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2022 EMC TESTING GUIDE

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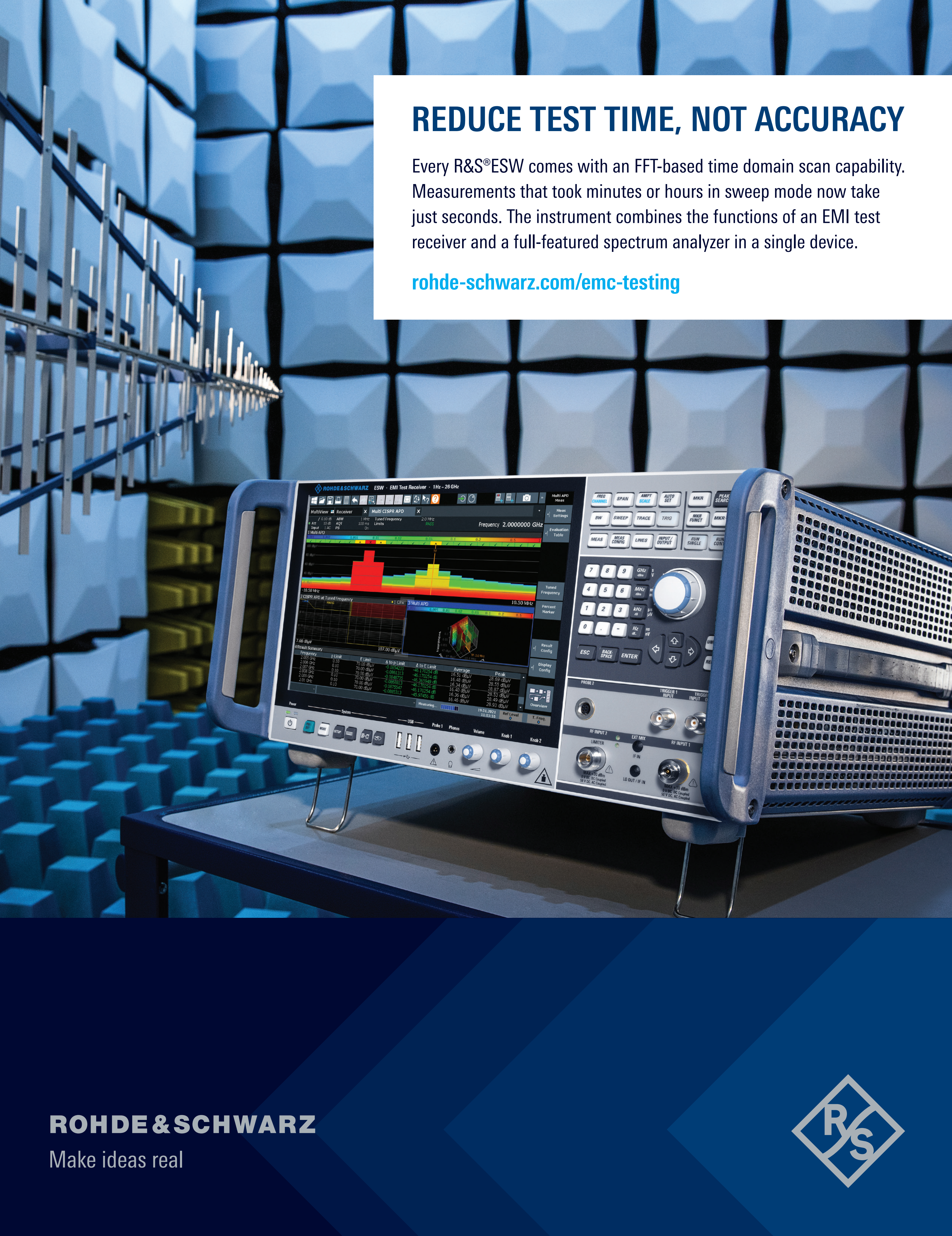
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2022 EMC SUPPLIER GUIDE

This section provides a quick guide to some of the top suppliers in each EMC category - test equipment, components, materials, services, and more. To find a product that meets your needs for applications, frequencies, standards requirements, etc., please search these individual supplier websites for the latest information and availability. If you have trouble finding a particular product or solution, email kenton@lectrixgroup.com for further supplier contacts.

	COMPANY	WEBSITE	AMPLIFIERS	ANTENNAS	CERTIFICATION	CONSULTANTS	DESIGN / SOFTWARE	EMI RECEIVERS	LIGHTNING & SURGE	SHIELDED ROOMS	SPECTRUM ANALYZERS	TEST EQUIPMENT	TEST EQUIPMENT RENTALS	TEST EQUIPMENT OTHER	TESTING	TESTING LABORATORIES	TRAINING SEMINARS & WORKSHOPS
A	Aaronia AG	www.aaronia.com	X	X				X			X						
	Advanced Test Equipment Corp. (ATEC)	www.atecorp.com	X	X	X			X	X	X	X	X	X	X	X		
	AH Systems, Inc.	www.ahsystems.com	X	X								X	X	X			
	Altair- US	www.altair.com				X	X										
	American Certification Body Inc.	https://acbcert.com/			X	X	X								X	X	X
	Ametek- CTS Compliance Test Solutions	www.ametek-cts.com	X	X								X		X			X
	Anritsu Company	www.anritsu.com		X							X	X		X	X		
	APITech	www.apitech.com							X						X	X	
	AR RF/Microwave Instrumentation	www.arworld.us	X	X			X					X	X				
B	Beehive Electronics	www.beehive-electronics.com													X		
	Bulgin	www.bulgin.com			X												
C	Captor Corporation (EMC Div.)	www.captorcorp.com															
	Compliance Direction, LLC	www.compliancedirection.com													X		X
	CPI- Communications & Power Industries (USA)	www.cpii.com/emc	X														
D	Dassault System Simulia Corp	www.3ds.com/					X										
	DLS Electronic Systems, Inc.	www.dlsemc.com				X										X	

	COMPANY	WEBSITE	AMPLIFIERS	ANTENNAS	CERTIFICATION	CONSULTANTS	DESIGN / SOFTWARE	EMI RECEIVERS	LIGHTNING & SURGE	SHIELDED ROOMS	SPECTRUM ANALYZERS	TEST EQUIPMENT	TEST EQUIPMENT RENTALS	TEST EQUIPMENT OTHER	TESTING	TESTING LABORATORIES	TRAINING SEMINARS & WORKSHOPS
E	Electro Rent	www.electrorent.com	X					X			X		X				
	Elite Electronic Engineering Co.	www.elitetest.com														X	
	EMC Live	www.emc.live															X
	EMC Partner	www.emc-partner.com										X					
	Empower RF Systems, Inc.	www.empowerrf.com	X										X				
	EM TEST USA	www.emtest.com										X					
	Exemplar Global (iNarte)	www.exemplarglobal.org															X
	EXODUS Advanced Communications	www.exoduscomm.com	X	X								X					
F	F2 Labs	www.f2labs.com			X	X									X	X	X
	Fischer Custom Communications	www.fischercc.com												X			
	Frankonia Solutions	www.frankonia-solutions.com								X		X				X	
G	Gauss Instruments	www.gauss-instruments.com						X			X						
H	Haefely	www.pfiffner-group.com					X					X			X		
	Heilind Electronics, Inc	www.heilind.com															
	HV TECHNOLOGIES, Inc.	www.hvtechnologies.com	X	X				X	X	X	X	X		X			
I	Instrument Rental Labs	www.testequip.com	X					X			X		X				
	Interference Technology	www.interferencetechnology.com															X
	Intertek	www.intertek.com														X	
K	Keysight Technologies	www.keysight.com/us/en						X			X		X	X			
	Kikusui America, Inc.	www.kikusuiamerica.com/solution	X									X					
	Krieger Specialty Products	www.kriegerproducts.com								X							
	Kyocera AVX	www.kyocera-avx.com		X													
L	Langer EMV-Technik	www.langer-emv.de/en/index												X			
M	MBP Srl	www.mbp.it/en/					X							X			
	Microlease	www.microlease.com	X					X			X		X				
	MILMEGA	www.ametek-cts.com	X														
	Montrose Compliance Services	www.montrosecompliance.com				X											
	MVG Microwave Vision Group	www.mvg-world.com		X	X					X							

	COMPANY	WEBSITE	AMPLIFIERS	ANTENNAS	CERTIFICATION	CONSULTANTS	DESIGN / SOFTWARE	EMI RECEIVERS	LIGHTNING & SURGE	SHIELDED ROOMS	SPECTRUM ANALYZERS	TEST EQUIPMENT	TEST EQUIPMENT RENTALS	TEST EQUIPMENT OTHER	TESTING	TESTING LABORATORIES	TRAINING SEMINARS & WORKSHOPS
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	Noise Laboratory Co., Ltd.	www.noiseken.com														X	
	NTS	www.nts.com													X		
O	Ohmite	www.ohmite.com						X									
	Ophir RF	www.ophirrf.com	X														
P	PPG Cuming Lehman Chambers	www.cuminglehman.com								X					X		
	Prana	www.prana-rd.com	X											X			
	Pulse Power & Measurement	https://ppmtest.com/												X			
Q	Quell Corporation	www.eeseal.com							X						X		
R	Radiometrics	www.radiomet.com														X	
	R&B Laboratory, Inc.	www.rblaboratory.com														X	
	Retlif Testing Laboratories	www.retlif.com													X	X	X
	RECOM Power GmbH	www.recom-power.com													X		
	RIGOL Technologies	www.rigolna.com	X					X			X	X		X			
	R&K Company Limited	www.rk-microwave.com	X					X									
	Rohde & Schwarz GmbH & Co. KG	www.rohde-schwarz.com/de	X	X				X		X	X	X					
	Rohde & Schwarz USA, Inc.	www.rohde-schwarz.com	X	X				X		X	X	X					
S	Schaffner EMC, Inc.	www.schaffner.com													X	X	
	Schurter, Inc.	www.schurter.com				X											
	Schwarzbeck Mess-Elektronik	www.schwarzbeck.com		X													
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	Siglent Technologies	www.siglentna.com										X					
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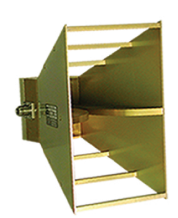

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T	TDK	www.tdk.com								X				X			
	Tektronix	www.tek.com									X	X	X				
	Teledyne LeCroy	www.teledynelecroy.com										X					
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	Test Equity	www.testequity.com/leasing/	X					X			X		X				
	Thurlby Thandar (AIM-TTi)	www.aimtti.com						X			X						
	Toyotech (Toyo)	www.toyotechus.com/emc-electromagnetic-compatibility/	X	X				X			X						
	TPI	www.rf-consultant.com				X											
	Transient Specialists	www.transientspecialists.com											X				
	TRSRenTelCo	www.trsrentelco.com/categories/spectrum-analyzers/emc-test-equipment	X	X				X			X	X	X		X		
V	Vectawave Technology	www.vectawave.com	X														
	V Technical Textiles / Shieldex US	www.vtechtextiles.com								X							
W	Washington Laboratories	www.wll.com			X	X	X		X						X	X	X
	Windfreak Technologies	www.windfreaktech.com										X			X		
	Würth Elektronik eiSos GmbH & Co. Kg	www.we-online.com		X			X		X								X
	Wyatt Technical Services	www.wyatt-tech.net				X											X

HOW TO BUILD YOUR OWN EMI TROUBLESHOOTING AND PRE-COMPLIANCE KIT

Dylan Stinson
Product Marketing Manager, Tektronix

HOW TO BUILD YOUR OWN EMI TROUBLESHOOTING AND PRE-COMPLIANCE KIT

Electromagnetic compatibility (EMC) and the related electromagnetic interference (EMI) are some of the obstacles that must be overcome before nearly any electronics product can be brought to market—whether it's an Industrial Internet of Things (IIoT) device, a consumer electronics product, or military and aerospace equipment. Products must not interfere with one another (radiated or conducted emissions), and they must be designed to be immune to external energy sources. Countries around the world impose EMC standards, which place limits on the level of emissions allowed, requiring full compliance testing of products at certified EMC test houses.

Failing EMI/EMC compliance testing can be among the design engineer's worst nightmare. Costs and time delays add up quickly, whether it's additional compliance and external lab testing costs, debug engineering time or in some cases unexpected board spins. To avoid these scenarios, a growing number of design teams—even those working on limited budgets—are developing their own in-house labs for conducting EMI troubleshooting and pre-compliance testing. As shown in Figure 1, such capabilities enable them to characterize and mitigate problems before heading to the third-party test house for emissions testing.

But is putting together an EMI lab really worth the time and effort involved? To answer that question, we'll first take a look at the costs involved with EMC compliance testing when in-house testing is not available and then look at how the latest real-time spectrum analyzers and RF-capable oscilloscopes coupled with dedicated software are making this job fast and easy, even for non-EMC experts.

TYPICAL COSTS

When calculating EMC/EMI compliance test costs, a number of factors come into play. These can include the type of product, the number of countries, the number of trips to an external test house, design and debug time, the number of boards involved, and certification test cost. *Table 1* provides an example of typical costs associated with FCC and CE compliance. The costs are not inclusive and additional expenses may exist, but this is a good start to illustrate some of the costs involved.

