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**Test Plan :** Above 1GHz emissions investigation, ANSI C63.4 WG  
**Version :** Rev 4 Draft (15 March 2016)

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# Purpose

To investigate the impact of varying the above 1GHz emission measurement process on actual EUTs so that we can:

* help to develop an effective process
* validate the assumptions and limitations
* have one process that is applicable to table top, floor standing and combination equipment
* attempt to maximize the emissions

# Introduction

The aim of the measurements is to find EUTs, with stable emissions, which emit signals above 1 GHz. Once the EUT has been found, measurements need repeating using one basic measurement process, then repeated using various setups (including antennas within different beamwidths, bore-sighting, planar scanning, limited height scanning and different measurement distances) so that the variances within the measurement characteristics can be established.

Typically, above 1GHz emissions are very directional and are related to operating frequencies of the device. The source of the emissions will be from slots, holes and defects within the chassis and from short elements directly from motherboards, ICs and other modules. They are not related to cables.

Most equipment does not use such high frequencies, but there are a few possible sources which may be used for this exercise:

* high end MME/ITE devices:
  + servers
  + high end TVs
  + PCs (using ultra-fast processors)
* network equipment (particularly with fiber optic modules);
* wireless devices:

a. for these devices the main carrier will need to be notched as it will overload (or blow up) the rx/spectrum analyser, or pre-amplifier.

b. the antenna port may not simulate unintentional emissions typically from slots.

# Setting up the EUT

For the measure to be effective the signal to noise ratio, of the emissions in under investigation, needs to be as high as possible. With regard to the EUT, the following points should be considered:

* operate the device at the highest supported data rates;
* remove panels (great care should be taken with mains and other voltages);
* create artificial slots, move a panel and then tape the panel back on but leave a slot. The panel needs to be very securely taped (or screwed) because for some of the investigations it is useful to change the height of the EUT.

Some examples…

|  |  |
| --- | --- |
|  |  |
|  |  |

To improve stability issues, try some of the following:

* before testing let the EUT warm up;
* do not operate using various cycles which could change the loading of the EUT, if possible just power the device into a BIOS type mode;
* turn off any spread spectrum clocking;
* do not attach cables, this only complicates the set up and adds uncertainty;
* pre-bundle the mains cables based upon any planned movement of the EUT.

# Test equipment consideration

## Test equipment consideration: General

The impact of the test equipment needs to be minimized:

* any table (or supporting structure) used shall be made of unpainted polystyrene foam;
* during the measurements, ensure all equipment is sufficiently warmed:
  + Pre amplifiers.
  + Spectrum analyser.
  + Receivers.
  + The equipment under test.
* ensure calibration routines have recently been operated;
* all equipment (antennas, cables, pre-amplifiers and chambers) have been calibrated (within the last 12 months);
* turn off auto calibration functions which could interrupt the measurements;
* ensure all connections are good:
  + Clean
  + Tight
  + Good working order
  + Capable of performing measurements in the relevant range
* do not multi-task the measurement control PC, allow the software to run without the possibility of interruption.

## Test equipment consideration: Calibration points

Calibration of amplifiers and cables needs to be established at a sufficient number of points to ensure that the measurements are not compromised.

|  |  |  |
| --- | --- | --- |
| Typical Pre-Amp Gain | Cable Loss |  |
|  |  |  |
|  | | |

Calibration at every 100 MHz will not provide sufficient detail to ensure that there are no resonances which can cause measurement difficulties. Whilst it is true that we are performing relative measurements, at resonances, levels will not be repeatable.

