

Application Note

AEROFLEX
A passion for performance.

EMC Measurements with the 3250 Series Spectrum Analyzer



The 3250 Series Spectrum Analyzer includes as an option a comprehensive EMI Receiver personality for pre-compliance testing to CISPR, KN, EN and FCC standards. An internal pre-amp extends the noise floor to -165 dBm ensuring highly sensitive measurements.

This comprehensive package provides a high performance entry into EMC testing and is ideal in any environment where pre-compliance testing at all stages of design and manufacture will save time in expensive EMC facilities.

Fast transient analysis, Quasi-peak detection, scan segmentation, zoom, multi-trace scans and many automatic features combine to make this package fast and easy to use and without requiring any special knowledge or training.

The 3251 is a 1 kHz to 3 GHz full featured spectrum analyzer which is ideal for many general purpose measurement tasks in the lab, in manufacture and in the field. The EMC personality option adds the capability to measure conducted and radiated emissions according to CISPR 16-1-1 and international standards up to CISPR Band D. The 3254 is a 1 kHz to 26.5 GHz spectrum analyzer which adds EMI radiated emission measurements according to CISPR Band E up to 18 GHz.

During development of electric and electronic devices, pre-compliance analyzers, which do not full fill all of the necessary standards, are used to detect EMI problems throughout a product life cycle. The 3250 Series is portable with DC power and battery pack options making it perfect for moving between indoor and outdoor test ranges.

CISPR 16-1-1 (2010) has been amended to allow spectrum analyzers to perform the majority of the required EMI measurements and the main difference now is that spectrum analyzers do not have pre-selecting filters. Not having a pre-selector limits the dynamic range of the measurement in pulsed or high power environments where the EMI signal must be measured in the presence of a large wanted signal.

For the majority of applications the 3250 Series Spectrum Analyzer with EMI personality (option 13) will produce results which are very close to the results from an EMI compliance receiver at a low cost and with the added benefit of being a general purpose instrument. Pre-selector filters for CISPR Band A and B can be added, as an option, to further improve the accuracy.

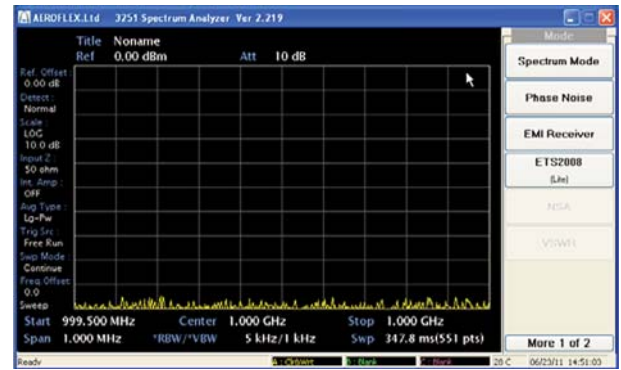
EMI Receiver Operation

BOLD – Hard key press, a dedicated front panel function key.

Italic – Soft key press, software menu key

Numeric entries are made using either keypad or rotary control. Key pad entries must be followed by a terminator Soft key or **ENTER**

The EMI Receiver personality is selected by pressing **MODE** followed by *EMI Receiver*. The display will switch to that of the EMI Receiver and the CISPR Measure Menu is displayed. You can switch between Spectrum analyzer and EMI Receiver functions by using the **MODE**. The EMI Receiver state is conserved as you move between personalities.



Instrument Operating Modes

Please refer to EMI Receiver Manual V2.12 for further information on the options and constraints available under each of the menus.

