

# TECHNICAL NOTES ON FILTERS, CAVITIES AND DUPLEXERS

Filters are important passive RF devices that perform selective frequency discrimination. As a class, filters also include duplexer and cavity resonators. Filters are designed to pass a band of frequencies, reject a band, or to combine those actions,

Four prime filter characteristics of concern to the system designer are insertion loss, attenuation, bandwidth, and selectivity. Each must be considered carefully in the selection of a filter product in order to ensure satisfactory system performance.

## INSERTION LOSS AND ATTENUATION

Both represent reduction of available signal power after filtering. Generally speaking, the designer selects the filter with the least loss and the most attenuation consistent with other application requirements.

Although one may discuss loss directly in terms of Watts, it is common practice to use the Decibel to express the ratio of power output to power input. Using Decibels makes insertion loss and attenuation performance characteristics independent of the actual powers or voltages in use.

The Decibel (abbreviated dB, where the B is in honor of Alexander Graham Bell) is computed as  $10 \log (P_{out}/P_{in})$  where log is the common logarithm function (base 10).  $P_{out}$  is the measured output power from the filter;  $P_{in}$  is the measure of power input to the filter. A few useful ratios and their corresponding Decibels are tabulated on chart to left.

As may be seen from the table, the often-heard expression "half-power point" signifies that spot on the response curve where the output power has been reduced by 3 dB, regardless of the actual power level.

Insertion loss is the amount of power unavoidably absorbed by the filter. It's an unintended side effect...a "cost of doing business" with the filter. In the band pass region of the filter's response curve, this figure sets the maximum amount of desired signal passed through to the output after processing. There are practical lower limits on insertion loss, around 0.5 dB. A 3 dB insertion loss, for example, spends half your power in the filter. Sometimes a relatively high amount is unavoidable, as in transmitter combiners.

## MORE ON ATTENUATION

Attenuation is also power absorbed by the filter as an intentional benefit. It applies to band rejection, and is the extent to which the undesired signal is blocked from the filter's output. In duplexers, whose task it is to prevent transmitter power from entering the receiver's input, a 60 dB attenuation is generally considered a minimal safety margin.

Some filters offer up to 100 dB or more attenuation, a very significant reduction in the unwanted signal. For repeater service, consult the radio manufacturer's data sheet for recommended attenuation required.

## ISOLATION

Isolation is the amount of attenuation between named ports of a filter. For example, a duplexer specified as having 60 dB of attenuation between the receiver port and the transmitter port may be said to have 60 dB port-to-port isolation.

## BANDWIDTH

The amount of frequency spectrum between the two half-power, or 3 dB, points of a filter's response curve is defined as the filter's bandwidth. If the filter has a complex response curve, there may be one or more pass bandwidths and reject bandwidths associated with the device.

## SELECTIVITY

The shape of the filter's response curve defines the filter's selectivity characteristics. Sharp curves with steep skirts have relatively narrow bandwidths, and are considered highly selective. A relatively wide bandwidth has broad selectivity. Each selectivity extreme has utility for a given set of circumstances facing the system designer.

DECIBEL LOSS	POWER LOSS
0.5 dB	10.8%
1.0 dB	20.5%
2.0 dB	36.9%
3.0 dB	50.0%
10.0 dB	90.0%
60.0 dB	99.9999%

THE DECIBEL IS ABBREVIATED dB WHERE B IS IN HONOR OF ALEXANDER GRAHAM BELL

SELECTIVITY