APPLICATION NOTE

Making Conducted and Radiated Emissions Measurements

KEYSIGHT

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Introduction

Radiated and Conducted Emissions Measurements

The concept of getting a product to market on time and within budget is nothing new. Companies know electromagnetic interference (EMI) compliance testing can be a bottleneck in the product development process. To ensure successful EMI compliance testing, precompliance testing has been added to the product development cycle. This is a low risk, cost effective method to ensure your device will pass final compliance testing. In precompliance testing, the electromagnetic compatibility EMC performance is evaluated from design through production units. Figure 1 illustrates a typical product development cycle.

Many manufacturers use (EMI) measurement systems to perform conducted and radiated EMI emissions evaluation prior to sending their product to a test facility for full compliance testing. Conducted emissions testing focuses on unwanted signals that are on the AC mains generated by the device under test (DUT). The frequency range for these commercial measurements is from 9 kHz to 30 MHz, depending on the regulation. Radiated emissions testing looks for signals broadcast for the DUT through air. The frequency range for these measurements is between 30 MHz and 1 GHz, and based on the regulation, can go up to 6 GHz and higher. These higher test frequencies are based on the highest internal clock frequency of the DUT. This preliminary testing is called precompliance testing.

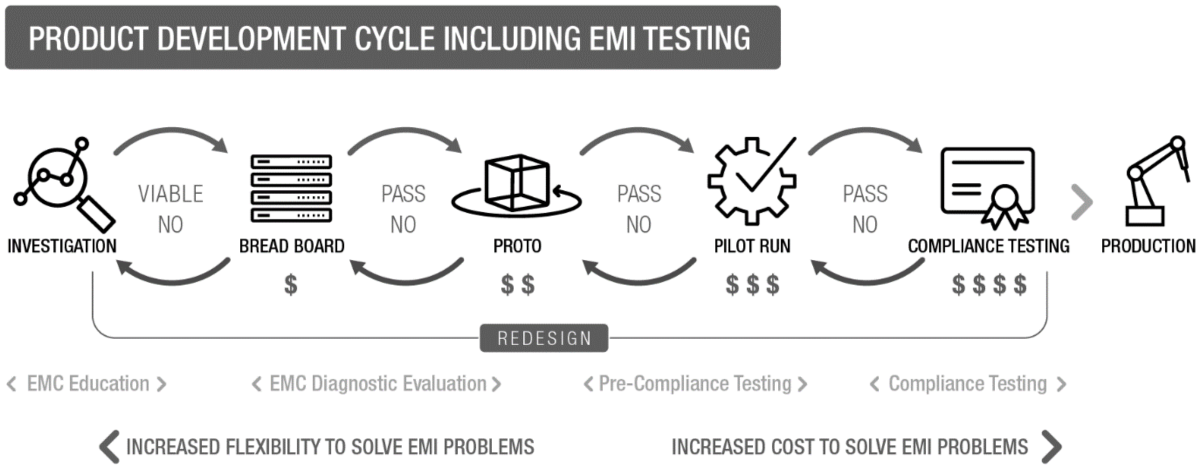


Figure 1. A typical product development cycle, including EMI testing.

Figure 2 illustrates the relationship between radiated emissions, radiated immunity, conducted emissions and conducted immunity. Radiated immunity is the ability of a device or product to withstand radiated electromagnetic fields. Conducted immunity is the ability of a device or product to withstand electrical disturbances on AC mains or data lines. In order to experience an electromagnetic compatibility (EMC) problem, such as when your radio interferes with your mobile phone reception and affects call quality, there must be a source or generator, coupling path and receptor. An EMC problem can be eliminated by removing one of these components.

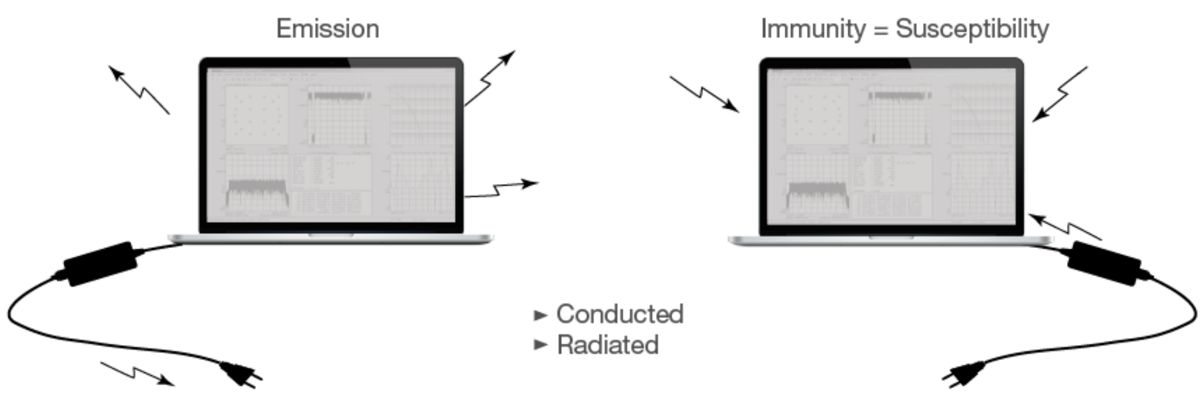


Figure 2. Electromagnetic compatibility between products.

European requirements pay special attention to product immunity. Product immunity is the level of electric field that a receptor can withstand before failure. The terms immunity and susceptibility are used interchangeably. This document will not cover immunity testing.

Precompliance versus full compliance EMI measurements

Full compliance measurements require the use of a receiver that meets the requirements set forth in CISPR16-1-1, a qualified open area test site or semi anechoic chamber and an antenna tower and turntable to maximize DUT signals. Great effort is taken to ensure accuracy and repeatability. These facilities can be quite expensive. In some specific cases, the full compliance receiver can be replaced by a signal analyzer with the correct bandwidths and detectors as long as the signal analyzer has the sensitivity required.

Precompliance measurements are intended to give an approximation of the EMI performance of the DUT. The cost of performing precompliance tests is a fraction of the cost of full compliance testing using an expensive facility.

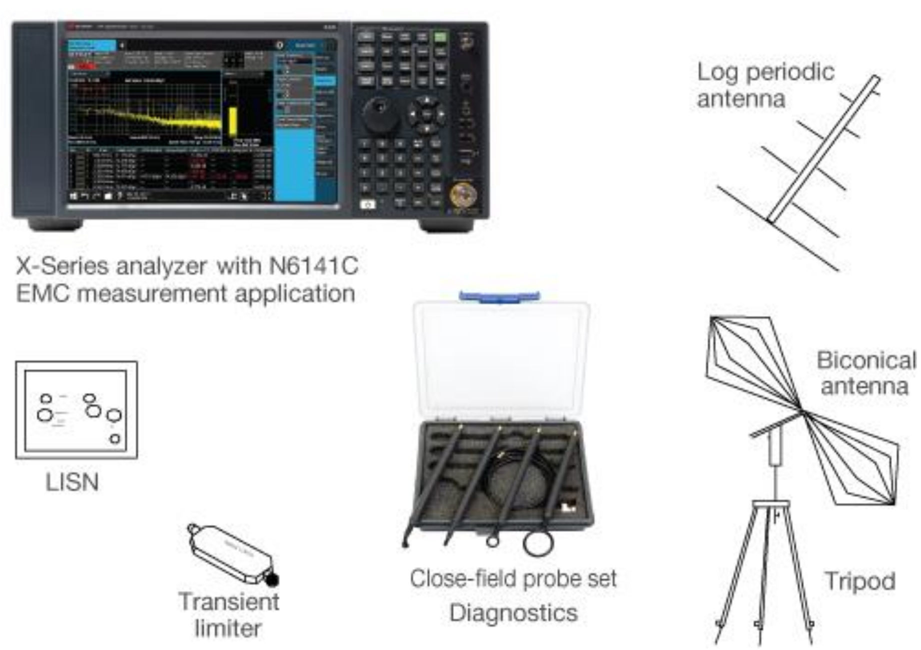
The more attention to detail in the measurement area, such as good ground plane and a minimal number reflective objects, the better the accuracy of the measurement.

Systems for performing precompliance measurements

The components used in systems for precompliance measurements are as follows: signal analyzer with N6141C EMI measurement application, line impedance stabilization network (LISN), transient limiter and antennas. To isolate problems after they have been identified, the close field probes N9311X-100 are used.

The environment for precompliance testing is usually less controlled than full compliance testing environments. See Figure 3 for the components used for precompliance testing.

EMI precompliance measurement system



Precompliance Measurements Process

The precompliance measurement process is fairly straightforward. However, before making measurements on your product, some preliminary questions must be answered.

