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PIM Power Levels – A Brief Tutorial

Introduction

Making Passive Intermodulation (PIM) measurements at a basestation is a new measurement for many people, and it can be confusing. Sometimes people talk about PIM measurement results in “dBm” and sometimes in “dBc”. To further confuse things, some tests are being done with 20 watts (the recommended international standard) and some with 2 watts (smaller and lighter test instrument).

It is critical to understand the difference between the results being measured and the way the data is presented. Incorrectly interpreting the data can result in leaving problem components and interconnections in the network and limiting the performance.

-150 dBc Measured with 2 watts is not the same as -150 dBc measured with 20 watts

This fact is not obvious, and many people incorrectly assume that -150 dBc equals -150 dBc regardless of the power used in the measurement. This invalid assumption is understandable; especially when a data sheet for a test instrument lists the measurement performance as -150 dBc, but never says the carrier power (this is the ‘c’ in the measurement unit ‘dBc’).

The fact is, if you don’t know the carrier power level used in the measurement, the test result is meaningless.

A -150 dBc test result using 2 x 2 watt (33 dBm) carrier power is a PIM level of -117 dBm (-150 +33). A PIM test result of -150 dBc with 2 x 20 watts (43 dBm) carrier powers is a PIM level of -107 dBm.

This might lead a person to believe that -150 dBc measured with 2 x 2 watts is better than -150 dBc measured with 20 watts, because it is lower in absolute power: -117 dBm versus -107 dBm. This would be another incorrect conclusion.

PIM Level Increases Rapidly With Increasing Carrier Power

PIM is caused by nonlinear junctions. In the basestation, these nonlinear junctions are caused by poor mechanical junctions in the components or the interconnection of the components and also due to contamination. This is why PIM is an effective way to evaluate the quality of construction at the basestation.

The fact that PIM increases rapidly with increasing carrier power is important to understand when comparing test results at 2 x 2 watts with test results performed at the industry accepted standard test level of 2 x 20 watts.

When measuring the third order IM product, which is the typical measurement when testing PIM at the basestation or in a production environment, theoretically the PIM level will increase 3 dB for every 1 dB increase in carrier power. This means that a measurement at 2 x 2 watts (33 dBm) could be as much as 30 dB higher when measured at 2 x 20 watts (43 dBm). What this means is that if you test an item with a 2 watt system and measure -150 dBc (-117 dBm), you may believe that this is not a defective item. However, if you tested that same item with 2 x 20 watts, it could measure at a level of -120 dBc (-87 dBm), which would have a serious performance impact on your network.

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Measurements have shown that the rate of increase is less than 3 dB for every 1 dB increase in carrier power (visit the Summitek website for more information), and that the actual increase varies between 2.2 dB per 1 dB and 2.8 dB per 1 dB depending upon what is creating the intermodulation. Whichever value you assume, it is important to understand that there is a large difference in performance.

An Example

In the following analysis, it is assumed that the PIM level increases at a rate of 2.2 dB for every 1 dB increase in carrier power.

Convert PIM level measured with 2 x 2 watt carrier power to 2 x 20 watt equivalent			
2 x 2 watts (2 x 33 dBm)		2 x 20 watts (2 x 43 dBm)	
dBm	dBc	dBm	dBc
-117	-150	-95	-138

As you see, a -150 dBc measurement at 2 x 2 watts is a PIM level of -117 dBm and would seem to be acceptable. However, if this were measured at the industry standard 20 watts, the PIM level would be -95 dBm, which would result in a raised noise floor at the basestation.

Convert PIM level measured with 2 x 20 watt carrier power to 2 watt equivalent			
2 x 2 watts (2 x 33 dBm)		2 x 20 watts (2 x 43 dBm)	
dBm	dBc	dBm	dBc
-129	-162	-107	-150

In this case (above), a measurement at -107 dBm, which would be good performance at the basestation, would require a measurement at -129 dBm (-162 dBc) if measured with a 2 watt system.

Summary

As PIM becomes an accepted and required test to determine basestation construction quality, it is important to understand the relationship between carrier power and the test results. If the test carrier power is not considered when evaluating the quality of construction, it is possible to overlook problem components and interconnections.

This power relationship becomes even more critical when attempting to measure TMA's, jumper cables and antennas at the top of the tower where the insertion loss will decrease the carrier powers and might make the measurement totally meaningless.

For more information, visit the Summitek website (www.SummitekInstruments.com) or feel free to email (support@SummitekInstruments.com) or call (303.768.8080). As the industry leader in PIM measurements with more than 11 years providing test solutions, it is our pleasure to help our customers understand the test methods and results.