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A Bird's Eye View

Receiver Intermodulation

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Here at Bird Site Optimization Services, searching for and resolving intermodulation problems is something we do on a regular basis. There is certainly enough of it out there to keep us, and probably a bunch of others busy for a long time.

First, before we get too deep into intermodulation or IM as we usually call it, I would like to point out that everything that goes bump, squeak or howl on your radio is not IM. Calling everything that interferes with your communications IM is like saying that every time someone sneezes they have pneumonia. There are lots of interference mechanisms out there.

In our training classes we generally say there are a few different kinds of IM and they are indentified by where they originate. One way of labeling IM is active vs. passive. Active IM is where the offending signals mix in an active device like a transmitter or receiver. The device has a power source and amplifiers and this type of IM generally has the highest amplitude. Passive IM on the other hand, occurs when signals mix in a passive device such as an antenna or connector or even within the antenna support structure. These IM products tend to have lower amplitude. However, they are all nasty and can sometimes be hard to locate.

In today's column I want to zero in on a particular type of active IM called receiver IM. Receiver IM occurs in the receiver or receiver multicoupler and normally occurs when strong signals drive one or more of the active stages, such as the first RF amplifier, into a non-linear operating region. Once the stage has become non-linear, signals can mix producing the various sum and difference products that we call intermodulation. If one of those products happens to fall on or near the receiver's operating frequency, destructive interference can occur which hampers the receiver's ability to receive the desired signals. Even if the mixing products do not fall within the receiver's pass band, there can still be negative effects such as desensitization. We don't usually call those things intermodulation however, they often share related mechanisms.

When investigating interference at a site we usually look at receiver intermodulation as a source of interference that affects the receiver in which the mixing occurs. Therefore we might not look closely at a receiver as a possible source of interference to another station at the site. We might ignore that little control station over in the corner or a receiver used as an RF modem for system monitoring. If we do suspect one of these devices as the source of our problem we might jump to the conclusion that the IM is occurring in the station's transmitter.
And, we might be wrong!

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Conventional wisdom tells us that RF flows from the antenna into the receiver not the other way around. This is not always the case. Here at the Bird Technologies Site Optimization Services group, we have investigated a number of interference problems where the source of the problem turned out to be IM occurring in a receiver that was otherwise totally unrelated to the problem. It was not part of the customer's system and the receiver's owner was not, to the best of our knowledge, complaining about any problems with his equipment.

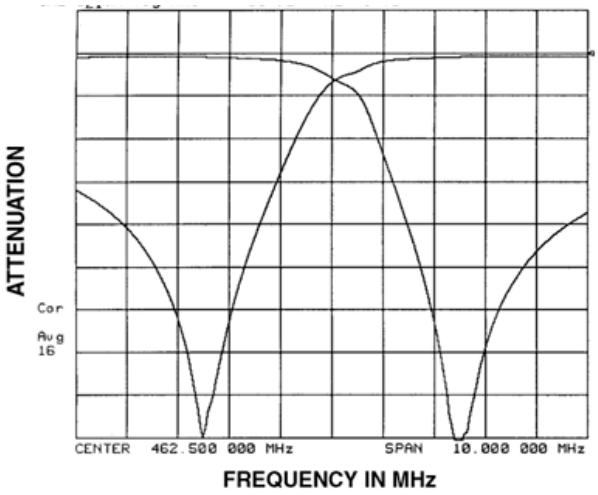
As an example let's look at a couple of projects we have worked on.

We were asked to assist in finding the source of some interference to a new UHF communications system. After some investigation we determined that there was an IM product occurring between two of the systems transmitters that was falling on one of the system receive frequencies. After determining that the IM was not occurring within the system's equipment we started looking for it on the roof of the building where the antennas were located. It didn't take too long to trace it to a specific antenna and then to follow the antenna to a little UHF repeater. It was a small unit from a major manufacturer made up of a couple of mobiles with a mobile type duplexer and the necessary control circuits. Now there is nothing wrong with these little repeaters in their proper environment, but a community antenna site with multiple high power transmitters is probably not the proper environment.

As I mentioned before, we naturally jumped to the conclusion that the IM was occurring in the repeaters transmitter as it was being radiated from the repeaters antenna to the UHF system's receive antenna at a rather strong level. We arranged with the owner of the unit to allow us to install some additional filtering in the form of an isolator and band pass cavity between the transmitter output and the duplexer input. We obtained the necessary components and installed them into the little repeater. When the two offending transmitters were keyed, the IM problem was still present. No improvement whatsoever! How could this be? Do we have the wrong mixing point? In order for us to remove our equipment we needed to disconnect the duplexer. When we removed the connection to the repeater's receiver, we received a call from the equipment room of the new UHF system. "We don't know what you did, but the problem just went away." What we did was disconnect the receiver. We told them to keep the offending transmitters keyed and reconnected the receiver. The IM returned. We repeated this test a few time until we were all convinced that the problem was definitely coming from the repeater's receiver.

Our new UHF system was operating in the 470-512 MHz part of the band and our little repeater was down in the 450 to 470 MHz band. We quickly reconfigured our filter and retuned the band pass cavity to the repeater's receive frequency. We installed it between the duplexer and the receiver. A quick check with the equipment room showed that the problem was solved.

What was happening is that the signals from the new UHF system were very strong into the little repeater's receiver. The receiver's input was being overloaded and creating a strong IM product that found its way back out to the antenna. The real culprit here was the mobile type duplexer in the little repeater.



The diagram shown here is the response curve of a reject only mobile duplexer from a major manufacturer. You can see that at two frequencies the duplexer has a high degree of attenuation. These are the repeater's transmit and receive frequencies. One notch protects the receiver from the transmitter's high power and the other removes transmitter noise that falls on the receiver's frequency. On all other frequencies there is little or no attenuation, so high level off frequency signals can easily find their way to the receiver.

This type of problem is not limited to lower tier equipment. On a more recent project we were looking for an IM product that we traced to a high end base station. In this case the station was simplex and had no additional RF protection in the form or a band pass cavity and isolator. The high level signals from our customer's equipment were mixing in the simplex station's receiver and then being reradiated back out the antenna. As soon as we disconnected the antenna to the simplex station, the problem was resolved.

We could cite several more examples however the lesson here is clear. Do not overlook the receivers on site when looking for IM mixing points. Also don't assume that because a station may be turned off and even unplugged from its AC or DC power source that it cannot produce IM. The transmitter output and receive input circuits can still provide a nonlinear environment in which to create IM and RF flows both ways on every transmission line.

That is a bird's eye view.