1. Where will the product be sold (for example, Europe, United States, Japan)?
2. What is the classification of the product?
    - Information technology equipment (ITE)
    - Industrial, scientific or medical equipment (ISM)
    - Automotive or communication
    - Generic (equipment not found in other standards)
3. Where will the product be used (for example home, commercial, light industry or heavy industry)?

With the answers to these questions, you can determine which standard your product must be tested against. For example, if you determined that your product is an information technology equipment (ITE) device, and you are going to sell it in the U.S., then you need to test your product to the FCC 15 standard. Table 1 below will help you choose the requirement for your product.

Table 1. Comparision of regulatory agency requirements

Emissions reglations (summary)

FCC	CISPR	EN's	Description
18	11	EN 55011	Industrial, scientific and medical equipment
--	12	--	Automotive
15	13	EN 55013	Broadcast receivers
	14	EN 55014	Household appliances/tools
	15	EN 55015	Fluorescent lights/luminaries
15	22	EN 55022	Information technology equipment
	--	EN61000-6-3,4	Generic emissions standards
	16	--	Measurement apparatus/methods
	16	EN 55025	Automotive component test

European norms descriptions

EN55011 (CISPR 11) ISM

Class A: Products used in establishments other than domestic areas.

Class B: Products suitable for use in domestic establishments.

Group 1: Laboratory, medical and scientific equipment. (For example: signal generators, measuring receivers, frequency counters, spectrum analyzers, switching mode power supplies, weighing machines and electron microscopes.)

Group 2: Industrial induction heating equipment, dielectric heating equipment, industrial microwave heating equipment, domestic microwave ovens, medical apparatus, spark erosion equipment and spot welders. (For example: metal melting, billet heating, component heating, soldering and brazing, wood gluing, plastic welding, food processing, food thawing, paper drying and microwave therapy equipment.)

EN55014 (CISPR 14)

This standard applies to electric motor operated and thermal appliances for household items, electric tools, and similar purposes. Limit line use depends upon the power rating of the item. EN55014 distinguishes between household appliances, motors less than 700W, less than 1000W and greater than 1000W. Limits for conducted emissions are 150 kHz to 30 MHz, and limits for radiated emissions are 30 MHz to 300 MHz.

EN55022 (CISPR 22)

Equipment with the primary function of data entry, storage, displaying, retrieval, transmission, processing, switching or controlling is considered ITE. For example, data processing equipment, office machines, electronic equipment, business equipment or telecommunications equipment would be considered ITE.

There are two classes of ITE, Class A which is not intended for domestic use and Class B which is intended for domestic use.

Federal communications commission

The FCC has divided products to be tested in two parts, Part 15 and Part 18. Part 15 is further divided into intentional radiators and unintentional radiators.

Unintentional radiators include TV broadcast receivers, FM receivers, cable system terminal devices, personal computers and peripherals and external switching power supplies. Unintentional radiators are then again divided into Class A devices that are used in industrial, commercial or business environments and Class B devices that are marketed for use in a residential environment.

Part 18 devices are ISM.

FCC requirements summary

The frequency range of conducted emissions measurements is 450 kHz to 30 MHz and the frequency range of radiated emissions measurements is 30 MHz to 1 GHz and up to 40 GHz, based on the device clock frequency.

Table 2. FCC requirements summary.

FCC requirements (summary)

Equipment type	FCC part
Broadcast receivers	Part 15
Household appliances	Part 15
Fluorescent lights/luminaries	Part 15
Information technology equipment	Part 15
Equipment classification	
Class A Industrial	Part 15
Class B Residential	Part 15
Industrial, scientific and medical equipment	Part 18

Emissions Testing

Introduction

After the appropriate regulations have been identified, the next step is to set up the test equipment and perform radiated and conducted emissions tests. The first group of tests is conducted emissions. The typical process is to interconnect the appropriate equipment, load the limit line or lines, add the correction factors for the LISN and transient limit.

Conducted emissions testing

1. Connect the signal analyzer to the limiter, LISN and DUT as shown in Figure 4. Operation of the LISN and limiter is covered in Appendix A. Ensure that the power cord between the device under test (DUT) and the LISN is as short as possible. The power cord can become an antenna if longer than necessary. Measure the signals on the power line with the DUT off. If you see the signal approaching the established limit lines, then some additional shielding may be required. Do not use ferrites on the power cord because common mode signals from the DUT may be suppressed causing a lower value measurement.

2. Next, be sure you are measuring within the appropriate frequency range for conducted emissions measurements, 150 kHz to 30 MHz. Keysight's EMI measurement application uses a scan table to make it easy to select the appropriate frequency range as shown in Figure 5. Deselect any other ranges that are selected.

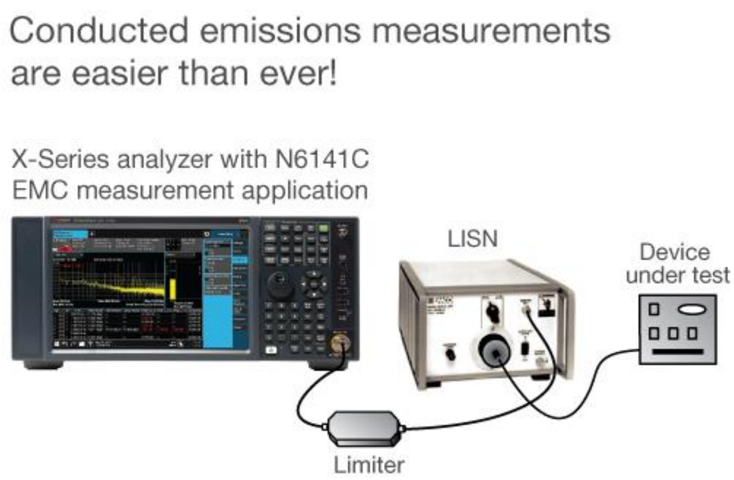


Figure 4. Conducted measurements interconnection.

Figure 5. Scan table.

1. Load limit lines and correction factors. In this case, the two limit lines used for conducted emissions are EN55022 Class A quasi-peak and EN55022 Class A EMI average. To compensate for measurement errors, add a margin to both limit lines.

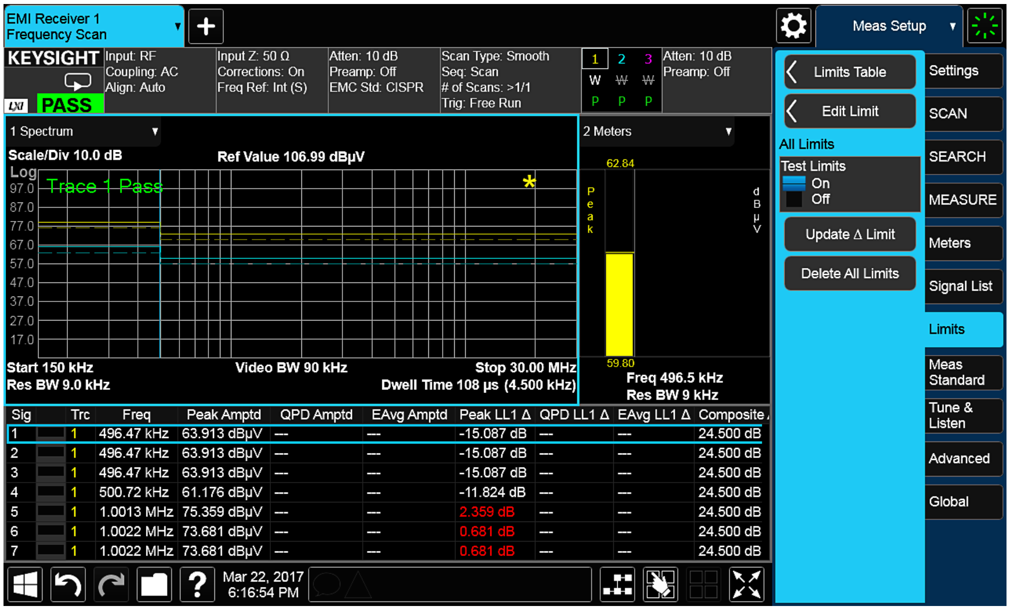


Figure 6. Conducted emissions display with limit lines and margin.

2. Correct for the LISN and the transient limiter which is used to protect the input mixer. The correction factors for the LISN and transient limiter are usually stored in the signal analyzer and they can be easily recalled (See Figure 7). View the ambient emissions (with the DUT off. If emissions above the limit are noted, the power cord between the LISN and the DUT may be acting as an antenna. Shorten the power cord to reduce the response to ambient signals.

