K = Boltzman's constant $1.38 \times 10^{-23}$ in joules per °K

B = Receiver bandwidth in Hz (3000 for ssb)

$P_n = 10 \log_{10} (1.38 \times 10^{-23}) (394.8) (3000)$
$= -167.9$ dBW or $-137.9$ dBm

The system noise temperature ($T_s$) can also be used to calculate system noise figure (SNF)

$SNF = 10 \log_{10} (T_s/290 + 1)$ dB

$SNF = 10 \log_{10} (394.8/290 + 1)$ dB = 3.73 dB

### 2M Signal Level Presented To The Receiver

| | |
|---|---|
| Satellite Output Power 14 W Average | +41.4 dBm |
| $10 \log_{10} (14) + 30$ dB | |
| Satellite Xmit Ant. Gain | +6 dB |
| Free Space Path Loss (146 MHz, 38,000 km) | −168 dB |
| Multi channel Loading Factor (downlink power sharing) | −10 dB |
| Propagation Loss | −1 dB |
| Antenna Pointing and Polarization Loss | −2 dB |
| Ground Station Antenna Gain (KLM16C) | +11 dB |
| Ground Station Feedline Loss (75 feet RG8/U) | −1.5 dB |
| Signal Level Arriving at the Rx | −124.1 dBm |

It was earlier determined that a −137.9 dBm signal can be heard with the receiver set-up. The predicted signal-to-noise ratio of the OSCAR-10 downlink therefore is:

−124.1 dBm − (−137.9) = +13.8 dB

Sat Sig Level Rx Thresh Sig = S/N Ratio

Thus a ground station with an 11-dB gain antenna with 15 dB gain/2 dB noise-figure preamp into a 2-meter receiver with a noise figure of 5 dB, should hear OSCAR-10's 2m Downlink signals consistently 13.8 dB above the noise.

### Simplified OSCAR-10 Uplink Budget

The analysis for uplink receiver threshold is somewhat easier for two reasons. First there are fewer obvious intervening variables for which to account (like multi-channel loading). Second, experience has been gained in manipulating the system variables of noise figure, noise temperature and receiver threshold sensitivity in the downlink example. The data to examine the uplink budget based on a typical station and the details known about OSCAR-10's receiver and antenna are:

| | |
|---|---|
| Ground Station Power Out = 90 W | +49.5 dBm |
| dBm = $10 \log_{10} (90) + 30$ dB | |
| Ground Station Xmit Ant Gain (KLM 18C) | +12 dBc |
| Ground Station Feedline Loss (50' of 7/8" hard line + 30' RG8/U foam) | −1.1 dB |
| Free Space Path Loss (436 MHz, 38,000 km) | −178 dB |
| Propagation Loss | −1 dB |
| Antenna Pointing & Polarization Loss | −2 dB |
| Satellite Receiver Antenna Gain | +6 dB |
| Predicted Signal Level to Satellite RX | −114.6 dBm |

OSCAR-10's receiver has been tested and two parameters have been published to this point. The receiver noise figure measures 3 dB, and from this it is easy to calculate the receiver threshold sensitivity. Also, agc cut in has been measured at −108 dBm (less antenna gain values). It is not clear at this time what the relationship between receiver threshold sensitivity and agc cut in threshold really means.

Receiver Threshold Determination:

Receiver Noise Figure - 3 dB

Convert NF to a ratio Antilog ($0.1 \times 3$ dB)

Ratio = 1.995

Convert Ratio to noise temp

Noise Temp = $(1.995 - 1) \times 290$°K = 288.6°K

Proceeding the same way we did for the downlink analysis, i.e., by specifying the background sky noise temperature and working back to the receiver input terminals.

1. Sky Noise Temperature (Ed. Note: plus the small contribution of the Earth.) - typical background noise temperature at 70 cm is generally agreed to be 100°K.
2. Satellite Antenna Feeder Loss - this variable is assumed to be on the same order as coupling loss, i.e., 0.2 dB. This corresponds to a loss ratio of 1.047, therefore, the equivalent sky temperature is: 100°K/1.047 = 95.5°K.
3. Equivalent Feedline Loss Temperature is equal to the loss ratio - one times 290°K divided by the loss ratio. Therefore:

$$\text{Equiv. Line Loss Temp.} = \frac{(1.047 - 1) \times 290°K}{(1.047)} = 13°K$$

4. 3 dB Noise Figure Satellite Receiver Expressed as a ratio

3 dB = Antilog ($0.1 \times 3$ dB) = 1.995

Noise Temperature =
$(1.995 - 1) \times 290$°K = 288.5°K

The system noise temperature, $T_s$, for the satellite receiver is therefore:

$T_x$ = Equivalent Sky Temp + Equivalent Line Loss Temp + Receiver Noise Temp

$T_s$ = 95.5°K + 13°K + 288.5°K

$T_s$ = 397°K

From this value for $T_s$ of 397°K it is possible to determine the satellite receiver threshold sensitivity using the equation:

$Pn_w = 10 \log_{10} KT_sB$
$= 10 \log_{10} (1.38 \times 10^{-23})(397°K)(3000)$
$= -167.8$ dBW or 137.8 dBm

It is also possible to convert system noise temperature, $T_s$, to system noise figure:

$SNF = 10 \log_{10}(T_s/290 + 1)$dB
$= 10 \log_{10}(397/290 + 1)$dB = 3.74 dB

Having calculated how much signal the example station will present to the satellite's receiver and determined the receiver threshold sensitivity of the satelite, subtracting these two figures gives the predicted signal-to-noise ratio of the signal as it arrives at the satellite: