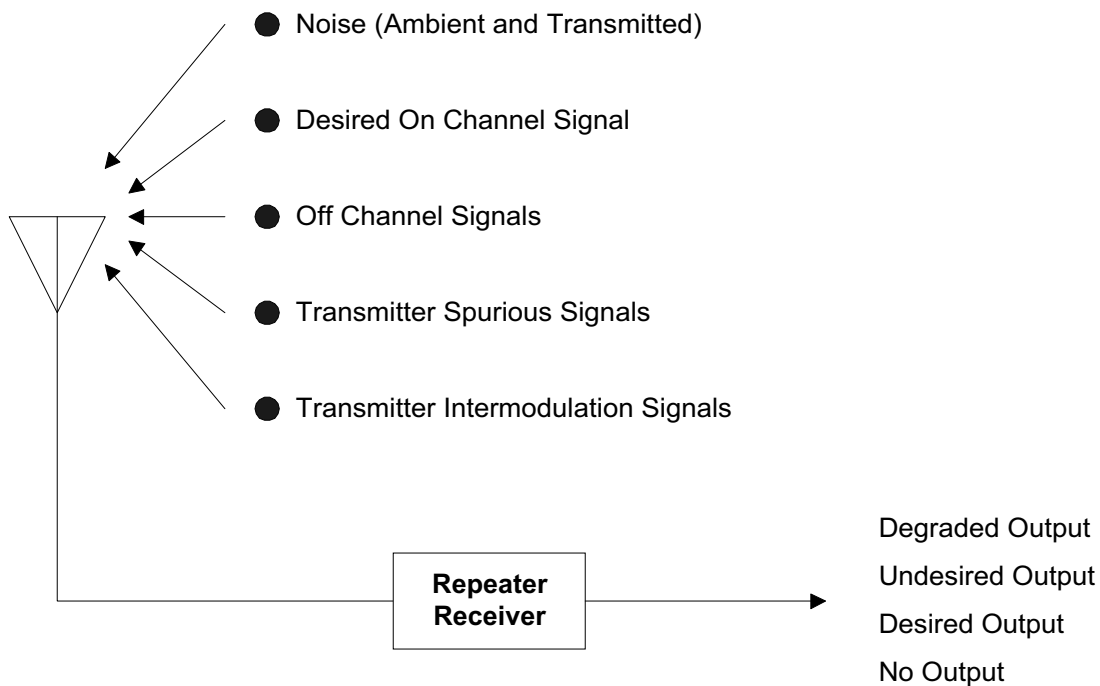


A Few Words About Intermodulation

Introduction To Intermodulation

It's a rough world out there. When you install your repeater system, you expect the receiver to receive the desired on-channel signal with excellent sensitivity and not have any trouble whatsoever with undesired signals. However, you may discover your receiver having a degraded output, an undesired output, or no signal output. Illustrated below are some of the types of signal and/or noise inputs your receiver is subjected to.

