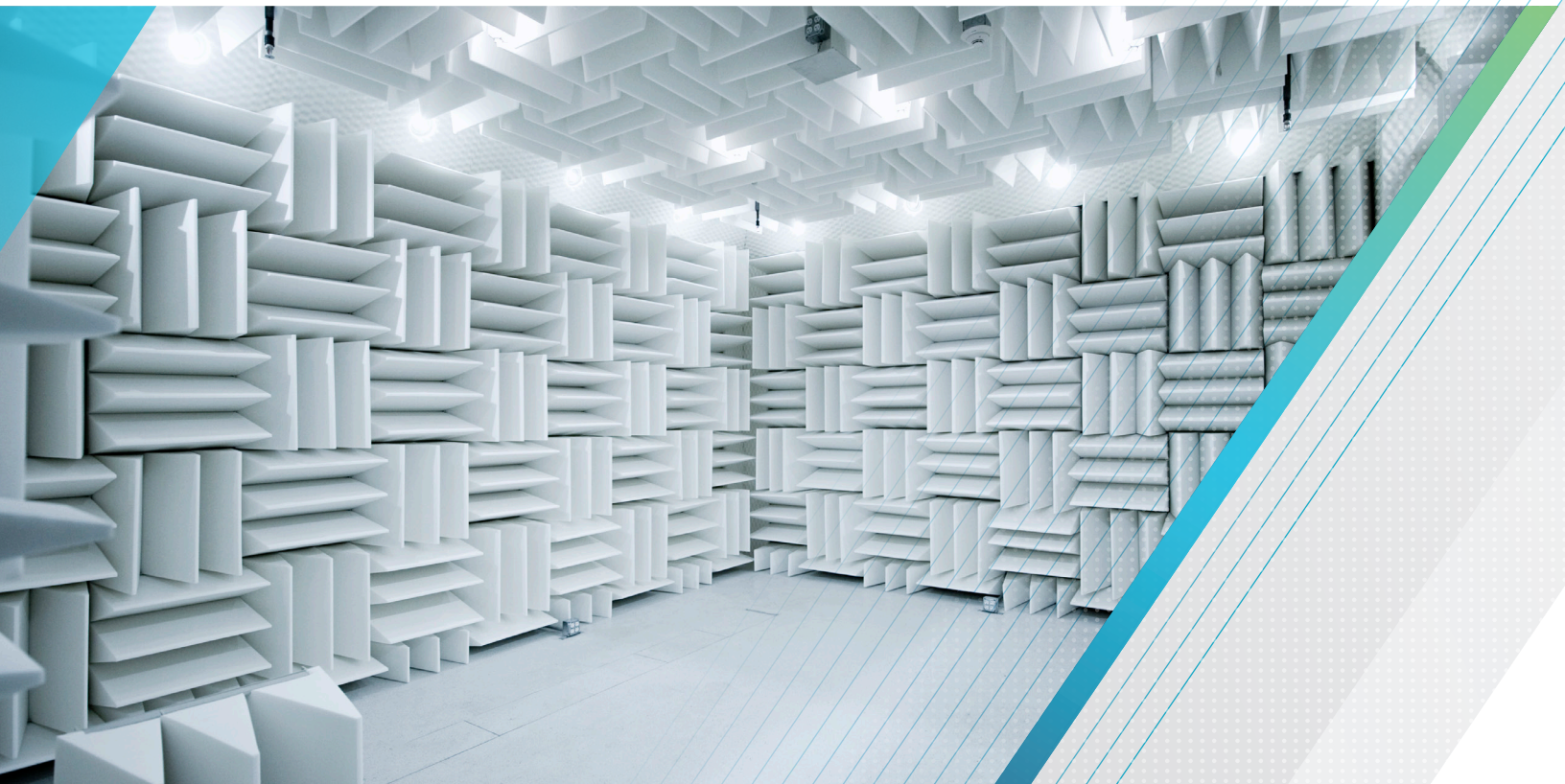


Conducted and Radiated Emissions Testing

APPLICATION NOTE



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Introduction to EMC Testing

EMI regulations are in place throughout the world to provide improved reliability and safety for users of electrical and electronic equipment. If you are developing a product emitting or susceptible to electro-magnetic interference, you are required to certify your products for EMI compliance. If you've taken a product through EMI certification, you know a great deal of time and effort goes into the design of a product to minimize the EMI signatures and the impact from failing EMC certification.

To ensure compliance with regulations, many companies have historically employed the services of a specialized test facility, or test house, to perform EMC pre-compliance and compliance testing. Unfortunately, using third party test houses can add significant product development costs and time to a project. As a result, companies are looking for and investing in easy-to-use, affordable pre-compliance testing solutions they can utilize in their workspace.

Comprehending compliance requirements, incorporating pre-compliance testing into the design and prototyping stages, and performing pre-compliance testing in-house can identify and address potential EMI issues before a product is submitted for compliance testing. Testing in your own lab gives you the time to methodically isolate your problem areas and apply different corrections, saving time and money.

This application note provides an overview of EMI testing, information on test set-up, setting up a measurement, configuring accessories to increase measurement accuracy, how to perform measurements and troubleshooting tools to accelerate debugging. This application note provides a step-by-step guide for performing pre-compliance testing using Tektronix Real-Time Spectrum Analyzers and SignalVu-PC with EMCVu software. Please note that while EMC testing requires both emission and susceptibility testing, this application note focuses on emission testing. Using these techniques can reduce the risk of your product failing final full compliance testing at the test house.

COMPLIANCE TESTING

Compliance testing requires methods, equipment and measurement sites in compliance with national or international standards. Testing is required to confirm that a device meets the required standards. It divides broadly into emissions testing and susceptibility testing. Compliance with national or international standards is defined by individual nations. It's important to note, different nations can require compliance with different standards.

Open-air test sites, or OATS, are the reference sites in most standards. They are especially useful for emissions testing of large equipment systems. However, RF testing of a physical prototype is more often carried out indoors, in a specialized EMC test chamber. Types of chambers include anechoic, reverberation and the gigahertz transverse electromagnetic cell (GTEM cell).

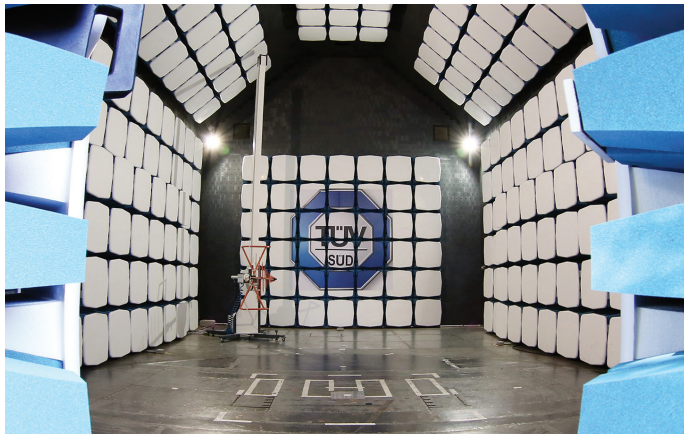


FIGURE 1. Example of an EMC test chamber (Image courtesy of Microwave Vision Group)

Compliance tests are commonly done prior to production of a device. Compliance testing can be exhaustive, time consuming and expensive. A failure in EMC compliance at this stage of product development can result in expensive re-designs and product introduction delays. Testing for EMC compliance includes both radiated and emissions tests.

The term **Radiated Emissions** refers to both the intentional and unintentional release of electromagnetic energy from an electronic device. To make sure a device is operating safely, a radiated test is performed to ensure emissions emanating from the Device Under Test (DUT) or the Equipment Under Test (EUT) comply with the applicable limits.

The term **Conducted Emission** refers to the mechanism that enables electromagnetic energy to be created in an electronic device and coupled to its power cord. Like radiated emissions, the allowable conducted emissions from electronic devices are controlled by different regulatory agencies.

The full compliance test in a certificated lab can be expensive with costs ranging from \$1,000 to greater than \$20,000 per submission depending on the device and the number of countries you are selling your product into. Full compliance testing can also be time consuming with emissions and immunity testing taking 2 to 6 days and generation of the test report taking another 3 to 10 days. Note, this doesn't include the time to get your product into the test queue.

To prepare for compliance testing, many companies have historically, rented time in full compliance test facilities. This too can be expensive with costs ranging from \$700 for a half day to \$10,000 per day depending on the services needed. As an alternative, some companies have chosen to set up fully compliant test facilities in-house. The benefit of this is testing in an environment that duplicates actual testing. The disadvantage is costs can range from 100s of thousands to millions of dollars.

PRE-COMPLIANCE TESTING

An affordable and convenient alternative to using fully accredited compliance labs is investing in a pre-compliance test solution. Pre-compliance testing offers a fast, affordable method for evaluating your design and any modifications made as you go through the design process. At the early stages of development, design-for-EMC techniques are combined with diagnostics to produce low compliance signatures and low susceptibility to both external and internal interference. Later in the development cycle, pre-compliance testing may be used to catch compliance problems early and improve the probability of a successful first pass of full EMC compliance testing without additional re-design.

The goal of pre-compliance testing is to mimic the compliance test set up within an acceptable margin to uncover potential problems and reduce risk of failure prior to the expensive compliance test stage. Pre-compliance testing does not require compliant test equipment and typically involves:

- Spectrum analyzer with quasi-peak detector
- Preamplifier (optional)
- Antenna with non-metallic stand for radiated emissions
- Line impedance stabilization network (LISN) for conducted test
- Power limiter for conducted test
- Near field probes for diagnostics (optional)
- Oscilloscope with frequency & time correlation capabilities to assist in debugging (optional)

Pre-compliance testing may be done using fast measurement techniques intended to give a 'quick look' at problem areas and is typically done at a temporary site by engineering personnel.

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 (Figure 2). Other considerations for improving accuracy involve having a good ground plane and reducing the number of reflective objects around the test area.

General-purpose spectrum analyzers, such as the Tektronix RSA300, 500 and 600 series offer general purpose filters and detectors that are employed in pre-compliance testing and troubleshooting any EMI issues.

Tektronix offers a full line of Real-time Spectrum Analyzers, oscilloscopes and validated accessories including antennas, Line Impedance Stabilization Networks and pre-amplifiers individually, or in two comprehensive accessory bundles for conducted and radiated tests. Additional information on these accessories are located in the Appendix section.

Test Setup

We start with an introduction to Radiated and Conducted Emission tests and a description of the setup to conduct pre-compliance testing. This section also includes information on Resolution Bandwidth (RBW) and Detection Methods.

RADIATED TESTS

The setup for radiated Compliance tests is specified in the applicable Standard document. You should refer to these standards when setting up radiated testing, attempting to mimic the testing as close as possible.

In setting up Radiated testing, there are several challenges you should be aware of. The first is electromagnetic waves don't extend out from your product in a nice spherical pattern. The emissions tend to be directional. To address this, a test lab will typically vary the height of the receiving antenna between 1 and 4 meters, as well as rotate the EUT on a turntable. The receiving antenna picks up both the signal direct from the EUT, as well as a bounce off the ground. The second is, to increase measurement accuracy, the ground is covered with an electromagnetically reflective surface (aluminum, steel, wire mesh etc.) to create a ground plane. For accuracy, the ground plane area should be relatively flat. The EUT is scanned in the frequency band of interest and you will look for emissions that are close to the limits.

A Radiated Emission Pre-Compliance test setup includes your EUT, Ground plane, Antenna mounted on a tripod, a pre-amplifier and a Spectrum analyzer (Figure 2). The radiation from the EUT is picked by the Antenna, with the output amplified by a pre-Amplifier for better sensitivity. The output of the pre-Amplifier is connected to the input of the Spectrum analyzer to acquire the signal and analyze it with the help of the software (EMCVu).

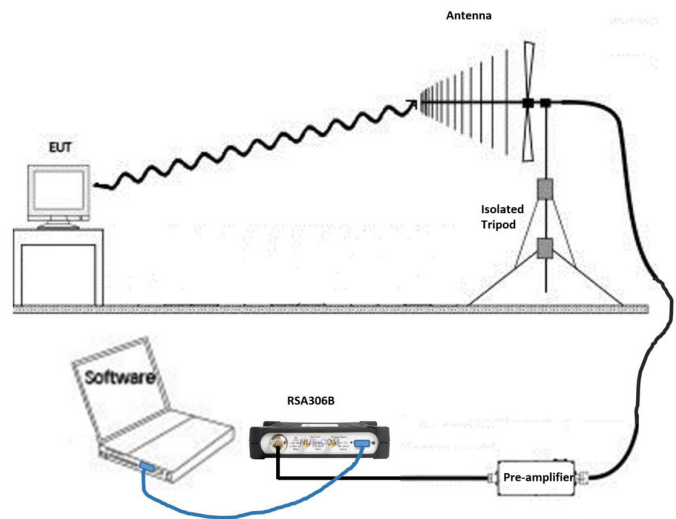


FIGURE 2. This diagram illustrates the set-up for Radiated testing with Antennas, Pre-Amplifiers and cables.

CONDUCTED TESTS

Conducted Emission tests are about testing that portion of electromagnetic energy created by your device that is conducted onto the power supply cord. The goal is to restrict the amount of interference your device can couple back onto a power supply. Test labs measure these emissions (usually from 150 kHz - 30 MHz) and verify that the EUT complies with specified limits.