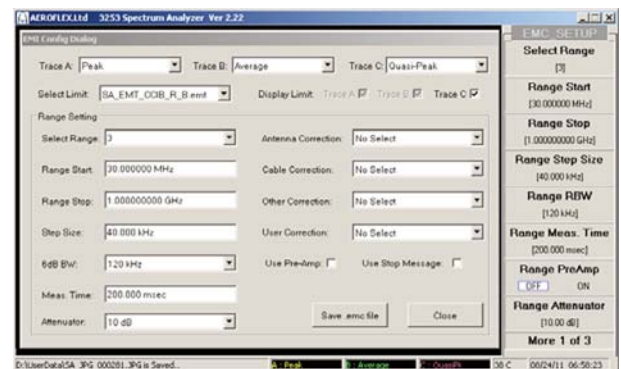
The EMI Measurement receiver has two main measurement modes. SCAN Mode is the major operating mode where the Receiver scans the frequency range set using the Frequency Menu according to the configuration defined in the EMI Configuration Dialog.

CISPR mode allows you to make immediate measurements at any frequency set manually or using the marker and peak search facility. So after a SCAN, use CISPR mode to examine problem areas in detail – perhaps resolving a problem with ferrite or absorptive materials and seeing its effect in real time. You can alter measurement and detector parameters and see the effect in real time.

EMI Receiver Configuration

Press SETUP to enter the EMC SETUP Menu. The EMI Config Dialog is displayed alongside the EMC_SETUP MENU. This is the main setup screen for the EMI SCAN.

This Menu is split into 3 parts which you can cycle through using the More soft function key.



Configuration Dialog

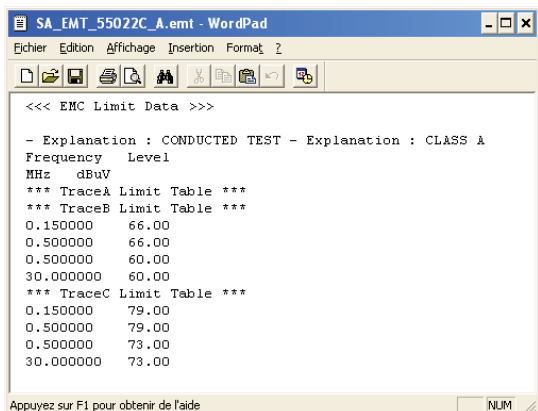
From the EMC SETUP MENU you can configure the SCAN in up to 6 Ranges. Ranges must be contiguous and each Range is defined as having a Start and Stop Frequency and a set of measurement parameters selected using the following functions from the EMC SETUP MENU or you can point to the dialog box and enter numeric values using the keypad.

- *Select Range* – select the range for which you will alter the measurement parameters

- *Range Start* - set the start frequency for the selected range
- *Range Stop* - set the stop frequency for the selected range
- *Range Step Size* – set the step size for the selected range. Note, if you define a low step size then the scan will take a long time but you will have better resolution. You can use this feature to do fast scans in regions with no problems and then slow the scan in regions of interest.
- *Range RBW* – set the resolution bandwidth of the step size for the selected range. Note, if you define a narrow filter then the scan will take a long time but you will have better resolution. Again, you can use this feature to do fast scans in regions with no problems and then slow the scan in regions of interest.
- *Range Meas. Time* – Set the measure time each point in the range. A long measurement time will lead to long scan times. Short measurement times leads to loss of accuracy. For accurate QP detection you should have a measurement time of at least 1s. Therefore define short measurement times where there are no signals of interest and slow down the measurement where there are.
- *Range PreAmp* - turn the pre-amp on or off in any range to increase the sensitivity of the EMI receiver if required.
- *Range Attenuator* – set the input attenuator for each range.
- *Use Stop Message* provides a windows notification and pauses the SCAN at the end of each range is selected.
- *Display Limit, Antenna, Cable, Other-* normally a correction file is associated with an item of equipment for example an antenna. However, it might be that the user will want to change the antenna above a maximum frequency. In this case a Range would be defined up to this frequency and the Stop message selected for that range. The SCAN is interrupted and the user can change the antenna and then continue the scan and the new correction table will be applied in the next Range.

Other configurable functions for SCAN mode are:

- *Select emt File-* Select and load the limit line file for the desired measurement standard. These can be downloaded from the Aeroflex website or you can create them yourself using text editor according to the example below. Limit files apply to the whole SCAN and are not segmented into ranges.