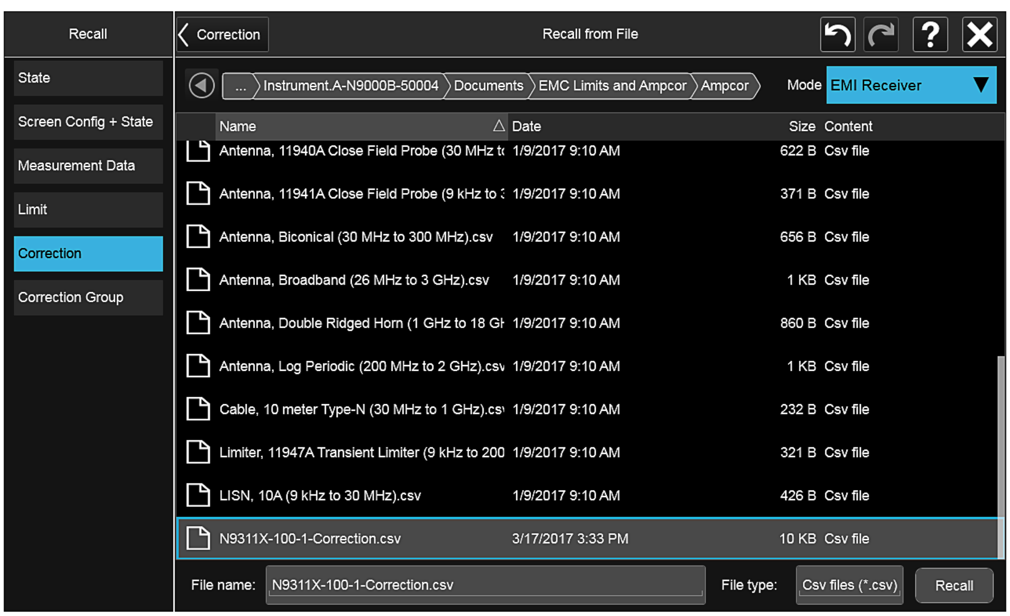
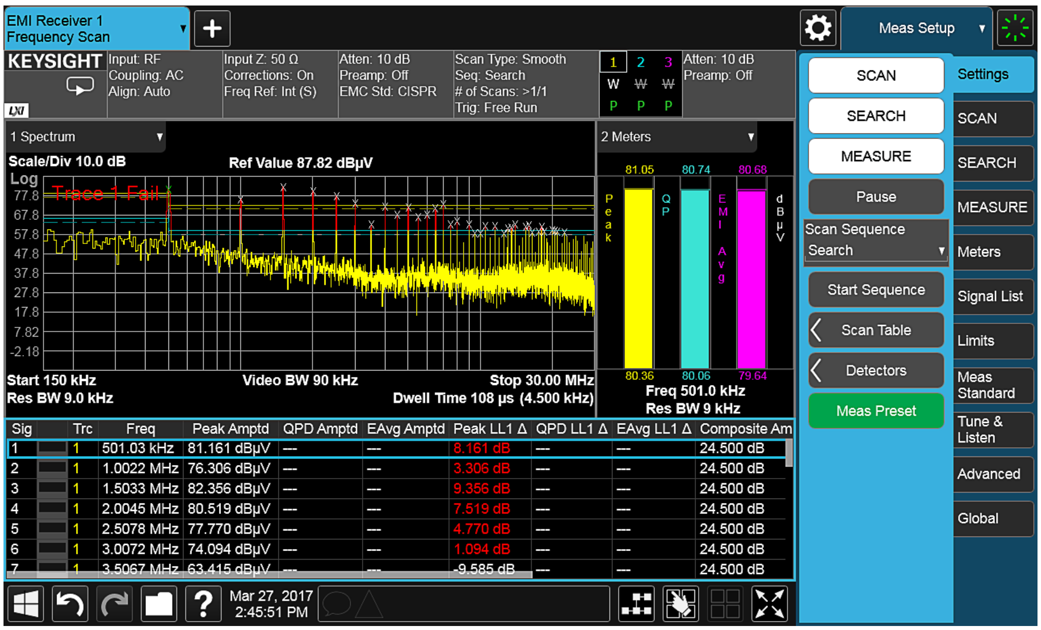


Figure 7. Conducted ambient emissions.

1. Switch on the DUT to find signals above the limit lines. This is a good time to check to make sure that the input of the signal analyzer is not overloaded. To do this, step the input attenuator up in value, if the display levels do not change, then there is no overload condition. If the display does change, then additional attenuation is required. The margin is also set so signals above the margin will also be listed. To identify the signals above the margin of either limit line, select scan and search to get the peak amplitude and frequency. The amplitude and frequency of the signals are displayed. In this case, 14 signals were captured (See Figure 8).



Sig	Trc	Freq	Peak Amptd	QPD Amptd	EAvg Amptd	Peak LL1 Δ	QPD LL1 Δ	EAvg LL1 Δ	Composite Am
1	1	501.03 kHz	81.161 dBµV	---	---	8.161 dB	---	---	24.500 dB
2	1	1.0022 MHz	76.306 dBµV	---	---	3.306 dB	---	---	24.500 dB
3	1	1.5033 MHz	82.356 dBµV	---	---	9.356 dB	---	---	24.500 dB
4	1	2.0045 MHz	80.519 dBµV	---	---	7.519 dB	---	---	24.500 dB
5	1	2.5078 MHz	77.770 dBµV	---	---	4.770 dB	---	---	24.500 dB
6	1	3.0072 MHz	74.094 dBµV	---	---	1.094 dB	---	---	24.500 dB
7	1	3.5067 MHz	63.415 dBµV	---	---	-9.585 dB	---	---	24.500 dB

Figure 8. Scan and search for signals above the limit.

2. Finally, the Quasi-peak and average of the signals need to be measured and compared to their respective limits. There are three detectors: Detector 1 will be set to peak, Detector 2 to Quasi-peak and Detector 3 to EMI average.

3. Review the measurement results. The QPD delta to Limit Line 1 and EAVE delta to Limit Line 2 should all have negative values. If some of the measurements are positive, then there is a problem with conducted emissions from the DUT. Check to be sure there is proper grounding if there are conducted emissions problems. Long ground leads can look inductive at higher conducted frequencies generated by switcher power supplies. If power line filtering is used, make sure that it is well grounded (See Figure 9).

Here are some additional hints when making conducted measurements:

1. If the signals you are looking at are in the lower frequency range of the conducted band (2 MHz or lower), you can reduce the stop frequency to get a closer look.

2. You may also note that there are fewer data points to view. You can add more data points by changing the scan table.

3. The default in the scan table is two data points per bandwidth, or 4.5 KHz per point. To get more data points, change the points per BW to 2.25 or 1.125 to give four or eight points per BW.

Radiated emissions measurements preparation

Performing radiated emissions measurements is not as straightforward as performing conducted emissions measurements. There is the added complexity of the ambient environment which could interfere when measuring the emissions from a DUT. There are some methods that can be used to discriminate between ambient environment and signals from the DUT. In more populated metropolitan areas, ambient environments could be extremely dense, overpowering emissions from a DUT. Testing in a semianechoic chamber can simplify and accelerate measurements because the ambient signals are no longer present. Chambers are an expensive alternative to open area testing. Following are some methods for determining if a signal is ambient:

1. The simplest method is to turn off the DUT to see if the signal remains. However, some DUTs are not easily powered down and up.
2. Use the tune and listen feature of the signal analyzer to determine if the signal is a local radio station. This method is useful for AM, FM or phase modulated signals.
3. If your device is placed on a turntable, rotate the device while observing a signal in question. If the signal amplitude remains constant during device rotation, then the signal is more likely to be an ambient signal. Signals from a DUT usually vary in amplitude based on its position.
4. A more sophisticated method of ambient discrimination is the two-antenna method. Place one antenna at the prescribed distance as called out by the regulatory body, and a second antenna at twice the distance of the first antenna. Connect the two antennas to a switch, which is then connected to the signal analyzer. If the signal is the same amplitude at both antennas, then the signal is likely to be an ambient signal. If the signal at the second antenna is 6 dB lower, then the signal originates from the DUT.

Setting up the equipment for radiated emissions measurements

1. Arrange the antenna, DUT and signal analyzer as shown in Figure 10. Separate the antenna and the DUT as specified by the regulator agency requirements. If space is limited, then the antenna can be moved closer to the DUT and you can edit the limits to reflect the new position. For example, if the antenna is moved from 10 meters to 3 meters, then the amplitude must be adjusted by 10.45 dB. It is important that the antenna is not placed in the near field of the radiating device which is l/2π or 15.9 MHz for 3 meters. Most commercial radiated emissions start at 30 MHz.