This helps to ensure that the local power supply remains relatively 'clean' and nearby devices won't be affected by your device. Conducted emissions testing is usually performed on devices that connect to an AC power supply. For some standards, there are also limits placed on devices that operate from a DC power supply.

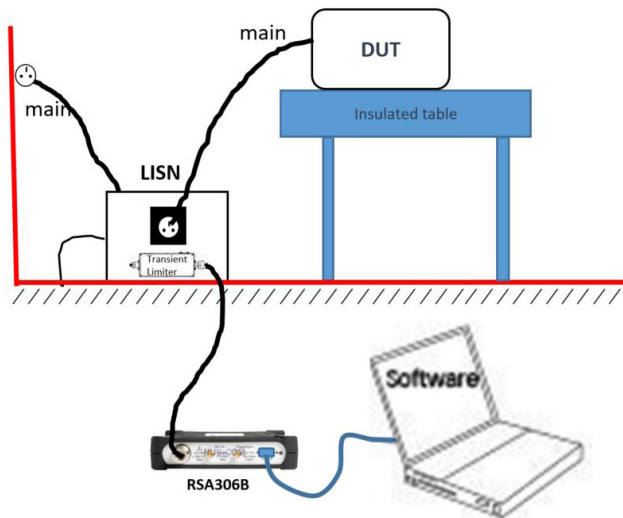


FIGURE 3. Conducted emissions test setup.

LISN (LINE IMPEDANCE STABILIZATION NETWORK)

For conducted measurement instead of antennas you use a LISN (line impedance stabilization network). A LISN3 is a low-pass filter which is placed between an ac or dc power source and the DUT to create a known impedance and to provide an RF noise measurement port. It also isolates the unwanted RF signals from the power source. Again, adding a pre-amplifier is a good way to boost the relative DUT signal levels. Figure 3 shows a block diagram of our setup.

Caution! It is critical that the spectrum analyzer input is disconnected from the LISN prior to unplugging the source power to the LISN! The discharge levels from the LISN can damage the front end of the spectrum analyzer.

Note that the interference being conducted on a 60 or 50 Hz power supply can be an issue for some. While most of the conducted EMI tests specify a measured frequency range of 9 kHz to 1 GHz, it can be useful to measure the signals at lower frequencies when the need arises. For low frequency measurements, the Tektronix RSA5100 Series real time spectrum analyzer is a good choice as it covers frequencies down to the sub-hertz frequency ranges.

For best conducted EMI measurements, it is advisable to use 2 LISN's: one for a defined impedance to the DUT, and the second to go to the spectrum analyzer or receiver.

MARKET SEGMENTS	EQUIPMENT TYPE	STANDARDS				
		IEC/CISPR	CENELEC/EN	FCC	MIL-STD	DEF-STAN
ISM	Industrial, scientific and medical equipment	CISPR 11	EN 55011	CFR Title 47 Part 18		
MEDICAL	Medical electrical apparatus	EN 60601-1-2				
AUTOMOTIVE	Vehicles, boats and internal combustion engines	CISPR 12	EN 55012	CFR Title 47 Part 15(*)		
	Components and modules on board vehicles	CISPR 25	EN 55025			
MULTIMEDIA	Sound and TV broadcast receivers	CISPR 13	EN 55013	CFR Title 47 Part 15		
	Information technology and telecommunications equipment (ITE)	CISPR 22 (superseded by EN55032)	EN 55022 (superseded by EN55032)			
	Professional audio/video/multimedia equipment	CISPR 32 (replaces CISPR 13 and 22)	EN 55032			
APPLIANCES	Electrical devices, household appliances and tools	CISPR 14-1	EN 55014-1	CFR Title 47 Part 15		
LUMINAIRES	Fluorescent lamps and luminaires	CISPR 15	EN 55015	CFR Title 47 Part 15		
MILITARY	Military equipment and systems				MIL-STD-461G	DEF-STAN 59-411

TABLE 1. Regulatory Standards.

REGULATIONS AND REGULATORY AGENCIES

Many commercial EMI measurements requirements are defined by the Comité International Spécial des Perturbations Radioélectriques (CISPR), a technical organization within the International Electrotechnical Commission (IEC), an international standards body. Other standards and certification bodies, such as TELEC in Japan, also have requirements for measurement methods and certification techniques. In the US, the Department of Defense has developed the MIL-STD 461G with special requirements for military equipment. Table 1 lists some of the standards as they relate to different market segments.

Operation in countries within defined regulatory domains may be subject to additional regulations. Companies developing products requiring Compliance certification should refer to the country regulatory sources for further information on specific products and country requirements. Table 2 lists some of the current regulatory bodies and the countries in which they have jurisdiction.

COUNTRY	APPROVED REGULATORY BODIES
United States	Federal Communications Commission (FCC)
Canada	Industry Canada (IC)
Europe	International Electrotechnical Commission (EN/IEC)
Japan	Ministry of Internal Affairs and Communications (MIC)
China	Ministry of Industry and Information Technology (MIIT)

TABLE 2. Examples of regulatory bodies.

EMC MEASUREMENT PARAMETERS

Resolution Bandwidth (RBW)

The bandwidth of the measurement is defined by a receiver bandwidth shape or a resolution bandwidth (RBW) filter in the case of a spectrum analyzer. The bandwidths used are representative of the perceived threats within the spectrum, and the bandwidths vary with the receive frequency. The level measured by a receiver or spectrum analyzer of any non-continuous signal will depend upon the measurement bandwidth used. To achieve consistent results, regulatory agencies have defined the bandwidth and shape of the filters used in compliance measurements. Filter bandwidths specified by CISPR for peak, RMS, and average detectors are shown in Table 3. The American National Standards Institute (ANSI) and MIL-STD-461 bandwidths are shown in Tables 4 and 5, respectively.

FREQUENCY RANGE	BANDWIDTH (6 DB)	REFERENCE BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz	200 Hz
0.15 MHz to 30 MHz (Band B)	8 kHz to 10 kHz	9 kHz
30 MHz to 1000 MHz (Bands C and D)	100 kHz to 500 kHz	120 kHz
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz	1 MHz

TABLE 3. Measurement Bandwidth versus Frequency specified by CISPR 16-1-1.

FREQUENCY RANGE	BANDWIDTH (6 DB)
10 Hz-20 kHz	10, 100, and 1000 Hz
10-150 kHz	1 and 10 kHz
150 kHz-30 MHz	1 and 10 kHz
30 MHz-1 GHz	10 and 100 kHz
1-40 GHz	0.1, 1.0 and 10 MHz

TABLE 4. Bandwidths versus frequency specified for peak, average and RMS detectors by ANSI C63.2.

FREQUENCY RANGE	BANDWIDTH (6 DB)
30 Hz – 1 kHz	10 Hz
1 kHz-10 kHz	100 Hz
10 kHz-150 kHz	1 kHz
150 kHz-30 MHz	10 kHz
30 MH-1 GHz	100 kHz
Above 1 GHz	1 MHz

TABLE 5. Bandwidths versus Frequency specified by Mil-STD-461E.

DETECTION METHODS

A detector calculates a single point that represents the signal over a defined sampling interval. Detection methods can calculate the positive or negative peak, the RMS or average value of voltage, or the Quasi-Peak (QP) value. The compliance labs use quasi-peak (QP) detectors for the full compliance test. The EMI department or the external labs typically begin their testing by performing a scan using simple peak detectors to find problem areas that exceed or are close to the specified limits. For signals that approach or exceed the limits, they perform QP measurements. The QP detector is a special detection method defined by CISPR 16-1-1 standards. The QP detector serves to detect the weighted peak value (quasi-peak) of the envelope of a signal. It weights signals depending upon their duration and repetition rate. Signals that occur more frequently or last longer will result in a higher QP measurement than infrequent, short impulses.

An example of peak and QP detection is seen in Figure 4. Here, a signal with an 8 μs pulse width and 10 ms repetition rate is seen in both peak and QP detection. The resultant QP value is 10.1 dB lower than the peak value. A good rule to remember is QP will always be less than or equal to peak detect, never larger. Tektronix SignalVu-PC with EMCVu software offers average and quasi peak detection to do your EMI troubleshooting and diagnostics. You can use the same approach used by the lab and start with a fast peak scan of the device to verify you find the same issues the lab reported. Then you can implement fixes and validate fixes with a localized quasi-peak detection.

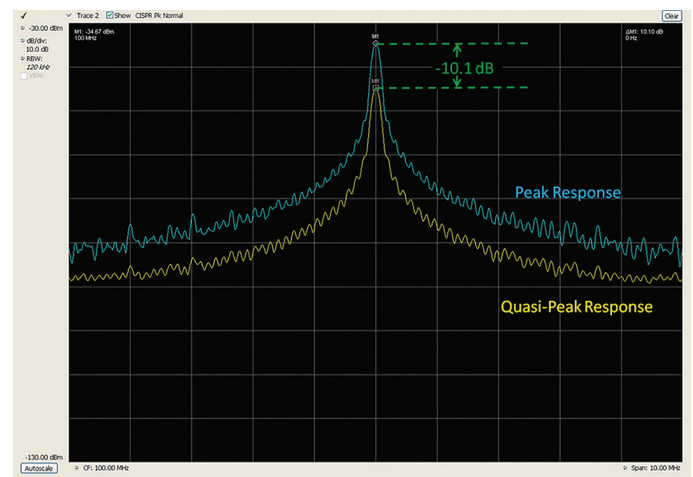


FIGURE 4. Quasi-peak and Peak measurements.

Setting Up a Measurement

Now let's walk through how to do Pre-compliance testing of your equipment with the Tektronix SignalVu-PC and EMCVu software.

The software provides four key features to perform Pre-compliance -

- Setup Wizard
- Measure Ambient
- Re-measure spot
- Report

SETUP WIZARD

Select **Setup > EMC > Setup Wizard** Or click on **Setup Wizard** in EMC Toolbar.

Setup Wizard leads the user through a series of well-defined steps to complete the test setup to perform a EMC pre-compliance test.

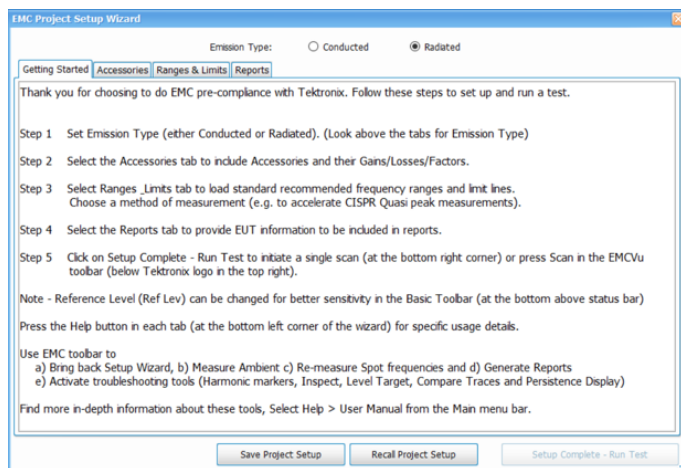


FIGURE 5. EMC Project Setup Wizard.

Tabs to set up your test

- **Getting Started:** Gives you a quick idea of the steps to be followed.
- **Accessories:** Lets you set the contribution of all the accessories used.
- **Ranges & Limits:** Lets you specify the ranges of the test and limits for comparison. Standard recommended values can be loaded too. Choose measurement modes.
- **Reports:** Lets you specify the details to be included in the report.

Other important selections

- **Emission Type:** Choose between Conducted or Radiated emission.
- **Setup Complete- Run Test:** Hit the button when the setup is complete to initiate a Scan.
- **Save Project Setup:** Saves the entire settings in the wizard as EMC Project Setup.
- **Recall Project Setup:** Recalls the entire settings saved earlier as EMC Project using Save Project Setup.

Detailed information about Adding Accessories, Ranges & Limits and Reports tab are as follows.

Adding Accessories

The Accessories setup allows you to include the contribution of the accessories used in the test. The final measurement reading is corrected based on these accessory contributions before it is shown in the display. The correction is calculated by negating the Combined Impact of all the accessories Gains/Losses entered by you.

Each of these accessories have their own Gain/Loss (Antenna factor in case of Antennas) that must be accounted for to get an accurate emission measurement. The measured reading must be corrected for the Gain/Loss/ Factor contribution due to these accessories.

The EMCVu software allows you to correct for the accessory contributions. You can either use the Setup Wizard – Accessories tab or the Accessories tab in the Settings control panel to account for these contributions. You can view the Combined Impact of all the accessories in a graph too.

The typical values of Gains/Losses/Factors of each of the Tektronix provided accessories is available for you to easy load. You can either use the “Load Tektronix provided Accessories Gains/Losses” from the Setup Wizard or you can load individual accessory files using “Configure Accessories > Edit > Load”. The individual csv files are available at C:\SignalVu-PCFiles\EMC Accessories.

ACCESSORY SELECTIONS

The accessories selection depends on the emission type selected.

EMISSION TYPE	AVAILABLE ACCESSORIES SELECTION
Conducted	LISN, Cable, Limiter, Amplifier, Attenuator, Filter and Others
Radiated	Antenna, Near field probe, Cable, Amplifier, Limiter, Attenuator, Filter and Others.

A maximum of six accessories can be included in the test setup as shown above.

