Namaste Link Analysis

version 2.0
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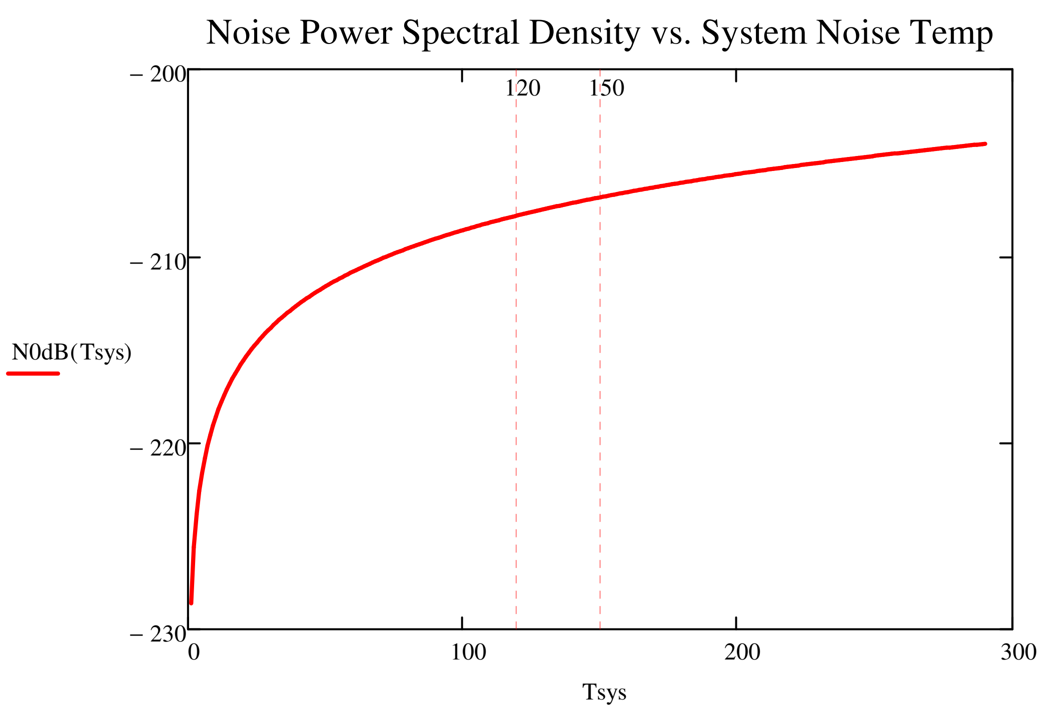
$k := 1.3806503 \cdot 10^{-23}$ Boltzmann's constant.

$Tsys := 0, 1 .. 290$ System noise temperature.

$N0dB(Tsys) := 10 \log(k \cdot Tsys)$ Noise power spectral density in dB



Receive noise temperature in the expected range of 120K to 150K gives the following spectral noise densities in dB.

$N0dB(120) = -207.807 \times 10^{0}$

$N0dB(150) = -206.838 \times 10^{0}$

$SdB := -142$ Assuming 20W RF power at spacecraft, 18dB gain at spacecraft, 195dB path loss, and 22dB gain at ground station. This is RF flux in dB.

$EbN0 := 3$ Required Eb/N0 for the voyager code.

$N0dB := -206, -207 .. -208$ Range of interest given 150 > Tsys > 120

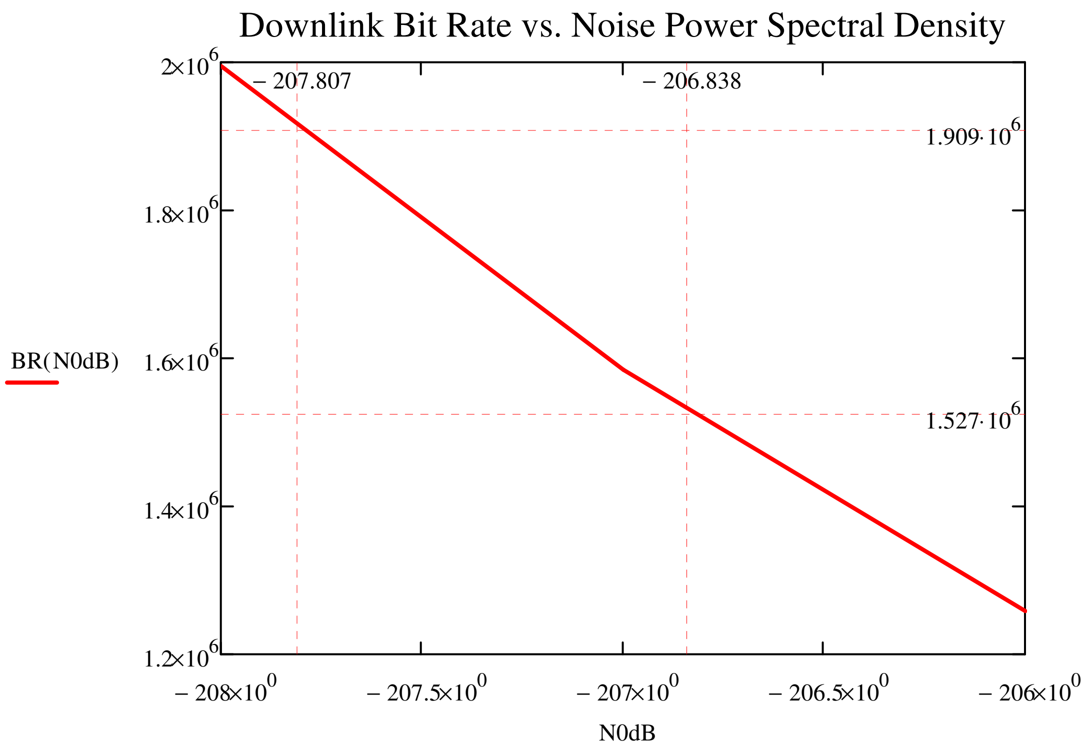
$BRdB(N0dB) := SdB - N0dB - EbN0$ Bit rate in dB