## Test equipment consideration: Tower and Turntable movements

|  |  |
| --- | --- |
|  | The movement of these devices needs to be slow enough to ensure that all the variances of the emissions from the EUT are captured. See section 5.3.  For example, if this device was measured at ‘every 5 degrees’ the worst case would not be found. |

## Test equipment consideration: Antenna Performance

Beamwidth is mentioned both in CISPR 16 (defined) and ANSI C63.4 (not defined). In addition, how the beamwidth is measured and controlled in not defined.

|  |  |
| --- | --- |
|  | This image shows the difference between the examples quoted in CISPR 16 and 3117. |
| |  |  |  | | --- | --- | --- | | 3117 | STLP 9148 | 3115 | |  |  |  | |  |  |  | | Good performance over the range. | Good performance over the range. | Whilst the device works up to 12 GHz, above this performance is weak. In addition for most of the range the device has a lower beamwidth than the other two devices. | | |
| The antenna performance needs to be understood. Please provide the relevant details.  Where the issue of beamwidth is used for changing the measuring process, the beamwidth relevant to signal being measured should be used or relevant to the highest signal to be measured. For example, testing frequencies at 1000 MHz, 2000 MHz, 2400 MHz, 3400 MHz, consider the beamwidth at 3400 MHz. Another possibility is to use the beamwidth at 6 GHz, based upon CISPR requirements.  NOTE For the purposes of this exercise, the is no use considering the beamwidth at 18 GHz, when the measured signal is at 2 GHz. | |

# Measurement process

## Measurement process: Prescan

Any prescan type process may be used, but the main aim is to find emissions, not assess the products against an emission requirement. The biggest issue is the noise floor of the system. If the typical settings of bandwidths (as required by the standards) are used then the noise floor of the system will mask emissions from the device. To get around this problem the following may be used:

* reduce the video bandwidth;
* reduce the resolution bandwidth;
* increase external pre-amplification (avoiding overload conditions):  
    
  - When using external pre-amps, internal pre-amplification does not often improve the noise floor.  
  - Use good quality cables.  
  - The preamp needs to be mounted as close to the antenna as possible.
* decrease the attenuation (avoiding overload conditions).

In deciding the amount of internal attenuation, or if the internal pre-amp should be used, set the bandwidth as required and actively monitor the noise floor, by lowering the attenuation, if the noise floor does not change then there is no impact and set the attenuation back to where it was.

If the bandwidths are reduced, obviously the sweep time will be increased, this may force the use of a different process. For example, just scanning at a few particular azimuths may be sufficient or dividing the range up into ‘sub chunks’. Remember the objective is to find emissions, not to assess all relevant emissions against a particular requirement.

These are a few examples of the use of bandwidth changes.

|  |  |
| --- | --- |
| C:\Temp\new1GHz from 10m\bore_extreme_2.2m.gif | In this example,  Video bandwidth : 10kHz  Resolution bandwidth : 100kHz  Range is divided into 4 sub scans to cope with the sweep time issues. |
|  | In this example,  Video bandwidth : 30kHz  Resolution bandwidth : 100kHz  Range is divided into 4 sub scans to cope with the sweep time issues. |
|  | In this example,  Blue Trace  Video bandwidth : 1MHz  Resolution bandwidth : 1MHz  Red Trace  Video bandwidth : 10kHz  Resolution bandwidth : 120kHz |

## Measurement process: Frequency of emissions

With regard to the frequencies found the aim is:

* find those of the highest value, largest signal/noise ratio;
* the frequency spread needs to cover a wide range;  
  - If there is a frequency at 1500 MHz, do not test one at 1512 MHz.  
  - Ignore emissions that are too highly modulated.
* the highest frequencies may provide the most useful information;  
  - test those whose levels are close to the noise floor and they may provide useful information;
* we need to assess the emission using both antenna polarisations. Sometimes only one of the polarisations will provide useful information;
* once found, the list of frequencies should be good for most configurations.

Dependent upon the analyser used, the frequencies of interest will have to be validated. Hence fine tune each emission of interest and measure them accurately. During the formal process these exact frequencies shall be re-measured each time. So turn off any ‘auto fine tune functionality’

## Measurement process: Video Bandwidth

To perform effective measurements during any tower / turntable movements the analyser needs to be set up based upon the impact of the EUT. The emissions that will be measured are very likely to be modulated clock frequencies and their harmonics. This modulation will cause major differences in the amplitudes during tower/turntable movements. In order to reduce this impact, the video bandwidth should be set to 500 Hz (or similar).