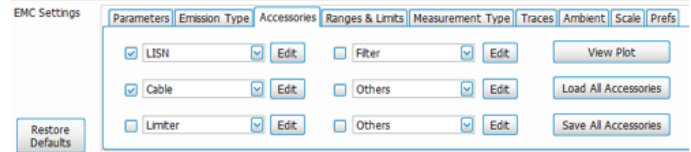


FIGURE 6. Accessories can be selected using the drop down provided.

SETTING	DESCRIPTION
View Plot	Gain/Loss plot can be viewed by clicking on View plot. Sample snapshot shown below. This will also show the Combined Gain/Loss as a net impact of all the accessories. Find more details below in the section Combined Gain/Loss.
Save all Accessories	Complete Accessories setup can be saved in a file for reuse. Clicking on this button will save details about all the accessories.
Load all Accessories	Complete Accessories setup can be Loaded from the saved file. Saves time as compared to loading them one by one.

EDIT ACCESSORY CONTRIBUTION

Accessories specific information and details like Model no, Serial no, Asset tag, calibration due date can be edited using Edit option. A window such as the one shown below will open. A sample snapshot is shown for Amplifier and Antenna (Factor and isotropic gain).

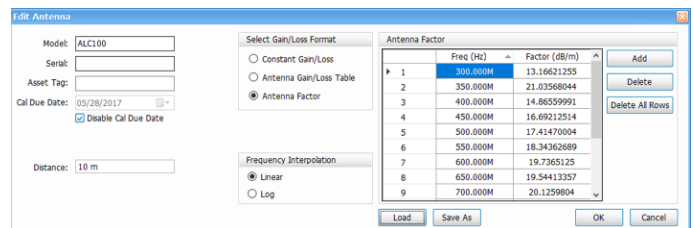
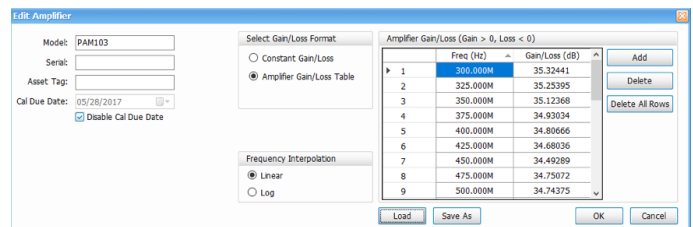


FIGURE 7. Overall impact of accessories gains/losses.

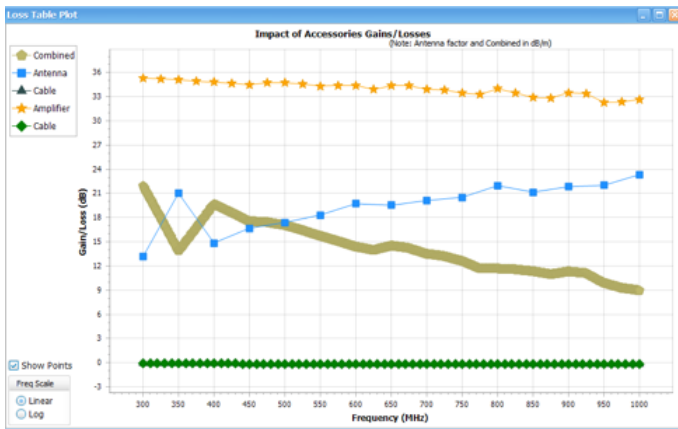
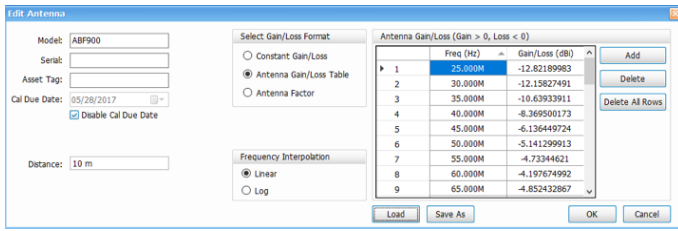


FIGURE 8. Add accessory specific information for each accessory.

LOADING TEK SUPPORTED ACCESSORIES FROM A FILE

Tektronix supports some of accessories namely Antenna, Amplifier, near field probe and LISN with their detailed information embedded in a .csv file which is readily available for the user as a part of the software in the location SignalVu-PC Files\Example Files.

LOADING NON-TEK SUPPORTED ACCESSORIES FROM A FILE

Details of Non - Tek supported accessories can be loaded by preparing a .csv file manually by the user. (You can also build it using the UI by adding a row for each frequency)

The Gain/Loss table values are usually found from the datasheet or graphs and accessory supported documents provided by the vendor when purchased.

You can build a csv file with only two columns (Freq column and Gain/Loss column) without headers and you can load the file into this User interface through Load button. You can also add more frequency rows by editing the csv file. Once you load such a csv file, you can enter the other details like Model, Serial number etc. and save the file again and another csv file with all additional details and with appropriate headers would get saved.

SETTING	DESCRIPTION
Model	Specify the Model Name/number of the accessory.
Serial	Specify the Serial Number of the accessory.
Asset Tag	Specify any user-specific Asset tag id for the accessory.
Cal Due Date	Specify the Calibration due date of the accessory. It can be disabled by checking the checkbox if not required.
Distance	Specify the Distance between EUT and Antenna (Applies only when accessory is antenna).
Select Gain/Loss Format	Choose between the options available below. A) Constant Gain/Loss, B) Gain/Loss Table. For Antenna, you will have a third selection available C) Antenna Factor
Constant Gain/Loss	Specify the loss value which is constant for the complete frequency range. The Gain/ Loss will be entered in dB. Gain values are entered as positive dB value and Loss as negative.
Gain/Loss Table	Specify the loss values at specific frequency points. The Gain/ Loss values in these tables will be entered in dB. Gain values are entered as positive dB value and Loss as negative. The values in between the frequency points are interpolated with frequency axis treated as Linear/Log based on the Frequency interpolation selection. Note- For Antenna, this table will be entered in dBi (isotropic Gain values) as shown in the snapshot above.
Antenna Factor	Applicable only for Antenna. Antenna factors are given in dB/m. These values are typically available in vendor data sheets. You can also load the typical values from Example Files if you have purchases them from Tektronix.
Frequency Interpolation	Specifies the frequency interpolation method used for interpolating Gain/Loss values or Antenna factors. The frequency axis points are either taken as Linear or Log values based on this choice. Linear interpolation is followed but x axis values can be either in Log or Linear as per this selection.
Load	Click to load a saved Accessory details from a file. This will recall all parameters seen in this window.
Save As	Click to save the Accessory details to a file. (All details shown above)
OK	Click OK to give confirmation of the entered details.
Cancel	Click Cancel to ignore the edit window and exit. This will discard any changes that you might have made before OK is pressed.

Note: Gain/Loss Table corresponds to the accessory selected.

COMBINED GAIN/LOSS AND VIEW PLOT

Non-Antenna accessories

Combined Gain/Loss is calculated by combining the individual Gains/Losses of individual accessories. Except for Antenna, all accessories Gains/Losses are in dB (Gain >0, Loss <0). So, the combined Gain/Loss is arrived at by just adding all the individual contributions. The plot shows the combined effect in dB too in such cases.

This Combined Impact of Accessories Gains/Losses is negated to arrive at the Correction factors and the correction factors are applied to the actual spectrum analyzer reading before it is shown in the respective displays.

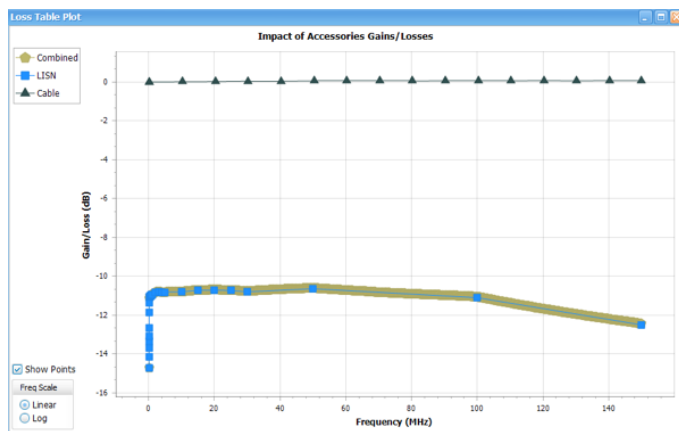


FIGURE 9. Impact on gain/loss is determined for the LISN and cable.

The Combined impact is calculated only for common frequency range. If there are individual accessories that have different frequency ranges, only the common range is chosen for calculation of Combined Gain/Loss. An example is shown below. The Combined loss range matches only that of Near Field Probe although Cable and Amplifier's Gain/Loss information entered for a wider frequency range.



FIGURE 10. The combined impact is calculated only for the accessories common frequency range.

It is this combined impact that is negated to arrive at correction factors which is eventually applied to the measured trace before it is shown in the displays.

Antenna

In case of Antenna, you can enter the accessory contribution either as isotropic gain values or as Antenna factors (both of which is commonly available in vendor data sheets). Isotropic gain should be entered as any other accessory contribution (Gain >0, Loss <0) and Antenna factors is expected to be entered as you would see the factors in any data sheet in dB/m.



FIGURE 11. For antennas enter either the isotropic gain or Antenna factor.

Antenna factors are used to adjust the final reading as follows

$$\text{Corrected Reading (dBuV/m)} = \text{Spectrum analyzer Reading (dBuV)} + \text{Antenna Factor (dB/m)}$$

So, when you have an Antenna as one of the accessory, the results are also shown in Field strength units dBuV/m.

Note – the snapshot above has a note that says Antenna factor and Combined Impact are in dB/m.

As mentioned earlier, the combined impact of all accessories are negated to arrive at correction factors. However, as Antenna factors are used as it is given in data sheet for correction of results, Antenna factors are negated before calculating Combined Impact of all Accessories Gains/Losses in the above plot. That is the reason you would observe the combined impact follows the inverse of Antenna factors in the above figure.

The Combined Impact in the above case would be

$$\text{Combined Impact (dB/m)} = \text{Amplifier Gain (dB)} + \text{Cable effect (dB)} - \text{Antenna factor (dB/m)}$$

(Please note Cable effect is entered as Gain >0 and Loss <0)

And the combined impact is eventually subtracted from the

$$\text{Corrected Reading (dBuV/m)} = \text{Spectrum Analyzer reading (dBuV)} - \text{Combined Impact (dB/m)}$$

Even when the user enters the antenna contribution as isotropic gain, they are converted to antenna factors before presenting in the Combined Impact plot.

$$\text{Antenna Factor (dB/m)} = (20 * \log_{10}(f \text{ (in MHz)} - 29.7707) - \text{Isotropic Gain}$$

Therefore, in the plot, you will always see the Antenna factor contribution and the combined Impact is calculated as explained above before it is finally negated to be employed as Correction factors to the measured readings.

WARNING WHEN FREQUENCY RANGE OF SCAN DOESN'T MATCH

A warning message is shown in the plot when the frequency range of the Correction factors (-1*Combined Impact) is smaller than the frequency range of the scan. When a scan is attempted beyond the frequency range of the Correction factors, the following warning message is shown

“Scan range exceeds range of Combined accessories.
Reduce scan range”

Performing a Measurement

CHOOSE MEASUREMENT METHOD

Once the right Ranges & Limits are loaded, you can decide to do the measurement in one of the three measurement methods available.

Three measurement methods available are available for most standards

- Pre-scan + Manual Spot - A quick pre-scan followed by choosing spots from results table and re-measuring them with detectors recommended by the standard (or that of your choice).
- Pre-scan + Auto Spot - A Pre-scan followed by an Automated re-measurement for a chosen number of spots.
- Complete Scan - A Complete scan with detectors recommended by the standard - could be time consuming if detectors such as CISPR Quasi Peak or CISPR Avg are chosen.

A Spot is a signal peak that exceeds both the Threshold and Excursion settings in the Ranges and Limits table. The Threshold and Excursion settings are specific to the selected range. If you want to use different settings for Spots in different ranges, you must set the values separately for each range. The Excursion control is used to avoid interpreting a single spot as multiple narrower spots by requiring the amplitude to drop by the Excursion amount between spots. Raising the Threshold value means that fewer, larger signals will be identified as spots.

The mapping of limit lines to the detectors is also shown under Scan Definition and Spot measurement. This tells you which detector will be used for Scan and Spot measurements and which limit line will the Scan or Spot results be compared against.

NOTE - Estimated Analysis Time is shown to give an idea of how much time the Scan is expected to take for the detectors chosen. This Estimated time is based out of the choice of detectors and the span of the actual scan measurement and is calculated under ideal conditions for a machine with 16 GB RAM. Actual time taken for measurement could vary.

This estimated analysis time could be higher if detectors such as CISPR Quasi Peak are used for a larger span range.

