Keysight X-Series Signal Analyzers

This manual provides documentation for the following analyzers:

PXA Signal Analyzer N9030A

MXA Signal Analyzer N9020A

EXA Signal Analyzer N9010A

CXA Signal Analyzer N9000A

MXE EMI Receiver N9038A

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EMI Measurement Application Measurement Guide

KEYSIGHT TECHNOLOGIES

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Manual Part Number

N6141-90002

Print Date

August 2014

Supersedes: March 2014

Printed in USA

Keysight Technologies Inc.
1400 Fountaingrove Parkway
Santa Rosa, CA 95403

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1 About the EMI Receiver Measurement Application

This book provides information on using the EMI Receiver Mode in your MXE EMI Receiver or your X-Series Signal Analyzer.

The MXE EMI Receiver allows you to make fully CISPR compliant measurements. The X-Series signal analyzers allow you to make the same measurements in a precompliance environment.

The N6141A and W6141A EMC measurement applications enable you to perform conducted and radiated emissions tests to both commercial and MIL-STD requirements. It provides better sensitivity, accuracy and reduces test margins, across the MXE EMI Receiver or X-Series signal analyzers, so you can make more precise measurements. The wide range of features enables you to use the scan table to set up frequency ranges, gains, bandwidths and dwell time. You can scan a frequency range and display the results in log or linear format, search for signals, measure the peak, quasi-peak and average values of the signals and place the results in a table. Use the Signal List feature to mark and delete unwanted signals, leaving only those of interest.

This measurement application enables you to:

- Identify out-of-limit device emissions
  - See device emissions typically hidden in the noise floor
  - Differentiate between ambient signals and device emissions
  - View signals over time to identify intermittent responses
- Maximize signals and compare against regulatory requirements
  - Built-in commercial and MIL-STD compliant bandwidths, detectors and band presets
  - Continuously monitor signals with bar meters to detect maximum amplitude
  - Compare measured emissions to regulatory limits

You can access this application by way of the front panel or a remote interface.

The Role of Precompliance in the Product Development Cycle

To ensure successful electromagnetic interference (EMI) compliance testing, precompliance testing has been added to the development cycle. In precompliance testing, the electromagnetic compatibility (EMC) performance is evaluated from design through production units.

It is important to have a strategy that will help you test for potential EMI problems throughout the product development cycle. It is also important to have equipment and processes in place that will allow you to observe how close you are to compliance at any given time in the development cycle. This reduces the time and cost associated with final compliance testing.

Compliance Measurements

Electrical or electronic equipment that uses the public power grid or has the potential for electromagnetic emissions must pass EMC (electromagnetic compatibility) requirements. These requirements fall into four broad types of testing:

- **Conducted emissions** testing focuses on signals present on the AC mains that are generated by the device under test (DUT). The frequency range of these measurements is typically 9 kHz to 30 MHz. However, MIL-STD measurement may have a wider frequency range.
- **Radiated emissions** testing searches for signals being emitted from the DUT through space. The typical frequency range for these measurements is 30 MHz to 1 GHz or 6 GHz, although FCC regulations require testing up to 40 GHz.
- **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 power or data lines.

2 Conducted Emissions Measurement Examples

Conducted emissions testing focuses on emissions that are conducted along a power line that are generated by the device under test (DUT). The transducer that is typically used to couple the emissions of the power line to the EMI Receiver is a line impedance stabilization network (LISN).

The regulatory limits specify the maximum DUT emission energy, usually in dBμV, detected by the LISN. The test range for these measurements is typically 150 kHz to 30 MHz, though some limits may start as low as 9 kHz, depending on the regulation.

Making Conducted Emission Measurements

CAUTION Before connecting a signal to the MXE receiver, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the RF Input connectors on the front panel.

See the AMPTD Y Scale menu for details on setting internal attenuation to prevent overloading the receiver.

Setting up and making an ambient measurement

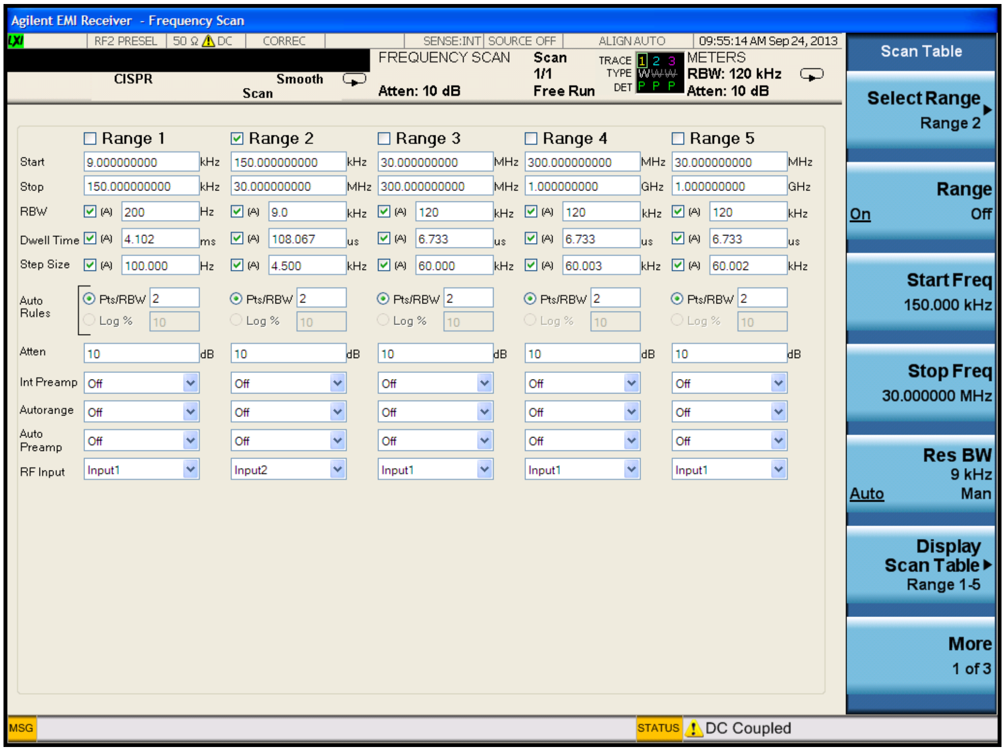
This section demonstrates how to set up and perform conducted emission tests in the 150 kHz to 30 MHz range.

NOTE Determine which regulatory requirements you will be testing to prior to starting the following procedure.

Step	Action	Notes
1 Turn on the instrument.	a. Press the front-panel power key.	
2 Select the EMI mode	a. Press **Mode, EMI Receive**r.	This is the default mode.
3 Ensure that the input is DC coupled	a. Press **Input/Output**, **RF Input**, **RF Coupling to DC**.	This step is not necessary if *Option 544* is installed.
4 Open the scan table and select the desired range	a. Press **Meas Setup**, **Scan Table**, **Range 2**, **Range** to **On**. b. Press **RF Input**, **Input2.**	Deselect any other range that has a green check.

Step	Action	Notes

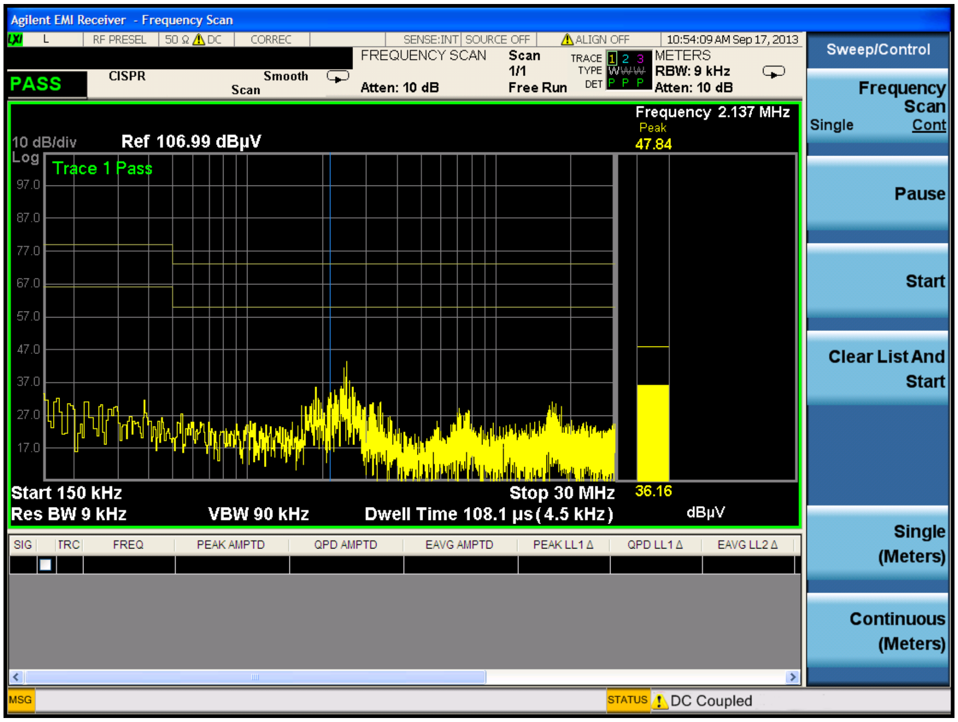
TIP



Step	Action	Notes
5 Load Quasi-peak limit line	a. Press **Recall**, **Data**, **Limit, Limit, Select Limit, Limit 1**. b. Press **Preloaded Limits**. c. Press **Return**, **Open**. d. Select `EN, Open, 55022, Open`. e. Scroll to `EN55022, Cond,Class A, Quasi-peak.csv, Open`.	The limit line will be turned on after loading, If no data exists for Trace 1, the Limit Line will not display.
6 Load Average limit line	a. Press **Recall**, **Data**, Limit, Limit, **Select Limit**, **Limit** 2. b. Press **Return**, **Open**. c. Scroll to `EN55022, Cond, Class A, Average.csv, Open`.	

Step	Action	Notes
7 Change EMI Average detector to compare to Limit Line 2	a. Press **Meas Setup**, **Detectors (Measure)**.	
	b. **Select Detector**, **Detector 3**.	
	c. **Press Limit for Δ**, **Limit 2**, **Enter**.	A dialog box may appear, `Changing limit for delta will discard delta values, are you sure you want to do this? Please press Enter of OK to proceed. Press ESC or Cancel to close this dialog.`
8 Load correction factors for the LISN	a. Press **Recall**, **Data**, **Amplitude Correction, Select Correction, Correction 1.**	This places the corrections for the LISN in Amplitude Correction 1.
	b. Press **Preloaded Limits**.	
	c. Press **Return**, **Open**.	
	d. Select `LISN-10A (9 kHz to 30MHz).csv`, `Open`.	These correction factors compensate for the losses of the LISN.
9 Insure that the correction factors are on	a. Press **Input/Output**, **More 1 of 2**, **Corrections**, **Correction 1**, **On**.	
10 Update the scan	a. Press **Sweep/Control**, **Start**.	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.

