

# Range Equation

$$f_0 := 2.408 \cdot 10^9 \cdot \text{Hz} \quad D := 2.7 \cdot 10^{-3} \text{m} \quad \lambda := \frac{c}{f_0} = 0.124 \text{m} \quad \gamma_{\text{air}} := 2$$

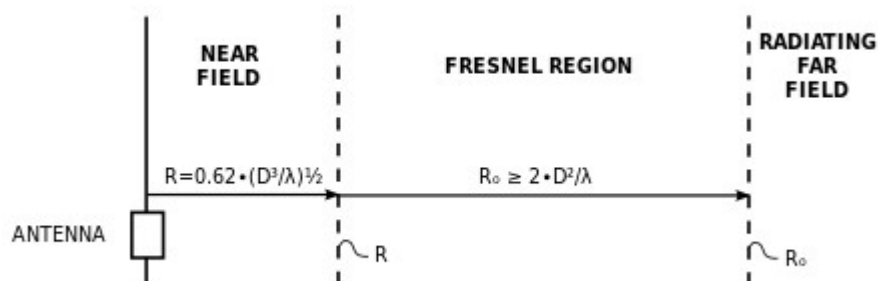
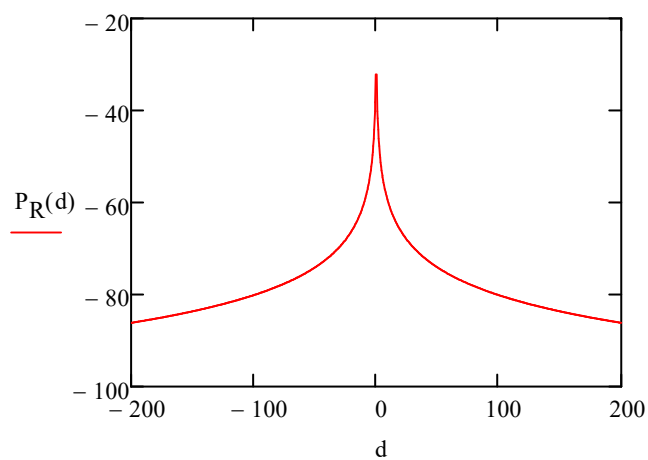
$$\gamma_{\text{Shannon}} := 5.5$$

$$d_0 := \frac{2 \cdot D^2}{\lambda} = 1.171 \times 10^{-4} \text{m} \quad G_t := 1 \quad G_r := 1 \quad P_{\text{tx}} := 0.001 \quad L_1 := 1$$

$$(1) \quad P_{\text{rcvd}}(d) = \frac{P_{\text{tx}} \cdot G_t \cdot G_r \cdot \lambda^2}{(4\pi)^2 \cdot d^2 \cdot L} = \frac{P_{\text{tx}} \cdot G_t \cdot G_r \cdot \lambda^2}{(4\pi)^2 \cdot d_0^2 \cdot L} \cdot \left(\frac{d_0}{d}\right)^2 = P_{\text{rcvd}}(d_0) \cdot \left(\frac{d_0}{d}\right)^{\gamma}$$

$$P_{\text{rcvd}0} := \frac{P_{\text{tx}} \cdot G_t \cdot G_r \cdot \lambda^2}{(4\pi)^2 \cdot d_0^2 \cdot L_1} = 7.157$$

$$P_R(d) := 10 \cdot \log \left[ \frac{P_{\text{rcvd}0} \cdot \left(\frac{d_0}{d \cdot \text{m}}\right)^2}{0.001} \right] \quad P_R(157.1) = -84.004$$