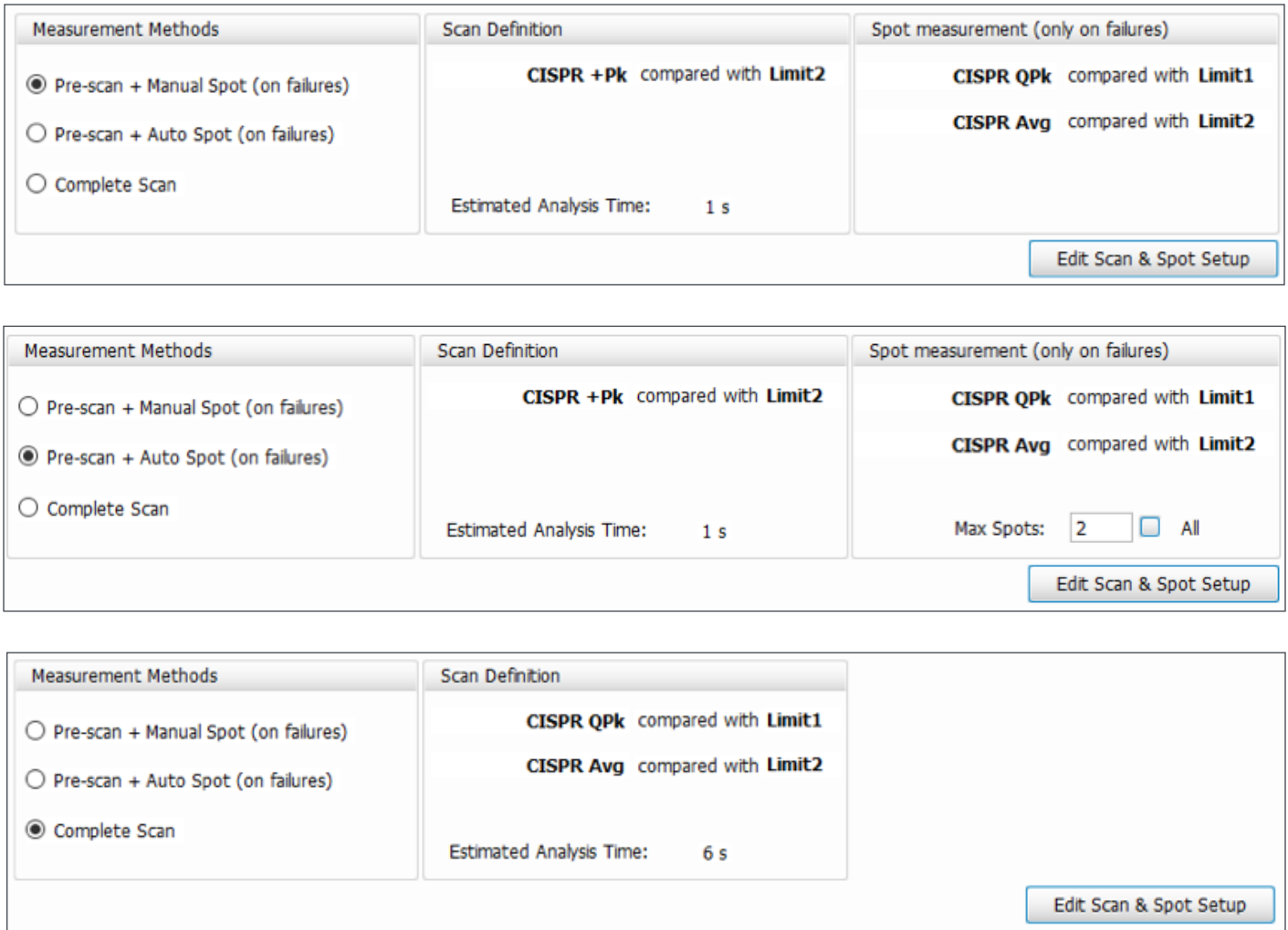


FIGURE 12. Snapshots of how the scan definition and spot measurement for the different Measurement methods.

Note – The three measurement methods might not be shown for some standards if they don't recommend detectors such as CISPR Quasi Peak (for e.g. Mil/Gov 461G and DEF STAN). This is because the scan itself is done with CISPR Peak detector which can be done faster and there is no need for a Pre-scan followed by spot measurements in such a case.

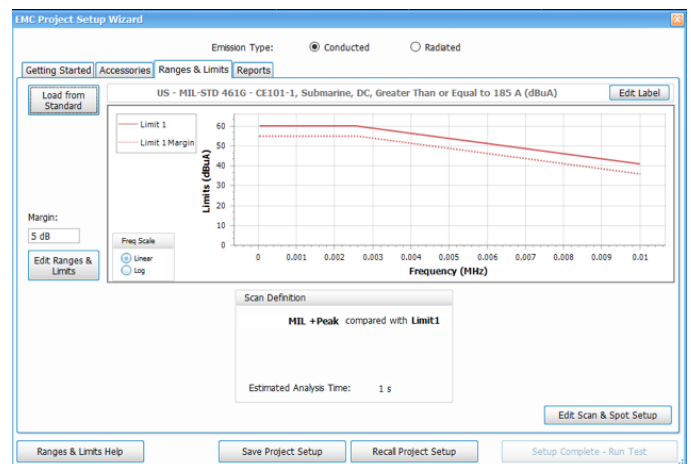


FIGURE 13. Example of ranges and limits shown per MIL-STD461G-CE101-1.

EDIT SCAN AND SPOT MEASUREMENT SETUP

Edit Scan and Spot Setup allows you to modify any detector choice or dwell time. You can also do the limit mapping appropriately.

- Choose the appropriate detector for scan and spot re-measurement
- Set dwell time
- Choose the limit line mapping

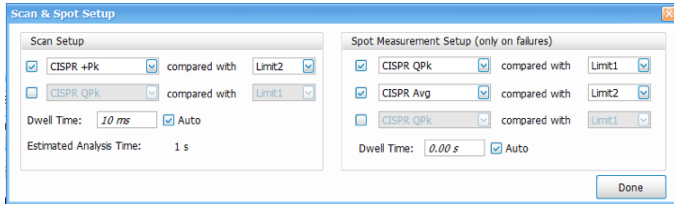


FIGURE 14. Scan and Spot setup menu.

By default, the standard recommended limit line is mapped to appropriate detectors.

MEASURE AMBIENT

Ambient scan is useful for capturing emissions caused by environment or the Spectrum analyzer equipment. Before an Ambient scan is done, the EUT must be switched off/or completely removed from the setup.

An Ambient scan analysis is done to quickly check if the Spots (Emission at frequencies) obtained are due to Ambient or the actual equipment.

- Click Setup > EMC > Measure Ambient or click on Measure Ambient in EMC Toolbar for an Ambient run.
- You will be prompted to switch off the equipment

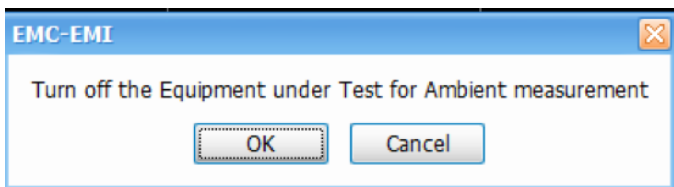


FIGURE 15. Prompt to turn off equipment power.

- The control settings for Ambient will be opened in case you want to change the detector type or dwell time for the Ambient measurement.
- The Ambient trace will be shown in the display.

COMPARISON OF RESULTS

If you have done a scan with equipment under test turned ON (referred to as Scan EUT ON below) and if the results table is populated with Spots (frequencies that have failed the threshold or limit line), then Comparison of results of Ambient and Scan EUT ON can be done.

- The Comparison of results is done only at all failing frequencies and Delta difference between the both are shown.
- The comparison of results is done only if the detector type for the Scan EUT ON and Ambient match.

Enable	Spur #	Range	Freq (Hz)	Scan CISPR +Pk		Ambient CISPR +Pk	
				Ampl	Delta(Limit1)	Ampl	Delta(Scan)
<input type="checkbox"/>	1	C	50.010 MHz	82.09 dBuV	16.09 dBuV	81.58 dBuV	0.51 dBuV
<input type="checkbox"/>	2	C	53.010 MHz	57.86 dBuV	-8.14 dBuV	23.70 dBuV	34.16 dBuV
<input type="checkbox"/>	3	C	35.975 MHz	53.24 dBuV	-12.76 dBuV	52.66 dBuV	0.58 dBuV

FIGURE 16. Spot results of Ambient and Scan EUT ON can be compared.

- This Delta difference is compared against a Delta threshold setting in the Ambient Settings Control tab.
- When the absolute difference between the Scan EUT ON and Ambient is less than this threshold, those frequency rows in Results table are shown colored to indicate that these emission frequencies could be due to Ambient and not because of the equipment under test.

The Measure Ambient button in the EMC toolbar will not be active if no instrument is connected or if no playback is selected.

Note: For more in-depth information, refer Ambient tab of control panel settings.

RE-MEASURE SPOT

Spot re-measurement is performed on the selected spot (frequencies that have failed Threshold/Limit lines) from the Emission Results table with detectors recommended by the standard or detectors defined by you. These detectors could typically be detectors that require larger measurement/dwell time like CISPR Quasi peak.

The Re-measure Spot is very useful when the user wants to do a quick pre-scan with Peak detectors and then apply detectors with larger dwell time only on those frequencies that have failed the Threshold or Limit line settings. The Re-measure Spot is useful when Measurement method is Pre-scan + Manual Spot or Pre-scan + Auto Spot.

- Once the scan is done for the trace, failing frequencies are listed in the Emission Results table and you can choose the spot(s) which should be re-measured.
- You can choose the Spot(s) for performing Spot Measurements either from the plot or from the Emission Results table.
- The RBW for Spot measurement will be the same as that used by the pre-scan. This is because it would only be correct to compare scan and spot results when they are done with the same RBW.
- The detector choice, limit line for comparison and dwell time for spot measurement are based on the choices you made while using the Setup Wizard.
- You can also change the choice of detector(s) from the Measurement tab of the settings control panel. You can also choose up to 3 detectors to analyze these spots.
- The Limit lines for comparison and the dwell time also can be edited.
- Click Setup > EMC > Re-measure Spot or click on Re-measure Spot in EMC Toolbar to perform the Spot re-measurement.
- The Re-measured spot results are then shown in the Emission Results table and compared with appropriate limit lines.

Spot ...		Spur #	Range	Freq (Hz)	Scan CISPR +Pk		Spot CISPR QPk		Spot CISPR Avg	
					Ampl	Delta(Limit1)	Ampl	Delta(Limit1)	Ampl	Delta(Limit1)
<input checked="" type="checkbox"/>	1	A	99.775 MHz	23.1 dBuV...	3.13 dBuV...	16.6 dBuV...	-3.42 dBu...	9.32 dBuV...	-10.7 dBu...	
<input checked="" type="checkbox"/>	2	B	560.041 MHz	21.3 dBuV...	1.32 dBuV...	14.2 dBuV...	-5.78 dBu...	9.30 dBuV...	-10.7 dBu...	
<input checked="" type="checkbox"/>	3	B	922.037 MHz	19.1 dBuV...	-0.899 dB...	5.18 dBuV...	-14.8 dBu...	-2.13 dBu...	-22.1 dBu...	
<input checked="" type="checkbox"/>	4	B	945.907 MHz	14.0 dBuV...	-6.01 dBu...	14.5 dBuV...	-5.47 dBu...	6.90 dBuV...	-13.1 dBu...	
<input type="checkbox"/>	5	B	606.337 MHz	11.0 dBuV...	-8.99 dBu...	-- dBuV/m	-- dBuV/m	-- dBuV/m	-- dBuV/m	

FIGURE 17. Re-measured spot results are shown in the Emission Results table and compared with appropriate limit lines.

In case the Measurement method chosen in Pre-scan + Auto Spot, the Re-measure Spot step is automatically done for you. The max number of spots that you wish to do an automatic Re-measure can be set by you in the Settings control panel – Measurement tab (under Spot measurement setup). This control is visible only when the measurement method is Pre-scan + Auto Spot.

The Re-measure Spot button in the EMC toolbar will not be active in the toolbar when no device is connected or when no playback is selected.

REPORTS

The Report wizard is used to save the test results and generate test reports for reference.

The Report Wizard can be used to merge multiple test results and generate the report.

To save the test Results

1. Select the Setup > EMC > Report or choose Report from the EMC Toolbar
2. The Save Results tab would open in Results and Reports Wizard
3. Specify a heading to the Measurement Test Results.
4. Any additional information or points related to the test can be provided in the User Notes space.
5. Browse the image file which should be included in the report (if any). Select the file and click OK.
6. Enable “Include Control Settings” check box to include Control panel settings in the Report.
7. Enable “Include Graph” check box and “Include Emission Results” check box to include plot results and emission results in the test report.
8. Enable “Include Inspect Freq Result” to include Inspect results in the test report. (this will be available only if Inspect measurement is chosen)
9. Click Save. Save will be done and you will be taken to the Generate Report tab.

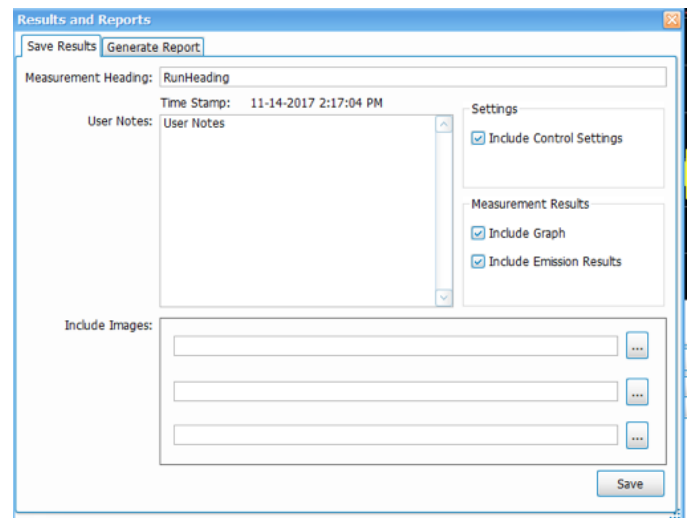


FIGURE 18. Save measurement results menu.

