their limiting factors are related to the parasitic capacitance present between each winding and overall capacitance located between one lead and the other.

The inductor's inter-winding parasitic capacitance is not as big a deal in regards to effectiveness for EMI suppression as is a capacitor's parasitic inductance. The main factors that change the intended behavior of capacitors is the parasitic inductance of the circuits in which they are installed, not necessarily the construction of the capacitor. Therefore, proper layout and placement then becomes the critical factor when attempting to effective utilize passive low-pass filters for EMI suppression.

LAYOUT AND PLACEMENT CONCERNS

Because there is going to be unknown and hidden parasitics involved, do not expect your filter design to work one-hundred percent the first time. As mentioned earlier, expect the need to perform some trial and error design and troubleshooting in the lab. If not available already, have on hand a selection of various components that you want to try out. Do not wait until the last minute to obtain the SMT capacitors, inductors, or ferrites that you want to use. Make sure the components selected are designed for the bandwidths involved. Create your own matrix of values, critical frequencies, and 6- and 20-dB roll-off curves.

In reviewing the layout, look for longer than necessary trace lengths that add extra inductance and impedance. When applying fixes, be sure keep connections short. If an R-C filter is added to the reset pin of a micro-controller, place it as close to the pin as possible and do not overlook the length of its return trace. In general, it is best to locate the filter as close to the offending signal source as possible, not some obscure location far away.

Watch out for trace or wire routing that allows for too much capacitive and inductive coupling to other noisy signal or traces. Filter components should be placed right at an entry connector (I/O and power inputs). Placement of a filter deeper inside a circuit or system allows EMI to enter the system.[6] If separation is not maintained, improper routing of input and output sections can mean that filter elements are essentially bypassed and no longer effective. On PCBs, capacitors should shunt unwanted signals to chassis not line to line or line to return.[6] It is best to understand the path of current flow and to not necessarily rely on "ground" as being the ultimate zero-ohm impedance and sole problem savior.

Finally, although they appear to be useful and easy to troubleshoot with, do not expect too much out of clamp-on ferrite common-mode chokes as they only provide about 10 dB of attenuation.[3]

CONCLUSION

The need to utilize passive low-pass filters to obtain EMC compliance is a given. They provide a low-impedance path for RF currents to return back to the local source of energy or provide a high impedance to prevent unwanted RF currents from flowing.

A filter that does both is ideal. Designing low-pass filters for EMI suppression is not that difficult. Proper knowledge and planning before the need for them arises can save developers some time and headaches.

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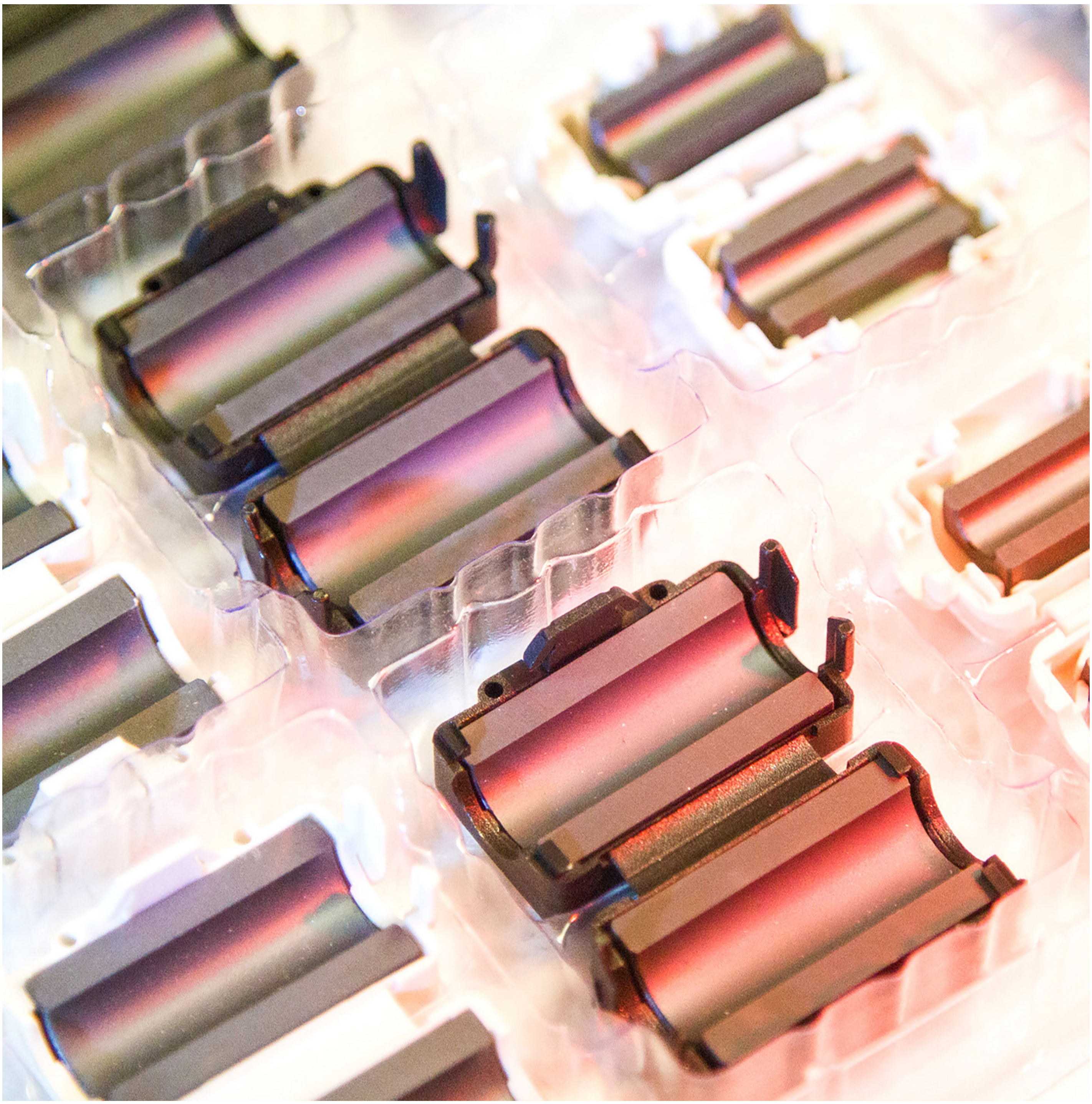

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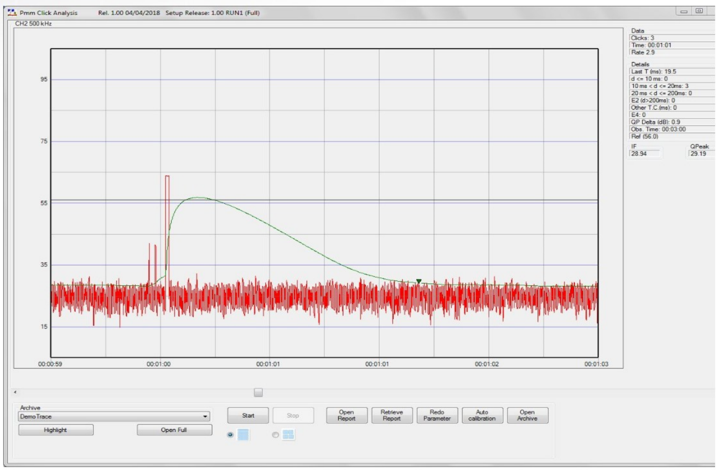

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WHAT IS THE MOST IMPORTANT EMC DESIGN GUIDELINE?

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INTRODUCTION

EMC design guidelines have always been a popular subject in the EMC design community. What is the most important EMC design guideline, i.e. the guideline with the highest impact on the emission and immunity of electronic circuitry? Studying books and literature from renowned EMC experts often tells us that the most important EMC design guideline is[1]:

- **Minimize loop areas associated with high-frequency (HF) signal currents.**

My preferred design guideline is another one. In this article, we will show with an experiment demonstration that there is another design parameter that has much more impact on the EMC behavior of an electronic circuit than just the loop area of the signal current. Do you want to know which design parameter this is? Read on.

EXPERIMENT DEMONSTRATION

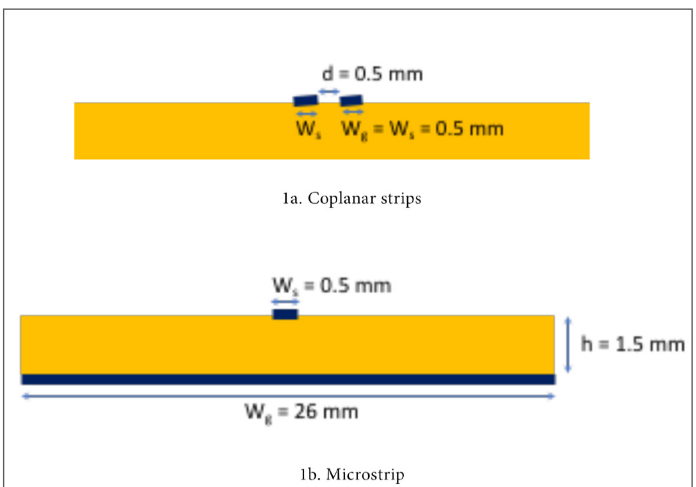

Figure 1: Printed circuit board configurations

The experiment demonstration consists of two configurations on a printed circuit board: a coplanar strips line and a microstrip line (*Figure 1*). Both lines have a length l = 100 mm. The coplanar traces have a width $W_{signal} = W_{ground} = 0.5$ mm. The distance between the two traces d = 0.5 mm. The microstrip has a trace width $W_{signal} = 0.5$ mm. The width of the ground plane underneath the trace is $W_{ground} = 26$ mm. The height of the trace above the ground plane is h = 1.5 mm. The copper thickness is 35 μm and the relative dielectric constant of the FR4 board material is $\varepsilon_r = 4.7$.

Figure 2 shows the demo board with the coplanar strips and microstrip lines.

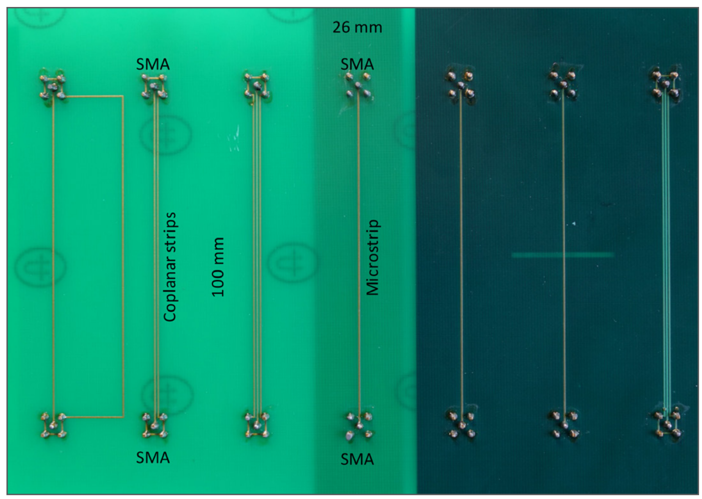

Figure 2: Demo board with coplanar strips and microstrip lines

Figure 3 shows the measurement setup. On the demo board both lines are terminated with an SMA 50 Ω RF load. The input of the line is connected to the tracking generator output of the Rigol DSA815 spectrum analyzer with an RG223 double braided coaxial cable of 1 m length. The tracking generator output level is 100 dBμV (100 mV) over the frequency range 30 MHz to 300 MHz. For the frequencies involved the length l of the board traces is small compared to the wavelength (l << 1 m). In both lines flows a differential mode (DM) current $I_{DM} = 100$ mV/50 Ω = 2 mA. With a current monitoring probe from Fischer Custom Communications (F-61) the common-mode (CM) current on the double braided coax cable is measured. The current probe is connected to the input of the spectrum analyzer. By shifting the current probe along the cable with the spectrum analyzer in the max hold mode the maximum CM current is recorded. The results will be discussed in the next section.

