3GPP TSG-RAN4 #57 R4-104307
Jacksonville, USA, 15 -19 Nov, 2010

Source: Motorola
Title: Measurement averaging for emission requirement
Agenda Item: 13.2.1
Document for: Discussion

1 Introduction

In TS36.521 section 6.6.3.3 specifies that Public Safety (PS) emissions should be average power, but the provision is not clear on how averaging should be done. The amount/type of averaging is very important for accurate measurement, particularly for spurious emissions which are noise like with a high variance. Although the focus of this paper is related to PS emissions, this aspect is applicable to all stringent emission limits as proposed in [1]

Even though the emissions from a given user equipment (UE) maybe deterministic in nature, the measuring instrument, such as a spectrum analyzer, will add uncertainty to the measurement. The uncertainty added by the measuring instrument maybe treated as random noise riding on top of the deterministic emissions from the UE. In this document we look at two averaging techniques as a means of reducing the measurement uncertainty and propose to specify a minimum value for both methods for the NS_07 emission requirements in RAN4. Exact test methodology can be then be addressed in R5 test specification

2 Background

This document describes two averaging techniques that can be applied to measurements taken on a spectrum analyzer. One method fixes the sweep time such that a certain amount of time is spent for each measured data point. We will refer to this method as "time-averaging". The other method applies trace averaging. We will refer to this method as "trace-averaging"

In the following section we show measured data collected by measuring the noise floor of a commercially available spectrum analyzer with both averaging methods and analyze the data to examine some of the statistics of the averaging methods. The measurement setup is essentially a spectrum analyzer with no input applied to the instrument. The input of the analyzer may be terminated in a matched load or left un-terminated. The data collected is a sweep of the noise floor of the spectrum analyzer based on its settings. In the following sub-sections we look at the methodology and measurement data for the two averaging techniques

2.1 Time averaging method

In this method we adjust the sweep time of the spectrum analyzer such that a desired amount of time is spent per measurement point. For example, let's consider a measurement that has a specified resolution bandwidth (RBW), the number of points in each sweep and see the impact of adjusting the sweep time.

Parameters:

- RBW = 6.25kHz
- Number of Sweep Points (NSP) = 625
- Measurement Time per Point (MTpP): Vary from 1ms to 20ms (for example: 1ms, 2ms, 4ms, 8ms, 10ms, 15ms, 20ms).
- VBW: Set value so that the measurement is not uncalibrated.
- Compute the span setting of the spectrum analyzer as: Span = NSP x RBW = 625 x 6.25kHz = 3.90625MHz
- Compute the sweep time of the spectrum analyzer as: Sweep Time = NSP x MTpP
- Attenuation: 26dB (a convenient value for these measurements).

For this experiment we varied the measurement time per point from 1ms to 20ms as described above and computed the statistics of the measured data. The parameters computed were maximum, minimum, average value,

peak-to-peak variation (max value-min value), and standard deviation. The computed parameters of the measured data are summarized in Table 2.1-1 below:

Spectrum Analyzer Settings								Noise Floor Measurement Statistics (time av.)				
RBW (kHz)	Span (kHz)	VBW (Hz)	SweepTime (ms)	Number of Points	Measurement Time per Point (ms)	Trace Averaging	Attenuation (dB)	MinPower (dBm)	MaxPower (dBm)	Pk-to-Pk Variation (dB)	Average (dBm)	Standard Deviation (dB)
6.25	3906.25	1100	625	625	1	N/A	26	-92.642	-83.301	9.341	-87.455	1.445
6.25	3906.25	510	1250	625	2	N/A	26	-90.734	-84.215	6.518	-87.331	1.034
6.25	3906.25	300	2500	625	4	N/A	26	-89.536	-85.04	4.496	-87.227	0.692
6.25	3906.25	200	5000	625	8	N/A	26	-88.774	-85.668	3.106	-87.233	0.473
6.25	3906.25	150	6250	625	10	N/A	26	-88.611	-85.816	2.795	-87.18	0.462
6.25	3906.25	100	9375	625	15	N/A	26	-88.41	-85.58	2.831	-87.16	0.373
6.25	3906.25	51	12500	625	20	N/A	26	-87.983	-86.2	1.783	-87.166	0.319

Table 2.1-1: Summary of Measured Noise Floor Data Using the Time-Averaging Method.

