RF Sensitivity of Series 7000 (MPT) DF

A Technical Application Note from Doppler Systems

8 July 2011

1.0 Introduction

This report presents the sensitivity test results obtained using the MPT processor and mobile RF summer. Results are given for a continuous unmodulated signal and for an over the air narrow band frequency modulated signal. The proper selection for the threshold value used by the MPT for signal detection is discussed.

2.0 Measurement

All data was taken in a bench setup. The RF summer tested was not mounted in its shielded enclosure so separation of the circuit from other cables and the MPT processor was important. A four way splitter with cable lengths set for the VHF band was used to simulate an antenna. A nominal bearing angle of 180 degrees was simulated. Figure 1 shows the test setup used.

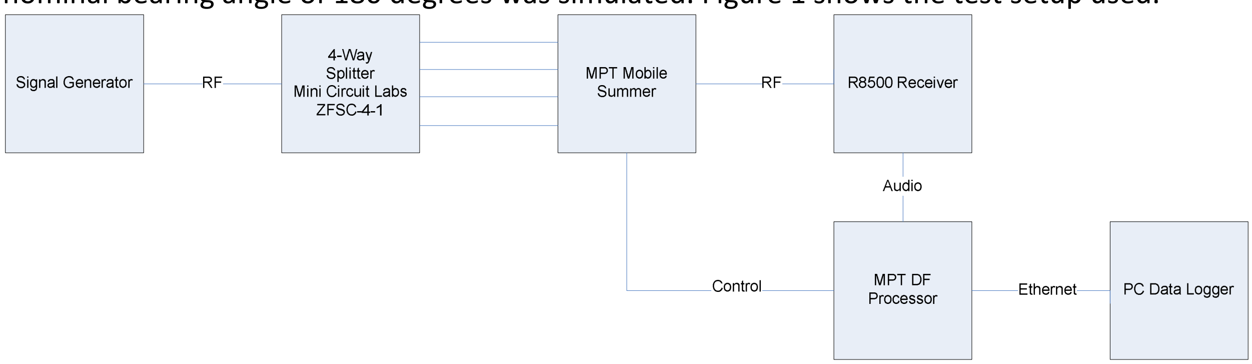

Figure 1 - MPT Sensitivity Test Setup

The receiver was set for 12 KHz bandwidth and the audio output adjusted to produce all green bars on the monitor program (approximately 11:00 setting of the R8500 volume control). The receiver squelch was set to be open (unsquelched). The MPT was set to its continuous mode, with the default sweep rate (nominally 1 KHz) and 2 averages so each measurement consisted of a CW and CCW rotation measurement. The measurement interval was 0.5 seconds. A total of 1000 data samples were recoreded at each test condition in order to provide a statistically significant basis for calculating the bearing average, standard deviation and probability of detection.

3.0 Results for Continuous Signal without Modulation

These signals were produced by the signal generator with no modulation. The frequency used was 177 MHz. However, the results are nearly identical to those obtained with an Amplitude Modulated signal.

Data was taken with MPT threshold settings of 1000, 2000 and 4000. A larger threshold provides greater sensitivity, but as discussed later it produces more frequent false bearings.

Figure 2 shows the mean bearing angle vs the input signal strength. The averaging of sequential CW and CCW measurement s by the MPT provides an average bearing angle that is practically independent of signal strength.

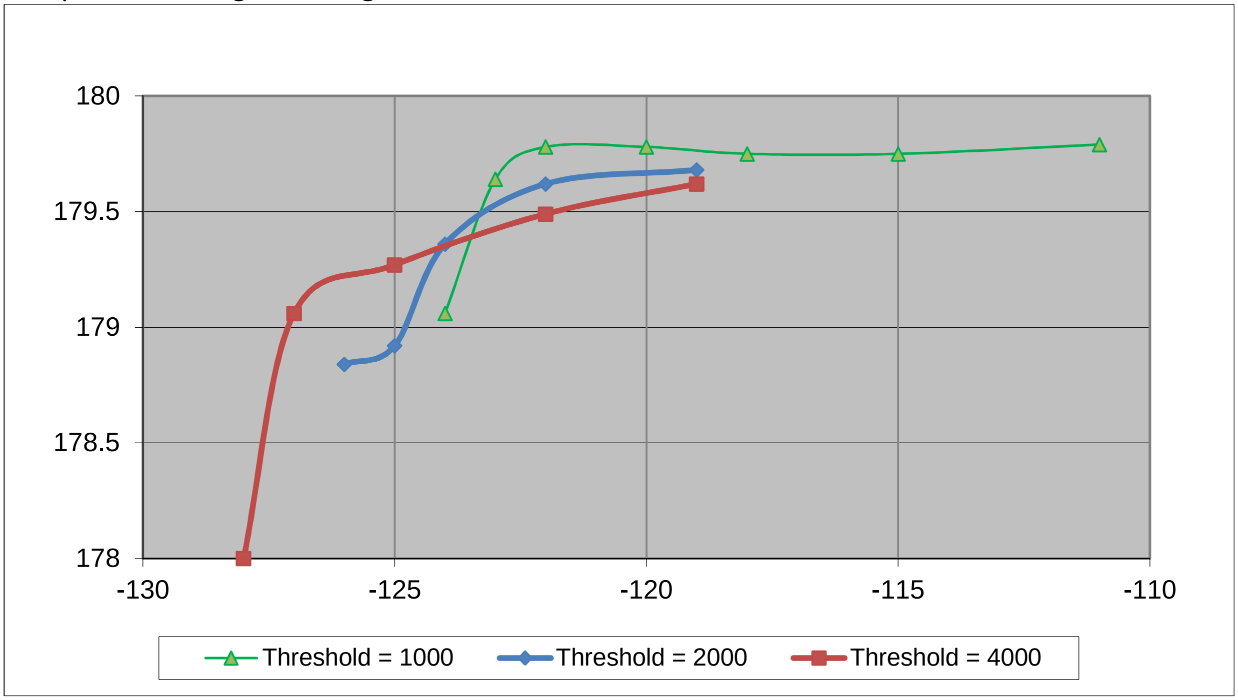

Figure 2 - Average Bearing Angle in Degrees vs Unmodulated Signal Strength in dBm

The standard deviation of the bearing increases slightly as the signal strength decreases, then it increases more rapidly around -120 dBm as shown in Figure 3. Sensitivity can be defined as the input that produces a specified value of bearing angle stability. If we use 2 degrees RMS as the stability, then the sensitivity of the MPT is about -123 or -124 dBm.

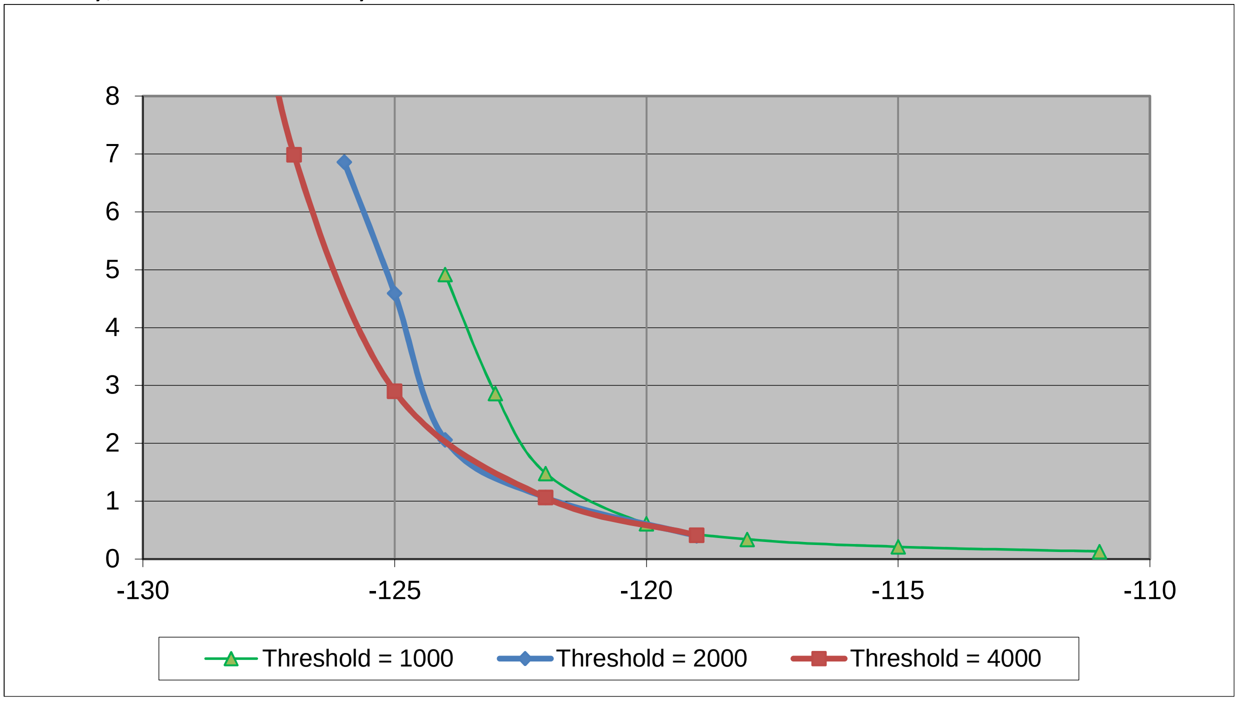

Figure 3 – Bearing Standard Deviation in Degrees vs Unmodulated Signal Strength in dBm

Alternatively, the sensitivity could be defined as the signal level that has a specified probability of producing a bearing angle measurement. This is shown in Figure 4. For a probability of 90%, the sensitivity of the MPT is between -123 and -128 dBm and depends on the threshold setting.

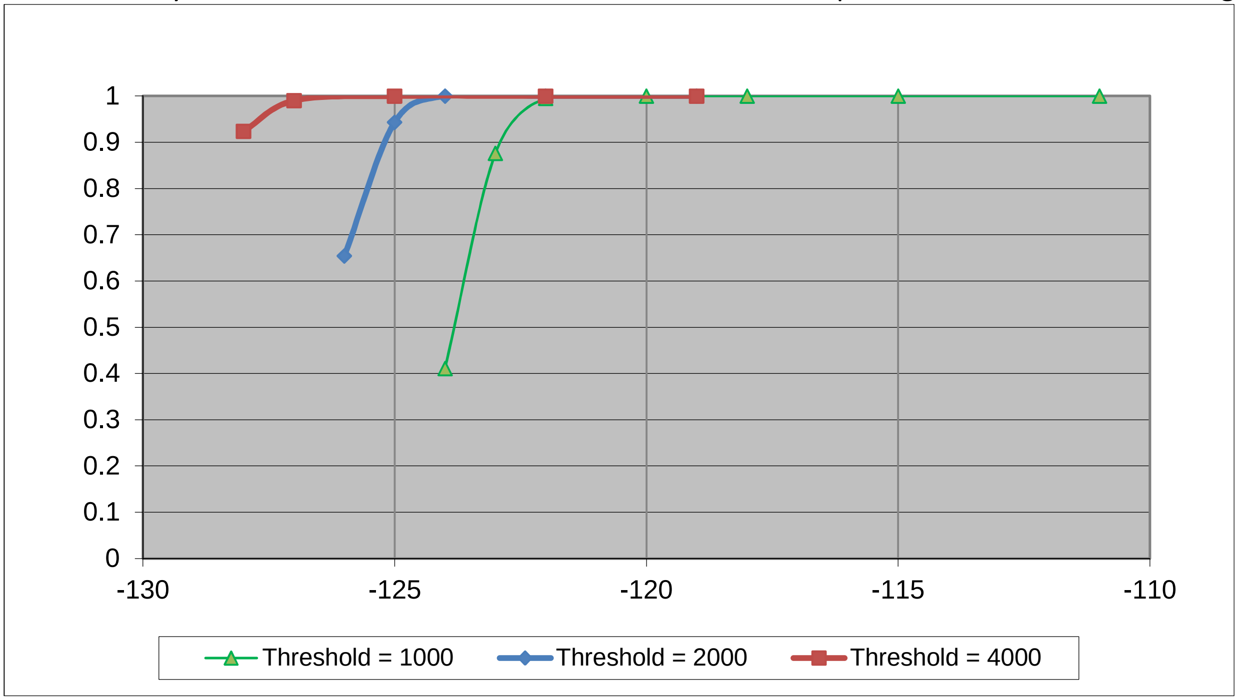

Figure 4 - Probability of Detection vs Unmodulated Signal Strength in dBm

4.0 Results for Continuous Signal with FM Modulation

For these tests, the signal generator was replaced by a roof mounted antenna and the receiver frequency was set to the Phoenix weather station at 162.550 MHz. This is a continous signal that is fm voice modulated. These measurements were made with the threshold set at 1000.

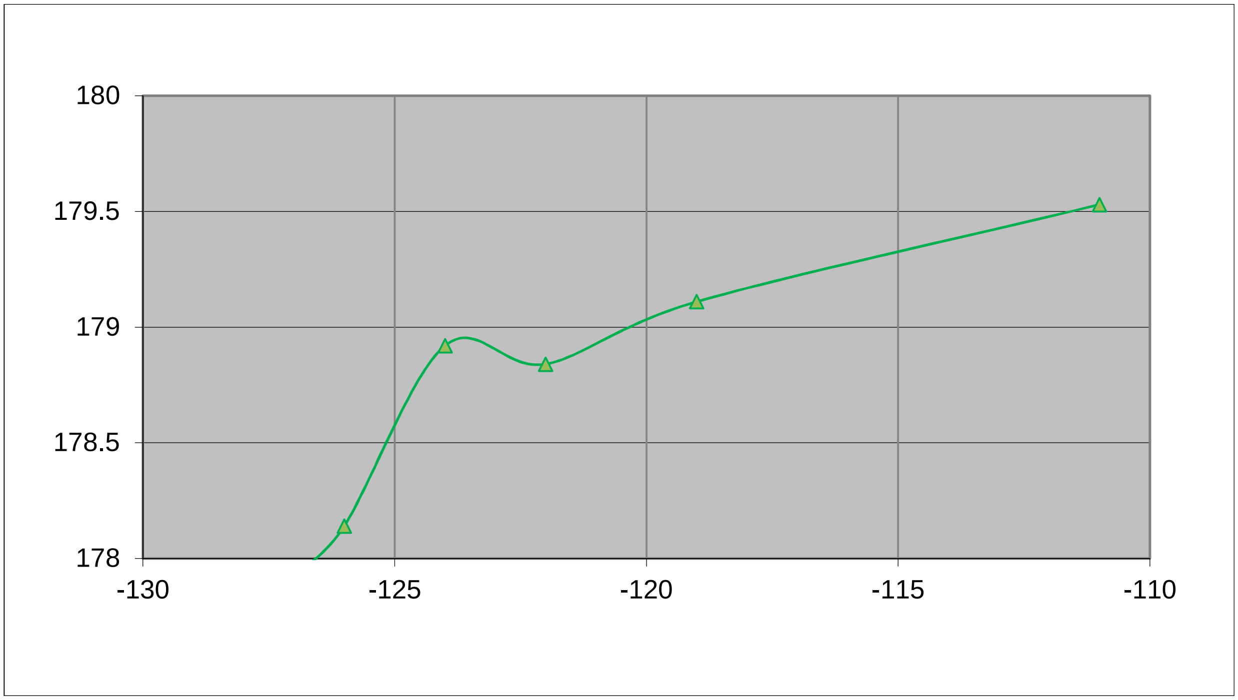

Figure 5 - Average Bearing Angle in Deg vs FM Signal Strength in dBm

As with the unmodulated signal, the average bearing does not change much with signal strength. However, the frequency modulation causes the bearing angle to fluctuate even at strong signal levels. So as shown in Figure 6, the standard deviation of the bearing is constant at about 2 or 2.5 degrees until the signal strength drops below -123 dBm. (The standard deviation for stronger signals is a consequence of the fm modulation that contains components near the sweep frequency of the direction finder). The probability of detection shown in Figure 7 is about the same as it was with this threshold for the unmodulated signal; about -124 dBm is the sensitivity for 90% probability of detection.

