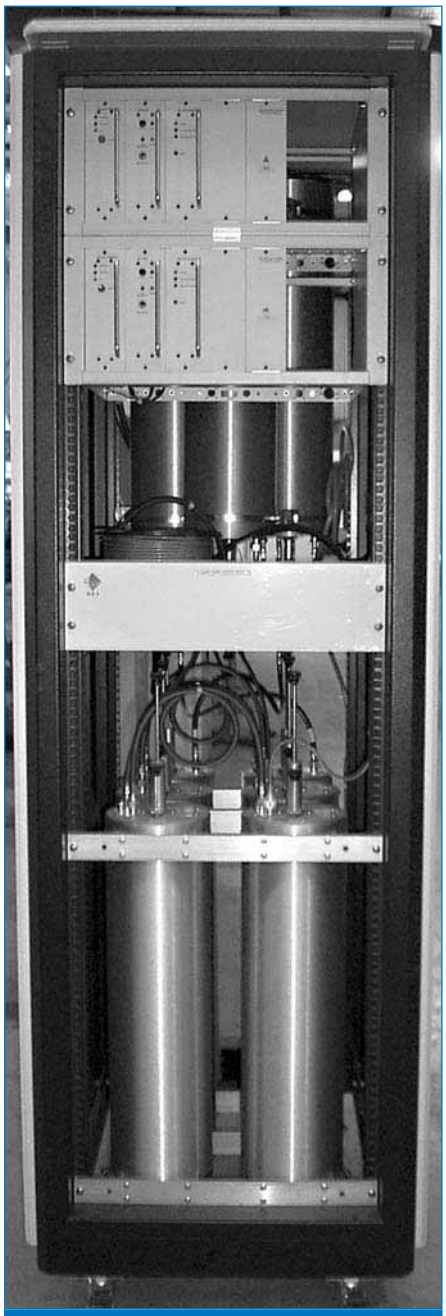
Passive Intermodulation (PIM) Information



RFI's VHF Test Bed

WHAT IS PIM?

Intermodulation, or intermod, as it is commonly abbreviated, is generated whenever multiple RF signals are present in a conductor of RF energy. Any non-linearities in the signal path, whether through an amplifier or an antenna system for example, will cause a mixing of the fundamental RF signal frequencies and the creation of new RF signals at different, mathematically related frequencies.

These new signals, or intermod products, can become a source of interference if not carefully controlled. This has been a topic of much discussion and there is a wealth of technically detailed literature available on the subject.

The intermodulation products of greatest concern are the so-called odd-order products, since these will exist at frequencies that are close to the original fundamental signal frequencies. The 3rd order and 5th order products have the potential to cause the greatest harm, since their signal level can be substantial, and their frequencies are most likely to fall within co-sited receiver frequency bands.

Passive intermodulation, or PIM as it is commonly referred to, is intermodulation that occurs in passive devices, such as antennas, tower structures, antenna clamps and the like. The signals are mixed by non-linear properties of junctions between dissimilar metals, or where corrosion exists. Poor mechanical junctions, the use of material that exhibits hysteresis, or contaminated surfaces or contacts within the RF path can also cause high PIM levels.

HOW IS PIM CONTROLLED?

Careful selection of materials, construction methods and the use of high performance cables and connectors, are all factors that need to be considered in the construction of antennas to ensure good PIM performance. As multi-user sites become more and more congested, excellent PIM performance is essential to ensure lower levels of interference and improved receiver performance.

We at RFI are very proud of our achievements in obtaining world-class PIM specifications on our range of high spec base station antennas. This has not happened by chance, but has involved many years of research, testing and re-evaluation of mechanical construction methods. The knowledge gained as a result has raised our awareness of PIM related issues to such an extent that it is now an embedded part of our design approach - a design approach that started with the development of some of the earliest PIM measurement facilities.

HOW IS IT MEASURED?

