2.4GHz Signal Golf Processing Gain

The Signal Golf ranging system consists of a hand held unit (Yard Dog) and a target unit (PIN) located on the flagpole in the cup. Distance to the PIN from the Yard Dog is measured by the time difference of the spreading code transmitted by the Yard Dog and echoed back by the PIN. Both PIN and Yard Dog use a sliding correlator to maximize the receive signal strength (RSSI) and thus align the local spreading code.

Processing gain for the Signal Golf system is measured using the CW jamming margin method and is calculated from **Pg = S/N + Mj + Lsys** as per FCC part 15.247e2 where:

Pg = Processing gain

S/N = signal to noise ratio for chosen BER. In the Signal Golf products, the BER is equivalent to a sync pulse. A sync pulse is produced in the PIN and Yard Dog when the RSSI increases by .45 volts, which corresponds to an increase of 14dB of RF signal at the receiver input. Therefore the **S/N** required for proper operation is 14dB.

Mj = Jamming margin and is calculated in the following manner. A CW jamming signal is added to a modulated transmitted signal. A spectrum analyzer with the VBW set to 30KHz is used to measure the jammer to signal (J/S) ratio. The CW jamming signal level is increased until the PIN or Yard Dog does not respond to the received signal (i.e. PIN does not lock and transmit, Yard Dog does not give distance reading). J/S is measured every 50KHz over a band of +/-5MHz from middle of the channel by changing the jamming frequency in 50KHz steps. As per 15.247e2, the lowest 20% of J/S are discarded and the next lowest value of J/S is used for Mj. Mj was measured at 14dB for the Signal Golf Products.

Lsys = system losses, assumed to be no more than 2dB.

Processing gain is then calculated to be **Pg = 14dB + 14dB + 2dB = 30dB** for the PIN and Yard Dog.

The table below contains measured data to calculate Processing Gain of a Signal Golf PIN. Data was measured every 50KHz from the center of channel 2 at 2431.3MHz out to greater than +5MHz. CW Po is the maximum CW power in dBm at the frequency listed in the table that will not jam the PIN. TX Ave Po is the power of the received signal in dBm at the measured frequency. J/S is the difference between CW Po and TX Ave Po. CW Po and TX Ave Po are combined and attenuated before going to the receiving PIN under test. The first 105 data points covering 5.25MHz of the upper half of the channel were used to calculate Processing Gain with the lowest 21 points discarded as per 15.247e2. The lower half of the channel is a mirror image of the upper half and was not used for the calculation.

Frequency	CW Po	TX Ave Po	J/S	Not Used
2431.30	-23	-38.5	15.5	
2431.35	-21	-42.3	21.3	
2431.40	-19	-39.0	20.0	

2431.45	-25	-37.0	12.0	X
2431.50	-23	-42.1	19.1	
2431.55	-25	-42.7	17.7	
2431.60	-31	-41.2	10.2	X
2431.65	-23	-40.0	17.0	
2431.70	-25	-40.3	15.3	
2431.75	-28	-37.6	9.6	X
2431.80	-24	-39.7	15.7	
2431.85	-11	-41.4	30.4	
2431.90	-17	-37.6	20.6	
2431.95	-21	-38.5	17.5	
2432.00	-18	-38.1	20.1	
2432.05	-26	-32.7	6.7	X
2432.10	-25	-33.5	8.5	X
2432.15	-17	-37.4	20.4	
2432.20	-20	-37.8	17.8	
2432.25	-18	-40.5	22.5	
2432.30	-20	-34.3	14.3	
2432.35	-26	-34.8	8.8	X
2432.40	-26	-35.4	9.4	X
2432.45	-12	-36.5	24.5	
2432.50	-18	-38.6	20.6	
2432.55	-14	-39.2	25.2	
2432.60	-19	-37.7	18.7	
2432.65	-22	-36.4	14.4	
2432.70	-21	-38.6	17.6	
2432.75	-23	-40.0	17.0	
2432.80	-19	-42.0	23.0	
2432.85	-26	-34.0	8.0	X
2432.90	-18	-44.0	26.0	
2432.95	-13	-44.0	31.0	
2433.00	-20	-38.2	18.2	
2433.05	-21	-37.8	16.8	
2433.10	-21	-38.6	17.6	
2433.15	-22	-38.1	16.1	
2433.20	-25	-34.4	9.4	X
2433.25	-25	-34.3	9.3	X
2433.30	-22	-36.7	14.7	
2433.35	-18	-37.4	19.4	
2433.40	-22	-38.3	16.3	
2433.45	-19	-35.7	16.7	
2433.50	-21	-35.7	14.7	
2433.55	-23	-36.3	13.3	X
2433.60	-21	-35.8	14.8	
2433.65	-25	-37.0	12.0	X
2433.70	-25	-33.2	8.2	X
2433.75	-19	-40.6	21.6	
2433.80	-23	-36.4	13.4	X
2433.85	-23	-37.5	14.5	
2433.90	-26	-36.8	10.8	X
2433.95	-17	-40.6	23.6	
2434.00	-20	-41.0	21.0	
2434.05	-23	-39.4	16.4	