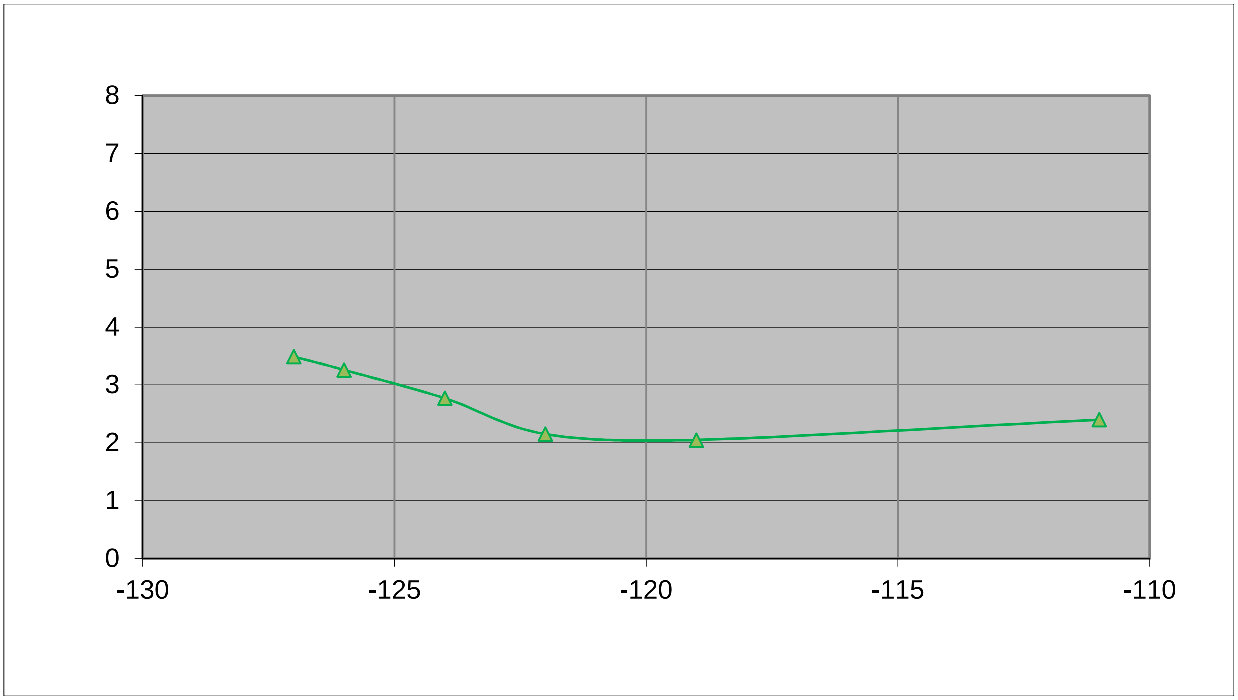

Figure 6 - Standard Deviation of Bearing in Deg vs FM Signal Strength in dBm

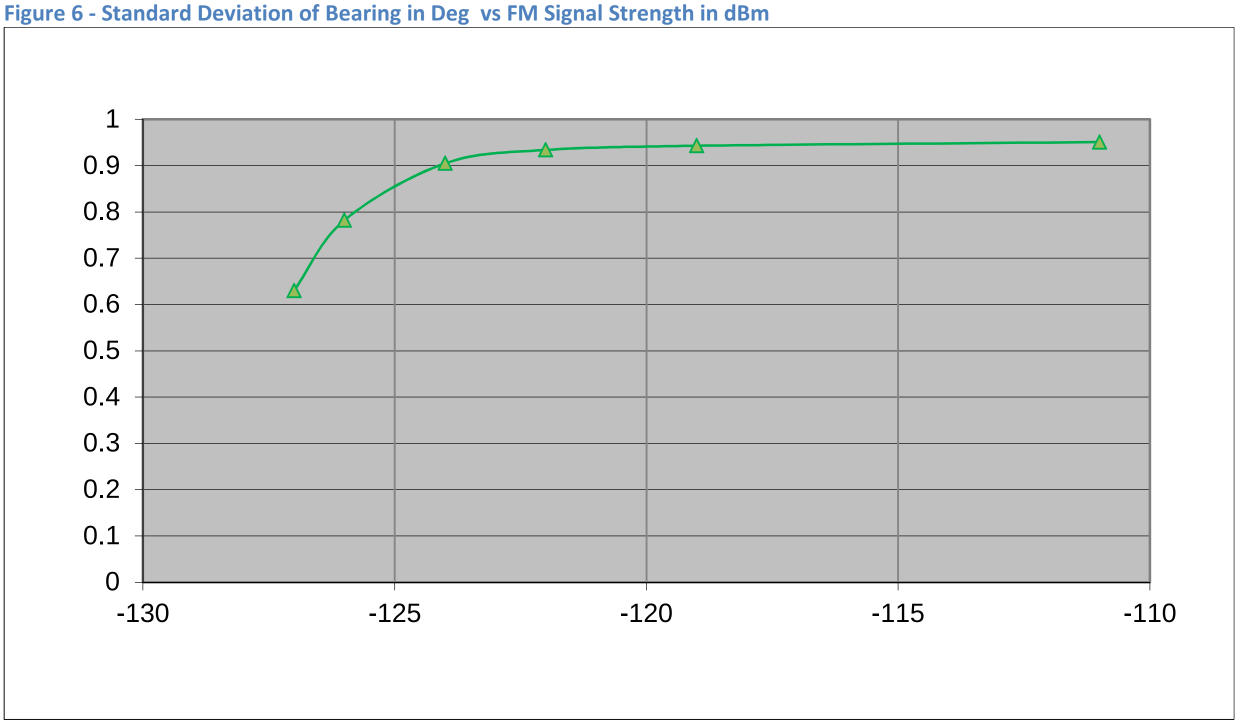

Figure 7 - Probability of Detection vs FM Signal Strength in dBm

5.0 Threshold Selection

The MPT uses a proprietary method for determining whether a signal is present. The method estimates the relative bearing stability and compares it to a threshold which can be set by the user. For a signal strength of -112 dBm (a weak signal with a small amount of noise) the average bearing and the standard deviation of the bearing are nearly constant as the threshold is varied. See Figure 8.