$$BR(N0dB) := 10^{\left(\frac{BRdB(N0dB)}{10}\right)}$$ Bit rate in Hz

Marked on the graph below are the data rates expected given receive system noise temperatures of 150K to 120K, 20W RF at spacecraft, 18dB gain at spacecraft, and 22dB of antenna gain on the ground.

At 150K, the bit rate is $BR(-206.838) = 1.527 \times 10^{6}$

At 120K, the bit rate is $BR(-207.807) = 1.909 \times 10^{6}$



Receive

Receive bandwidth is 3400-3410 MHz.

A simple evaluation of the capacity of the downlink is as follows. Assume 15kHz per user for voice. This includes a generous amount for a quality vocoder as well as the overhead for that vocoder. 15kHz per user goes into a data rate of 1.5 Mbps one hundred times, for a capacity of approximately 100 simultaneous downlink voice users, if the system noise temperature is150K and the assumptions given above concerning the receive RF flux are true.

$$\frac{1.527 \cdot 10^6}{15 \cdot 10^3} = 101.8 \times 10^0$$

Transmit - 8ary FSK

Transmit bandwidth is 10MHz located within 5650-5670 MHz.

For a bit rate of 15kbps, using 8ary FSK, that is 5ksymbols/second. Every three bits is represented as one tone. In order to maintain orthogonality using noncoherent modulation, the 8 tones must be separated by the symbol rate, so each user takes 40kHz of bandwidth [(8 tones)(5kHz)]. This rate can be halved with coherent modulation, for a result of 20kHz.

Coherency means that the phase of each tone has a fixed phase relationship with respect to a reference. This means that transitions from tone to tone must be phase continuous. This means that the frequency differences between the tones and symbol rate must be interrelated. The frequency differences between the tones is called the shift.

A synchronous FSK signal which has the shift equal to an exact integral multiple of the keying rate in bauds is the most common form of coherent FSK. Coherent FSK has superior error performance. Noncoherent FSK is simpler to generate. Noncoherent FSK has no special phase relationship between consecutive elements.

$M := 8$ Set the order of the modulation.

$data\_rate := 15 \cdot 10^3$ Set the data rate.

$bits\_per\_symbol := \log(M, 2)$

$bits\_per\_symbol = 3 \times 10^0$ Obtain bits per symbol.

$$symbol\_rate := \frac{data\_rate}{bits\_per\_symbol}$$

$symbol\_rate = 5 \times 10^3$ Obtain the symbol rate.

$noncoherent\_bandwidth := symbol\_rate \cdot M$

$noncoherent\_bandwidth = 40 \times 10^3$ Minimum noncoherent modulation bandwidth required.

$$\text{coherent\_bandwidth} := \text{symbol\_rate} \cdot \frac{M}{2}$$

$$\text{coherent\_bandwidth} = 20 \times 10^{3}$$

Minimum coherent modulation bandwidth required.

$$\text{uplink\_bandwidth} := 10 \cdot 10^{6}$$

Set the uplink bandwidth available.

$$\text{uplink\_noncoherent\_capacity} := \frac{\text{uplink\_bandwidth}}{\text{noncoherent\_bandwidth}}$$

$$\text{uplink\_noncoherent\_capacity} = 250 \times 10^{0}$$

Maximum uplink voice capacity for noncoherent modulation case.

$$\text{uplink\_noncoherent\_capacity} := \frac{\text{uplink\_bandwidth}}{\text{coherent\_bandwidth}}$$

$$\text{uplink\_noncoherent\_capacity} = 500 \times 10^{0}$$

Maximum uplink voice capacity for coherent modulation case.

Noncoherent voice rate modulation tones would last for 25 microseconds. Coherent voice rate modulation tones would last for 50 microseconds.

$$\frac{1}{\text{noncoherent\_bandwidth}} = 25 \times 10^{-6}$$

$$\frac{1}{\text{coherent\_bandwidth}} = 50 \times 10^{-6}$$

Revision History

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