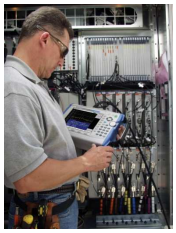

PIM Workshop

Passive InterModulation

Dublin 13/10/2015

Agenda

- ❑ PIM Fundamentals
- ❑ About Field Measurements
- ❑ Anritsu PIM Master™
- ❑ Hands On

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PIM Fundamentals

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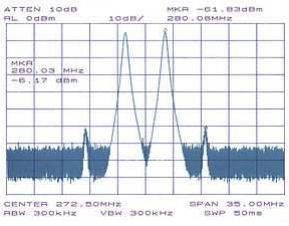
PIM Fundamentals

- What is Intermodulation?

  Intermodulation distortion (IMD) is a multi-tone distortion product that results when two or more signals are present at the input of a non-linear device.

  Intermodulation is caused by non-linear behavior



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PIM Fundamentals

- Linear/Non Linear Device

  Linear device: A device for which the output is, within a given dynamic range, linearly proportional to the input

  Non Linear device: Introducing frequencies

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PIM Fundamentals

- Active/Passive Device

  An active component must be biased (Amplifier)

  A passive device does not require a source of energy for its operation

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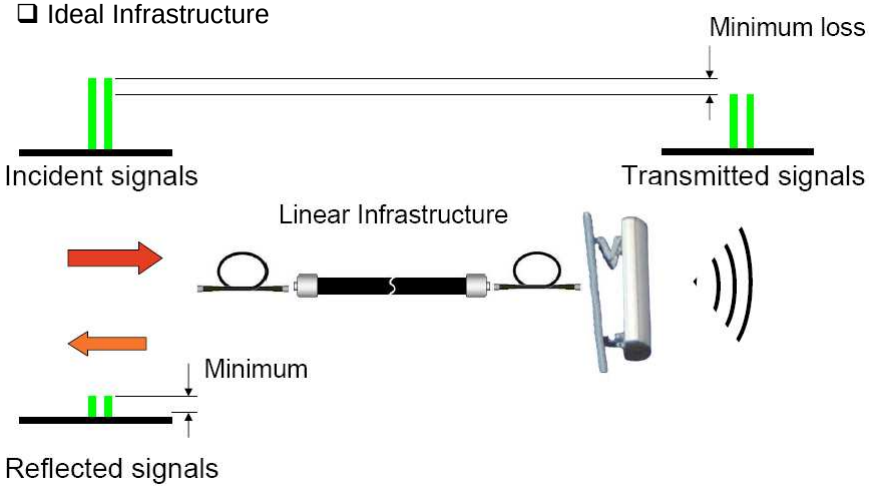
PIM Fundamentals

❑ Ideal Infrastructure



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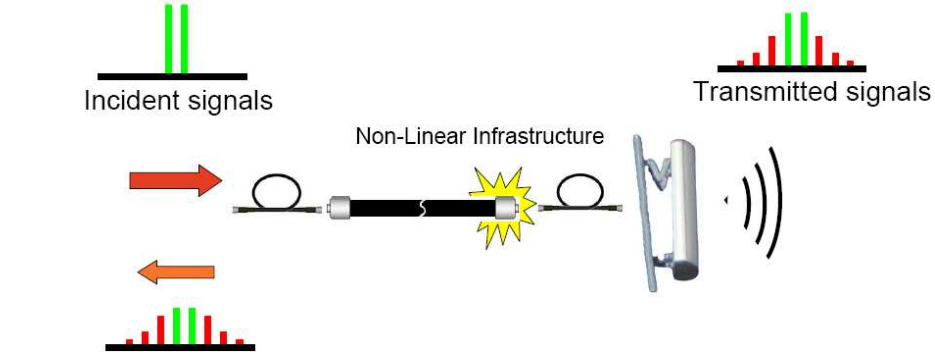
PIM Fundamentals

❑ Non-Ideal Infrastructure



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PIM Fundamentals

- What are the mixing products created by PIM?