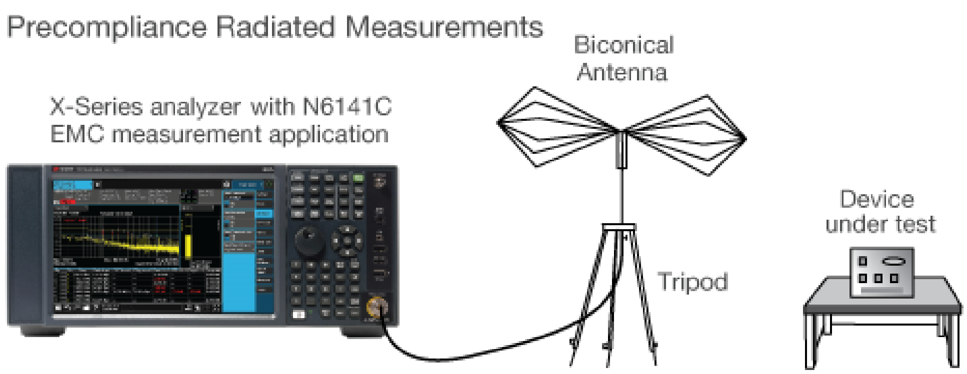


Figure 10. Radiated emissions test setup.

2. Set up the signal analyzer for the correct span, bandwidths and limit lines with margin included. After the signal analyzer has been powered up and completed its calibration, use the scan table to select Range 3, and deselect all others. This gives a frequency range of 30 MHz to 300 MHz, bandwidth of 120 kHz and two data points per bandwidth. Load limit lines for EN55022 Class A. To get the best sensitivity, switch on the signal analyzer's preamplifier and set the attenuator to 0 dB.

Performing radiated emissions measurements

The goal of radiated emissions testing is to identify and measure signals emitting from the DUT. If the signals measured using the correct detector are below the margin set at the beginning of the measurement, then the DUT passes. These measurements must be repeated for each face of the DUT. The orientation change of the DUT is achieved using a turntable. The test sequence follows:

1. With the DUT off, perform a scan and search of the signals over the band of interest, and store the list of frequency amplitude pairs to a file you may want to mark ambient.
2. With the DUT on and oriented at the 0-degree position, perform a scan and search.
3. A second group of signals will be added to the existing ambient signals in the list.
4. Search for duplicates using the “mark all duplicates.”
5. Delete the marked signal, which now leaves only the DUT signals (and those that were not present during the ambient scan).
6. Perform measurements using the QP detector and compare to delta limit.
7. If the signals are below the limit, then the DUT passes. If not, then some work needs to be done to improve emissions. Store the signals shown in Figure 14 for future reference when troubleshooting problems.

Repeat the process, Step 1-7, for another position of the turntable, such as 90 degrees. If you have stored the ambient signal in the previous measurement, then you recall the list and process with Step 2, which is where the DUT is switched on.

After you have observed the DUT on all four sides you will have a list of signals for each side. If you note a signal that is the same amplitude for all four sides of the DUT, it could be an ambient signal that was missed during the ambient scan.

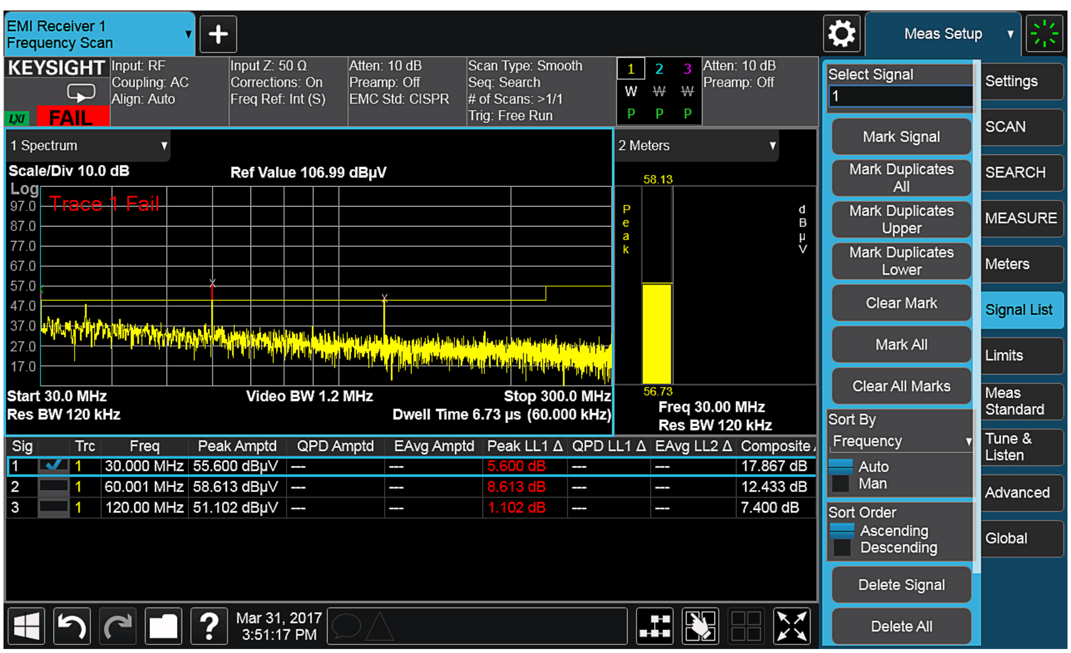
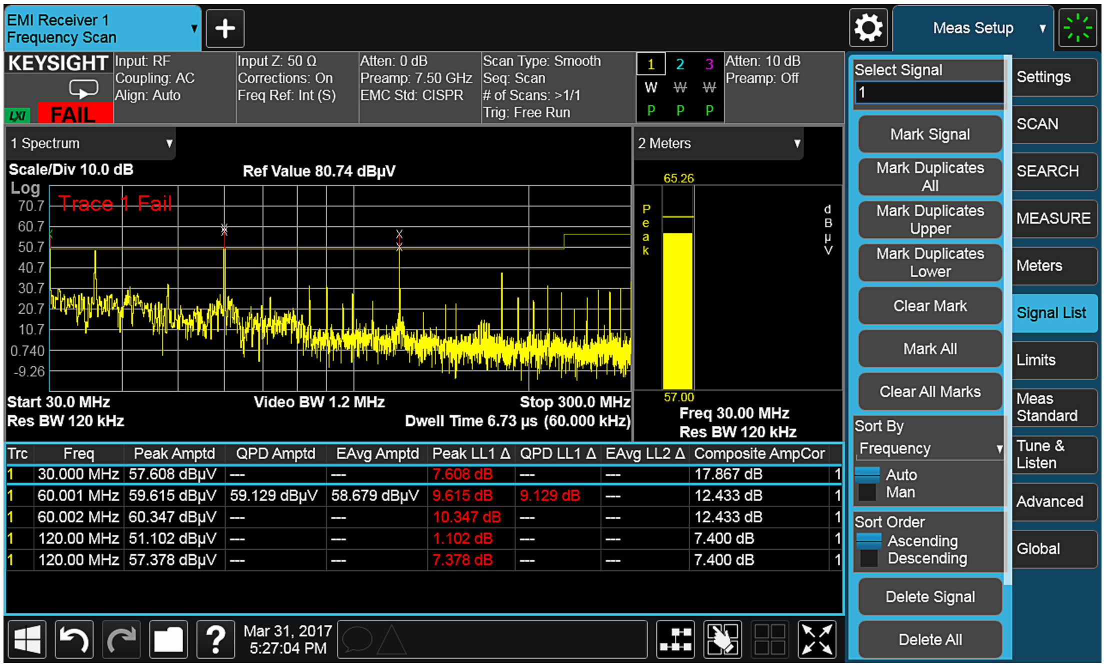
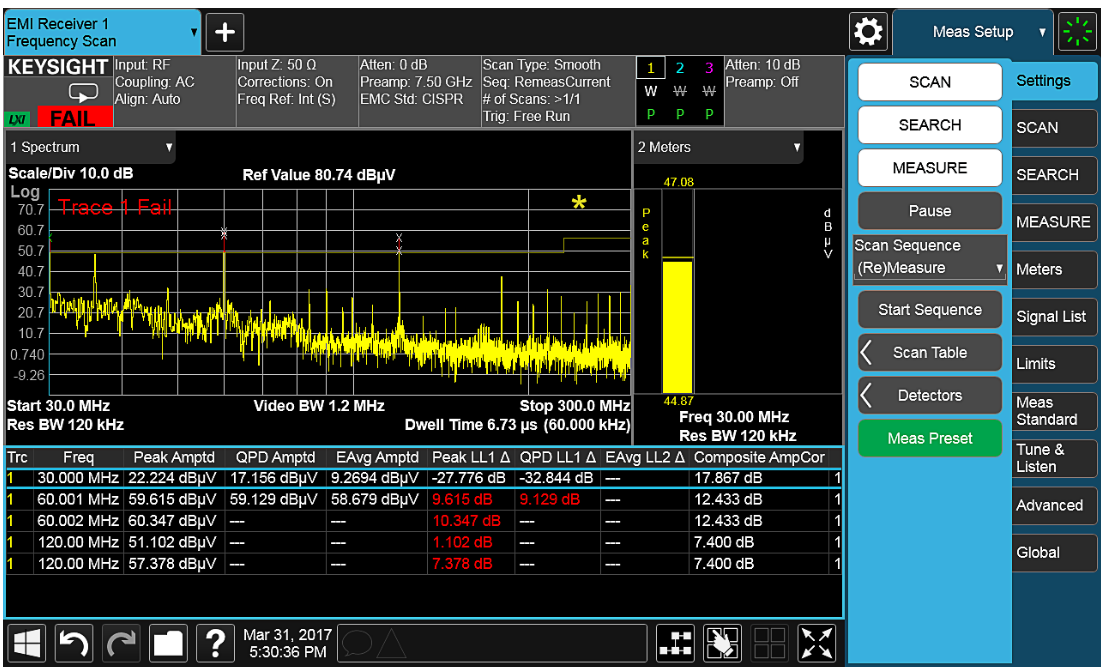


Figure 11. Mark ambient noise and delete it.



Trc	Freq	Peak Amptd	QPD Amptd	EAvg Amptd	Peak LL1 Δ	QPD LL1 Δ	EAvg LL2 Δ	Composite AmpCor
1	30.000 MHz	57.608 dBµV	---	---	7.608 dB	---	---	17.867 dB
1	60.001 MHz	59.615 dBµV	59.129 dBµV	58.679 dBµV	9.615 dB	9.129 dB	---	12.433 dB
1	60.002 MHz	60.347 dBµV	---	---	10.347 dB	---	---	12.433 dB
1	120.00 MHz	51.102 dBµV	---	---	1.102 dB	---	---	7.400 dB
1	120.00 MHz	57.378 dBµV	---	---	7.378 dB	---	---	7.400 dB

Figure 12. Duplicate ambient signals marked.



Trc	Freq	Peak Amptd	QPD Amptd	EAvg Amptd	Peak LL1 Δ	QPD LL1 Δ	EAvg LL2 Δ	Composite AmpCor
1	30.000 MHz	22.224 dBµV	17.156 dBµV	9.2694 dBµV	-27.776 dB	-32.844 dB	---	17.867 dB
1	60.001 MHz	59.615 dBµV	59.129 dBµV	58.679 dBµV	9.615 dB	9.129 dB	---	12.433 dB
1	60.002 MHz	60.347 dBµV	---	---	10.347 dB	---	---	12.433 dB
1	120.00 MHz	51.102 dBµV	---	---	1.102 dB	---	---	7.400 dB
1	120.00 MHz	57.378 dBµV	---	---	7.378 dB	---	---	7.400 dB

Figure 13. DUT signals with quasi-peak measurement compared to limit.

Problem Solving and Troubleshooting

After the product is tested and the results are recorded and saved, your product is either ready for full compliance testing and production, or it must go back to the bench for further diagnosis and repair.

If your product needs further redesign, the following process is recommended:

1. Connect the diagnostics tools as shown in Figure 15.
2. From your previous radiated tests, identify the problem frequencies.
3. Use the probe to locate the source or sources of the problem signals.
4. With the probe placed to give the maximum signal on the analyzer, save the trace to internal memory.
5. Make circuit changes as necessary to reduce the emissions.
6. Measure the circuit again using the same setting as before and save the results in another trace.
7. Recall the previously saved trace and compare the results to the current measurement.

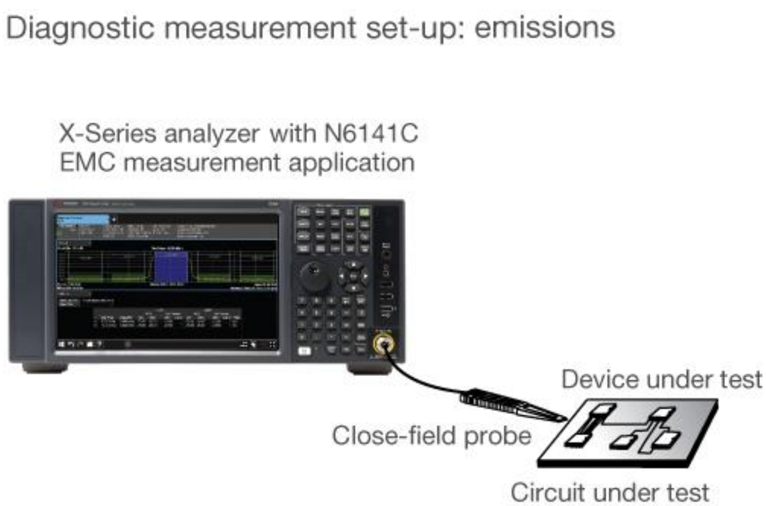


Figure 14. Diagnostics setup interconnection.

Diagnostics testing setup

It is recommended that the spectrum analyzer mode be used for diagnosis. Correction factors for the probe should be loaded from the internal memory. The Keysight N9311X-100 probe kit contains four H-field probes, covering 30 MHz - 3 GHz frequency range, with different sensitivity and resolution. Place the signal analyzer into the spectrum analyzer mode. Connect the probe for the appropriate frequency range and recall the correction factors from internal memory.

Problem isolation

Using information stored earlier from the conducted and radiated tests, tune the signal analyzer to one of the problem frequencies with a narrow enough span to give adequate differentiation between signals. Move the close field probe slowly over the DUT. Observe the display for maximum emissions as you isolate the source of the emissions. After you have isolated the source of the emissions, record the location and store the display to an internal register (See Figure 15).

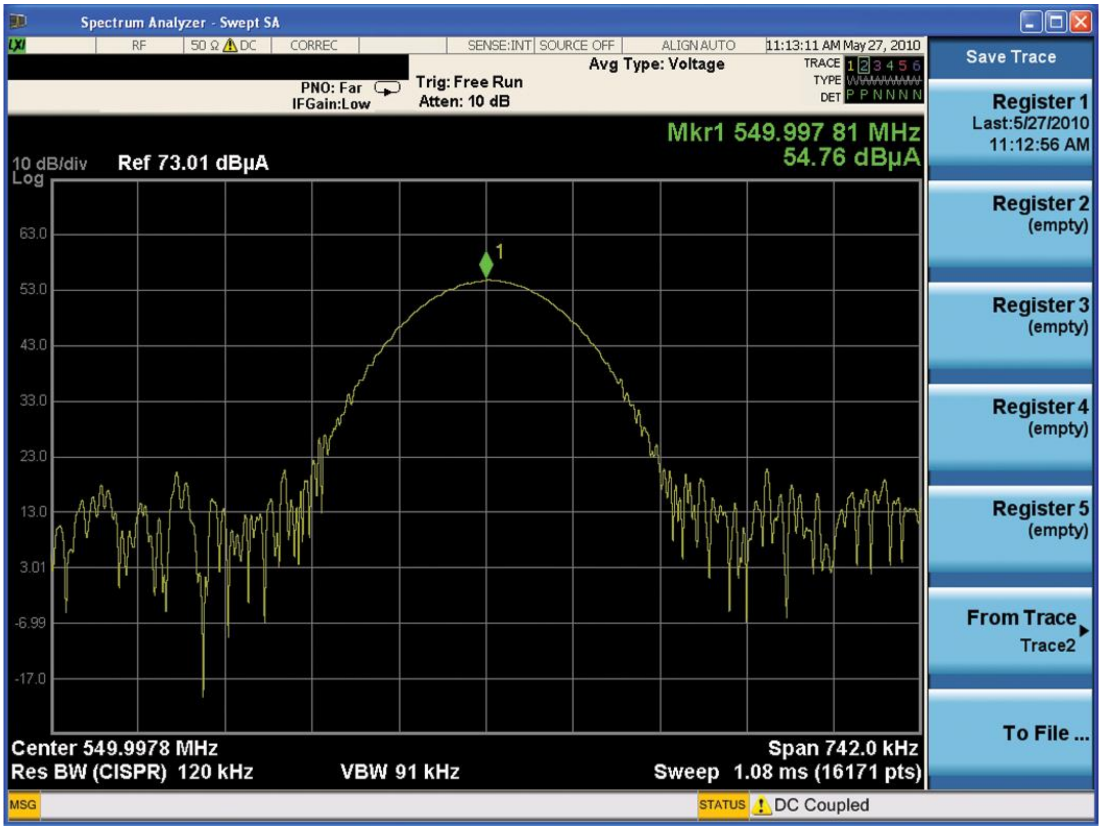


Figure 15. Preliminary diagnostics trace.

The next step is to make design changes to reduce emissions. This can be accomplished by adding or changing circuit components, redesigning the problem circuit or adding shielding. After the redesign, compare the results again to the previously recorded trace.

With your probe on the trouble spot, compare the emissions before and after repairing the problem. As you can see from the difference between the two traces in Figure 17, there has been about a 10 dB improvement in the emissions. There is a one-to-one correlation between changes in close field probe measurements and changes in far field measurements. For example, if you note a 10 dB change in measurements made by a close field probe, you will also note a 10 dB change when you perform a far field measurement using an antenna and a signal analyzer.

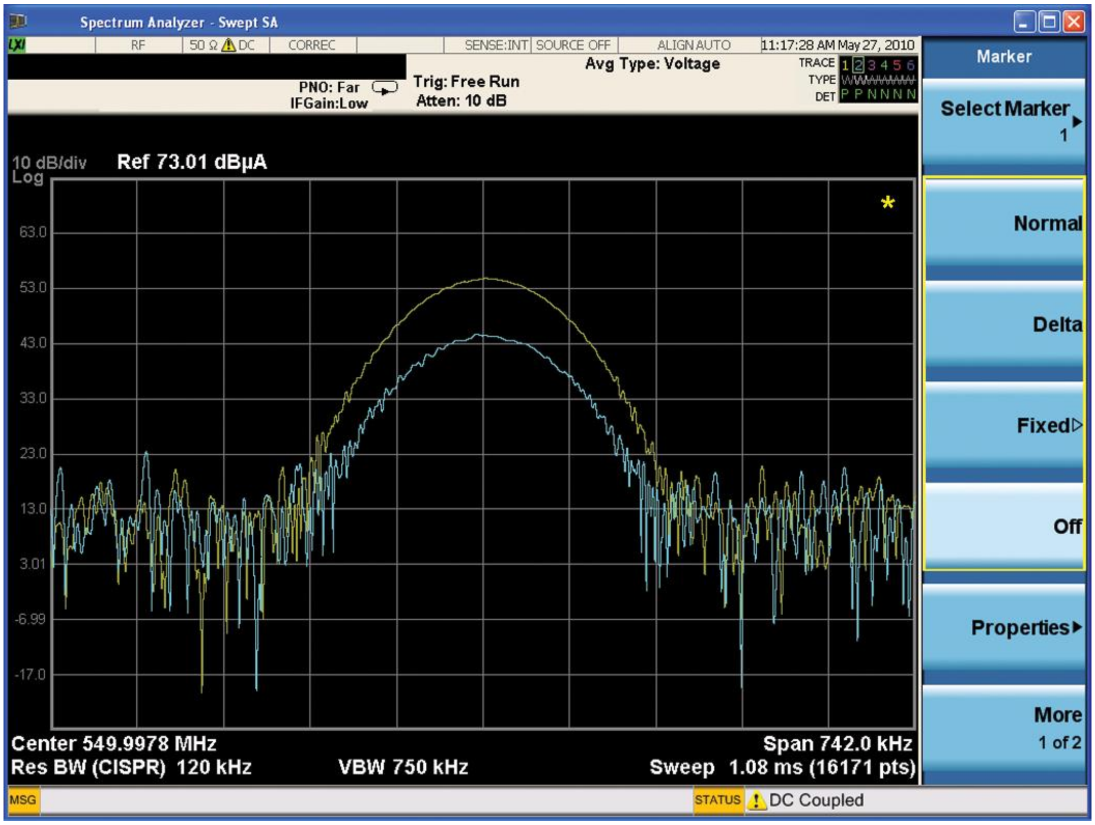


Figure 16. Diagnostics traces before and after redesign.

Appendix A: Line Impedance Stabilization Networks (LISN)

A1.0 Purpose of a LISN

A line impedance stabilization network serves three purposes:

1. The LISN isolates the power mains from the equipment under test. The power supplied to the DUT must be as clean as possible. Any noise on the line will be coupled to the X-Series signal analyzer and interpreted as noise generated by the DUT.

2. The LISN isolates any noise generated by the DUT from being coupled to the power mains. Excess noise on the power mains can cause interference with the proper operation of other devices on the line.

3. The signals generated by the DUT are coupled to the X-Series analyzer using a high-pass filter, which is part of the LISN. Signals that are in the pass band of the high-pass filter see

A1.1 LISN operation

The diagram in Figure A-1 below shows the circuit for one side of the line relative to earth ground.

The 1 μF in combination with the 50 μH inductor is the filter that isolates the mains from the DUT. The 50 μH inductor isolates the noise generated by the DUT from the mains. The 0.1μF couples the noise generated by the DUT to the X-Series signal analyzer or receiver. At frequencies above 150 kHz, the DUT signals are presented with a 50-Ω impedance.

The chart in Figure A-1 represents the impedance of the DUT port versus frequency.

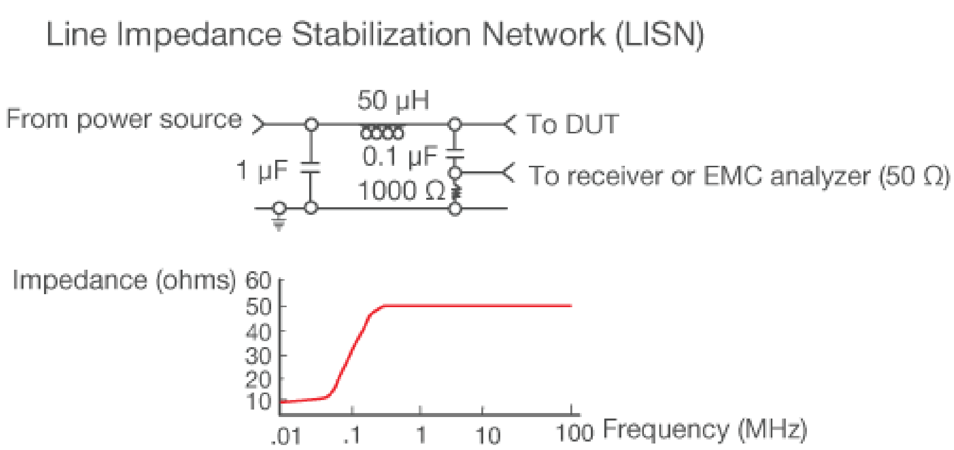


Figure A-1. Typical LISN circuit diagram.

A1.2 Types of LISNs

The most common type of LISN is the V-LISN. It measures the unsymmetric voltage between line and ground. This is done for both the hot and the neutral lines or for a three-phase circuit in a "Y" configuration, between each line and ground. There are other specialized types of LISNs. A delta LISN measures the line-to-line or symmetric emissions voltage. The T-LISN, sometimes used for telecommunications equipment, measures the asymmetric voltage, which is the potential difference between the midpoint potential between two lines and ground.

A2.0 Transient limiter operation

The purpose of the limiter is to protect the input of the EMC analyzer from large transients when connected to a LISN. Switching DUT power on or off can cause large spikes generated in the LISN.

Appendix B: Antenna Factors

B1.0 Field strength units

Radiated EMI emissions measurements measure the electric field. The field strength is calibrated in dBμV/m. Field strength in dBμV/m is derived from the following:

P_t = total power radiated from an isotropic radiator

P_D = the power density at a distance r from the isotropic radiator (far field)

$P_D = P_t / 4\pi r^2$

$R = 120\pi\Omega$

$P_D = E^2/R$

$E^2/R = P_t / 4\pi r^2$

$E = (P_t \times 30)^{1/2} / r$ (V/m)

Far field[1] is considered to be $> \lambda/2\pi$

B1.1 Antenna factors

The definition of antenna factors is the ratio of the electric field in volts per meter present at the plane of the antenna versus the voltage out of the antenna connector.

[1] Far field is the minimum distance from a radiator where the field becomes a planar wave.

Note: Antenna factors are not the same as antenna gain.

B1.2 Types of antennas used for commercial radiated measurements

There are three types of antennas used for commercial radiated emissions measurements.

Biconical antenna: 30 MHz to 300 MHz

Log periodic antenna: 200 MHz to 1 GHz (the biconical and log periodic overlap frequency)

Broadband antenna: 30 MHz to 1 GHz (larger format than the biconical or log periodic antennas)

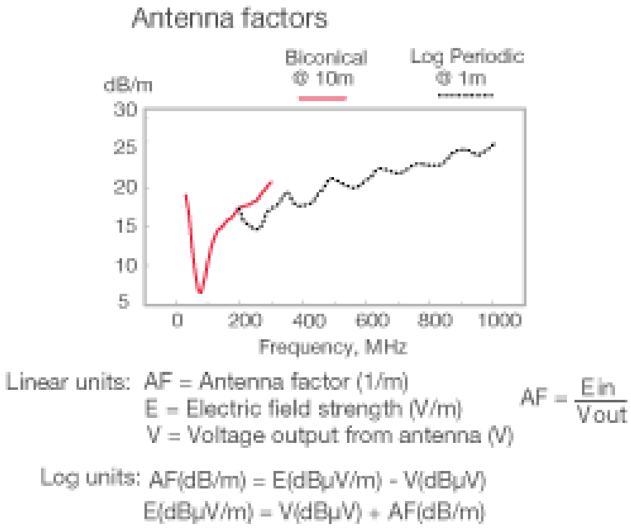


Figure B-1. Typical antenna factor shapes.