Step	Action	Notes



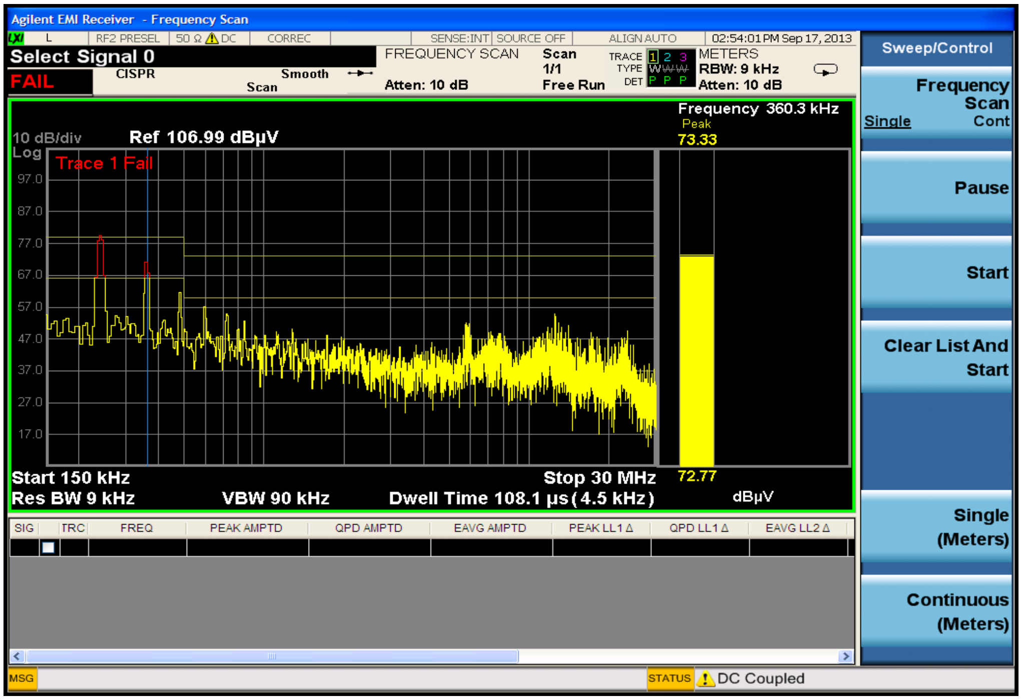
11 Stop the scan — a. Press **Stop**.

Running Frequency Scan

Step	Action	Notes
1 Turn on the DUT	a. Configure the LISN and DUT. b. Turn the DUT on.	
2 Set Up	a. Connect the DUT and LISN, to the EMI Receiver as shown below:	Ensure that the power cord between the DUT and the LISN is as short as possible. The power cord can become an antenna if allowed to be longer than necessary.

3 Start the scan	a. Press **Meas Setup**, **Scan Sequence**, **Scan Only**, **Sweep/Control**, **Start**.	Signals above the limit are designated in red.
4 Stop the scan	a. Press **Stop**.	This step will not be necessary if the measurement has completed the number of scans set or the desired time.

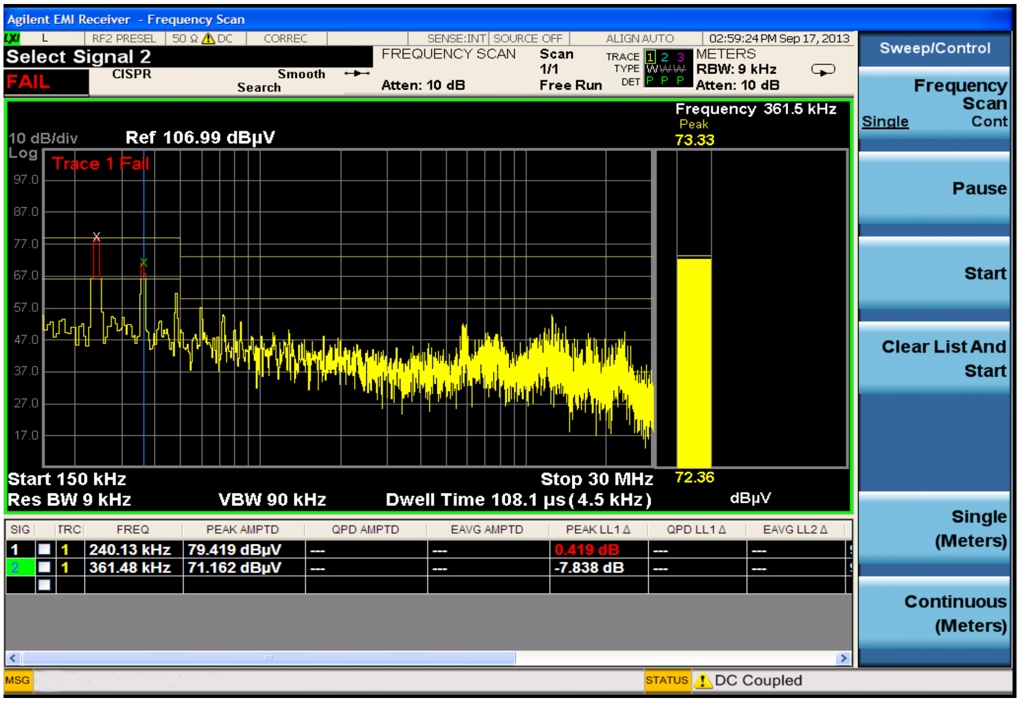
Step	Action	Notes



Adding signals to the signal list

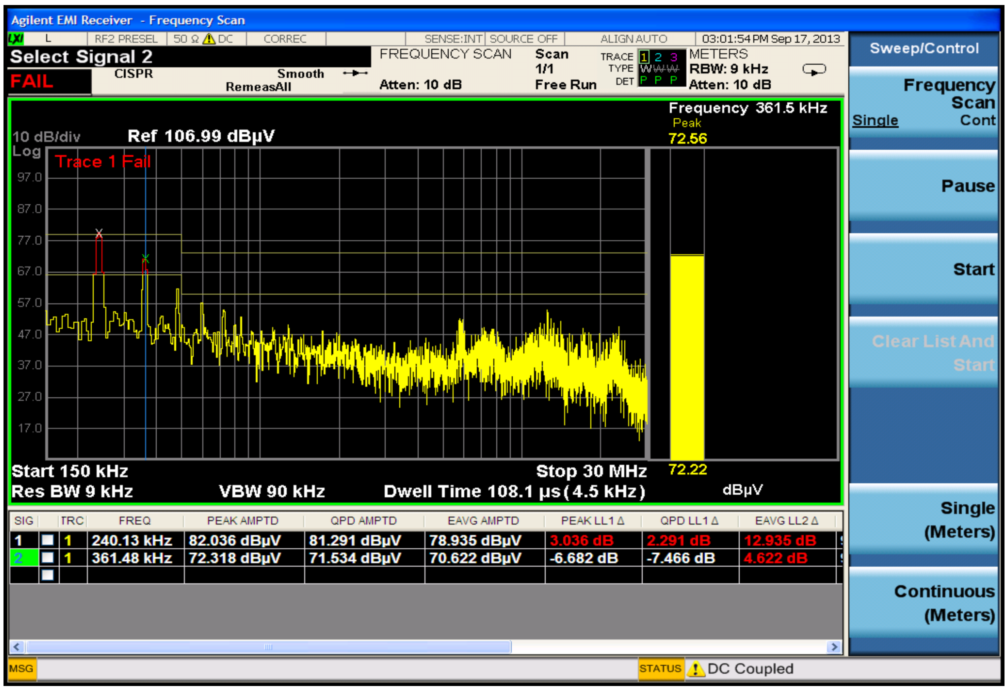
Step	Action	Notes
1 Clear any existing signal list	a. Press **Meas Setup**, **Signal List**, **Delete Signals**, **Delete All**.	
2 Switch to search	a. Press **Meas Setup**, **Scan. Sequence**, **Search Only**.	
3 Set the search criteria to peak criteria and limits	a. Press **Meas Setup**, **More 1 of 2**, **Limits**, **Search Criteria**, **Peak. Criteria and Limits**.	This is the default setting.
4 Add signals to the Signal List	a. Press **Sweep/Control**, **Start** or press the **Restart** key.	

Step	Action	Notes



Measuring the Quasi-peak and average values of the signals

Step	Action	Notes
1 Perform a Re-measure on all signals in the list	a. Press **Meas Setup**, **Scan. Sequence**, **(Re)measure, (Re)measure**, **All Signals**, **Sweep/Control**, **Start**.	



Step	Action	Notes
2 Review the measurement results		The delta to Limit Line values should all be negative. If some of the measurements are positive, there is a problem with conducted emissions from the DUT.

Measurement tip

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. Note that there are fewer points to view. You can add more data points using the scan table. The default setting in the scan table is two data points per BW or 4.5 kHz per point in this case since the resolution bandwidth is 9 kHz. To get more data points, change the points per bandwidth to four points.

3 Radiated Emissions Measurement Examples

Radiated emissions measurements are not as straightforward as conducted emissions measurements. There is the added complexity of the ambient environment, which could interfere with measuring the emissions from the device under test (DUT).

Making Radiated Emission Measurements

CAUTION Before connecting a signal to the MXE receiver, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the RF Input connectors on the front panel.

See the AMPTD Y Scale menu for details on setting internal attenuation to prevent overloading the receiver.

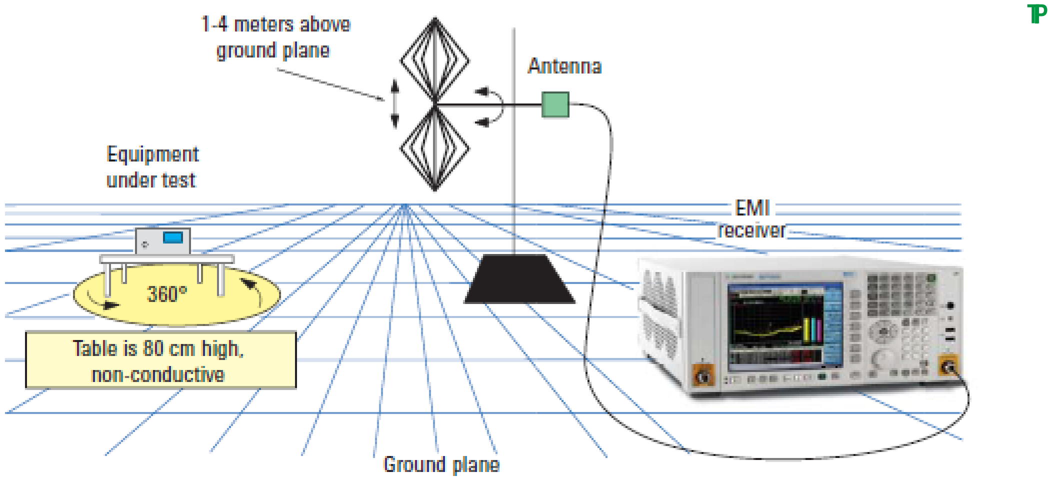
Setting up and making an ambient measurement

This section demonstrates how to set up and perform radiated emission tests in the 30 to 300 MHz range.

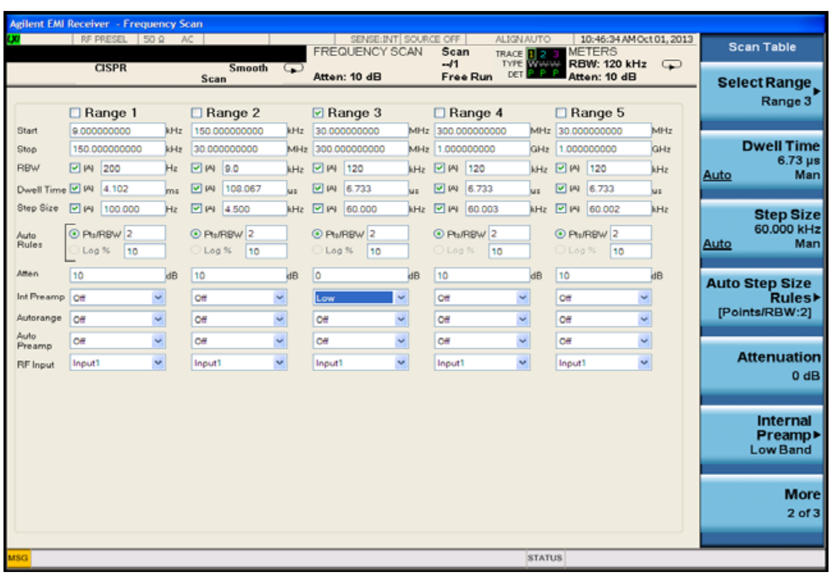
NOTE Determine which regulatory requirements you will be testing to prior to starting the following procedure.