$IM_{n+m} = n*F1 - m*F2$ (low side)
$IM_{n+m} = n*F2 - m*F1$ (high side)

IM3, 3rd order is the strongest product

$IM_3 = 2*F1 - F2$ (low side)
$IM_3 = F2 - 2*F1$ (high side)

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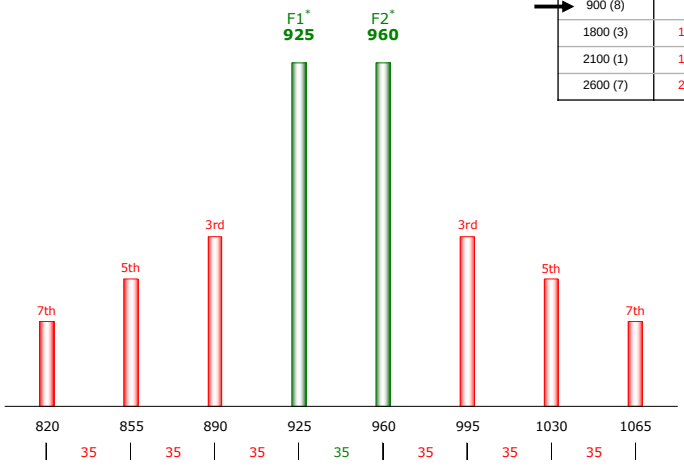
PIM Fundamentals

- E-GSM Case

EU Bands	Rx	Tx
800 (20)	832 □□ 862	791 □□ 821
900 (R/T)	870 □□ 880	915 □□ 925
900 (8)	880 □□ 915	925 □□ 960
1800 (3)	1710 □□ 1785	1805 □□ 1880
2100 (1)	1920 □□ 1980	2110 □□ 2170
2600 (7)	2500 □□ 2570	2620 □□ 2690



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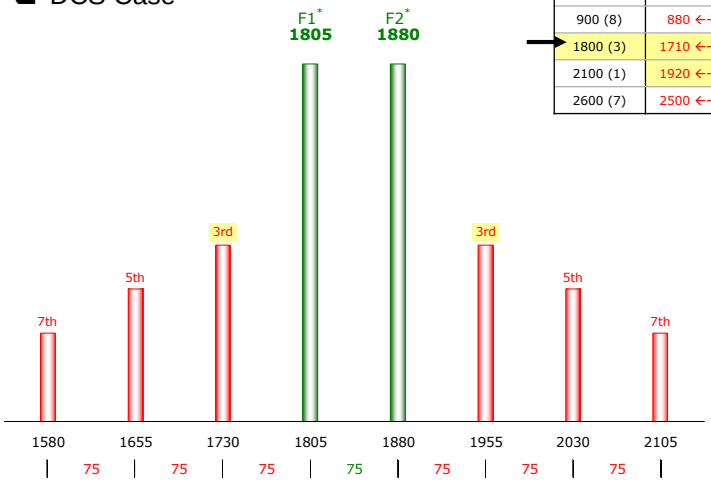
PIM Fundamentals

❑ DCS Case

EU Bands	Rx	Tx
800 (20)	832 ↔ 862	791 ↔ 821
900 (R/T)	870 ↔ 880	915 ↔ 925
900 (8)	880 ↔ 915	925 ↔ 960
1800 (3)	1710 ↔ 1785	1805 ↔ 1880
2100 (1)	1920 ↔ 1980	2110 ↔ 2170
2600 (7)	2500 ↔ 2570	2620 ↔ 2690



