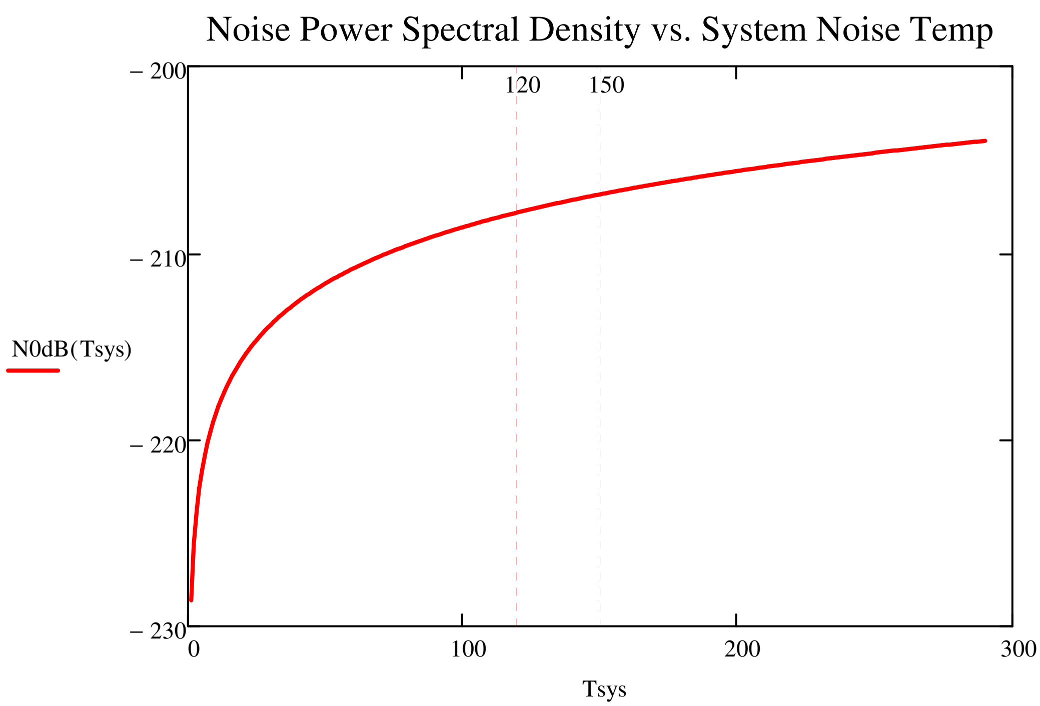
$k := 1.3806503 \cdot 10^{-23}$ Boltzmann's constant.

$Tsys := 0, 1 .. 290$ 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

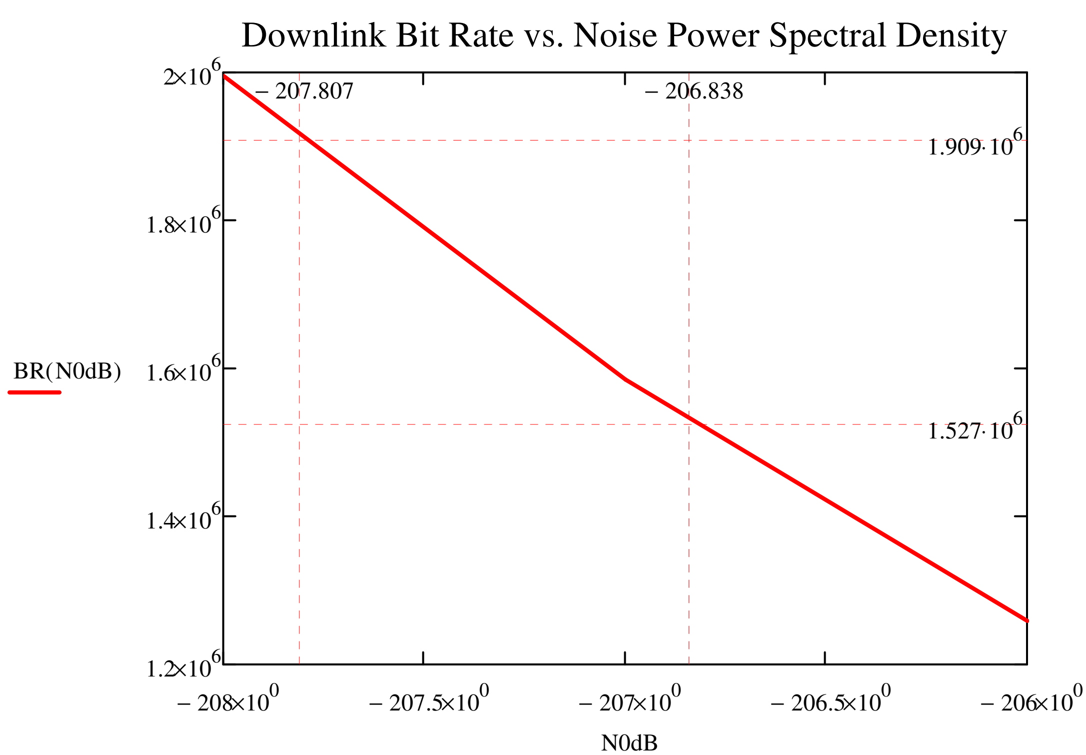
$BRdB(N0dB) := SdB - N0dB - EbN0$ Bit rate in dB

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

Marked on the graph below are the data rates expected given receive system noise temperatures of 150K to 120K.

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 bandwidth is 3400-3410 MHz.

An 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 100 simultaneous voice users, if the system noise temperature is 150K and the assumptions given above concerning the receive RF flux are true.

$$\frac{1.5 \cdot 10^6}{15 \cdot 10^3} = 100 \times 10^0$$

For a bit rate of 15kbps, using 8ary FSK, that is 5ksymbols/second. Every three bits is represented as one tone.

Tone would last for 200 microseconds. To be continued. Comments and feedback requested.