To generate the report

1. Go to Generate Report tab in the Results and Reports Wizard.
2. Select the details which are to be included in the report by checking the check boxes of User Information, Environment information and EUT information. You can also edit the content for these sections which you might have already set in the Setup Wizard (for User, Environment or EUT information).
3. Select the saved test results among those listed in the History List to include them in final report.
4. Use Generate Report button to view a preview of the final report.
5. Generated report can be exported in the preferred format (pdf, rtf and xlsx etc.) and saved locally for future use. Recommended file types are pdf and rtf.
6. You can also choose to email the report if you have an internet connection.

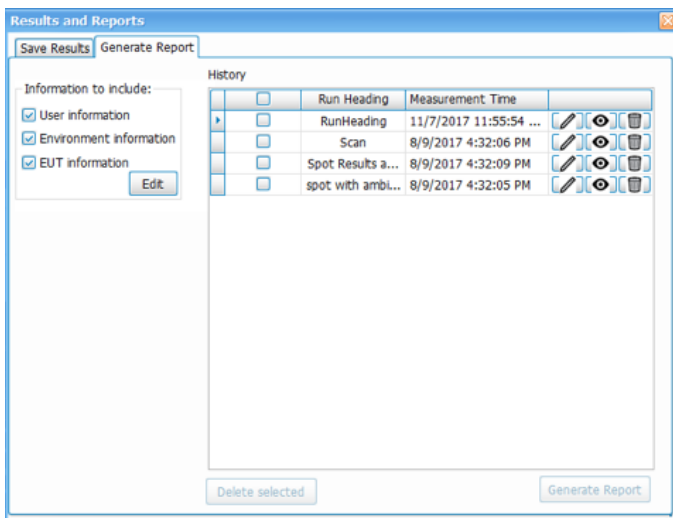


FIGURE 19. Generate measurement result report menu.

Troubleshooting Tools

EMC testing with Tektronix provides you a suite of troubleshooting tools to assist in debugging.

Troubleshooting tools include:

1. Harmonic Markers
2. Inspect (Suspect frequencies)
3. Level Target
4. Compare Traces
5. Persistence

Additional Information on Troubleshooting Tools

HARMONIC MARKERS

Harmonic markers tool allows you to place the markers at selected harmonic factors of a chosen fundamental frequency. It will be helpful for you to see if certain emissions that result out of a scan are caused due to the harmonics of a known fundamental frequency.

Harmonic marker toolbar is used to define the fundamental frequency and harmonic factors.

Click **Setup > EMC > Harmonic Markers** or click on **Harmonic Markers** in EMC Toolbar to open the harmonic toolbar that will open in the bottom above the Marker toolbar.

In the Harmonic marker toolbar, enter the Fundamental frequency. This is the base frequency on which harmonics are calculated.



FIGURE 20. Harmonic marker toolbar.

Marker	Frequency	Δ Frequency	Time	Δ Time	Amplitude	Δ Amplitude	Phase	Δ Phase	Distance	Δ Distance	EMC-EMI	Δ EMC-EMI
MR	0.000 Hz		-5.086 ms		106.99 dBm		0.0000 °		0.000 m		---	---
M1	0.000 Hz	0.000 Hz	-5.086 ms	0.0000 s	106.99 dBm	0.00 dBm	0.0000 °	0.0000 °	0.000 m	0.000 m	---	---
M2	0.000 Hz	0.000 Hz	-5.086 ms	0.0000 s	106.99 dBm	0.00 dBm	0.0000 °	0.0000 °	0.000 m	0.000 m	---	---
M3	0.000 Hz	0.000 Hz	-5.086 ms	0.0000 s	106.99 dBm	0.00 dBm	0.0000 °	0.0000 °	0.000 m	0.000 m	---	---
M4	0.000 Hz	0.000 Hz	-5.086 ms	0.0000 s	106.99 dBm	0.00 dBm	0.0000 °	0.0000 °	0.000 m	0.000 m	---	---

FIGURE 21. Marker Readout Table.

Choose the harmonic factors from the drop down for the 5 markers (MR, M1, M2, M3, M4). The harmonic factors in the drop down can be 1/8, 1/4, 1/2, 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10.

Click **Apply** to place the markers at the appropriate harmonics.

Clicking Apply will also open the Marker table which will give information about the frequency at which these markers are placed, and the amplitude values can be seen under the respective display column (e.g. – EMC-EMI if that is the active display)

Note: Harmonic markers can be used for other spectral displays too (displays having Amplitude vs freq e.g. – Spectrum, DPX etc.). Even if EMC-EMI display is not open, this toolbar can be invoked from View> Harmonic Markers toolbar.

When the chosen harmonic factors are not in the range of the scan results then the markers could be aligned with the left or right edges to indicate that the chosen factors are outside the range of the scan. (e.g. – if the stop frequency is 6.2 GHz and if we attempt to place a marker at the 10th harmonic of a fundamental frequency that is 1 GHz, then the marker will be placed at 6.2 GHz itself.

INSPECT

Inspect suspect frequencies is a troubleshooting tool that can be used by you to analyze a set of suspect frequencies in more detail. As many as 3 detectors can be selected and the detector results will be shown in a table format for each of the suspect frequency. The result can also be compared with a comparison level and the entire set of results can be reported out too.

On Selecting Inspect from EMC Toolbar or from Setup > EMC > Inspect, the results table and the Settings Control will open.

The results table will show the Inspect results. The measurement can be triggered by hitting Single or Continuous which can be found at the top of results table. The results can also be brought into the Report using the Report tool from EMC Toolbar.

Inspect display has 2 modes of harmonics measurement. Harmonic and Discrete

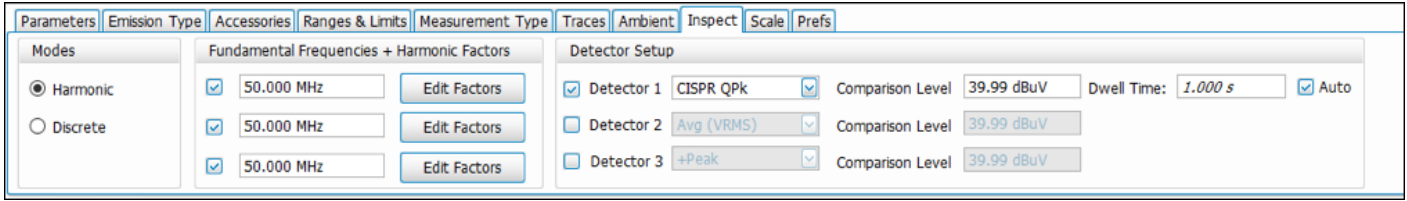


FIGURE 22. Inspect display of Harmonic measurements.

Harmonic Mode

In Harmonic mode, the suspect frequencies are built as harmonics of fundamental frequencies.

The detectors can be chosen from the drop down in the Detectors Setup. As many as 3 detectors can be chosen. Comparison level can also be chosen for each detector too. Dwell time can be controlled too.

Harmonic factors can be entered for each of the fundamental frequency by clicking on Edit factors (see snapshots below). Final frequency is calculated as Fundamental Frequency * Harmonic factor. The Edit Harmonic Factors/RBW table will allow you to edit RBW settings for the frequency that is being analyzed. Auto RBW flag will set RBW based on the chosen detector and frequency band in which the final frequency falls.

On hitting Single or Continuous in the Inspect Suspect frequencies display, the Inspect results will be shown as below and is compared against the respective Comparison Levels. Failures will be shown in red color.

Inspect Suspect frequencies can be done in Single (Stops after all suspect frequencies are analyzed once) or Continuous mode (will continue updating the results table until stopped).

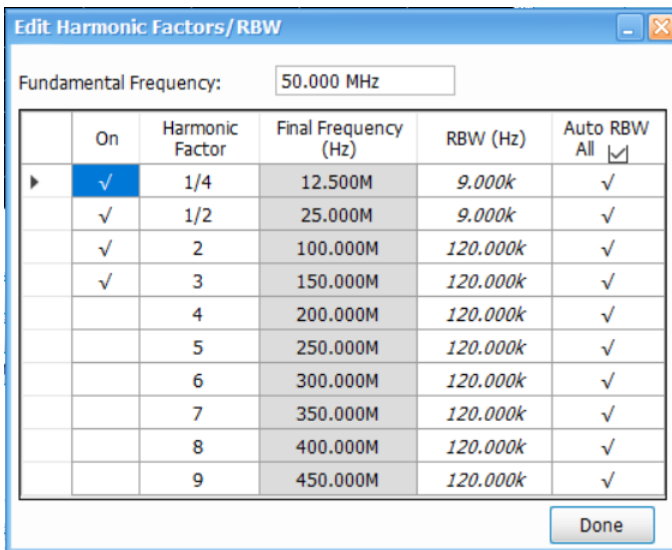


FIGURE 23. Harmonic factors can be entered for each of the fundamental frequency.

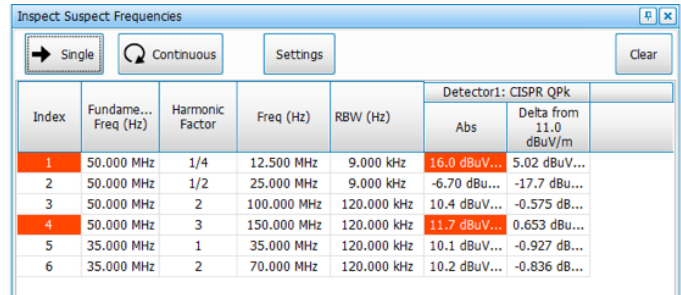


FIGURE 24. Inspect Suspect frequencies can be done in Single or Continuous mode.

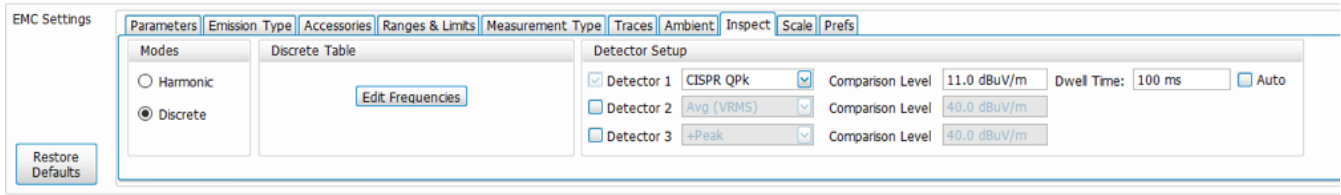


FIGURE 25. Discrete mode displays a list of suspect frequencies.

Discrete Mode

1. In Discrete mode, you can develop a list of suspect frequencies by clicking on Edit Frequencies.
2. The detectors can be chosen from the drop down in the Detectors Setup. As many as 3 detectors can be chosen. Comparison level can also be chosen for each detector.
3. Suspect frequencies can be entered by clicking on Edit Frequencies button.
4. The suspect list can also be loaded from “Load from Emission results” which will load the top 15 spots recorded in the Emission Results table at the result of a scan.

5. If no spots are listed in the Emission Results table, the following warning message is shown when “Load from Emission results” is hit.

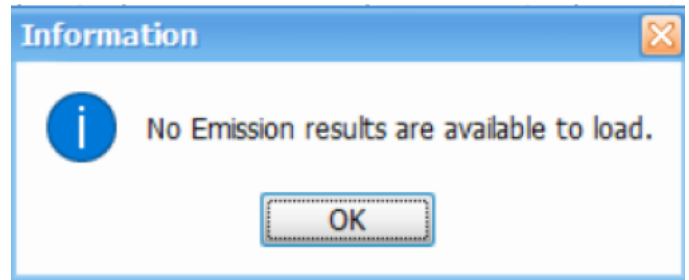


FIGURE 27. Warning message if no spots are listed in the Emission Results table.

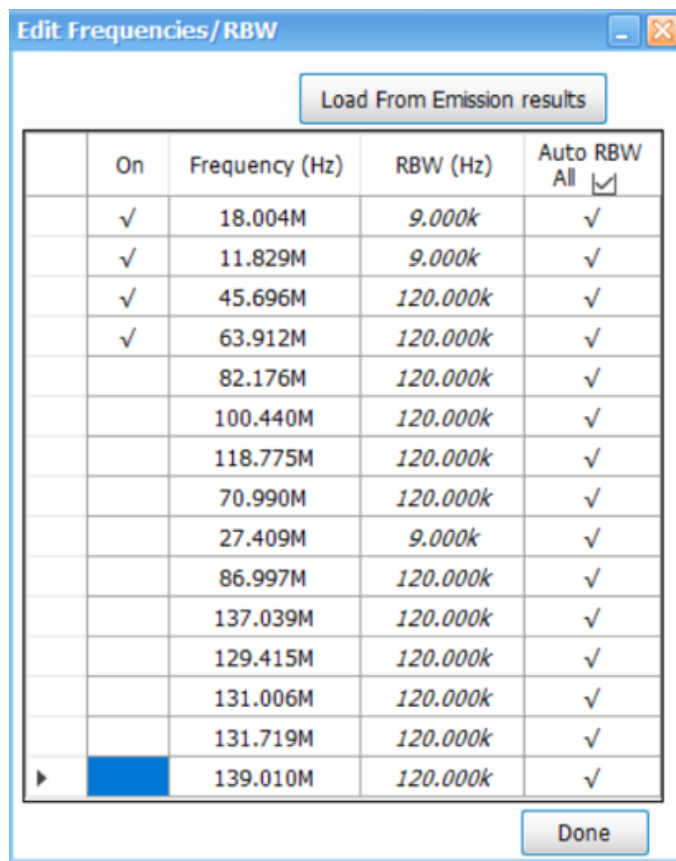


FIGURE 26. The suspect list can be loaded from “Load from Emission results”.

