Welcome to AntennaSelect™ Volume 12 – July 2014

Welcome to Volume 12 of our newsletter, AntennaSelect™. Each month we will be giving you an "under the radome" look at antenna and RF technology. If there are subjects you would like to see covered, please let us know what you would like to see by emailing us at: info@micronetixx.com

In this issue:

- **Passive Intermodulation (PIM) – part 2 !**
- **How we build antennas to eliminate PIM**
- **Grounding LPFM antennas**

Passive Intermodulation (PIM) – part 2 !

MICRONETIXX COMMUNICATIONS

From last months article we had one reader pose a question about what happens when there is PIM generated from a wider bandwidth signal, i.e. an ATSC transmission. In the spectrum examples shown last month we used just a pair of un-modulated carriers to show the spectral distribution of those two signals. Since we were modeling FM stations in real life the PIM could be a few hundred kHz wide when factoring in the analog and digital signals. So lets look at what happens when PIM is generated from two ATSC or 8 VSB signals.

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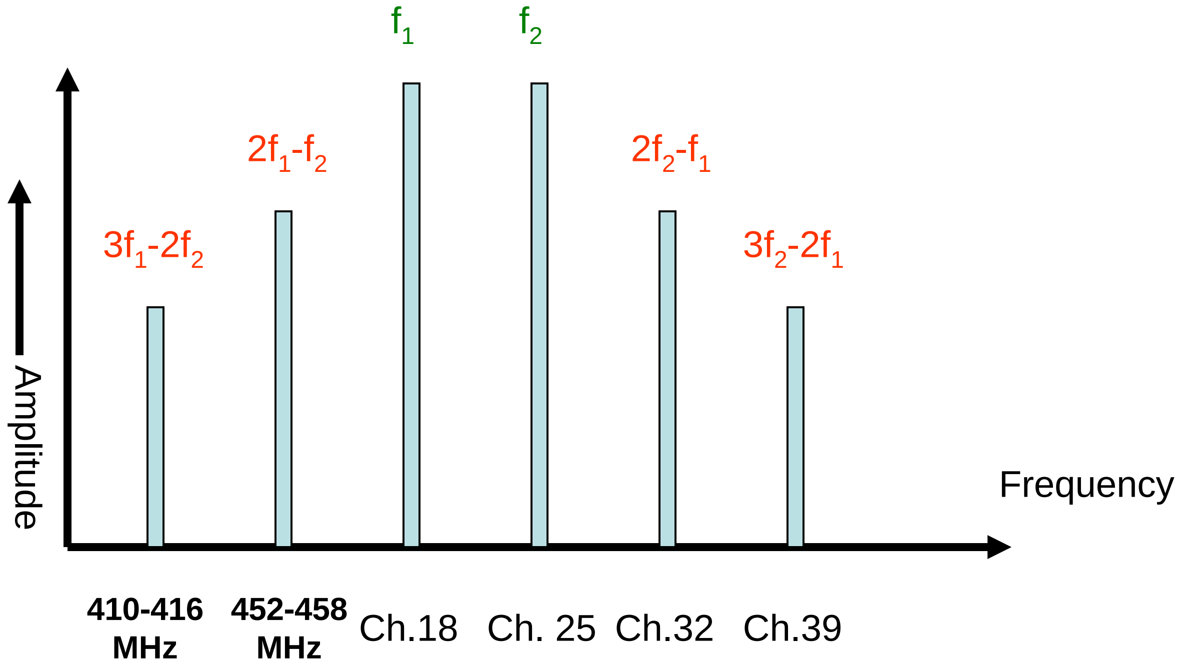

The above graph shows a channel 18 and 25 ATSC signals that face impairments. These signals are approximately 6 MHz wide and consist of 8 VSB carriers. The PIM products will have the same bandwidth as the desired signals. In addition to causing possible interference to two additional TV channels, the 452 to 458 MHz range will be under the lower third order intermodulation product. If there was an additional desired signal present, lets say channel 13 (210 to 216 MHz), the third order product of f_1 (channel 18) and that signal would be at 778 to 784 MHz. That could cause interference to a 6 MHz slice of the C block of the 700 MHz band.

The third order product of channel 13 and f_2 (channel 25) would end up at 862 to 868 MHz. That could interfere with the secondary U.S./Mexico public safety band that runs from 863.5 to 869 MHz. If the transmitting site is also used to receive 700 and 800 MHz band signals, they could be swamped by locally generated PIM products. Add a few more desired signals to the site an the number of PIM products will grow exponentially.

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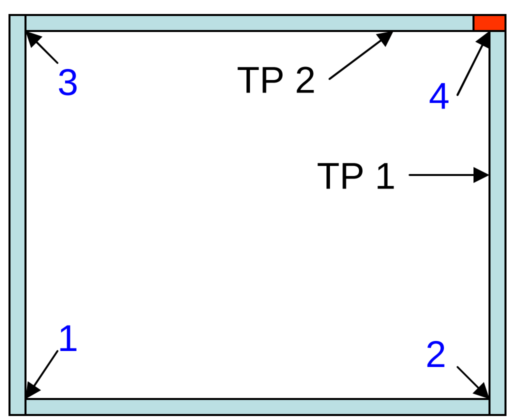
When a junction or connection exhibits a tight bond that allow the ratio of voltage to current to remain constant over a wide range of signals, intermodulation products are not produced. This is called a **constant V to I ratio.** A linear transfer of energy takes place at all energy levels.

Any corrosion, cracked or broken joints that causes a junction not to have a linear energy transfer can cause intermodulation products. Lets look at some causes below:

Corrosion and rusting of components and surfaces

This is a photo of a very badly corroded bury cup at the bottom of an antenna pylon. Any of the rusted bolts could produce PIM. Worse yet there may not be a good DC bond between parts, possibly making the transmission line a better ground when struck by lightning.

Four tower members bolted together



So how do we get intermodulation from what seems to be bonded together DC wise ? If we measure from TP 1 to TP 2 with an Ohmmeter, we get a short circuit. There is an excellent mechanical bond at points 1, 2, and 3. A rusty bolt is at point 4 and has caused the area to rust as well. Little electrical contact exists there.

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When the small structure we have drawn is excited by two RF electrical fields, the rusty bolt and corroded area act like a diode. The steel members have inductance and the ability to radiate the generated intermodulation products. In reality they are unintended transmitting antennas for RF signals that are not wanted.

Corroded surfaces can also act as PIM generators. In untreated steel, mill scale on the surface begins to oxidize. The mill scale is electro-chemically cathodic bonded to the steel and can act like a diode as it rusts. This problem is found when new unprotected steel is installed. Even painting the steel will not help as any water or moisture getting under the paint will start it to fail. After a period of time the layer of mill scale will break apart leaving a rusty surface on the underlying steel.

Aluminum when pitted or corroded has surface areas of material that is called Aluminum Oxide. With its crystal like structure, it is quite non-linear to the transfer of voltage when excited with RF fields. This non linearity of the Aluminum Oxide act like diodes.

Aluminum components held together by pop rivets can be a major source of PIM. The pop rivet can start to corrode and the surfaces around it will decay. Each of the pop rivets become diode like when it comes to the linear flow of RF energy through them. One consumer antenna manufacturer used solid steel peg rivets in their design to hold the elements in place. The rivets were treated with an anticorrosion process. When the rivets were stamped in place they were slightly deformed on the end. Over time they would rust and corrode the aluminum elements around them. Since the electrical bond at RF frequencies was going bad, the gain would drop and azimuth pattern of the antenna would begin to change. If there were strong out of band signals nearby, in band PIM products could be generated, which could desensitize the receiver connected to the antenna, or simply swamp out desired signals.

How we build antennas to eliminate PIM

The RF currents flowing around the surface of a slot antenna are extremely strong. All surfaces and elements of the antenna need to be fully bonded at RF frequencies and have a linear voltage to current transfer ratio. Not only does this bonding need to be in place when the antenna is first installed, it needs to be in place throughout the service life of the antenna.

All of the side mount antennas we build are aluminum and the entire antenna pylon is given a Class 1-A chromate treatment. This greatly cuts down on any corrosion over time. All aluminum piece parts are treated. Many of the parts are welded to the pylon. Parts that are not welded are fastened in place with high quality stainless steel fasteners.

The photo to the right show the top end of a cardioid pattern slot antenna. The radome stop is welded to the antenna pylon. On each side of the pylon the two wings form the cardioid azimuth pattern. They are fastened to the pylon by a number of stainless steel fasteners.

On the right side of the picture the top mounting tab can be seen. These tabs are welded in place and large stainless steel mounting brackets are then bolted in place. This is important because there are strong RF currents flowing at this point. All elements of the antenna are firmly bonded to ensure a linear V to I transfer ratio.