NOTE Do not set the bandwidth to as low as 10Hz/3Hz or something so small because this increases the setting time of the analyser dramatically.

If a receiver is being used, using the average detector will provide similar results.

These are examples of the impact on some emissions.

|  |  |
| --- | --- |
| Res Bw: 1MHz, Video Bw: 1MHz Red trace is a moving average | Res Bw: 1MHz, Video Bw: 500Hz |
|  |  |
|  |  |
|  |  |
|  |  |
| This signal was highly modulated with a slow repetation frequency and hence reducing the Video bandwidth had limited use. | |
|  |  |

The changing amplitude for the tower must be recorded. With this information, we can determine some of the other possible solutions, for example, limiting the scan to the height of the EUT.

## Measurement process: Tower / Turntable

The tower/turntable process shall include:

1. Configure antenna setup (run prescan process and determine frequencies)

2. Set the analyser/rx to one of the frequencies found during the prescan measurement

3 Set analyser to zero span

4. set the antenna to vertical (or horizontal) polarity

5. Set the antenna to height where the emission can be observed (if possible)

6. Begin to measure the emission, and fully rotate the EUT through 360 degrees (0-360).

7. Go back to the worst case azimuth

8. Fully scan the antenna from 100cm – 400cm (or as required by the process chosen)

Step a. Repeat steps (1 - 8) for all relevant frequencies.

Step b. Repeat step a. with the antenna set to horizontal (or vertical) as required.

NOTE the tower/turntable speed (combined with the analyser marker measurement) shall be slow enough that a measurement is recorded (as a minimum) at each azimuth (0, 1, 2…) and at ever cm height. (100, 101, 102…..).

NOTE it is very important to fully rotate the turntable, and not just choose a single azimuth, measurements have shown that the worst case emissions will tend to be at low height, when the azimuth has been maximised.

The changing amplitude for the tower must be recorded. With this information, we can determine some of the other possible solutions, for example, limiting the scan to the height of the EUT.

# Possible test variations

There are numerous ways to perform this test, CISPR methods are highly defined but do not give results anywhere near the maximum and are not do not give repeatable results from large rack equipment that can have sources at various heights. ANSI methods are not effectively defined and hence with can lead to wild variability, but by requiring antenna movement in all circumstances, meaning that a more maximised result will be obtained compared with CISPR methods.

Sections 6.1 to 6.9 show some the possible variants. In addition the following table provided some additional alternatives.

|  |  |
| --- | --- |
| **Change** | **Comment** |
| Measurement distance | By changing the measurement distance, the size of the ‘area measured’ will change. Hence repeat an identical measurement but at different distances, for example at 1 m, 3 m, 5 m and 10 m. Obviously at 10 m the system noise floor may become an issue. |
| Antenna beamwidth.  See section 4.4 | For example, repeating an identical measurement with antennas that have widely different beamwidth (3115 compared with a 3117).  Processes 6.7 and 6.8 show that once a method is defined by beamwidth, setting up the measurement process at the extremes will provide information about how effective the definitions are. |
| Beamwidth | Where the issue of beamwidth is used for changing the measuring process, the beamwidth relevant to signal being measured should be used or relevant to the highest signal to be measured. For example, testing frequencies at 1000 MHz, 2000 MHz, 2400 MHz, 3400 MHz, consider the beamwidth at 3400 MHz. Another possibility is to use the beamwidth at 6 GHz, based upon CISPR requirements. |

