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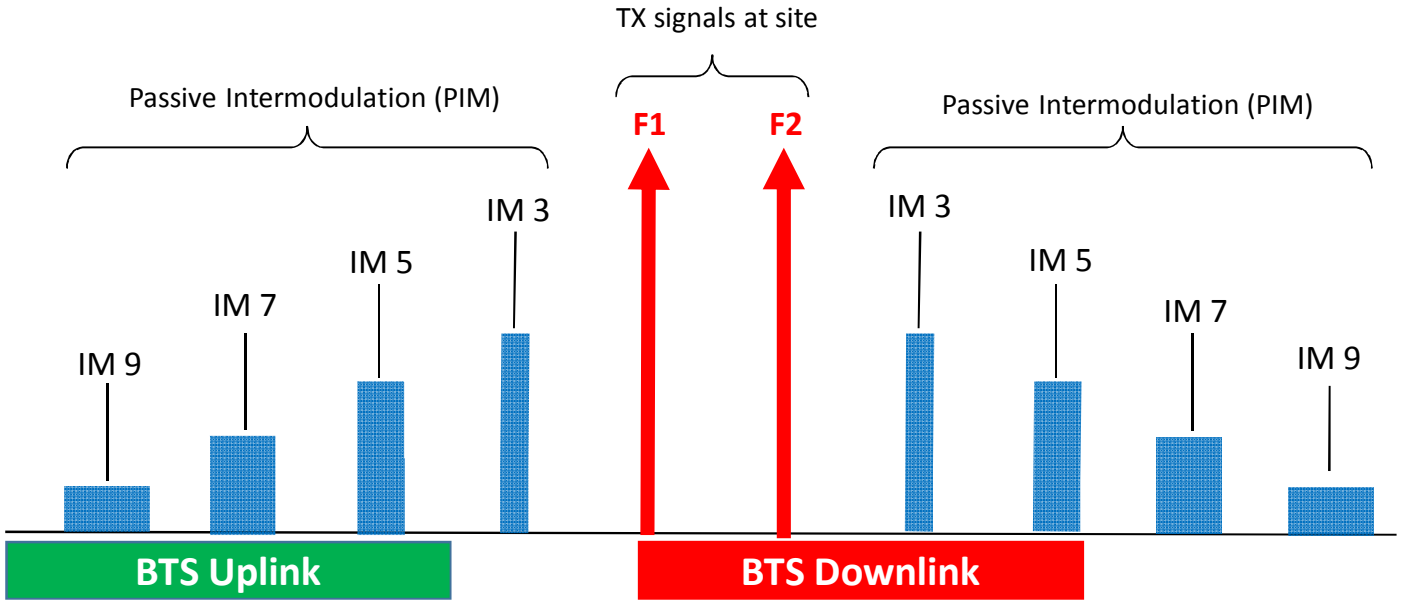
Pasivní intermodulace

What is Passive Intermodulation (PIM)



What is a non-linear junction?

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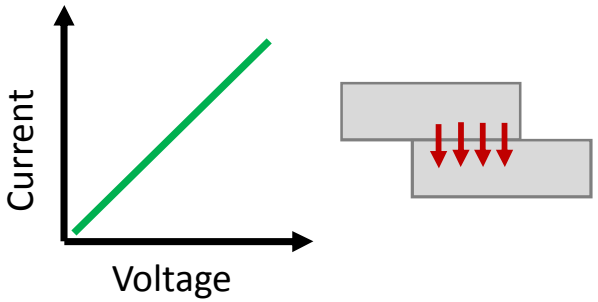
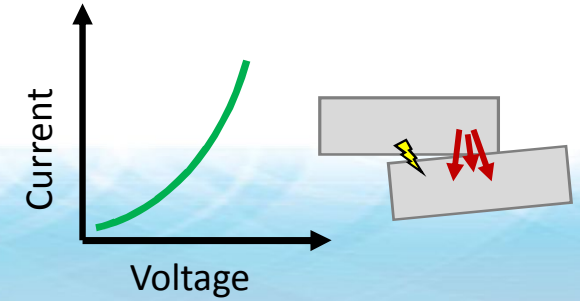
Linear junctions



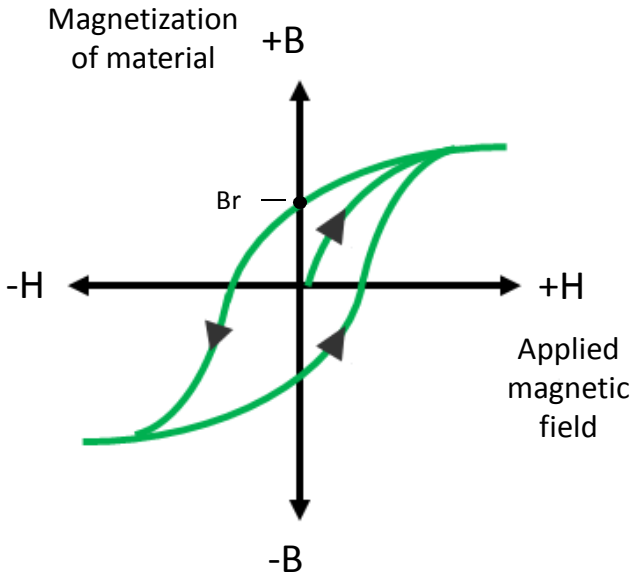
- Current increases linearly with applied voltage
- High pressure, metal-to-metal contacts
- Welded or soldered connections.

Non-Linear junctions



- Current does not increase linearly with voltage
- Low pressure, metal-to-metal contacts
- Oxide layers on metal surfaces
- Arcing across small air gaps or cracks

What is a non-linear material?



- Hysteresis in B-H curve
- Material remains magnetized when magnetic field is removed
- Nickel (plating), Iron, Steels

What is non-linear at a cell site?

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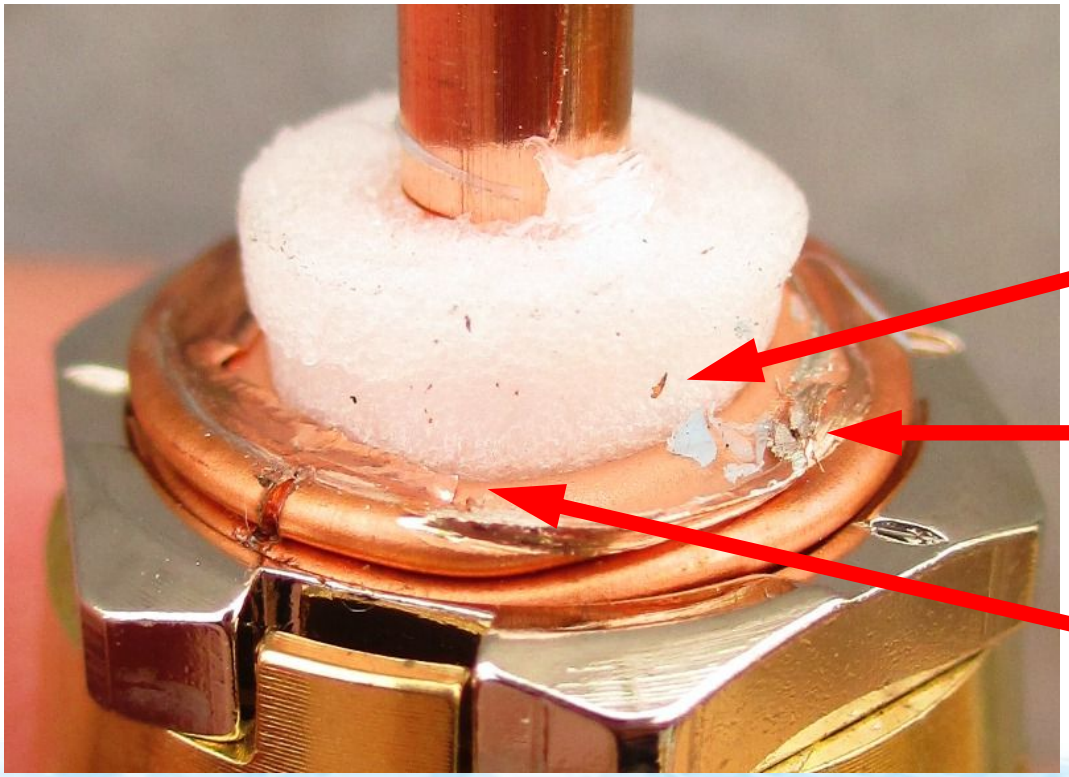


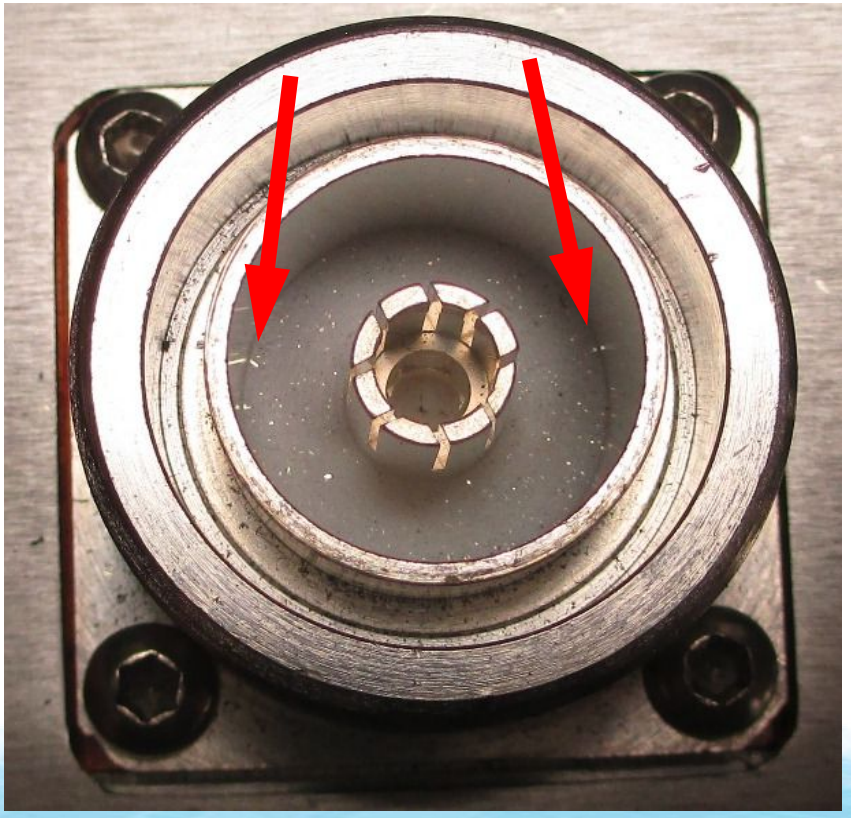
Poor connector termination

Metal flakes

Loose copper

Metal folded on itself

What is non-linear at a cell site?