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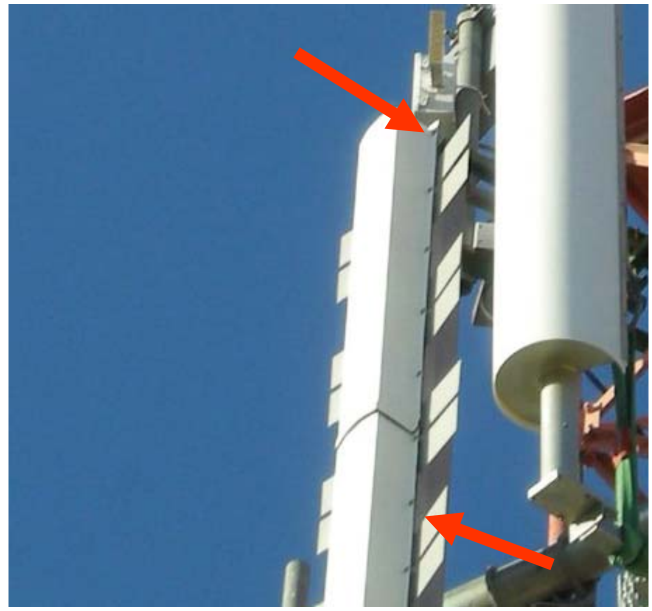
In the picture on the previous page the continuous wings we use to form the directional azimuth pattern form one long well bonded piece part. With the many points that it is fastened, the RF bond will remain excellent over the length of the antenna.

The photo to the right shows two antennas. The one to the left is a competitors, while the one to the right getting hoisted up is a **Micronetixx CS** series. Note the flimsy parasitic elements on the competitors antenna. They are only held in place with two screws. These .062” thin elements with a non anodized finish can become perfect PIM generators when they work loose, or start to corrode.



We have even seen some antenna models that use pop rivets to hold the elements in place. When these elements finally fail and fall off, the tuning of the antenna changes and the differential group delay across the channel can skyrocket. As elements fail, the azimuth pattern of the antenna changes as well.

A close up picture of one of our slot antennas. The parasitic elements are bolted to the pylon and them welded at each end. The mounting tabs are welded to the pylon and they attach to custom stainless steel mounting brackets. This ensures an excellent bond between the tower and antenna. With these extra steps we have taken there no chance for PIM generation from one of our antennas.

Grounding LPFM antennas

Many more LPFM operators are planning their station transmission systems. We are getting some questions as to how to effectively ground the antenna and transmission line to prevent damage from lightning. Preventing damage is the main goal of a good ground system – lightning is unpredictable and even the best engineered systems can be damaged. So what are some of the steps a new LPFM operator can do to lessen the chance that lightning will damage their facility ?

The first thing is selecting an FM antenna that has all it elements held at DC ground. Both of our LPFM antennas, the **FML series** and **FMP series** meet this criteria. All elements are stainless steel and are welded in place to the mounting bracket.

The second thing is coming up with a good grounding system for the antenna, antenna support system and transmission line. If you are moving into a existing multi user site, the tower is most likely well grounded and there are usually a number of grounding opportunities for your transmission line as it enters into the building. The key here is to keep the DC potential between the mounting structure as low as possible between the tower or mounting structure if lightning hits. A well grounded tower will have a much lower DC resistance than a run of ½ inch foam flex line, so grounding the line at multiple locations to the tower is the answer.

Let's look at the first case – a new LPFM antenna that is mounted on the side of a cell phone tower. The cell tower is about 160 feet (48.7 meters) high and the new LPFM antenna will be mounted at 98 feet (30 meters) above the ground. The new antenna will be installed on an outrigged pipe off the leg of the tower.