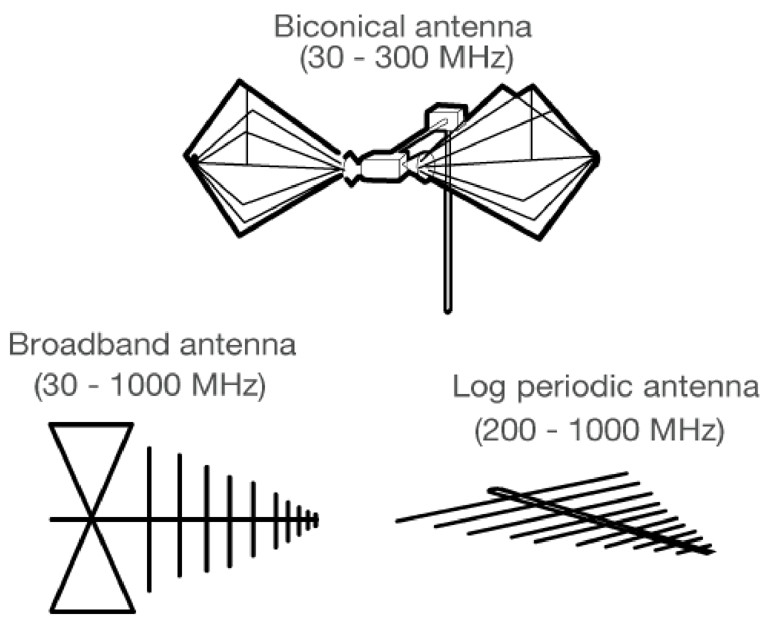


Figure B-2. Antennas used in EMI emissions measurements.

Appendix C: Basic Electrical Relationships

The decibel is used extensively in electromagnetic measurements. It is the log of the ratio of two amplitudes. The amplitudes are in power, voltage, amps, electric field units and magnetic field units.

decibel = dB = 10 log (P_2 /P_1)

Data is sometimes expressed in volts or field strength units. In this case, replace P with V^2/ R.

If the impedances are equal, the equation becomes:

dB = 20 log (V_2 / V_1)

A unit of measure used in EMI measurements is dBµV or dBµA. The relationship of dBµV and dBm is as follows:

dBµV = 107 + P_{dBm}

This is true for an impedance of 50 Ω.

Wave length (l) is determined using the following relationship:

$\lambda = 3 \times 10^8/f$ (Hz) or $\lambda = 300/f$ (MHz)

Appendix D: Detectors Used in EMI Measurements

D1.0 Peak detector

Initial EMI measurements are made using the peak detector. This mode is much faster than quasi-peak, or average modes of detection. Signals are normally displayed on spectrum analyzers or EMC analyzers in peak mode. Since signals measured in peak detection mode always have amplitude values equal to or higher than quasi-peak or average detection modes, it is a very easy process to take a sweep and compare the results to a limit line. If all signals fall below the limit, then the product passes and no further testing is needed.

D1.1 Peak detector operation

The EMC analyzer has an envelope or peak detector in the IF chain that has a time constant, such that the voltage at the detector output follows the peak value of the IF signal at all times. In other words, the detector can follow the fastest possible changes in the envelope of the IF signal, but not the instantaneous value of the IF sine wave (See Figure D-1).

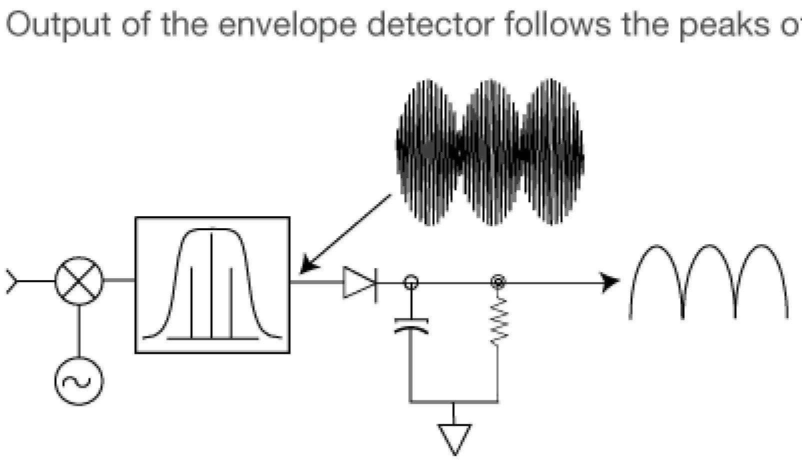


Figure D-1. Peak detector diagram.

D2.0 Quasi-peak detector

Most radiated and conducted limits are based on quasi-peak detection mode. Quasipeak detectors weigh signals according to their repetition rate, which is a way of measuring their annoyance factor. As the repetition rate increases, the quasi-peak detector does not have time to discharge as much, resulting in a higher voltage output (See Figure D-2). For continuous wave (CW) signals, the peak and the quasi-peak are the same.

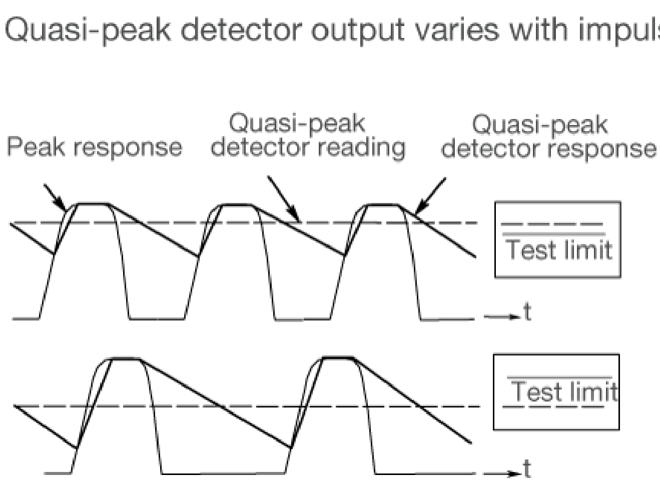


Figure D-2. Quasi-peak detector response diagram.

Since the quasi-peak detector always gives a reading less than or equal to peak detection, why not use quasi-peak detection all the time? Won't that make it easier to pass EMI tests? It's true that you can pass the tests more easily; however, quasi-peak measurements are much slower by two or three orders of magnitude compared to using the peak detector.

D2.1 Quasi-peak detector operation

The quasi-peak detector has a charge rate much faster than the discharge rate; therefore, the higher the repetition rate of the signal, the higher the output of the quasipeak detector. The quasi-peak detector also responds to different amplitude signals in a linear fashion. High-amplitude, low-repetition-rate signals could produce the same output as low-amplitude, high-repetition-rate signals.

D3.0 Average detector

The average detector is required for some conducted emissions tests in conjunction with using the quasi-peak detector. Also, radiated emissions measurements above 1 GHz are performed using average detection. The average detector output is always less than or equal to peak detection.

D3.1 Average detector operation

Average detection is similar in many respects to peak detection. Figure D-3 shows a signal that has just passed through the IF and is about to be detected. The output of the envelope detector is the modulation envelope. Peak detection occurs when the post detection bandwidth is wider than the resolution bandwidth. For average detection to take place, the peak detected signal must pass through a filter whose bandwidth is much less than the resolution bandwidth. The filter averages the higher frequency components, such as noise at the output of the envelope detector.

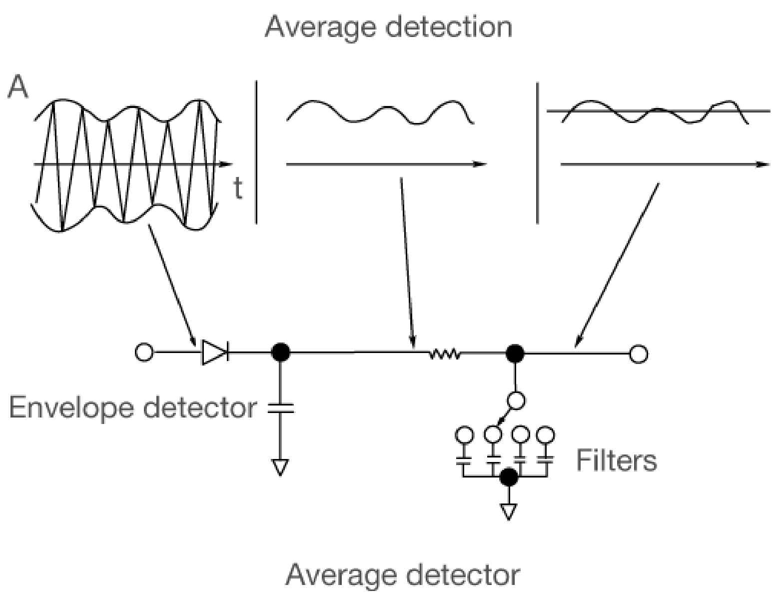


Figure D-3. Average detection response diagram.