Metal flakes inside connector

Touching inner conductor

Touching outer conductor

What is non-linear at a cell site?

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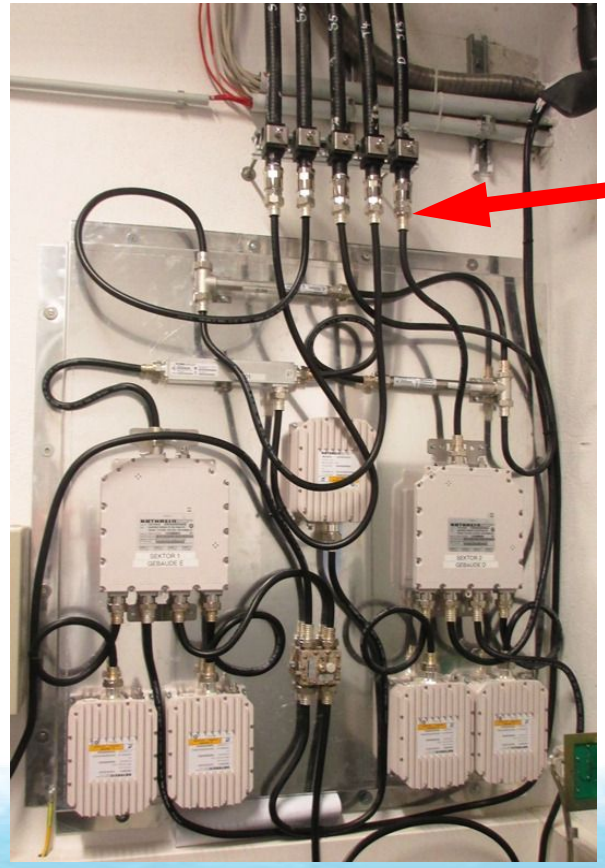

Connectors only hand tightened

Must be torqued with at torque wrench

What is non-linear at a cell site?

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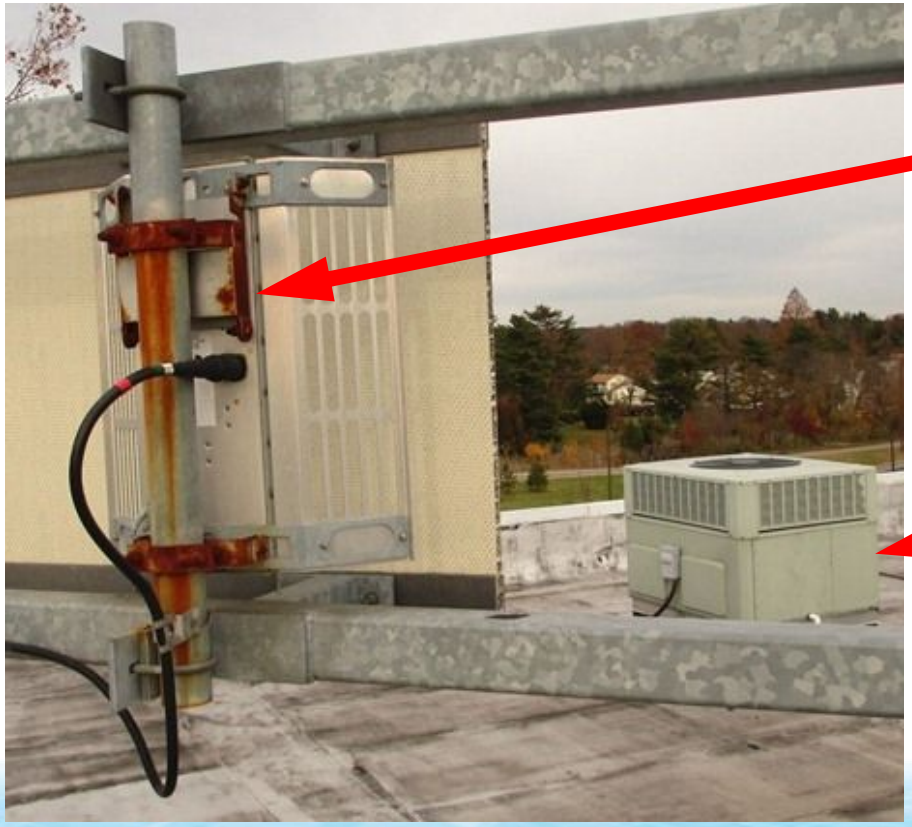
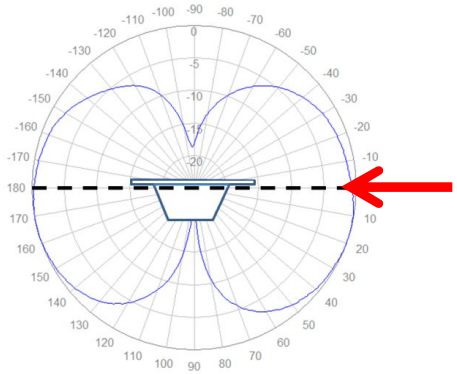


Rusty mounting brackets

Metal objects in front of antennas

What is non-linear at a cell site?

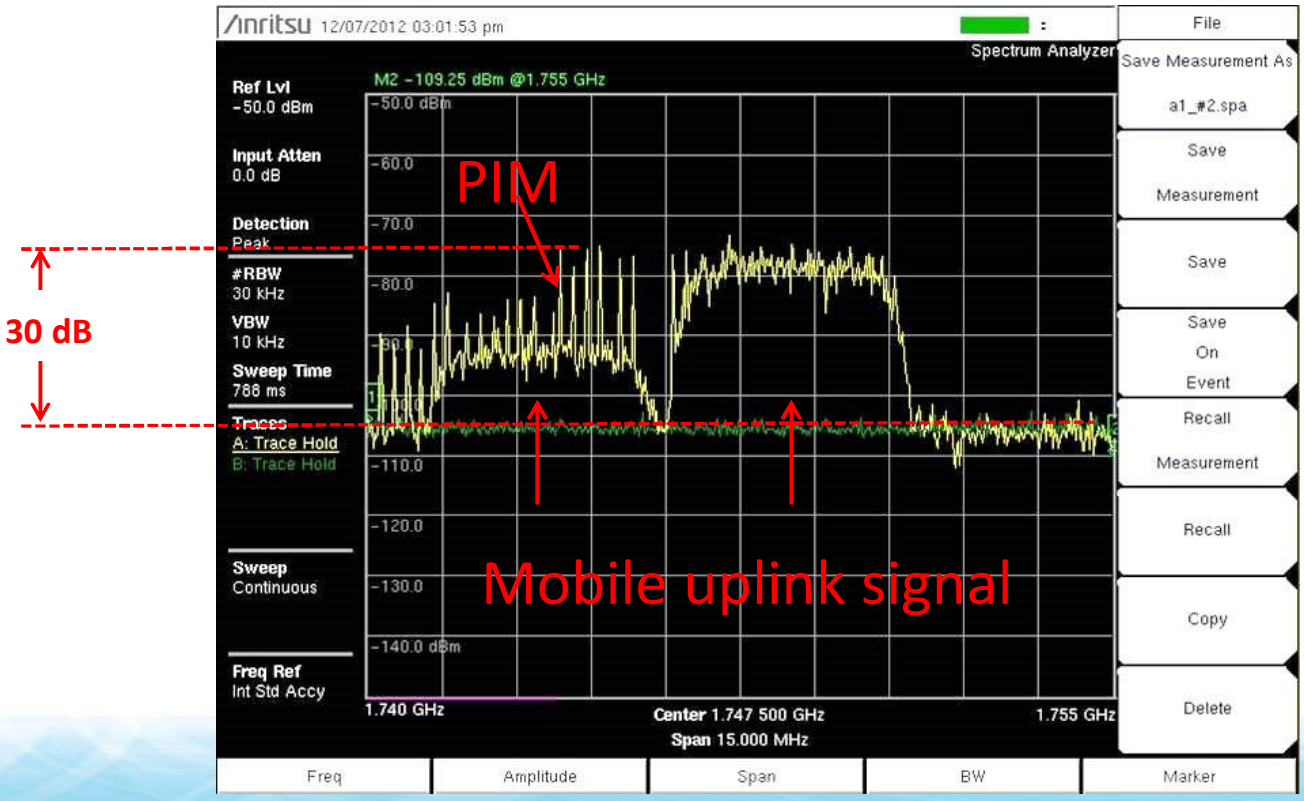


Antennas flush mounted to ceiling

PIM Sources

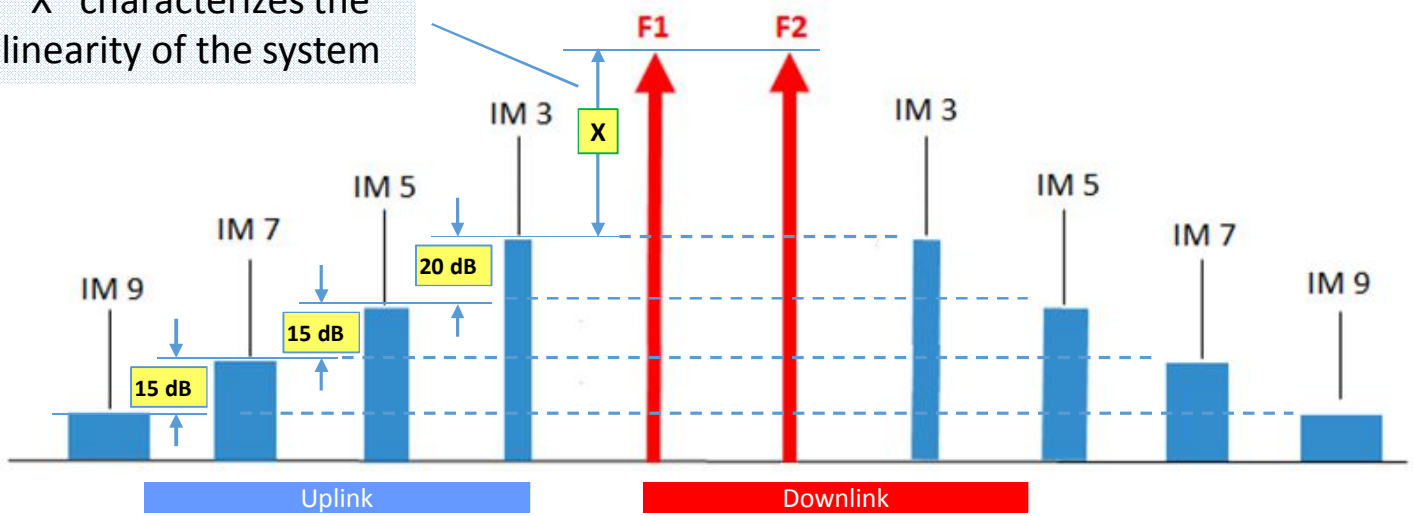
- Fire suppression pipes
- Aixternal r handling ductwork
- Metal hangers
- Lighting fixtures
- Ceiling tile frames
- Etc., etc., etc.

What does PIM look like at the site?



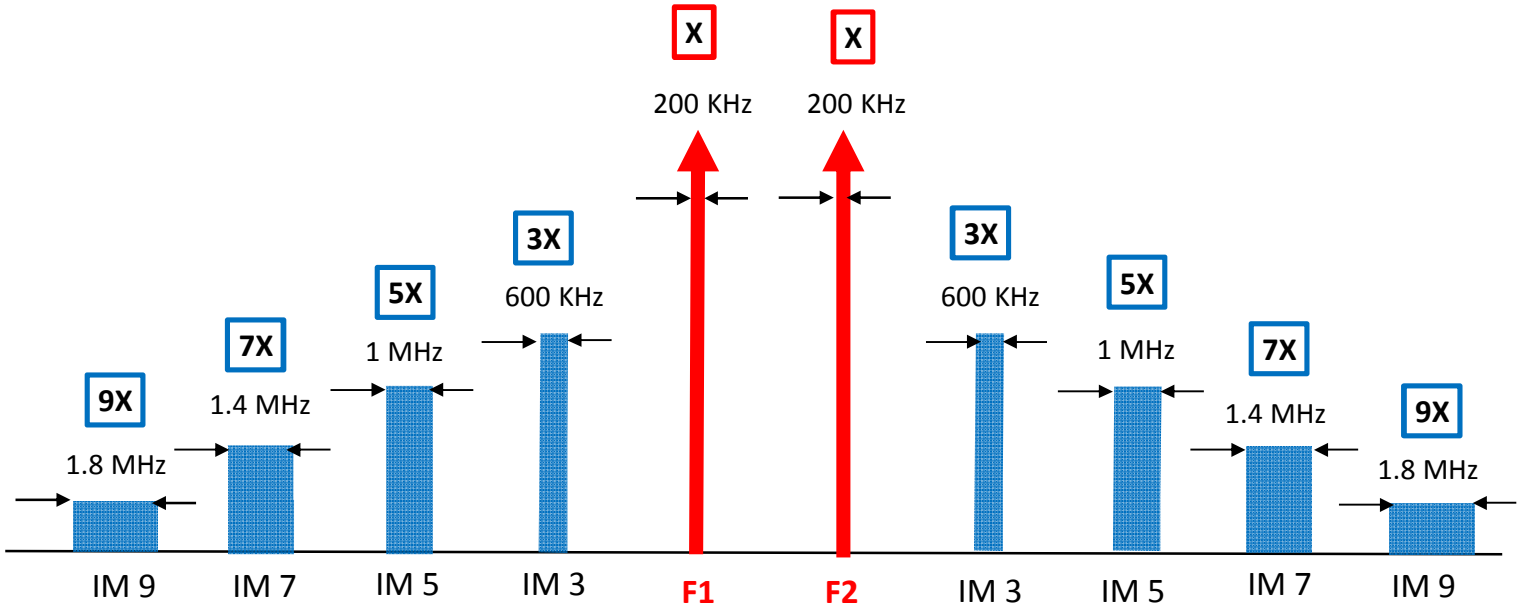
PIM magnitude

"X" characterizes the linearity of the system



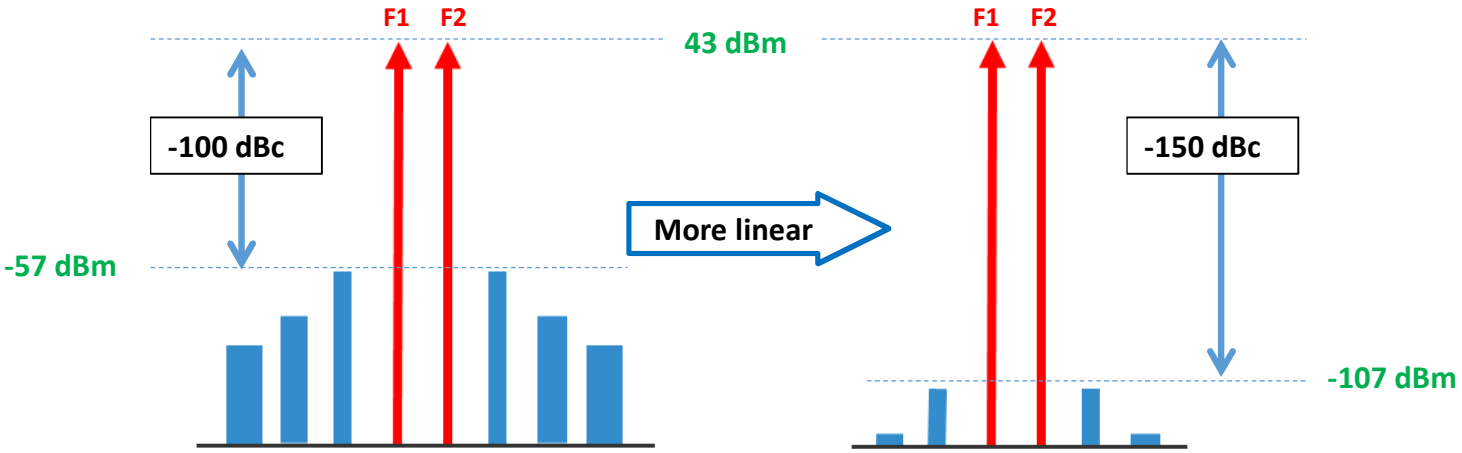
- Low order IM products (IM3 & IM5) are higher magnitude than high order products (IM7, IM9, etc)
- Higher magnitude = more likely to cause interference
- Does not mean IM7, IM9, etc. are never a problem… just less likely

PIM bandwidth



- PIM bandwidth increases as carrier bandwidth increases
- PIM bandwidth increase with PIM order

How can we eliminate PIM?



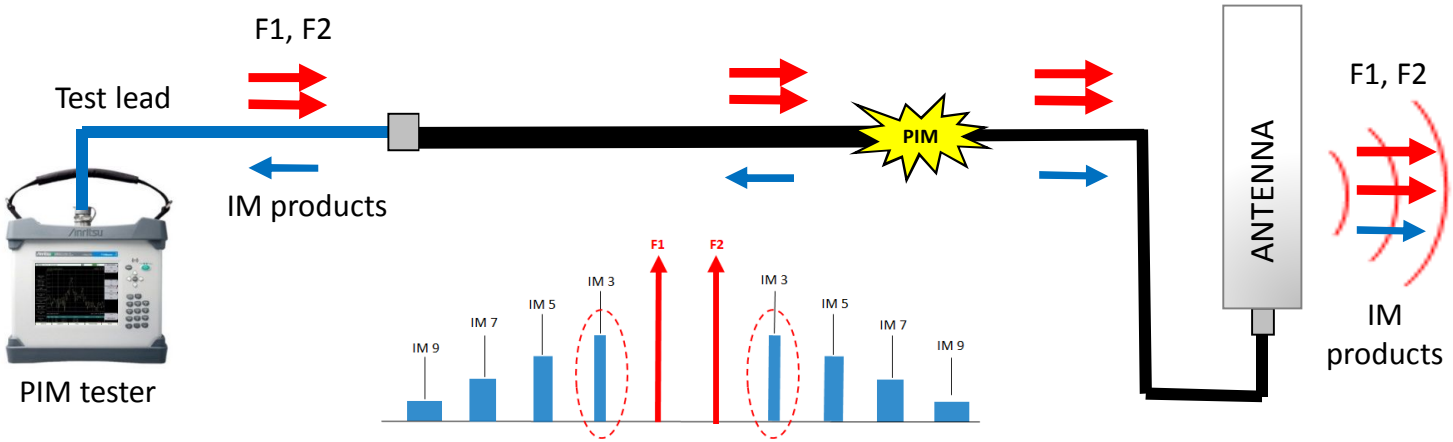
Improving linearity reduces PIM

- Loose RF connector
- Metal flakes in connectors
- Braided cables
- Antenna near PIM source

More linear

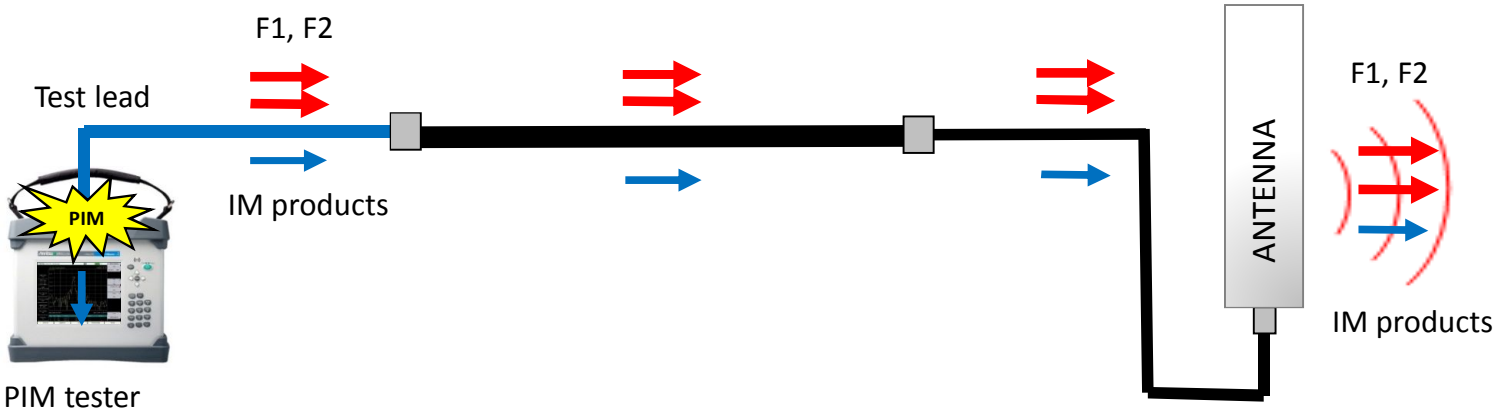
- Tight RF connector
- Connectors clean
- Corrugated cables
- Antenna re-located

How do we measure linearity?



- With a PIM tester!
- Inject two CW test signals at a known magnitude
- Measure 3rd order intermodulation product (IM3)
- IM3 “characterizes” the linearity of the system
  - If IM3 is low = linearity is good
  - If IM3 is high = linearity is poor

Your test equipment can generate PIM !

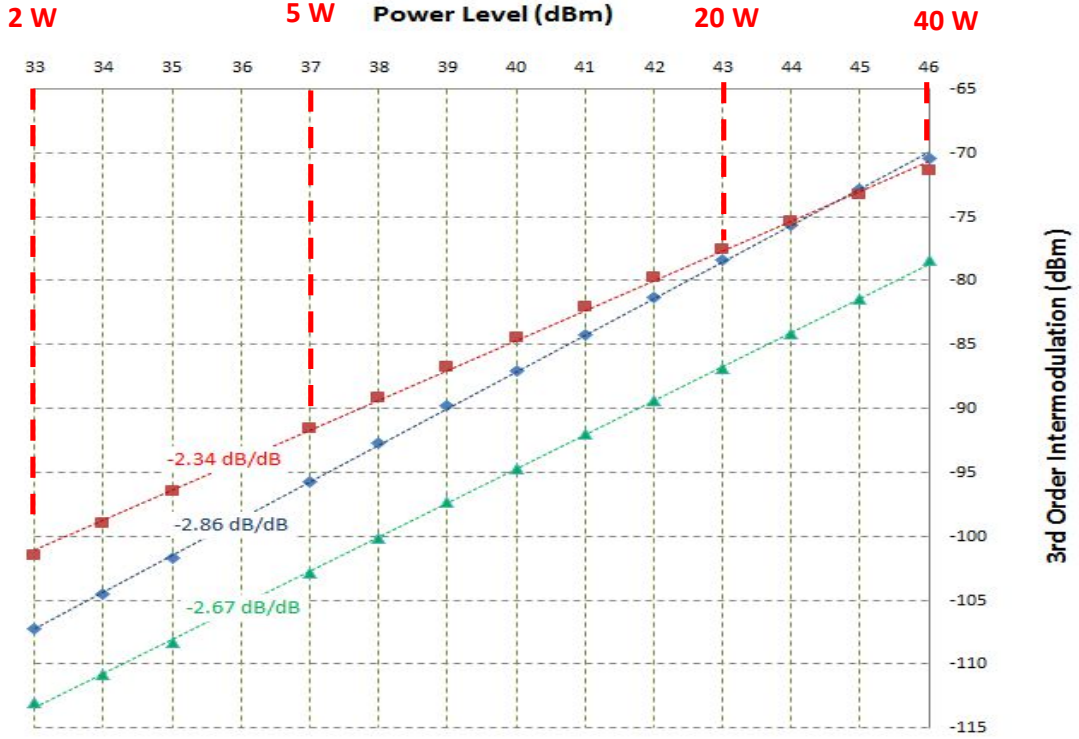


- Take good care of your equipment
- Verify PIM performance daily before use
- Test equipment PIM must be 10 dB lower than the system you will test

Example: Customer spec: <-140 dBc (<-97 dBm)

Test equipment: <-150 dBc (<-107 dBm)

PIM is power sensitive



- PIM level increases as power increases
- IM3 typically increases is 2.2 to 2.8 dB for each 1 dB increase in power
- Different PIM sources behave differently
- PIM vs. Power shown above for PIM standard, jumper cable & antenna

Anritsu PIM Master MW82119B

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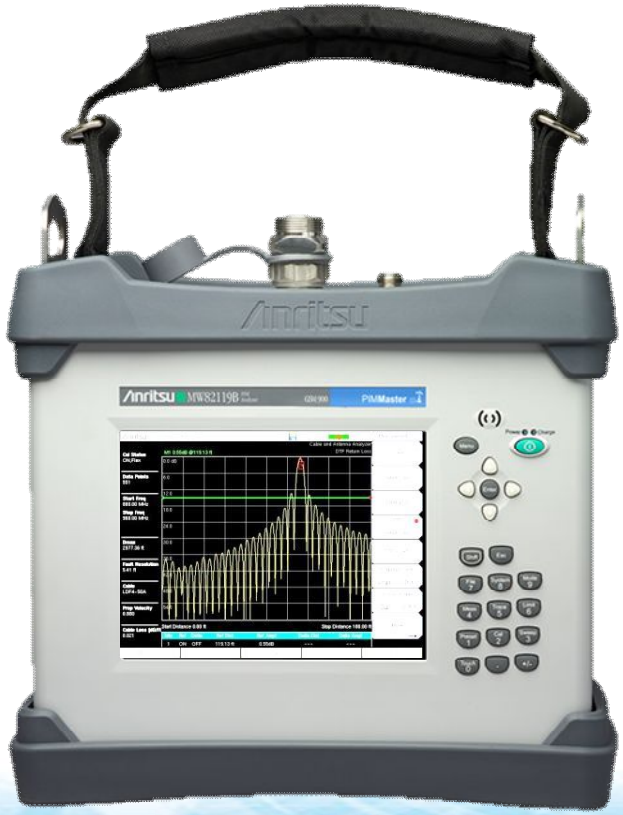
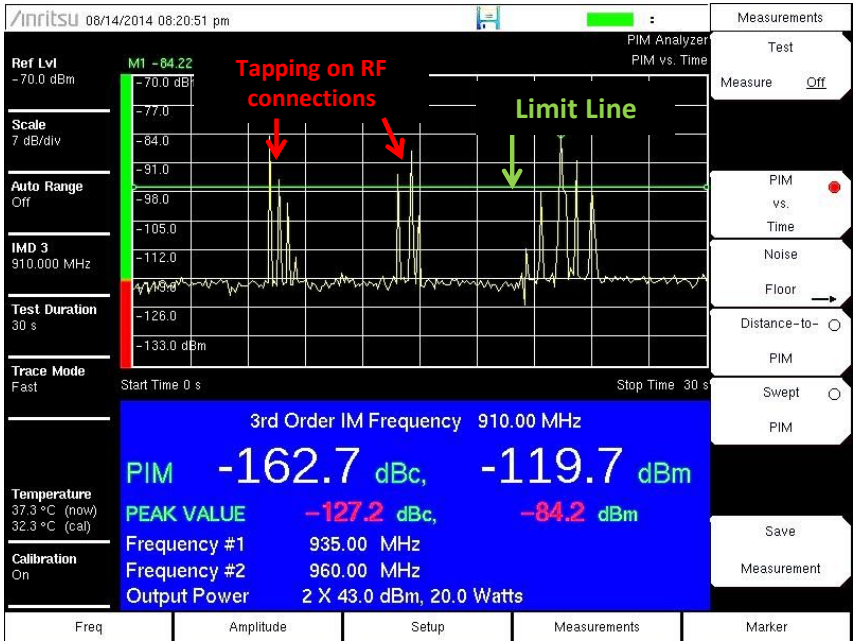


MW82119B – Wireless browser control

- Control PIM Master using web browser software on Wi-Fi enabled device (tablet, phone, laptop PC)
- Safari 6, Internet Explorer 10, Chrome 30, FireFox 23 (or later)
- Firmware v1.15 (or greater)
- ZyXEL MWR102 router (or equiv.)
- Range: >100m (328FT) line-of-site

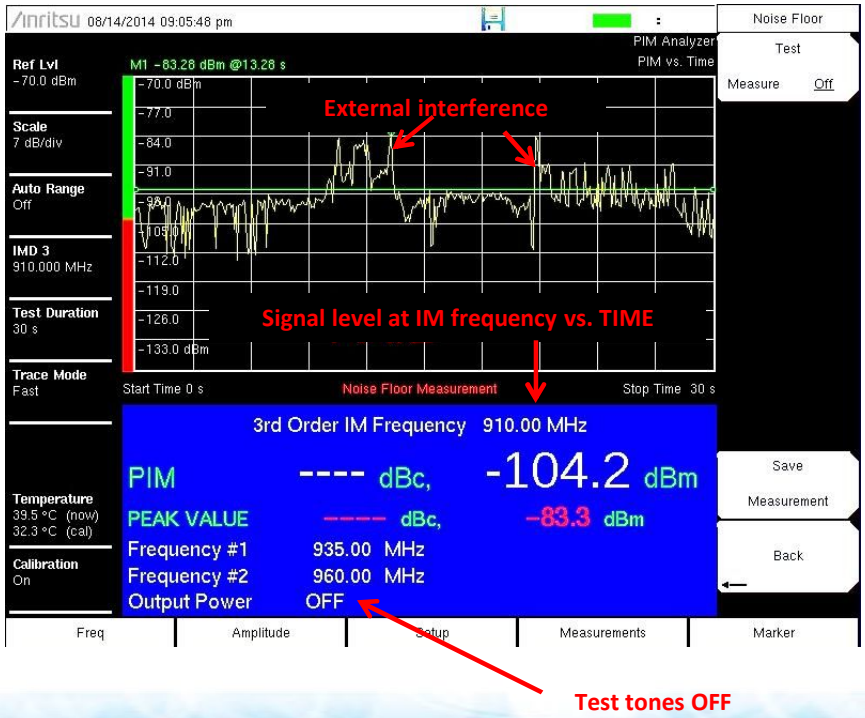
See Application Note 11410-00784 for step-by-step instructions

