MICROLAB/FXR PIM Application Note

PASSIVE INTERMODULATION (PIM)

The advent of wireless with its tightly grouped, high power, high frequency signals and the associated high sensitivity receivers has created many unanticipated PIM (Passive Intermodulation) problems. PIM is caused by improper design of the passive components that transport the high power wireless signal from the transmitter to the airwaves. PIM becomes a significant problem when this transmission line is shared by the receive signal, either directly or coupled in some way, since the PIM products can fall in the receive band and interfere with the receive performance.

This brief overview describes a few of the problems and solutions encountered by Microlab/FXR in its efforts to supply PIM-free wireless components.

What is PIM: PIM is the unwanted presence in a high-sensitivity receiver band of intermodulation components generated by two or more high power transmitter signals. It is of particular concern whenever:

Two or more transmitter channels share a common antenna.
Transmitter signal levels are high (e.g., over 100 watts).
Receiver sensitivity is high.
Transmitters and receivers are diplexed (e.g., share a common antenna)

System degradation will result if high levels of PIM are allowed into the receiver path. System performance can be improved by minimizing the generation of PIM in the transmitter path. PIM can be minimized through the use of certain materials and manufacturing processes, as discussed later in this paper.

All Components are Active: When PIM is considered, all so-called passive components are really active components with surprising complexity. Certain physical phenomenon can cause passive devices to become mixers and modulators and frequency multipliers. These effects, called Passive InterModulation or PIM, can become the limiting factor in overall system performance.

Why is PIM Becoming More Important? Firstly, the number of channels per antenna is rapidly increasing; second the average power per channel is also increasing; third the digital systems of today are more prone to PIM interference than the older analog systems. The peak to RMS ratio of digital systems is much higher, raising instantaneous power and higher PIM values. In addition, digital systems are more susceptible to signal interference, increasing the probability of dropped calls.

Surface Oxides: Corrosion of the surfaces of metal parts produces non-linear oxides which, in turn, are serious PIM offenders. Active metals such as aluminum must be avoided in the center conductor path. All metal parts must be properly plated, irridited or otherwise treated so as to prevent the formation of surface oxides. Finished surfaces must never be scratched or mishandled so as to expose the raw metal underneath. White cotton gloves must be worn while handling metal parts (or non-metal parts that might later come in contact with metal parts) to prevent body oils from adhering to the parts.

Metals in Contact: Loose metal-to-metal contact must be avoided, whether the contacting metals are the same or different materials. Non-linear oxides may develop at such points of contact, caused by rubbing or chafing or from arcing at high power. Parts should be firmly and completely soldered whenever possible. Where this is not possible, contacts of beryllium copper should be used to assure long-life positive contacts. Certain metal-to-metal combinations should be completely avoided because of galvanic incompatibility. Furthermore, unnecessary assembly and disassembly should be minimized.

Plating and Finishing: The finish of all metal parts must both be compatible with the underlying metals and one that does not of itself develop non-linear oxides. Silver and gold plating and aluminum irriditing are generally acceptable. Nickel plating or even nickel under-plating must be avoided.

Magnetic Non-Linear Effects: Certain ferromagnetic materials, such as steel and nickel, must be avoided whenever possible. The hysteresis associated with these permeable materials creates non-linearity and thus PIM. When it is necessary to utilize these materials, they must be carefully shielded from the high power transmitter path.

Configure for Lowest PIM: Sometimes a potential source of PIM must be utilized in a component in the transmitter path. For example, stainless steel hardware is commonly employed to hold stripline boards together. Special shielding must then be used to prevent high power transmitter signals from reaching the stainless steel hardware.

Frequency Spectrum: When a non-linear component is excited by two unmodulated transmitter signals of frequencies f and f+d (where d is the frequency difference of the two signals), the resultant signal contains all of the following frequencies:

$$f,\ f \pm d,\ f \pm 2d,\ f \pm 3d, \ldots$$

If the number of transmitter signals or channels is increased from two to twenty (typical in today's wireless transmitters), the number of sidebands increases exponentially. PIM becomes more likely to occur at vulnerable receiver frequencies as the number of transmitter channels is increased. These sidebands cannot be filtered. They must be minimized at their point of origin.

Amplitude of Sideband Signals: The amplitude of the PIM signals follows typically follows a square law relationship with regard to incident power level. A 10 dB increase in transmitter signal results in a 20 dB increase in PIM content. Thus, PIM becomes much more troublesome as the incident power level is increased. It is only a problem in the high power transmitter path and rarely if ever a problem in the low power receiver path.

Testing PIM: All recognized PIM test setups measure the sidebands generated when two signals with a specified power and frequency are applied to the device under test. Filters are required to prevent the high power signals from entering the highly selective receiver.

We hope this non-technical overview of PIM will be of assistance to you in your component planning and selection. Please contact us at sales@microlab.fxr.com if you wish to discuss PIM with our engineers.

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