Even if you only have access to a small shielded enclosure, you can still make valuable measurement of your device. Emission signals found in the small chamber can save you time later on in an open area test site by providing information about the emissions of interest.

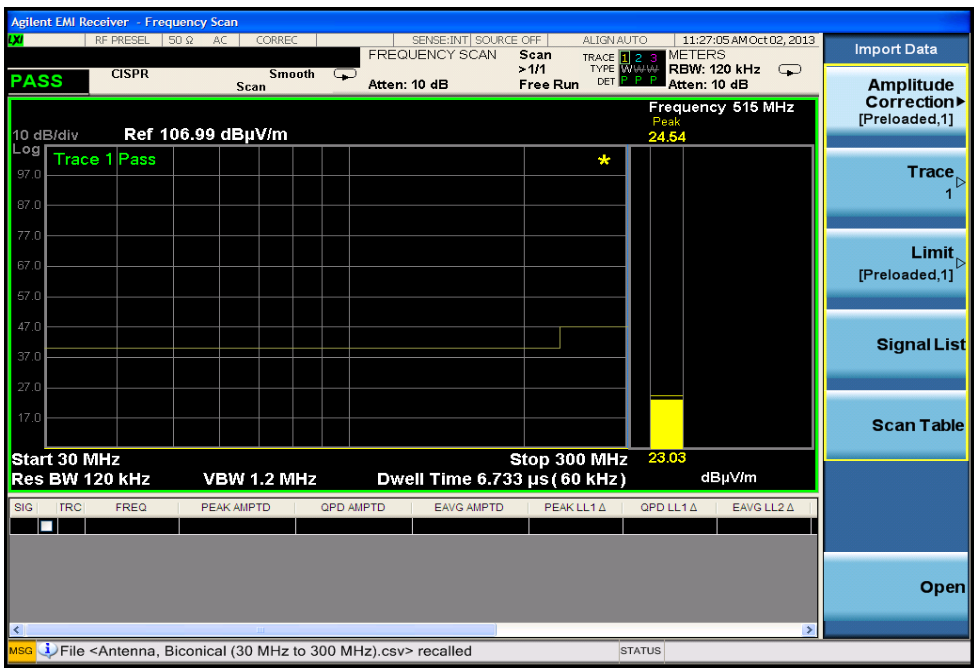
Step	Action	Notes
1 Test Set Up	b. Arrange the antenna, DUT and instrument as shown in the following graphic:	Separate the antenna and the device under test (DUT) as specified by the regulatory agency requirements. If space is limited, the antenna can be moved closer to the DUT and you can edit the limits to reflect the new position. For example, if the antenna is moved from 10 meters to 3 meters, 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.



Step	Action	Notes
2 Turn on the instrument.	a. Press the front-panel power key.	
3 Select the EMI mode.	a. Press **Mode, EMI receive**r.	This is the default mode.
4 Open the scan table and select the desired range	a. Press **Meas Setup**, **Scan Table**. b. **Press Select Range**, **Range 3, Range** to **On**.	Deselect any range that has a green check.
5 Set the attenuation and internal amplifier	a. Press **More 1 of 3**, **Attenuation**, **0**, **dB**, **Internal Preamp**, **Low Band**.	

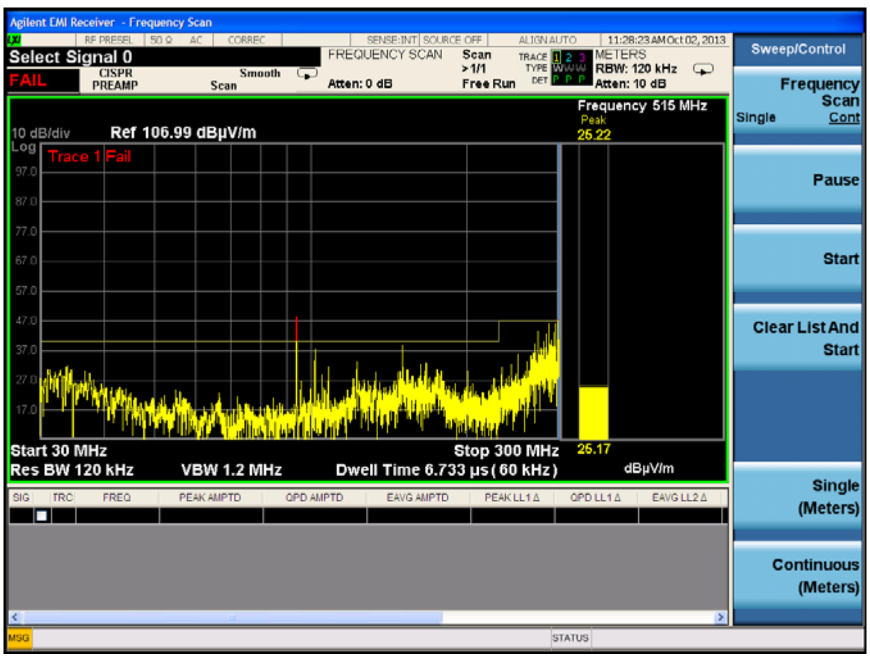


Step	Action	Notes
6 Load limit lines	a. Press **Recall**, **Data**, **Limit (Preloaded 1)**, **Open**. b. Scroll to `EN 55022, Rad, Class A, 30 MHz to 1 GHz (10m).csv`, Open.	
7 Load correction factors for the biconical antenna	a. Press **Amplitude Corrections (Preloaded 1), Open**. b. Select `Antenna, Biconical (30 MHz to 300 MHz).csv`, Open.	



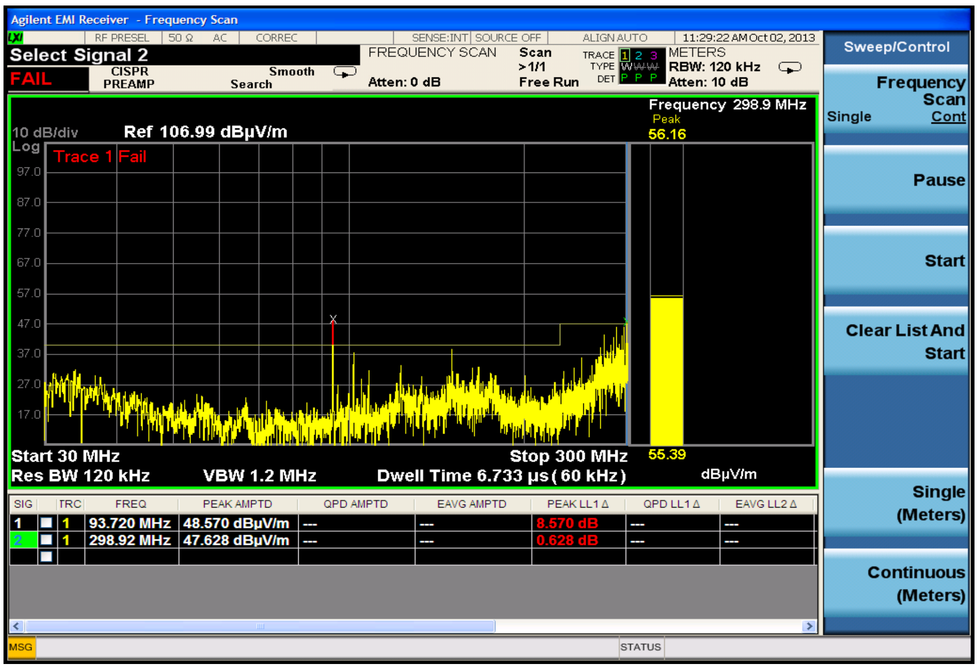
Running Frequency Scan

Step	Action	Notes
1 Clear any existing signal list	a. Press **Meas Setup**, **Signal List**, **Delete Signals**, **Delete All**.	
2 Turn on the DUT and start frequency scan	a. Turn the DUT on. b. Press **Meas Setup**, **Scan Sequence**, **Scan Only.** c. Press **Sweep/Control**, **Start**.	Let the Receiver take a number of scans before going to the next step.
3 Stop the scan	a. Press **Stop.**	



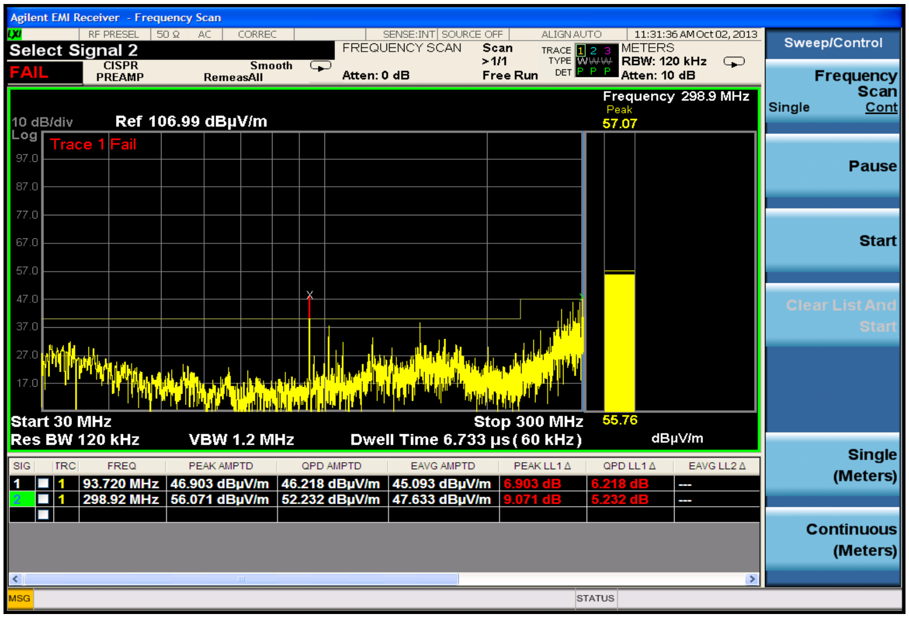
Adding signals to the list

Step	Action	Notes
1 Set the search criteria to peak criteria and limits	a. Press **Meas Setup**, **More 1 of 2**, **Limits**, **Search Criteria**, **Peak Criteria and Limits.**	This is the default value.
2 Switch to search	a. Press **Meas Setup**, **Scan Sequence**, **Search Only**.	
3 Add signals to the Signal List	a. Press **Sweep/Control**, **Start**.	



Measuring the Quasi-peak and average values of the signals

Step	Action	Notes
1 Measure remaining signals	a. Press **Meas Setup**, **Scan Sequence**, **(Re)measure**, (Re)measure **All Signals**. b. Press **Sweep/Control**, **Start**.	



Step	Action	Notes
2 Review the measurement results		

4 Disturbance Analyzer (Click) Measurements

The following topics are in this section:

"Overview" on page 28

"Making a Measurement" on page 29

"Quick Reference to Menus" on page 36

"Setup Table Menu Features" on page 38

Overview

A broad range of commercially-available electronic devices exhibit intermittent operation that generates impulsive (or discontinuous) radiated and conducted disturbances. Common examples of these devices are washing machines, refrigerators, thermostats, motor-operated apparati, and automatic dispensing machines.   The level of effective interference created by the discontinuous nature of these disturbances is significantly different (and typically less) than the effective interference created by a continuous disturbance.