Table 1: An estimate of EMC/EMI compliance testing costs for FCC and CE compliance.

EMC Cost Estimate (EMC + RF Only)	Cost Estimate
Certification cost	
• Unintentional Radiator (FCC + CE)	$5,000 – $10,000
• Intentional Radiator (FCC + CE)	$10,000 – $20,000
External Testing Lab	$1,000 – $10,000 per day
Engineering Resources (debug, design, layout, test)	$80 – $200 wper hour per person
Board Spin if necessary (Cost/Board + Set-up Cost)	$1,000 – $15,000
Total (not including Engineering Resources)	$17,000 – $55,000

As if those numbers aren't daunting enough, let's take a look at a couple of real-world scenarios:

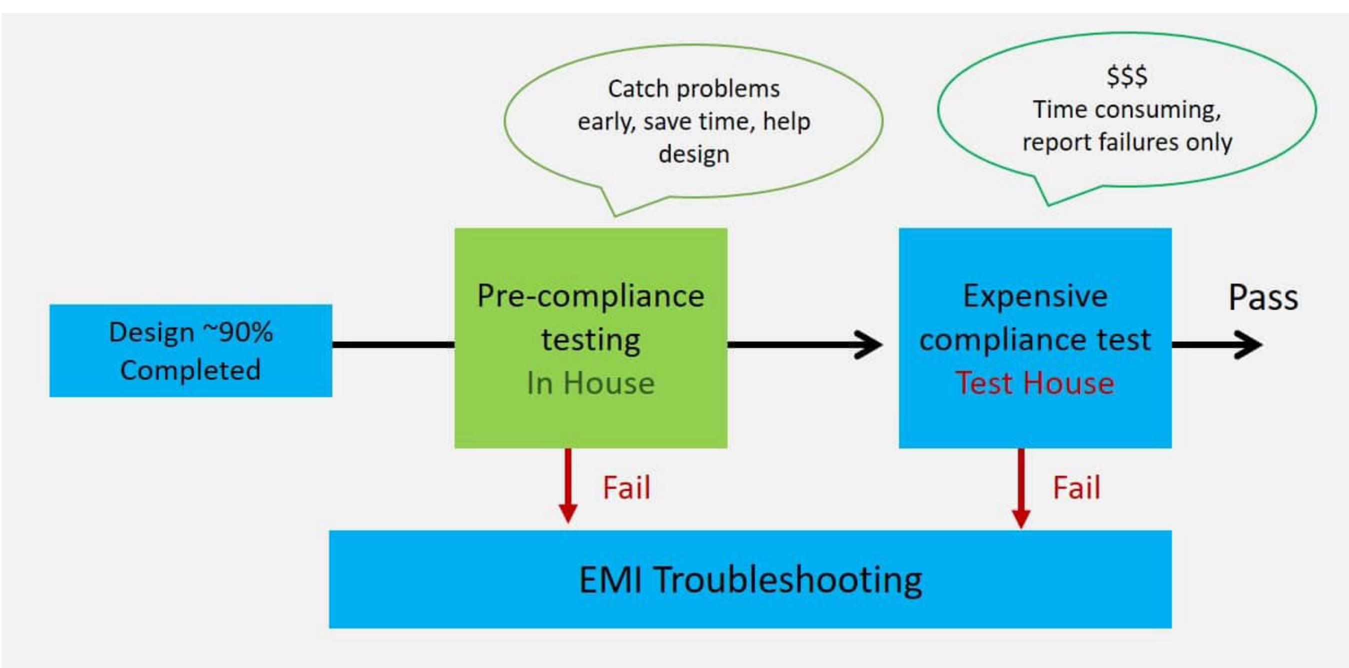

Figure 1: A suggested product workfl ow and testing process to keep a lid on EMC compliance test costs andavoid unexpected delays.

Scenario #1: The design team has been taking products to a test house for years and uses the services of an external anechoic chamber provider to prepare for compliance. For the last two products they developed, they estimated taking 40 trips per year at a cost of $700 per half day, for a total of $28,000. In addition, they estimated the cost for full compliance testing, which involves more than just emission testing, was approximately $30,000.

Scenario #2: This team faced a major challenge as it spent a year trying to figure out where the "noise" in their product was coming from. To test the product, they went to a lab with an anechoic chamber for pre-scans at a cost of $1,250 per hour for a technician, equipment, and chamber. They went to the lab once a quarter with up to 12 boards. On some occasions, they would spend a full day. In reviewing their EMC/EMI pre-compliance expenses, they discovered they had incurred lab expenses of approximately $30,000 for the year, not to mention product delays and lost staff time. This number also doesn't include actual certification costs.

The bad news is that these are far from isolated incidents. As product complexities increase and form factors shrink, designers need to find cost-effective ways to identify issues well in advance during product development cycles—not just before heading to production.

EMI TROUBLESHOOTING VERSUS PRE-COMPLIANCE TESTING

There's a difference between general troubleshooting or debugging EMI issues and pre-compliance testing, which is important to understand when planning your own in-house EMI test kit. General troubleshooting is usually performed with a set of near-field probes or RF current probe, and a spectrum analyzer or an RF-capable oscilloscope. The goal is to identify sources of harmonic energy and determine fixes that reduce the harmonic amplitudes. Here, we're mainly looking for relative changes. While full compliance testing procedures are designed to produce absolute, calibrated measurements, troubleshooting can be performed using relative measurements.

Pre-compliance testing, on the other hand, attempts to duplicate the way the full compliance tests are run to the best ability possible and to compare with actual emission test limits (*Figure 2*). This requires a calibrated EMI antenna, knowledge of the gains or losses in the measurement system, and emission limit tables based on the standards of interest.

For best results, the radiated and conducted emissions test is usually performed inside a semi-anechoic chamber or GTEM cell in order to eliminate outside received signals (ambient signals), such as broadcast radio, television, two-way radio, or cell phones. However, this can add considerable expense and is not always needed with modern test equipment and software tools. As a result, in-house emissions pre-compliance tests can often be set up outside a shielded chamber and techniques can be used to distinguish ambient signals from those emanating from the product under test.

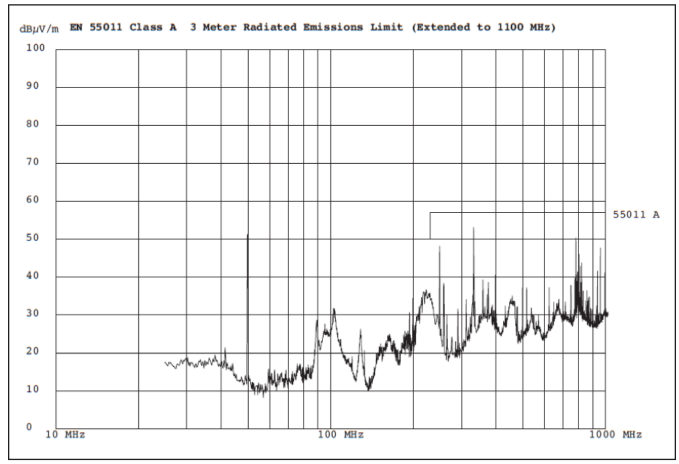

Figure 2. Example of an EMC scan from a compliance lab showing a spur exceeding the limit at about50MHz.

For example, some spectrum analyzers with EMC pre-compliance software support making an ambient measurement of the environment while the product is turned off to give a baseline of what RF noise is present. This can then be subtracted from the actual measurement using a math trace so the user can distinguish between failures coming from the device under test and the surrounding environment.

SETTING UP YOUR LAB

So, what's involved in developing a basic EMI troubleshooting and pre-compliance test lab? It's not nearly as expensive as you might think. As noted above, pre-compliance EMC testing and troubleshooting does not necessarily require a semi-anechoic or EMC chamber, and the equipment is less expensive than full compliance test equipment.

Figure 3 shows the equipment required for radiated emissions pre-compliance testing including a calibrated antenna, preamp, and spectrum analyzer with EMC software. For conducted emissions testing, all you'll likely need are a spectrum analyzer and a line impedance stabilization network (LISN) and optional power filter or preamp. However, by far, the most common EMC failure encountered by designers during a full EMC compliance test is due to radiated emissions.

Here's a run-down on the equipment you'll need to get started performing your own radiated and conducted emissions testing:

Spectrum Analyzer or RF-Capable Oscilloscope

An affordable USB-based real-time spectrum analyzer is the preferred option for this application because unlike a

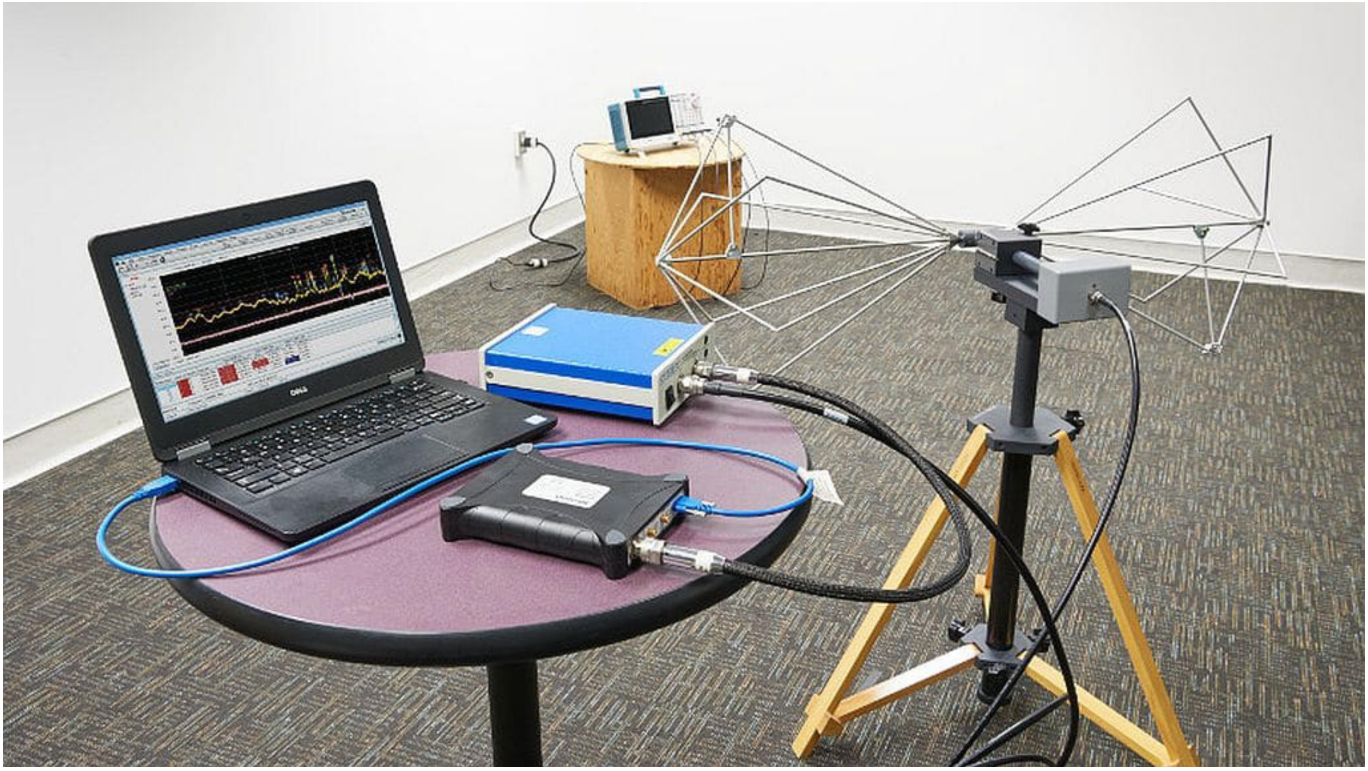

Figure 3: Typical radiated emissions pre-compliance test setup in a large room. The spacing between the EMI antenna and equipment under test is 3 m.

traditional swept-tuned spectrum analyzer, it can capture and display intermittent or infrequent signals with high precision and high probability of intercept. The real-time spectrum/signal analyzer can make measurements, using narrow resolution bandwidths (RBW), orders of magnitude faster than traditional swept-tuned analyzers, saving users time when scanning and searching for low-level RF spurs. To verify the performance of a wireless module or radio, it can also perform signal analysis such as EVM measurements and constellation diagrams to verify the quality and performance of many common wireless signal standards.

But for teams with limited budgets or who prefer to focus their testing on EMI troubleshooting, it may make more sense to consider a multi-purpose RF-capable oscilloscope that has a separate RF input coupled with an internal spectrum analyzer. The latest mixed-signal oscilloscopes also offer multi-domain capabilities beyond traditional oscilloscope FFTs, allowing independent time and frequency domain control over multiple channels. The ability to correlate signals in both domains significantly improves troubleshooting.

While an oscilloscope is very useful for determining rise times and ringing and may have built-in frequency-domain capabilities, a real-time spectrum analyzer is still the desired instrument for EMI troubleshooting and pre-compliance measurements. For pre-compliance scanning, depending on the standard, CISPR detectors for peak, avg, and quasi-peak (QP) may be needed. So, make sure your spectrum analyzer supports CISPR detectors, when necessary and to always refer to your standard(s) of interest to determine exactly what's needed.