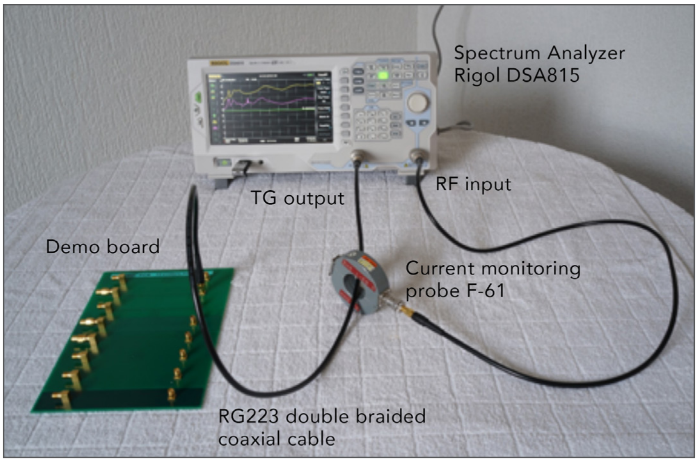

Figure 3: Measurement setup Common-Mode current generated by coplanar strips and microstrip

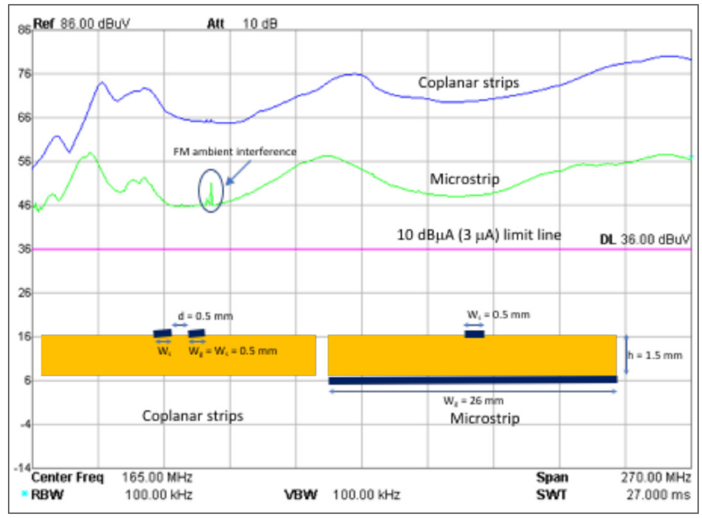

Figure 4: Measurement results common-mode current coplanar strips versus microstrip

Now let's have a look to the loop area of the high frequency signal current. For the coplanar strips line, the signal current loop area is approximately (taking the proximity effect into account) l × d = 100 mm × 0.5 mm = 50 mm[2]. The microstrip line has a signal current loop area l × h = 100 mm × 1.5 mm = 150 mm[2]. In our experiment demonstration the current loop area of the microstrip configuration is three times (10 dB) larger than that of the coplanar strips configuration.

At high frequencies (> MHz), signal currents take the path of least impedance, this is generally the path of least inductance, which is generally the path that minimizes the loop area. Currents return as close as possible to the path of the outgoing current. In the case of the microstrip most of the return current flows in the ground plane directly underneath the signal trace.

RESULTS AND DISCUSSION

The measurement results of the maximum CM current for the coplanar strips and microstrip configuration are depicted in *Figure 4*. Over the full frequency range from 30 MHz to 300 MHz, the coplanar strips line generates approximately 20 dB higher CM currents than the microstrip line, although its current loop area is 10 dB smaller. The CM current limit line of 10 dBμA (3 μA) shown in *Figure 4* is based on the far field radiation of a resonant half wave dipole antenna and corresponds roughly with a maximum electric field strength of 30 μV/m (30 dBμV/m) at a 10-meter distance from the antenna (legal radiated emission limit). The current probe F-61 has a transfer impedance of 20 Ω in the frequency range 30 MHz to 300 MHz. So, a current of 3 μA will give at the 50 Ω input of the spectrum analyzer a voltage of 3 μA × 20 Ω = 60 μV = 36 dBμV.

What is the physics behind this CM current generation? The DM current I_{DM} in the circuit loop on the board induces a CM voltage V_g across the ground return conductor. This CM ground voltage V_g acts as the antenna voltage for the cable connected to the board and generates antenna currents (CM currents) on the shield of the coax cable. The cable is an efficient antenna in the frequency range 30 MHz to 300 MHz and in the graphs in *Figure 4* the cable resonances are clearly visible. The radiated emission is proportional to the antenna current (CM current).

The CM ground voltage is determined by the partial inductance of the ground return lead: $V_{CM} = I_{DM} 2\pi f L_g$.

As a first order approximation for the partial inductance of a microstrip ground plane we can use the formula[2]:

$$L_g \approx (\mu_0 h)/(2W_g) \text{ if } W_g >> h \quad \text{permeability } \mu_0 = 4\pi 10^{-7} \text{ (H/m)}.$$

The ground plane inductance L_g (Henry/m) is proportional with the trace height h (m) above the plane and inversely proportional with the ground plane width W_g (m).

For our microstrip configuration (h = 1.5 mm, W_g = 26 mm) the resulting ground plane inductance is:

$$L_{g\ microstrip} = 36 \text{ nH/m}.$$

For our coplanar strips configuration (d = 0.5 mm, W_g = 0.5 mm) the inductance of the ground return trace is approximately:

$L_{g\ coplanar\ trace}$ = 300 nH/m, i.e. an 18 dB higher inductance than that of the microstrip ground plane.

This difference of approximately 18 dB in ground return inductance is reflected in the CM current (radiated emission) plots of the coplanar strips and microstrip in *Figure 4*. The lower the ground return inductance the lower the radiated emission. In[3] the theory of partial inductance to control emissions is explained very clearly.

CONCLUDING REMARKS

From the experiment we learn that although the differential mode current loop area of the microstrip line is much larger (10 dB) than that of the coplanar strips line the radiated emission of the microstrip line is much lower (20 dB) in the frequency range 30 MHz to 300 MHz. The main reason for this behavior is the partial inductance of the ground return lead. The ground plane of the microstrip has a much lower inductance than the ground trace of the coplanar strips, which results in a much lower common-mode ground voltage for the microstrip line and consequently a much lower radiated emission. The design parameter that has the highest impact on the EMC performance of an electronic circuit is not just the signal loop area but the partial inductance of the ground return conductor.

We may conclude that the most important EMC design guideline is:

- **Minimize the inductance of the ground return conductor.**

On a printed circuit board this can be realized by making the ground return conductor shorter, placing the signal trace closer to the ground plane and by making the ground return plane wider. This is also valid for flex foil cables. The ultimate example of an extremely low ground return inductance (low transfer impedance) is an HF coax cable with a semi-rigid coaxial shield. This solid shield results in hardly any field leakage, assuming perfect connectors.

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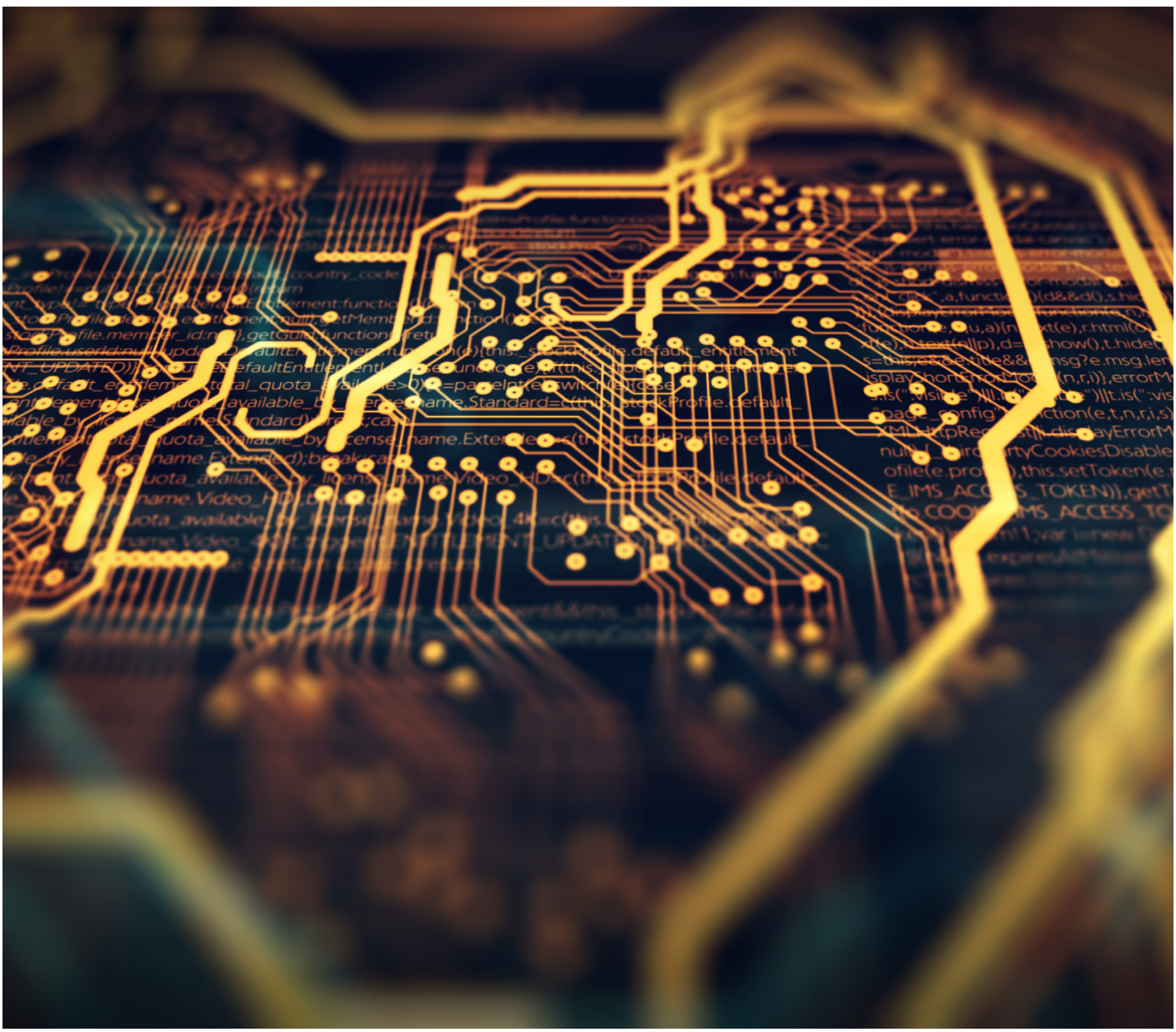

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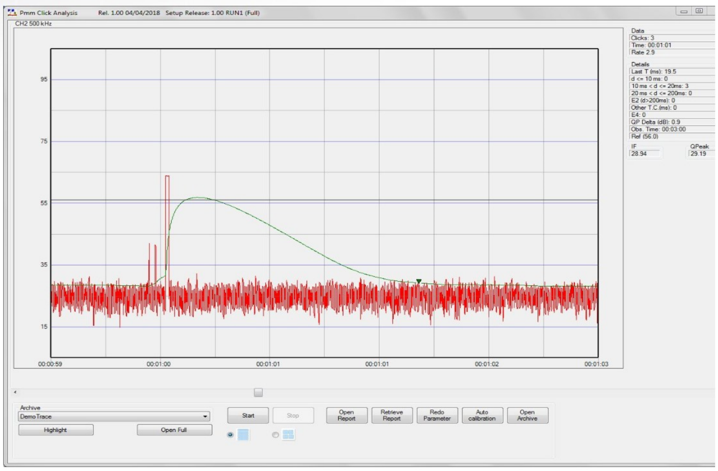

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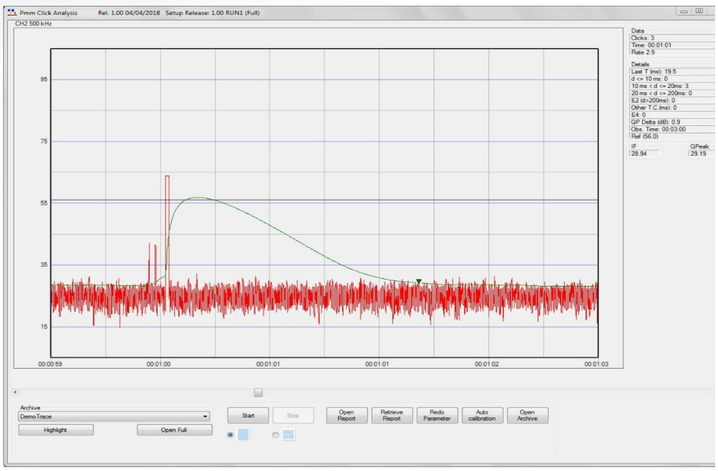

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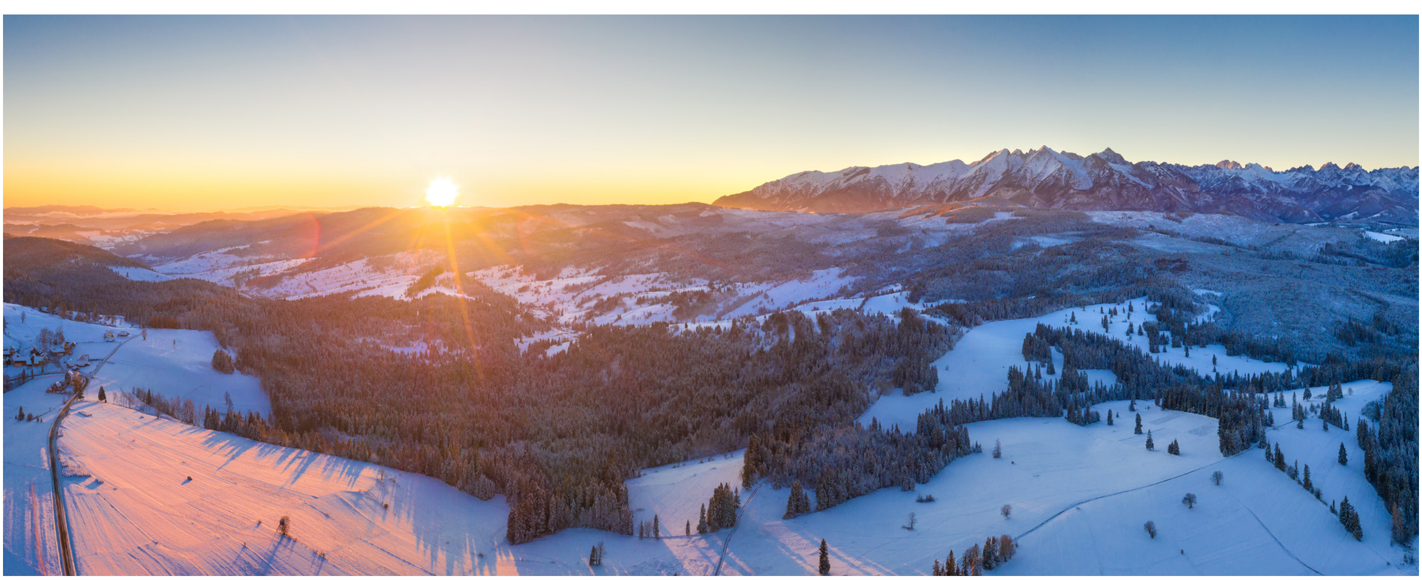