To address this situation, CISPR (Comite International Special des Perturbations Radioelectriques) developed different sets of conducted emissions limits for these classes of devices. There is one set of limits for continuous disturbances and a different set of limits for discontinuous disturbances, commonly called "clicks". The definitions of a click, the measurement conditions and methodologies, and the limits associated with different classes of equipment are all presented in the CISPR 14-1 International Standard document.

Because the effective level of interference caused by a discontinuous disturbance can be less than the effective level of interference caused by a continuous disturbance, CISPR limits for click amplitudes are relaxed from limits for continuous disturbances. The amount of relaxation depends upon the rate of the measured clicks over time. The lower the click rate, the greater the relaxation.

The following sections describe the operation of the Disturbance Analyzer measurement application included in the Agilent N9038A MXE EMI receiver. It is important to note that compliant discontinuous disturbance measurements require an EMI receiver or a spectrum analyzer that is CISPR-compliant.

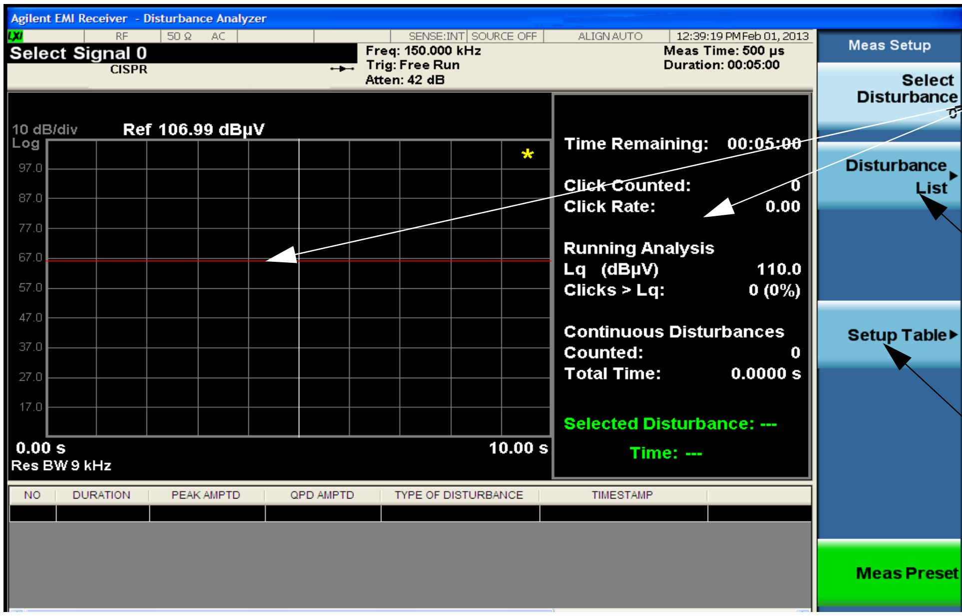
Making a Measurement

Setting up a Click measurement

Step	Action	Notes
1 Turn on the receiver	a. Press the front-panel power key.	
2 Test Set Up	a. Configure the Device Under Test (DUT) b. Connect the DUT power cable to a Line Impedance Stabilization Network (LISN) c. Connect the LISN to the mains power d. Connect the output RF port from the LISN to the N9038A MXE EMI Receiver	

3 Select the Disturbance Analyzer measurement	e. Press **Mode**, **EMI Receiver**, **Meas**, **Disturbance Analyzer** (Click)	This brings up the following Click Measurement display.

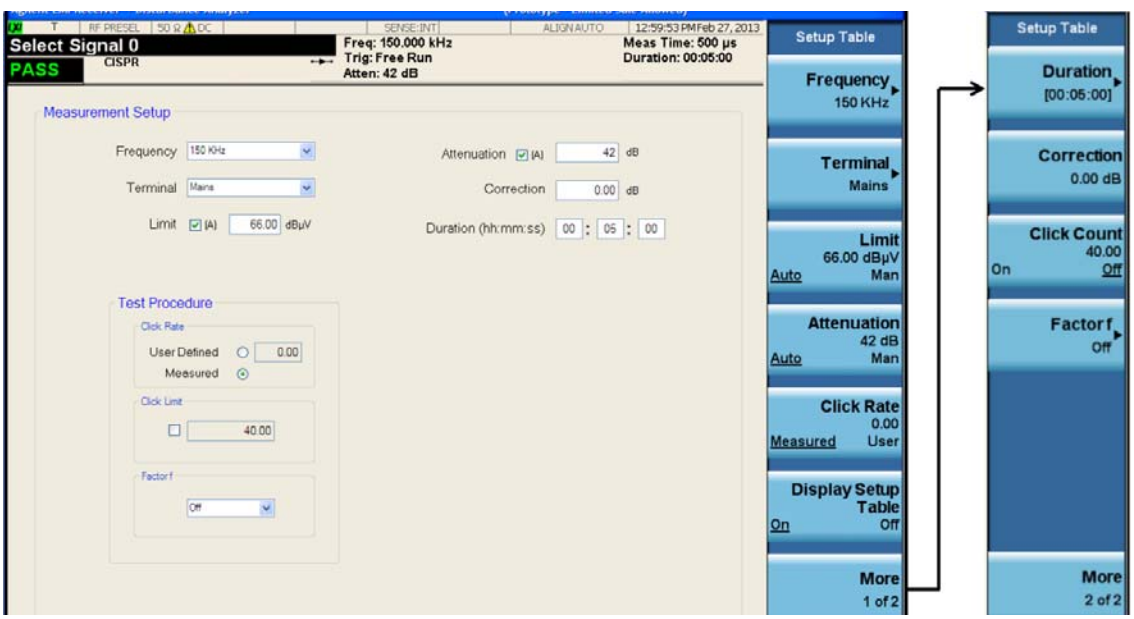
Step	Action	Notes



From this display you can:

- View the status of a data collection in progress.
- Access the navigation and editing features of the disturbance list.
- Access the measurement setup table

Step	Action	Notes
4 Access the Setup Table to configure a Click measurement	a. Press **Setup Table**	This table enables you to configure the measurement with all of the parameters needed to measure Clicks to the appropriate limit.

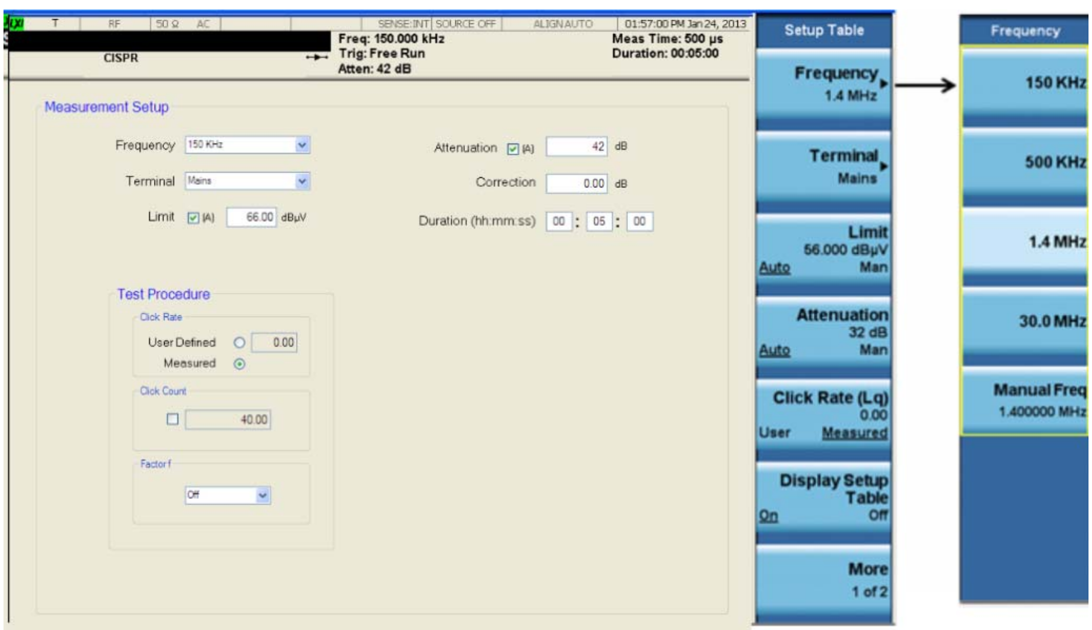


NOTE The MXE allows you to either make measurements using autocoupled settings or manual settings. When using autocoupled settings, the limits and input attenuation settings used during the measurement are determined by your measurement frequency and terminal selection. These autocoupled settings provide the appropriate limit values as given in CISPR 14.

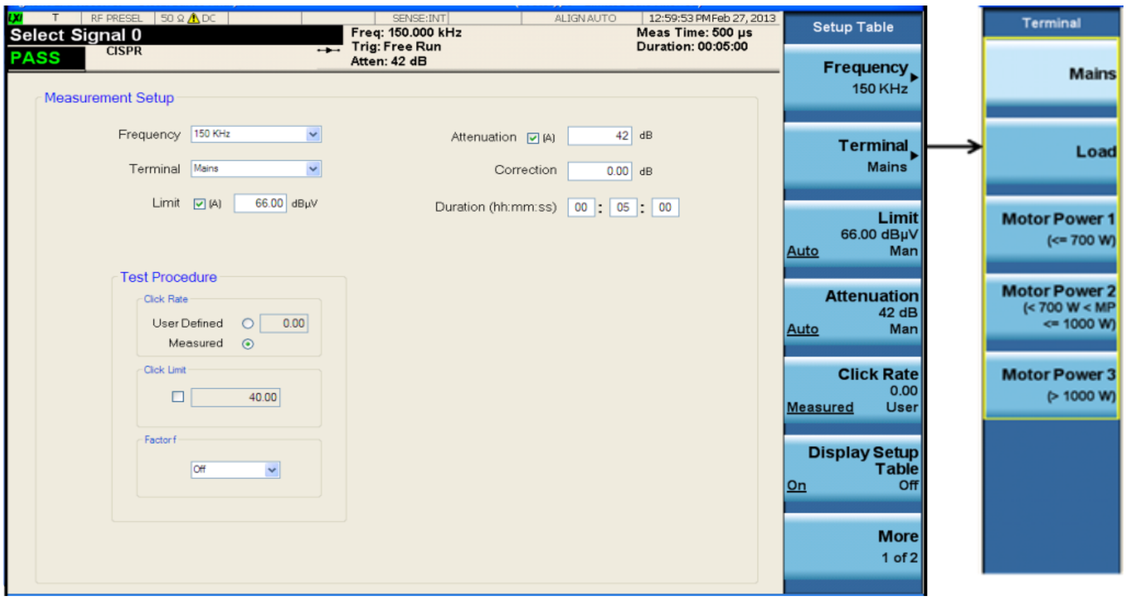
Setting up the Disturbance Analyzer measurement

The Click measurement can be set up using either the Setup Table screen, the menu keys or a combination of both. The following procedure guides you through the measurement using the menu keys.

Step	Action	Notes
1 Frequency selection	a. Press **Frequency** and select one of the configured frequency keys Or b. Press **Frequency**, **Manual Frequency** and enter the desired frequency using the numerical keypad	**TIP** For more information see "Frequency" on page 38. **NOTE** When using autocoupled settings, once you have selected a frequency, the MXE will automatically select the appropriate limit and attenuation settings for the currently selected Terminals setting.