As can be seen from Table 2.1-1, the peak-to-peak variation and the standard deviation of the noise floor of the spectrum analyzer become smaller as the time spent per measurement point increases. It is essential to note that average value of the noise floor is essentially constant.

In Figure 2.1-1 we present a plot of the raw data showing the peak-to-peak variation of the spectrum analyzer noise floor for 1ms per measurement point (no averaging), and 10ms per measurement point. If we imagine the noise riding on top of the emissions we need to measure and we use no averaging, we observe from Figure 2.1-1 that we may add approximately ±4.65dB of uncertainty to the measurement. So if the noise excursion at the measurement point of interest is +4.5dB, we may fail the test even if we have 4dB of margin in the UE. On the other hand, if we use 10ms per measurement point as a means of averaging, then the uncertainty introduced in the form of peak-to-peak variation may be expressed as ±1.4dB.

For same UE that has a 4dB margin, measured using 10ms per measurement point averaging will now pass the test with 2.6dB of margin. Furthermore, if no averaging is used in the measurement, repeated measurements of the same UE will yield different results due to the large variation of the spectrum analyzer's noise floor.

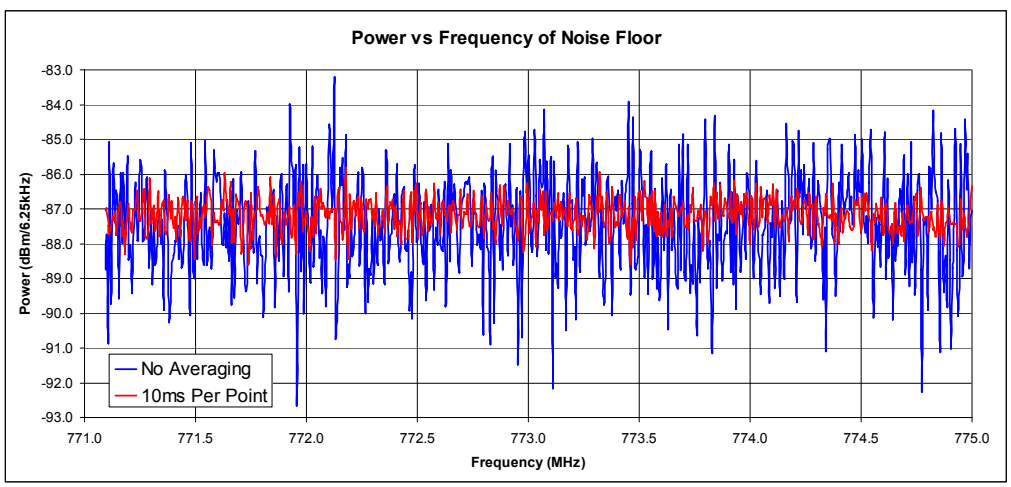

Figure 2.1-1: Peak-to-peak Variation of the Spectrum Analyzer's Measured Noise Floor with no External Input.

2.2 Trace averaging method

In this case we followed the setup described in the FCC document [1] "measurement of signal" in the section titled "Measurement of Average Power Spectral Density" with two minor variations. In the FCC document the span of

the spectrum analyzer is set to 2x the "occupied bandwidth", in our measurements we set the span so that each point in the sweep has the same resolution bandwidth. The span for this method is computed in the same manner as in the time-averaging method. In the FCC document the center frequency of the analyzer is set to the "nominal signal center frequency", where as in the method described here, the start and stop frequencies are specified based on the computed span.

Parameters:

- RBW = 6.25kHz
- Number of Sweep Points (NSP) = 625
- Compute the span setting of the spectrum analyzer as:
- Span = NSP x RBW = 625 x 6.25kHz = 3.90625MHz
- Compute the sweep time of the spectrum analyzer as:
- Sweep Time = NSP x MTpP
- with MTpP = 1ms, hence the Sweep Time is = 625ms
- Attenuation: 26dB (a convenient value for these measurements).
- Activate trace averaging routine over a minimum of 10 sweeps.