|  |  |  |
| --- | --- | --- |
| **#** | **Set Up** | **Comments and discussion** |
| Process 6.1, CISPR 16, fixed at the middle of the EUT | | |
|  |  | **Details**  Fixed height at the middle of the EUT.  **CISPR 16**  As CISPR 16 (up to 6 GHz)  **ANSI**  Does not meet ANSI requirements for scanning height or possible pointing.  **General**  Not a very good method for detecting directional signals. Can be a repeatable test method (simple). If the EUT can vary, for example, rack equipment with lots of slots, then results will vary widely. |
| Process 6.2, CISPR 16, full scan of the EUT | | |
|  |  | **Details**  Scan fully from 1m to height of the EUT.  **CISPR 16**  Meets CISPR over the entire range.  **ANSI**  Does not meet ANSI requirements for scanning height or possible pointing.  **General**  Minor improvement of method 6.1. |
| Process 6.3, CISPR 16, 1m-4m, planar scan of the EUT | | |
|  |  | **Details**  Scan fully from 1m to 4m.  **CISPR 16**  Exceeds CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth will satisfy any need for pointing)  **General**  Method for detecting directional signals.  Repeatable for most EUTs.  Simple method to define and follow.  May not be maximum because there is no pointing. |
| Process 6.4, CISPR 16, 1m-4m, planar scan of the EUT + point down | | |
|  |  | **Details**  Scan fully from 1m to 4m. Then repeat with antenna at a height of 4m with antenna pointing at 0.8m.  **CISPR 16**  Exceeds CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth will satisfy any need for pointing)  **General**  Method for detecting directional signals.  Repeatable for most EUTs.  Simple method to define and follow.  May not be maximum because there is no pointing. |
| Process 6.5, CISPR 16, 1m-4m, planar scan with antenna @ angle | | |
|  |  | **Details**  Scan fully from 1m to 4m, with antenna at a fix angle.  **CISPR 16**  Exceeds CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth will satisfy any need for pointing)  **General**  Method for detecting directional signals.  Repeatable for most EUTs.  Simple method to define and follow.  May not be maximum because there is no pointing. |
| Process 6.6, Bore-sight (at 0.8m) | | |
|  |  | **Details**  Scan fully from 1m to 4m @ 3m, whilst bore-sighting to a 0.8m height point  **CISPR 16**  May not meet CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth may satisfy any need for pointing).  **General**  Process will only work for table top EUTs.  Were the antenna pivots will change the results? (antenna to EUT distance) |
| Process 6.7, Bore-sight (at 0.8m), upper limit of 3dB point | | |
|  |  | **Details**  Scan fully from 1m to 4m @ 3m, whilst bore-sighting to a 0.8m but to the top of the 3dB beamwidth.  **CISPR 16**  Not meet CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth may satisfy any need for pointing).  **General**  Process will only work for table top EUTs.  Were the antenna pivots will change the results? (antenna to EUT distance) |
| Process 6.8, Bore-sight (at 0.8m), lower limit of 3dB point | | |
|  |  | **Details**  Scan fully from 1m to 4m @ 3m, whilst bore-sighting to a 0.8m but to the bottom of the 3dB beamwidth.  **CISPR 16**  Not meet CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth may satisfy any need for pointing).  **General**  Process may work for table top and rack mounted EUTs.  Were the antenna pivots will change the results? (antenna to EUT distance)  Process is difficult to define. |
| Process 6.9, Bore-sight (at 2.1m) | | |
|  |  | **Details**  Scan fully from 1m to 4m @ 3m, whilst bore-sighting to a 0.8m but to the top of the 3dB beamwidth.  **CISPR 16**  Not meet CISPR requirements  **ANSI**  Meets ANSI requirements for scanning height, dependent upon antenna performance (beamwidth may satisfy any need for pointing).  **General**  Process will only work for table top EUTs.  Were the antenna pivots will change the results? (antenna to EUT distance) |

# Results and information

Upon completion please provide the information about the exercised following, including but not limited to:

* list of test equipment used;
* plots of pre-amp gain applied;
* plots of cable loss;
* plots of antenna factors;
* photographs of the EUT;
* photographs of the test set up;
* plots of the system noise floor;
* plots of the EUT emission profiles;
* plots that illustrate the signal profile during turntable rotation;
* plots that illustrate the signal profile during tower movement rotation;
* plots of the variances between the different processes followed;
* a detail description of processed followed;
* if bore-sight methods were used:
  + How the antenna height was calculated.
  + Where the antenna pivot point was defined.
  + How the measurement distance was chosen.
  + Where was the actual bore-sight point?
* summary;
* conclusions & recommends.