MW82119B – PIM vs. Time measurement



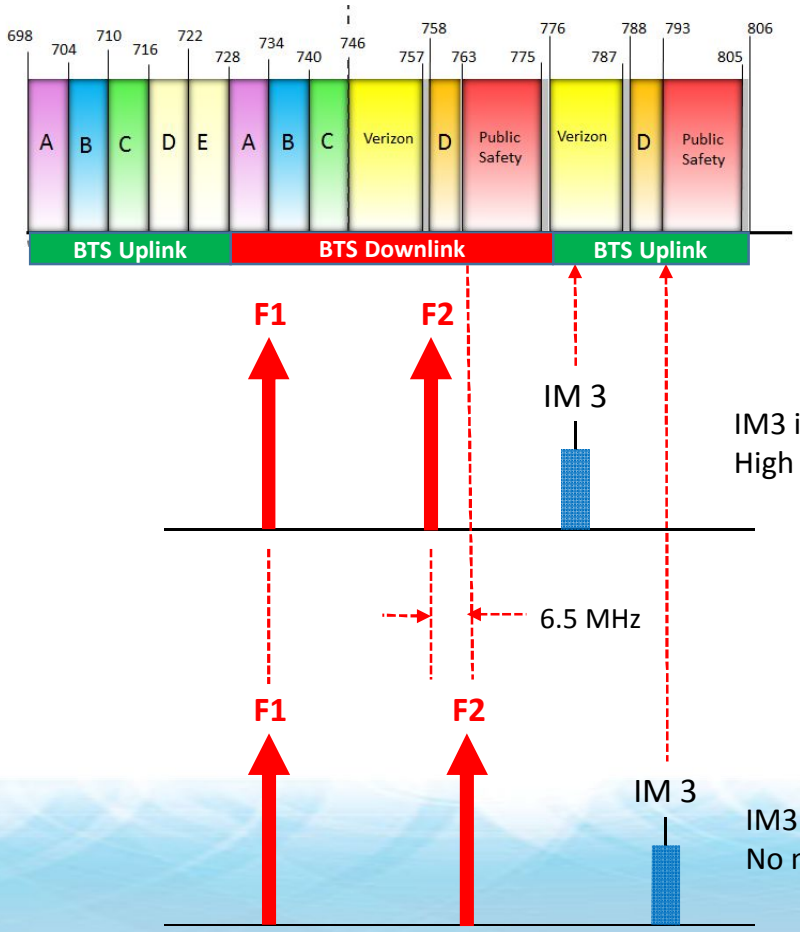
- F1 and F2 fixed
- PIM magnitude vs. time
- Visual indication of PIM stability
- Peak PIM held for Pass/Fail
- Used for dynamic PIM testing

MW82119B – Noise Floor measurement



- Measures IM frequency with transmitters turned OFF
- Verify no external interference
- If interference:
  - Turn off all cell phones
  - Change test frequencies

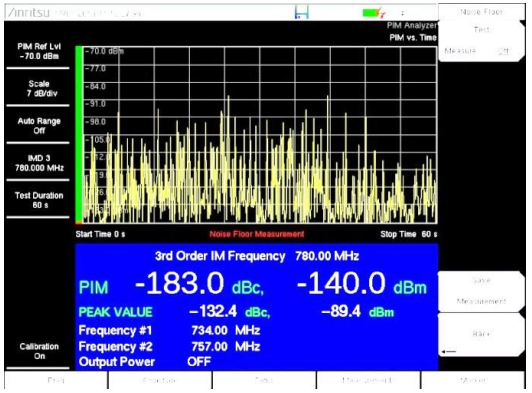
MW82119B– Noise Floor measurement

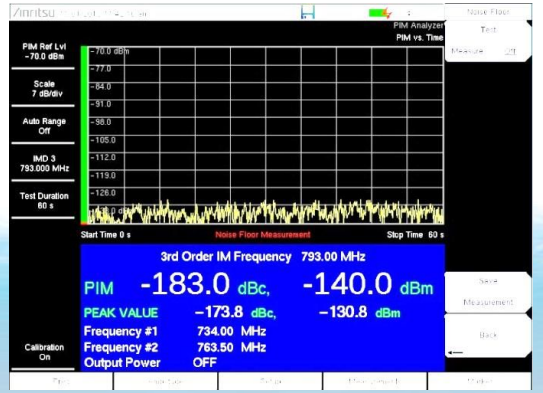


IM3 in uplink
High mobile traffic

IM3 in guard band
No mobile traffic

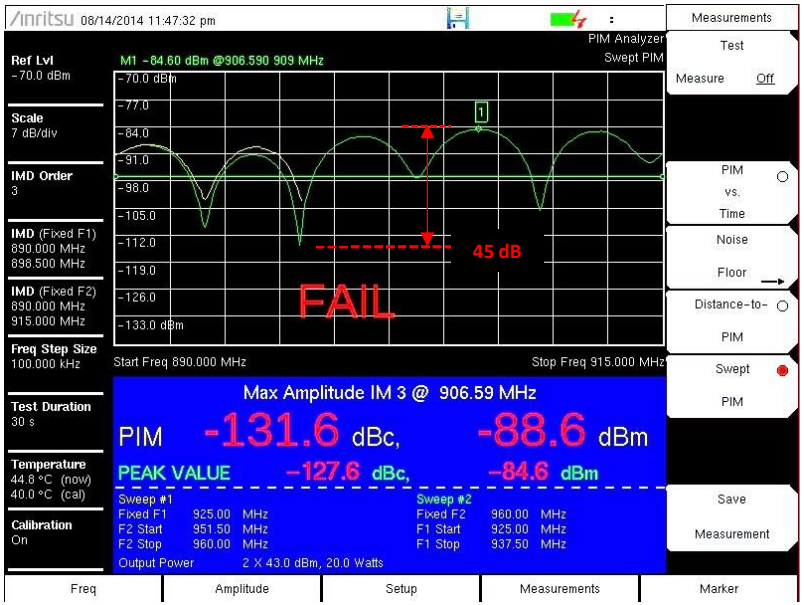
- F2 moved 6.5 MHz
- Noise reduced 60 dB





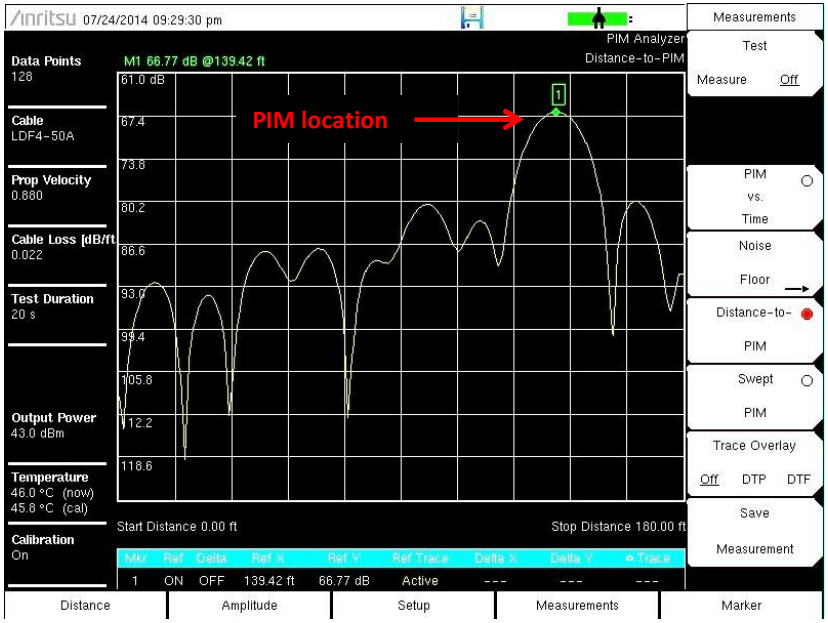
MW82119B – Swept PIM measurement

Multiple PIM signals on a line combining in and out of phase



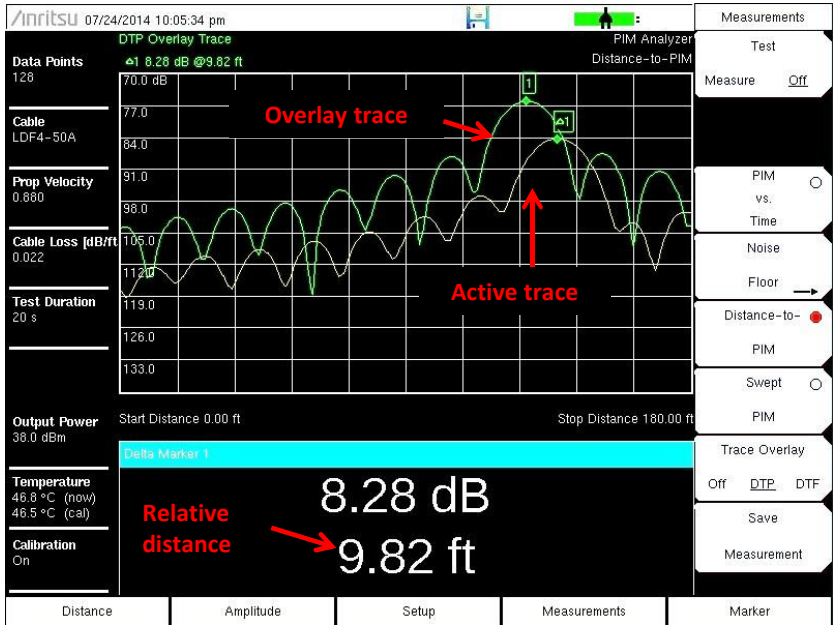
- F1 fixed, F2 swept
- F2 fixed, F1 swept
- PIM magnitude vs. frequency
- Shows worst case PIM level
- 30 dB variation due to phasing!

