# Mars Pathfinder X-band Downlink Budget

| Item | Symbol | Value (linear units) | Value (logarithmic units) |
|---|---|---|---|
| Transmit power | $W_t$ | 10 W | +10 dBW |
| Transmit antenna gain | $G_t$ | 251.1 | +24.0 dBi |
| Effective isotropic radiated power | EIRP | 2.51 kW | +34 dBw |
| Free space path loss | $\left(\frac{\lambda}{4\pi R}\right)^2$ | $220 \times 10^{-30}$ | -276.6 dB |
| Received isotropic power | $W_r/G_r$ | $554 \times 10^{-27}$ W | -242.6 dBW |
| Receive antenna gain | $G_r$ | $6.31 \times 10^3$ | 68.0 dBi |
| Power at receiver | $W_r$ | $3.49 \times 10^{-18}$ W | -174.6 dBW or -144.6 dBm |

## Details

| Item | Value |
|---|---|
| Operating frequency | 8420 MHz |
| Mars-Earth distance as of 4-Jul-97 | $191 \times 10^6$ km |

The operating wavelength is $c/f = 3.56$ cm, which is used in the path loss calculation.

To put things in perspective, a standard cellular phone would require approximately -100 dBm of received power to even properly recover a signal. The NASA receiver is obviously much more sensitive (approximately 45 dB more sensitive, or 31,600 times as sensitive).

The NASA Deep Space Network uses a series of large reflector antennas to receive signals from distance probes. The antenna uses here was a 34 m reflector antenna. An ideal aperture of this area would produce $D = \frac{4\pi}{\lambda^2}(\pi \cdot 17^2) = 69.5$ dBi of gain. Most reflectors have an aperture efficiency of 70%, so after you account for this the gain shown in the table matches well with this simple calculation.

Reference: `http://www.ka9q.net/mpf_budget.html`