For this measurement we varied the number of averaged traces from 1 to 20 in the same increments that was done for the time averaging method. As before, we computed the same statistical parameters of the measured data. The computed parameters of the measured data are summarized in Table 2.2 -1 below:

Spectrum Analyzer Settings								Noise Floor Measurement Statistics				
RBW (kHz)	Span (kHz)	VBW (kHz)	SweepTime (ms)	Number of Points	ent Time per Point (ms)	Trace Averaging	Attenuation (dB)	MinPower (dBm)	MaxPower (dBm)	Pk-to-Pk Variation (dB)	Average (dBm)	Standard Deviation (dB)
6.25	3906.25	20	625	625	1	1	26	-93.026	-83.773	9.253	-87.326	1.371
6.25	3906.25	20	625	625	1	2	26	-89.25	-85.178	4.072	-87.21	0.635
6.25	3906.25	20	625	625	1	4	26	-88.615	-85.754	2.861	-87.193	0.452
6.25	3906.25	20	625	625	1	8	26	-88.083	-86.263	1.819	-87.168	0.332
6.25	3906.25	20	625	625	1	10	26	-88.156	-86.103	2.053	-87.158	0.309
6.25	3906.25	20	625	625	1	15	26	-88.122	-86.208	1.914	-87.161	0.28
6.25	3906.25	20	625	625	1	20	26	-87.922	-86.273	1.649	-87.146	0.246

Table 2.2-1 Summary of Measured Noise Floor Data Using the Trace-Averaging Method

As can be seen from Table 2.2-1, the peak-to-peak variation and the standard deviation of the noise floor of the spectrum analyzer become smaller as the time spent per measurement point increases. The reduction in peak-to-peak variation and standard deviation with increasing number of the averaged traces is similar to the reduction observed in the time averaging method. It is easy to observe that the average value of the noise floor is also essentially a constant in this methodology.

3 Comparison of the two averaging methods

In this section we will compare the two averaging methods based on the measured data presented in the previous two sections. Figure 3-1 and 3-2 show the peak-to-peak variation and the standard deviation of the spectrum analyzer's noise floor for the two averaging methods.

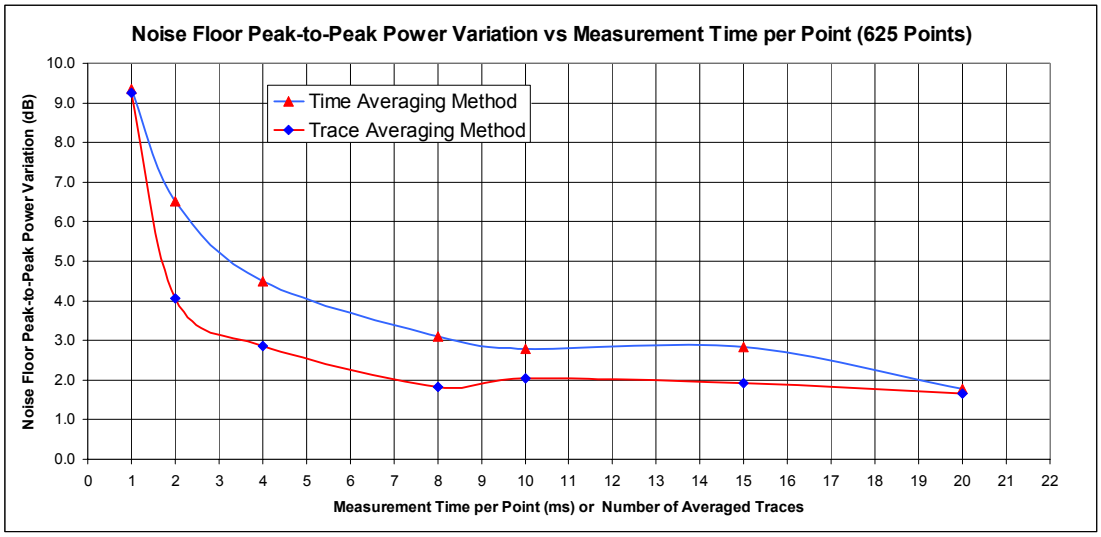

Figure 3-1: Peak-to-Peak Variation of the Spectrum Analyzer's Measured Noise Floor with no External Input.