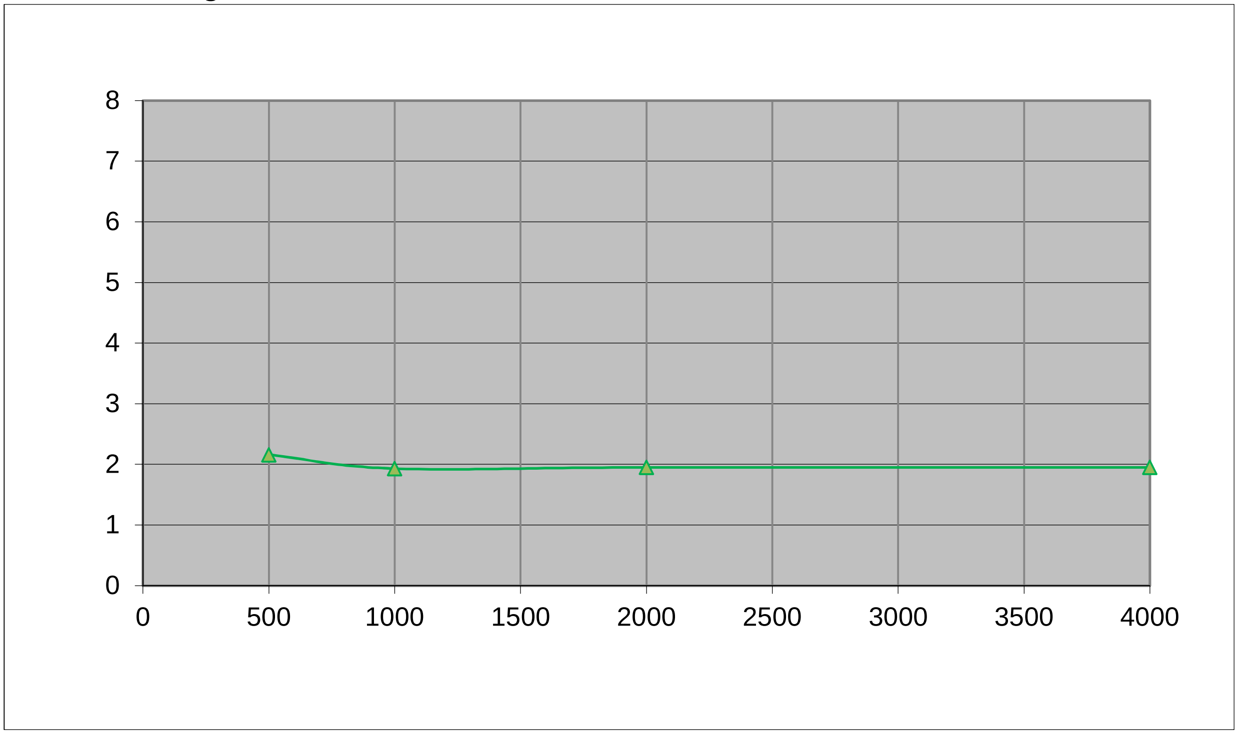

Figure 8 - Standard Deviation in Deg vs Threshold with an FM Signal at -112 dBm

However, the probablility of detection P(Det) and the probability of a false alarm P(FA) are both affected by the threshold. In Figure 9, the probabiliy of detection is shown for a -112 dBm FM signal while 1-P(FA), the probability of not detecting an extraneous bearing are both plotted against the threshold setting. This plot indicates that the threshold