

# Passive Intermodulation

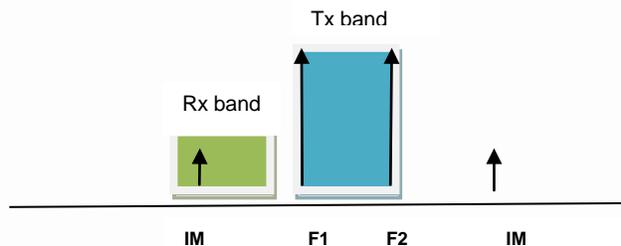
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## Introduction

There are many variables involved in the design and construction of a radio communications system. One in particular that becomes extremely difficult to troubleshoot is Passive Modulation (PIM). This application note will give you tips on what to look for when experiencing problems in your radio communications system.

Non-linearity in radio frequency assemblies can create intermodulation products known as Passive Intermodulation or PIM. Components in coaxial feeder assemblies such as connectors, jumper cables, splitters, hybrids, filters, DC blocks and antennas can cause PIM problems if they are not manufactured, assembled and/or maintained properly.

When the amplitude of the Intermodulation (IM) product is sufficiently large, particularly third order IM (IM3), it can degrade or overtake the desired received signal by the receiving equipment, see Figure 1. This type of interference can render the desired radio link to be completely unreliable. Although intermittent, intermodulation products are usually repeatable so long as all the component frequencies (F1 and F2) needed to produce IM are simultaneously present at the same point in time.



In a digital system a common consequence of Passive Intermodulation is a destructive increase in the bit error rate (BER). This will degrade the throughput of the link, rendering the data information or voice communications unusable.

Intermodulation products are the emissions at frequencies generated by the combination of two or more frequencies in a non-linear device. A non-linear device is one whose output signal is not directly proportional to its input signal. A simple example of such a device is a diode or an element that behaves like a diode. Non-linearity can be found, for example,

in antennas and feeds or in-building-DAS with poor or marginal PIM. Other sources, such as RF effects of ceiling grids, rusty rebar in concrete, and even rusty bolts in the building structure, can contribute to poor or marginal PIM. PIM signals are unwanted because they interfere with signals in the receive path. In reality, any linear component has a non-linear factor that can cause PIM distortion. For optimal operation of RF systems, PIM has to be kept at a very low level that has virtually no influence on the network operation. PIM distortion is often the result of flaws in component design and manufacturing processes, but it may also be caused by wear and tear of components due to mechanical constraints or environmental conditions. Ferromagnetic materials such as nickel or steel within the current path, especially at higher power levels, can contribute to higher PIM due to the hysteresis effect of these materials and the non-linear voltage to current ratio.

Examples include particles from machining operations or soldering splatters that touch current carrying surfaces, separation of current carrying contact zones through irregular contact surfaces, corrosion and insufficient contact pressure, and dissimilar metals at contact areas. Insufficient thickness of plated metal causing RF heating through the skin effect of RF, and bad solder joints are possible sources for PIM increase, see Figure 2.



Figure 2

Other factors that can aggravate PIM performance are of mechanical nature such as poor mechanical alignment, connections with too little or too much torque, and contaminated connections. Also, environmental factors such as wind induced vibrations that weaken or break down joints, temperature changes due to weather changes, and oxidation caused by dirt and moisture on materials can negatively impact PIM performance.

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All these possible sources for PIM degradation are shown to underline the need to ensure the equipment and structures that hold them are built properly and are subsequently well maintained.

Antenna elements, for example, should be inspected for signs of corrosion, see Figure 3. Where blemish of the surface metal is evident, replacement is recommended. Far field performance for antennas on a site should be measured every two to three years, and compared to gain and radiation pattern measurements recorded at installation. Any antenna showing substantial deviation should then be further examined to determine the cause.



**Figure 3**

New equipment should be installed in accordance with good engineering practice, in order to minimize the possibilities of the new equipment contributing to any interference problems. This is only a start; a maintenance plan must be implemented to prevent future deterioration of system performance.

As you can see, PIM is very difficult to track down and eliminate. Yet it is a very common cause of system problems. Your maintenance program should include the inspection and, when necessary, the repair of all the items mentioned in this Application Note.