2434.10	-21	-39.0	18.0	
2434.15	-14	-42.6	28.6	
2434.20	-24	-37.7	13.7	**X**
2434.25	-20	-33.8	13.8	**X**
2434.30	-22	-39.0	17.0	
2434.35	-23	-41.2	18.2	
2434.40	-15	-37.5	22.5	
2434.45	-24	-41.6	17.6	
2434.50	-19	-39.2	20.2	
2434.55	-25	-38.7	13.7	**X**
2434.60	-22	-39.5	17.5	
2434.65	-23	-37.6	14.6	
2434.70	-20	-37.4	17.4	
2434.75	-17	-43.3	26.3	
2434.80	-17	-42.1	25.1	
2434.85	-24	-37.5	13.5	**X**
2434.90	-22	-39.0	17.0	
2434.95	-21	-36.5	15.5	
2435.00	-23	-36.5	13.5	**X**
2435.05	-18	-37.8	19.8	
2435.10	-20	-41.1	21.1	
2435.15	-18	-43.0	25.0	
2435.20	-21	-41.2	20.2	
2435.25	-21	-39.9	18.9	
2435.30	-21	-38.3	17.3	
2435.35	-20	-40.5	20.5	
2435.40	-19	-37.7	18.7	
2435.45	-18	-38.3	20.3	
2435.50	-17	-42.0	25.0	
2435.55	-16	-41.7	25.7	
2435.60	-18	-38.2	20.2	
2435.65	-19	-42.4	23.4	
2435.70	-22	-38.9	16.9	
2435.75	-15	-40.3	25.3	
2435.80	-15	-43.7	28.7	
2435.85	-23	-40.7	17.7	
2435.90	-25	-38.1	13.1	**X**
2435.95	-16	-42.0	26.0	
2436.00	-19	-40.4	21.4	
2436.05	-13	-41.0	28.0	
2436.10	-18	-41.5	23.5	
2436.15	-18	-40.8	22.8	
2436.20	-15	-40.6	25.6	
2436.25	-23	-42.1	19.1	
2436.30	-21	-40.0	19.0	
2436.35	-23	-37.0	14.0	**Used**
2436.40	-17	-39.8	22.8	
2436.45	-21	-41.5	20.5	
2436.50	-17	-41.6	24.6	
2436.55	-18	-43.4	25.4	Last data
2436.60	-16	-40.6	24.6	Point used
2436.65	-14	-40.6	26.6	
2436.70	-16	-43.2	27.2	

2436.75	-19	-41.7	22.7	
2436.80	-11	-42.8	31.8	
2436.85	-19	-40.7	21.7	
2436.90	-15	-38.2	23.2	
2436.95	-13	-41.2	28.2	
2437.00	-18	-43.0	25.0	
2437.05	-18	-41.0	23.0	
2437.10	-19	-43.2	24.2	
2437.15	-13	-46.7	33.7	
2437.20	-20	-41.0	21.0	
2437.25	-16	-42.5	26.5	

An alternative method of determining the process gain of a receiver is to compare the noise bandwidth of the receiver with the noise bandwidth of the transmitted signal. For the Signal Golf products the transmitted bandwidth is 10.08MHz and the receiver IF bandwidth is 30KHz. Therefore Pg = 10Log(10.08MHz/30KHz) = 25.26dB. This method cannot be used for FCC qualification but shows that the Signal Golf products should meet the 20dB processing gain margin needed for FCC with respect to noise bandwidth ratio.