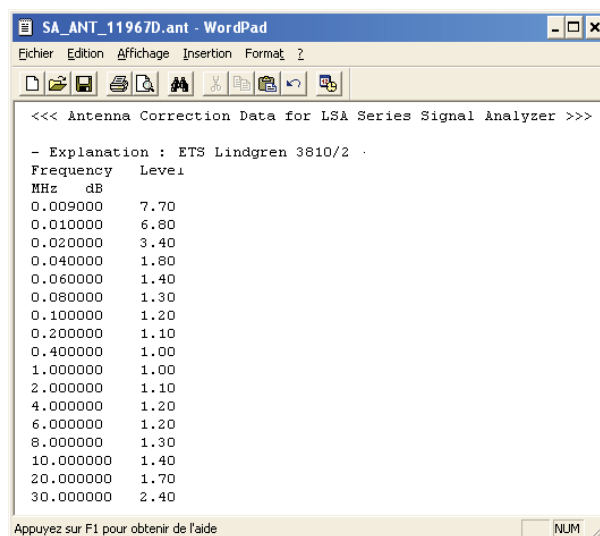


Limit Line File .emt

- *Save .emc file* – This button in the config dialog saves the entire EMI Receiver configuration. Filenames are automatically created and date stamped
- *Load EMC Setup* – this SETUP MENU option displays file management dialog and you can select and load a configuration file created earlier.
- *Max Range* – Defines the number of Ranges which will make up the SCAN.
- *Scan Mode* – sets the SCAN display to linear or logarithmic.

Correction Tables

Correction factor files are text files which can be obtained from manufacturers to suit their equipment or created using a text editor according to the example below. There is also a Correction Table Editor in the Amplitude Menu, but this is beyond the scope of this application note.



Correction Factors

SCAN Measurement Mode

Press **FREQ** to display the Frequency Menu. From this menu you set the:

- *Start Freq* – sets the start frequency for the SCAN
- *Stop Freq* – sets the end frequency for the SCAN

The SCAN is made between these two frequencies and the CISPR measurement is made according to the Range Data in the EMI configuration table at each frequency step.

Press **AMPL** to display the Amplitude Menu. From this menu you can set the

- *Ref. Level* – adjusts the level for the reference line. Adjust to fit the traces into the range of the display.
- *Scale / Div* – sets the scale for the display from 1 dB to 20 dB per division.

Press **MEAS** to display the EMC_MEAS Menu. From this menu you can set the

- *RUN* – starts the SCAN according to the previously set configuration. Measurements are compared with the limit lines and excursions marked with an x. A total error count is displayed,
- *Hold* – pauses the SCAN but changes to the SCAN configuration are not allowed. The SCAN can be restarted using RUN
- *Stop* – ends the SCAN at the last measurement point and enters CISPR measurement mode. Changes to the SCAN configuration can be made and the SCAN restarted from the start frequency.
- *Repetition* – runs the SCAN and stops or runs the SCAN and restarts.
- *Screen Mode* – Displays the SCAN results full screen or the SCAN results and the CISPR measurement histogram in dual screen view.
- *Error Info* – Enters the Error Info Menu to display any errors over the limit line in a table format.
- *Range Peak Info* – Enters the Range Peak Info Menu to display and analyze peak excursions in the SCAN.

CISPR Measurement Mode

CISPR Measurement mode is available whenever SCAN is not running. Press **CONTROL** to display the CISPR Measure Menu. In this mode, the CISPR histogram is displayed for the measurement frequency according to the selections made using the CISPR Measure Menu you can select the following:

- *Meas. Freq* – leave in auto and the measurement frequency will track the current marker position. You can use Peak Search to skip through peaks in a SCAN or select manual mode to enter the frequency of interest using the keypad or wheel. The CISPR data display will show the live measurement histogram at the selected frequency. You can observe the live data compared to the data recorded during the scan and trouble shoot accordingly.
- *Meas. Time* – use the wheel to select measurement times from the available options.
- *Meas. BW* – Leave in Auto or select from the available options for the selected filter types.
- *Meas. Att* – Select from 0 to 55 dB attenuation in 5 dB steps
- *Meas. Detector* – brings up the EMC Detector Menu and allows you to select from QP, Peak, Average, RMS Average, Log Average and CISPR Average detectors. Return to the CISPR Measure menu by pressing Previous
- *Set Preamp* – turn the pre-amp on or off to increase the sensitivity of the EMI receiver is required.
- *Reset Value* – resets the min and max values of the detectors.
- *Att Adjust* – adjusts the input attenuation automatically according the measured signal level.

Conducted Emission Measurements

For conducted measurements, the 3250 Series Spectrum Analyzer is used with a LISN and shielded room if available or with

the Aeroflex 4933 shielded enclosure which provides an ideal test environment for the equipment under test (EUT) up to laptop size.



Conducted emission measurements



Aeroflex 4933 RF Shielded Enclosure

Connect the 3250 Series Spectrum Analyzer to the EUT and LISN and set the configuration as described above. Connect the equipment but do not apply power.

Set up the EMI Receiver for the required measurement standard using the EMI Receiver Configuration procedure described above.

Select or create the Limit Line file to suit the radiated test. For instance the file SA_EMT_55022C_A sets the Limit line for EN55022 Radiated Class A.

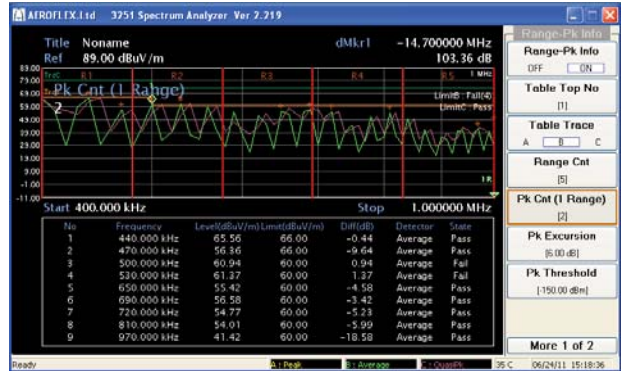
Run the EMI measurement SCAN to check for ambient emissions. These should be well below the defined limits. If any major peaks are displayed then these should be investigated as there must be some ingress to the measuring environment.



Ambient Measurement

Apply power to the EUT and repeat the sweep to check for signals above the limits.

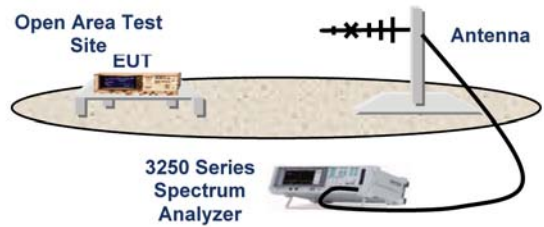
If necessary you can adjust the Pre-amp, Attenuator and Reference Level settings for best dynamic range.



Range Peak Display

Radiated Emission Test Setup

Radiated EMI is measured according to the methods in CISPR 22 which defines an Open Area Test Site (OATS) as a 3m or 10m range free or reflecting objects except a ground plane.



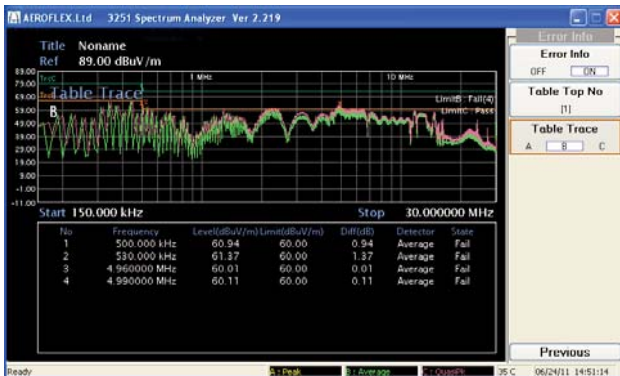
Open Area Test Site for Radiated emission measurements.