6. On hitting Single or Continuous in the Inspect Suspect frequencies display, the Inspect results in Discrete mode will be shown as below. The results are then compared against the respective Comparison Levels and failures will be shown in red color.

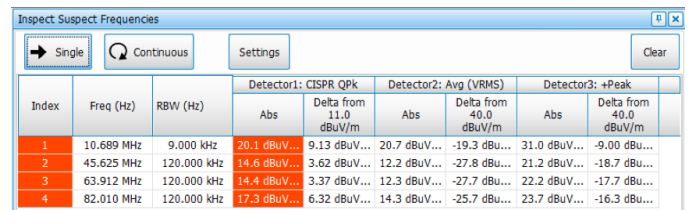


FIGURE 27. Inspect results in Discrete mode are compared against the respective Comparison Levels.

In Inspect suspect frequencies display, all detector results are held on between acquisitions unlike the scan results which is computed afresh every scan. When Clear button is hit, all detectors results will be cleared. This will allow you to set a smaller dwell time even for detectors such as CISPR Quasi Peak and build stable results over acquisitions resulting in faster analysis/updating.

Note: For more in-depth information, refer Inspect section of Control Panel settings.

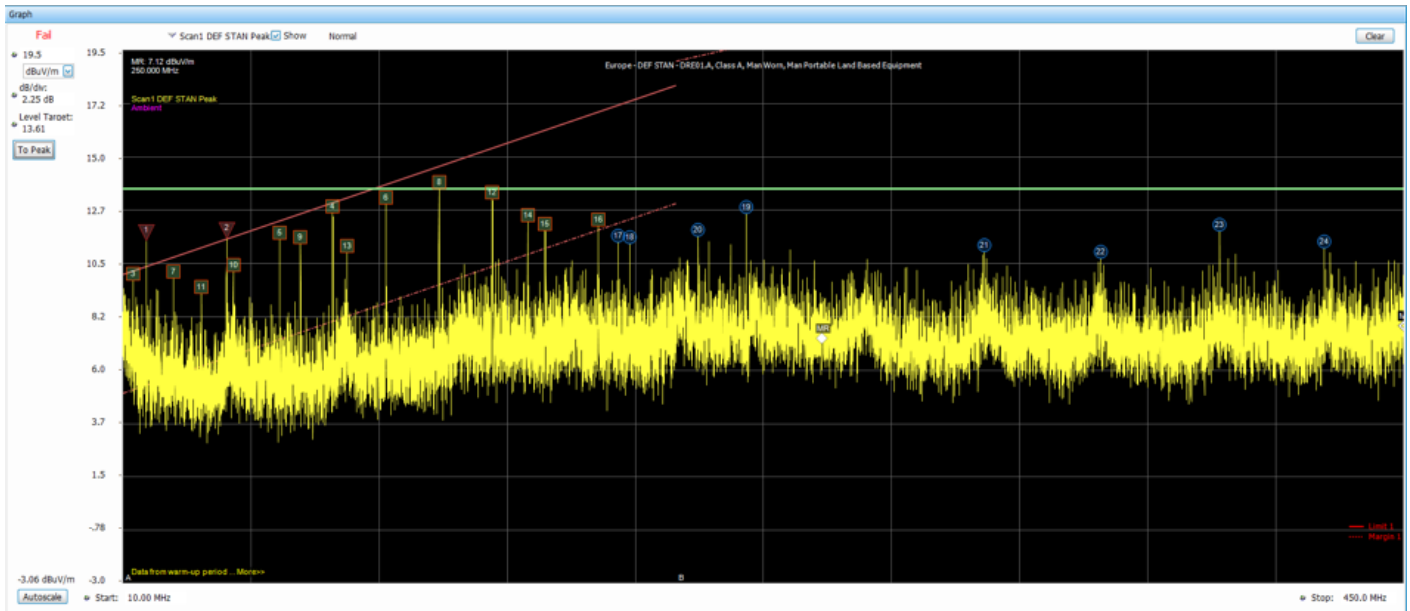


FIGURE 28. Use Level Target to assign it to the peak of a scan and retain the level for comparison for the next scan.

LEVEL TARGET

Level target is an indicator on the display that can be set by you. You can move it with a mouse. It can also be set at the Peak of the active waveform. This tool is available on four displays (EMC-EMI, Spectrum, DPX and Spurious). The Level Target will change in other displays too when changed in the active display.

You can use Level Target to assign it to the peak of a scan and retain the level for comparison for the next scan and see how it compares with the new scan results.

1. Click **Setup > EMC > Level Target** or click on **Level Target** in EMC Toolbar.
This will open Spectrum if it is not open already and place the Level Target in the display. If Spectrum is already open, then hitting Level Target toggles visibility of Level Target.
2. Clicking on "To Peak" in the vertical control of the display or the Prefs Control Panel moves the Level target to peak of the trace.
3. Level Target indicator can be shown or hidden in the display by enabling or disabling the checkbox "Show Level Target" in the Prefs Control Panel settings.

COMPARE TRACES

This troubleshooting tool can be used to compare any traces. This tool can be used to compare as many as 2 live scan traces, 3 spot traces, 5 recalled traces and a Math Trace (which is the result of subtracting any two traces). Legends for these traces will be shown in the graph too.

The scan and spot results are saved in the form of trace. Each result is saved in a different trace.

This trace tab gives the information of the list of Live Traces saved, Recalled trace and Math Trace.

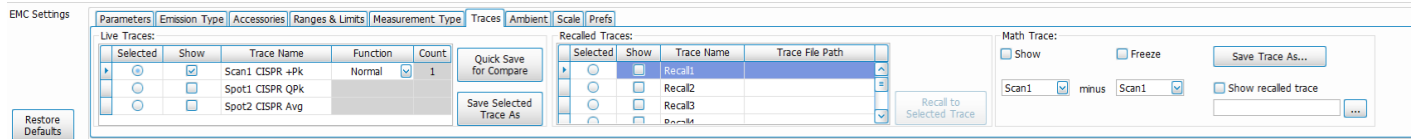


FIGURE 29. Compare Traces menu.

SETTINGS	DESCRIPTION
Live Traces	
Selected	Specifies the trace selected in the list. This also serves the purpose of making a trace active (Active trace is also selected from the top of the graph). Active trace selection puts the trace on the top of other graphs. This is useful when there are multiple traces viewed together.
Show	Shows / hides the selected trace.
Trace Name	Specifies the name of the trace. For Live Traces, these names are set by appending Detector choice with the measurement (Scan vs Spot based on whether scan is done or Re-measure Spot is done). The number after Scan or Spot is based on the number of detectors chosen for Scan and Re-measure spot measurements in Measurement tab.
Function	Specifies the function performed on the trace. Applicable only for scan trace in Live Traces.
Count	Specifies the count value for Function when Function is not Normal (Max Hold, Average etc.). When Function is Normal, this control is not editable as the Count is 1.
Quick Save for Compare	When this button is pressed, the selected Live Trace is saved automatically in your drive and recalled into one of the rows in Recalled Traces depending on which one is free. The search is done from Recall1 through Recall 5 in that order. There will be a timed pop message indicating the Recall Trace in which it is available for comparison. If none of the Recalled Traces are free, then clicking on "Quick Save for Compare" will save the trace in your drive and recall the trace as Recall 1 (replace the earlier recalled trace in Recall 1). However, the files replaced can be browsed for and recalled using "Recall to Selected Trace". All traces saved with "Quick Save for Compare" are saved in SignalVu-PC Files directory
Save Selected Trace As	Saves the Selected trace to a file for Recall and later analysis. This button is active only when a Live Trace is selected and only the selected trace is Saved.
Recalled Traces	
Selected	Specifies the trace selected (This will also make the Recalled Trace active and bring it to the top of all displays). Emission Results table will be populated with Spots based on the comparison of selected Recalled trace with Limit 1.
Show	Shows / hides the selected trace.
Trace Name	Specifies the name of the trace which was saved.
Trace File Path	Specifies the path of the saved trace file to be recalled.
Recall to Selected Trace	Recalls the trace for analysis into the Selected Recalled Traces row.
Math Trace	
Show	Shows / hides the Math trace.
Freeze	Freeze the Math trace.
Save Trace As	Saves the trace to a file for recall and future Analysis.
Show Recalled Trace	Displays a saved trace instead of a live trace.
Trace Selections for Math	Choose trace for difference operation from two drop downs. Trace 1- Trace 2 is done at every trace point.

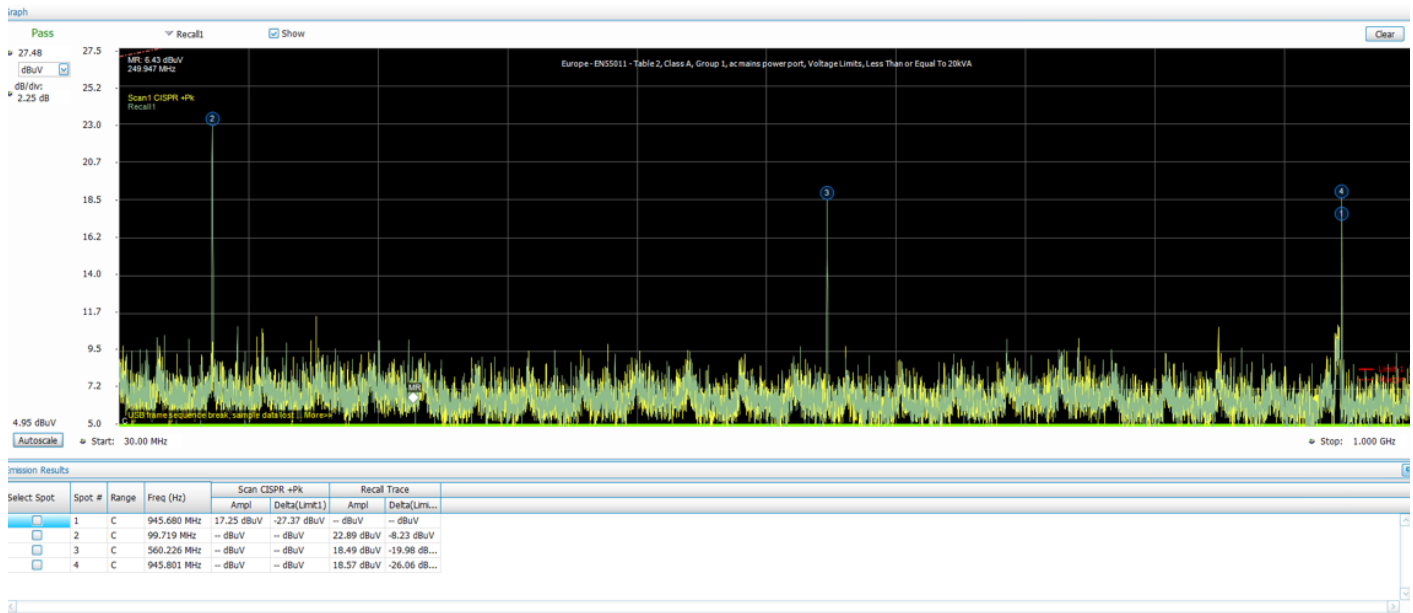


FIGURE 30. Emission Results table.

Saving Traces

To save a trace for later analysis:

1. Select a Live Trace
2. Select the Save Selected Trace As button. This displays the Save As dialog box.
3. Navigate to the desired folder or use the default.
4. Type a name for the saved trace and click Save.

Recalling Traces

You can recall a previously saved trace for analysis or comparison to a live trace.