MW82119B – Distance-to-PIM™ (DTP) measurement



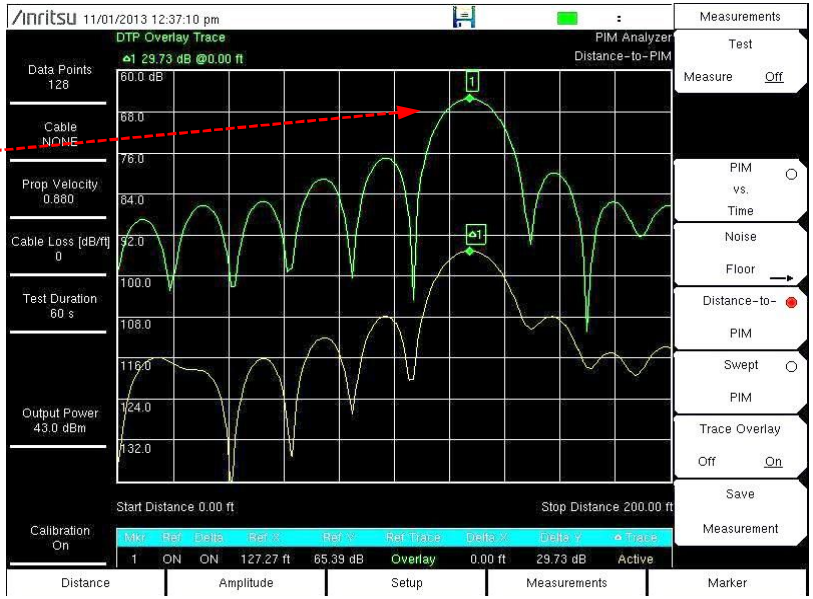
- F1 fixed, F2 swept
- PIM magnitude vs. distance
- The fastest way to locate PIM
- See PIM beyond the antenna
- 6 markers + marker table

MW82119B – DTP / DTP overlay



- Compare two DTP measurements
- Automatically displays distance between peaks
- Useful for:
  - Showing “before” & “after” results
  - Identifying PIM beyond the antenna
- Saving the measurement keeps both traces for reports

Using DTP / DTP Overlay

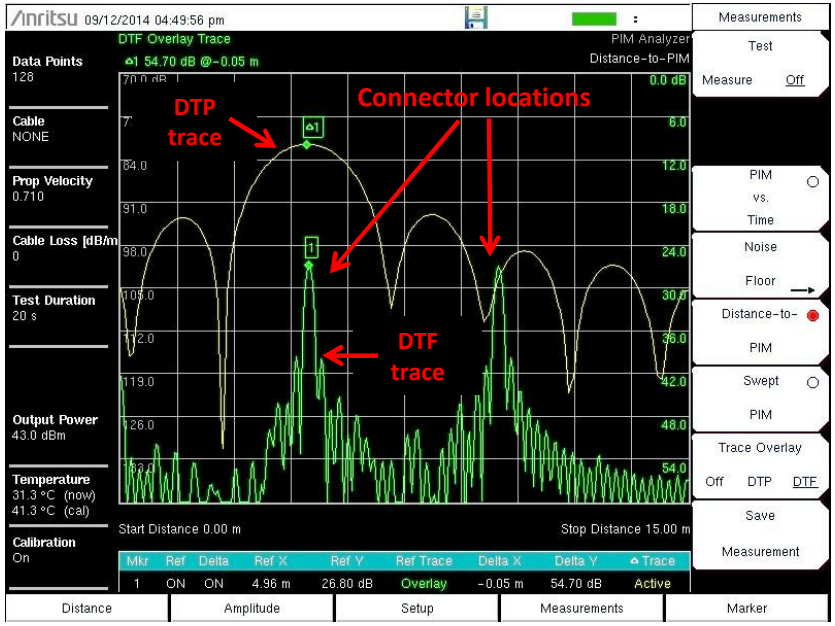


Steel wool as
“PIM marker”

- Green trace = DTP with steel wool on antenna radome
- Yellow trace = DTP with steel wool removed

- Both peaks occur at the same location (Δ distance = 0 ft)
- PIM source is at the antenna aperture
- The antenna is bad

MW82119B– DTP / DTF overlay



- Compare DTP to previously recorded DTF measurement
- PIM often occurs at RF connections
- DTF provides a “map” showing connector locations
- Use high resolution DTF to help identify PIM location.

Equipment verification / calibration

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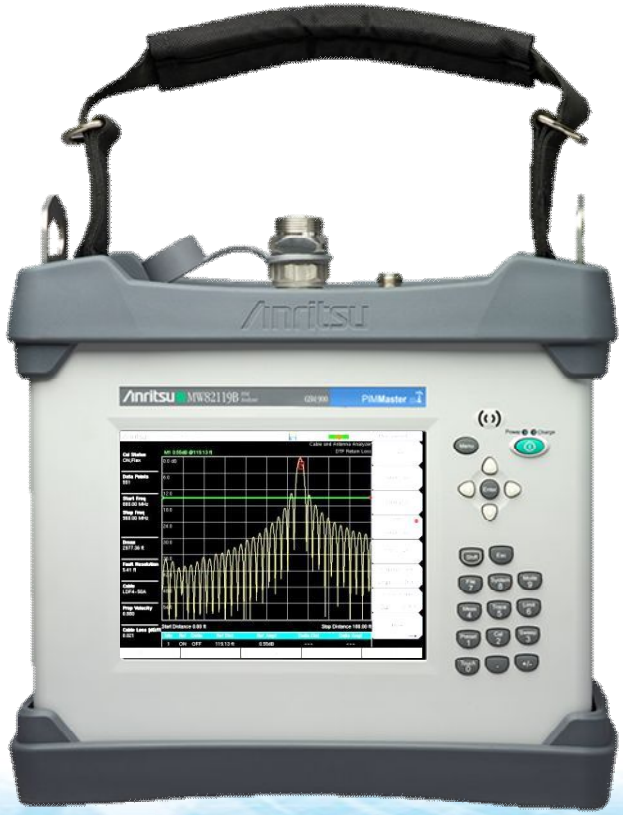
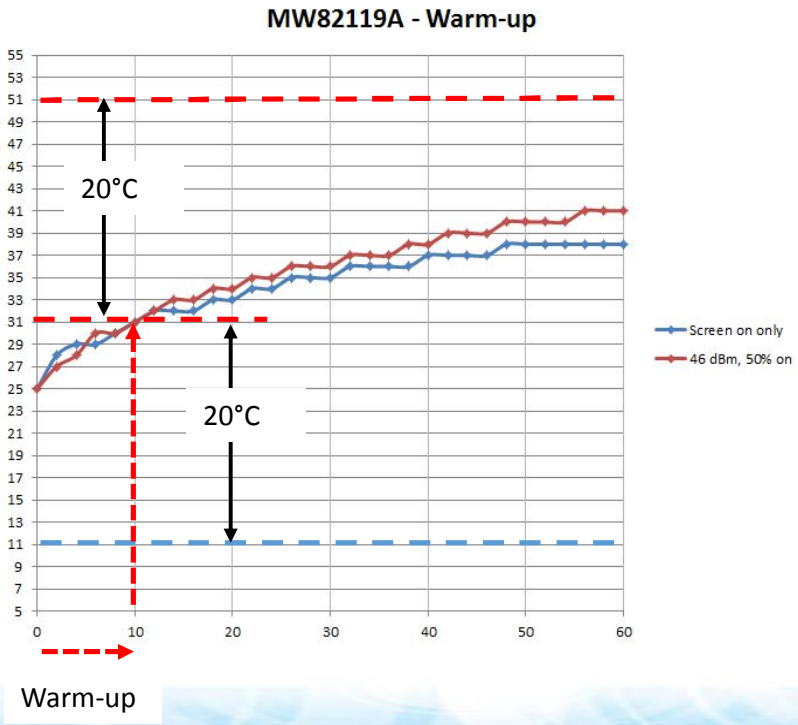
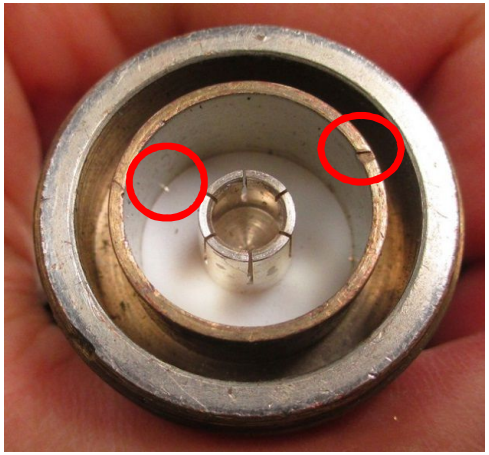


Step 1 – Turn on equipment to warm-up



- Turn on MW82119A
- Warm-up 10 minutes before calibration
- New calibration required after 20°C temp change

Step 2 – Clean & inspect test equipment



- Clean RF connectors with alcohol wipe
- Push wipe with non-metallic stick
- Remove all metal flakes inside connector
- Visually inspect connectors for damage