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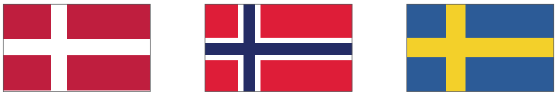

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Fax: +34 93 320 80 56
info@wavecontrol.com
www.wavecontrol.com

Lifasa International Capacitors
c/. Vallès, 32 - Polígono Urvasa,
08130, Santa Perpètua De Mogoda,
Barcelona, Spain
Tel: +34 93 574 70 17
Fax: +34 93 544 84 33
info@lifasa.com
www.lifasa.com

P

Premo Group
Severo Ochoa 47 Parque Tecnologico de Andalucia 29590 Campanillas Malaga, Spain
Tel: +34 95 123 13 20
Fax: +34 95 123 13 21
info@grupopremo.com
www.grupopremo.com

R

Rohde & Schwarz España, SA
(Office Madrid)
Avenida de Manoteras, 6
28050 Madrid
Tel: +34 91 334-1070
Fax: +34 91 803 58 33
bcn.spain@rohde-schwarz.com
www.rohde-schwarz.es

S

Schlegel Electronic Materials
RC Microelectrònica S.A.,
Francesc Moragas 72, nave 3, 08907 L' Hospitalet de Llobregat, Barcelona, Spain
Tel: +34 93 260 21 66
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Ventas@rcmicro.es
www.rcmicro.es

Schneider Electric
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Tel: +34 93 484 3100
cac@schneider-electric.com
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SGS
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28042 Madrid, España
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www.appluslaboratories.com

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48160 Derio (Vizcaya), Spain
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www.tecnalia.com

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SPAIN
PRODUCTS AND SERVICES DIRECTORY

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Amplifiers

AFJ INSTRUMENTS SRL
A.H. Systems, Inc.
AR RF/Microwave Instrumentation
BONN Elektronik GmbH
Exodus Advanced Communications
Narda Safety Test Solutions GmbH
Rohde & Schwarz España, SA

Antennas

AFJ INSTRUMENTS SRL
A.H. Systems, Inc.
AR RF/Microwave Instrumentation
Exodus Advanced Communications
Narda Safety Test Solutions GmbH
Rohde & Schwarz España, SA

Chambers

CST France Eurl

Filters

Fair-Rite Products
Lifasa International Capacitors
Premo Group
Salicru S.A.
Würth Elektronik Spain

Shielding

AR RF/Microwave Instrumentation
Eldonvasa AB
Federal-Mogul Corporation
Kemtron Ltd
Schlegel Electronic Materials
Schneider Electric
Würth Elektronik Spain

Spectrum Analyzers

AFJ INSTRUMENTS SRL
AR RF/Microwave Instrumentation
Rohde & Schwarz España, SA

Test Instrumentation

Adler Instrumentos
AFJ INSTRUMENTS SRL
A.H. Systems, Inc.
AR RF/Microwave Instrumentation
Exodus Advanced Communications
Langer EMV-Technik GmbH
Rohde & Schwarz España, SA
Wavecontrol, S.L. Pallars,

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IEEE EMC Society Chapter Spain

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Instituto Nacional De Tecnica Aeroespacail
Laboratorio ICEM. Asociacion ITACA
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Turkey

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A

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E

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Fax: +90 216 5752919
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Testing Laboratories in Turkey

EMC Testi Yapan Kuruluşlar
TSE DENEY VE KALİBRASYON MERKEZİ BAŞKANLIĞI Deney Laboratuvarları
Short name: TSE
Location: KOCAELİ and ANKARA
Accreditation: TURKAK
Type: National Institute of Turkey (Governmental)
Open to all clients: Yes
URL: https://www.tse.org.tr/tr/kurumsalsablondetay/621/645/hakkimizda.aspx

ELDAŞ Elektrik Elektronik Sanayi Ve Ticaret A. Ş.
Short name: ELDAŞ
Location: ANKARA
Accreditation: TURKAK
Type: Commercial company (Owner: Termikel Group which is a manufacturer)
Open to all clients: Yes
URL: http://eldas.com.tr

TÜBİTAK ULUSAL METROLOJİ ENSTİTÜSÜ DENEY LABORATUVARI
Short name: TÜBİTAK UME (National Metrology Institute)
Location: KOCAELİ
Accreditation: TURKAK
Type: Research Institute (Governmental)
Open to all clients: Yes
URL: http://www.ume.tubitak.gov.tr

ESİM Test Hizmetleri
Short name: ESİM
Location: Çayırova/KOCAELİ
Accreditation: TURKAK
Type: Commercial company
Open to all clients: Yes
URL: http://esim.com.tr

BİLGİ TEKNOLOJİLERİ VE İLETİŞİM KURUMU Piyasa Gözetim Laboratuvarı Müdürlüğü
Short name: BTK
Location: ANKARA
Accreditation: TURKAK
Type: Regulatory body (Governmental)
Open to all clients: Yes
URL: https://www.btk.gov.tr/tr-TR/Anasayfa

VESTEL ELEKTRONİK Emc Laboratuvarı
Short name: VESTEL
Location: MANİSA
Accreditation: TURKAK
Type: Commercial company (Owner: Vestel Group which is a manufacturer)
Open to all clients: No (only internal testing in the factory)
URL: https://www.vestel.com.tr/kurumsal

LVT TEST LABORATUVARLARI
Short name: LVT
Location: ANKARA
Accreditation: TURKAK
Type: Commercial company
Open to all clients: Yes
URL: http://www.lvt.com.tr

EMC TEST VE KONTROL HİZMETLERİ Deney Laboratuvarı
Short name: EMC Elektronik
Location: KOCAELİ
Accreditation: TURKAK
Type: Commercial company
Open to all clients: Yes
URL: http://www.emcas.com.tr

ARCELIK A.S. CAMAŞIR MAKİNASI ISLETMESI EMC TEST LABORATUVARI
Short name: ARÇELİK
Location: İSTANBUL
Accreditation: TURKAK
Type: Commercial company (Owner: Arçelik-KOÇ Group which is a manufacturer)
Open to all clients: No (only internal testing in the factory)
URL: https://www.arcelik.com.tr

EGETEST CENTER ELEKTRİK ELEKTRONİK
Short name: EGE TEST CENTER
Location: İZMİR
Type: Commercial company
Open to all clients: Yes
URL: https://www.egetestcenter.com

ASELSAN ELEKTRONİK
Short name: ASELSAN
Location: ANKARA
Accreditation: TURKAK
Type: Commercial company (Owner: Aselsan which is a manufacturer)
Open to all clients: No (only internal MIL-STD-461 and DO-160 testing in factory)
URL: http://aselsan.com.tr

OTOKAR OTOMOTİV VE SAVUNMA
Short name: OTOKAR
Location: SAKARYA
Accreditation: TURKAK
Type: Commercial company (Owner: KOÇ Group which is a manufacturer)
Open to all clients: Yes
URL: https://www.otokar.com.tr/tr
URL: in English: https://www.otokar.com/en-us/rd/Pages/Testing-and-Validation-Center.aspx

Consept Test ve Teknoloji Merkezi
Short name: CONSEPT
Location: KOCAELİ
Accreditation: IAS
Type: Commercial company
Open to all clients: Yes
URL: http://www.conseptrd.com

SAKARYA Üniversitesi Elektromanyetik Araştırma Merkezi
Short name: SAKARYA ÜNİVERSİTESİ
Location: SAKARYA
Type: University
Open to all clients: Yes
URL: http://www.semam.sakarya.edu.tr

AKDENİZ Üniversitesi EMUMUAM
Short name: AKDENİZ ÜNİVERSİTESİ
Location: ANTALYA
Type: University
Open to all clients: Yes
URL: http://emumuam.akdeniz.edu.tr/tr

İstanbul Teknik Üniversitesi EESlab
Short name: İTÜ
Location: İSTANBUL
Type: University
Open to all clients: Yes
URL: http://www.eeslab.itu.edu.tr/index.html

SDT UZAY & SAVUNMA TEKNOLOJİLERİ
Short Name: SDT
Location: ANKARA
Accreditation: Yes
URL: http://www.sdt.com.tr/tr/kabiliyetler/test-kabiliyetleri/
Contact: Serkan Akyüz Chief/Electromagnetic Interference/Compatibility Avionics and Electrical Engineering
sakyuz@tai.com.tr

EMİTEL-TR Elektro Man.uym.ve İç Dış Tic.ltd.şti.
Location: İZMIR
Type: Commercial
Accreditation: Yes
URL: www.emitel.com.tr

Consultancy Companies

Turcert
URL: https://www.turcert.com

SGS Türkiye
URL: http://www.sgs.com.tr

TÜV SÜD Türkiye
URL: https://www.tuv-sud.com.tr/tr-tr

Taşar Danışmanlık
URL: http://www.tasardanismanlik.com

Femko
URL: https://www.femko.com.tr/

Ege Test Center
URL: https://www.egetestcenter.com

Mobilite
URL: http://www.mobilite.com.tr

CSA Group Türkiye (Emitel Tr)
URL: http://www.emitel-tr.com

Manufacturers

AKE Elektronik
URL: http://www.akeelektronik.com

EMC Elektronik
URL: http://www.emcelectronic.com/Ürünlerimiz.html

Distributors

Ege Test Center
URL: https://www.egetestcenter.com/urunler/

Orko
URL: http://www.orkoltd.com

Aktif-Neser
URL: http://www.aktifneser.com.tr

Netes
URL: http://www.netes.com.tr

Yıldırım Elektronik
URL: http://www.yildirimelektronik.com

Testmar
URL: http://www.testmar.com.tr

Würth Elektronik Türkiye
URL: www.we-online.com

Esen Elektronik
URL: http://www.esenel.com

Ortak Elektronik
URL: http://ortakelektronik.com/

Partner Electronic
URL: https://www.partnerelectronic.com/

Spark Ölçüm Teknolojileri
URL: http://www.sparkmeasure.com/anasayfa

Ege Rate
URL: http://www.egerate.com

R&D Support to Manufacturers

AKE Elektronik
URL: http://www.akeelektronik.com

EMC Elektronik
URL: http://www.emcas.com.tr

Ege Test Center
URL: https://www.egetestcenter.com

Consept
URL: http://www.conseptrd.com

Trainers

Aysam AKSES
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URL: https://www.linkedin.com/in/aysam-akses-ph-d-71a23044/

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Prof. Dr. Şükrü ÖZEN
Akdeniz Üniversitesi
URL: http://aves.akdeniz.edu.tr/sukruozen/

Yrd.Doç.Dr. Şuayb Çağrı YENER
Sakarya Üniversitesi
URL: http://www.syener.sakarya.edu.tr/tr/iletisim

Calibration Laboratories

SİMKAL, İstanbul
URL: http://www.simkal.com.tr

METKAL, İstanbul
URL: www.metkal.com.tr

SMS KALİBRASYON, İstanbul
URL: www.smskal.com

SPARK, Ankara
URL: www.sparkkalibrasyon.com.tr

ANTEK, Ankara
URL: www.antekkalibrasyon.com.tr

EGEMET, İzmir
URL: www.egemet.com.tr

TÜBİTAK UME, Kocaeli
URL: http://www.ume.tubitak.gov.tr

EMC Equipment Suppliers

URL: **http://www.aktifneser.com.tr/**

URL: **http://www.netes.com.tr/**

URL: **https://www.femko.com.tr/**

URL: **http://www.testmar.com.tr/emc-test-cihazlari**

TURKEY
PRODUCTS AND SERVICES DIRECTORY

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Amplifiers

AR RF/Microwave Instrumentation
Exodus Advanced Communications
Rohde & Schwarz GmbH & Co. KG

Antennas

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Exodus Advanced Communications
Rohde & Schwarz GmbH & Co. KG

Shielding

AR RF/Microwave Instrumentation

Spectrum Analyzers

AR RF/Microwave Instrumentation
Rohde & Schwarz GmbH & Co. KG

Test Instrumentation

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Exodus Advanced Communications
Rohde & Schwarz GmbH & Co. KG

Testing Laboratories in Turkey

EMC Testi Yapan Kuruluşlar
ELDAŞ Elektrik Elektronik Sanayi Ve Ticaret A. Ş.
TÜBİTAK ULUSAL METROLOJİ ENSTİTÜSÜ DENEY LABORATUVARI
ESİM Test Hizmetleri
BİLGİ TEKNOLOJİLERİ VE İLETİŞİM KURUMU Piyasa Gözetim Laboratuvarı Müdürlüğü
VESTEL ELEKTRONİK Emc Laboratuvarı
LVT TEST LABORATUVARLARI
EMC TEST VE KONTROL HİZMETLERİ Deney Laboratuvarı
ARCELIK A.S. CAMAŞIR MAKİNASI ISLETMESI EMC TEST LABORATUVARI
EGETEST CENTER ELEKTRİK ELEKTRONİK
ASELSAN ELEKTRONİK
OTOKAR OTOMOTİV VE SAVUNMA
Consept Test ve Teknoloji Merkezi
SAKARYA Üniversitesi Elektromanyetik Araştırma Merkezi
AKDENİZ Üniversitesi EMUMUAM
İstanbul Teknik Üniversitesi EESlab
SDT UZAY & SAVUNMA TEKNOLOJİLERİ
EMİTEL-TR Elektro Man.uym.ve İç Dış Tic.ltd.şti.