Any OATS will suffer from ambient signals which are generated from the surroundings unless it is placed in a screened room which attenuates ambient signals. For most organizations, a screened room this size is not a realistic option until formal testing at the end of a product cycle.



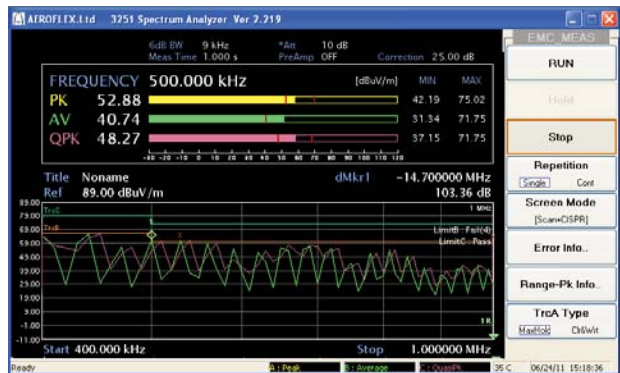
CISPR Scan Result

Check for signals failing limits and view using the error information display.



Error Information Display

Alter the center frequency and reduce the span to show more detail in regions where emissions are seen to occur. Use peak search and CISPR at marker functions to provide more information on the signal peaks.



Scan Regions of Interest

Range Peak Info segments the display into the ranges defined in the configuration dialog and peak information is displayed for each range.

An emissions plot will therefore contain ambient signals which make it harder to interpret the results from the EUT and may even mask EUT emissions completely. Therefore the test site must be characterized by running a complete series of scans without the EUT being powered. These will show any pre-existing signals which must then be discounted from the measurement.

At one end of the OATS is located a receiving antenna such as a bi-conical or log-periodic connected to the 3250 spectrum analyzer. The choice of antenna is according to the frequency needed with Bi-conical typically used from 30 MHz to 300 MHz and Log periodic from 300 MHz to 2 GHz.

Radiated EMI has to be characterized in each plane and so it is conventional to mount the EUT on a turntable located at the other end of the test site and the antenna on a height adjustable stand which allows it to be clamped in both polarizations.

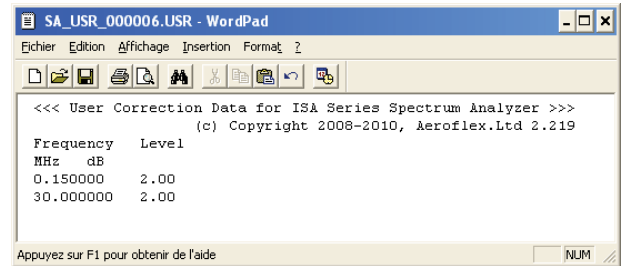
The ETS2008 PC software package can be used to control the 3250 Spectrum Analyzer over GPIB, Serial port or LAN, as well as the turntable to gather, analyze and manage measurement results from all the open area test scans.

Radiated Emissions Limit Lines

Enter Antenna correction factors to suit the antenna in use. These can be manually defined or loaded from database, eg SA_ANT_11966C for Bi-conical antenna.

Antenna Correction Factors

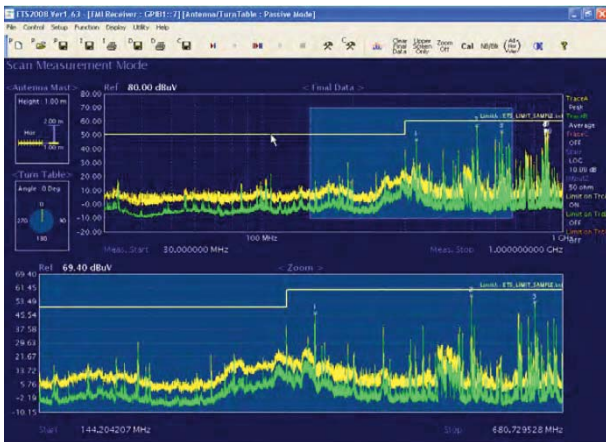
A margin for safety or to compensate for known measurement site anomalies can be entered as a user correction table. For example, the file SA_USR_000006.USR applies a 2 dB correction across the whole band.