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PIM Fundamentals

❑ UMTS Band I Case

EU Bands	Rx	Tx
800 (20)	832 □□ 862	791 □□ 821
900 (R/T)	870 □□ 880	915 □□ 925
900 (8)	880 □□ 915	925 □□ 960
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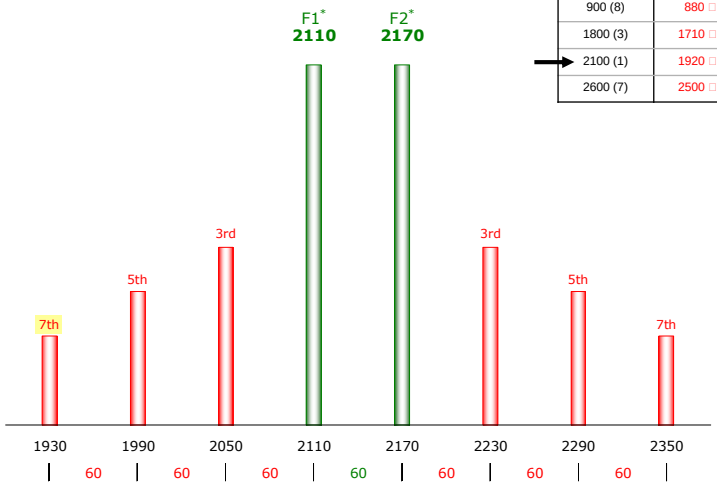

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PIM Fundamentals

- Is PIM frequency dependent?

  NO!

  Value of PIM will change, but PIM effect stays

- Is PIM power dependent?

  YES!

  As the transmitter power increases, the importance of PIM on the overall system performance becomes of increasing concern

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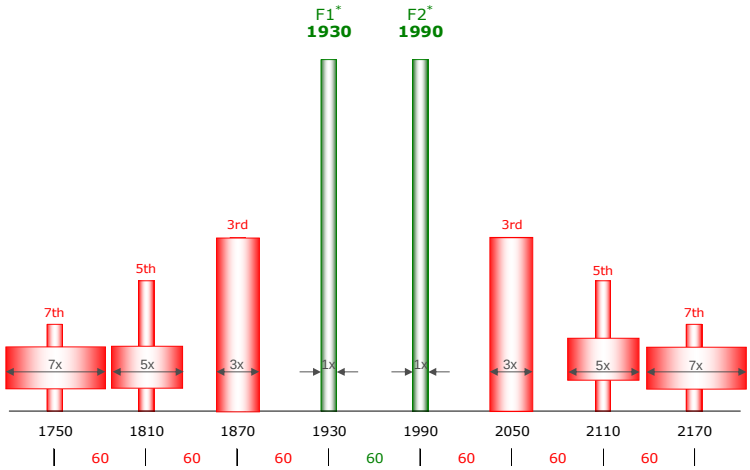
PIM Fundamentals

- Bandwidth of mixing products



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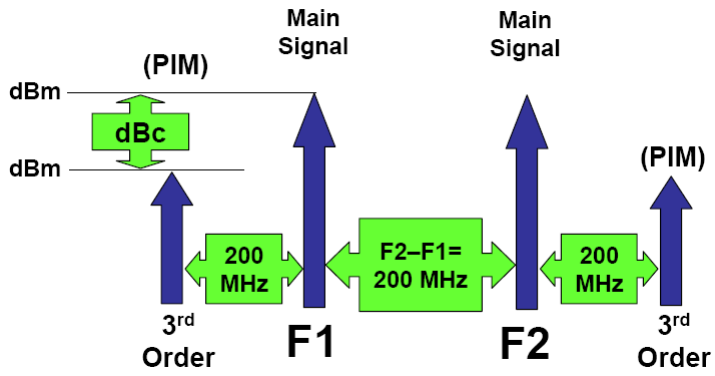
PIM Fundamentals

- PIM Amplitude: dBm or dBc



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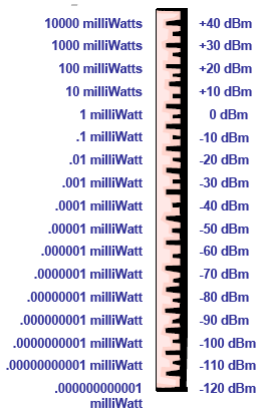
PIM Fundamentals

- PIM Amplitude: dBm VS Watts



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PIM Fundamentals

- PIM Load

A 50 Ohm termination designed to produce very little or no PIM.
Used to replace an antenna when testing the cable at a site

- PIM Source

A 50 Ohm device designed to produce a known amount of PIM.
Used to check the PIM Test Set

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PIM Fundamentals

- Shall we sweep the line or PIM test it?