## Doppler spread

$$\text{runningMetersPerPackage} := \frac{12000}{60 \cdot 60 \cdot 4} = 0.833 \quad \text{packageTime} := 0.25 \quad c_{\text{lightspeed}} := 2.998 \times 10^8$$

$$\text{pEnd}_{\text{length}} := \begin{pmatrix} 200 \\ 0 \end{pmatrix} \quad \text{pOnePack}_{\text{length}} := \begin{pmatrix} \text{pEnd}_{\text{length}_0} + \text{runningMetersPerPackage} \\ \text{pEnd}_{\text{length}_1} - 0.4 \end{pmatrix}$$

$$\text{dl}_{\text{length}} := \sqrt{\left(\text{pEnd}_{\text{length}_0} - \text{pOnePack}_{\text{length}_0}\right)^2 + \left(\text{pEnd}_{\text{length}_1} - \text{pOnePack}_{\text{length}_1}\right)^2} = 0.924$$

$$\begin{aligned} v_{\text{length}} &:= \frac{\text{dl}_{\text{length}}}{\text{packageTime}} = 3.697 & v_{\text{height}} &:= \frac{\text{dl}_{\text{height}}}{\text{packageTime}} = 3.333 \\ &(13.30920\text{kph}) & &(11.99880\text{kph}) \end{aligned}$$

$$f_{\text{doppler\_length}} := \frac{v_{\text{length}}}{c_{\text{lightspeed}}} f_0 = 29.698 \cdot \text{Hz} \quad f_{\text{doppler\_height}} := \frac{v_{\text{height}}}{c_{\text{lightspeed}}} f_0 = 26.773 \cdot \text{Hz}$$

$$\text{dv}_{\text{extreme}} := \frac{\text{dv}_{\text{extreme}}}{c_{\text{lightspeed}}} f_0 = 1100000\text{Hz} \text{ solve, } \text{dv}_{\text{extreme}} \rightarrow 136951.82724252491694$$

(493023.6kph)

## Samples Per Round Theory

$$\text{Runde} := 906.1739$$

$$\text{packages} := \frac{\text{Runde}}{\text{runningMetersPerPackage}} = 1.087 \times 10^3$$

$$\frac{2\pi}{\text{packages}} = 5.778 \times 10^{-3}$$

$$\frac{\text{packages}}{4} = 271.852$$

$$\text{outOfRange} := 61$$

$$\text{inRange} := 271.852 - \text{outOfRange} = 210.852$$

## Samples Per Round Small Track Test Setup

$$\text{PackagesPerSec} := 50$$

$$\text{runningMetersPerPackage\_Tog} := \frac{0.2604}{50}$$

$$\text{Round\_small} := 0.435 \quad \text{Rounds\_small} := 168$$

$$\text{totalLength} := \text{Rounds\_small} \cdot \text{Round\_small} = 73.08$$

$$\text{packages\_small} := \frac{\text{Round\_small}}{\text{runningMetersPerPackage\_Tog}} = 83.525$$

$$\text{Length\_in\_range} := 2 \cdot (0.131 + 0.05)$$

$$\text{Packages\_in\_range} := \frac{\text{Length\_in\_range}}{\text{runningMetersPerPackage\_Tog}} = 69.508$$

$$\text{outOfRange\_Package\_small} := \text{packages\_small} - \text{Packages\_in\_range} = 14.017$$

$$\text{TotalRelayedPackages\_small} := \text{outOfRange\_Package\_small} \cdot \text{Rounds\_small} = 2.355 \times 10^3$$

## Samples Per Round Large Track Test Setup

$$\text{Runde\_large} := 0.56 \quad \text{Rounds\_large} := \frac{\text{totalLength}}{\text{Runde\_large}} = 130.5$$

$$\text{packages\_large} := \frac{\text{Runde\_large}}{\text{runningMetersPerPackage\_Tog}} = 107.527$$

$$\text{outOfRange\_Package\_Out\_Large} := \text{packages\_large} - \text{Packages\_in\_range} = 38.018$$

$$\text{TotalRelayedPackages\_large} := \text{outOfRange\_Package\_Out\_Large} \cdot \text{Rounds\_large} = 4.961 \times 10^3$$

## Relationship of the tracks

$$\text{TrackRelayPercentage} := \frac{\text{TotalRelayedPackages\_large}}{\text{TotalRelayedPackages\_small}} \cdot 100 = 210.69$$

$$\text{RelaysDiff} := \text{TotalRelayedPackages\_large} - \text{TotalRelayedPackages\_small} = 2.607 \times 10^3$$