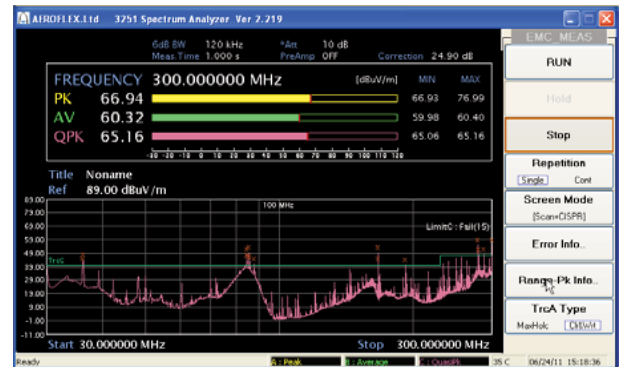
User Correction Data

Press [FREQ] and enter the start frequency and the stop frequency for the scan.

Press [RUN] to start the EMI measurement with EUT off to check for ambient emissions.



ETS2008 EMI Management Software



Background Radiation at Test Site

As expected there are background, or ambient, signals which exceed the limit line. It is easy to discount those peaks which exceed the limit line. But it is important also to note those peaks that are in danger of masking any potential problems in the EUT.

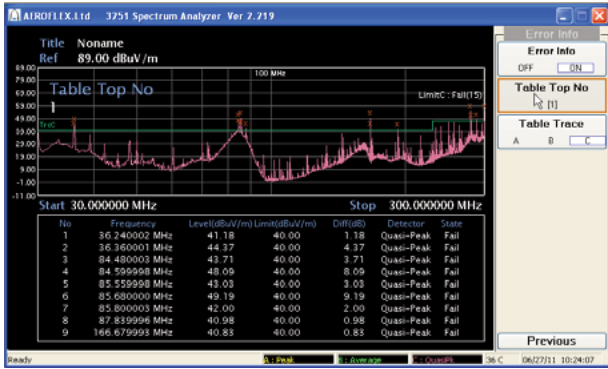
Pressing [Error Info.] will display a list of peaks exceeding the limit line. [Table Top No] can be changed to extend the table. The data can also be saved in .CSV format for later use.



Bi-conical and Log Periodic antennas

Radiated Emission Measurements

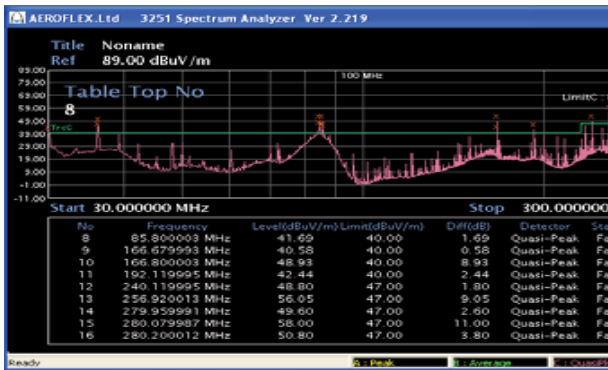
Setup the 3250 Series Spectrum Analyzer following the EMI Receiver Configuration procedure above. Select or create the Limit Line file to suit the radiated test. For instance the file SA_EMT_55022R_A sets the Limit line for EN55022 Radiated Class A.



Background Radiation Error Information

The scan of the ambient environment should be repeated to characterize the EMI environment with different antenna, antenna polarizations and antenna heights.

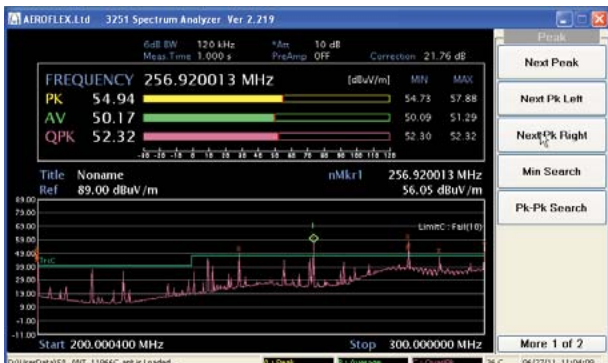
Turn on the EUT and repeat the scans to check for signals from the EUT which are above the limit.