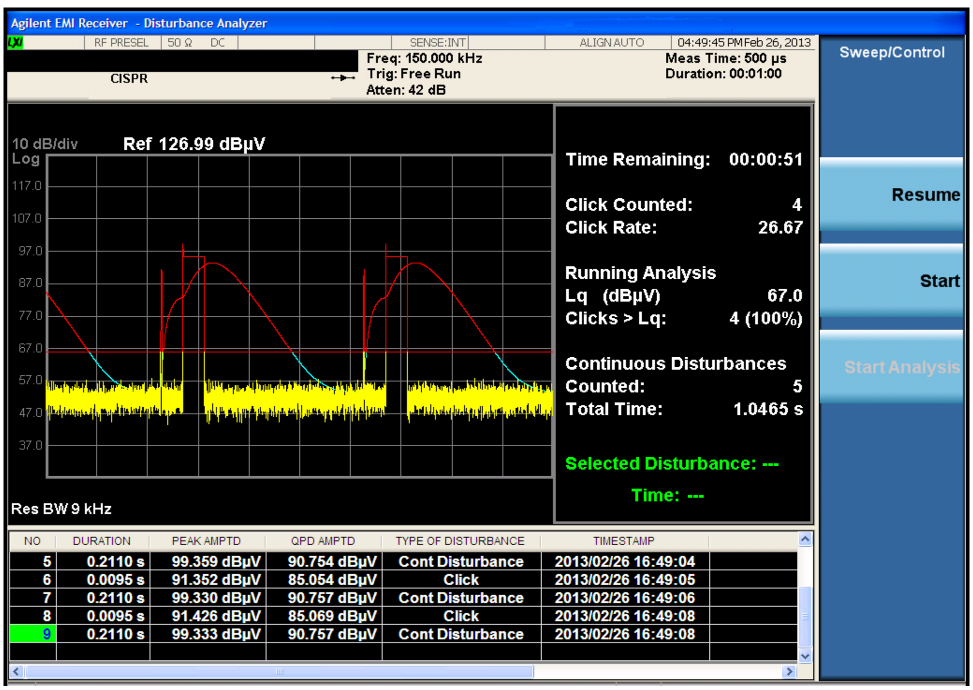


Step	Action	Notes
2 Terminal selection	a. Press **Terminal** and select one of the configured terminal keys	For more information see "Terminal" on page 38. **NOTE** When using autocoupled settings, once you have selected a Terminal choice, the MXE will automatically select the appropriate limit and attenuation settings for the currently selected frequency.



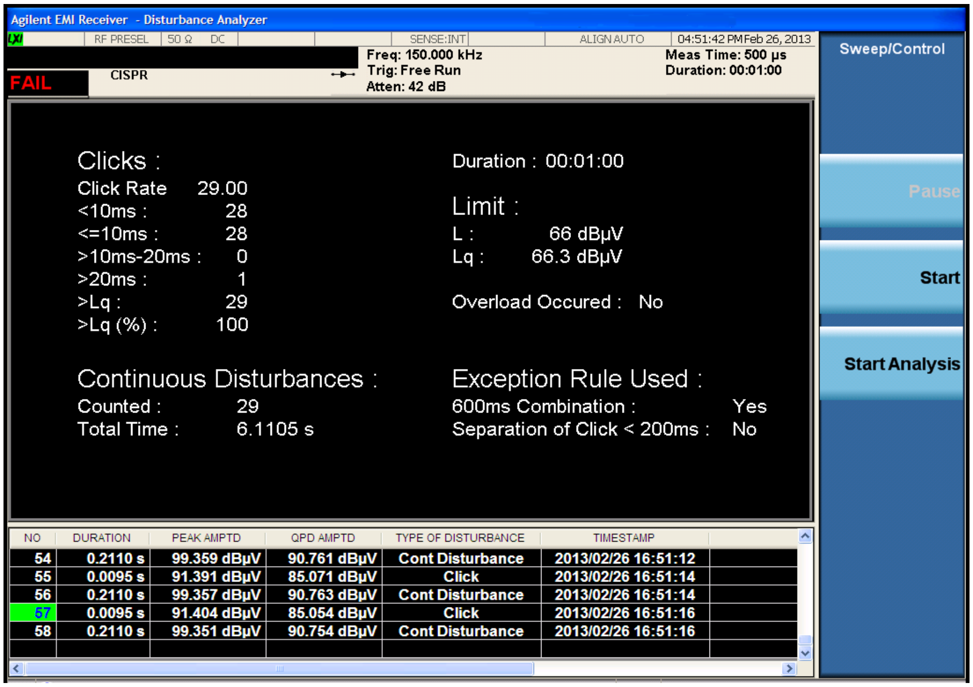
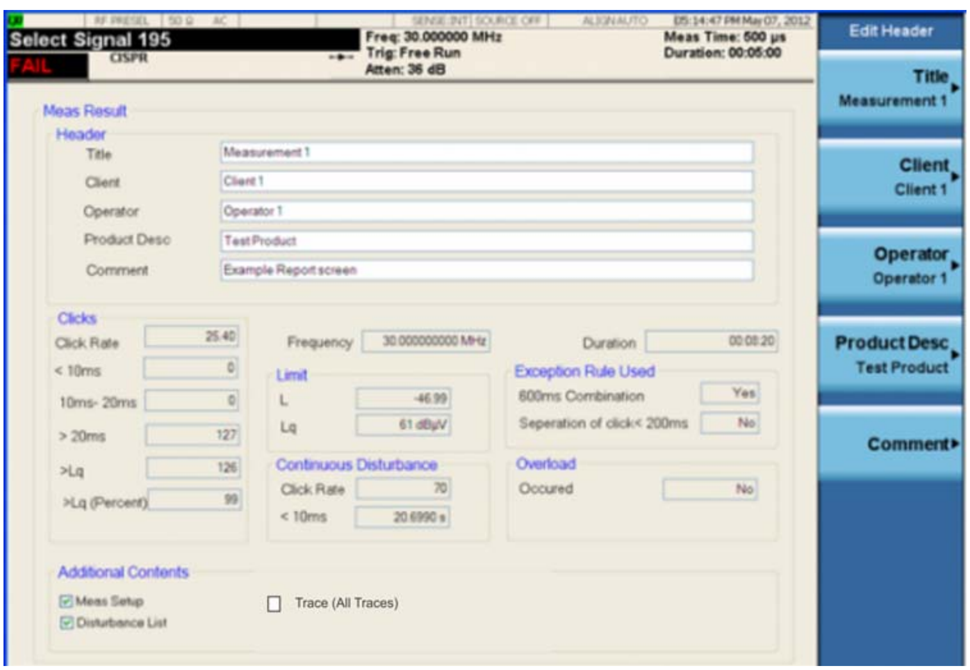
Step	Action	Notes
3 If a manual limit choice is desired	a. Press **Limit** to select **Man and enter the desired value using the numeric keypad.** b. Select the units key.	For more information see “Limit” on page 38.
4 If a manual attenuation setting is desired	a. Press **Attenuation to select Man and enter the desired value using the numeric keypad.** b. Select the **dB** units key.	For more information see “Attenuation” on page 38.
5 If a manual click rate is desired (It is recommended that the Measured click rate be used.)	a. Press **Click Rate to select User and enter the desired value using the numeric keypad.** b. Select the **Enter** key.	For more information see “Click Rate” on page 39.
6 Set the duration of the measurement	a. Press **Duration to access the menu keys that enable you to set hours, minutes and seconds.** b. Select each key and enter the desired value followed by the **Enter** key.	For more information see “Duration” on page 39.

Step	Action	Notes
7 If desired, set the number of clicks as a limit for data collection	a. Press **Click Count to select On.** b. Enter the desired value using the numeric keypad and select the **Enter** key.	For more information see “Click Count” on page 39.
8 Set the Factor f of the measurement	a. Press **factor f and select one of the configured Factor f menu keys.**	For more information see “Factor f” on page 40.
9 Collect the Disturbance data	a. Press **Sweep/Control**, **Start**. Or, b. Press **Restart**.	The collected information is displayed automatically into the disturbance list and categorized either as a click or a continuous disturbance.



TIP Collecting data

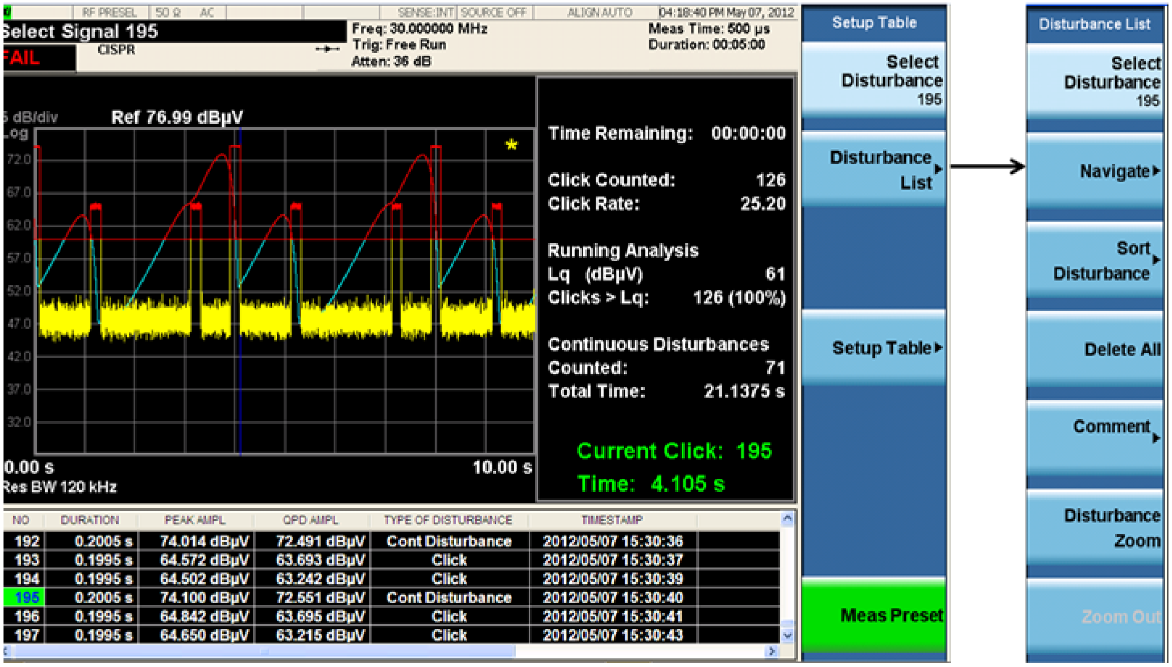
Step	Action	Notes
10 Review the final analysis	a. Automatically presented after the data collection has finished (either by test duration or click count)	After the data collection has finished, the Disturbance Measurement will automatically analyze the data, apply all appropriate exceptions (as defined in CISPR14) and present the results in the final analysis window.

Step	Action	Notes
		Final analysis
11 Create a report	a. Press **Save**, **Data**, **Meas Result**	
		To edit each of the header elements, press the associated softkey and type in your information using either a keyboard or the built-in text editor.

Step	Action	Notes
12 Save the report	a. Press **Return, Save As.** b. Enter the filename and location into the Save dialog box. c. Press **Save**.	
13 Return to Measurement screen	a. Press **Meas Setup.**	

Quick Reference to Menus

Disturbance List Menu



Navigation Menu

Sort Disturbance Menu

NO	DURATION	PEAK AMPL	QPD AMPL	TYPE OF DISTURBANCE	TIMESTAMP
192	0.2005 s	74.014 dBµV	72.491 dBµV	Cont Disturbance	2012/05/07 15:30:36
193	0.1995 s	64.572 dBµV	63.693 dBµV	Click	2012/05/07 15:30:37
194	0.1995 s	64.502 dBµV	63.242 dBµV	Click	2012/05/07 15:30:39
195	0.2005 s	74.100 dBµV	72.551 dBµV	Cont Disturbance	2012/05/07 15:30:40
196	0.1995 s	64.842 dBµV	63.695 dBµV	Click	2012/05/07 15:30:41
197	0.1995 s	64.650 dBµV	63.215 dBµV	Click	2012/05/07 15:30:43

Setup Table Menu Features

Frequency

CISPR 14 requires that discontinuous disturbance measurements be made at 4 frequencies: 150kHz, 500kHz, 1.4 MHz and 30 MHz. The MXE allows you to select these default frequencies or to enter a non-standard measurement frequency.