Consultancy Companies

Turcert
SGS Türkiye
TÜV SÜD Türkiye
Taşar Danışmanlık
Femko
Ege Test Center
Mobilite
CSA Group Türkiye (Emitel Tr)

Manufacturers

AKE Elektronik
EMC Elektronik

Distributors

Ege Test Center
Orko
Aktif-Neser
Netes
Yıldırım Elektronik
Testmar
Würth Elektronik Türkiye
Esen Elektronik
Ortak Elektronik
Partner Electronic
Spark Ölçüm Teknolojileri
Ege Rate

R&D Support to Manufacturers

AKE Elektronik
EMC Elektronik
Ege Test Center
Consept

Trainers

Aysam AKSES
Prof. Dr. Levent SEVGİ
Yusuf Ulas KABUKCU

University Researchers

Prof. Dr. Levent SRVGİ
Ahmet ÖZKURT
Prof. Dr. Korkut YEĞİN
Prof. Dr. Şükrü ÖZEN
Yrd.Doç.Dr. Şuayb Çağrı YENER
Sakarya Üniversitesi

Calibration Laboratories

SİMKAL, İstanbul
METKAL, İstanbul
SMS KALİBRASYON, İstanbul
SPARK, Ankara
ANTEK, Ankara
EGEMET, İzmirTÜBİTAK UME, Kocaeli

EMC Equipment Suppliers

URL: **http://www.aktifneser.com.tr/**
URL: **http://www.netes.com.tr/**
URL: **https://www.femko.com.tr/**
URL: **http://www.testmar.com.tr/emc-test-cihazlari**

United Kingdom

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www.alrad.co.uk

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B

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Bulgin (Elektron Technology)
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www.bulgin.co.uk

C

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www.caltest.co.uk

Carlisle Interconnect Technologies
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A.H. Systems

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ce@cassindustries.com
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keith.armstrong@cherryclough.com
www.cherryclough.com

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enquiries@conformance-services.com
www.conformance-services.com

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Cranford House, Queens Drive, Ilkley, West Yorkshire, LS29 9QW United Kingdom
Tel: +44 (0)1943 969647
info@coreshield.co.uk
www.coreshield.co.uk

Cranage EMC & Safety
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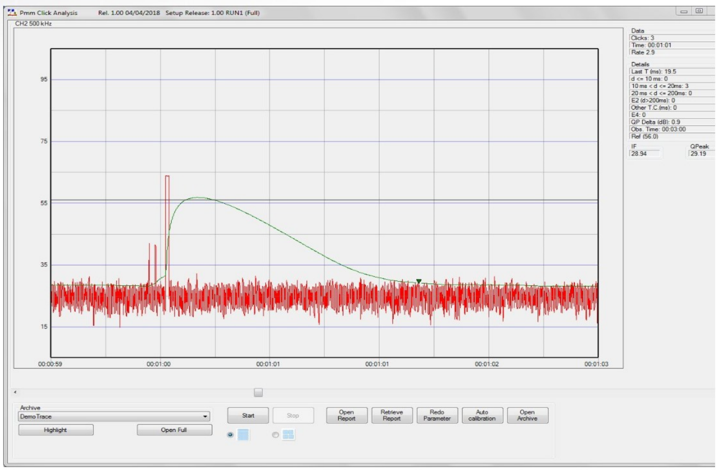

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EU FLIGHT EXPERIENCE: BRIEF INTRODUCTION TO CE MARKING AND EMC EU STANDARDS FOR ELECTRONIC PRODUCTS

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"Devices and systems, we are now landing on EU. Please provide your EMC reports and Declarations of Conformity. Remain seated up to the end of tests. Thank you, and happy landing!" This could be the announcement for all the products put into EU market. Of course, EMC is only one of the great number of tests, measurements, inspections, that a product should undergo in order to have the glorious "CE marking" on its label.

EMC is definitely the most underestimated, unknown, and mysterious set of measurements that a device should pass. With this article I will try to clear things up, in order to make our way out from this jungle made of standards...

I will go through the following subjects:

- Regulatory framework versus product: how can I find the right EMC standard for my device?
- Intended use of a device versus regulatory framework: does the chosen regulatory framework addresses the correct intended use of my device?
- CE marking rules: CE device vs CE systems... CE device + CE device = CE system?

All these items are actually questions; problems that trouble our customer's minds...

After that I would like to "sweep" across standards, from the base ones up to the generic civil/industrial ones, to finish with some product standards. Also, I will try to explain what is the meaning of “harmonized standard”.

REGULATORY FRAMEWORK VERSUS PRODUCT

When a customer asks me, what standard could be used for his device, he is asking me what Regulatory Framework is applicable to the device he is selling or manufacturing. I personally know EMC labs that leave this hard task to customers. I am not fully in agreement with that, because if in some cases the research of a suitable standard is easy, in some others is definitely not an easy task. Hence, the expert EMC lab engineer comes in, and with his knowledge will surely be of great help.

In some cases, customers tell the EMC lab which standard they want, together with a test plan (often detailed): in these cases, we say to the customer "Chapeau!" (with the meaning of "great! You are a very well-trained customer!").

INTENDED USE VERSUS REGULATORY FRAMEWORK

After having found the right standard, it is necessary to check that the intended use of the device is concurrent to the EMC standard previously chosen. In other words, we have to check if the device is in the scope of the standard, and consistent with its intended use.

Let me use an example: I produce a power supply for medical devices, and I know there is a specific standard (product standard) for power supplies. That standard generically addresses power supplies, but I want to sell my power supply to medical devices manufacturers. So, I have to apply the medical devices EMC standard to my product, and hence other tests and other measurements are to be done, maybe dramatically different, in levels and limits, from those contained into the power supply product standard. In this example, the intended use played a heavy role. We should always take it into account.

CE MARKING RULES

Supposing there are different devices that make up a system. For example a power supply, a motor driver, a motor, and a signaling industrial tower. Each of these components are CE marked. We could be led to think that the system is automatically CE marked... well not exactly! Not at all!

The system has to go under a full measurement campaign, and only then, if all the tests and measurements are passed, the manufacturer can issue the Declaration of Conformity and label the system with the CE marking. Why is it necessary to do so? Well, 9 out of 10, you will find that all the different components of the system have been CE marked with different standards. Besides, in order to connect the different components together, you have to route cables and


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connections of many kinds. Hence, you add variables and possible means of transportation of the disturbance around the system, changing the "EM shape" of the single component.

Now, having said that, let's have a look at the main standards, widely used in EU. We will stick to the major ones. Before that, let's talk about harmonized standards…what are they? The explanation is clearly written on the European Community website (please see references below).

Standards are issued by Recognized Standards Organizations. If a standard is published in the EU OJ (European Community Official Journal), it is then “harmonized”. As soon as a standard is harmonized, every single EU country can add that standard in their own OJ, as is or by changing something throughout the document. Then, a suffix is added, depending of the country: Italy has CEI, UK has BS. Mind that the use of a harmonized standard is voluntary. And now… let's go for the standard list!

Base Standards (derived from IEC standards, they contain test methods, characteristics of test instruments, calibration methods):

- EN 61000-4-2: is about electrostatic discharges application on civil/industrial EUTs
- EN 61000-4-3: method for radiated immunity from 80 MHz to 6 GHz
- EN 61000-4-4: EFT/B, also known as BURSTs or fast transients. Required on both power supply and signal cables (of more than 3 m long)
- EN 61000-4-5: Surge, in order to simulate lighting strike on cables. Required also on screened cables
- EN 61000-4-6: Common mode RF conducted immunity. From 150 kHz to 80 MHz (some product standards extend up to 230MHz). Required on both power supply and signal cables (of more than 3m long)
- EN 61000-4-8: immunity to magnetic fields at power supply frequency. To be executed at 50 Hz and 60 Hz.

Generic Standards (they can modify base standards, applicable is product standards are not available):

- EN 61000-6-1: immunity levels for residential and commercial areas
- EN 61000-6-2: immunity levels for industrial areas (where the power supply lines are not directly connected to the public network)
- EN 61000-6-3: emissions limits (both conducted and radiated) for residential and commercial areas
- EN 61000-6-4: emissions limits (both conducted and radiated) for industrial areas
- EN 61000-6-5: NEW ENTRY! Immunity levels for equipment used in power station and substation environment

Product Standards (they identify clearly what kind of devices are in the scope, they can modify Base standards):

EN 55011: this standard addresses EUTs called ISM (industrial, scientific, medical). It contains limits for emissions (both conducted and radiated).

EN 55032/EN 55024 (EN 55035): the scope of these two standards are MME (multimedia equipment). In the previous versions was used the short form ITE (information technology equipment). These two standards supersede the previous EN 55022 (for emissions). For immunity it is still applicable EN 55024 but it will be superseded by EN 55035 (in Italy, not yet harmonized).

EN 61326-1: this standard is about laboratory instruments, control and measurement devices. It defines three different environments: basic, industrial, special (shielded rooms, or areas where EM radiation is under control). The manufactures should choose the environment in advance because levels and limits are not the same for the three environments.

EN 60601-1-2: medical devices and medical equipment. This standard went through a heavy maintenance process. Edition 4 (2014) contains substantial differences and it will be compulsory from the end of 2018. Briefly, the main differences are: more involvement of the manufacturer in the EMC measurement and test process, electrostatic discharges on air at 15 kV, increased levels of radiated immunity in certain wireless and communications bands up to 6 GHz, additional tests for EUTs installed of light vehicles (included ambulances).

And then, I will end this long article with a final question. Where can I find EU standards? Well, don't try to buy standards from the CEN CENELEC website: you won't find anything. In the References below I give you a link to the CEN CENELEC website, from where you can be redirected to Affiliates and CEN National Members, from where you can download the standards.

REFERENCES

Guide for the EMCD:
https://ec.europa.eu/docsroom/documents/28323, to assist with the common application of the Directive 2014/30/EU. The guide has no weight in law, but deals with a number of practical issues that will be of interest to manufacturers and other stakeholders.

Blue Guide:
https://ec.europa.eu/growth/content/'blue-guide'-implementation-eu-product-rules-0_it, the update of the Guide to the implementation of directives based on the New Approach and the Global Approach (the "Blue Guide").

Harmonized standards definition:
https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards_en

CEN CENELEC:
www.cenenelec.eu/standards/ENpurchase/Pages/default.aspx

ABOUT THE AUTHOR

Claudio Stazzone works as a Technical Responsible for the EMC Lab of Eurofins Product Testing Italy, Eurofins Scientific Group. In his everyday activity there are EMC measurements with customers, and general management of the EMC activity of the lab from the technical point of view. He is responsible for the EMC and RED directives for Notified Body activity.

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PROPOSED CHANGES TO CISPR SC I STANDARDS

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Are you familiar with CISPR 32 and CISPR 35? CISPR 32 was originally published in 2012, followed by a pair of corrigenda and then the 2nd edition was published in 2015. CISPR 32 replaced CISPR 13 (Broadcast receivers emissions) and CISPR 22 (ITE emissions). In the EU CISPR 32 is published as EN 55032 and it has superseded EN 55013 and EN 55022. By now you should all be comfortable with CISPR 32 and your labs should be using it.

Likewise, CISPR 35 was published in 2016 and replaces CISPR 24 (ITE immunity). It ultimately will replace CISPR 20, as well. EN 55035 is applicable in the EU for the Radio Equipment Directive, but hasn't been listed for the EMC Directive. This article will leave that discussion alone, but you should be aware of CISPR 35. Korea adopted its own version of CISPR 35 a while ago, but their standard is based on the Committee Draft for Vote (CDV) that resulted in a Final Draft International Standard (FDIS) that failed in voting in CISPR SC I. Confused yet?

It will only get worse. Recall the scene from the original *Star Trek* movie where Bones McCoy comes aboard the newly remodeled star ship Enterprise and goes off mumbling about having to look at the new sick bay. He knows it will be different, "I know engineers. They love to change things!" I'm sure whoever wrote that line had been around engineers, because it is true. We love to change things. That's what we do.

Why do I bring this up? Because, guess what? Changes for CISPR 32 and CISPR 35 are afoot. Don't worry, the changes won't happen tomorrow, but they are scheduled to happen in late 2019 for CISPR 32 and 2020 for CISPR 35. This is, of course, if all goes according to schedule.

So, what's changing?

CISPR 32

CISPR SC I MT7[1] is working on Amendment 1 to CISPR 32:2015. There are a bunch of items that they are looking at, and the items were divided up into six fragments. Five of these were circulated to the national committees last year as five Committee Draft (CD) documents. CDs are commented on by national committees, but they are not voted on. MT7 has reviewed the comments (most recently on February 28 / March 1 of 2019 in Milan) and is taking the next step on three of them. Fragment 4 deals with termination of the AC mains cables where they leave the measurement area and this is being dealt with by CISPR SC A. No further work will be done by MT7 on this until SC A amends the appropriate CISPR 16 standards and a CD was not circulated in 2018 for this fragment. Fragment 5 deals with wireless power transfer (WPT) and this work is not mature enough at this time. Finally, fragment 6 deals with the RMS-Average detector and this work, as well, is not mature enough to go forward.

So, what do fragments 1, 2, and 3 impact? A bunch of items.

Fragment 1 deals with a large number of items. Too many to discuss in detail in a blog. A few are close coupling ports[2], allowable receive antenna positions when running tests, cable length between the EUT and AMN/AAN requirements, and AC mains cable routing. Wording was updated to try and reduce confusion. There is also a point dealing with HDMI cables, but this will be worked further and will not appear in the CDV in 2019.

Fragment 2 deals with a few items, the most important of which is a change to Clause 11 of CISPR 32 to require full compliance with the measurement instrumentation uncertainty requirements in CISPR 16-4-2. Watch out for this one.

Fragment 3 primarily deals with suggested changes to the limits and methods of measurement for emissions above 1 GHz. No change in frequency range is being proposed, but the changes proposed will bring CISPR 32 into alignment with the FCC limits from 1 GHz to 3 GHz (some would call this a relaxation in CISPR 32) and the test methods in ANSI C63.4. In other words, height scans for all EUTs, not just those too tall to fit in the 3 dB beam width of the receive antenna. The voting on this CDV, and the comments that go with the negative votes, should be interesting.

In short, there will be 3 CDVs circulated to the national committees in 2019 after the French translation is prepared. These will deal with fragments 1, 2 and 3. The parts that pass will likely be circulated as a single FDIS in 2019. As the stability date for CISPR 32 in 2019 (the earliest any amendment could be published), passage of this FDIS will result in an amendment to CISPR 32. A new stability date will be agreed at the next CISPR SC I plenary meeting following publication of the amendment (late 2019 in Shanghai or late 2020 in San Francisco).

CISPR 35

The work on Amendment 1 to CISPR 35 Edition 1 is not as advanced as the work on amending CISPR 32. An RR document to officially start the work has not been issued, as this would start the clock running as to when the work must be complete. The meeting on February 26 and 27 in Milan was supposed to simply discuss whether or not a particular item should be included in the next amendment. The discussions instead went into details of these items. The original plan was to divide the work into items that were felt to be "easy" and those that would take more work. The "easy" items would be included in the next amendment and the others would follow at some time in the future. While a number of items are under discussion, there will be no documents forwarded to the national committees for comment prior to the next meeting of MT8[3] in Busan, South Korea next October. Suffice to say, if all goes as expected there should be an amendment to CISPR 35 published in 2020. More details as they become available.

CONCLUSION

In conclusion, Bones McCoy was correct in his observation in the first *Star Trek* movie. Engineers do love to change things and CISPR 32 and CISPR 35 are not static standards. Don't get comfortable with the standards as they exist today. Remember, CISPR 22 had six editions in its lifetime from 1985 to 2008. These standards won't be any different.

NOTES:

[1] Maintenance Team 7? Where did this come from? Working Group 2 was dissolved in the CISPR SC I meeting last October and replaced with MT7.

[2] Much more than can be discussed here, as it took an hour or more to discuss in Milan on February 28.

[3] MT8 replaced WG4 last October.

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EUROPEAN EMC (AND RELATED) CONFERENCES

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March 15-19, 2020
Anaheim, California
http://www.apec-conf.org

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EMV INTERNATIONAL EXHIBITION
March 17-19, 2020
Cologne, Germany
https://emv.mesago.com/events/en.html

MICROWAVE AND RF EXPO
March 18-19, 2020
Paris, France
http://www.microwave-rf.com

EXPO ELECTRONICA
April 14-16, 2020
Moscow, Russia
http://www.expoelectronica.ru

THE BATTERY SHOW - EUROPE
April 28-30, 2020
Stuttgart, Germany
http://www.thebatteryshow.eu

The Battery Show Europe Exhibition & Conference is a showcase of advanced battery manufacturing and technology for electric & hybrid vehicles, utility & renewable energy support, portable electronics, medical technology, military and telecommunications.

APEMC 2020
May 19-22, 2020
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Stuttgart, Germany
http://www.testing-expo.com/europe/english/

This conference includes the very latest technologies and services that are designed to ensure that the highest standards are met in terms of product quality, reliability, durability and safety.

GLOBAL AUTOMOTIVE COMPONENTS AND SUPPLIERS
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Stuttgart, Germany
www.globalautomotivecomponentsandsuppliersexpo.com/en/

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AUTOMOBIL ELEKTRONIK KONGRESS
June 23-24, 2020
Ludwigsburg, Germany
https://www.automobil-elektronik-kongress.de/en/

The European Electric & Hybrid Vehicle Congress is a global platform to foster exchange of views between the R&D, the industry, the authorities, and end users to develop synergies in the field of e-mobility.

IEEE INTERNATIONAL SYMPOSIUM ON EMC/SIPI
July 27-31, 2020
Reno, Nevada
https://www.emc2020.emcss.org/

EMC EUROPE 2021
July 30-August 6, 2021
Glasgow, Scotland
http://www.emc2021.org/

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EMC EVENTS EUROPE

EUROPEAN EMC (AND RELATED) CONFERENCES *CONTINUED*

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EMC EUROPE 2020
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http://www.emceurope2020.org/

The Symposium will cover the entire scope of EMC including traditional areas and EMC aspects of emerging technologies as 5G, autonomous drive systems, industry 4.0, IoT, wireless power transfer, nanotechnologies, health, etc.

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http://www.evtechexpo.com

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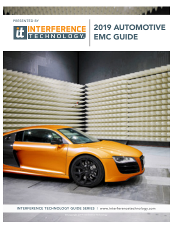

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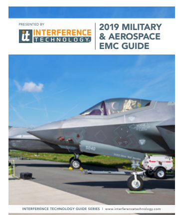

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Reference:
https://learnemc.com/commercial-emc-test-standards
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ANSI	
Document Number	Title
C63.4	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

IEC	
Document Number	Title
IEC 60050-161	International Electrotechnical Vocabulary. Chapter 161: Electromagnetic compatibility
IEC 60060-1	High-voltage test techniques. Part 1: General definitions and test requirements
IEC 60060-2	High-voltage test techniques - Part 2: Measuring systems
IEC 60060-3	High-voltage test techniques - Part 3: Definitions and requirements for on-site testing
IEC 60118-13	Electroacoustics - Hearing aids - Part 13: Electromagnetic compatibility (EMC)
IEC 60255-26	Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements
IEC 60364-4-44	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbance
IEC 60469	Transitions, pulses and related waveforms - Terms, definitions and algorithms
IEC 60533	Electrical and electronic installations in ships - Electromagnetic compatibility (EMC) - Ships with a metallic hull
IEC 60601-1-2	Medical electrical equipment - Part 1-2: General requirements for basic safety and essential performance - Collateral Standard: Electromagnetic disturbances - Requirements and tests
IEC 60601-2-2	Medical electrical equipment - Part 2-2: Particular requirements for the basic safety and essential performance of high frequency surgical equipment and high frequency surgical accessories
IEC 60601-4-2	Medical electrical equipment - Part 4-2: Guidance and interpretation - Electromagnetic immunity: performance of medical electrical equipment and medical electrical systems
IEC 60728-2	Cabled distribution systems for television and sound signals - Part 2: Electromagnetic compatibility for equipment
IEC 60728-12	Cabled distribution systems for television and sound signals - Part 12: Electromagnetic compatibility of systems

IEC (continued)	
Document Number	Title
IEC/TS 60816	Guide on methods of measurement of short duration transients on low-voltage power and signal lines
IEC 60870-2-1	Telecontrol equipment and systems - Part 2: Operating conditions - Section 1: Power supply and electromagnetic compatibility
IEC 60940	Guidance information on the application of capacitors, resistors, inductors and complete filter units for electromagnetic interference suppression
IEC 60974-10	Arc welding equipment - Part 10: Electromagnetic compatibility (EMC) requirements
IEC/TR 61000-1-1	Electromagnetic compatibility (EMC) - Part 1: General - Section 1: Application and interpretation of fundamental definitions and terms
IEC/TS 61000-1-2	Electromagnetic compatibility (EMC) - Part 1-2: General - Methodology for the achievement of the functional safety of electrical and electronic equipment with regard to electromagnetic phenomena
IEC/TR 61000-1-3	Electromagnetic compatibility (EMC) - Part 1-3: General - The effects of high-altitude EMP (HEMP) on civil equipment and systems
IEC/TR 61000-1-4	Electromagnetic compatibility (EMC) - Part 1-4: General - Historical rationale for the limitation of power-frequency conducted harmonic current emissions from equipment, in the frequency range up to 2 kHz
IEC/TR 61000-1-5	Electromagnetic compatibility (EMC) - Part 1-5: General - High power electromagnetic (HPEM) effects on civil systems
IEC/TR 61000-1-6	Electromagnetic compatibility (EMC) - Part 1-6: General - Guide to the assessment of measurement uncertainty
IEC/TR 61000-1-7	Electromagnetic compatibility (EMC) - Part 1-7: General - Power factor in single-phase systems under non-sinusoidal conditions
IEC/TR 61000-2-1	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signaling in public power supply systems
IEC 61000-2-2	Electromagnetic compatibility (EMC) - Part 2-2: Environment - Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems
IEC/TR 61000-2-3	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 3: Description of the environment - Radiated and non-network-frequency-related conducted phenomena

IEC (continued)	
Document Number	Title
IEC 61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances
IEC/TS 61000-2-5	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 5: Classification of electromagnetic environments. Basic EMC publication
IEC/TR 61000-2-6	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 6: Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances
IEC/TR 61000-2-7	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 7: Low frequency magnetic fields in various environments
IEC/TR 61000-2-8	Electromagnetic compatibility (EMC) - Part 2-8: Environment - Voltage dips and short interruptions on public electric power supply systems with statistical measurement results
IEC 61000-2-9	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 9: Description of HEMP environment - Radiated disturbance. Basic EMC publication
IEC 61000-2-10	Electromagnetic compatibility (EMC) - Part 2-10: Environment - Description of HEMP environment - Conducted disturbance
IEC 61000-2-11	Electromagnetic compatibility (EMC) - Part 2-11: Environment - Classification of HEMP environments
IEC 61000-2-12	Electromagnetic compatibility (EMC) - Part 2-12: Environment - Compatibility levels for low-frequency conducted disturbances and signaling in public medium-voltage power supply systems
IEC 61000-2-13	Electromagnetic compatibility (EMC) - Part 2-13: Environment - High-power electromagnetic (HPEM) environments - Radiated and conducted
IEC/TR 61000-2-14	Electromagnetic compatibility (EMC) - Part 2-14: Environment - Overvoltages on public electricity distribution networks
IEC 61000-3-2	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
IEC 61000-3-3	Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
IEC/TS 61000-3-4	Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A
IEC/TS 61000-3-5	Electromagnetic compatibility (EMC) - Part 3: Limits - Section 5: Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A
IEC/TR 61000-3-6	Electromagnetic compatibility (EMC) - Part 3: Limits - Section 6: Assessment of emission limits for distorting loads in MV and HV power systems - Basic EMC publication
IEC/TR 61000-3-7	Electromagnetic compatibility (EMC) - Part 3: Limits - Section 7: Assessment of emission limits for fluctuating loads in MV and HV power systems - Basic EMC publication
IEC 61000-3-8	Electromagnetic compatibility (EMC) - Part 3: Limits - Section 8: Signaling on low-voltage electrical installations - Emission levels, frequency bands and electromagnetic disturbance levels
IEC 61000-3-11	Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection

IEC (continued)	
Document Number	Title
IEC 61000-3-12	Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and <=75 A per phase
IEC/TR 61000-3-13	Electromagnetic compatibility (EMC) - Part 3-13: Limits - Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems
IEC/TR 61000-3-14	Electromagnetic compatibility (EMC) - Part 3-14: Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems
IEC/TR 61000-3-15	Electromagnetic compatibility (EMC) - Part 3-15: Limits - Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network
IEC TR 61000-4-1	Electromagnetic compatibility (EMC) - Part 4-1: Testing and measurement techniques - Overview of IEC 61000-4 series
IEC 61000-4-2	Electromagnetic compatibility (EMC)- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic compatibility (EMC) - Part 4-3 : Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
IEC 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4 : Testing and measurement techniques – Electrical fast transient/burst immunity test
IEC 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test
IEC 61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
IEC 61000-4-7	Electromagnetic compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto
IEC 61000-4-8	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test
IEC 61000-4-9	Electromagnetic compatibility (EMC) - Part 4-9: Testing and measurement techniques - Impulse magnetic field immunity test
IEC 61000-4-10	Electromagnetic compatibility (EMC) - Part 4-10: Testing and measurement techniques - Damped oscillatory magnetic field immunity test
IEC 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests
IEC 61000-4-12	Electromagnetic compatibility (EMC) - Part 4-12: Testing and measurement techniques - Ring wave immunity test
IEC 61000-4-13	Electromagnetic compatibility (EMC) - Part 4-13: Testing and measurement techniques - Harmonics and interharmonics including mains signaling at a.c. power port, low frequency immunity tests
IEC 61000-4-14	Electromagnetic compatibility (EMC) - Part 4-14: Testing and measurement techniques - Voltage fluctuation immunity test
IEC 61000-4-15	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 15: Flickermeter - Functional and design specifications
IEC 61000-4-16	Electromagnetic compatibility (EMC) - Part 4-16: Testing and measurement techniques - Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz

IEC (continued)	
Document Number	Title
IEC 61000-4-17	Electromagnetic compatibility (EMC) - Part 4-17: Testing and measurement techniques - Ripple on d.c. input power port immunity test
IEC 61000-4-18	Electromagnetic compatibility (EMC) - Part 4-18: Testing and measurement techniques - Damped oscillatory wave immunity test
IEC 61000-4-19	Electromagnetic compatibility (EMC) - Part 4-19: Testing and measurement techniques - Test for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports
IEC 61000-4-20	Electromagnetic compatibility (EMC) - Part 4-20: Testing and measurement techniques - Emission and immunity testing in transverse electromagnetic (TEM) waveguides
IEC 61000-4-21	Electromagnetic compatibility (EMC) - Part 4-21: Testing and measurement techniques - Reverberation chamber test methods
IEC 61000-4-22	Electromagnetic compatibility (EMC) - Part 4-22: Testing and measurement techniques - Radiated emissions and immunity measurements in fully anechoic rooms (FARs)
IEC 61000-4-23	Electromagnetic compatibility (EMC) - Part 4-23: Testing and measurement techniques - Test methods for protective devices for HEMP and other radiated disturbances
IEC 61000-4-24	Electromagnetic compatibility (EMC) - Part 4-24: Testing and measurement techniques - Test methods for protective devices for HEMP conducted disturbance
IEC 61000-4-25	Electromagnetic compatibility (EMC) - Part 4-25: Testing and measurement techniques - HEMP immunity test methods for equipment and systems
IEC 61000-4-27	Electromagnetic compatibility (EMC) - Part 4-27: Testing and measurement techniques - Unbalance, immunity test
IEC 61000-4-28	Electromagnetic compatibility (EMC) - Part 4-28: Testing and measurement techniques - Variation of power frequency, immunity test
IEC 61000-4-29	Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests
IEC 61000-4-30	Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods
IEC 61000-4-31	Electromagnetic compatibility (EMC) - Part 4-31: Testing and measurement techniques - AC mains ports broadband conducted disturbance immunity test
IEC/TR 61000-4-32	Electromagnetic compatibility (EMC) - Part 4-32: Testing and measurement techniques - High-altitude electromagnetic pulse (HEMP) simulator compendium
IEC 61000-4-33	Electromagnetic compatibility (EMC) - Part 4-33: Testing and measurement techniques - Measurement methods for high-power transient parameters
IEC 61000-4-34	Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase
IEC TR 61000-4-35	Electromagnetic compatibility (EMC) - Part 4-35: Testing and measurement techniques - HPEM simulator compendium
IEC 61000-4-36	Electromagnetic compatibility (EMC) - Part 4-36: Testing and measurement techniques - IEMI immunity test methods for equipment and systems
IEC TR 61000-4-37	Electromagnetic compatibility (EMC) - Calibration and verification protocol for harmonic emission compliance test systems
IEC TR 61000-4-38	Electromagnetic compatibility (EMC) - Part 4-38: Testing and measurement techniques - Test, verification and calibration protocol for voltage fluctuation and flicker compliance test systems

IEC (continued)	
Document Number	Title
IEC/TR 61000-5-1	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 1: General considerations - Basic EMC publication
IEC/TR 61000-5-2	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 2: Earthing and cabling
IEC/TR 61000-5-3	Electromagnetic compatibility (EMC) - Part 5-3: Installation and mitigation guidelines - HEMP protection concepts
IEC/TS 61000-5-4	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 4: Immunity to HEMP - Specifications for protective devices against HEMP radiated disturbance. Basic EMC Publication
IEC 61000-5-5	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 5: Specification of protective devices for HEMP conducted disturbance. Basic EMC Publication
IEC/TR 61000-5-6	Electromagnetic compatibility (EMC) - Part 5-6: Installation and mitigation guidelines - Mitigation of external EM influences
IEC 61000-5-7	Electromagnetic compatibility (EMC) - Part 5-7: Installation and mitigation guidelines - Degrees of protection provided by enclosures against electromagnetic disturbances (EM code)
IEC 61000-5-8	Electromagnetic compatibility (EMC) - Part 5-8: Installation and mitigation guidelines - HEMP protection methods for the distributed infrastructure
IEC 61000-5-9	Electromagnetic compatibility (EMC) - Part 5-9: Installation and mitigation guidelines - System-level susceptibility assessments for HEMP and HPEM
IEC 61000-6-1	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity standard for residential, commercial and light-industrial environments
IEC 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-3	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments
IEC 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 61000-6-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for power station and substation environments
IEC 61000-6-6	Electromagnetic compatibility (EMC) - Part 6-6: Generic standards - HEMP immunity for indoor equipment
IEC 61000-6-7	Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations
IEC 61326-1	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements
IEC 61326-2-1	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-1: Particular requirements - Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications
IEC 61326-2-2	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-2: Particular requirements - Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems

IEC (continued)	
Document Number	Title
IEC 61326-2-3	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-3: Particular requirements - Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning
IEC 61326-2-4	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-4: Particular requirements - Test configurations, operational conditions and performance criteria for insulation monitoring devices according to IEC 61557-8 and for equipment for insulation fault location according to IEC 61557-9
IEC 61326-2-5	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-5: Particular requirements - Test configurations, operational conditions and performance criteria for field devices with field bus interfaces according to IEC 61784-1
IEC 61326-2-6	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-6: Particular requirements - In vitro diagnostic (IVD) medical equipment
IEC 61326-3-1	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications
IEC 61326-3-2	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - Industrial applications with specified electromagnetic environment
IEC 61340-3-1	Electrostatics - Part 3-1: Methods for simulation of electrostatic effects - Human body model (HBM) electrostatic discharge test waveforms
IEC 61543	Residual current-operated protective devices (RCDs) for household and similar use - Electromagnetic compatibility
IEC 61800-3	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
IEC 61967-1	Integrated circuits - Measurement of electromagnetic emissions, 150 kHz to 1 GHz - Part 1: General conditions and definitions
IEC 62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility EMC) requirements
IEC 62041	Power transformers, power supply units, reactors and similar products - EMC requirements
IEC 62153-4-0	Metallic communication cable test methods - Part 4-0: Electromagnetic compatibility (EMC) - Relationship between surface transfer impedance and screening attenuation, recommended limits
IEC 62153-4-1	Metallic communication cable test methods - Part 4-1: Electromagnetic compatibility (EMC) - Introduction to electromagnetic screening measurements
IEC 62153-4-2	Metallic communication cable test methods - Part 4-2: Electromagnetic compatibility (EMC) - Screening and coupling attenuation - Injection clamp method
IEC 62153-4-3	Metallic communication cable test methods - Part 4-3: Electromagnetic compatibility (EMC) - Surface transfer impedance - Triaxial method
IEC 62153-4-4	Metallic communication cable test methods - Part 4-4: Electromagnetic compatibility (EMC) - Test method for measuring of the screening attenuation as up to and above 3 GHz, triaxial method
IEC 62153-4-5	Metallic communication cables test methods - Part 4-5: Electromagnetic compatibility (EMC) - Coupling or screening attenuation - Absorbing clamp method

IEC (continued)	
Document Number	Title
IEC 62153-4-6	Metallic communication cable test methods - Part 4-6: Electromagnetic compatibility (EMC) - Surface transfer impedance - Line injection method
IEC 62153-4-7	Metallic communication cable test methods - Part 4-7: Electromagnetic compatibility (EMC) - Test method for measuring of transfer impedance ZT and screening attenuation aS or coupling attenuation aC of connectors and assemblies up to and above 3 GHz - Triaxial tube in tube method
IEC 62153-4-8	Metallic communication cable test methods - Part 4-8: Electromagnetic compatibility (EMC) - Capacitive coupling admittance
IEC 62153-4-9	Metallic communication cable test methods - Part 4-9: Electromagnetic compatibility (EMC) - Coupling attenuation of screened balanced cables, triaxial method
IEC 62153-4-10	Metallic communication cable test methods - Part 4-10: Electromagnetic compatibility (EMC) - Transfer impedance and screening attenuation of feed-throughs and electromagnetic gaskets - Double coaxial test method
IEC 62153-4-11	Metallic communication cable test methods - Part 4-11: Electromagnetic compatibility (EMC) - Coupling attenuation or screening attenuation of patch cords, coaxial cable assemblies, pre-connectorized cables - Absorbing clamp method
IEC 62153-4-12	Metallic communication cable test methods - Part 4-12: Electromagnetic compatibility (EMC) - Coupling attenuation or screening attenuation of connecting hardware - Absorbing clamp method
IEC 62153-4-13	Metallic communication cable test methods - Part 4-13: Electromagnetic compatibility (EMC) - Coupling attenuation of links and channels (laboratory conditions) - Absorbing clamp method
IEC 62153-4-14	Metallic communication cable test methods - Part 4-14: Electromagnetic compatibility (EMC) - Coupling attenuation of cable assemblies (Field conditions) absorbing clamp method
IEC 62153-4-15	Metallic communication cable test methods - Part 4-15: Electromagnetic compatibility (EMC) - Test method for measuring transfer impedance and screening attenuation - or coupling attenuation with triaxial cell
IEC 62236-1	Railway applications - Electromagnetic compatibility - Part 1: General
IEC 62236-2	Railway applications - Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world
IEC 62236-3-1	Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle
IEC 62236-3-2	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus
IEC 62236-4	Railway applications - Electromagnetic compatibility - Part 4: Emission and immunity of the signalling and telecommunications apparatus
IEC 62236-5	Railway applications - Electromagnetic compatibility - Part 5: Emission and immunity of fixed power supply installations and apparatus
IEC 62305-1	Protection against lightning - Part 1: General principles
IEC 62305-2	Protection against lightning - Part 2: Risk management
IEC 62305-3	Protection against lightning - Part 3: Physical damage to structures and life hazard

IEC (continued)	
Document Number	Title
IEC 62305-4	Protection against lightning - Part 4: Electrical and electronic systems within structures
IEC 62310-2	Static transfer systems (STS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC/TR 62482	Electrical installations in ships - Electromagnetic compatibility - Optimising of cable installations on ships - Testing method of routing distance

CISPR	
Document Number	Title
CISPR 11	Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement
CISPR 12	Vehicles, boats and internal combustion engines - Radio disturbance characteristics - Limits and methods of measurement for the protection of off-board receivers
CISPR 13	Sound and television broadcast receivers and associated equipment - Radio disturbance characteristics - Limits and methods of measurement
CISPR 14-1	Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission
CISPR 14-2	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 2: Immunity – Product family standard
CISPR 15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
CISPR 16-1-1	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus
CISPR 16-1-2	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-2: Radio disturbance and immunity measuring apparatus - Coupling devices for conducted disturbance measurements
CISPR 16-1-3	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-3: Radio disturbance and immunity measuring apparatus - Ancillary equipment - Disturbance power
CISPR 16-1-4	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus - Antennas and test sites for radiated disturbance measurements
CISPR 16-1-5	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-5: Radio disturbance and immunity measuring apparatus - Antenna calibration sites and reference test sites for 5 MHz to 18 GHz
CISPR 16-1-6	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-6: Radio disturbance and immunity measuring apparatus - EMC antenna calibration
CISPR 16-2-1	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements
CISPR 16-2-2	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-2: Methods of measurement of disturbances and immunity - Measurement of disturbance power
CISPR 16-2-3	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements

CISPR (continued)	
Document Number	Title
CISPR 16-2-4	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-4: Methods of measurement of disturbances and immunity - Immunity measurements
CISPR TR 16-2-5	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-5: In situ measurements for disturbing emissions produced by physically large equipment
CISPR TR 16-3	Specification for radio disturbance and immunity measuring apparatus and methods - Part 3: CISPR technical reports
CISPR TR 16-4-1	Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-1: Uncertainties, statistics and limit modelling - Uncertainties in standardized EMC tests
CISPR 16-4-2	Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty
CISPR TR 16-4-3	Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-3: Uncertainties, statistics and limit modelling - Statistical considerations in the determination of EMC compliance of mass-produced products
CISPR TR 16-4-4	Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-4: Uncertainties, statistics and limit modelling - Statistics of complaints and a model for the calculation of limits for the protection of radio services
CISPR TR 16-4-5	Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-5: Uncertainties, statistics and limit modelling - Conditions for the use of alternative test methods
CISPR 17	Methods of measurement of the suppression characteristics of passive EMC filtering devices
CISPR TR 18-1	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 1: Description of phenomena
CISPR TR 18-2	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 2: Methods of measurement and procedure for determining limits
CISPR TR 18-3	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 3: Code of practice for minimizing the generation of radio noise
CISPR 20	Sound and television broadcast receivers and associated equipment - Immunity characteristics - Limits and methods of measurement
CISPR 24	Information technology equipment - Immunity characteristics - Limits and methods of measurement *Will be withdrawn July 2020
CISPR 25	Vehicles, boats and internal combustion engines - Radio disturbance characteristics - Limits and methods of measurement for the protection of on-board receivers
CISPR 32	Electromagnetic compatibility of multimedia equipment – Emission requirements
CISPR 35	Electromagnetic compatibility of multimedia equipment - Immunity requirements

ISO	
Document Number	Title
ISO 13766:2006	Earth-moving machinery -- Electromagnetic compatibility

EUROPEAN & INTERNATIONAL STANDARDS UPDATES

List of Common EMC Standards

You shouldn't be surprised that Wikipedia has a comprehensive list of EMC standards. The list includes CISPR, IEC, ISO, European EN, FCC, and MIL-STD. There is also a link to the GR-1089-CORE EMC and product safety standards for network telecommunications equipment. A good link to bookmark. For more, Click here.

EU: NEW CENELEC STANDARDS RECENTLY RELEASED

- **EN ISO/IEC 17011:2017** - 12/13/2017 - Conformity assessment - Requirements for accreditation bodies accrediting conformity assessment bodies (ISO/IEC 17011:2017)
- **EN ISO/IEC 17025:2017** - 12/13/2017 - General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2017)
- **CLC/TR 50669:2017** - 12/15/2017 - Investigation Results on Electromagnetic Interference in the Frequency Range below 150 kHz
- **EN 16602-40:2018** - (4/18/18) - Space product assurance - Safety
- **EN 50364:2018** - 1/12/2018 - Product standard for human exposure to electromagnetic fields from devices operating in the frequency range 0 Hz to 300 GHz, used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications
- **EN 50443:2011** - (3/14/18) - Effects of electromagnetic interference on pipelines caused by high voltage a.c. electric traction systems and/or high voltage a.c. power supply systems
- **EN 50496:2018** - (3/16/18) - Determination of workers' exposure to electromagnetic fields and assessment of risk at a broadcast site
- **EN 50527-2-2:2018** - 5/11/2018 - Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices - Part 2-2: Specific assessment for workers with cardioverter defibrillators (ICDs)
- **EN 50636-2-107:2015/A1:2018** - 1/12/2018 - Safety of household and similar appliances - Part 2-107: Particular requirements for robotic battery powered electrical lawnmowers
- **CLC/TR 50442:2018** - 1/19/2018 - Guidelines for product committees on the preparation of standards related to human exposure from electromagnetic fields
- **EN IEC 60079-7:2015/A1:2018** - 1/19/2018 - Explosive atmospheres - Part 7: Equipment protection by increased safety "e"
- **EN IEC 60519-12:2018** - (March 2018) - Safety in installations for electroheating and electromagnetic processing - Part 12: Particular requirements for infrared electroheating
- **EN 60598-1:2015/A1:2018** - (February 2018) - Luminaires - Part 1: General requirements and tests
- **EN IEC 61010-2-120:2018** - (4/13/18) - Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 2-120: Particular safety requirements for machinery aspects of equipment
- **EN 61000-6-5:2015/AC:2018-01** - 1/19/2018 - Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment
- **EN IEC 61204-7:2018** - (3/16/18) - Low-voltage switch mode power supplies - Part 7: Safety requirements
- **EN 61400-22:2011** - 5/16/2018 - Wind turbines - Part 22: Conformity testing and certification
- **EN IEC 61730-1:2018** - (4/27/18) - Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
- **EN IEC 61730-2:2018** - (4/27/18) - Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
- **EN IEC 60601-2-2:2018** - 5/18/2018 - Medical electrical equipment - Part 2-2: Particular requirements for the basic safety and essential performance of high frequency surgical equipment and high frequency surgical accessories

- **EN 60601-2-43:2010/A1:2018** - 5/18/2018 - Medical electrical equipment - Part 2-43: Particular requirements for the basic safety and essential performance of X-ray equipment for interventional procedures

- **EN 62053-11:2003/A1:2017/AC:2018-05** - 5/4/2018 - Electricity metering equipment (a.c.) - Particular requirements - Part 11: Electromechanical meters for active energy (classes 0,5, 1 and 2)

- **EN 62053-21:2003/A1:2017/AC:2018-05** - 5/4/2018 - Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2)

- **EN 62053-22:2003/A1:2017/AC:2018-05** - 5/4/2018 - Electricity metering equipment (a.c.) - Particular requirements - Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)

- **EN 62053-23:2003/A1:2017/AC:2018-05** - 5/4/2018 - Electricity metering equipment (a.c.) - Particular requirements - Part 23: Static meters for reactive energy (classes 2 and 3)

- **EN 62053-24:2015/A1:2017/AC:2018-05** - 5/4/2018 - Electricity metering equipment (a.c.) - Particular requirements - Part 24: Static meters for reactive energy at fundamental frequency (classes 0,5 S, 1 S and 1)

- **EN IEC 62228-1:2018** - 6/1/2018 - Integrated circuits - EMC evaluation of transceivers - Part 1: General conditions and definitions

- **EN IEC 62485-1:2018** - 5/4/2018 - Safety requirements for secondary batteries and battery installations - Part 1: General safety information

- **EN IEC 62485-2:2018** - 5/4/2018 - Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries

- **EN IEC 62485-4:2018** - 5/4/2018 - Safety requirements for secondary batteries and battery installations - Part 4: Valve-regulated lead-acid batteries for use in portable appliances

- **EN 62489-1:2010/A2:2018** - (February 2018) - Electroacoustics - Audio-frequency induction loop systems for assisted hearing - Part 1: Methods of measuring and specifying the performance of system components

- **EN IEC 60749-26:2018** - (3/23/18) - Semiconductor devices - Mechanical and climatic test methods - Part 26: Electrostatic discharge (ESD) sensitivity testing - Human body model (HBM)

- **EN IEC 62822-3:2018** - (February 2018) - Electric welding equipment - Assessment of restrictions related to human exposure to electromagnetic fields (0 Hz to 300 Hz) - Part 3: Resistance welding equipment

- **EN IEC 62828-1:2018** - (February 2018) - Reference conditions and procedures for testing industrial and process measurement transmitters - Part 1: General procedures for all types of transmitters

- **EN 62927:2017/AC:2018-01** - 1/19/2018 - Voltage sourced converter (VSC) valves for static synchronous compensator (STATCOM) - Electrical Testing

- **EN IEC 63044-3:2018 - 1/19/2018** - Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 3: Electrical safety requirements

- **EN 55016-1-2:2014/A1:2018** - 2/2/2018 - Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-2: Radio disturbance and immunity measuring apparatus - Coupling devices for conducted disturbance measurements

See CENELEC for additional information.

EU: NEW ETSI STANDARDS RECENTLY RELEASED

- **ETSI EN 300 718-1 V2.1.1** - (January 2018) - Avalanche Beacons operating at 457 kHz; Transmitter-receiver systems; Part 1: Harmonised Standard for access to radio spectrum

- **ETSI EN 300 718-2 V2.1.1** - (January 2018) - Avalanche Beacons operating at 457 kHz; Transmitter-receiver systems; Part 2: Harmonised Standard for features for emergency services

- **ETSI EN 302 245 V2.1.1**- (June 2018) - Transmitting equipment for the Digital Radio Mondiale (DRM) sound broadcasting service; Harmonised Standard for access to radio spectrum

- **ETSI EN 302 969 V1.3.1** - (May 2018) - Reconfigurable Radio Systems (RRS); Radio Reconfiguration related requirements for Mobile Devices

- **ETSI EN 303 095 V1.3.1** - (May 2018) - Reconfigurable Radio Systems (RRS); Radio reconfiguration related architecture for Mobile Devices (MD)

- **ETSI EN 303 316 V1.2.1** - April 2018 - Broadband Direct Air-to-Ground Communications; Equipment operating in the 1 900 MHz to 1 920 MHz and 5 855 MHz to 5 875 MHz frequency bands; Beamforming antennas; Harmonised Standard for access to radio spectrum

- **ETSI EN 303 454 V1.1.1** - (January 2018) - Short Range Devices (SRD); Metal and object detection sensors in the frequency range 1 kHz to 148,5 kHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU

- **ETSI EN 301 598 V2.1.1** - (January 2018) - White Space Devices (WSD); Wireless Access Systems operating in the 470 MHz to 790 MHz TV broadcast band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU

- **ETSI EN 303 980 V1.1.1** - (December 2017) - Satellite Earth Stations and Systems (SES); Harmonised Standard for fixed and in-motion Earth Stations communicating with non-geostationary satellite systems (NEST) in the 11 GHz to 14 GHz frequency bands covering essential requirements of article 3.2 of Directive 2014/53/EU

- **ETSI TS 102 361-4 V1.9.2** - April 2018 - Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 4: DMR trunking protocol

- **ETSI TS 137 145-2 V14.3.0** - (January 2018) - Universal Mobile Telecommunications System (UMTS); LTE; Active Antenna System (AAS) Base Station (BS) conformance testing; Part 2: radiated conformance testing (3GPP TS 37.145-2 version 14.3.0 Release 14)

- **ETSI TS 137 145-2 V13.5.0** - (January 2018) - Universal Mobile Telecommunications System (UMTS); LTE; Active Antenna System (AAS) Base Station (BS) conformance testing; Part 2: radiated conformance testing (3GPP TS 37.145-2 version 13.5.0 Release 13)

- **ETSI EN 302 054 V2.2.1** - (February 2018) - Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW; Harmonised Standard for access to radio spectrum

- **ETSI TR 103 541 V1.1.1** - (May 2018) - Environmental Engineering (EE); Best practice to assess energy performance of future Radio Access Network (RAN) deployment

- **ETSI TR 103 265 V1.2.1** - (February 2018) - Electromagnetic compatibility and Radio spectrum Matters (ERM); Definition of radio parameters

See ETSI website for additional information.

EU: NEW IEC STANDARDS RECENTLY RELEASED

- **CISPR 15:2018 PRV, Ed. 9.0** - (2/16/2018) - Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

- **CISPR 16-1-1:2015/ISH1:2018, Ed. 4.0** - (4/10/18) - Interpretation sheet 1 - Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus

- **CISPR 16-4-2/AMD2:2018 PRV, Ed. 2.0** - (4/13/18) - Amendment 2 - Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty

- **IEC TR 61340-1:2012/COR2:2017, Ed. 1.0** - (12/13/2017) - Corrigendum 1 - Electrostatics - Part 1: Electrostatic phenomena - Principles and measurements

- **IEC TR 62905:2018, Ed. 1.0** - (2/6/2018) - Exposure assessment methods for wireless power transfer systems

- **IEC 60068-2:2018, Ed. 1.0** - (2/20/2018) - Environmental testing - Part 2: Tests - ALL PARTS

- **IEC 60079:2018, Ed. 1.0** - (2/20/2018) - Explosive atmospheres - ALL PARTS

- **IEC 60086:2018, Ed. 1.0** - (2/20/2018) - Primary batteries - ALL PARTS

- **IEC 60204:2018, Ed. 1.0** - (2/20/2018) - Safety of machinery - Electrical equipment of machines - ALL PARTS

- **IEC 60939-3:2015/COR2:2018, Ed. 1.0** - 5/7/2018 - Corrigendum 2 - Passive filter units for electromagnetic interference suppression - Part 3: Passive filter units for which safety tests are appropriate

- **IEC 61000-2-2:2002+AMD1:2017+AMD2:2018, Ed. 2.2** - 5/9/2018 - Electromagnetic compatibility (EMC) - Environment - Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems

- **IEC 61000-2-2:2002/AMD2:2018, Ed. 2.0** - 5/9/2018 - Amendment 2 - Electromagnetic compatibility (EMC) - Environment - Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems

- **IEC 61000-6-4:2018, Ed. 3.0** - (2/7/2018) - Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

- **IEC 61000-6-4:2018 RLV, Ed. 3.0** - (2/7/2018) - Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

- **IEC 60335-2-76:2018 PRV, Ed. 3.0** - (4/13/18) - Household and similar electrical appliances - Safety - Part 2-76: Particular requirements for electric fence energizers

- **IEC 61340-4-3:2017, Ed. 2.0** - (12/19/2017) - Electrostatics - Part 4-3: Standard test methods for specific applications - Footwear