To select a trace for recall:

1. Select a Recalled Traces row into which you want to recall a trace.
2. Select the Recall to Selected Trace button. This displays the Open dialog box.
3. Navigate to the desired folder or use the default.
4. Select the appropriate trace to be opened and click Open.
5. Recalled Trace will be plotted on the graph and comparison with Limit1 will be done and results will be shown in the Emission Results table

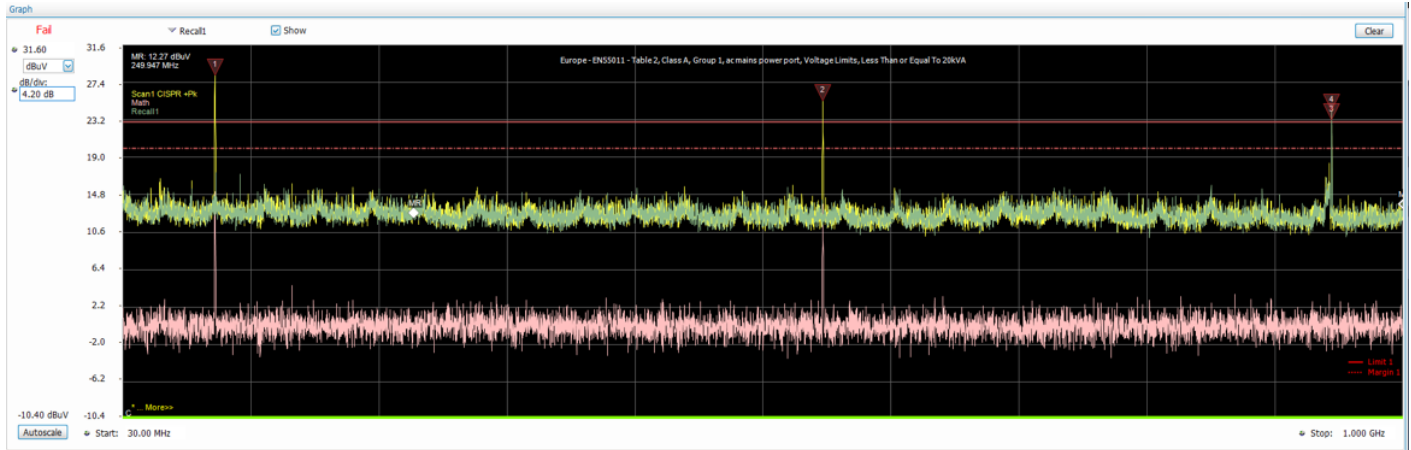


FIGURE 31. The Math trace is a mathematically-derived trace defined as Difference between two traces.

Math Trace

The Math trace is a mathematically-derived trace defined as Difference between two traces. You can select the two traces for difference calculation among the Live Traces, Recalled Trace and the Ambient Trace.

1. Select any of the trace from the list of traces provided in drop down (Trace1 and Trace2)
2. Traces can either be Live Scan Traces, any of the 5 Recalled trace or Ambient trace.
3. Difference between the two traces can be derived from the operation Trace1 minus Trace 2.
4. The resulting trace can be shown on the graph region by using Show checkbox and can be frozen using the Freeze checkbox.
5. The resulting trace can be saved into a file using Save Trace As button.
6. The saved trace can be recalled for the analysis by navigating to the desired folder. When a trace is recalled under Math, controls such as Show, Freeze and selections of traces for Math will be disabled.
7. The Math functionality is done for each range in the Ranges & Limits settings control.
8. If the span or trace points for any range doesn't match, then an error message will be put up for Math traces. e.g.
 - “No Math trace: Unmatched trace X range”
 - “No Math trace: Unmatched trace lengths”
9. The Math trace is done only for log units in Y axis and the difference trace is calculated by mere subtraction of the dB values.

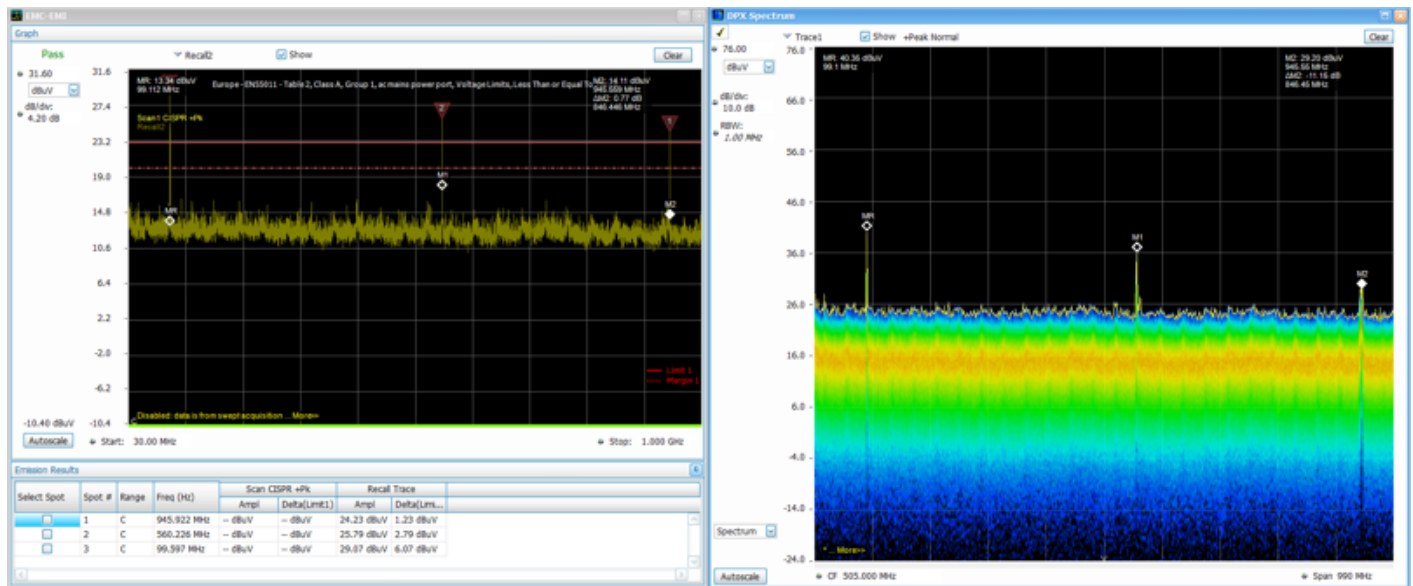


FIGURE 32. The DPX™ spectrum display, unique to Tektronix RTSAs, ensures that any signal lasting longer than a few 10s of microseconds is instantaneously captured and displayed.

PERSISTENCE DISPLAY

This troubleshooting tool launches the DPX display which has the capability to show persistent view over multiple acquisitions. DPX is fast and lets you pick even transient emission.

The DPX™ spectrum display, unique to Tektronix RTSAs, processes more than 10,000 spectrum measurements per second (exact number depends on which instrument in the portfolio is chosen), and ensures that any signal lasting longer than a few 10s of microseconds is instantaneously captured and displayed. More information on the operation of the DPX spectrum processor in RTSAs can be found in application note 37W-19638. The color grading seen in the

display indicates frequency of occurrence of the signal. More frequently occurring signals are presented in red and infrequent signals in blue to green. With a potential problem discovered by DPX, the next step is to trigger on and capture the signal for further analysis. This is easily accomplished by defining a frequency mask trigger based on the continuous signal profile, and capturing the infrequently occurring transient when it appears in the spectrum. Any signal above the frequency mask threshold lasting longer than the specified minimum signal duration will cause a trigger and store the pre-trigger and post-trigger signal into memory.

Click **Setup > EMC > Persistence Display** or click on **Persistence Display** in EMC Toolbar to open DPX.

NEAR FIELD TOOLS FOR DEBUGGING

The far field test can accurately tell whether the product passes or fails but cannot pinpoint the source of a problem. Using only the far-field test, one cannot isolate problems down to specific components or locations, like too much RF energy “leaking” from an opening in a metal enclosure or help identify a cable radiating too much RF energy. The near-field test is a good way to locate such emission sources and is typically performed using a spectrum analyzer and near-field probe.

Near-field Probes for EMI are electromagnetic pickups used to capture either the electric (E) or magnetic (H) field at the area of interest and are used with the spectrum analyzer. We provide a kit of probes (EMI-NF-PROBE) that offer the best compromise between size, sensitivity and frequency range, and you may need all the sizes in your toolkit to solve your problem. Selection between an H-field or E-field probe may be driven by location of a signal in your design, or by the nature of its source (voltage or current). For example, the presence of a metal shield may suppress the E-field, making it necessary to use an H-field probe for the application. Near-field probes must be used to either pick up the signal near the device under test. For further information Tektronix has an application note that focuses on troubleshooting EMI problems using near field probes.¹ We also offer an amplifier for the near field probe to increase the measurement reading EMI-NF-AMP- to be used mostly with the E-Field.



FIGURE 33. A near field probe can be used to discover the location of unintended RF emissions.

Conclusion

Failing an EMI compliance test is expensive and can put a product development schedule at risk. However, setting up your own pre-compliance testing can help you isolate any problem areas and fix them before you go to the complaint test house. Tektronix offers a low cost pre-compliance capability that will help you minimize both your expense and schedule in getting your products EMI certified.

¹ “Practical EMI Troubleshooting”, <http://www.tek.com/document/application-overview/troubleshooting-emi-problems>

Appendix

Setting Ranges & Limits

Use the Ranges and Limits tab to specify the parameters that control the EMC-EMI measurement. From the Ranges and Limits tab, you can specify the start and stop frequencies for ranges, the parameters that define a Spot (for listing in the Emission Results table) and Pass/Fail parameters for Limit testing.

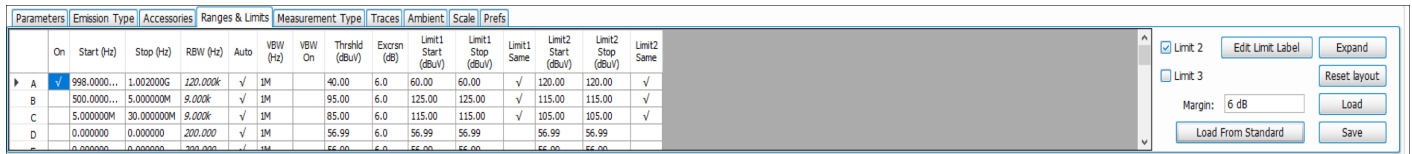


FIGURE 34. Ranges and Limits menu.

SETTING	DESCRIPTION
Expand	Displays the Ranges & Limits Table in a new, resizable window.
Reset layout	You can reorder columns in the Ranges and Limits Table by dragging the columns to a new position. Clicking Reset Layout returns the column order to the factory default order.
Load	Click to load a saved Ranges and Limits table from a file.
Save	Click to save the current Ranges and Limits table to a file.
Limit 2	Enable to set and Limit 2.
Limit 3	Enable to set and Limit 3.
Margin	Click to set the Margin value.
Load from Standard	Click to load a Ranges & Limits table as defined by a Standard.
Edit Limit Label	Click to edit the Limit label.

You can edit the Ranges and Limits table in two ways:

- Edit values directly from the Ranges and Limits tab. You may have to scroll the table to access all settings when multiple ranges are selected.
- Click the **Expand** button. This displays the Ranges and Limits Table in a new window that can be sized to the full screen.

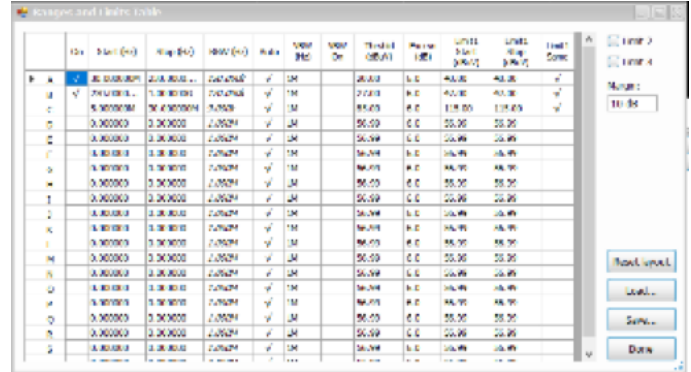


FIGURE 35. Edit values directly from the Ranges and Limits tab.

The following table describes the parameters that are set in the Ranges and Limits Table.

RANGES AND LIMITS TABLE SETTINGS	
SETTING	DESCRIPTION
On	Specifies whether the measurements are taken in the specified range or not.
Start (Hz)	Readout of the start frequency for the selected range.
Stop (Hz)	Readout of the stop frequency for the selected range.
RBW (Hz)	Specifies the Resolution bandwidth used for the selected range.
Auto	Sets the RBW automatically. For CISPR standards, frequency range decide the RBW.
VBW (Hz)	Adjusts the VBW (Video Bandwidth) value. VBW Maximum: RBW current value; VBW Minimum: 1/10,000 RBW setting.
VBW On	Specifies whether the VBW filter is applied.
Threshld (dBuV or dBuV/m)	Threshold specifies the level that must be exceeded for a signal peak to be recognized as a Spot. A signal peak must also exceed the Excursion setting to be considered a Spot.
Excrsn (dB)	Excursion specifies the peak to peak magnitude that must be exceeded for a signal peak to be recognized as a spot. A signal transition must also exceed the Threshold setting to be considered a Spot. A Spot requires the amplitude to drop by the Excursion amount between spots.
Limit 1/2/3 Start (dBuV or dBuV/m)	Specifies the Limit at the start frequency.
Limit 1/2/3 Stop (dBuV or dBuV/m)	Specifies the Limit at the stop frequency. The limit values for the frequency range is calculated by linear interpolating between Limit Start and Limit Stop. The frequency start and stop values are taken in Linear or Log based on the scale choice.
Limit 1/2/3 Same	Enables to set the starting and stopping limit as same.
Limit 2	Enable to set and display limit 2.
Limit 3	Enable to set and display limit 3.
Margin	Click to set the Margin value. (Applied to all limits)
Reset layout	You can reorder columns in the Ranges and Limits Table by dragging the columns to a new position. Clicking Reset Layout returns the column order to the factory default order.
Save	Click to save the current Ranges and Limits table to a file.
Load	Click to load a saved Ranges and Limits table from a file.
Done	Save changes and close the Ranges and Limits Table window.