Terminal

CISPR 14 defines limits based on the terminals at which the measurements are made. Table 1 in CISPR 14 defines the limits for continuous disturbance over frequency for both mains and load terminals and for motors of varying power levels. The limits for discontinuous disturbances (clicks) are based on these limits.

Limit

The limit used for the data analysis is a function of the nature and rate of the measured discontinuous disturbances and the level of the continuous disturbances. CISPR 14-1 defines the limit for a continuous disturbance (L) as a function of frequency and measurement location (mains or terminal). This document also defines a limit that can be used for discontinuous disturbances (Lq). Lq is relaxed from L according to the number of clicks measured per minute, known as the click rate N:

44 dB for $N < 0.2$

20 log (30/N) dB for $0.2 <= N < 30$

No relaxation for $N >= 30$

Selecting Auto Limit configures the MXE to autocouple the default continuous disturbance limit values to the frequency and terminal selection. This will be the starting point of the Lq calculation once N has been calculated during and after the data collection. Selecting Man allows you to enter a specific limit value to be used as a starting point from which to calculate a discontinuous disturbance limit based on the characteristics of the measured signal.

Attenuation

The attenuation is set so that, in the worst case, an input signal with a Quasi-Peak value equal to the maximum relaxed discontinuous disturbance limit will not overload the receiver. If you know in advance that your input signals will be lower, you can use a lower value of input attenuation.

Click Rate

The click rate (N) is the key metric used to determine the click limit Lq. The click rate is determined by counting the number of clicks per minute. The determination of N is based on whether you are using continuous operation or switching cycles to collect clicks. For devices that operate continuously:

N = n1/T,

where n1 = number of clicks during the operation time
T = observation time.

For certain appliances requiring switching operations as defined in CISPR 14-1, Annex A, N is calculated as:

N= (n2 * f)/T,

where n2 = number of switching operations during the operation time
f = factor given in CISPR 14 Annex A.

CISPR 14-1 requires that the click rate N be determined at:

- 150 kHz for measurements in the frequency range of 148.5 kHz - 500 kHz
- 500 kHz for measurements in the frequency range of 500 kHz - 30 MHz.

In this application you have two choices of click rate to be used to determine the click limit:

- MEASURED - the click rate measured from the particular signal under test, using the formulas listed above, or;
- USER - a manually-entered click rate

Duration

Enables you to set the duration of the measurement.

Correction

This feature enables you to offset the amplitude of all measured values by the value you enter.

Click Count

This feature enables you to use a fixed number of clicks to terminate the click data collection cycle. The measurement will use both the number entered and the set measurement duration as terminators for data collection.

Factor f

For certain types of products that must be cycled to emit discontinuous disturbances (rather than run continuously), CISPR 14-1 requires users to operate the product over enough cycles to product 40 clicks.

Factor f is used to calculate the click rate for these types of devices. See CISPR 14-1, Annex A Table A.2 for the factor to use for your specific DUT.

NOTE This information is given as an example. CISPR 14-1 is the reference document for disturbance measurement requirements. Refer to CISPR 14-1 to identify the test requirements for your specific DUT.

5 Saving Data

The following topics are in this section:

"Overview" on page 42

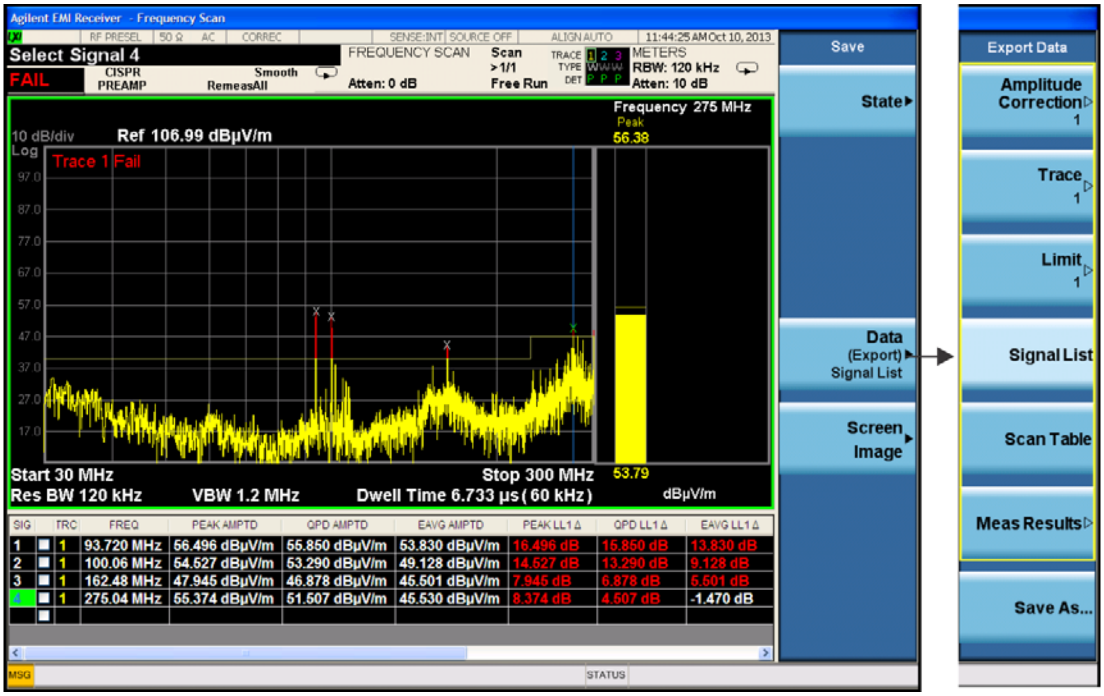
"Export Data Menu Details" on page 42

"Data file examples" on page 43

Overview

Saving Data (Data Export) stores data from the current measurement to mass storage files. The Export Menu only contains data types that are supported by the current measurement.

The following graphics displays the Save Data menu for the EMI Receiver Mode.



Note that some of the selections have "hollow points" that indicate they must be pressed to activate and pressed again to view the selections on the next menu.

Since the commonly exported data files are in .csv format, the data can be edited by you prior to importing. This allows you to export a data file, manipulate the data in Excel (the most common PC Application for manipulating .csv files) and then import it.

Selecting an Export Data menu key will not actually cause the exporting to occur, since the analyzer still needs to know where you wish to save the data. Pressing the **Save As...** key in this menu brings up the Save As dialog and Save As menu that allows you to specify the destination file and directory. Once a filename has been selected or entered in the Open menu, the export will occur as soon as the **Save** key is pressed.

Export Data Menu Details

Amplitude Correction

A Corrections Data File contains a copy of one of the receiver correction tables. Corrections provide a way to adjust the trace display for predetermined gain curves. There are 6 Corrections available for the Mode. Once a correction is selected, the key returns back to the Export Data menu and the selected Correction number is annotated on the key. See “Correction Data File” on page 44.

Trace The trace file contains "meta" data which describes the current setting of the receiver, but it is not the full state of the receiver.

You can select Traces 1, 2 3, or All. You cannot recall a trace file that was saved with "All" selected. See the following:

“Frequency Scan Trace Data File” on page 45.

“Strip Chart Trace Data File” on page 46

“Monitor Spectrum (IF Mode0 Trace Data File” on page 47

Limit Limits may be exported into a data file with a .csv extension. They may be imported from that data file; they may also be imported from a legacy limit file with a .lim extension. The .lim files meet the specification for limit files contained in the EMI measurement guide, HP E7415A. See “Limit Data Files” on page 47.

Signal List A Signal List file contains a copy of one of the signal lists obtained during measurement. See “Signal List Data Files” on page 49.

Scan Table A Scan Table file contains a copy of one of the files obtained during a measurement.

Meas Results In the Frequency Scan measurement, the Meas Result file is in the format of .html or .pdf. It is a report that contains the measurement result. You can configure the content using either the setup form or softkeys. Using a mouse and keyboard may make filling out the form easier, but you can also accomplish the task through the front panel keys. The checkboxes or radio buttons on the setup form are tied to the corresponded softkeys as you select them. See “Meas Results Data Files” on page 50.

Data file examples

Most of the files are text files in .csv (comma separated values) form, to make them importable into Excel or other spreadsheet programs. The data follows the DATA row, as comma separated X, Y pairs; one pair per line.

Correction Data File

The file will look like the following example:

Ampcor_1.csv

	A	B	C
1	Correction		
2	Biconical Antenna (30 MHz to 300 MHz)		
3			
4			
5		1	
6	Frequency Unit	MHz	
7	Antenna Unit	dBuV/m	
8	Frequency Interpolation	Linear	
9	DATA		
10	30	0	
11	30	19	
12	40	17.9	
13	50	13.2	
14	60	9	
15	70	6.6	
16	80	7.6	
17	90	9.2	
18	100	10.5	
19	110	12	
20	120	14	
21	130	16.3	
22	140	18.4	
23	150	19.4	
24	160	19	
25	170	18.3	
26	180	17.6	
27	190	17	
28	200	16.7	
29	210	17	
30	220	17.4	
31	230	18.2	
32	240	19.1	
33	250	20.4	
34	260	22.4	
35	270	24.5	
36	280	25.5	
37	290	25	
38	300	24.9	
39	300	0	

Trace Data Files

Frequency Scan Trace Data File

Trace_0001.csv

	A	B	C
1	Trace		
2	EMI:FSCAN		
3	A.13.54	N9038A	
4	526 B25 C35 CR3 DP2 EI	1	
5			
6	Preselector	On	
7	Scan Type	Smooth	
8	Number of scans	1	
9	Y Axis Unit	dBuV/m	
10	Ref Level Offset	0 dB	
11	Coupling	AC	
12	Input Z Correction	50 ohm	
13			
14	DATA		
15	Trace	1	
16	Detector	Peak	
17	30000000	10.53846713	
18	30060000	25.69418308	
19	30120000	27.75291415	
20	30180000	27.08617374	
21	30240000	26.39983341	
22	30300000	28.5055997	
23	30360000	29.50341769	
24	30420000	28.379379	
25	30480000	24.78073093	
26	30540000	28.83588382	
27	30600000	28.78323337	
28	30660000	30.35070773	
29	30720000	30.33856174	
30	30780000	24.59847995	
31	30840000	28.48639652	
⋮			⋮
4512	299700000	28.64932987	
4513	299760000	27.94029208	
4514	299820000	25.39032718	
4515	299880000	41.15170261	
4516	299940000	48.9457204	
4517	300000000	49.11469241	

Strip Chart Trace Data File

AllTrace			
EMI:SCHart			
A.07.00_R0009	N9020A		
526 EA3 B25 P26 PFR	1		
Frequency	600000000		
Freq Offset	0		
Attenuation	10		
Y Axis Unit	dBuV		
Ref Level Offset	0		
Internal Preamp State	Off		
Internal Preamp Band	Low		
Resolution Bandwidth	120000		
Dwell Time	0.05		
Peak Hold	Infinite		
Peak Hold Time	2		
Max Duration	500		
Data			
Trace	1	2	3
Detector	Peak	QuasiPeak	EmiAverage
Max	25.4396633	20.242876	12.356569
0	23.7515958	20.173686	12.282337
-0.05	24.6648769	20.194918	12.262222
-0.1	23.3178199	20.213507	12.253423
-0.15	23.5216423	20.221337	12.258119
-0.2	23.4602343	20.220859	12.262763
-0.25	23.5765176	20.212508	12.297994
-0.3	23.7032533	20.197088	12.325791
-0.35	24.825583	20.185434	12.332104
-0.4	23.6549108	20.186032	12.352822
-0.45	23.1558073	20.184001	12.356569
-0.5	23.8378283	20.171481	12.352344
-0.55	24.0481835	20.148553	12.329247
-0.6	23.7659679	20.165786	12.308906
-0.65	23.6379256	20.191835	12.330754
-0.7	23.1793252	20.20728	12.316628
-0.75	23.7241582	20.208026	12.324215
-0.8	24.0573294	20.205218	12.343919

