Receiver Sensitivity and Noise

Sensitivity is defined as the lowest power level at which a receiver can detect an RF signal and successfully demodulate the data. Thus, a receiver with a smaller (more negative) sensitivity rating will be able to detect weaker RF signals and demodulate the data. This behavior translates into superior range performance over less sensitive receivers, assuming a constant transmit power from the data source. Since receiver sensitivity can be used to improve range, companies such as MaxStream, TI, Maxim, and Xemics have carefully applied RF design principles to develop receive sensitivity levels well below -100dBm (the more negative the number, the better the sensitivity) for products operating in the ISM band.

The relationship between receiver sensitivity (P_R) and range (r) is given by the Friis transmission formula below. (A detailed look at the effects of this formula can be found in MaxStream's Sensitivity Report.)

$$P_R = [P_T G_T G_R \lambda^2] \ / \ [F_S (4\pi r)^2]$$

Since the Received Power (P_R) is proportional to $1/(r)^2$, the range of the transmitted signal will double for every 6dB improvement (more negative) in sensitivity. As shown in Figure 1 below, a mere 6dB improvement in sensitivity would allow the radio labeled "R2" to receive over twice the range as the radio labeled "R1".

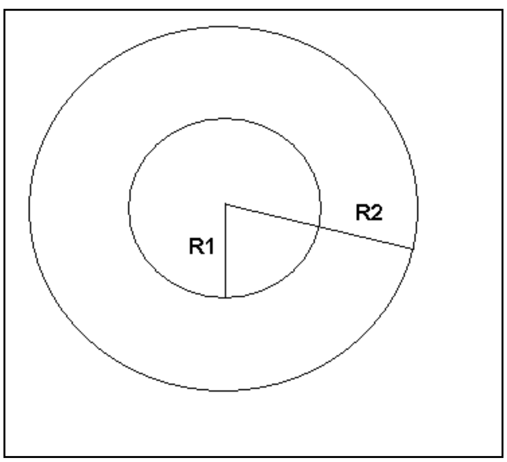

Figure 1a – Range differences due to improved sensitivity in Receiver 2. (Receivers 1 and 2 are located at the center of the circles.)

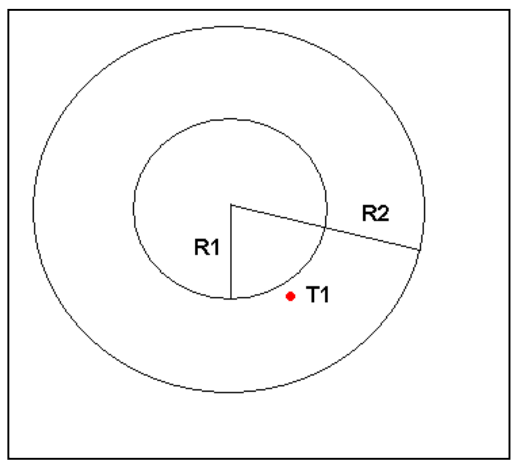

Figure 1b – In this illustration, Receiver 1 would not detect data from the Transmitter labeled T1.

Noise Effects on Highly Sensitive Receivers

The arguments made above are quite valid in an ideal environment where noise does not interfere with radio transmissions. But what about receiver performance in a noisy environment? How is data throughput affected by RF noise in the ISM band? Suppose, for example, an interfering signal was located at the transmitter location labeled "T1" in Figure 1b. This interferer lies outside of the range of Radio 1, although it would be detected by Radio 2. This scenario results from the fact that as radio range increases, so does the probability of picking up noise from other communications in the ISM band. What is the best way to avoid noise from other transmissions? Is it best to reduce the range of the radio to decrease the likelihood of detecting noise? If so, since a smaller range will reduce the risk of noise interference, what is the optimum range (1 meter, 5 meters, 100 meters, 1000 meters, etc)?

Rather than limit the range of its transceivers, MaxStream has designed their modules to filter out nearby interference so it does not affect the desired signal. The following graph illustrates the abilities of the 9XStream to filter noise.

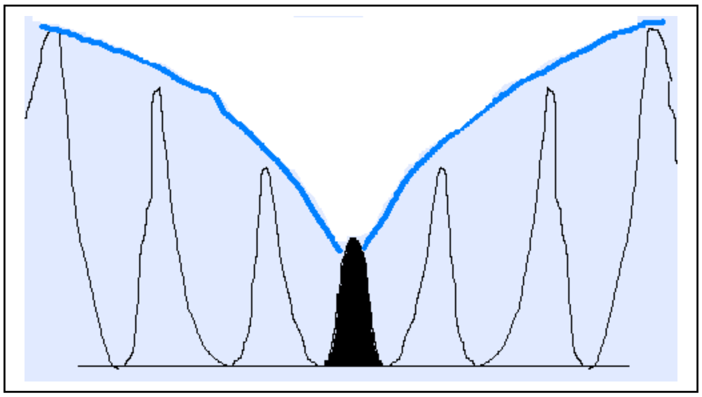

Figure 2 – Noise rejection of 9XStream module.

As shown in Figure 2, the 9XStream has the ability to reject nearby noise and demodulate RF data, even when the interfering signal is stronger than the desired signal! For example, an interfering signal at a frequency 1 MHz away from the desired signal must be 10,000 times stronger (40dB) than the desired signal to interfere. The 9XStream rejects cell and pager frequencies that are over 10,000,000 times stronger (70dB) than the desired signal.

If an interfering frequency is on the same frequency as the desired signal, the 9XStream will still detect and successfully demodulate the data if the desired signal is 6dB stronger than the noise. Furthermore, the frequency-hopping algorithm of the 9XStream helps minimize the effects of noise on a given channel, as it will not dwell on a frequency for more than 40ms.

Thus, in most RF environments, the XStream modules offer significant range increases while maintaining low transmit power, and thus, lower current levels. These features have attracted a wide customer base that utilizes these advantages in a variety of environments to achieve longer distances, longer battery life, and a less-costly solution.

We invite you to try the XStream module for yourself in your own environment and see the benefits of high sensitivity and stringent noise rejection.