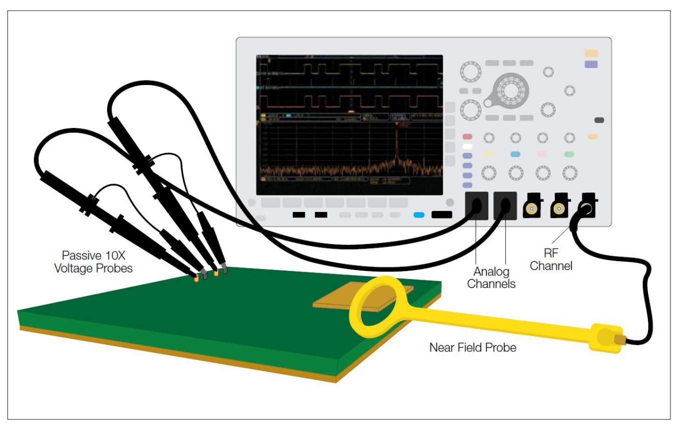

Figure 4. Test setup combines analog oscilloscope channels and a spectrum analyzer channel with near field probe on a mixed domain oscilloscope (MDO).

The frequency range required will depend on the standards and regions you will be testing for. The lowest frequency range is typically determined by the lowest frequency clock included in your design. The maximum frequency measurement range is a factor of the highest frequency generated or used in the device or on which the device operates or tunes. *Table 2* shows how the FCC defines it for unintentional radiators:

Table 2. Instrument frequency range for EMI pre-compliance testing

Highest frequency generated or used in the device, or the device operates or tunes	
Below 1.705 MHz	30 MHz
1.705 -108 MHz	1,000 MHz
108 – 500 MHz	2,000 MHz
500 – 1,000 MHz	5,000 MHz
Above 1,000 MHz	5th harmonic of the highest frequency or 40 GHz, whichever is greater

There are many caveats with frequency ranges depending on the type of product. For understanding this more for your exact frequency measurement range, be sure to look at FCC Part 15.33 or the specific standards you're testing for. Important things to look for when deciding on a spectrum analyzer or oscilloscope-based solution for EMC pre-compliance testing include the following:

- Low noise floor
- Wide frequency range (to cover your measurement range)
- Peak, AVG, and Quasi-Peak detectors (similar to actual EMI receivers)
- Adjustable RBW that can go as low as 1 Hz
- Programmable interface
- Reliable and within cal
- EMC software allowing you to:
    - Account for the gains/losses of accessories
    - Compare traces
    - Distinguish ambient signals
    - Apply limit lines
    - Report notes, images, and results

Antenna, Probes
For troubleshooting, you'll want a set of near-field probes and a current probe. For pre-compliance radiated emissions scanning you'll want an EMI antenna. The antenna you need will depend on the frequency range of your required measurement. Occasionally, you will need multiple antennas because gain profiles vary with frequency. You may not be able to see your measurement if the gain of the antenna isn't high enough and the measured signal is hidden by the noise floor. To boost the gain, you can use an external preamplifier or RF amplifier between the antenna and spectrum analyzer.

Here are the four most common types of antennas used for EMC compliance testing and their typical frequency ranges:

- Loop: 10 kHz–30 MHz
- Biconical: 25 MHz–300 MHz
- Log periodic: 300 MHz–1 GHz
- Horn: 1 GHz–26 GHz

Line Impedance Stabilization Network
For conducted emissions measurements, instead of antennas, you use a LISN (line impedance stabilization network). A LISN is essentially a low-pass filter that is placed between an wAC or DC power source and the DUT to create a known impedance (often 50 ohms) and to provide an RF noise measurement port. It also serves to isolate the unwanted RF signals from the power source.

Preamplifier
A preamplifier can help by boosting low-level signals above the noise floor and improving the sensitivity of your measurement system. Make sure it operates over your frequency range of interest and has sufficient gain. Some preamplifiers have the added benefit of having a rechargeable battery, allowing you to make measurements when a power source is not available.

Antenna Tripod
You'll need a non-radiating tripod, preferably capable of raising, lowering, and rotating. Your particular standard may require a different kind of tripod. There's a benefit to having a solidly constructed tripod made specifically for EMC testing if you can afford it, but you may be able to get away with constructing your own tripod out of wood and PBC piping.

Coaxial Cables
You'll need two RF cables. One for connecting between the antenna and preamplifier and one for connecting between the preamplifier and spectrum analyzer or oscilloscope. They don't need to be very expensive. As long as they operate over the frequency range you need, match the impedance of your antenna, and are stable while being bent you should be good. Cable lengths typically vary between 1 m, 5 m or 10 m.

Turntable
You're going to need to position your device or equipment under test in various angles depending on the EMC standard. Turntables designed for EMC testing can be purchased to allow easy and precise rotation. For those on a budget, a cardboard box positioned at the correct height and distance is a cost-effective alternative.

Test environment
Unlike full EMC/EMI compliance testing, pre-compliance testing does not necessarily require compliant test equipment or anechoic chamber. Today you can make relatively accurate results in your own office environment, conference room, or basement. While an actual chamber is ideal, you can usually get along fine without it and save 10s or even 100s of thousands of dollars. However, when in very noisy environments, low-cost pre-compliance RF enclosures or TEM cells can be used as well.

When selecting a test site, it is best to pick a location that will minimize external signal sources. Rural areas, conference rooms or basements are good because they minimize signals that might mask the DUT emission levels you are trying to measure. Other considerations for improving accuracy involve having a good ground plane and reducing the number of reflective objects around the test area. You can also implement measurement techniques which involve making a baseline ambient noise measurement, as mentioned earlier.

Conclusion
An in-house pre-compliance EMC/EMI test solution can help you pass full compliance testing, saving you considerable time, frustration and expense, particularly when you test early in the design cycle when problems can be identified and mitigated relatively easily. Developing in-house EMC pre-compliance and troubleshooting capability can be done cost effectively, especially in comparison to the cost of multiple trips to the test house. Unlike full compliance testing, pre-compliance testing does not necessarily require expensive compliant test equipment or an anechoic chamber.

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   https://interferencetechnology.com/assembling-low-cost-emi-troubleshooting-kit-part-1-radiated-emissions/

EMC TEST EQUIPMENT SELECTION AND SIZING

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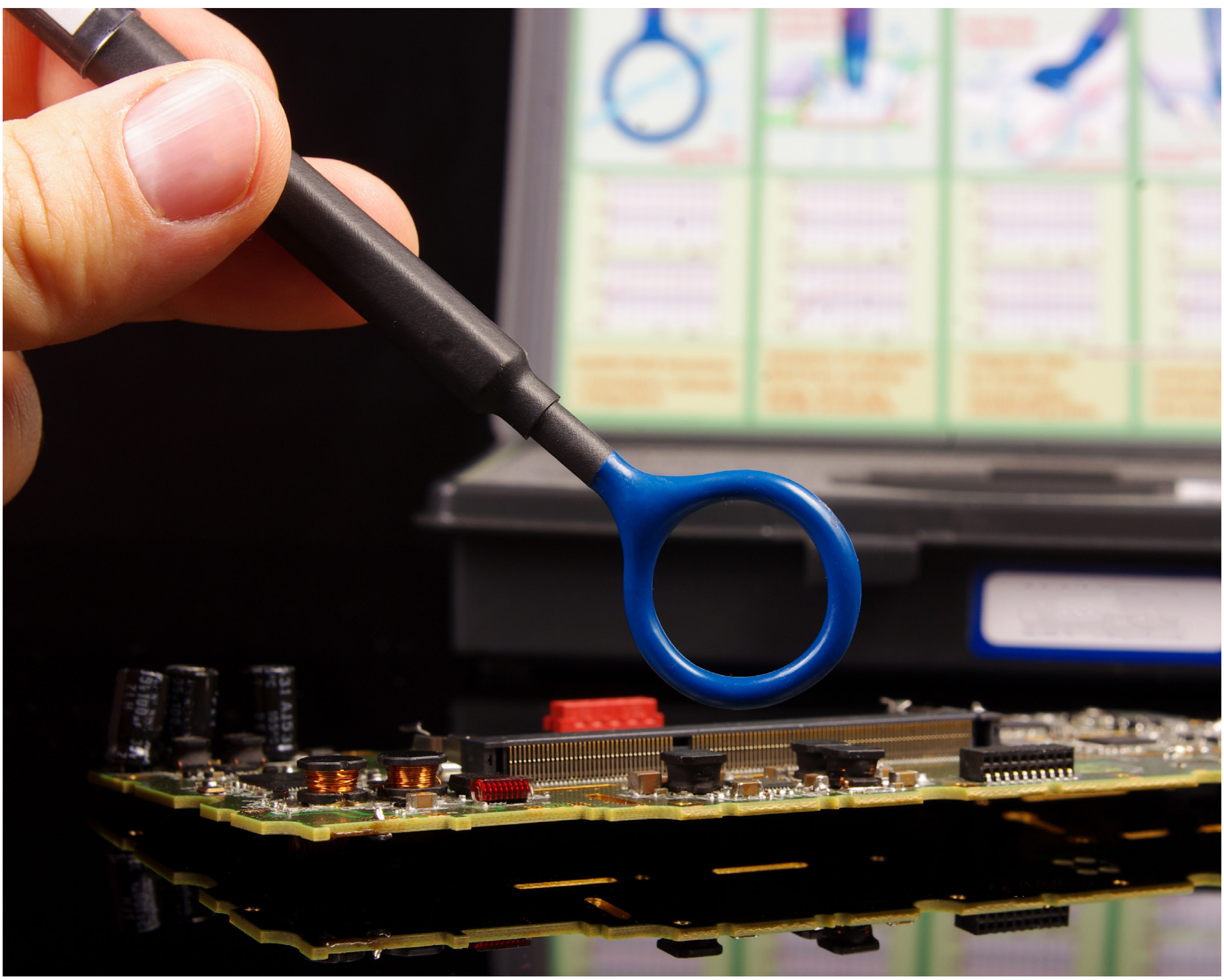
Supervisor of Applications Engineering, AR, Souderton, Pennsylvania, USA

Explosive growth in technologies like portable electronics, Internet of Things (IoT) devices, and autonomous vehicles has led to a world full of electromagnetic interference. Efficient EMC testing is more critical than ever, and is dependent on high-quality test equipment.



INTRODUCTION

Electromagnetic compatibility (EMC) testing has been around for decades and will continue as long as there are electronic devices in use. What has become apparent, is that the need for EMC testing has continued to grow nearly exponentially throughout its existence. Test environments and requirements across all industries continue to evolve at a rapid pace. While this rapid growth certainly drives the need for new and additional test equipment to accommodate new requirements, the growth also drives the need for educated and experienced EMC engineers and test personnel.

The problem is that this growth tends to outpace available EMC resources. It is not uncommon to see engineers and technicians with little or no EMC test experience thrust into positions where even a seasoned EMC engineer could face difficulties. Again, formal EMC education is not always readily available to some organizations and test programs often don't have the available time for someone to get up to speed. That said, this paper is intended to examine the thought process behind selecting and sizing appropriate test equipment when the need arises. There are numerous types of EMC testing, which require numerous types of test equipment. Significant amounts of time could be spent on each one of these tests, but in the interest of brevity, we will focus the efforts of this paper on radiated immunity (RI) and RF conducted immunity (CI).

DEFINING TEST REQUIREMENTS

The first step in selecting the proper equipment for RI and CI testing is to understand the requirements of the test itself. Across all industries, RI and CI testing share a lot of commonalities. However, when you dive into the respective test standards, you begin to realize that there are, in fact, some significant differences. An example of these differences for RI can be seen in *Table 1*. This table is not intended to be comprehensive; however, it does identify some of the key differences between some of the more common test standards in today's electronics marketplace.

Table 1: Example Differences Between Common RI Standards.