LOADING FROM STANDARD

To Load:

1. Click the **Load From Standard** button on the **Range and Limits** tab.
2. Select the required region form the drop-down provided.
3. Select the required standard form the drop-down provided. (The version of the standard from which limit lines tables are listed is shown). You will need to procure the standard for knowing the test setup and other details.
4. Select the required Limit Table based on the EUT to be tested form the drop-down provided.
5. Click **OK** to load the Ranges/Limits in this tab and the detector choices/Limit line mapping in the Measurement tab.

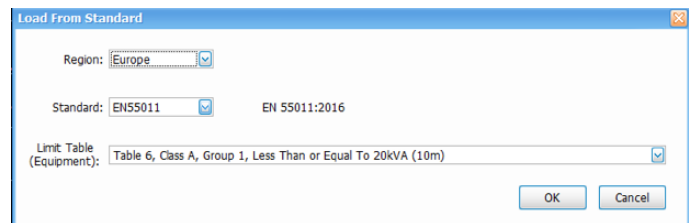


FIGURE 36. Use the Load From Standard button to set the Range and Limits per the standard.

CHANGING THE RANGE START AND STOP FREQUENCIES

To change the range start and stop frequencies, edit the Start and Stop frequencies in the Ranges and Limits Table:

1. Click the **Expand** button on the **Settings > Range and Limits** tab. This displays the Ranges and Limits Table.
2. Click the **On** box for a range to take measurements in the range.
3. Click on the Start or Stop frequency setting to change it. Type in a number for the frequency and a letter as a multiplier. You can use k, m, or g to set the frequency multiplier.
4. Click **Done** to save your changes.

SPECIFYING SPOT REQUIREMENTS

A Spot is a signal peak that exceeds both the Threshold and Excursion settings in the Ranges and Limits table. The Threshold and Excursion settings are specific to the selected range. If you want to use different settings for Spots in different ranges, you must set the values separately for each range. The Excursion control is used to avoid interpreting a single spot as multiple narrower spots by requiring the amplitude to drop by the Excursion amount between spots. Raising the Threshold value means that fewer, larger signals will be identified as spots.

To specify the Spot requirements for a range:

1. Click the **Expand** button on the **Range and Limits** tab. This displays the Ranges and Limits Table.
2. Select the **Range (A–T)** for which you want to specify the Spot requirements.
3. Set the **Thrshld** value.
4. Set the **Excrsn** value.

Note: Spot specification is also dependent on the “List Spots” selection in the Parameters tab. By default, this selection is All Spots, in which case, all frequency peaks above the Thrshld (subject to Excrsn violation) are classified as Spots for listing in the Emission Results table. If this selection is Over Limit, then only those frequency peaks above the limit line classify as a Spot for listing in the Emission results table. The third selection is “Over Limit with Margin” which will only classify frequency peak that violate Limit line with Margin included in them.

SETTING LIMITS

Use the Limits settings in the Ranges and Limits Table to specify the pass/fail parameters for the EMC-EMI measurement. When the Mask setting is set to any value except off, the instrument identifies any signal peak that exceeds the specified limits as a violation and displays Fail on the screen. If no signal peak exceeds the limits, the instrument displays Pass on the screen. The Margin control lets you set the elbow room that you would want around the Limit line. The frequency peaks that violate the limit lines are shown in red color both in the graph and Emission results sections. If they violate only the limit line, then they are shown in Orange color.

PERFORMING PASS/FAIL LIMIT TESTING

To set limits:

1. Click the **Expand** button on the **Range and Limits** tab. This displays the Ranges and Limits Table.
2. Adjust the Start and Stop frequencies as required for each range you want to test.
3. For ranges that you wish to test, verify that the **On** box is checked.
4. Set the limits as desired in the **Start, Stop**.
5. Set the required RBW and VBW.
6. Verify that the **Thrshld** and **Excrsn** values are set as required. These are the values that define a Spot.
7. Click **Done** to save your changes and close the Range and Limits Table window.
8. Click **Run** to begin testing.

Note: All above parameters can be set either manually, or can be loaded from a file or from a specified Standard.

ACCESSORIES

Tektronix offers fully validated accessories including antennas, Line Impedance Stabilization Networks and pre-amplifiers individually, or in two comprehensive accessory bundles for conducted and radiated tests. These accessories are validated by Tektronix with characterization of accessories, including Gains and Losses values, pre-loaded into EMCVu to provide simple set-up and greater accuracy in your measurements.

ANTENNAS

EMI-BICON-ANT

The EMI-BICON-ANT is a broadband, linearly polarized Biconical Dipole Antenna with collapsible elements, operating over the frequency range of 25 MHz to 300 MHz. Each full-size biconical element (54 cm cage diameter) collapses to a maximum diameter of 5 cm for easy transport/storage.

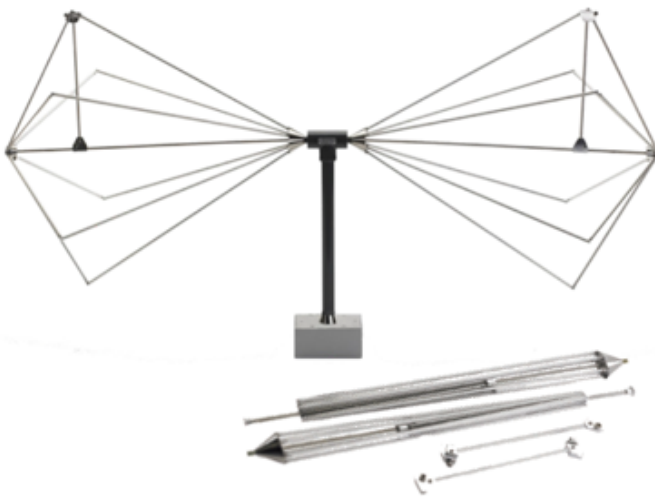


FIGURE 37. EMI-BICON-ANT Biconical Antenna.

The EMI-BICON-ANT Biconical Antenna is intended for use as an EMI test antenna for qualification-level regulatory compliance measurements (FCC, CE, Mil-Std, RTCA DO-160, FDA, SAE Automotive, etc.).

EMI-BICON-ANT has the following characteristics (Antenna factor)

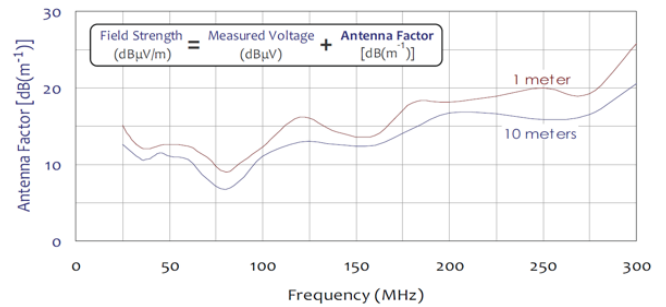


FIGURE 38. EMI-BICON-ANT antenna factor.

These factors can be loaded into the Accessories tab of the Settings control panel or through the Setup Wizard of the EMCVu software. The file will be available to you when you install the software in C:\SignalVu-PCFiles\EMC_Accessories

EMI-CLP-ANT

The EMI-CLP-ANT is a broadband, linearly polarized Log Periodic Dipole Array (LPDA) Antenna, operating over the frequency range of 200 MHz to 1 GHz; and with excellent efficiency between 300 MHz and 1 GHz.

The EMI-CLP-ANT Compact Log Periodic Antenna is intended for use as an EMI test antenna for qualification-level regulatory compliance measurements (FCC, CE, RTCA DO-160, FDA, SAE Automotive, etc.).



FIGURE 39. EMI-CLP-ANT Log Periodic Dipole Array (LPDA) Antenna.

The EMI-CLP-ANT can also be mounted using the EMI-TRIPOD tripod (which is a part of the accessories given by Tektronix)

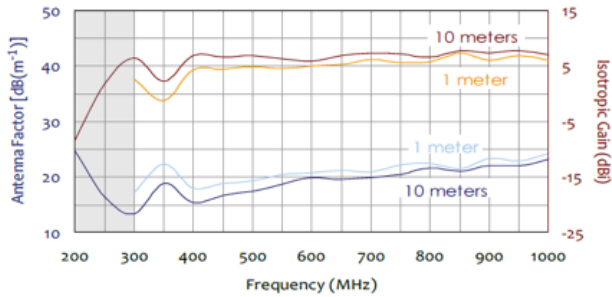


FIGURE 40. EMI-CLP-ANT antenna factor.

EMI-TRIPOD

The recommended support structures for the EMI-BICON-ANT is the EMI-TRIPOD Antenna Tripod. One of the standard accessories is the EMI-TRIPOD Antenna Pipe Holder, which clamps securely around the one-inch diameter feed tube of the EMI-BICON-ANT. It is then secured to a tripod or mast via its 1/4" x 20 thread mounting hole.



FIGURE 41. EMI-TRIPOD Antenna Tripod.

PREAMPLIFIER

EMI-PREAMP

The EMI-PREAMP is a broadband, high gain, low-noise preamplifier operating over the frequency range of 1 MHz to 1 GHz. Its high gain (33 dB ±3 dB) and low noise figure (<3.3 dB) make the preamplifier the ideal choice for optimizing your EMI measurement system, whether it be a test chamber, open area test site or tem-cell.

The EMI-PREAMP can be powered by its internal, rechargeable battery packs, or by its AC to DC Power Adapter/Battery Charger. On a full charge, the preamp will operate on battery power for over 13 hours. The battery low indicator light will let you know when it is time to plug it in; and the charging indicator light will let you know that its charging. If you are unable to plug it in, you can feel confident in continuing your test, as the EMI-PREAMP will turn itself off well before the battery voltage reaches the point at which the gain could become unstable. Whether it's operating on battery power or external power; if the amp is on, you can rest assured that the output is stable and that the gain will remain constant.



FIGURE 42. EMI-CLP-ANT broadband, high gain, low-noise preamplifier.

Nearly all measurement systems for radiated EMI tests require preamplification to achieve the necessary sensitivity.

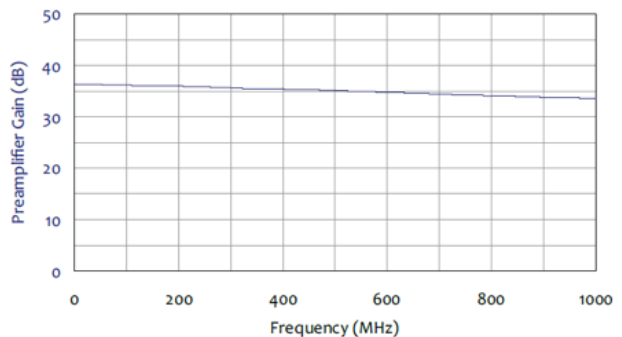


FIGURE 43. EMI-CLP-ANT gain.

TBLC08 50 μ H AC-LISN - TEKBOX

The TBLC08 is a Line Impedance Stabilization Network for the measurement of line-conducted interference within the range of 9kHz to 30MHz, as per the CISPR16 standard. The device is designed for testing single phase, AC-powered equipment with supply voltages up to maximum 260 V. Conducted noise can be measured on the phase and on the neutral conductor. The TBLC08 is equipped with a switchable limiter/attenuator.

The LISN provides for stabilization and lets you measure what amount of energy is fed back to the power line. The LISN is powered and the front-end power socket lets you power your equipment under test (EUT). The emissions that is fed back to the power line is available at RF out for a receiver or spectrum analyzer to measure.

The LISN is connected to the AC power supply and provides power to the EUT. The spectrum analyzer is connected to the RF out of the LISN. TBLC08 has an inbuilt limiter which can be switched ON to avoid transients. The emission that are usually fed back to the power line is made available at RF out by the stabilization network.



FIGURE 44. TBLC08 Line Impedance Stabilization Network (LISN).

Contact Information:

Australia* 1 800 709 465
Austria 00800 2255 4835
Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium* 00800 2255 4835
Brazil +55 (11) 3759 7627
Canada 1 800 833 9200
Central East Europe / Baltics +41 52 675 3777
Central Europe / Greece +41 52 675 3777
Denmark +45 80 88 1401
Finland +41 52 675 3777
France* 00800 2255 4835
Germany* 00800 2255 4835
Hong Kong 400 820 5835
India 000 800 650 1835
Indonesia 007 803 601 5249
Italy 00800 2255 4835
Japan 81 (3) 6714 3010
Luxembourg +41 52 675 3777
Malaysia 1 800 22 55835
Mexico, Central/South America and Caribbean 52 (55) 56 04 50 90
Middle East, Asia, and North Africa +41 52 675 3777
The Netherlands* 00800 2255 4835
New Zealand 0800 800 238
Norway 800 16098
People's Republic of China 400 820 5835
Philippines 1 800 1601 0077
Poland +41 52 675 3777
Portugal 80 08 12370
Republic of Korea +82 2 6917 5000
Russia / CIS +7 (495) 6647564
Singapore 800 6011 473
South Africa +41 52 675 3777
Spain* 00800 2255 4835
Sweden* 00800 2255 4835
Switzerland* 00800 2255 4835
Taiwan 886 (2) 2656 6688
Thailand 1 800 011 931
United Kingdom / Ireland* 00800 2255 4835
USA 1 800 833 9200
Vietnam 12060128

* European toll-free number. If not accessible, call: +41 52 675 3777

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