Monitor Spectrum (IF Mode0 Trace Data File

Trace	
EMI:MON	
A.13.00	N9038A
526 DP2 EMC LSN	1
Preselector	On
Y Axis Unit	dBuV
Ref Level Offset	0 dB
Coupling	AC
Input Z Correction	50 ohm
DATA	
Trace	1
Detector	Peak
29740009.9	9.302139008
29741009.9	9.609657014
29742009.9	9.945373261
29743009.9	10.28534671
29744009.9	10.59982272
29745009.9	10.84645816
29746009.9	10.97216769
29747009.9	10.93370792
29748009.9	10.70057651
29749009.9	10.21771213
29750009.9	9.474250519
29751009.9	8.374183381
29752009.9	6.909049714
29753009.9	4.86714145
29754009.9	2.253837311
29755009.9	-0.937874114
29756009.9	-4.154472625

Limit Data Files

.csv file format

The Amplitude Unit line in the limits file may contain an antenna factor unit, for example:

Amplitude Unit=dBuV/m

Antenna factor units are dBuV/m, dBuA/m, dBpT, and dBG. In this case, the unit is treated exactly as though it were dBuV, meaning that all of the limits are interpreted to have units of dBuV. The box does NOT change Y Axis Units when such a limit is loaded in.

The X axis unit also specifies the domain (time or frequency). It is not possible to have both time-domain lines and frequency-domain lines at the same time; if a time-domain line is imported while the other lines are in the frequency domain (or vice-versa), all limit lines will be deleted prior to import.

If the sign of the margin is inappropriate for the limit type (for example a positive margin for an upper limit), the sign of the margin will be changed internally so that it is appropriate.

The remaining lines describe the data. Each line in the file represents an X-Y pair. The X values should be monotonically non-decreasing, although adjacent lines in the file can have the same X value as an aid to building a stair-stepped limit line. To specify a region over which there is no limit, use +1000 dBm for upper limits or -1000 dBm for lower limits.

Limit_1.csv

	A	B
1	Limit	
2	EN 55022, Radiated, Class A, 30 MHz to 1 GHz (10m)	
3	Quasi-Peak Detector	
4	A.13.54	N9038A
5	526 B25 C35 CR3 DP2 EDP EMC ESC LSN NFE P26 PFR TDS YAS	1
6	Type	Upper
7	X Axis Unit	MHz
8	Amplitude Unit	dBuV
9	Frequency Interpolation	Logarithmic
10	Amplitude Interpolation	Logarithmic
11	X Control	Fixed
12	Y Control	Fixed
13	Margin	0
14	X Offset	0
15	Y Offset	0
16	DATA	
17	30	40
18	230	40
19	230	47
20	1000	47

.lim file format

This is a legacy format which allows files saved from older analyzers to be loaded into the X-Series. Design of files in this format is not recommended.

Signal List Data Files

SignalL_data.csv

	A	B	C	D	E	F
1	SignalList					
2	EMI:FSCan					
3	A.13.54	N9038A				
4	526 B25 C35 CR3 DP2 EDP EMC ESC LSN NFE P26 PFR TDS YAS	1				
5	Y Axis Unit	dBuV/m				
6	Limit LL1	EN 55022	Radiated	Class A	30 MHz to 1 GHz (10m)	
7	DATA					
8	SIG	MRK	TRC	FREQ	PEAK AMPL	QPD AMPL
9	1	FALSE	1	93720000	56.49619759	55.8503783
10	2	FALSE	1	1E+08	54.52693626	53.2897052
11	3	FALSE	1	1.62E+08	47.94459764	46.877976
12	4	FALSE	1	2.75E+08	55.37426816	51.5070286

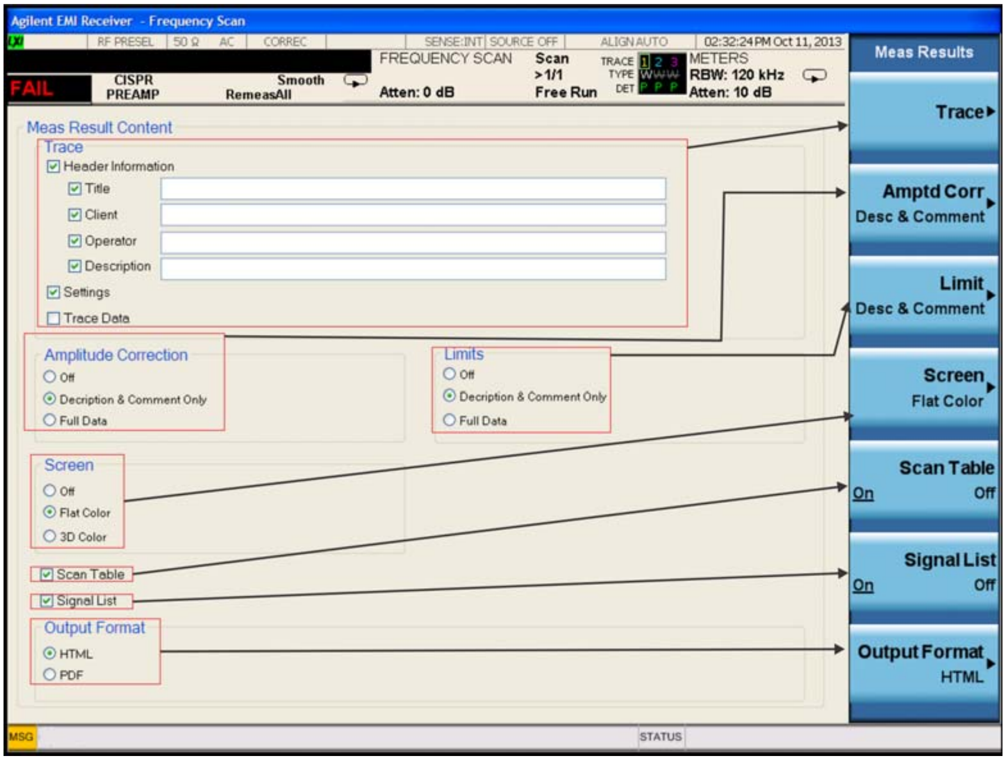
	G	H	I	J	K	L	M	N	O	P
	EAVG AMPL	PEAK LL1 DELTA	QPD LL1 DELTA	EAVG LL1 DELTA	RBW	RBW TYPE	TIMESTAMP	COMMEN'	USE ANTENNA UNIT	
	53.82983996	16.49619759	15.85037829	13.82983996	120000	CISPR	10/10/2013 11:43		TRUE	
	49.12778653	14.52693626	13.28970517	9.127786528	120000	CISPR	10/10/2013 11:43		TRUE	
	45.50062618	7.944597645	6.877976035	5.500626181	120000	CISPR	10/10/2013 11:43		TRUE	
	45.53013803	8.374268163	4.507028596	-1.469861968	120000	CISPR	10/10/2013 11:43		TRUE	

Scan Table Data File

	A	B	C	D	E	F	G	H	I	J	K
1	ScanTable										
2	EMI:FSCAN										
3	A.13.54	N9038A									
4	526 B25 C35 CR3 DP2	1									
5	Step Time Control	Step Size & Dwell Time									
6	State	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
7	Start Freq	9000	150000	30000000	300000000	30000000	1000000000	1000000000	1000100000	1000200000	1000300000
8	Stop Freq	150000	30000000	300000000	1000000000	1000000000	18000000000	1000100000	1000200000	1000300000	1000400000
9	RBW	200	9000	120000	120000	120000	1000000	1000000	1000000	1000000	1000000
10	RBW Mode	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
11	Dwell Time	0.004102133	0.000108067	6.73E-06	6.73E-06	6.73E-06	6.67E-06	0.001	0.001	0.001	0.001
12	Dwell Time Mode	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
13	Step Size	100	4499.547784	60000	60003.42877	60002.47433	500000	100000	100000	100000	100000
14	Step Size Mode	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
15	Scan Points	1411	6635	4501	11667	16167	34001	2	2	2	2
16	Scan Points Mode	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
17	Scan Time	5.784008	0.716914267	0.0303	0.078551067	0.108851067	0.226666667	0.001	0.001	0.001	0.001
18	Scan Time Mode	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
19	Auto Step Size Rules	Points per RBW	Points per RBW	Points per RBV	Points per RBW	Points per RBW	Points per RBW	Points per RBW	Points per RBW	Points per RBW	Points per RBW
20	Pts/RBW	2	2	2	2	2	2	2	2	2	2
21	Log %	10	10	10	10	10	10	10	10	10	10
22	Atten	10	10	0	10	10	10	10	10	10	10
23	Int Preamp	OFF	OFF	LOW	OFF	OFF	OFF	OFF	OFF	OFF	OFF
24	RF Input	Input1	Input1	Input1	Input1	Input1	Input1	Input1	Input1	Input1	Input1

Meas Results Data Files

The keys correspond to the sections in the Meas Results Contents form as shown below:



Trace

This key/section enables you to customize the trace related information to be added to the report. You can also select whether settings and Trace data will be part of the output by turning the selections On or Off.

Amptd Corr

This key/section enables you to choose whether to show only the file name and description or the Amplitude Correction complete data by turning the selections On or Off.

Limit

This key/section enables you to choose whether to show only the file name and description or the Limit complete data by turning the selections On or Off.

Screen

This key/selection enables you to choose the color theme of the screen image in the report. You are given the option to turn this On or Off.

Scan Table

This key/selection enables you to choose whether or not to show the Scan Table information in the report.

Signal List

This key/selection enables you to choose whether or not to show the Signal List information in the report.

Output Format

This key/selection enables you to select the output format of Measurement Results. If the Output Format is set to HTML, a .html file will be saved and a directory that contains the .png file for the screen image will be created. If the Output Format is set to PDF, a .pdf file will be saved.

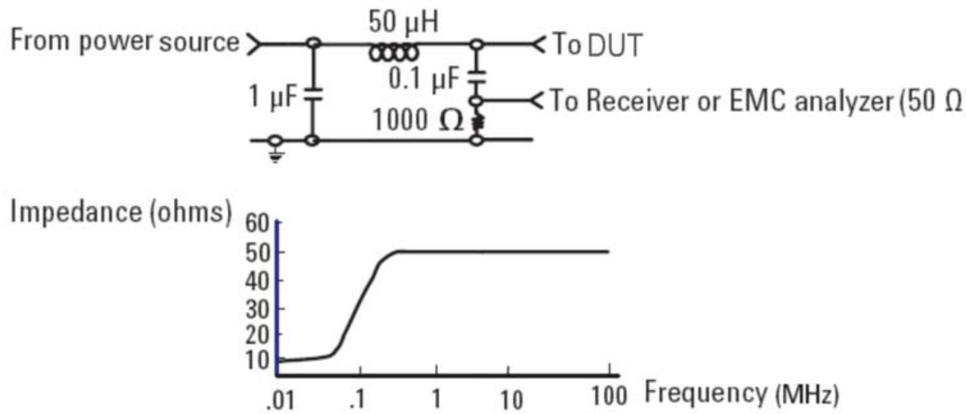
A: Line Impedance Stabilization Networks (LISN)

A line impedance stabilization network serves three purposes:

1. The LISN isolates the power mains from the device under test. the power supplied to the DUT must be as clean a possible. Any noise on the line will be coupled to the EMI Receiver 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 EMI Receiver using a high-pass filter, which is part of the LISN. Signals that are in the pass band of the high-pass filter see a 50-Ω load, which is the input to the EMI Receiver.