EUT and Background Radiation Error Information

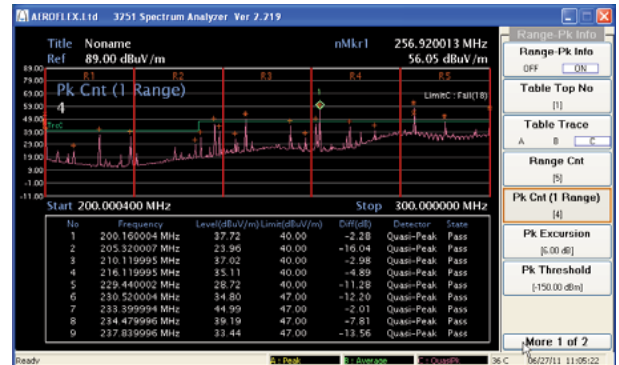
Again, the Error Information table is invaluable in pin pointing those peaks which are due to the EUT emissions. Signal which fail are marked with an X and you can compare them with the results from the ambient measurement to identify emissions from the EUT.

Where EUT emissions above the limit are identified, then they can be investigated further by using a reduced span. Place markers on peaks and you can view the results of the CISPR measurements for that point.



Expand Regions of Interest

To find a peak in a certain area of the scan, you can turn on the Range Peak Info display. This allows you to look in more detail in defined ranges of the scan and can be a great aid if there are many peaks of a peak from the EUT which is in close proximity to an ambient peak.



Range Peak Information Display

Investigation and Diagnostics

During EMI pre-compliance tests, some investigation may be required to find and solve emission problems.

For radiated measurements the AC0100 near field probe set can be used to identify the source of unwanted radiated signals while working in close proximity to the EUT. This is probably the most useful tool during product development as it locates possible emitters at early stages of a design.



AC0100 Near Field Probe Set

In such an application the 3250 Spectrum Analyzer should be used in Spectrum Mode.

Press the **MODE** button and then *Spectrum Mode*

In this example, we are going to look at an emitter which we previously identified during an EMI Receiver SCAN. It is centered at 256.79 MHz. We will use the Multi-Trace facility to identify problem emissions and possible solutions.

Connect the Near Field Probe Set to the 3250 Series Spectrum Analyzer and locate the probe close to the EUT whilst the EUT is operating. It is useful to have a clamp to hold the probe in a fixed position.

It is possible to load correction factors for the probe using the Correction Factors function in the Amplitude Menu. However, in this case we are looking for a relative improvement over a narrow bandwidth and so correction factors are not essential.

Press **FREQ** and set *Center Freq* to 256.79 MHz. Press **SPAN** and set the *Span Width* to 1 MHz.

Confirm that the emitter previously identified is displayed. Alter Reference level and attenuator settings if necessary to display the peak.

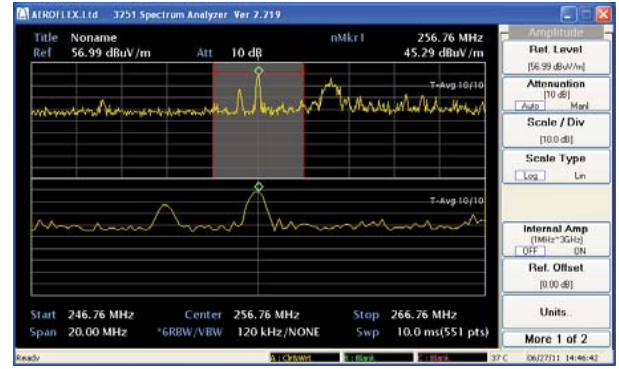
Press **TRACE** and ensure *Select Trace* is set to A.

Press *Max Hold* and the maximum is displayed.