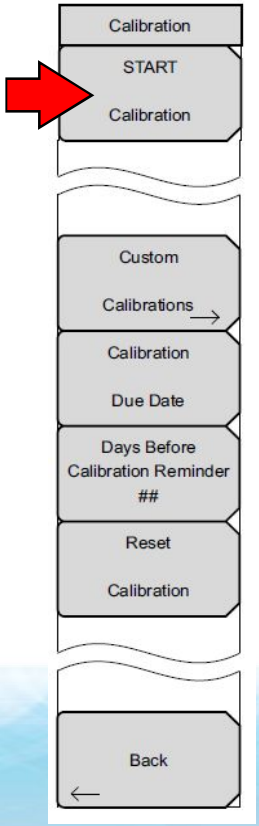
Step 3 – Verify test parameters

SHIFT <6>

- Previous test settings remain active until changed
- Set-up files can be saved / recalled to save time

Step 4a - Calibration

SHIFT
<2>



Step 1 screen instructions

Attention

TO CALIBRATE:

1. Connect a PIM standard to TEST PORT.

2. Connect a Low PIM Termination onto the PIM Standard.

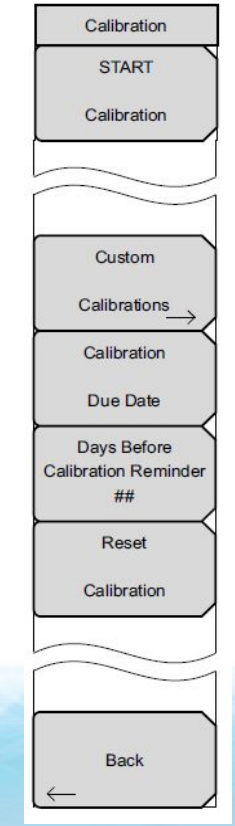
Note
Before calibration verify:
– Power Level
– Test Frequencies (F1, F2)
– IM Order
Changing these parameters may require re-calibration.

3. Press ENTER to Calibrate or ESCAPE to Exit.

- Either PIM standard (910 or 1775 MHz) can be used for calibration

Step 4b - Calibration

SHIFT
<2>



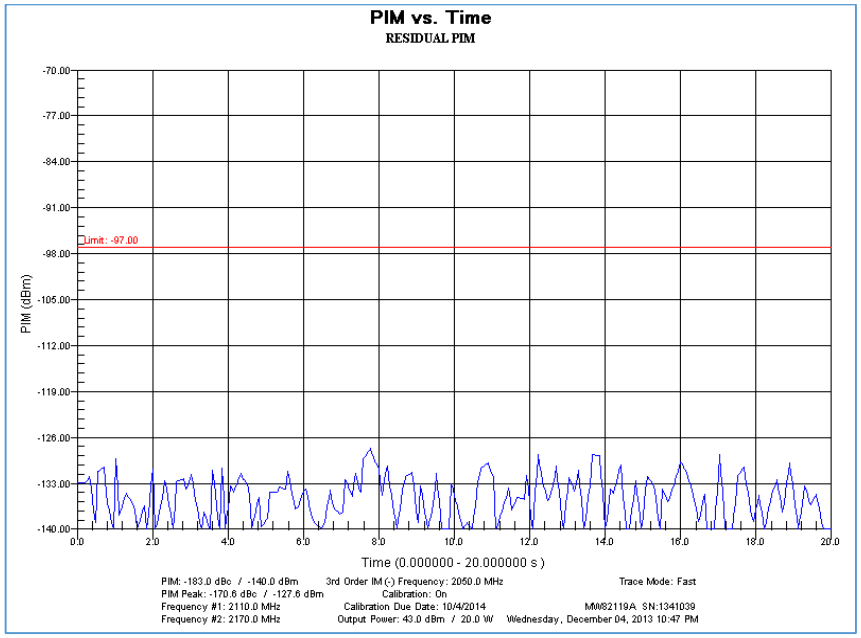
Step 2 screen instructions

Attention

1. Remove the PIM Standard and Low PIM Termination from the TEST PORT.
2. Re-connect ONLY the Low PIM Termination to the TEST PORT.
3. Press ENTER to Calibrate or ESCAPE to Exit.

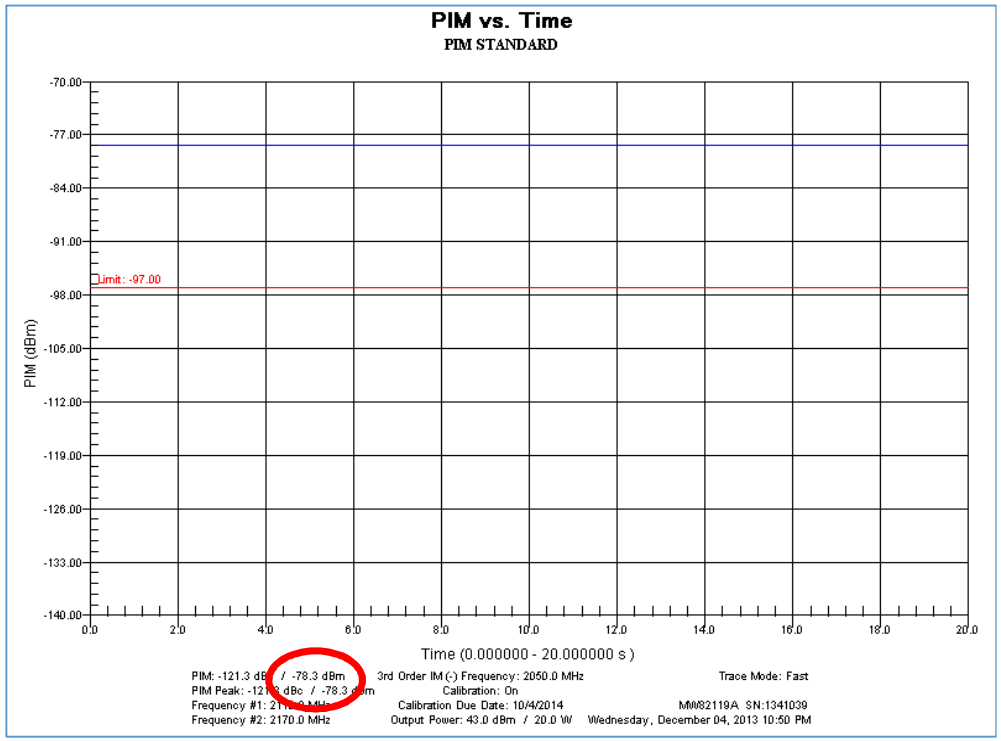
- This step must be low PIM
- No metal flakes in connector during calibration
- Connectors must be tight for this step

Step 5a – Residual PIM verification



- Measure PIM vs. TIME with low PIM termination attached to instrument
- Lightly tap termination with rubber end of wrench
- PIM must remain 10 dB lower than limit

Step 5b – PIM standard verification

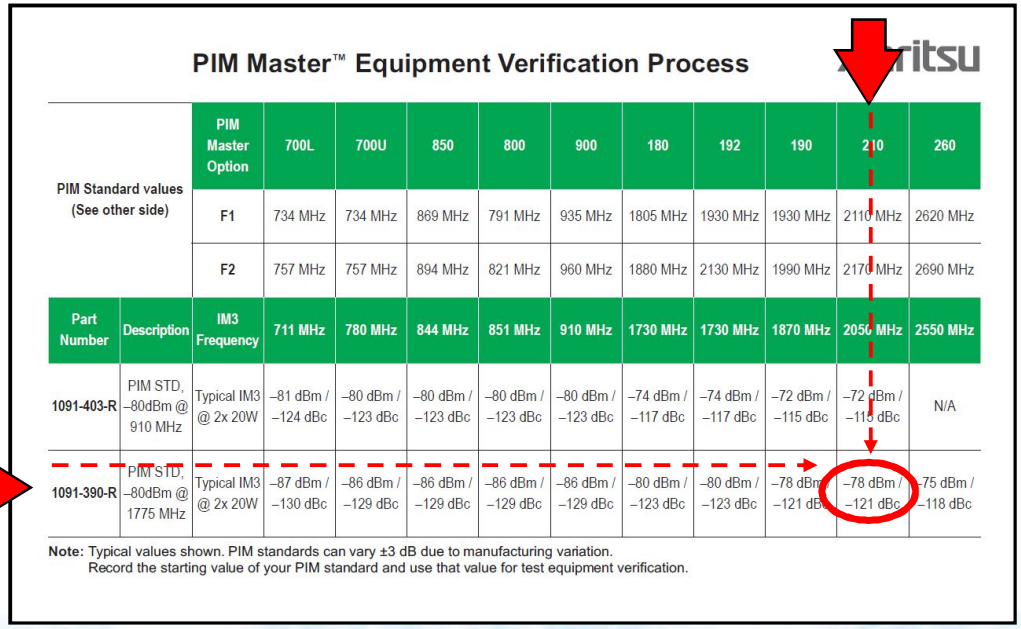


- Measure PIM standard
- Verify measurement = expected value ± 3 dB

Step 5b – PIM standard verification

PIM tester
you are using

PIM standard
you are using



PIM Master™ Equipment Verification Process

PIM Standard values (See other side)	PIM Master Option	700L	700U	850	800	900	180	192	190	210	260
	F1	734 MHz	734 MHz	869 MHz	791 MHz	935 MHz	1805 MHz	1930 MHz	1930 MHz	2110 MHz	2620 MHz
	F2	757 MHz	757 MHz	894 MHz	821 MHz	960 MHz	1880 MHz	2130 MHz	1990 MHz	2170 MHz	2690 MHz

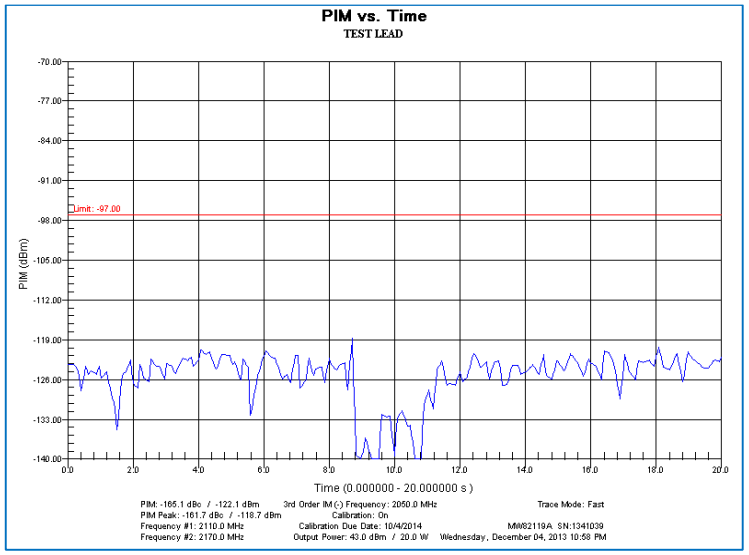
Part Number	Description	IM3 Frequency	711 MHz	780 MHz	844 MHz	851 MHz	910 MHz	1730 MHz	1730 MHz	1870 MHz	2050 MHz	2550 MHz
1091-403-R	PIM STD, –80dBm @ 910 MHz	Typical IM3 @ 2x 20W	–81 dBm / –124 dBc	–80 dBm / –123 dBc	–80 dBm / –123 dBc	–80 dBm / –123 dBc	–80 dBm / –123 dBc	–74 dBm / –117 dBc	–74 dBm / –117 dBc	–72 dBm / –115 dBc	–72 dBm / –115 dBc	N/A
1091-390-R	PIM STD, –80dBm @ 1775 MHz	Typical IM3 @ 2x 20W	–87 dBm / –130 dBc	–86 dBm / –129 dBc	–86 dBm / –129 dBc	–86 dBm / –129 dBc	–86 dBm / –129 dBc	–80 dBm / –123 dBc	–80 dBm / –123 dBc	–78 dBm / –121 dBc	–78 dBm / –121 dBc	–75 dBm / –118 dBc

Note: Typical values shown. PIM standards can vary ±3 dB due to manufacturing variation.
Record the starting value of your PIM standard and use that value for test equipment verification.

Expected value

Equipment verification card: 11410-00726 (download from Anritsu website)

Step 6 – Test lead verification



- You test lead will eventually wear out!
- Attach test lead to instrument
- Attach low PIM termination to other end
- Lightly flex cable at connectors
- PIM must remain 10 dB lower than limit
- Save results

Site test procedure

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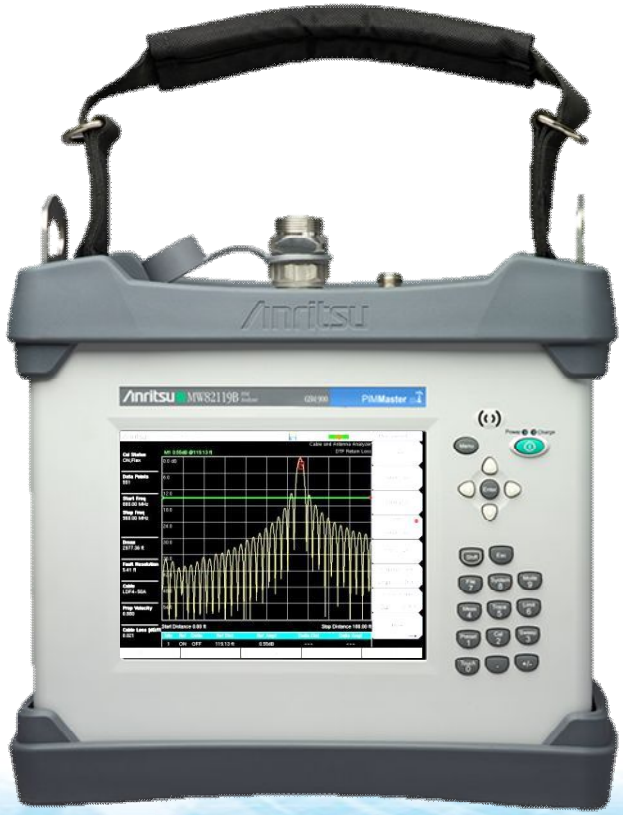

The recommended test process

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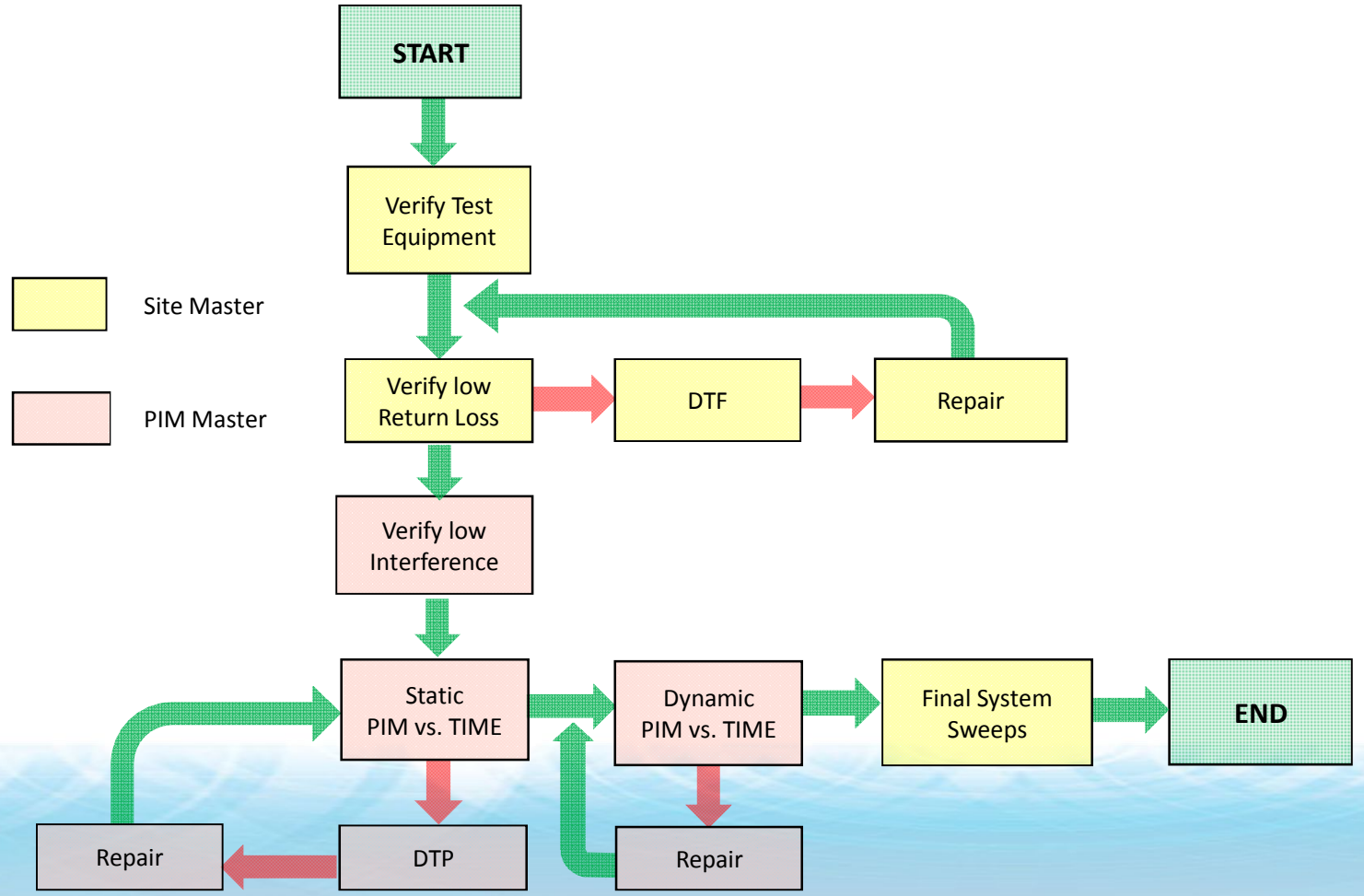

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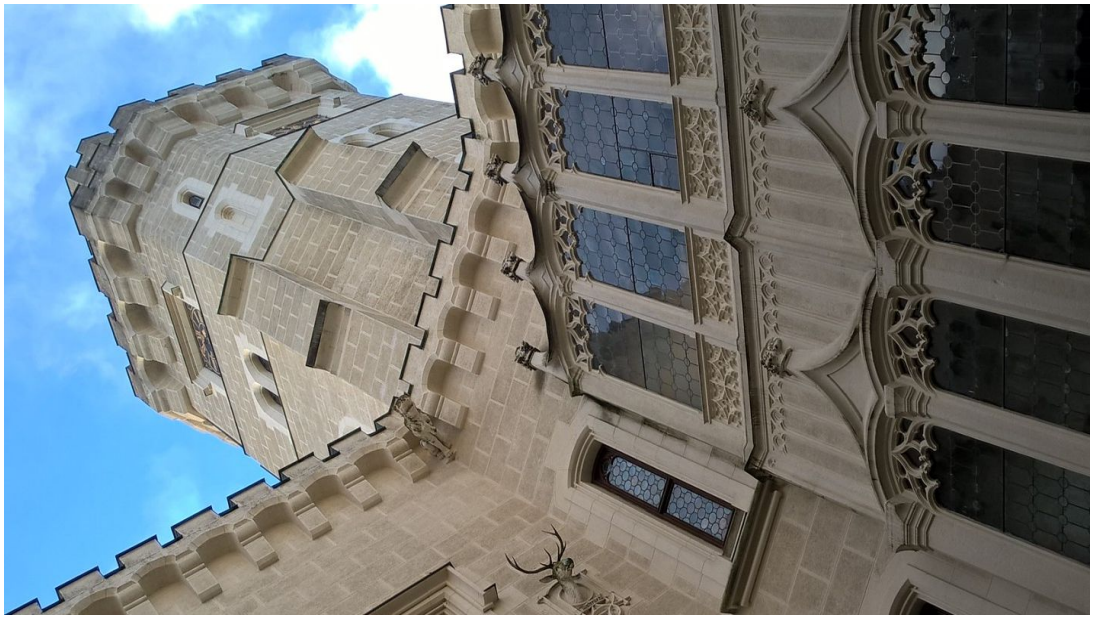

..\datasheets_presentations\Understanding-PIM.pdf

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