Radiated Immunity	Frequency	Test Level	Modulation	Distance	Leveling Method
IEC 61000-4-3 ed 3.0 2006	80MHz-6GHz, product and usage dependent	1-30V/m, and Special	1kHz AM, 80% Calibrate CW at 1.8x target field level	3m recommended; 1m minimum	substitution
MIL-STD-461, RS103 components and subsystems	30MHz - 18GHz required 2MHz - 40GHz optional extended	5 - 200V/m, application dependent	1kHz 50% duty PM	1m, or greater	closed loop
DO-169=0G Section 20.5 (Anechoic Chamber Method) 2010	100MHz - 18GHz	1 - 490V/m CW, 150 - 7200V/m Pulse; Category and freq dependent	CW, and Pulse	1m, or greater, Allows <1m at high freqs if far-field	substitution
ISO 11451-2:2015 Fourth edition Road vehicles vehicle test methods, Off-vehicle external radiation sources	10kHz - 18GHz	user defined; 20 - 100V/m typical, frequency and Test Level Category dependent; or Custom	CW 10kHz - 18GHz AM 1kHz 80% 10kHz - 800MHz PM 577us, 4600us period 800MHz - 1.2GHZ PM 577us, 4600us period 1.4GHz - 2.7GHz PM 3us, 3333 us period 1.2GHz - 1.4GHz PM 3us, 3333 us period 2.7GHz - 18GHz Peak Conservation/Constant Peak	no part of radiating antenna closer than 0.5m; antenna phase center ≥ 2m horizontally from reference point	substitution
ISO 11452-2 3rd edition Jan 2019; component test	80MHz - 18GHz	user defined; 25 - 100V/m typical, frequency and Test Level Category dependent; or Custom	CW 80MHz - 18GHz AM 1kHz 80% 80MHz - 800 MHz PM 577us, 4600us period 800MHz - 18GHz Peak Conservation/Constant Peak	1m	substitution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To the uninitiated, some of these differences may not seem that drastic. For example, looking at the cost of an amplifier needed for 200 V/m testing at a 1-meter test distance versus the cost of an amplifier for 200 V/m testing at 2 meters, one might change their mind. Another example involves required modulations. Sizing equipment for a 10 V/m MIL-STD-461 RS103 system may not be sufficient to use for a 10 V/m IEC 61000-4-3 system. The reason is that IEC 61000-4-3 requires a 1 kHz, 80% amplitude modulated signal. This type of modulation increases the overall amplitude of the signal, if not adjusted as in the case of other standards. Therefore, this test would need to be calibrated at 18 V/m, rather than just 10 V/m. This brings up another key difference between these two test standards. IEC uses what's termed a 'substitution method' of testing, where the intended field must be calibrated prior to running a test. In this case, field probes are not used during the test. Conversely, MIL-STD-461 allows the use of field probes to actively measure the field during testing, negating the need for calibration.

Again, these are examples and the list could go on and on. The important takeaway here is to ensure that the test requirements are fully realized and understood prior to investigating test equipment. Purchasing the wrong test equipment can prove to be a costly mistake in terms of lost test time and overall expenditures.

COMPONENT CATEGORY CONSIDERATIONS

Once you are clear on what your test requirements are, you can start considering your options for test equipment. As a matter of staying organized, we will break down equipment according to various categories here.

A. AMPLIFIERS

The foundation for proper amplifier selection is in understanding critical amplifier specifications. Amplifiers have a broad spectrum of specification parameters. Each of these parameters certainly has relevance for various applications, however, there are a few key parameters to keep in mind relating to EMC testing.

First, let's look at power. When looking at an amplifier spec sheet, you may see various definitions of power like rated power, Psat, P1dB, and so on. *Figure 1* shows an example of the various power levels of a 500-watt (rated power) amplifier.

P1dB refers to the amp's 1 dB compression point. This is the power level where, theoretically, a 10 dB increase in input power produces a 9 dB increase in output power. Effectively, the P1dB power is the top end of the amplifier's linear region. Beyond the P1dB point, the amplifier will go further into compression. What this means to an EMC engineer, is that up to the P1dB point, the amplifier will operate within its linear region. This is important when testing to standards that have linearity requirements. For example, IEC 61000-4-3, the test method used for testing most commercial electronic products in today's marketplace has a specific test as part of its calibration routine to verify that the amplifier used is operating in its linear region. If the amp is not, the test system fails calibration and cannot be used. If this is the test method you're designing your system around, it would be wise to size your amplifiers according to their P1dB specification.

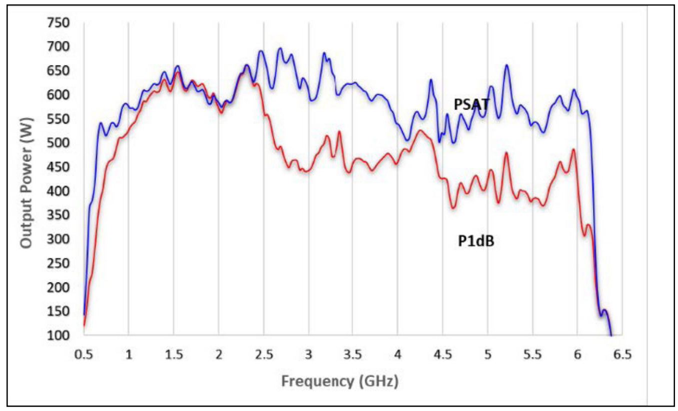


Figure 1: Various Power Ratings of a 500 Watt Amplifier

Psat is a common nomenclature for saturated power. Here, the amplifier is outside of its linear region, and an increase in input power will have no increase in output power. As we just discussed, Psat would not be the best choice for sizing an amplifier if you're testing commercial products. However, many other test standards do not have such stringent linearity requirements. Standards like MIL-STD-461, DO-160, and ISO 11451/11452 for the military, aviation, and automotive industries respectively, fall into this category. In these cases, it would be acceptable to size an amplifier according to its Psat.

The last power definition we'll touch on is rated power. The most important thing to remember about rated power is that there is no 'textbook' definition for rated power. It is a manufacturer-specific definition. One manufacturer may consider their rated power to be Psat, another may use P1dB, and another may use an entirely different definition. A 1,000-watt amplifier from Company A is not necessarily the same as a 1,000-watt amplifier from Company B. The point is, when looking at the rated power of an amplifier, it's extremely important to understand the manufacturer's definition of rated power.

Regardless of the definition of power you're considering, it is always important to add margin onto what you think you need. In EMC testing, there are always unknowns. Poorly matched transducers, chamber loading/reflections, poor cables, and many more factors can result in the need for more power than expected.

Another important amplifier parameter to consider is amplifier harmonics. Harmonics are unwanted signals occurring at multiples of the fundamental frequency and are an inherent type of distortion to all amplifiers. In EMC testing, it's important to limit this type of distortion for two key reasons (among others). One being the repeatability of a test. RI and CI tests are swept in frequency and equipment under test (EUTs) are tested at a single frequency at a time, unless you are testing using multi-tone methodology. If the EUT fails and there is a great amount of harmonic distortion, it may not be clear whether the EUT failed as a result of the incident fundamental frequency or from one of its harmonics. A second reason is due to the prevalence of broadband measurement equipment. In most cases, EMC tests utilize broadband power meters to measure amplifier power and broadband field probes to measure the generated electric field. These types of devices are not frequency-selective and therefore cannot differentiate between a fundamental and harmonic signal. Additionally, if the EUT is a broadband device it may also fail as a result of the total spectrum power, including the fundamental and harmonics, rather than failing from any single signal.

Lastly, we'll briefly discuss mismatch tolerance. Mismatch tolerance is the ability of an amplifier to handle unmatched loads, and thus varying amounts of reflected power. In EMC applications, especially at lower frequencies, transducers (antennas/clamps/etc.) can be a very poor match to 50 Ohms (typical nominal output impedance of RF amplifiers). Field reflections/standing waves can cause significant reflected power as well. During the test, it is important to continue to deliver forward power as well as protect the amp from reflected power damage.

B. ANTENNAS

Similar to amplifiers, antennas have many specification parameters, and certain parameters are more relevant in relation to EMC testing. When choosing equipment for radiated immunity, proper antenna selection is critical. Selecting the wrong antenna could mean limited exposure areas, insufficient fields, and other problems.

The first, and possibly most important, parameter to consider is the measured field strength of an antenna. This is empirical data of electric field strength produced by a given input power. This is highly useful for determining amp/antenna combinations for target immunity field strengths. Again, it's very important to size the amp with margin (6 dB is good target, 3 dB minimum) as non-free space conditions can contribute considerable loss (not just cables!). Measured data can be scaled for other power inputs. Also, the measured field is typically lowest at the lowest operable frequency, corresponding to the lowest antenna gain. Keep in mind that test distance greatly affects field strength. *Figures 2* and *3* show the measured field strength of a horn antenna at both 1 meter and 3 meter test distances. The difference caused by gain is apparent.

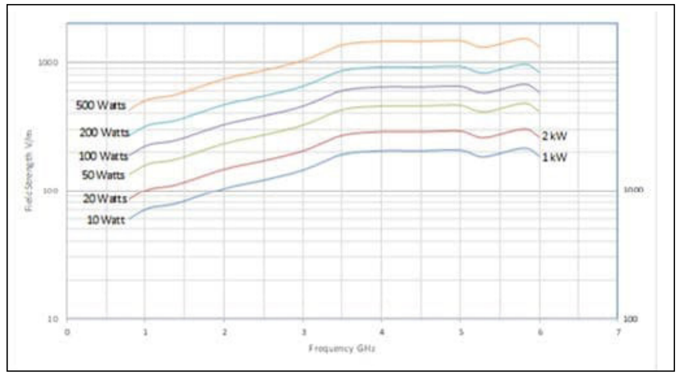


Figure 2: Measured Field Strength at 1 Meter.

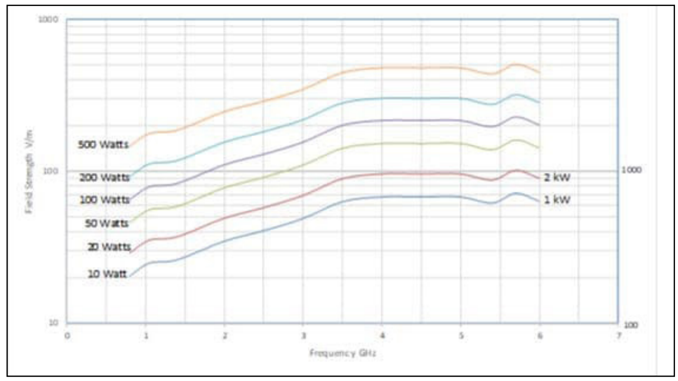


Figure 3: Measured Field Strength at 3 Meters.

In general, the more power that is put into an antenna, the more field is generated. However, there is no antenna that can handle infinite power. Input power is often limited by the power handling of the RF connector on the antenna, but there are other factors that can limit the power further. Some antenna manufacturers will specify just a single power level for power handling. This, unfortunately, is ambiguous. Input power ratings really vary over the frequency with power ratings typically decreasing as frequency increases. *Figure 4* shows the power handling of the same antenna represented in *Figures 2* and *3*.

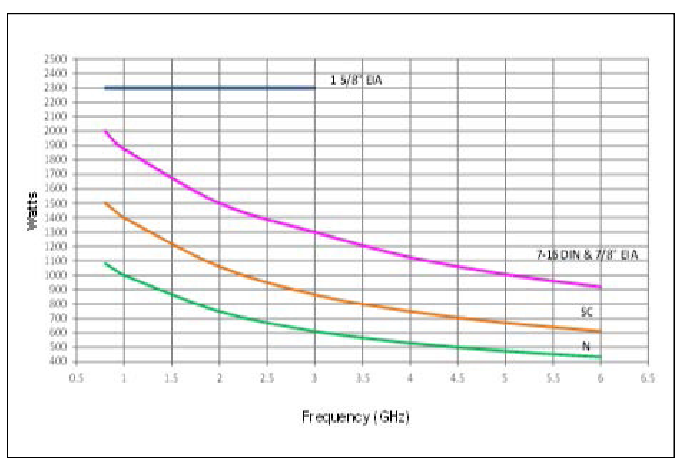


Figure 4: Antenna Power Handling.

When a single value is presented, this can sometimes be misconstrued as the maximum power rating over the full band. If this isn't made clear, it can be very easy to input this power level at a higher frequency and cause damage to the antenna. It should also be noted that these power levels are almost always defined as continuous or average power. Some immunity applications require high field strength pulsed tests. In these cases, large amounts of power are applied to the antenna but in very short durations and duty cycles. In these scenarios, the average power is very low, and therefore the antenna can handle much higher 'peak' power. Peak power handling of antenna is less well defined as voltage breakdown becomes the primary failure mechanism, and there are difficulties in characterizing this type of failure.