Press **TRACE** and ensure *Select Trace* is set to B.

Press *Clear&Write* and trace B will display the emitter in green. You can move the probe while viewing the effect on the emitter and, in this way, gauge the source.

You can alter screening and apply radiation absorptive materials to further narrow down the location of the emitter. And once located, you can quickly test any solution before going back the EMI Measurement SCAN to confirm the solution.

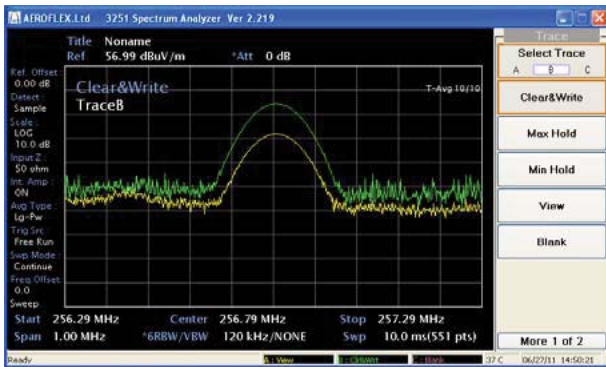


Zoom for Better View

A useful feature in the 3250 Series armory is the Spectrogram function which will show the Spectrum Display over time as a waterfall display.

Press the **MODE** button and then **More 1 of 2** and then *Vector Analyzer*

Press *Spectrogram* to display the spectrum against time. Higher signal levels are denoted by brighter colors according to the displayed key. You can identify intermittent signals with the Spectrogram view.



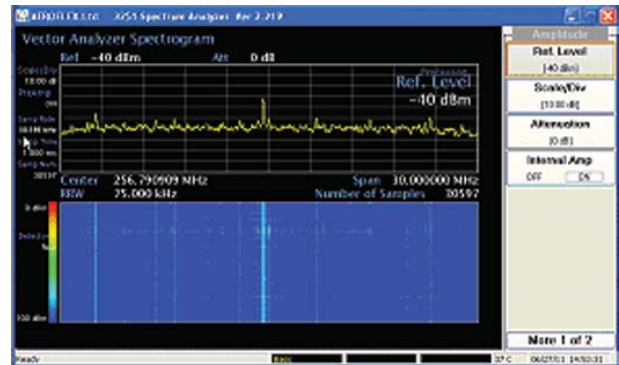
Multi-trace Spectrum Display at Peak Error Frequency

Press **SPAN** and set the *Span Width* to 20 MHz.

Press **DISPLAY** and select *Zoom Display* to be ON. The screen will change to dual display with the original trace in the upper section with a shaded zoom area. The bandwidth of the zoom area is shown expanded to the full display width in the lower half of the display.

Select *Zoom Span* and adjust the zoom area shown shaded using the control knob or by entering using the numeric keypad.

The zoom feature allows more details to be observed



Spectrogram Display to Locate Intermittent Emissions

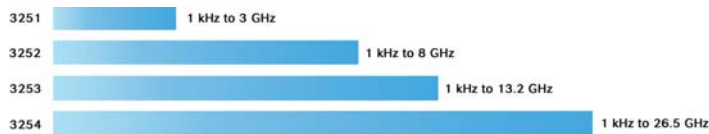
Conclusion

The 3250 Series Spectrum analyzer and the EMI Receiver personality option offer a combination of high performance Spectrum Analysis and sensitive EMI measurement and debugging tools. It's extremely low noise floor of -165dBm allows detailed observations of EMI in complex and cluttered environments.

It's portability allows it to move easily between bench and open area test site which can more easily be located away from strong interfering emitters.

The EMI Measurement tools speed up enormously debugging of any electro-mechanical equipment and will pay for themselves very quickly in terms of time saved in development and at expensive EMI certification facilities.

The 3250 Series Spectrum Analyzers provide powerful tools for to enable quick, easy and yet comprehensive pre-compliance measurements of EMC.



Option 13 EMI Receiver Personality

Option 06 Pre-selector for Band A, B if required

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