WalkMate Processing Gain Measurement

The processing gain for the WalkMate system is measured using the CW jamming margin method as described in 15.247(e)(2) where Gp = S/N + Mj + Lsys. For this system, the BER requirements are derived from the required message error rate because the direct sequence spread spectrum (DSSS) receiver can provide metrics for message errors, but not actual bit errors. (The system uses burst transmissions, and the bursts are discarded if a single bit error occurs.)

The remainder of this memo includes the derivation of the BER requirements, a description of the test setup and procedure, a summary of the results of the testing and an attachment which contains the detailed data from the test.

BER Requirements Derivation

A message throughput rate of 75 percent is acceptable for reliable operations. The burst transmission consists of 40 bits and a *single bit error will cause a message error*. The message error rate is related to the BER by the binomial distribution. The probability of having exactly k bits in error out of a 40 bit transmission is given by,

Pm(k)= {L/k}Pb^k(1-Pb) ^(L-k)

Where {L/k} = L!/(k!(L-k)!)

Where, Pm is the probability of receiving a message without errors

Pb is the bit error rate probability or BER

L is the length of the message

In order to receive a message with no errors, k = 0, so that

{L/k} = 40!/(0!(40!)) = 1

then,

Pm(0) = Pb^0(1-Pb)^40 or,

Pm = (1 – Pb)^L

Solving for Pb, given Pm = 75 %, we have,

Pb = 1 – (Pm)^(1/L) or,

Pb = 1 – (.75)^(1/40) = .0072

Test Setup and Procedure

The processing gain test set-up consists of the following equipment:

- WalkMate unit under test
- HP8648c signal generator
- HP8562e spectrum analyzer
- Two Minicircuits power splitters
- HP variable attenuators
- DSSS burst receiver

The test was conducted by first setting the RF tag in a CW test mode and measuring the power level on the spectrum analyzer. The jammer level was then set relative to the carrier level and measured using marker delta of the spectrum analyzer.

The RF tag was then put in a test mode whereby it output its 40 bit message once every 50 milliseconds. Message error rate software was written to record the number of good messages received in a group of 16 messages.

The passband of the system is +/- 30.5 MHz, so there are 61MHz/50KHz = 1220 test points across the passband of the system. The jammer frequency was set to the lowest frequency in the passband and the jammer level was adjusted until the good message rate measured 12 /16 for the nominal 75% throughput. The jammer was then stepped across the passband in 50 KHz increments and the highest jammer level which still allowed 75% throughput was logged at each frequency. This information was recorded in an Excel spreadsheet.

Test Results

Using the jamming margin method, the processing gain (in dB) is defined as

$$Gp = S/N + Mj + Lsys$$

The required S/N, was derived from the equation Pb = ½ exp(-S/N) for non coherent DBPSK waveforms. Using the BER of .0072 determined above resulted in a S/N of 6.3 dB.

To determine Mj, the test data from the jamming margin test was utilized. An Excel Spreadsheet showing the maximum J/S ratio which allowed a good message rate of 75 % for each of the 1220 frequencies in the passband has been submitted as a separate document. A graph summarizing this data is shown in Attachment A. After removing the J/S ratios of the worst 20 %, the lowest remaining J/S level is 7.3 dB.

Given the design parameters of this system, Lsys was estimated to be 2 dB. Combining these results, the measured processing gain is:

$$\text{Measured Processing Gain} = 6.3\text{dB} + 7.3\text{dB} + 2\text{dB} = 15.6\text{ dB}$$

Attachment A

Jammer Level and J/S Ratio Across Passband