Proactively Dealing with PIM Interference

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BACKGROUND

Interference caused by passive intermodulation (PIM) has become a serious problem for network operators around the world. As more and more frequency bands are deployed at cell sites, operators will eventually create a condition where 3rd order intermodulation products (IM3) fall in one or more of their uplink bands. These 3rd order intermodulation products are strong enough to “deafen” uplink receivers, significantly reducing network performance.

So, what can operators do to eliminate PIM interference? The first option is to “do nothing” and live with the reduced network performance. The second option is to turn off or significantly reduce the power of the offending frequency bands generating the IM3 interference. Neither the first or second option may be practical due to growing coverage and capacity requirements. The third option is to “wage war” on PIM and remove as many PIM sources as possible in the RF path.

When choosing the third option, be prepared for change. The entire site build process needs to be re-evaluated starting with site selection. Antenna placement guidelines will need to be revised, materials used to build cell sites will need to change and attention to detail during installation will need to improve. This will take a coordinated effort across the entire organization to make the required changes (site acquisition, RF design, site construction, RF optimization). The pay-off will be more efficient use of available spectrum resulting in improved network performance. Sites will also be able to be put

on air more efficiently, reducing cost and reducing schedule over-runs.

This document is intended to help guide operators in their PIM mitigation journey. It breaks down PIM sources into two types, internal and external, and provides a list of controls that are needed to proactively prevent these sources from occurring in the field. Material separation guidelines are provided in wavelengths based on lab tests and on what has proven effective in the field. Operators are encouraged to translate these requirements into “feet” or “meters” in their construction standards based on the frequency bands deployed. (Operators deploying 600 MHz spectrum, for instance, may require different spacings than operators deploying 900 MHz as their lowest operating frequency band.)

A ”Y/N” column (Yes/No) is provided in each table that is intended to be used by operators for self-assessment. To truly be proactive in mitigating PIM interference, an action plan should be put in place to create guidelines / specifications to address all the “No’s”.

INTERNAL PIM MITIGATION REQUIREMENTS (PIM SOURCES INSIDE THE ANTENNA FEED SYSTEM)

Category	Y/N	Requirement	Suggested Specification / Comments
Product Specification		Require base station (BS) radio equipment to not self-generate unacceptable levels of Passive Intermodulation (PIM).	Currently, there is no specific BS PIM measurement in 3GPP standards (Ref TR 37.808). BS sensitivity measurements provide indirect verification of internal PIM performance.
Product Specification		Require all passive RF components in the RF path to be low PIM by design. Require manufacturers to 100% test RF products during production to certify low PIM performance.	IM3 <-150 dBc (-107 dBm) when tested in accordance with IEC 62037, 2x 20-Watt test tones.
		Antennas	
		RF cable system (Jumper cables, feed lines, adapters)	
		RF filters (Frequency combiners, bandpass filters)	
		Tower Mounted Amplifiers	
Installation		Require installers to properly handle RF equipment to prevent excess mechanical shock from the time the equipment leaves manufacturer's protective packaging to time of installation.	
Installation		Require installers to use calibrated torque wrenches during installation to make sure proper torque is applied to RF connections.	PIM can be generated with too little or too much torque. Reference manufacturer's specified torque requirements.
Installation		Require installers to clean RF connections to remove dirt / metallic debris prior to assembly and each time the RF connection is opened.	Use low lent wipe dipped in alcohol and non-metallic "push stick". Blow-out any excess alcohol prior to assembly.

EXTERNAL PIM MITIGATION REQUIREMENTS (PIM SOURCES BEYOND THE ANTENNA)