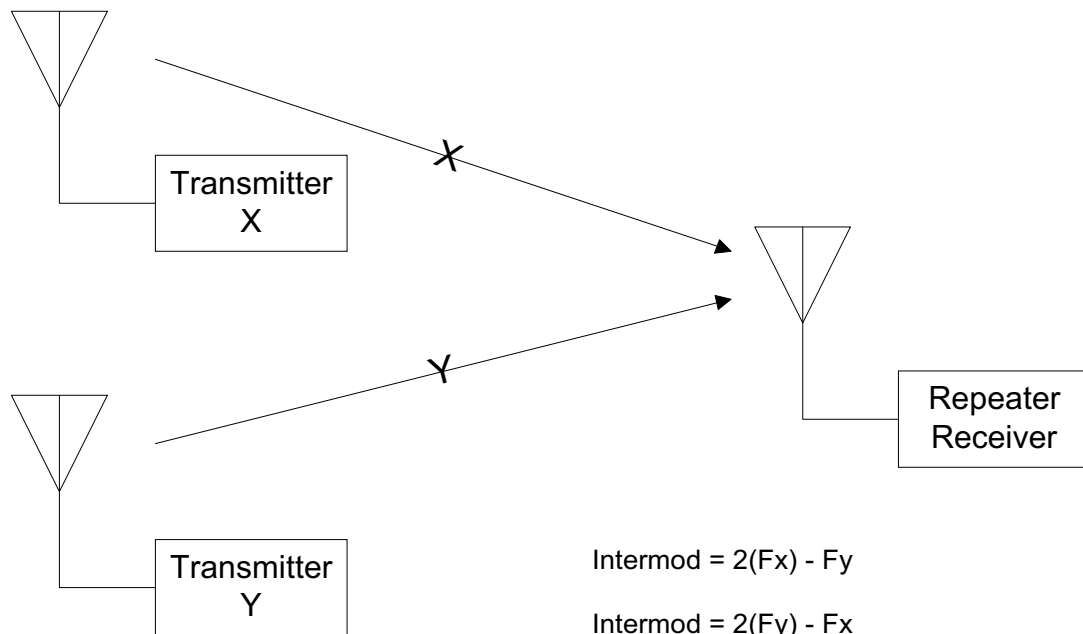


One of the undesired signals is intermodulation. Intermodulation is a result of multi signals. That is, two or more signals combine in some non linear element to produce a new signal which falls within the desired repeater receiver passband. The non linear suspect is usually the front end of the interfered receiver or the output circuits within a transmitter which, on there own, produce additional output signals other than the desired signal.

A Few Words About Intermodulation

Receiver Produced Intermodulation

For a two signal 3rd-order intermodulation (intermod), the product frequency is two times one of the frequencies, minus the other. Illustrated below is an example of receiver produced intermod.



Receive Produced Intermodulation, 3rd Order

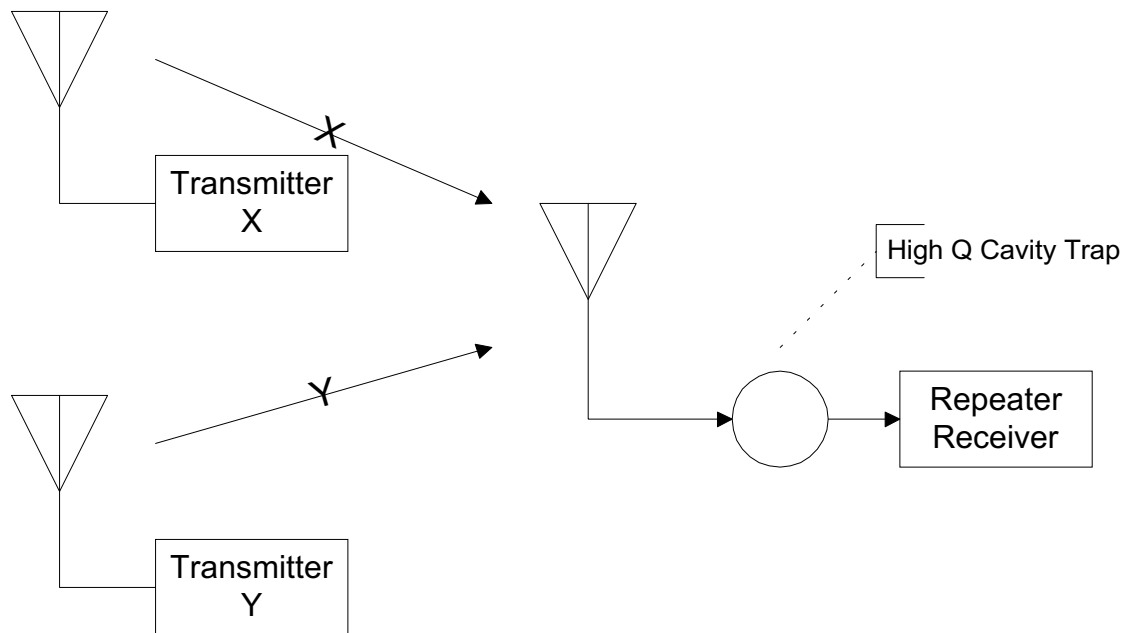
Receiver produced intermod is usually produced within the receiver's front end circuits. In some installations, attenuation of the offending signal can be corrected with an improved receiver selectivity circuits. Some installations may require a cavity "trap" within the received antenna line to prevent the offending signal from reaching the receivers front end.