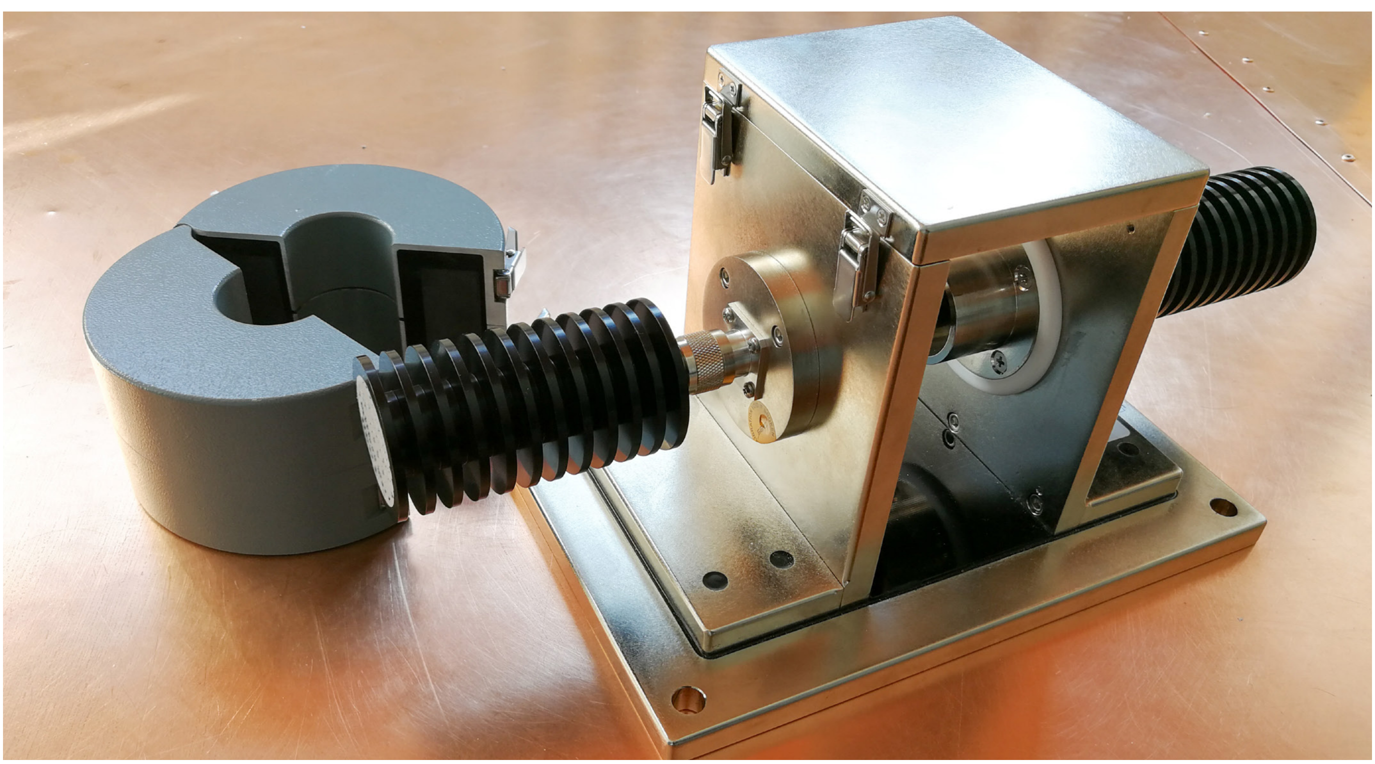
C. MEASUREMENT EQUIPMENT

The last equipment category we'll touch on is measurement equipment. The most common types of measurement equipment used in immunity testing are RF power meters and electric field probes. Typically, both of these types of devices are broadband measurement devices, measuring RMS power or electric field of continuous wave (CW) signals. As we discussed before, this can present problems when harmonics or other unwanted signals are present, as these signals would contribute to the measured power or field. This is why it's so important to limit harmonics and other unwanted signals. If frequency-selective measurements are desired, a receive antenna would need to be used along with a spectrum analyzer or EMI receiver. However, it should be noted that this method is typically not allowed in most test standards.

Another inherent problem of these devices is their ability, or rather inability, to accurately measure modulated signals. The majority of test standards require some type of modulation to be applied to the test signal. Traditional RF power meters and electric field probes are only capable of measuring CW signals, so either the test must first be calibrated without modulation applied, or the intented test signal must first be generated as a CW signal, then modulation applied. Either way, extra steps are involved. The adjective 'traditional' was used intentionally, as technologies are evolving, and some new RF power meters and electric field probes have the capability of measuring modulated signals. While these types of devices are gaining traction, the bulk of test standards are still written around the use of their traditional average measurement counterparts.

SUMMARY

As you can see, there are many factors to consider when selecting equipment for EMC testing. It's important to fully understand the multitude of requirements and specifications of not only the equipment itself, but the standards documents that dictate the tests. Of these equipment parameters, many are typically presented for a given piece of equipment, but not all parameters may be relevant to your particular application. With an in-depth knowledge of these parameters, it can be much easier to select the proper equipment for EMC testing applications.



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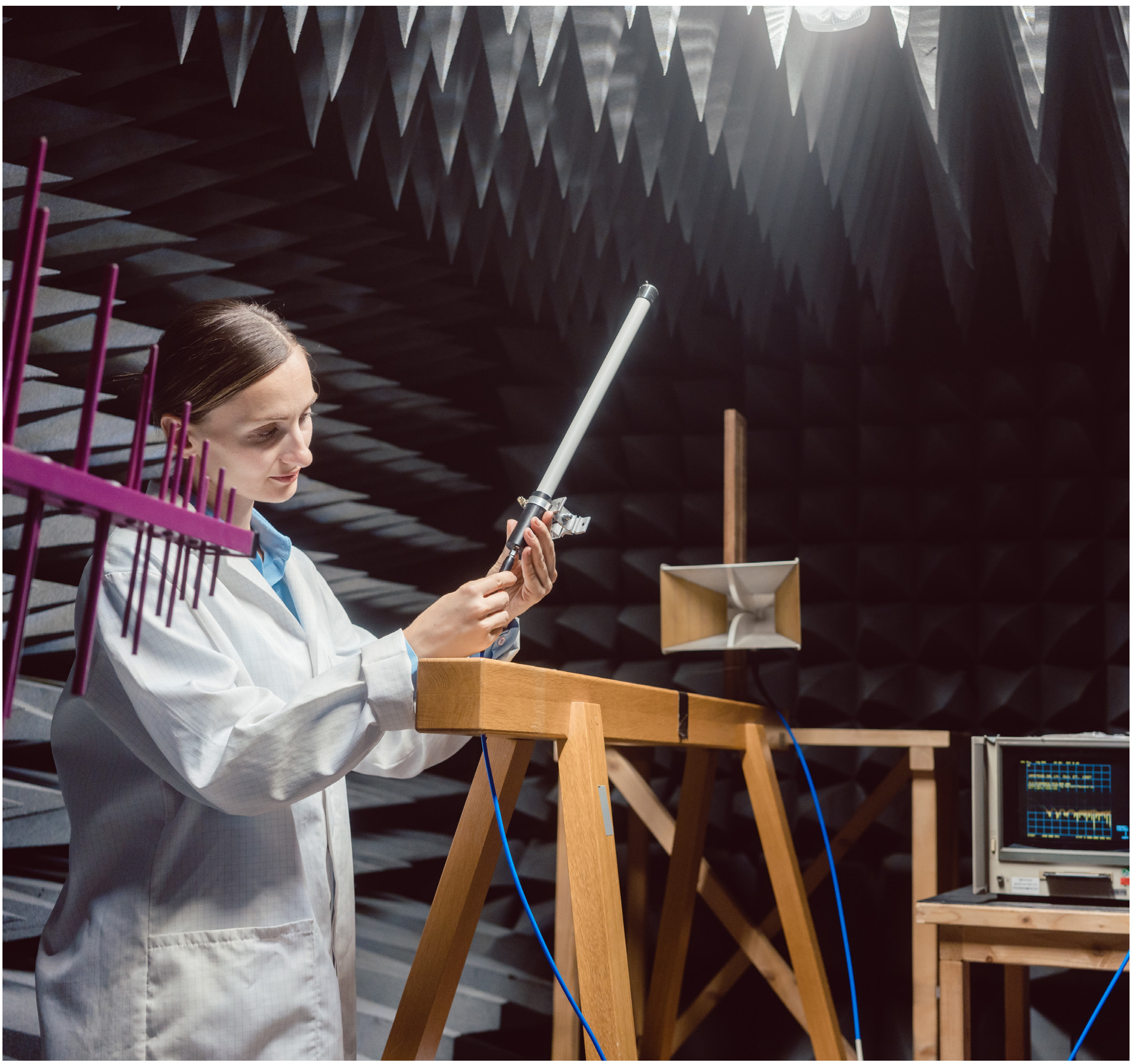
A SIMPLE GUIDE TO ANTENNA SELECTION

A.H. Systems, Inc.



Selecting an antenna for testing can sometimes be straightforward but often requires some specific consideration. One aspect of antenna selection is knowing the intended test frequencies and then selecting a matching antenna.

Not all antennas are created equal, and when it comes to frequency different antenna styles perform better at some frequencies and not at others. Some special considerations are sometimes required in antenna design typically at very high and very low frequencies. Take an antenna for a low frequency in the kHz range. A single wavelength at this range is on the order of miles long. Even a ¼ wavelength antenna at kHz frequencies is impractical at around 10,000 ft long. To get a better understanding of wavelength size and frequency, a frequency and wavelength calculator is helpful.

Low-frequency radio signals tend to act more like low-frequency audio, traveling through and around objects in non-directional ways. On the other hand, elements for high frequency antennas on the order of GHz can be very small, but signals tend to propagate in very directional ways more like light, but also won't go around or through objects. Because of this, low-frequency signals are naturally more omnidirectional and high frequency ones are more directional. Attempting to make directional low-frequency antennas or omnidirectional high frequency ones can be challenging.

Other antenna design factors such as bandwidth are frequency dependent as well. High frequencies require more precise length elements, making it more difficult to construct a wide bandwidth high-frequency antenna, but some designs manage to achieve this.

ACTIVE AND PASSIVE

Receiving and transmitting RF signals, while related, have some different antenna requirements. Reception picks up very small signals and delivers them to the receiver, requiring a well-tuned sensitive antenna. To aid with weak signals, some antennas or receivers employ active circuitry that amplifies the incoming signal. The amplifiers are better located near to or on the antenna to reduce the chance of it amplifying the noise as well, but ideally will boost weak signals. When used with a transceiver, these amplifiers need to be switched in and out since they do not handle transmit power. They are designed so they are connected during reception but bypassed during transmission.

BEAMWIDTH AND ANTENNA GAIN

Another factor in antenna selection is beamwidth, or the gain of the signal versus how directional it is. Directional antennas have a narrow beamwidth in the shape of a lobe in the intended direction, while omnidirectional antennas have a more spherical propagation. Other antennas — such as doughnut-shaped ones — have some directionality. In this case, the signal does not propagate up or down much but does cover 360° on a single plane. An antenna beamwidth coverage calculator can be help determine beamwidth requirements.

FREQUENCY RANGE

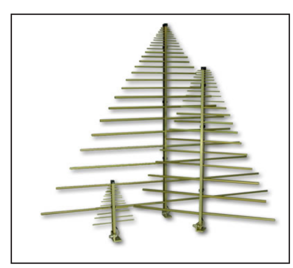
Antennas have different frequencies they are tuned for, in addition to the bandwidth or range of frequencies they can cover. Horn antennas and similar designs have a relatively narrow bandwidth while others such as a log periodic in comparison are very wide. Choosing an antenna with a wider bandwidth will also impact its other characteristics. If only a narrow test frequency is needed, it is preferable to have an antenna designed solely for that range.

LOOP ANTENNAS

For low frequencies below 30 MHz, loop antennas are ideal for magnetic field strength measurements. These consist of a typically circular loop or coil; the size and number of turns of the loop impact the frequency the antenna works on. Without any matching network, loop antennas are resonant such that the circumference is a single wavelength of the desired frequency. They can be adjusted with a matching network to be anywhere from 10% of the size up to full-size wavelength.

Loop antennas are convenient to use due to their small size relative to their frequency. For magnetic field testing at low frequencies, loop antennas produce a voltage for a given field strength, making them easy to use. They are less ideal for higher frequencies due to their size and response characteristics.

MONOPOLES



Monopoles can be used in many frequency ranges depending on their size, but like other antennas get larger at lower frequencies. Matching networks used with monopoles allow them to work over a wider range. Monopoles are constructed of a ground plane that is typically around 1/4 wavelength and a single radiating/reception element in the middle of the ground plane and perpendicular to it. Monopoles are good for measuring the electric field in testing.

LOG PERIODIC AND HYBRID ANTENNAS

The log periodic antenna is another broadband antenna that is much more directional and handles higher frequencies than other similar designs. They are constructed of multiple elements that become progressively smaller toward the tip of the antenna. These antennas are a good choice for both emission and immunity testing and can be used for both reception and transmission.

The hybrid or biological antenna design is a mix of a log periodic and a bow tie type design as a reflector. This antenna design has a wideband response, making it a good choice for testing a wide range of frequencies without having to switch antennas. It can be used for immunity and other compliance testing with repeatable results.

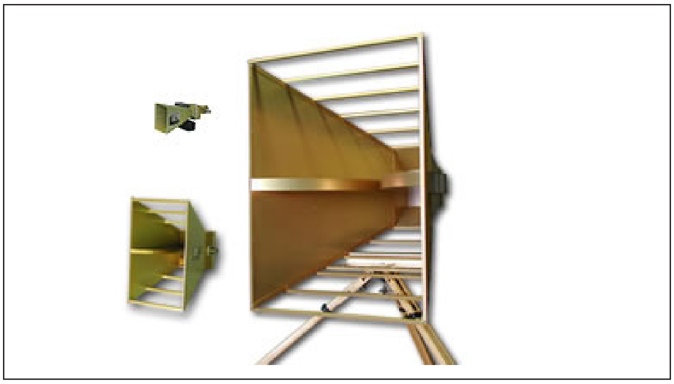
DIPOLES

The dipole is a simple design and is considered somewhat of a standard when it comes to antennas. Its design consists of two equal lengths of tuned elements in line with each other but opposite in direction. The elements on a dipole are typically tuned to ¼ wavelength such that the total length is ½ wavelength. The dipole is simple but also an effective antenna with a radiation pattern that covers a 360° doughnut-like pattern when vertically polarized. When horizontally polarized, the same doughnut pattern makes them bidirectional. Shorter dipoles can also be constructed with matching network components. The dipole does not have a very wide bandwidth and while still useful it is less desirable for testing a wide range of frequencies as it requires adjustments or multiple antennas for different test frequencies.

