# ALTERNATE TWO-WAY RADAR EQUATION

In this section the same radar equation factors are grouped differently to create different constants as is used by some authors.

**TWO-WAY RADAR EQUATION (MONOSTATIC)**

Peak power at the radar receiver input is: $P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4} = \frac{P_t G_t G_r \sigma c^2}{(4\pi)^3 f^2 R^4}$ * $\quad$ ($Note$: $\lambda = \frac{c}{f}$ and $\sigma$ is $RCS$) **[1]**

* Keep λ or c, σ, and R in the same units. On reducing the above equation to log form we have:

or: $\mathbf{10\log P_r = 10\log P_t + 10\log G_t + 10\log G_r - \alpha_2}$ (in dB)

Where: $\alpha_2 = 20\log f_1 R^2 - 10\log \sigma + K_3$, and $K_3 = -10\log c^2/(4\pi)^3$

Note: Losses due to antenna polarization and atmospheric absorption (Sections 3-2 and 5-1) are not included in these equations.

$K_3$ Values: (dB)

| Range Units | $f_1$ in MHz σ in $m^2$ | $f_1$ in GHz σ in $m^2$ | $f_1$ in MHz σ in $ft^2$ | $f_1$ in GHz σ in $ft^2$ |
|---|---|---|---|---|
| NM | 114.15 | 174.15 | 124.47 | 184.47 |
| km | 103.44 | 163.44 | 113.76 | 173.76 |
| m | -16.56 | 43.44 | -6.24 | 53.76 |
| yd | -18.1 | 41.9 | -7.78 | 52.22 |
| ft | -37.2 | 22.8 | -26.88 | 33.12 |

In the last section, we had the basic radar equation given as equation [6] and it is repeated as equation [1] in the table above.

In section 4-4, in order to maintain the concept and use of the one-way space loss coefficient, $\alpha_1$, we didn't cancel like terms which was done to form equation [6] there. Rather, we regrouped the factors of equation [5]. This resulted in two minus $\alpha_1$ terms and we defined the remaining term as $G_\sigma$, which accounted for RCS (see equation [8] & [9]).

Some authors take a different approach, and instead develop an entirely new single factor $\alpha_2$, which is used instead of the combination of $\alpha_1$ and $G_\sigma$.

If equation [1] is reduced to log form, (and noting that $f = c/\lambda$) it becomes:

$$10\log P_r = 10\log P_t + 10\log G_t + 10\log G_r - 20\log (f R^2) + 10\log \sigma + 10\log (c^2/(4\pi)^3) \quad \textbf{[2]}$$

We now call the last three terms on the right minus $\alpha_2$ and use it as a single term instead of the two terms $\alpha_1$ and $G_\sigma$. The concept of dealing with one variable factor may be easier although we still need to know the range, frequency and radar cross section to evaluate $\alpha_2$. Additionally, we can no longer use a nomograph like we did in computing $\alpha_1$ and visualize a two-way space loss consisting of two times the one-way space loss, since there are now 3 variables vs two.

Equation [2] reduces to: $\mathbf{10\log P_r = 10\log P_t + 10\log G_t + 10\log G_r - \alpha_2}$ (in dB) **[3]**

Where $\alpha_2 = 20\log (f_1 R^2) - 10\log \sigma + K_3$ and where $f_1$ is the MHz or GHz value of frequency

and $K_3 = -10\log (c^2/(4\pi)^3) + 20\log$ (conversion for Hz to MHz or GHz)+ 40log (range unit conversions if not in meters) - 20log (RCS conversions for meters to feet)

The values of $K_3$ are given in the table above.

Comparing equation [3] to equation [10] in Section 4-4, it can be seen that $\alpha_2 = 2\alpha_1 - G_\sigma$.