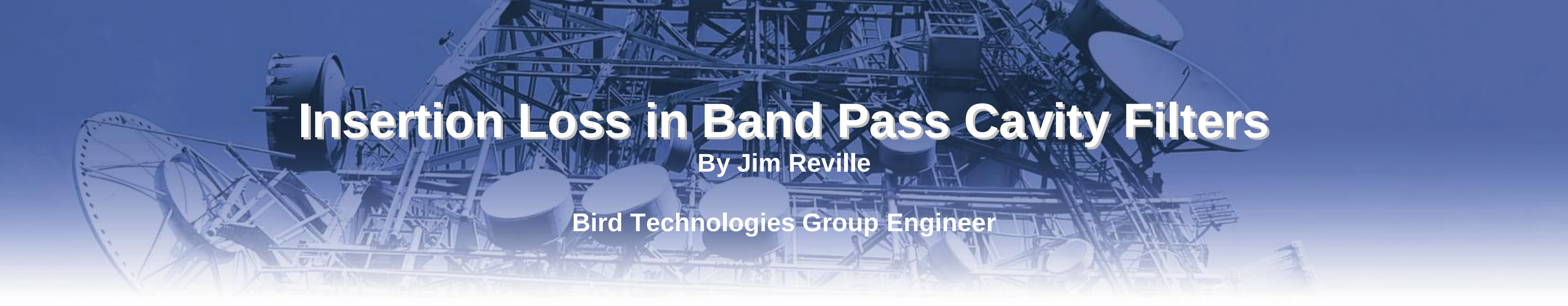

# Insertion Loss in Band Pass Cavity Filters

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## In Land Mobile Radio (LMR) transmitting and receiving applications, cavity filtering is used in two ways.

First, a cavity filter must be able to pass the desired signal with a minimum of loss. Second, the filter must reduce, or eliminate undesirable signals with maximum efficiency.  An ideal (perfect) filter of the highest quality would allow us to pass a desirable signal through it without any loss. It would also be capable of completely removing all undesirable portions of the signal. But, we do not live in a perfect world and we must abide by the laws of physics

*Figure 1 – Top view of a typical band pass cavity filter*

In our imperfect world, radio transmitters generate both a desirable signal as well as undesirable signals. The undesirable signals we will discuss here are called wide band transmit noise. Many modern transmitters often generate more of this type of noise than traditional transmitters.  Cavity filters are used to in both transmitter and receiver systems.

There are two considerations in providing filtering in LMR type transmitter and receiver systems. When using a duplexer or TX/RX combiner filtering system, you must filter the wide band transmitter noise out of the transmitted signals to protect your site receivers. TN/RD is short for transmitter noise and receiver desense. You must also supply filtering on your receivers to prevent a transmitter from overloading or desensitizing a receiver. Transmitter noise suppression (TN) is the amount of isolation required on the transmitter to protect the receiver from sideband noise. Receiver desense carrier suppression (RD) is the amount of isolation required to protect the receiver from a high level transmitter carrier.

Bandpass cavity filters are used to pass a desired signal at the filters tuned frequency. The desired frequency is at the center of the curve in figure 2.

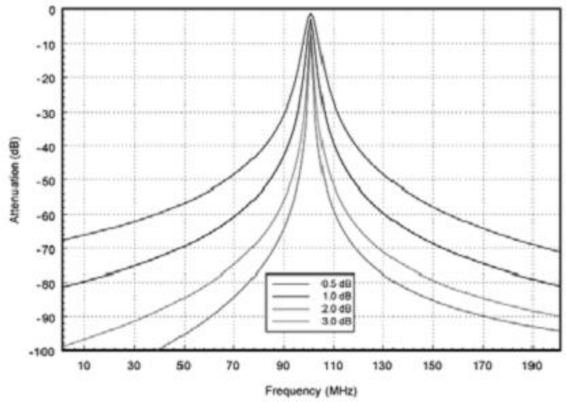

*Figure 2 – Band pass cavity curves*

Insertion loss has the following affect on the filtering provided: the higher the insertion loss setting, the narrower the bandwidth of the desired signal passed through the filter. A lower insertion loss setting results in a wider bandwidth.  Bandwidth may also be modified by adding additional bandpass cavities in series.   Additionally, the bandwidth may be affected by the length of the cable used between the cavities if more than one is used in a particular application. Insertion loss is not the only factor that affects bandwidth of the signal passed through the filter.

In a cavity filter, the amount of insertion loss determines, in part, how much filtering you get out of the cavity.  In the figure 2 the insertion loss settings have been varied from a loss of 0.5dB up to 3.0 dB to show the resulting filtering characteristics. The higher the insertion loss setting is, the sharper or narrower the band of pass frequencies. The curve at the top of figure 1 shows the lowest insertion loss setting. The bottom curve illustrates the response of the filter at the highest insertion loss setting. The lower the insertion loss setting, the less filtering is supplied, which produces a wider pass band. The higher the insertion loss setting, the narrower the frequency pass band is, covering a narrower spectrum.  It then provides more attenuation above and below the pass frequency.

In this type of cavity filter the insertion loss is adjusted by rotating the loops. A photograph of the loop appears in figure 4 below.

*Figure 4 – One of two loops used in a UHF band pass cavity*

The loops are both rotated relative to the stationary probe. See figure 5 below for the stationary probe. The lowest insertion loss is achieved when the loops are rotated such that the widest part of the loop is facing toward the stationary probe. In this position the RF signal is fully coupled through the cavity. To achieve maximum coupling, the tuning probe must be adjusted to a length equal to ¼ wavelength of pass frequency. This is accomplished by moving the movable probe which is shown in figure 5 below. The physics involved here is illustrated in figure 6 below.

*Figure 5 – Cutaway showing band pass cavity internal construction*

The highest insertion loss is achieved when the loops are rotated 90 degrees so that the narrowest side of the loop is facing the stationary probe. This is the position where the RF signal is minimally coupled through the cavity.

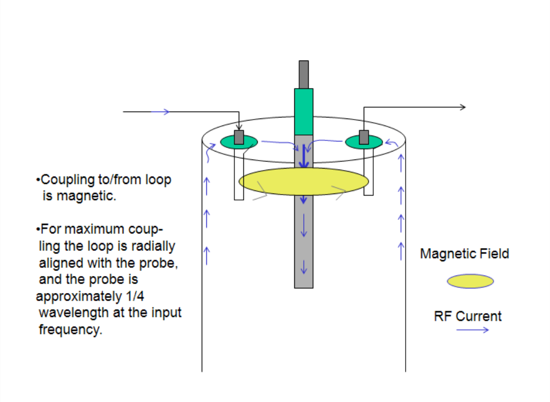

*Figure 6 – band pass cavity theory*

There are several factors which contribute to energy losses that occur in a cavity filter. There is no free lunch when it comes to physics. An increase in filtering requires a corresponding increase in insertion loss.

In a transmitter application, physics dictates that an increase in the insertion loss setting of a cavity will cause a corresponding increase of power dissipation in the form of heat. The cavity must be able to dissipate the heat generated without affecting the filters characteristics such as resonant frequency (pass frequency) that the cavity is tuned to. A temperature compensated cavity provides temperature stability.

Radiated Energy can be lost through poorly shielded interconnect cables. Bird Technologies suggests the use of double shielded cable in all of our systems to minimize this type of loss.

There are other types of cavities that have different characteristics.  These may be the topic of future papers.