BICONICAL ANTENNAS

Biconical antennas are a modified type of dipole where the two elements form a roughly conical shape. This change allows them to have a wider bandwidth versus a regular dipole. The cones used on these are rarely solid and are often made of multiple elements, making them easier to fold or transport. Their broadband nature allows quick testing without having to adjust or change the antenna. They are linearly polarized and typically work in frequency from 20 MHz to 300 MHz, but when designed for it, they can work as high as 18 GHz.

HORNS



Horn Antennas at frequencies around 1 GHz and higher, a horn antenna becomes a practical choice. Horns are too large for sub-1 GHz use but they work well for high frequencies. Horn antennas are very directional both for receiving and transmitting so they can both pick up weak signals and transmit a strong signal to a device. This makes them a good choice for both immunity and emission testing.

Above 1 GHz a horn is still a good choice, and they get physically smaller and more directional as frequency increases. Horns work well up to 40 GHz and above, but the addition of a pre-amplifier for reception is a good addition to improve the dynamic range of the antenna.

CONCLUSION

Selecting the right antenna for a situation can sometimes seem confusing when considering all the necessary criteria. Frequency is a paramount consideration and often the starting point for a design. To help get past the confusion, contact an expert in the field. A.H. Systems carries a line of antennas for all kinds of testing situations and can help best fit your application or need.

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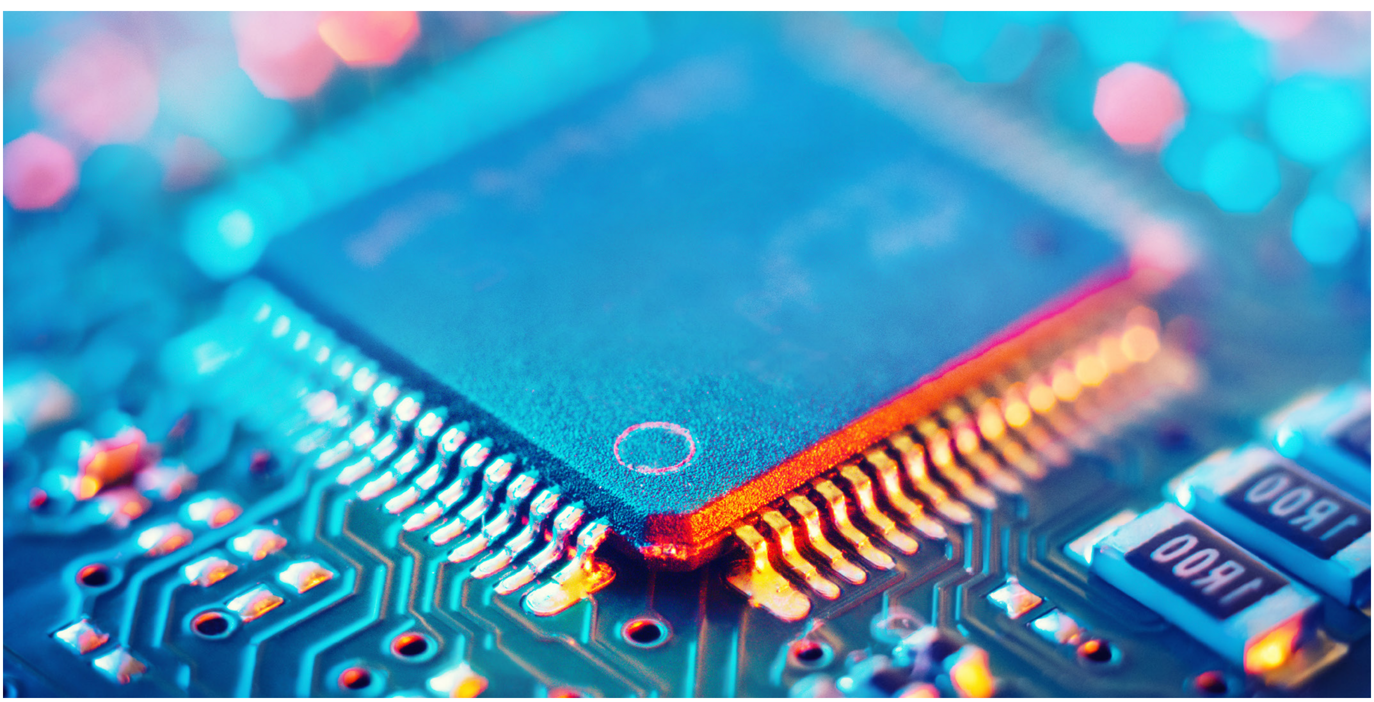

2022 CONSOLIDATED STANDARDS

MANY IEC STANDARDS have been adopted by the European Union with an EN designation replacing the IEC while maintaining the same number. In several cases, the standard may have been modified. When using an IEC standard, one should check for IEC – EN differences and in both cases check for the current edition.

The standards list adds a category column to help assign the identified standard to a particular type or discipline. Most are self-explanatory, but to avoid confusion the category assignments follow. Often a particular standard could fit in more than one category, so the assignment is simply a judgment call.

- Apparatus – this category is used to group standards for a product or device where it fails to fit in a specific group. For example, a medical device could be a product but it fits into the medical category more closely.
- Auto/Vehicle – standard primarily deals with automotive but includes ship or rail.
- General – primarily deals with definitive or general EM control information.
- Generic – deals with product standards not assigned to a particular group.
- Medical – medical equipment or methods
- MIL/Aero – MIL-STD, Space, Aeronautical equipment, or methods – includes associated design guides.
- Test – primarily deals with test methods
- Wireless – primarily deals with intentional RF emitters or receivers.

Useful websites associated with standards include but are not limited to:

ANSI	http://webstore.ansi.org; www.ansi.org; www.c63.org
APLAC	Asia Pacific Laboratory Accreditation Cooperation (APLAC) https://www.apac-accreditation.org/
BSMI	http://www.bsmi.gov.tw/wSite/mp?mp=95
CSA	http://www.cnca.gov.cn/
EN	https://www.en-standard.eu/
FCC	Federal Communications Commission (FCC) www.fcc.gov; Electronic Code of Fderal Regulations https://www.ecfr.gov
FDA	FDA Center for Devices & Radiological Health (CDRH) https://www.fda.gov/MedicalDevices/default.htm
Ford	https://www.fordemc.com
GM	https://global.ihs.com
IC	Industry Canada (Certifications and Standards) http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf06165.html
IEC / CISPR	https://webstore.iec.ch
IEEE	IEEE Standards Association https://standards.ieee.org/
IEEE EMC	IEEE EMC Society Standards Development Committee (SDCOM) https://standards.ieee.org/develop/index.html
ISED	Innovation, Science and Economic Development Canada; https://www.ic.gc.ca/eic/site/icgc.nsf/eng/home
ISO	ISO (International Organization for Standards) http://www.iso.org/iso/home.html
MIL-STD	https://quicksearch.dla.mil/qsSearch.aspx

RTCA	https://www.rtca.org
Russia	Gosstandart (Russia) https://gosstandart.gov.by/en
SAE	SAE EMC Standards Committee www.sae.org
UK EMCIA	Electromagnetic Compatibility Industry Association UK http://www.emcia.org
VCCI	VCCI (Japan, Voluntary Control Council for Interference) http://www.vcci.jp/vcci_e/

Category	Publisher	Number	Title
Apparatus	IEC	60118-13	Electroacoustics - Hearing aids - Part 13: Electromagnetic compatibility (EMC)
Apparatus	IEC	60255-26	Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements
Apparatus	IEC	60364-4-44	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbance
Apparatus	IEC	60728-12	Cabled distribution systems for television and sound signals - Part 12: Electromagnetic compatibility of systems IEC (continued)
Apparatus	IEC	60728-2	Cabled distribution systems for television and sound signals - Part 2: Electromagnetic compatibility for equipment
Apparatus	IEC	60870-2-1	Telecontrol equipment and systems - Part 2: Operating conditions - Section 1: Power supply and electromagnetic compatibility
Apparatus	IEC	60974-10	Arc welding equipment - Part 10: Electromagnetic compatibility (EMC) requirements
Apparatus	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)
Apparatus	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
Apparatus	IEC	61000-3-2	Electromagnetic compatibility (EMC)–Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
Apparatus	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
Apparatus	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
Apparatus	IEC	61326-1	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements
Apparatus	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
Apparatus	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

Category	Publisher	Number	Title
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	IEC	61543	Residual current-operated protective devices (RCDs) for household and similar use - Electromagnetic compatibility
Apparatus	IEC	61800-3	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
Apparatus	IEC	61967-1	Integrated circuits - Measurement of electromagnetic emissions, 150 kHz to 1 GHz - Part 1: General conditions and definitions
Apparatus	IEC	62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility EMC) requirements
Apparatus	IEC	62041	Power transformers, power supply units, reactors and similar products - EMC requirements
Apparatus	IEC	62310-2	Static transfer systems (STS) - Part 2: Electromagnetic compatibility (EMC) requirements
Apparatus	IEC	CISPR 11	Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement
Apparatus	IEC	CISPR 14-1	Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission
Apparatus	IEC	CISPR 14-2	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 2: Immunity – Product family standard
Apparatus	IEC	CISPR 15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
Apparatus	IEC	CISPR 32	Electromagnetic compatibility of multimedia equipment – Emission requirements
Apparatus	IEC	CISPR 35	Electromagnetic compatibility of multimedia equipment - Immunity requirements

Category	Publisher	Number	Title
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Apparatus	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
Auto/Vehicle	Audi	TL 82466	Electrostatic Discharge
Auto/Vehicle	BMW	600 13.0	Electric- / Electronic components in cars BMW GS 95002 Electromagnetic Compatibility (EMC) Requirements and Tests
Auto/Vehicle	BMW	GS 95003-2	GS 95003-2 Electric- / Electronic assemblies in motor vehicles
Auto/Vehicle	Chrysler	PF 9326	Electrical electronic modules and motors
Auto/vehicle	Diamer Chrysler	DC-10614	EMC Performance Requirements – Components
Auto/vehicle	Diamer Chrysler	DC-10615	Electrical System Performance Requirements for Electrical and Electronic Components
Auto/vehicle	Diamer Chrysler	DC-11223	Performance Requirements -- Vehicle Automotive Electromagnetic Compatibility Standards
Auto/vehicle	Diamer Chrysler	DC-11224	EMC Performance Requirements – Components
Auto/vehicle	Diamer Chrysler	DC-11225	EMC Supplemental Information and Alternative Component Requirements
Auto/Vehicle	Fiat	9.90110	Electric and electronic devices for motor vehicles Freightliner 49-00085 EMC Requirements
Auto/vehicle	FORD	EMC-CS-2009.1	Component EMC Specification. EMC-CS-2009.1
Auto/vehicle	FORD	F-2	Electrical and Electronics System Engineering
Auto/vehicle	FORD	WSF-M22P5-A1	Printed Circuit Boards, PTF, Double Sided, Flexible
Auto/vehicle	GM	GMW3091	General Specification for Vehicles, Electromagnetic Compatibility (EMC)-Engl; Revision H; Supersedes GMI 12559 R and GMI 12559 V
Auto/vehicle	GM	GMW3097	General Specification for Electrical/Electronic Components and Subsystems, Electromagnetic Compatibility-Engl; Revision H; Supersedes GMW12559, GMW3100, GMW12002R AND GMW12002V

Category	Publisher	Number	Title
Auto/vehicle	GM	GMW3103	General Specification for Electrical/Electronic Components and Subsystems, Electromagnetic Compatibility Global EMC Component/Subsystem Validation Acceptance Process-Engl; Revision F; Contains Color; Replaces GMW12003, GMW12004 and GMW3106
Auto/Vehicle	Honda	3838Z-S5AA-L000	Noise Simulation Test
Auto/Vehicle	Honda	3982Z-SDA-0030	Battery Simulation Test
Auto/Vehicle	Hyundia Kia	ES 39111-00	EMC Requirements
Auto/Vehicle	Hyundia Kia	ES 95400-10	Battery Simulation Tests
Auto/Vehicle	Hyundia Kia	ES 96100-01	EMC Requirements
Auto/vehicle	IEC	60533	Electrical and electronic installations in ships - Electromagnetic compatibility (EMC) - Ships with a metallic hull
Auto/vehicle	IEC	62236-1	Railway applications - Electromagnetic compatibility - Part 1: General
Auto/vehicle	IEC	62236-2	Railway applications - Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world
Auto/vehicle	IEC	62236-3-1	Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle
Auto/vehicle	IEC	62236-3-2	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock – Apparatus
Auto/vehicle	IEC	62236-4	Railway applications - Electromagnetic compatibility - Part 4: Emission and immunity of the signaling and telecommunications apparatus
Auto/vehicle	IEC	62236-5	Railway applications - Electromagnetic compatibility - Part 5: Emission and immunity of fixed power supply installations and apparatus
Auto/vehicle	IEC	CISPR 12	Vehicles, boats and internal combustion engines - Radio disturbance characteristics - Limits and methods of measurement for the protection of off-board receivers
Auto/vehicle	IEC	CISPR 25	Vehicles, boats and internal combustion engines - Radio disturbance characteristics - Limits and methods of measurement for the protection of on-board receivers
Auto/vehicle	IEC	TR 62482	Electrical installations in ships - Electromagnetic compatibility - Optimizing of cable installations on ships - Testing method of routing distance
Auto/vehicle	ISL	11451-3	Road vehicles -- Electrical disturbances by narrowband radiated electromagnetic energy -- Vehicle test methods -- Part 3: On-board transmitter simulation
Auto/vehicle	ISO	10605	Road vehicles -- Test methods for electrical disturbances from electrostatic discharge
Auto/vehicle	ISO	11451-1	Road vehicles -- Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 1: General principles and terminology
Auto/vehicle	ISO	11451-2	Road vehicles -- Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 2: Off-vehicle radiation sources
Auto/vehicle	ISO	11451-4	Road vehicles -- Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 4: Bulk current injection (BCI)
Auto/Vehicle	ISO	11452-1	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology

Category	Publisher	Number	Title
Auto/vehicle	ISO	11452-10	Road vehicles -- Component test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 10: Immunity to conducted disturbances in the extended audio frequency range
Auto/Vehicle	ISO	11452-11	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 11: Reverberation chamber ISO 13766 Earth-moving machinery – Electromagnetic compatibility
Auto/Vehicle	ISO	11452-2	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Absorber-lined shielded enclosure
Auto/Vehicle	ISO	11452-3	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: Transverse electromagnetic mode (TEM) cell
Auto/vehicle	ISO	11452-4	Road vehicles -- Component test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 4: Bulk current injection (BCI)
Auto/Vehicle	ISO	11452-5	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 5: Stripline
Auto/vehicle	ISO	11452-7	Road vehicles -- Component test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 7: Direct radio frequency (RF) power injection
Auto/vehicle	ISO	11452-8	Road vehicles -- Component test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 8: Immunity to magnetic fields
Auto/vehicle	ISO	7637-1	Road vehicles -- Electrical disturbances from conduction and coupling -- Part 1: Definitions and general considerations
Auto/vehicle	ISO	7637-2	Road vehicles -- Electrical disturbances from conduction and coupling -- Part 2: Electrical transient conduction along supply lines only
Auto/vehicle	ISO	7637-3	Road vehicles -- Electrical disturbance by conduction and coupling -- Part 3: Vehicles with nominal 12 V or 24 V supply voltage -- Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines
Auto/vehicle	ISO	TR 10305-1	Road vehicles -- Calibration of electromagnetic field strength measuring devices -- Part 1: Devices for measurement of electromagnetic fields at frequencies > 0 Hz
Auto/vehicle	ISO	TR 10305-2	Road vehicles -- Calibration of electromagnetic field strength measuring devices -- Part 2: IEEE standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz
Auto/Vehicle	ISO	TS 14907-1	Road transport and traffic telematics -- Electronic fee collection – Test procedures for user and fixed equipment – Part 1: Description of test procedures
Auto/Vehicle	ISO	TS 14907-2	Road transport and traffic telematics – Electronic fee collection -- Test procedures for user and fixed equipment -- Part 2: Conformance test for the onboard unit application interface
Auto/vehicle	ISO	TS 21609	Road vehicles -- (EMC) guidelines for installation of aftermarket radio frequency transmitting equipment
Auto/Vehicle	KVECO	16-2103	EMC Requirements
Auto/Vehicle	Lotus	17.39.01	Lotus Engineering Standard: Electromagnetic Compatibility
Auto/Vehicle	Mack	606GS15	EMC Requirements MAN 3285 EMC Requirements
Auto/Vehicle	Mazda	MES PW 67600	Automobile parts standard (electronic devices)
Auto/Vehicle	Mercedes	A 211 000 42 99	Instruction specification of test method for E/Ecomponents

Category	Publisher	Number	Title
Auto/Vehicle	Mercedes	AV EMV	Electric aggregate and electronics in cars
Auto/Vehicle	Mercedes	MBN 10284-2	EMC requirements and tests of E/E-systems (component test procedures)
Auto/Vehicle	Mercedes	MBN 2200-2	Electric / electronic elements, devices in trucks
Auto/Vehicle	Mitsubishi	ES-X82010	General specification of environment tests on automotive electronic equipment
Auto/Vehicle	Nissan	28400 NDS03	Low frequency surge resistance of electronic parts
Auto/Vehicle	Nissan	28400 NDS04	Burst and Impulse Waveforms
Auto/Vehicle	Nissan	28400 NDS07	Immunity against low frequency surge (induction surge) of electronic parts
Auto/Vehicle	Nissan	28401 NDS02	EMC requirements (instruction concerning vehicle and electrical ...)
Auto/Vehicle	Peugeot	B217110	Load Dump Pulses
Auto/Vehicle	Porsche	AV EMC EN	EMC Requirements
Auto/Vehicle	PSA	B21 7090	EMC Requirements (electric and electronics equipment)
Auto/Vehicle	PSA	B21 7110	EMC requirements (electric and electronics equipment)
Auto/Vehicle	Renault	36.00.400	Physical environment of electrical and electronic equipment
Auto/Vehicle	Renault	36.00.808	EMC requirements (cars and electrical / electronic components)
Auto/vehicle	SAE	J1113/1	Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (Up to 15 M), and Machines (Except Aircraft) (50 Hz to 18 Ghz)
Auto/vehicle	SAE	J1113/11	Immunity to Conducted Transients on Power Leads
Auto/vehicle	SAE	J1113/12	Electrical Interference by Conduction and Coupling - Capacitive and Inductive Coupling via Lines Other than Supply Lines
Auto/vehicle	SAE	J1113/13	Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 13: Immunity to Electrostatic Discharge
Auto/vehicle	SAE	J1113/2	Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft)--Conducted Immunity, 15 Hz to 250 kHz--All Leads
Auto/vehicle	SAE	J1113/21	Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 21: Immunity to Electromagnetic Fields, 30 MHz to 18 GHz, Absorber-Lined Chamber
Auto/vehicle	SAE	J1113/26	Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Immunity to AC Power Line Electric Fields
Auto/vehicle	SAE	J1113/27	Electromagnetic Compatibility Measurements Procedure for Vehicle Components - Part 27: Immunity to Radiated Electromagnetic Fields - Mode Stir Reverberation Method
Auto/vehicle	SAE	J1113/28	Electromagnetic Compatibility Measurements Procedure for Vehicle Components--Part 28--Immunity to Radiated Electromagnetic Fields--Reverberation Method (Mode Tuning)
Auto/vehicle	SAE	J1113/4	Immunity to Radiated Electromagnetic Fields-Bulk Current Injection (BCI) Method
Auto/vehicle	SAE	J1752/1	Electromagnetic Compatibility Measurement Procedures for Integrated Circuits-Integrated Circuit EMC Measurement Procedures-General and Definition
Auto/vehicle	SAE	J1752/2	Measurement of Radiated Emissions from Integrated Circuits -- Surface Scan Method (Loop Probe Method) 10 MHz to 3 GHz

Category	Publisher	Number	Title
Auto/vehicle	SAE	J1752/3	Measurement of Radiated Emissions from Integrated Circuits -- TEM/ Wideband TEM (GTEM) Cell Method; TEM Cell (150 kHz to 1 GHz), Wideband TEM Cell (150 kHz to 8 GHz)
Auto/vehicle	SAE	J1812	Function Performance Status Classification for EMC Immunity Testing
Auto/vehicle	SAE	J2556	Radiated Emissions (RE) Narrowband Data Analysis--Power Spectral Density (PSD)
Auto/Vehicle	SAE	J2556	Radiated Emissions (RE) Narrowband Data Analysis–Power Spectral Density (PSD)
Auto/vehicle	SAE	J2628	Characterization--Conducted Immunity
Auto/Vehicle	SAE	J2628	Characterization–Conducted Immunity
Auto/vehicle	SAE	J551/15	Vehicle Electromagnetic Immunity--Electrostatic Discharge (ESD)
Auto/vehicle	SAE	J551/16	Electromagnetic Immunity - Off-Vehicle Source (Reverberation Chamber Method) - Part 16 - Immunity to Radiated Electromagnetic Fields
Auto/vehicle	SAE	J551/17	Vehicle Electromagnetic Immunity -- Power Line Magnetic Fields
Auto/vehicle	SAE	J551/5	Performance Levels and Methods of Measurement of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 9 kHz To 30 MHz
Auto/Vehicle	Scania	TB1400	EMC Requirements
Auto/Vehicle	Scania	TB1700	Load Dump Test
Auto/Vehicle	Smart	DE10005B	EMC requirements (electric aggregate and electronics in cars)
Auto/Vehicle	Toyota	TSC203G	Engineering standard (ABS-TRC computers)
Auto/Vehicle	Toyota	TSC7001G	Engineering standard (electric noise of electronic devices)
Auto/Vehicle	Toyota	TSC7001G-5.1	Power Supply Voltage Characteristic Test
Auto/Vehicle	Toyota	TSC7001G-5.2	Field Decay Test
Auto/Vehicle	Toyota	TSC7001G-5.3	Floating Ground Test
Auto/Vehicle	Toyota	TSC7001G-5.4	Induction Noise Resistance
Auto/Vehicle	Toyota	TSC7001G-5.5.3	Load Dump Test-1
Auto/Vehicle	Toyota	TSC7001G-5.5.4	Load Dump Test-2
Auto/Vehicle	Toyota	TSC7001G-5.5.5	Load Dump Test-3
Auto/Vehicle	Toyota	TSC7001G-5.6	Over Voltage Test
Auto/Vehicle	Toyota	TSC7001G-5.7.3	Ignition Pulse (Battery Waveforms) Test-1
Auto/Vehicle	Toyota	TSC7001G-5.7.4	Ignition Pulse (Battery Waveforms) Test-2
Auto/Vehicle	Toyota	TSC7001G-5.8	Reverse Voltage
Auto/Vehicle	Toyota	TSC7006G-4.4.2	Wide Band-Width Antenna Nearby Test (0.4 to 2 GHz)
Auto/Vehicle	Toyota	TSC7006G-4.4.3	Radio Equipment Antenna nearby Test (28 MHz ...)
Auto/Vehicle	Toyota	TSC7006G-4.4.4	Mobile Phone Antenna Nearby Test (835 MHz ...)
Auto/Vehicle	Toyota	TSC7018G	Static Electricity Test
Auto/Vehicle	Toyota	TSC7025G-5	TEM Cell Test (1 to 400 MHz)
Auto/Vehicle	Toyota	TSC7025G-6	Free Field Immunity Test (20 MHz to 1 GHz AM, 0.8 to 2 GHz PM)
Auto/Vehicle	Toyota	TSC7025G-7	Strip Line Test (20 - 400 MHz)

Category	Publisher	Number	Title
Auto/Vehicle	Toyota	TSC7026G-3.4	Narrow Band Emissions
Auto/Vehicle	Toyota	TSC7203	Voltage Drop / Micro Drops
Auto/Vehicle	Toyota	TSC7508G-3.3.1	Conductive Noise in FM and TV Bands
Auto/Vehicle	Toyota	TSC7508G-3.3.2	Conductive noise in LW, AM and SW Bands
Auto/Vehicle	Toyota	TSC7508G-3.3.3	Radiated Noise in FM and TV Bands
Auto/Vehicle	Toyota	TSC7508G-3.3.4	Radiated Noise in AM, SW, and LW Bands
Auto/Vehicle	Toyota	TXC7315G	Electrostatic Discharge (Gap Method)
Auto/Vehicle	Viston	ES-XU3F-1316-AA	Electronic Component - Subsystem Electromagnetic Compatibility (EMC) Requirements and Test Procedures
Auto/Vehicle	Volvo	N/A	EMC Requirements EMC requirements for 12V and 24V systems
Auto/Vehicle	VW	TL 801 01	Electric and electronic components in cars
Auto/Vehicle	VW	TL 820 66	Conducted Interference
Auto/Vehicle	VW	TL 821 66	EMC requirements of electronic components - bulk current injection (BCI)
Auto/Vehicle	VW	TL 823 66	Coupled Interference on Sensor Cables
Auto/Vehicle	VW	TL 824 66	Immunity Against Electrostatic Discharge
Auto/Vehicle	VW	TL 965	Short-Distance Interference Suppression
General	ANSI	S20.20	ESD Association Standard for the Development of and Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies, and Equipment
General	IEC	60050-161	International Electrotechnical Vocabulary. Chapter 161: Electromagnetic compatibility
General	IEC	60469	Transitions, pulses and related waveforms - Terms, definitions and algorithms
General	IEC	60940	Guidance information on the application of capacitors, resistors, inductors and complete filter units for electromagnetic interference suppression
General	IEC	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
General	IEc	61000-2-10	Electromagnetic compatibility (EMC) - Part 2-10: Environment - Description of HEMP environment - Conducted disturbance
General	IEC	61000-2-11	Electromagnetic compatibility (EMC) - Part 2-11: Environment - Classification of HEMP environments
General	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
General	IEC	61000-2-13	Electromagnetic compatibility (EMC) - Part 2-13: Environment - High-power electromagnetic (HPEM) environments - Radiated and conducted
General	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
General	IEC	61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances
General	IEC	61000-2-9	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 9: Description of HEMP environment - Radiated disturbance. Basic EMC publication

Category	Publisher	Number	Title
General	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
General	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)
General	IEC	61000-5-8	Electromagnetic compatibility (EMC) - Part 5-8: Installation and mitigation guidelines - HEMP protection methods for the distributed infrastructure
General	IEC	61000-5-9	Electromagnetic compatibility (EMC) - Part 5-9: Installation and mitigation guidelines - System-level susceptibility assessments for HEMP and HPEM
General	IEC	62305-1	Protection against lightning - Part 1: General principles
General	IEC	62305-2	Protection against lightning - Part 2: Risk management
General	IEC	62305-3	Protection against lightning - Part 3: Physical damage to structures and life hazard
General	IEC	62305-4	Protection against lightning - Part 4: Electrical and electronic systems within structures
General	IEC	TR 61000-1-1	Electromagnetic compatibility (EMC) - Part 1: General - Section 1: Application and interpretation of fundamental definitions and terms
General	IEC	TR 61000-1-3	Electromagnetic compatibility (EMC) - Part 1-3: General - The effects of high-altitude EMP (HEMP) on civil equipment and systems
General	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
General	IEC	TR 61000-1-5	Electromagnetic compatibility (EMC) - Part 1-5: General - High power electromagnetic (HPEM) effects on civil systems
General	IEC	TR 61000-1-6	Electromagnetic compatibility (EMC) - Part 1-6: General - Guide to the assessment of measurement uncertainty
General	IEC	TR 61000-1-7	Electromagnetic compatibility (EMC) - Part 1-7: General - Power factor in single-phase systems under non-sinusoidal conditions
General	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
General	IEC	TR 61000-2-14	Electromagnetic compatibility (EMC) - Part 2-14: Environment - Overvoltages on public electricity distribution networks
General	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
General	IEC	TR 61000-2-5	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 5: Classification of electromagnetic environments. Basic EMC publication
General	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
General	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
General	IEC	TR 61000-5-1	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 1: General considerations - Basic EMC publication

Category	Publisher	Number	Title
General	IEC	TR 61000-5-2	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 1: General considerations - Basic EMC publication
General	IEC	TR 61000-5-3	Electromagnetic compatibility (EMC) - Part 5-3: Installation and mitigation guidelines - HEMP protection concepts
General	IEC	TR 61000-5-6	Electromagnetic compatibility (EMC) - Part 5-6: Installation and mitigation guidelines - Mitigation of external EM influences
General	IEC	TR-61000-2-7	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 7: Low frequency magnetic fields in various environments
General	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
Generic	IEC	61000-6-1	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity standard for residential, commercial and light-industrial environments
Generic	IEC	61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
Generic	IEC	61000-6-3	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments
Generic	IEC	61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
Generic	IEC	61000-6-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for power station and substation environments
Generic	IEC	61000-6-6	Electromagnetic compatibility (EMC) - Part 6-6: Generic standards - HEMP immunity for indoor equipment
Generic	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
Medical	IEC	60601-1-1	Safety requirements for medical electrical systems
Medical	IEC	60601-1-10	Requirements for the development of physiologic closed-loop controllers
Medical	IEC	60601-1-11	Medical electrical equipment and medical electrical systems used in the home healthcare environment
Medical	IEC	60601-1-12	Medical electrical equipment and medical electrical systems used in the medical services environment
Medical	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
Medical	IEC	60601-1-3	Radiation protection in diagnostic x-ray equipment
Medical	IEC	60601-1-6	General requirements for basic safety and essential performance – Usability
Medical	IEC	60601-1-8	General requirements for basic safety and essential performance - Alarm systems
Medical	IEC	60601-1-9	Requirements for environmentally conscious design
Medical	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
Medical	IEC	60601-4-2	Medical electrical equipment–Part 4-2: Guidance and interpretation - Electromagnetic immunity: performance of medical electrical equipment and medical electrical systems
Medical	IEC	TR 60601-4-2	Electromagnetic immunity performance

Category	Publisher	Number	Title
Medical	IEC	TR 60601-4-3	Considerations of unaddressed safety aspects in the third edition of IEC 60601-1
Medical	IEC	TR 62354	General testing procedures for medical electrical equipment
Medical	ISO	14708-1	Active implantable medical devices
MIL/Aero	AIAA	S-121	Electromagnetic Compatibility Requirements for Space Equipment and Systems, 2017
MIL/Aero	DoD	ADS-37A-PRF	Electromagnetic Environmental Effects (E3) Performance and Verification Requirements, 28 May 1996 (Army Aviation and Troop Command)
MIL/Aero	DoD	DoDD 4650.01	Policy and Procedures for Management and Use of the Electromagnetic Spectrum, 09 Jan 2009
MIL/Aero	DoD	DoDI 3222.03	DoD Electromagnetic Environmental Effects (E3) Program, Change Notice 2, 10 October 2017.
MIL/Aero	DoD	DoDI 6055.11	Protecting Personnel from Electromagnetic Fields, 19 Aug 2009
MIL/Aero	DoD	DOD-STD-1399-70	Section 070 Part 1 D.C. Magnetic Field Environment, (Notice 1 Validation, 30 Nov 1989)
MIL/Aero	DoD	MIL-HDBK-1195	Radio Frequency Shielded Enclosures, 30 Sep 1988
MIL/Aero	DoD	MIL-HDBK-1857	Grounding, Bonding and Shielding Design Practices, 27 Mar 1998
MIL/Aero	DoD	MIL-HDBK-2036	Preparation of Electronic Equipment Specifications, 1 November 1999
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MIL/Aero	DoD	MIL-HDBK-240-3	Electromagnetic Environmental Effects to Ordnance Guide Part 3 Electrostatic Discharge to Ordnance
MIL/Aero	DoD	MIL-HDBK-240-4	Electromagnetic Environmental Effects to Ordnance Guide Part 4 External Radio Frequency Electromagnetic Environments
MIL/Aero	DoD	MIL-HDBK-240-5	Electromagnetic Environmental Effects to Ordnance Guide Part 5 Lightning Effects to Ordnance (Notice 1 is administrative placeholder)
MIL/Aero	DoD	MIL-HDBK-240-6	Electromagnetic Environmental Effects to Ordnance Guide Part 6 Characterization of the Electromagnetic Environment for HERO
MIL/Aero	DoD	MIL-HDBK-240-7	Electromagnetic Environmental Effects to Ordnance Test Guide Part 7 Hazards of Electromagnetic Radiation to Ordnance Operational Guidance
MIL/Aero	DoD	MIL-HDBK-274A	Electrical Grounding for Aircraft Safety, 14 Nov 2011. (Notice 2 Validation 20 May 2021)
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MIL/Aero	RTCA	DO-363	Guidance for the Development of Portable Electronic Devices (PED) Tolerance for Civil Aircraft

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MIL/Aero	SAE	ARP 5583A	Guide to Certification of Aircraft in a High Intensity Radiation (HIRF) Environment
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Test	IEC	60060-1	International Electrotechnical Vocabulary. Chapter 161: Electromagnetic compatibility
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Test	IEC	60060-3	High-voltage test techniques - Part 3: Definitions and requirements for on-site testing
Test	IEC	61000-4-10	Electromagnetic compatibility (EMC) - Part 4-10: Testing and measurement techniques - Damped oscillatory magnetic field immunity test
Test	IEC	61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests
Test	IEC	61000-4-12	Electromagnetic compatibility (EMC) - Part 4-12: Testing and measurement techniques - Ring wave immunity test
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
Test	IEC	61000-4-14	Electromagnetic compatibility (EMC) - Part 4-14: Testing and measurement techniques - Voltage fluctuation immunity test
Test	IEC	61000-4-15	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 15: Flickermeter - Functional and design specifications
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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
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Test	IEC	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
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Test	IEC	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
Test	IEC	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
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Test	IEC	CISPR 17	Methods of measurement of the suppression characteristics of passive EMC filtering devices
Test	IEC	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
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Test	IEC	TR 61000-4-35	Electromagnetic compatibility (EMC) - Part 4-35: Testing and measurement techniques - HPEM simulator compendium
Test	IEC	TR 61000-4-37	Electromagnetic compatibility (EMC) - Part 4-36: Testing and measurement techniques - IEMI immunity test methods for equipment and systems
Test	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
Test	IEC	TS 60816	Guide on methods of measurement of short duration transients on low-voltage power and signal lines
Wireless	ETSI EN	300 220	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25MHz to 1000MHz frequency range with power levels ranging up to 500mW
Wireless	ETSI EN	300 328	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2.4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering essential requirements
Wireless	ETSI EN	300 330	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 9kHz to 25MHz frequency range and inductive loop systems in the 9kHz to 30MHz frequency range
Wireless	ETSI EN	300 440	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 1GHz to 40GHz frequency range
Wireless	ETSI EN	301 489-17	Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Wideband data and HIPERLAN equipment
Wireless	ETSI EN	301 489-3	Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short Range Devices (SRD) operating on frequencies between 9kHz and 40GHz
Wireless	ETSI EN	301 893	Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements
Wireless	ETSI EN	303 413	GPS receivers
Wireless	ETSI EN	303 417	Wireless Power Transfer

EMC STANDARDS ORGANIZATIONS

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www.ansi.org

ANSI Accredited C63
www.c63.org

Asia Pacific Laboratory Accreditation Cooperation (APLAC)
https://www.apac-accreditation.org/

BSMI (Taiwan)
http://www.bsmi.gov.tw/wSite/mp?mp=95

Canadian Standards Association (CSA)
www.csa.ca

CISPR
http://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1298,25

CNCA (China)
http://www.cnca.gov.cn/

Electromagnetic Compatibility Industry Association UK
http://www.emcia.org

FDA Center for Devices & Radiological Health (CDRH)
https://www.fda.gov/MedicalDevices/default.htm

Federal Communications Commission (FCC)
www.fcc.gov

Gosstandart (Russia)
https://gosstandart.gov.by/en/

IEC
http://www.iec.ch/index.htm

IEEE Standards Association
https://standards.ieee.org/

IEEE EMC Society Standards Development Committee (SDCOM)
https://standards.ieee.org/develop/index.html

Industry Canada (Certifications and Standards)
http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf06165.html

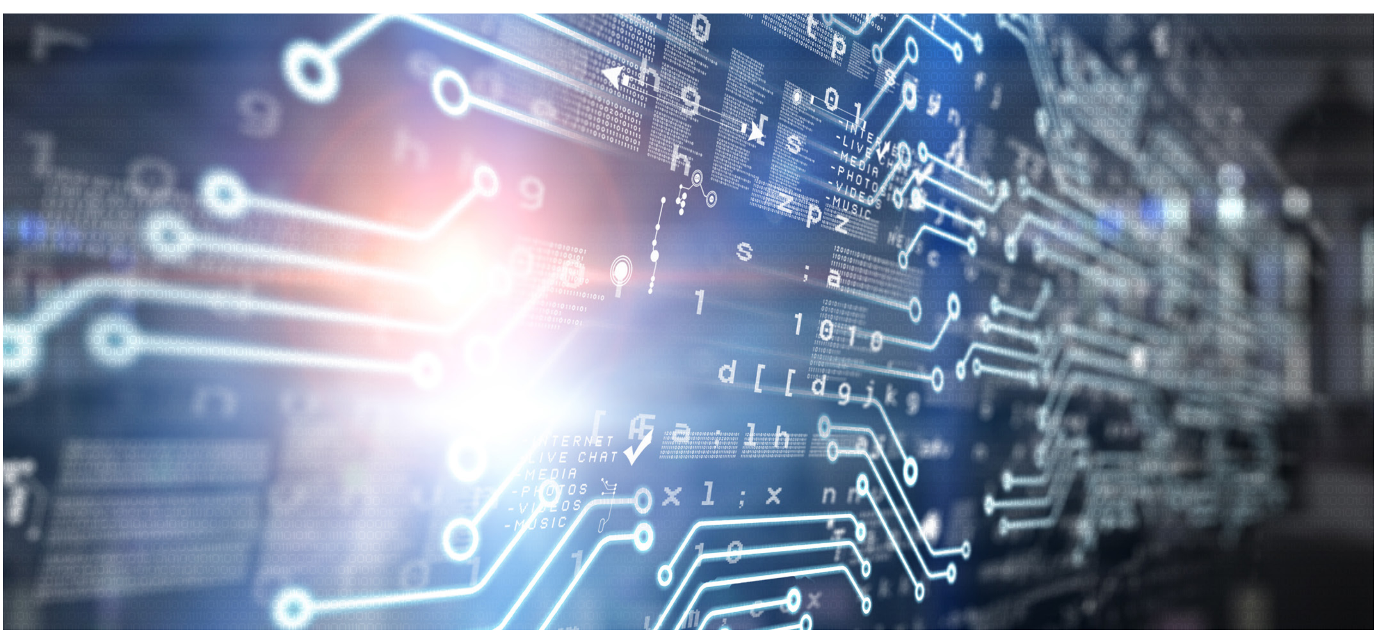
ISO (International Organization for Standards)
http://www.iso.org/iso/home.html

RTCA
https://www.rtca.org

SAE EMC Standards Committee
www.sae.org

SAE EMC Standards
http://www.sae.org/servlets/works/committeeHome.do?comtID=TEVEES17

VCCI (Japan, Voluntary Control Council for Interference)
http://www.vcci.jp/vcci_e/



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