Combiner & Receiver Multicoupler Desgin

Bird Systems/Applications Engineering

Introduction

The ultimate goal of a transmit combiner / receiver multicoupler design is to provide a system which allows full duplex operation while minimizing interference to the receive system. This can only be achieved when transmitter IM products are controlled and sufficient isolation is provided between the transmit and receive systems to prevent overload of the receiver front end by the transmit carriers (carrier suppression) or desensitization of the receive system by transmitter sideband noise (noise suppression).

In either case, the key factor in designing a successful system is providing sufficient isolation between the TX and RX portions of the system. This isolation is provided in two ways:

1. Filtering isolation in the combiner / multicoupler
2. Antenna to antenna isolation between the TX and RX antennas.

In those cases where a single antenna solution is workable i.e., there are no problematic IM mixes, the antenna isolation is zero due to the common antenna. For all other cases, the amount of isolation provided by the separation of the TX and RX antennas reduces the isolation requirements of the combining / multicoupling system by the amount of the antenna isolation.

How much Isolation is required?

The answer to this question is a function of the actual transmitter and receiver performance. For the transmitter, the key factor is the level of sideband noise at the receive frequency. For the receiver, the key factor is how much overload can be tolerated from off-frequency carriers. In both cases, the levels are a function of the amount of offset between the TX and RX frequencies as well as the transmitter power level.

Most manufacturers do not publish this TNRD data (Transmit Noise / Receiver Desense), so TX RX utilizes data which has been gathered over the years for “typical” commercial grade VHF, UHF and 800 / 900 MHz repeaters. Since noise and selectivity performance of both transmitters and receivers has improved over the years, this data results in fairly conservative designs.

For VHF systems, 90 dB of isolation is a typical number, although that can vary depending on T/R frequency spacing along with transmitter power. Since there is no defined band plan at VHF, the requirements can vary widely as transmit and receive frequencies are often interleaved with each other. Situations often occur where the TX to RX separation is simply too small to filter using conventional cavity filtering. In these cases, a note is added to the combiner design indicating that the affected receiver must be muted when the adjacent transmitter keys up.

At UHF, a target of about 100 dB isolation is common. The defined T/R spacing (5 MHz for 450 – 470 MHz and 3 MHz for 470 – 512 MHz) allows more “standardized” designs since the TX and RX bands are fixed and separate. The worst case scenarios are when a receiver at one end of the receive band needs protection against a transmitter at the edge of the adjacent transmit band. In this case additional filtering is required on both the TX and RX sides.

At 800 and 900 MHz, the isolation requirements are minimized due to the large T/R splits (45 or 39 MHz) which are used. For 800 MHz, the worst case condition would be a receiver at 824 MHz and a transmitter at 851 MHz. This minimum spacing is referred to as the Guard Band and is 27 MHz at 800 and is 34 MHz in the 900 MHz band.

Design Considerations

Once the transmit and receive frequencies are known, along with the transmit power levels, the required isolation can be determined. From that, the antenna to antenna isolation is subtracted and the remainder is the isolation which must be provided by the combiner / multicoupler. That value determines the number and size of cavities required. (Figure 1)

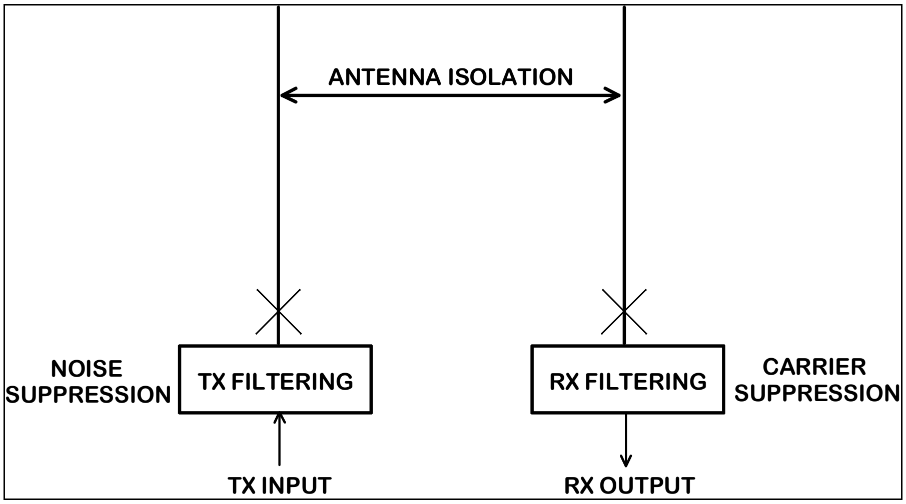

Figure 1

Antenna Isolation

If the antenna isolation is maximized, the requirements for the combiner / multicoupler are reduced by approximately an equal amount which results in a savings of both physical size and cost in the combining equipment.

Vertical separation of antennas produces the maximum isolation (see Figure 2). When mounted on a tower, an excellent rule of thumb is to provide at least the following vertical separation between the TX and RX antennas (measured from the tip of the lower antenna to the base of the upper antenna):

VHF	30 feet
UHF	20 feet
800 MHz	10 – 12 feet

The actual isolation will approach 50 dB in such cases. Note that with tower mounting, 50 – 55 dB is about the limit of isolation which can be achieved. At that point, adding vertical separation does not result in substantially higher isolation i.e., a point of diminishing returns is reached.

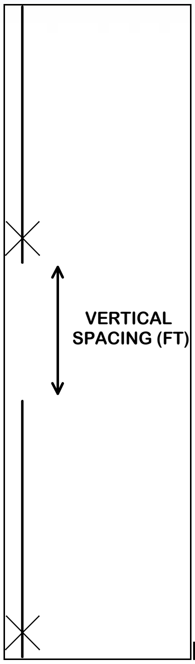

Figure 2

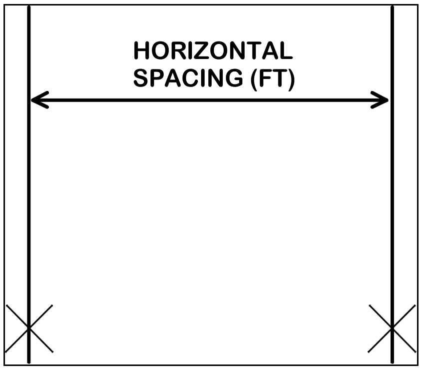

Figure 3

Note that multiple TX antennas can be mounted at the same height, however the worst case spacing between any of them and any receive antennas should adhere to the vertical spacing's listed above.

Horizontal spacing of antennas, as on a rooftop site, provides the least amount of protection (Figure 3). For reference, the following isolation values are typical for two antennas spaced 10 feet apart:

VHF:	26 dB
UHF:	36 dB
860 MHz:	40 dB

Note that the antenna gain is not a factor when the antennas are in the "near field". These isolation figures are approximate and essentially antenna gain independent. For other spacings, use 6 dB as the change whenever the spacing between the antennas is either doubled or halved. Keep in mind that the site environment can significantly alter these values. These estimates are based on two antennas in the clear with their cables running downward from each.