Appendix E

EMC regulatory agencies

IEC and CISPR

Geneva, Switzerland

IEC www.iec.ch

CISPR http://www.iec.ch/emc/iec_emc/iec_emc_players_cispr.htm

ITU-R (CCIR)

ITU, General Secretariat, Sales Service

Geneva, Switzerland

http://www.itu.int/ITU-R

Australia

Australia Electromechanical Committee Standards Association of Australia

Sydney, Australia

AustraliaElecto-technical Committee

http://www.ihs.com.au/standards/iec/

Belgium

Comite Electrotechnique Belge

Brussels, Belgium

http://www.ceb-bec.be

Canada

Standards Council of Canada Standards Sales Division

Ottawa, ON Canada

http://www.scc.ca

Canadians Standards Association - CSA

Mississauga, Ontario, Canada

http://www.csa.ca

Denmark

Dansk Elektroteknisk Komite

Nordhavn, Denmark

http://www.ds.dk/en

France

Comite Electrotechnique Francais

Brussels, Belgium

http://www.cenelec.eu/

Germany

VDE VERLAG GmbH

Berlin, Germany

http://vde-verlag.de/english.html

India

Bureau of Indian Standards, Sales Department

New Delhi, India

http://www.bis.org.in

Italy

CEI-Comitato Elettrotecnico Italiano

Milano, Italy

http://www.ceiweb.it

Japan

Japanese Standards Association

Tokyo, Japan

http://www.jsa.or.jp/default_english.asp

Netherlands

Nederlands Normalisatie-Instituut

Delft, Netherlands

http://www.nen.nl/

Norway

Norsk Elektroteknisk Komite

Lysaker, Norway

http://www.standard.no/toppvalg/nek/

South Africa

South African Bureau of Standards

Electronic Engineering Department

Pretoria, Republic of South Africa

https://www.sabs.co.za/Sectors-and-Services/Sectors/Electronics/index.asp

Spain

Comite Nacional Espanol de la CEI

Madrid, Spain

http://www.aenor.es

Sweden

Svenska Elektriska Kommissionen

Stockholm, Sweden

http://www.elstandard.se/standarder/emc_standarder.asp

Switzerland

Swiss Electrotechnical Committee

Swiss Electromechanical Association

Fehraltorf, Switzerland

http://www.electrosuisse.ch/

United Kingdom

BSI Standards

London, United Kingdom

http://www.bsigroup.com

British Defence Standards DStan Helpdesk

UKDefence Standardization

Glasgow, Scotland

http://www.gov.uk/uk-defence-standardization

United States of America

America National Standards Institute Inc.

Washington, DC

http://www.ansi.org

FCC Rules and Regulations Wireless

Telecommunications Branch

Washington, DC

http://www.fcc.gov

FCC Equipment Authorization Branch

Columbia, MD

http://www.fcc.gov

Glossary of Acronyms and Definitions

Ambient level

- The values of radiated and conducted signal and noise existing at a specified test location and time when the test sample is not activated.
- Those levels of radiated and conducted signal and noise existing at a specified test location and time when the test sample is inoperative. Atmospherics, interference from other sources, and circuit noise, or other interference generated within the measuring set compose the ambient level.

Amplitude modulation

- In a signal transmission system, the process, or the result of the process, where the amplitude of one electrical quantity isvaried in accordance with some selected characteristic of a second quantity, which need not be electrical in nature.
- The process by which the amplitude of a carrier wave is varied following a specified law.

Anechoic chamber

- A shielded room which is lined with radio absorbing material to reduce reflections from all internal surfaces. Fully lined anechoic chambers have such material on all internal surfaces, wall, ceiling and floor. Its also called a "fully anechoic chamber." A semi-anechoic chamber is a shielded room which has absorbing material on all surfaces except the floor.

Antenna (aerial)

- A means for radiated or receiving radio waves.
- A transducer which either emits radio frequency power into space from a signal source or intercepts an arriving electromagnetic field, converting it into an electrical signal.

Antenna factor

The factor which, when properly applied to the voltage at the input terminals of the measuring instrument, yields the electric field strength in volts per meter and a magnetic field strength in amperes per meter.

Antenna induced voltage

The voltage which is measured or calculated to exist across the open circuited antenna terminals.

Antenna terminal conducted interference

Any undesired voltage or current generated within a receiver, transmitter, or their associated equipment appearing at the antenna terminals.

Auxiliary equipment

Equipment not under test that is nevertheless indispensable for setting up all the functions and assessing the correct performance of the DUT during its exposure to the disturbance.

Balun

A balun is an antenna balancing device, which facilitates use of coaxial feeds with symmetrical antennae such as a dipole.

Broadband emission

Broadband is the definition for an interference amplitude when several spectral lines are within the RFI receivers specified bandwidth.

Broadband interference (measurements)

A disturbance that has a spectral energy distribution sufficiently broad, so that the response of the measuring receiver in use does not vary significantly when tuned over a specified number of receiver bandwidths.

Conducted interference

Interference resulting from conducted radio noise or unwanted signals entering a transducer (receiver) by direct coupling.

Cross coupling

The coupling of a signal from one channel, circuit, or conductor to another, where it becomes an undesired signal.

Decoupling network

A decoupling network is an electrical circuit for preventing test signals which are applied to the DUT from affecting other devices, equipment, or systems that are not under test. IEC 801-6 states that the coupling and decoupling network systems can be integrated in one box or they can be in separate networks.

Dipole

- An antenna consisting of a straight conductor usually not more than a half-wavelength long, divided at its electrical center for connection to a transmission line.
- Any one of a class of antennas producing a radiation pattern approximating that of an elementary electric dipole.

Electromagnetic compatibility (EMC)

- The capability of electronic equipment of systems to be operated within defined margins of safety in the intended operating environment at designed levels of efficiency without degradation due to interference.
- EMC is the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable disturbances into that environment or into other equipment.

Electromagnetic interference

Electromagnetic interference is the impairment of a wanted electromagnetic signal by an electromagnetic disturbance.

Electromagnetic wave

The radiant energy produced by the oscillation of an electric charge characterized by oscillation of the electric and magnetic fields.

Emission

Electromagnetic energy propagated from a source by radiation or conduction.

Far field

The region where the power flux density from an antenna approximately obeys an inverse squares law of the distance. For a dipole this corresponds to distances greater than l/2 where l is the wave length of the radiation.

Ground plane

- A conducting surface or plate used as a common reference point for circuit returns and electric or signal potentials.
- A metal sheet or plate used as a common reference point for circuit returns and electrical or signal potentials.

Immunity

- The property of a receiver or any other equipment or system enabling it to reject a radio disturbance.
- The ability of electronic equipment to withstand radiated electromagnetic fields without producing undesirable responses.

Intermodulation

Mixing of two or more signals in a nonlinear element, producing signals at frequencies equal to the sums and differences of integral multiples of the original signals.

Isotropic

Isotropic means having properties of equal values in all directions.

Monopole

An antenna consisting of a straight conductor, usually not more than one-quarter wave length long, mounted immediately above, and normal to, a ground plane. It is connected to a transmission line at its base and behaves, with its image, like a dipole.

Narrowband emission

That which has its principal spectral energy lying within the bandpass of the measuring receiver in use.

Open area

A site for radiated electromagnetic interference measurements which is open flat terrain at a distance far enough away from buildings, electric lines, fences, trees, underground cables, and pipe lines so that effects due to such are negligible. This site should have a sufficiently low level of ambient interference to permit testing to the required limits.

Polarization

A term used to describe the orientation of the field vector of a radiated field.

Radiated interference

Radio interference resulting from radiated noise of unwanted signals. Compare radio frequency = interference below.

Radiation

The emission of energy in the form of electromagnetic waves.

Radio frequency interference

RFI is the high frequency interference with radio reception. This occurs when undesired electromagnetic oscillations find entrance to the high frequency input of a receiver or antenna system.

RFI sources

Sources are equipment and systems as well as their components which can cause RFI.

Shielded enclosure

A screened or solid metal housing designed expressly for the purpose of isolating the internal from the external electromagnetic environment. The purpose is to prevent outside ambient electromagnetic fields from causing performance degradation and to prevent emissions from causing interference to outside activities.

Stripline

Parallel plate transmission line to generate an electromagnetic field for testing purposes.

Susceptibility

Susceptibility is the characteristic of electronic equipment that permits undesirable responses when subjected to electromagnetic energy.