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Receiver Cavity "Trap".

Let us look at an example by applying some frequencies for our receiver, and to transmitter X, Y.

Desired Received Frequency is 146.010 Mhz.

Offending Transmitter Frequency X is 152.330 Mhz.

Offending Transmitter Frequency Y is 158.650 Mhz

$$2X - Y = 2(152.33) - 158.65 \text{ Mhz} = 304.66 - 158.65 = 146.010 \text{ Mhz}$$

$$2Y - X = 2(158.65) - 152.33 \text{ Mhz} = 317.30 - 152.33 = 164.970 \text{ Mhz}$$

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We can see that one of the calculations is right on the desired repeater input frequency. You will notice that it does require both of the offending stations to be on the air at the same time. Since in this example the offending signals are within the commercial communications band, most of the stations are not on continuous. Therefore, the offending signal may not be at all times because again both signals are necessary.

By attenuating one of the signals using a tuned cavity, the problem could be solved. In most high dense areas, the two offending signals may be at totally different locations. Tracking down where and what frequency the signals are can be a real task depending on how often these signals are present. If you have determined the problem is intermod and you also have determined the receiver input is producing the problem, here's one way to attack the situation.

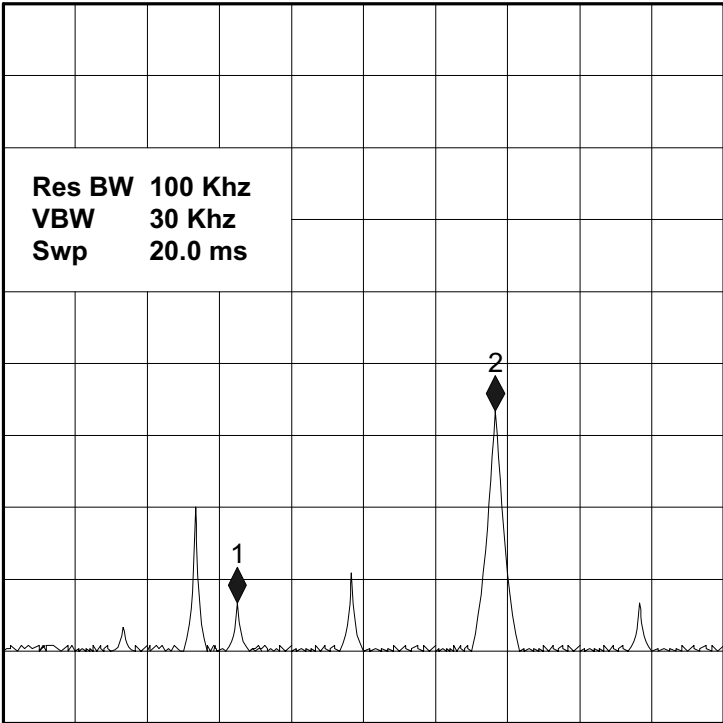
Try to get your hands on a good spectrum analyzer. One of the primary uses of a spectrum analyzer is to search out low level signals. Set up the analyzer with an antenna to provide a desired spectrum display. Be careful not to overload the analyzer's own front end. Spectrum analyzers have mixer inputs (non linear) and so always generate intermodulation distortion of its own. With the analyzer properly adjusted, only small unwanted distortion products are generated at the input mixer therefore be careful about the analyzers dynamic range.

While monitoring the repeater's input frequency, listen for the offending intermod. When present, look carefully for signals to appear on the spectrum analyzer at the same time. Once you have a general idea at what frequencies they are, listen on a scanner receiver to "zero in" on the exact frequency and note down that frequency value. By finding one of the offending frequencies, you can then calculate the frequency of the other.

An example of a spectrum display is illustrated on the next page. The two markers 1 and 2 in our example show both of the offending signals that is resulting in the receiver intermod problem on the repeater's receiver.



