Radar Range Equation: Received Power and Maximum Range

Received echo power and maximum detection range of a monostatic radar from transmit power, antenna gain, frequency, target cross-section and sensitivity.

Method: Monostatic radar range equation

Input parameters

Unit system: SI

Parameter	Value	Unit
Peak transmit power	10.000	kW
Antenna gain (dBi)	30.000	
Frequency	9.4000	GHz
Radar cross-section of the target	10.000	m²
System losses (dB)	4.0000	
Minimum detectable signal (dBm)	-95.000	
Target range	20.000	km

Calculated results

Parameter	Value	Unit
Wavelength	31.893	mm
Received power at the range (dBm)	-98.944	
Maximum detection range	15.938	km
Margin at the range (dB)	-3.9436	

Notes for this case

• Power radiated from the antenna spreads over a sphere, a target of cross-section σ re-radiates what it intercepts, and the echo spreads again on the way back, so the received power falls with the fourth power of range: P_r = P_t G² λ² σ/[(4π)³ R⁴ L]. Doubling the range needs 16 times the power. The maximum range is where P_r equals the minimum detectable signal; pulse integration and the probability of detection change the effective sensitivity.

Formula and method

$$P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4 L}, \quad R_{max} = \left[\frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 L\, S_{min}}\right]^{1/4}$$

Variables

P_t	Peak transmit power	W
G	Antenna gain (dBi)	-
f	Frequency	1/s
σ	Radar cross-section of the target	m²
L	System losses (dB)	-
S_{min}	Minimum detectable signal (dBm)	-
R	Target range	m
λ	Wavelength	m
P_r	Received power at the range (dBm)	-
R_{max}	Maximum detection range	m
$P_r - S_{min}$	Margin at the range (dB)	-

Method and standards

Radar equation.

Assumptions and limits

- Free space; same antenna for transmit and receive; no clutter.

References

Monostatic radar range equation

Report details

Report reference	FCC-6YRY-MKY9 (the same inputs always give the same reference)
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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/electronics/radar-range-equation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.