LISN Operation

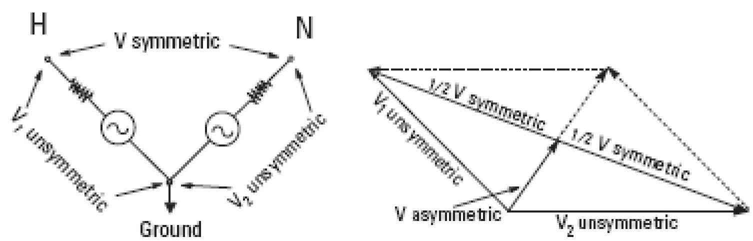
The following graphic shows a typical LISN circuit diagram for one side of the line relative to earth ground. The chart represents the impedance of the DUT port versus frequency.



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 0.1 µF couples the noise generated by the DUT to the EMI Receiver. At frequencies above 150 kHz, the DUT signals are presented with a 50Ω impedance.

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.



V-LISN   Vector Diagram

V-LISN: Unsymmetric emissions (line-to-ground)
Δ-LISN: Symmetric emissions (line-to-line)
T-LISN: Asymmetric emissions (mid point line-to-line)

Transient Limiter Operation

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

The Keysight 11947A transient limiter incorporates a limiter, high-pass filter, and an attenuator. It can withstand 10 kW for 10 µsec and has a frequency range of 9 kHz to 200 MHz. The high-pass filter reduces the line frequencies coupled to the EMI Receiver.

B: Antenna Factors

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:

Pt = total power radiated from an isotropic radiator

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

$PD = Pt / 4\pi r2$

$R = 120m\Omega$

$PD = E2/R$

$E2/R = Pt / 4\pi r2$

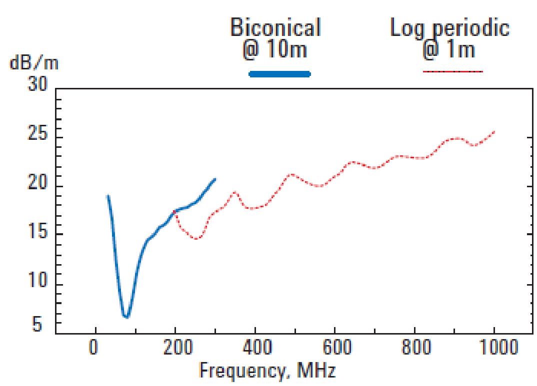
$E = (Pt \times 30)1/2 / r \ (V/m)$

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

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.

NOTE Antenna factors are not the same as antenna gain.



Linear units: AF = Antenna factor (1/m)
E = Electric field strength (V/m)
V = Voltage output from antenna (V)

$$AF = \frac{Ein}{V\ out}$$

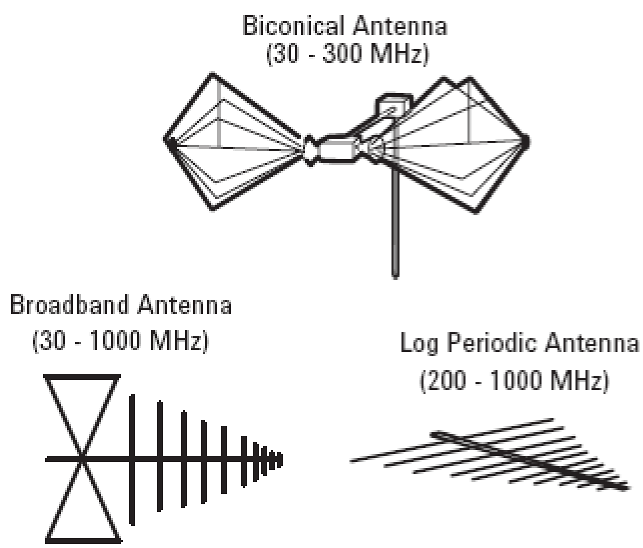
Log units: AF(dB/m) = E(dBµV/m) - V(dBµV)
E(dBµV/m) = V(dBµV) + AF(dB/m)

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

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)



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 (P2/P1)

Data is sometimes expressed in volts or field strength units. In this case, replace P with V2/R.

If the impedances are equal, the equation becomes:

dB = 20 log (V2/V1)

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

dBμV = 107 + PdBm

This is true for an impedance of 50Ω.

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

λ = 3x108/f (Hz) or λ = 300/f (MHz)

D: Detectors Used in EMI Measurements

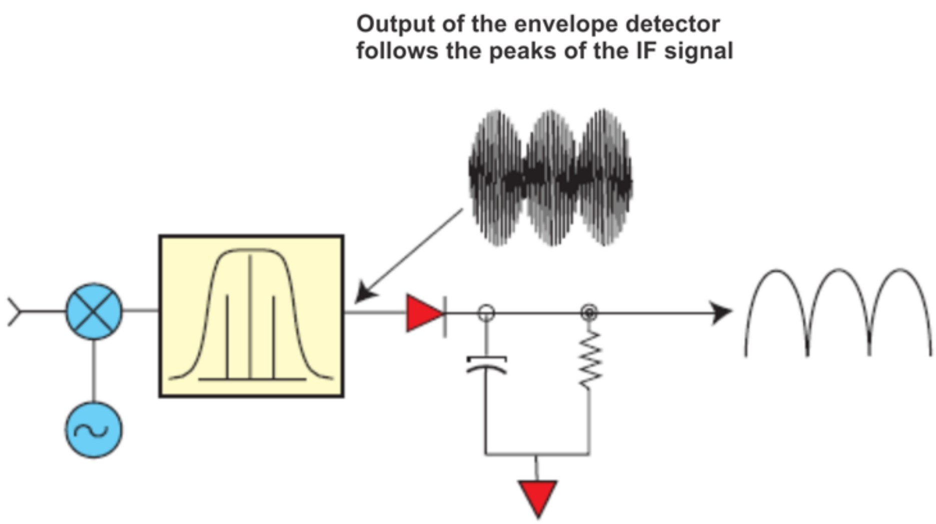
Peak Detector

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.

Peak detector operation

The EMI Receiver 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.

Peak detector diagram



Quasi-peak Detector

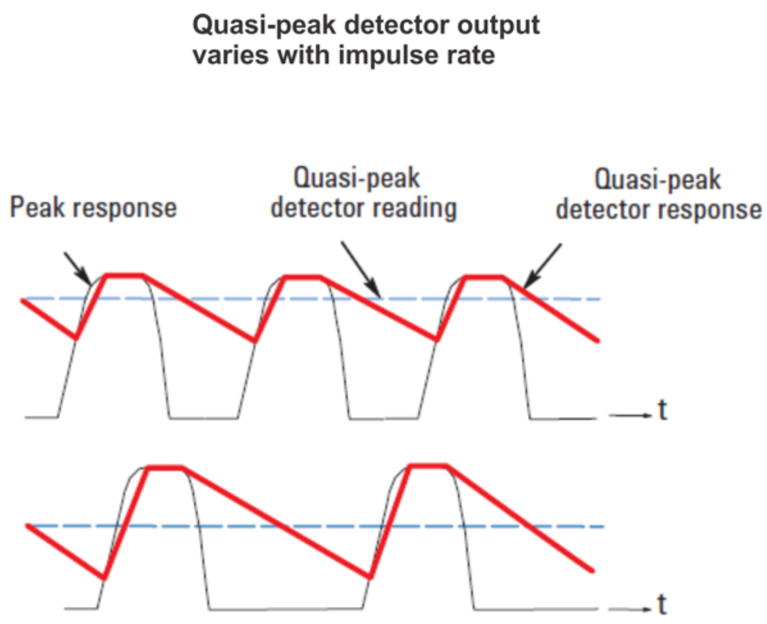
Most radiated and conducted limits are based on quasi-peak detection mode. Quasi-peak detectors weigh signals according to their repetition rate, which is a way of measuring their annoyance factor. As the repetition rate increases, the quasi-peak detector does not have time to discharge as much, resulting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

Quasi-peak detectors always give a reading less than or equal to peak detectors, but quasi-peak measurements are much slower by two or three orders of magnitude compared to a peak detector.

Quasi-peak detector operation

The quasi-peak detector has a charge rate much faster than the discharge rate. The higher the repetition rate of the signal, the higher the output of the quasi-peak 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.

Quasi-peak detector response diagram



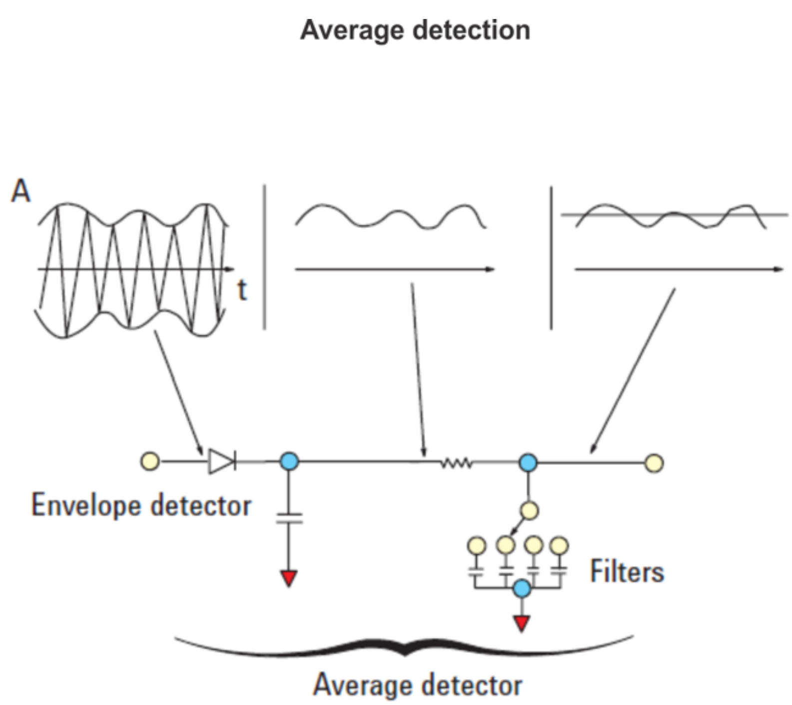
Average Detector

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.

Average detector operation

Average detection is similar in many respects to peak detection. The following graphic 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.

Average detection response diagram



Glossary of Acronyms and Definitions

Ambient level

1. The values of radiated and conducted signal and noise existing at a specified test location and time when the test sample is not activated

2. 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

1. In a signal transmission system, the process, or the result of the process, where the amplitude of one electrical quantity is varied in accordance with some selected characteristic of a second quantity, which need not be electrical in nature.

2. 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 semianechoic chamber is a shielded room which has absorbing material on all surfaces except the floor.

Antenna (aerial)

1. 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.

2. 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 EUT 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 emissions

Broadband is the definition for an interference amplitude when several spectral lines a 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 on 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 separate networks.

Dipole

1. 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.

2. Any one of a class of antennas producing a radiation pattern approximating that of an elementary electric dipole.

Electromagnetic compatibility (EMC)

1. 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.

2. 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

1. A conducting surface or plate used as a common reference point for circuit returns and electric or signal potentials.

2. A metal sheet or plate used as a common reference point for circuit returns and electrical or signal potentials.

Immunity

1. The property of a receiver or any other equipment or system enabling it to reject a radio disturbance.

2. 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.

Mono pol

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 emissions

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.