Sweep test measures efficiency of signal propagation.

PIM test measures ability to propagate signals without generating interference.

Both tests are important and necessary
to ensure quality site construction.

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PIM Fundamentals

!! PIM is not the same as VSWR and Return Loss !!

- Return Loss (or VSWR) Measures:
  Impedance Mismatch vs. Frequency
- DTF (Distance to Fault) Measures :
  Impedance Mismatch vs. Distance

These are all essential measurements of cables/antennas, but the they don y don't measure PIM

- PIM Measures:
  Non-Linearity and Loose Connections
- DTP (Distance To PIM) Measures:
  PIM Location

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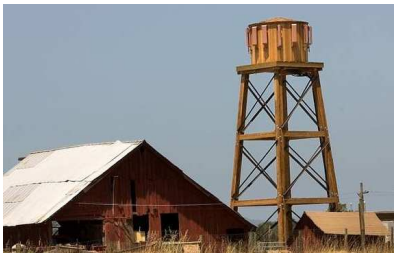
PIM Fundamentals

- Environmental Diodes, what?

  Name used for elements outside the BTS in the nearby environment that are acting like diodes in mixing signals.

  This due to physical properties of materials

  Corroded objects are one of the main problems," Rusty Bolt Effect"



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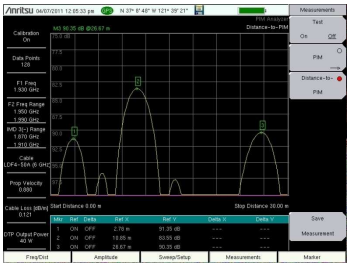
PIM Fundamentals

- Where is my PIM?

A US mobile operator says that 50% of their network PIM problems are not related to the base stations

Anritsu Distance-to-PIM™ can tell you



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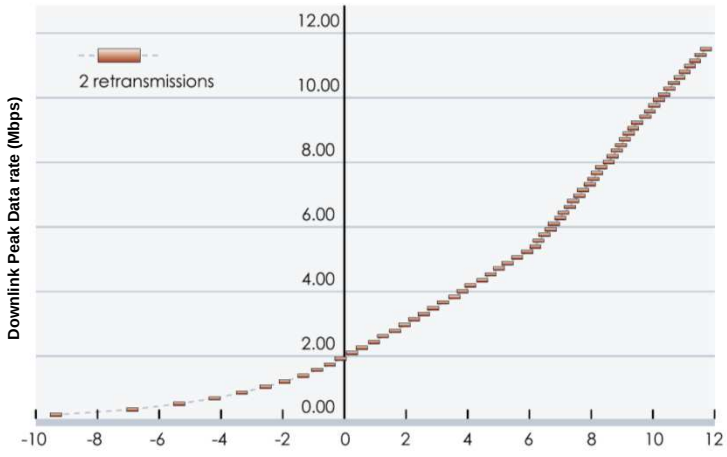
PIM Fundamentals

HSDPA Peak Data (Physical Layer) vs. C/I or E_c/N_t



- **PIM looks like interference to the system, lowering the C/I ratio and the data rate**

Source: Qualcomm, "HSDPA for Improved Downlink Data Transfer," Oct 2004

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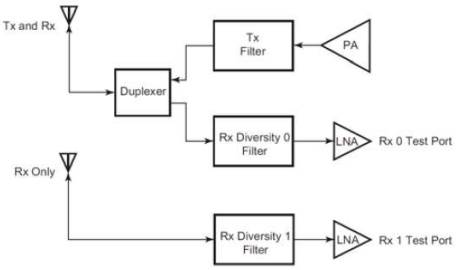
PIM Fundamentals

- Indicators of PIM Problems – Case 1

  PIM often shows up as poor statistics from the affected sector

  One of the first and most direct indications of PIM can be seen in cells with two receive paths. If the **noise floor** is not equal between the two paths, the cause is likely PIM generated inside the noisy receive path