A Few Words About Intermodulation



Start 145.00 Mhz

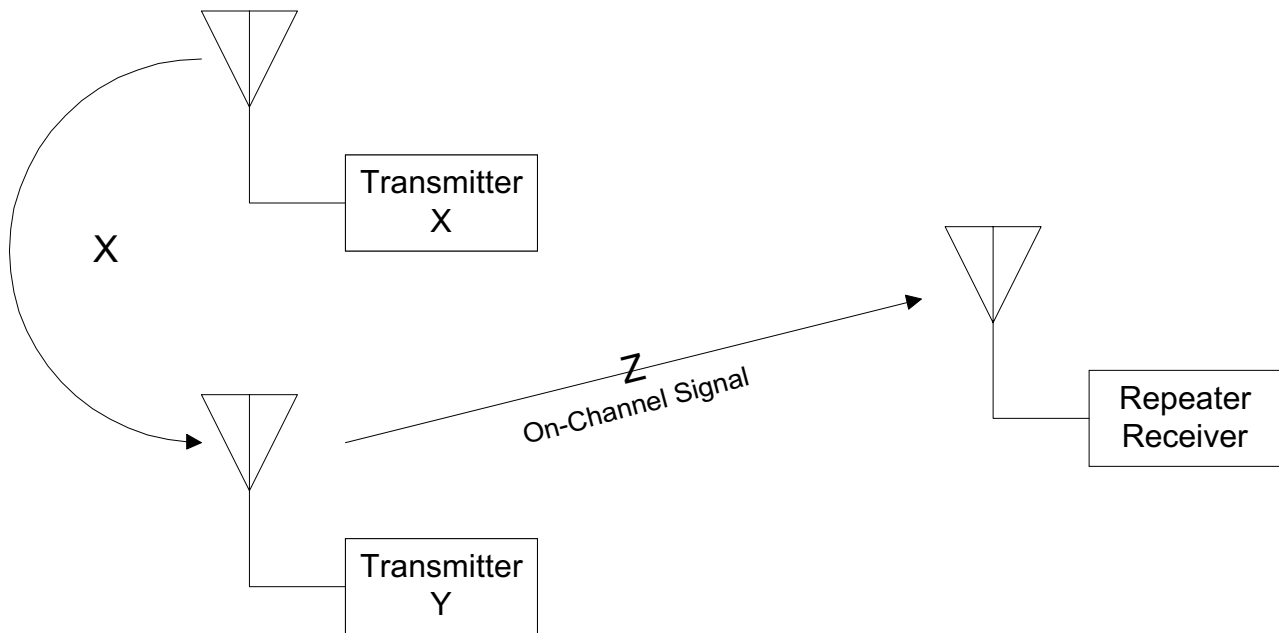
Stop 165.00 Mhz

From the display above, it was noted that the two signals (markers 1 & 2) appeared together whenever the intermod is present on the repeaters receiver.

A Few Words About Intermodulation

Transmitter Produced Intermodulation

Transmitter produced intermodulation is usually generated within the output power amplifier of a transmitter.



In this example illustration, second harmonic energy inside transmitter Y is being mixed with the received energy from transmitter X. The product generated within transmitter Y is radiated into the repeater's receiver causing the problem. Note that the interference occurs only when both transmitters are in their transmit mode. If you find out that both transmitters are paging transmitters, this interference can almost be continuous with digital modulated data. If the offending transmitter (transmitter Y in above example) belongs to another organization, you now will have your hands full since corrective action must be taken with the offending transmitter. There is nothing you can do with the receiver to correct this problem.

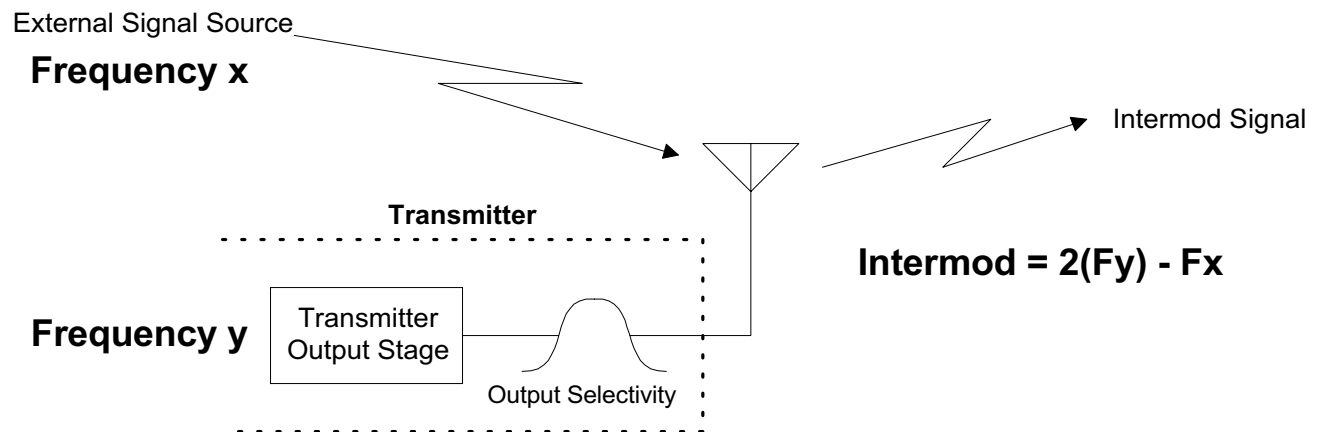
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A Few Words About Inter- modulation

As mentioned, transmitter produced intermodulation is produced within the transmitters output stage. A portion of the transmitters second harmonic energy is being coupled with RF energy from another transmitter (coming in through the antenna), mixing and radiating its products. The new frequencies generating are now radiating out the same antenna along with the transmitters assigned frequency. Here's a look at 3rd order transmitted intermod illustration.



If the external signal is “in band” with the offending transmitter, minimal attenuation will take place within the output selectivity stage (harmonic filtering) allowing the signal to pass directly to the transmitter output stage.

To correct this problem will require the reduction of the other signal (frequency x) that is entering and creating problems within the transmitter. Of course space attenuation would be helpful, but moving one of the sites may not be possible. Otherwise, work will be necessary with the site who's transmitter is causing the intermod. There have been cases were ferrite isolators or circulators have been installed and totality cured the problem. These devices pass signals in one direction while attenuating signals in the opposite direction.

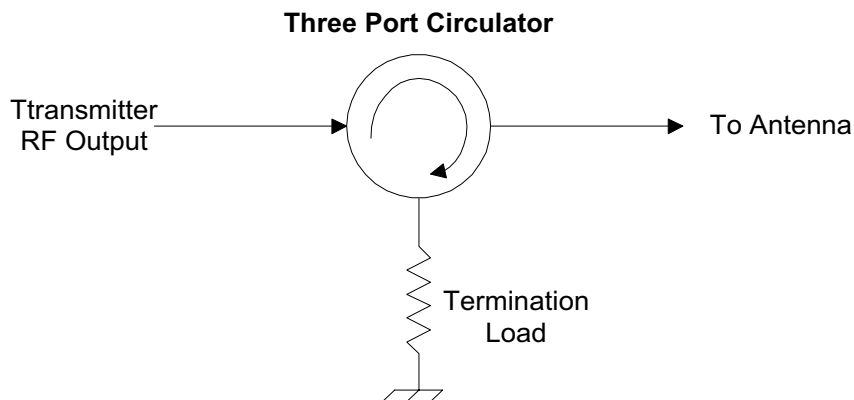


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A Few Words About Intermodulation



Illustrated above, the transmitter output is passed through to the antenna (following the direction of the arrow) with very little loss. Any signal coming back in from the antenna will be dissipated by the termination load rather than passing onto the transmitter output stages. Therefore, the “other” signal is removed or attenuated to a point where the intermod generated within the transmitters output stage is eliminated.

Another correction could be by adding selectivity between the transmitter and the antenna. However the selectivity necessary will vary dependant on the signal separation, second transmitter strength, etc. Cost wise, this approach may be the better way to go as circulators can be expensive depending on the frequency band the transmitter is operating in.