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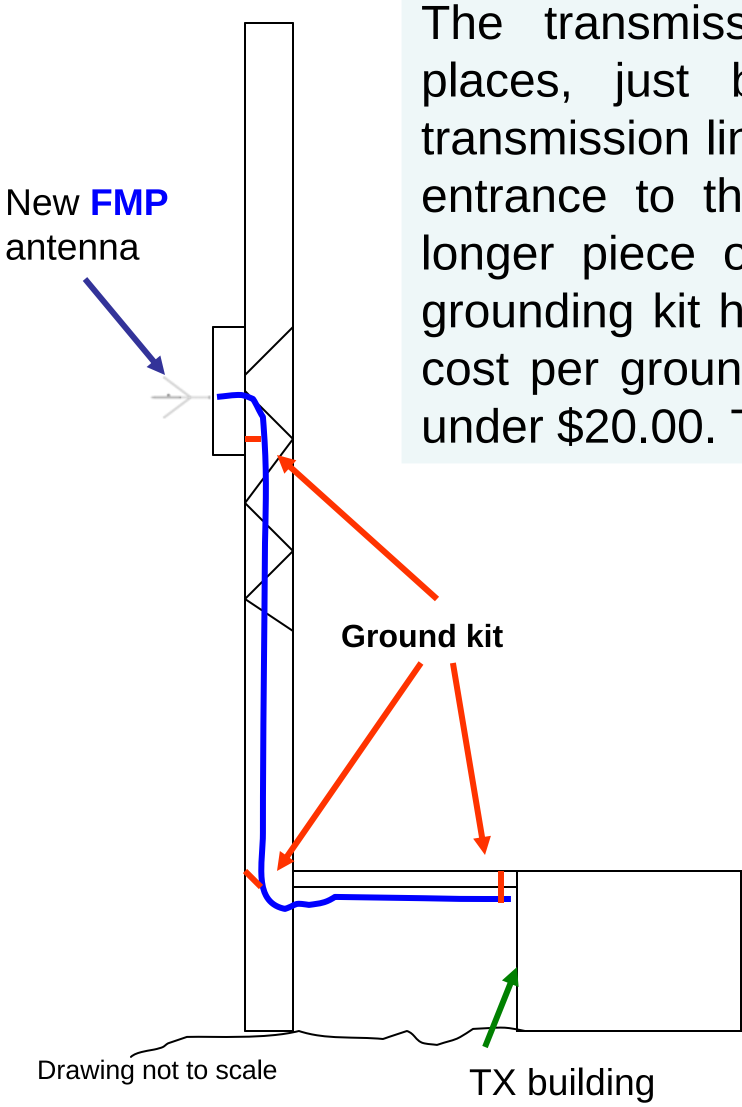
The transmission line is grounded in three places, just below the antenna, where the transmission line enters the ice bridge and at the entrance to the building. If you are running a longer piece of transmission line an additional grounding kit half way up is not a bad idea. The cost per ground kit for ½ inch LDF4-50A line is under $20.00. That is cheap insurance.



If the transmitter site is in very lightning prone area, you might want to also consider additional bonding of the outrigged pole system to the tower. The tower site manager and tower riggers can be a great source of information as to past tower operations.

Next let's look at several scenarios where your new LPFM antenna is going to be mounted at the top of a structure or support monopole. Antennas mounted at the top of these structures are more likely to get a direct strike of lightning. So good grounding techniques become even more important.

Once example of an LPFM tower top mounted antenna uses a 90 foot high Rohn 25 series tower and a top mounted 12 foot pole. The LPFM antenna is placed on the pole at the 98 foot level. The pole is held in place by a bolt that pushes it against the mounting stem. The pole should be electrically bonded to the tower with a ground strap. The transmission line should have a grounding kit installed at the top of the tower and at the bottom of the tower. Another grounding kit should be

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Installed where the transmission line enters the building. A licensed electrician can design and install an effective ground system for the tower, and transmitter building.

The antenna in this example is mounted 4 feet below the top of the support pole. Increasing the height of the pole another 5 feet or so will reduce the chance that if lightning struck, it would strike the pole and not the antenna. Also consider using a heavier wall pipe to support the antenna. If there is a lightning strike, the thicker wall pole would have a lower DC resistance. A set of lightning rods can also lessen the chance that the antenna would be hit directly.

Some tower crews and engineers swear by the use of static dissipation devices, claiming that they reduce the chance of the tower getting hit and the intensity of the strike. These stainless steel bristle like dissipation devices are mounted on the top of the support monopole and in some cases on the side of the tower near the top. Some are quite inexpensive, coming in less than $100. Two of the installers we work with in Florida use them on every project.

To sum up **good grounding** is the best insurance you have for protecting you station from damage. Consulting with a licensed electrician and tower installer to come up with an effective plan will save you money down the road and help keep you on the air.

Be on the lookout for the next volume of AntennaSelect™ coming out in August