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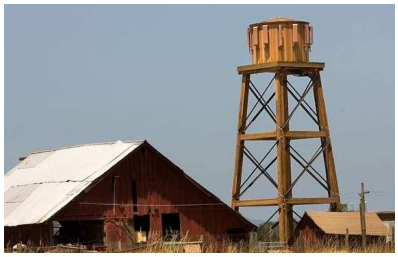
PIM Fundamentals

- Indicators of PIM Problems – Case 2

  If a cell site performs poorly when dry conditions exist but improves dramatically when a rainstorm passes through the region, the technician should immediately inspect the surrounding area for items that have rusty mounts



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PIM Fundamentals

- Causes of PIM - 1

Mechanical Considerations
Metallic Contact
Tunneling Effects
Rusty Bolt Effect
Fritting
Ferromagnetic Materials

such as iron, nickel, cobalt, and some alloys of magnesium, aluminum and copper

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PIM Fundamentals

- Causes of PIM - 2

Connectors

Poor connector attachment causes electrical Arcing
Arcing creates serious interferences

Types of poor connectors attachment
- Loose connector body
- Improper soldering of center Pin
- Recessed center Pin
- Cable cut at an angle
- Rough hacksaw cut

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PIM Fundamentals

❑ Causes of PIM - 3

Connectors/Cables Termination

Loose Mating of connectors
- Should be tightened to spec
- Sometimes loosened by installer to achieve RL spec

Over tightened connectors
- Causes center contact to fracture or bend
- Sometimes over-tightened by installer to achieve RL spec

Poor weatherproofing
- Water in cable causing corrosion

Dirty connectors/cables
- Use alcohol swabs

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PIM Fundamentals

❑ Causes of PIM - 4

Manufacturing Defects in:

Cables

Bad weld in cable sheath
Missing foam inside cable

Antennas

Internal failures

Other Passive Devices

Directional couplers
Diplexers
Lightning protectors

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PIM Fundamentals

- Causes of PIM - 5

Adapters

Use quality adapters
Test them to be sure they have low PIM
Discard adapters with high PIM
Clean with denatured Alcohol

Adapters are for testing
Should never ne in-circuit when actually providing service

Keep them clean!

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PIM Fundamentals

- Causes of PIM - 5

Cable bent near connector

Cable Bent Near Connector

A bend close to connector can cause PIM
Some antennas have poorly placed connectors, the connector is obstructed by the mounting pipe
This difficult access results in a bend near the connector

Two Fist Widths

The minimum distance between the connector and the first bend should be two fist widths or more

Observe the manufacturer's minimum bend radius, excessive bend pull the center conductor out the connector

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About Field Measurement

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About Field Measurement

- Safety

  PIM Test Sets generate 80 Watts of RF Power (2 x 40 W).

  This amount of power is required to find PIM Problems and is safe when the cable is terminated with a Load

  This amount of power may be unsafe when applied to an antenna that has a person close by.

Test Power	Frequency	Gain (dBi)	Distance (m)	Distance (ft)	Gain (dBi)	Distance (m)	Distance (ft)	Gain (dBi)	Distance (m)	Distance (ft)
20 W	750-950	6	1.59	5.22	12	3.18	10.42	20	7.98	26.17
40 W	750-950	6	2.25	7.38	12	4.49	14.73	20	11.28	37.01
20 W	1930-2150	6	0.99	3.26	12	1.98	6.49	20	4.97	16.31
40 W	1930-2150	6	1.40	4.60	12	2.80	9.19	20	7.03	23.07

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About Field Measurement

- Things NOT TO DO

No Standing over antenna during test!