PIM specifications must always be referenced to the power level of the two fundamental RF signal sources, which for testing purposes will always be set to the same level. Therefore, a PIM specification of -150dBc (150dB below carrier) for example will indicate that the actual PIM level generated by the antenna is 150dB below the carrier input level of the RF signal sources.

PIM Information cont'd

The measurement of PIM in antennas requires sophisticated PIM test facilities, which are generally designed to measure the 3rd order PIM levels in the devices being tested. These test "beds" will comprise two or more separate RF signal sources, combining and filtering equipment, and amplifiers to boost the resultant antenna PIM level above the noise floor of the test and measurement equipment.

However, even the most fastidiously constructed test bed itself will generate intermodulation products, referred to as the residual IM. Typically, a good antenna may exhibit a PIM spec of -140dBc, which means that the residual test bed IM must be at least -150dBc for this to be able to be measured reliably. This level of residual IM can only be achieved by paying a great deal of attention to the design and layout of the test bed, and through the use of the highest quality combining equipment, cables and connectors.

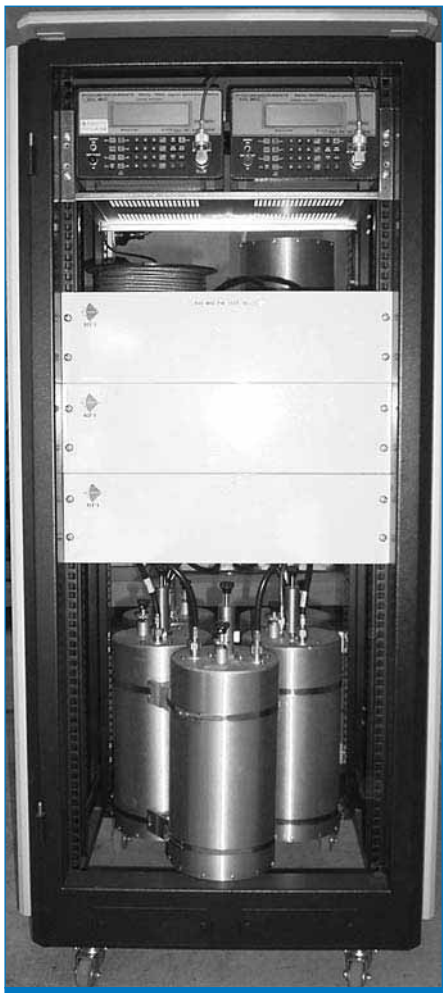
RFI'S PIM TEST BEDS

Four separate PIM test beds, covering VHF, UHF and 800 MHz test requirements, have been set up at our manufacturing facility in Melbourne. These test beds have the following specifications:

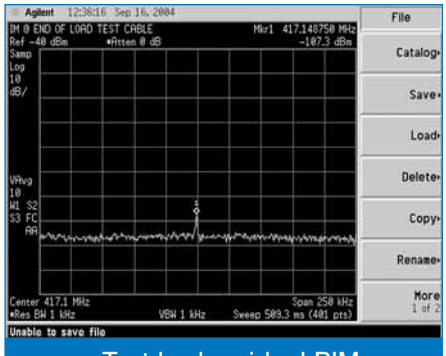
Test Bed	Frequency	Signal Sources	Residual IM
VHF	147-174 MHz	2 x 20W (+43dBm)	-160dBc
UHF	400-420 MHz	2 x 20W (+43dBm)	-161dBc
UHF	400-420 MHz	4 x 10W (+40dBm)	-161dBc
800 MHz	700- 1000 MHz	2 x 0.4W (+26dBm)	-160dBc

PIM measurements are made based on 3rd order products as these occur at higher, and therefore more easily measured, levels. The construction techniques which define the PIM performance of an antenna system component ensure that reducing the 3rd order PIM response has a like effect on all PIM outputs.

There are no true industry-defined power and performance levels for PIM, especially in the digital radio domain, but these are emerging. The power input levels chosen for our PIM test beds have been based on the anticipated typical power levels at the antenna and are therefore a close approximation to real site conditions.



RFI's 800MHz Test Bed



Test bed residual PIM