Category	Y/N	Requirement	Suggested Specification / Comments
Product specification		Require all equipment & associated mounting hardware installed near antennas (above, below, behind, beside) to be low PIM by design.	Any equipment installed within 3 wave lengths of the BS antenna, measured at the lowest operating frequency. IM3 <-143 dBc (-100 dBm) when tested in accordance with IEC 62037-8, 2x 20-Watt test tones, near field test, apply dynamic stimulus using fiberglass rod during test, test DUT using one set of mid-band (1800 to 2100 MHz) frequencies and one set of low band (600 to 900 MHz) frequencies.
		Remote Radios + supporting brackets	
		Microwave backhaul equipment + supporting brackets	
		Fiber / power distribution equipment + supporting brackets	
		RF components + supporting brackets (antennas, filters, combiners)	
		Cable support brackets (RF, power, fiber, RET)	
		Antenna mounting structures (tower, rooftop, stealth cylinders, etc.)	
		Stealth materials + supporting hardware (cylinders, panels, fake tree limbs)	
Installation		Have installers eliminate galvanic mis-matches and loose, metal-to-metal contacts near antenna (above, below, behind, beside) by removing, repairing or replacing the offending connections. (PIM Hygiene)	Perform PIM Hygiene in region within 3 wave lengths of the BS antenna, measured at the lowest operating frequency.
		Verify all bolted connections are tight.	Reference manufacturer's torque requirements.
		Insulate or mechanically isolate lightly touching metal brackets or frame members.	
		Remove all metal trash / metal debris	
		Remove unused metal brackets / supports	

EXTERNAL PIM MITIGATION REQUIREMENTS (PIM SOURCES BEYOND THE ANTENNA)

Category	Y/N	Requirement	Suggested Specification / Comments
Installation		Insulate or eliminate dissimilar metal connections	Eliminate instances where galvanized steel touches stainless steel. Aluminum touching galvanized steel is okay.
		Remove rust	Remove rust using metal brush. Wipe surface to remove metal dust. Coat with rust inhibiting paint / primer.
		Replace known "PIM prone" cable supports with low PIM alternatives	
Site Design		Eliminate antenna skew with respect to the antenna mounting frame.	Skew greatly increases radiated energy into adjacent antennas & the mounting frame / hardware.
Site Design		Provide adequate separation between adjacent antennas on the sector frame.	2 wavelengths minimum separation at the lowest operating frequency. Increasing separation reduces the amount of energy coupled into adjacent antennas & their mounting hardware.
Site Design		If multiple operators are co-located on the same tower, provide adequate vertical separation between each operator's equipment.	2 wavelengths minimum separation at the lowest operating frequency.
Site Design		Eliminate metal site equipment in front of antennas in the horizontal plane (+/- 90 degrees from antenna boresight).	• Adjacent antennas on the same sector • Microwave backhaul equipment • Remote Radios • Support frames / antennas from adjacent sectors
Product Specification		If RF safety signs / barriers are required to be installed in front of antennas, require that this equipment be low PIM by design.	IM3 <-143 dBc (-100 dBm) when tested in accordance with IEC 62037-8, 2x 20-Watt test tones, near field test, apply dynamic stimulus using fiberglass rod during test, test DUT using one set of mid-band (1800 to 2100 MHz) frequencies and one set of low band (600 to 900 MHz) frequencies.

EXTERNAL PIM MITIGATION REQUIREMENTS (PIM SOURCES BEYOND THE ANTENNA)

Category	Y/N	Requirement	Suggested Specification / Comments
Site Design		Site equipment installed behind antennas should be spaced a minimum distance away from the back of the antenna. (Do not install equipment on the antenna mounting pipe directly behind the antenna.)	2 wavelengths minimum separation at the lowest operating frequency.
Site Design		Limit / eliminate non-site equipment in front of antennas in the horizontal plane +/- 45 degrees from antenna boresight.	Avoid objects capable of producing PIM within 50 meters of the front of the antenna. • Power lines • Buildings • Adjacent towers • Rooftop equipment (HVAC units, Vents, cable trays, solar panels) • Other operator's antennas / equipment on rooftops
Site Design		Minimize antenna set-back on rooftop installations to limit the rooftop area illuminated by the site antennas.	PIM mitigation such as PIM Paint or PIM Tape may still be required. Reducing the distance antennas are set-back reduces the area requiring mitigation.

NOTE:

If non-site equipment / large antenna set-backs are unavoidable at candidate rooftop sites, an antenna of similar gain
/ beamwidth as the planned site antenna may be temporarily placed at the design location to evaluate PIM levels. During the evaluation, temporary mitigation (PIM blankets, PIM foil) can be deployed to identify the location and magnitude of external PIM sources requiring mitigation. "Distance-to-PIM" can be used to identify the location and magnitude of PIM sources off the sector (power lines, nearby buildings) that may not be able to be mitigated. Armed with this knowledge, operators can estimate PIM interference levels and decide whether or not to proceed with the candidate site / sector configuration.