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About Field Measurement

- Things NOT TO DO

No tools on antenna during test

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About Field Measurement

- Things NOT TO DO

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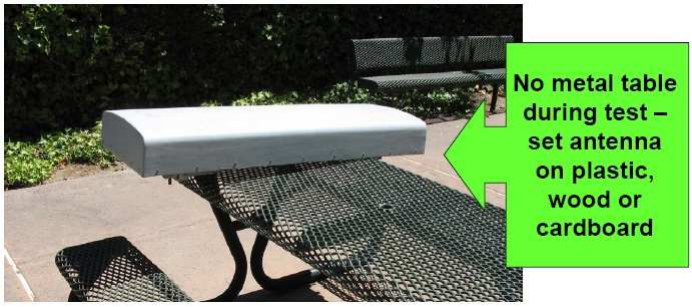
About Field Measurement

- Things NOT TO DO



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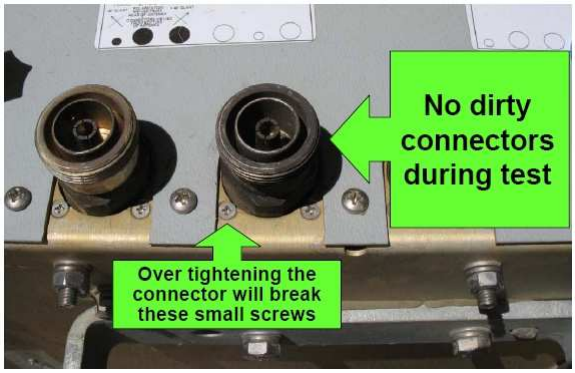
About Field Measurement

- Things NOT TO DO



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About Field Measurement

- Things NOT TO DO

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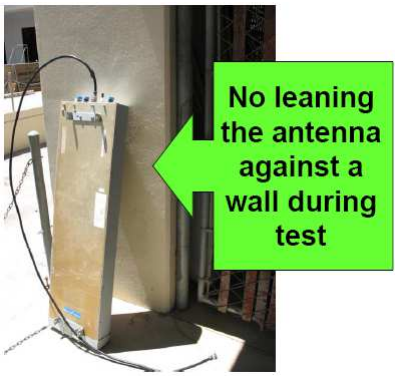
About Field Measurement

- Things NOT TO DO



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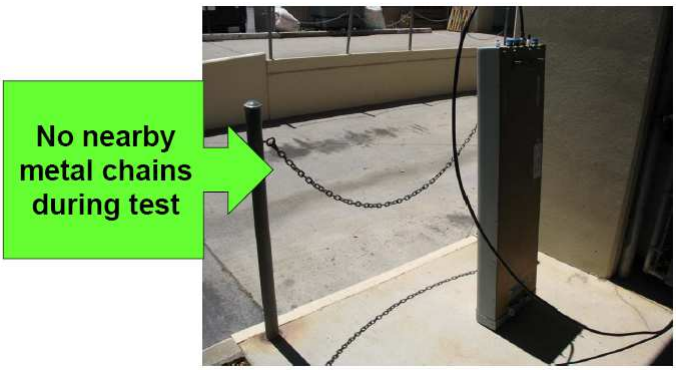
About Field Measurement

- Things NOT TO DO



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About Field Measurement

- The right way to do it

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About Field Measurement

- Troubleshooting Guide

1. Start with **VSWR and DTF** if needed to check transmission
2. **PIM test** the cable with the antenna connected, 2x40W
3. If PIM fails, use **DTP** to locate hot spots
   - Establish location of the antenna by connecting a PIM Standard after the cable
   - You can then see if PIM is caused by external sources
4. Remember to tap (dynamic) test all Hot Spots as well as the Lightning Protector, Current Injector (Bias Tee), Connectors and ground at attachment points
5. Correct any PIM Hot Spots
6. If nearby objects (rusty objects near antenna) are causing PIM failure, report these to the antenna owner for resolution

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About Field Measurement

- PIM Limits

  Antennas that were installed 10 years ago were probably not manufactured with PIM performance in mind, so it would be unrealistic to set a PIM level greater than **-80 dBm** because very few would measure favorably

  A standard figure used around the world is a pass level of **-97 dBm**

  With the overlay of LTE services now beginning, a pass value of -97 dBm may not be enough, and it would be wise to achieve the specified receiver sensitivity level (usually around **-107 dBm**) with PIM testing

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