should be set somewhere between 1000 and 2200. The probablility of false alarm data was taken by connecting the antenna simulator to the outside antenna and tuning to an unused frequency (177 MHz). This was done so as to include the ambient atmospheric noise. If the ambient noise is higher, a lower value would be used for the threshold.

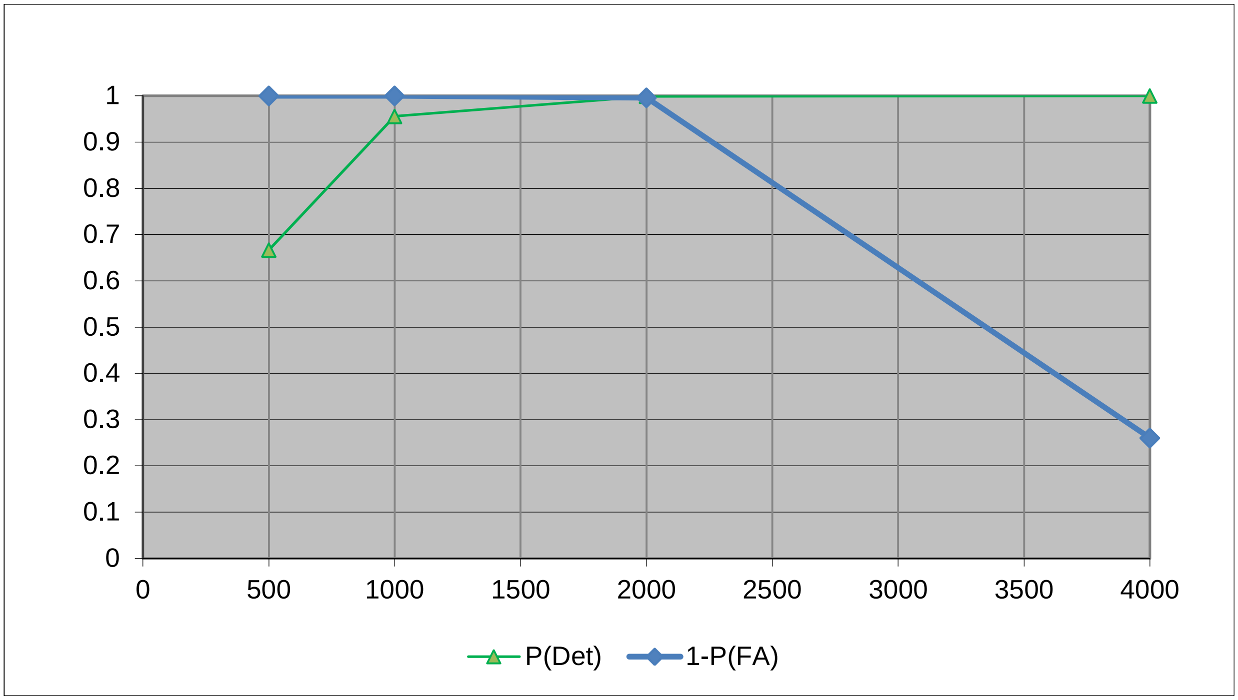

Figure 9 - Probabilities of Detecting a Weak NBFM Signal and of Avoiding False Alarms vs Threshold