- **IEC 60601-1:2018, Ed. 1.0** - (2/20/2018) - Medical electrical equipment - ALL PARTS

- **IEC 60825:2018, Ed. 1.0** - (1/8/2018) - Safety of laser products - ALL PARTS

- **IEC PAS 61076-3-126:2018, Ed. 1.0** - (1/9/2018) - Connectors for electrical and electronic equipment - Product requirements - Part 3-126: Rectangular connectors - Detail specification for 5 pole power connector for industrial environments with push-pull locking

- **IEC PAS 63151:2018, Ed. 1.0** - (1/9/2018) - Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Vector measurement-based systems (Frequency range of 30 MHz to 6 GHz)

- **IEC 61097-7:1996+AMD1:2018, Ed. 1.1** - (1/10/2018) - Global maritime distress and safety system (GMDSS) - Part 7: Shipborne VHF radiotelephone transmitter and receiver - Operational and performance requirements, methods of testing and required test results

- **IEC 61097-7:1996/AMD1:2018, Ed. 1.0** - (1/10/2018) - Amendment 1 - Global maritime distress and safety system (GMDSS) - Part 7: Shipborne VHF radiotelephone transmitter and receiver - Operational and performance requirements, methods of testing and required test results

- **IEC 62153-4-7:2015/AMD1:2018, Ed. 2.0** - 5/9/2018 - Amendment 1 - Metallic communication cable test methods - Part 4-7: Electromagnetic compatibility (EMC) - Test method for measuring of transfer impedance ZT and screening attenuation aS or coupling attenuation aC of connectors and assemblies up to and above 3 GHz - Triaxial tube in tube method

- **IEC 62153-4-7:2015+AMD1:2018, Ed. 2.1** - 5/9/2018 - Metallic communication cable test methods - Part 4-7: Electromagnetic compatibility (EMC) - Test method for measuring of transfer impedance ZT and screening attenuation aS or coupling attenuation aC of connectors and assemblies up to and above 3 GHz - Triaxial tube in tube method

- **IEC 62153-4-17:2018, Ed. 1.0** - 5/11/2018 - Metallic cables and other passive components - Test methods - Part 4-17: Electromagnetic compatibility (EMC) - Reduction factor

- **IEC 62228-1:2018, Ed. 1.0** - (1/15/2018) - Integrated circuits - EMC evaluation of transceivers - Part 1: General conditions and definitions

- **IEC 60335-2-5:2012/AMD1:2018, Ed. 6.0** - (2/9/2018) - Amendment 1 - Household and similar electrical appliances - Safety - Part 2-5: Particular requirements for dishwashers

- **IEC 60364-4-44:2007+AMD1:2015+AMD2:2018, Ed. 2.2** - (1/16/2018) - Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances

- **IEC 60364-4-44:2007/AMD2:2018, Ed. 2.0** - (1/16/2018) - Amendment 2 - Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances

- **IEC 61162-460:2018, Ed. 2.0** - (1/19/2018) - Maritime navigation and radiocommunication equipment and systems - Digital interfaces - Part 460: Multiple talkers and multiple listeners - Ethernet interconnection - Safety and security

- **IEC 60335-2-114:2018, Ed. 1.0** - (1/26/2018) - Household and similar electrical appliances - Safety - Part 2-114: Particular requirements for self-balancing personal transport devices for use with batteries containing alkaline or other non-acid electrolytes

- **IEC 61000-3-2:2018, Ed. 5.0** - (1/26/2018) - Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)

- **IEC 61000-3-2:2018, Ed. 5.0** - (1/26/2018) - Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)

- **IEC 61000-3:2018, Ed. 1.0** - (1/29/2018) - Electromagnetic compatibility (EMC) - Part 3: Limit - ALL PARTS

- **IEC 61010-031:2015/AMD1:2018, Ed. 2.0** - 5/29/2018 - Amendment 1 - Safety requirements for electrical equipment for measurement, control and laboratory use - Part 031: Safety requirements for hand-held and hand-manipulated probe assemblies for electrical test and measurement.

- **IEC 61010-031:2015+AMD1:2018, Ed. 2.1** - 5/29/2018 - Safety requirements for electrical equipment for measurement, control and laboratory use - Part 031: Safety requirements for hand-held and hand-manipulated probe assemblies for electrical test and measurement.

- **IEC 61340-4-4:2018, Ed. 3.0** - (1/30/2018) - Electrostatics - Part 4-4: Standard test methods for specific applications - Electrostatic classification of flexible intermediate bulk containers (FIBC)

- **IEC 61340-4-4:2018, Ed. 3.0** - (1/30/2018) - Electrostatics - Part 4-4: Standard test methods for specific applications - Electrostatic classification of flexible intermediate bulk containers (FIBC)

- **IEC 61340-6-1:2018, Ed. 1.0** - 6/1/2018 - Electrostatics - Part 6-1: Electrostatic control for healthcare - General requirements for facilities

- **IEC 62153-4-7/AMD1:2018, Ed. 2.0** - (2/2/2018) - Metallic communication cable test methods - Part 4-7: Electromagnetic compatibility (EMC) - Test method for measuring of transfer impedance ZT and screening attenuation aS or coupling attenuation aC of connectors and assemblies up to and above 3 GHz - Triaxial tube in tube method

- **IEC 62153-4-8:2018 PRV, Ed. 2.0** - (4/6/18) - Metallic cables and other passive components - Test methods - Part 4-8: Electromagnetic compatibility (EMC) - Capacitive coupling admittance

- **IEC 62153-4-9:2018 RLV** - 5/29/2018 - Metallic communication cable test methods - Part 4 - 9: Electromagnetic compatibility (EMC) - Coupling attenuation of screened balanced cables, triaxial method

- **IEC 62153-4-9:2018, Ed. 2.0** - 5/29/2018 - Metallic communication cable test methods - Part 4 - 9: Electromagnetic compatibility (EMC) - Coupling attenuation of screened balanced cables, triaxial method
- **IEC 62236-1:2018, Ed. 3.0** - (2/9/2018) - Railway applications - Electromagnetic compatibility - Part 1: General
- **IEC 62236-1:2018 RLV, Ed. 3.0** - (2/9/2018) - Railway applications - Electromagnetic compatibility - Part 1: General
- **IEC 62236-2:2018, Ed. 3.0** - (2/9/2018) - Railway applications - Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world
- **IEC 62236-2:2018 RLV, Ed. 3.0** - (2/9/2018) - Railway applications - Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world
- **IEC 62236-3-1:2018, Ed. 3.0** - (2/15/18) - Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle
- **IEC 62236-4:2018 RLV, Ed. 3.0** - (2/15/2018) - Railway applications - Electromagnetic compatibility - Part 4: Emission and immunity of the signalling and telecommunications apparatus
- **IEC 62368-1:2018, Ed. 3.0** - 5/25/2018 - Audio/video, information and communication technology equipment - Part 1: Safety requirements
- **IEC TS 62915:2018, Ed. 1.0** - 5/7/2018 - Photovoltaic (PV) modules - Type approval, design and safety qualification - Retesting
- **IEC 62988:2018 PRV, Ed. 1.0** - (2/16/2018) - Nuclear power plants - Instrumentation and control systems important to safety - Selection and use of wireless devices
- **IEC 62995:2018 PRV, Ed. 1.0** - (2/9/2018) - Railway applications - Rolling stock - Rules for installation of cabling
- **ISO 80601-2-55:2018, Ed. 2.0** - (2/12/2018) - Medical electrical equipment - Part 2-55: Particular requirements for the basic safety and essential performance of respiratory gas monitors

See IEC for additional information.

CANADA

Canada's Innovation, Science and Economic Development (ISED) published Radio Standards Specification 133, Issue 6, 2 GHz Personal Communications Services, replacing Issue 5 dated February 2009.

Canada's Innovation, Science and Economic Development (ISED released Procedure for the Recognition of Foreign Testing Laboratories, Issue 6 (RECLAB, Issue 6) describing the criteria and procedure for recognition by ISED of foreign testing laboratories to test to Canadian requirements for telecommunications terminal equipment, radio apparatus (NEW) and broadcasting equipment (NEW) standards.

Canada's Innovation, Science and Economic Development (ISED) published Radio Standards Specification 140 (RSS140), Issue 1, Equipment Operating in the Public Safety Broadband Frequency Bands 758768 MHz and 788-798 MHz, setting out the certification requirements for equipment operating in the public safety broadband frequency bands 758768 MHz and 788798 MHz.

Canada's Innovation, Science and Economic Development (ISED) published Radio Standards Specification RSSGen, Issue 5, General Requirements for Compliance of Radio Apparatus, replacing prior version RSSGen, issue 4, dated November 2014.

CHINA

China's Certification and Accreditation Administration (CNCA) published an update for its CCC mark. As of March 20, 2018, CCC mark printing no longer needs to be approved by the CNCA, and the CCC mark application fee has been eliminated. Manufacturers may now print and use the CCC mark per the CNCA regulation.

EU

The European Commission published National language requirements for the Radio Equipment Directive (RED; 2014/53/EU).

UKRAINE

In accordance with Decree #355 of the Council of Ministers of Ukraine, a new Technical Regulation based upon the Radio Equipment Directive (RED) 2014/53/EC of the European Parliament and of the Council, will come into effect for radio-based products in Ukraine. This regulation includes a transition period until April 1, 2019 during which manufacturers may continue to ship products approved under the R&TTE.

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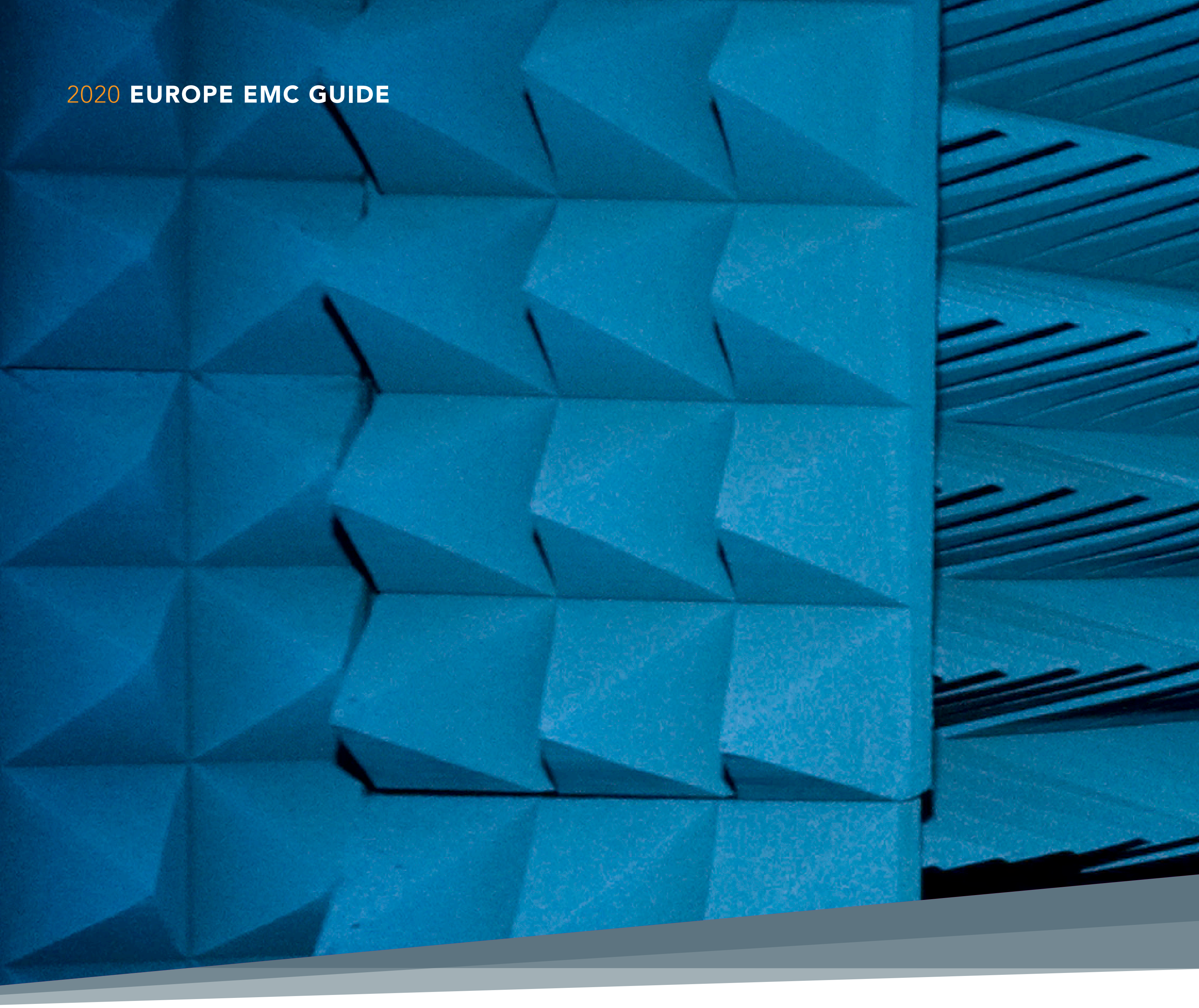

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