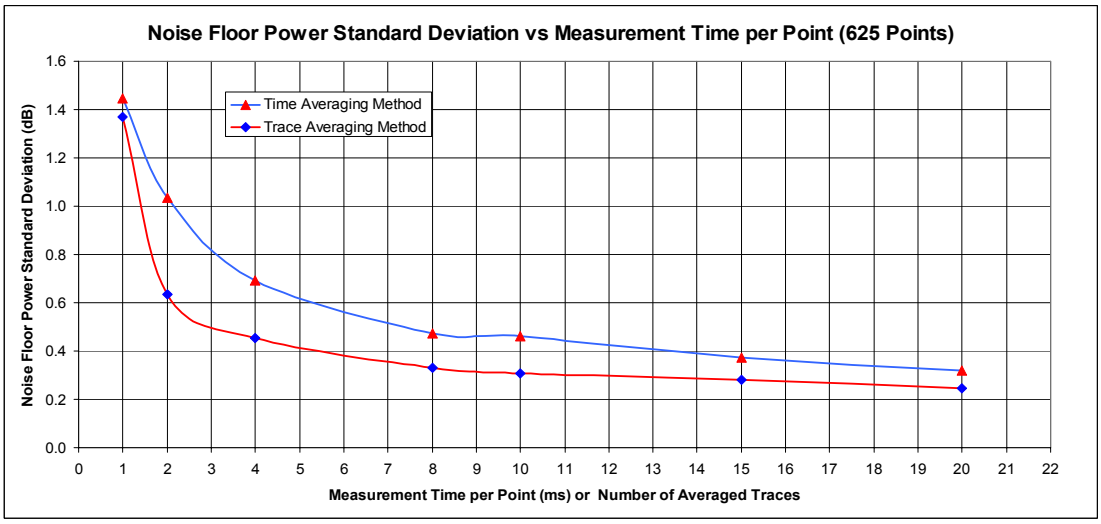

Figure 3-2: Standard Deviation of the Spectrum Analyzer's Measured Noise Floor with no External Input.

From Figure 3-1, it is easy to observe that the peak-to-peak variation of the spectrum analyzer's noise floor decays rapidly when either the measurement time per point, or the number of averaged traces increase. The reduction in this parameter essentially flattens out after the measurement time per point or the number of averaged traces increases beyond 10ms or 10 traces. Increasing the averaging beyond these values yields only a small amount of improvement in reducing the uncertainty of the measurement. It is clear that data plotted in Figure 3-2 show similar trends to those shown in Figure 3-1

4 Conclusion

We presented two methods that may be applied to measuring the power density of emissions from a UE. One method is based on the time averaging where the averaging is achieved by controlling the measurement time per point, or the sweep time of the spectrum analyzer. The other method is based on trace averaging, where several trace sweeps are used to achieve averaging in the measurement. We also demonstrated that each averaging method will reduce the uncertainty in the measurement, particularly in the peak-to-peak variation of the noise excursions due to the spectrum analyzer.

The presented results clearly show the need for averaging in the measurement, as the peak-to-peak variation in the noise excursions can be on the order of ±4.5dB without any averaging. The computed statistical parameters of the measurements show that if 10ms per measurement point or 10 trace sweeps are used for averaging, then the peak-to-peak variation in the added noise level will be limited to approximately ±1.0dB-1.5dB depending on the averaging method. Although the focus of this paper is related to PS emissions this aspect is applicable to all stringent emission limits as proposed in [1]

The following TP is proposed for clause 6.6.3.3.2 of TS36.101 (shown with change bars) for PS emission

6.6.3.3.2 Minimum requirement (network signalled value "NS_07")

When "NS_07" is indicated in the cell, the power of any UE emission shall not exceed the levels specified in Table 6.6.3.3.2-1.

Table 6.6.3.3.2-1: Additional requirements

Frequency band (MHz)	Channel bandwidth / Spectrum emission limit (dBm)	Measurement bandwidth
	10 MHz	
769 ≤ f ≤ 775	-57	6.25 kHz
Note 1. In the case of a time average measurements ≥ 10ms shall be used per sample point to determine compliance to this emission limit 2. In the case of trace average measurement ≥ 10 numbers of trace averages shall be used to determine compliance to this emission limit		

NOTE: For measurement conditions at the edge of each frequency range, the lowest frequency of the measurement position in each frequency range should be set at the lowest boundary of the frequency range plus MBW/2. The highest frequency of the measurement position in each frequency range should be set at the highest boundary of the frequency range minus MBW/2. MBW denotes the measurement bandwidth (6.25 kHz).

5 Reference

[1] Federal Communications Commission Staff "Procedures for Compliance Measurement of the Fundamental Emission Power of Licensed Wideband (> 1 MHz) Digital Transmission Systems", Publication 971168.

View Document: Procedures for Compliance Measurement of the Fundamental Emission Power of Licensed Wideband (> 1 MHz) Digital Transmission Systems