# Antenna Return Loss v Reflected Power & Mismatch

The table converts between return-loss, VSWR, reflection coefficient, and mismatch loss. It also shows the percentage of forward to reflected power. Particularly, reflected power and mismatch loss help describe the need for the antenna (with its matching network) to present a suitable return-loss to the active electronics. Note that the VSWR and reflection coefficient are just different ways to represent return-loss.

| Return Loss (dB) | Reflected Pwr (%) | Forward Power (%) | Mismatch Loss (dB) | VSWR | Reflection Coefficient |
|---|---|---|---|---|---|
| 0.00 | 100.00 | 0.00 | ∞ | ∞ | 1.00 |
| 1.00 | 79.43 | 20.57 | 6.87 | 17.39 | 0.89 |
| 2.00 | 63.10 | 36.90 | 4.33 | 8.72 | 0.79 |
| 3.00 | 50.12 | 49.88 | 3.02 | 5.85 | 0.71 |
| 4.00 | 39.81 | 60.19 | 2.20 | 4.42 | 0.63 |
| 5.00 | 31.62 | 68.38 | 1.65 | 3.57 | 0.56 |
| 6.00 | 25.12 | 74.88 | 1.26 | 3.01 | 0.50 |
| 7.00 | 19.95 | 80.05 | 0.97 | 2.61 | 0.45 |
| 8.00 | 15.85 | 84.15 | 0.75 | 2.32 | 0.40 |
| 9.00 | 12.59 | 87.41 | 0.58 | 2.10 | 0.35 |
| 10.00 | 10.00 | 90.00 | 0.46 | 1.92 | 0.32 |
| 12.00 | 6.31 | 93.69 | 0.28 | 1.67 | 0.25 |
| 15.00 | 3.16 | 96.84 | 0.14 | 1.43 | 0.18 |
| 20.00 | 1.00 | 99.00 | 0.04 | 1.22 | 0.10 |
| 30.00 | 0.10 | 99.90 | 0.00 | 1.07 | 0.03 |
| ∞ | 0.00 | 100.00 | 0.00 | 1.00 | 0.00 |

Return Loss = -10 x log [Source Power/ Reflected Power]

Return Loss (dB) = -20 log $|\Gamma|$

Mismatch Loss (dB) = 10 log$[1-\Gamma^2]$

Reflected Power (%) = 100 * $\Gamma^2$

Forward Power (%) = 100 $[1-\Gamma^2]$

VSWR = $[1+|\Gamma|]/[1-|\Gamma|]$

Reflection Coefficient $\Gamma$ = 10^ (-Return Loss/20)

## Return Loss

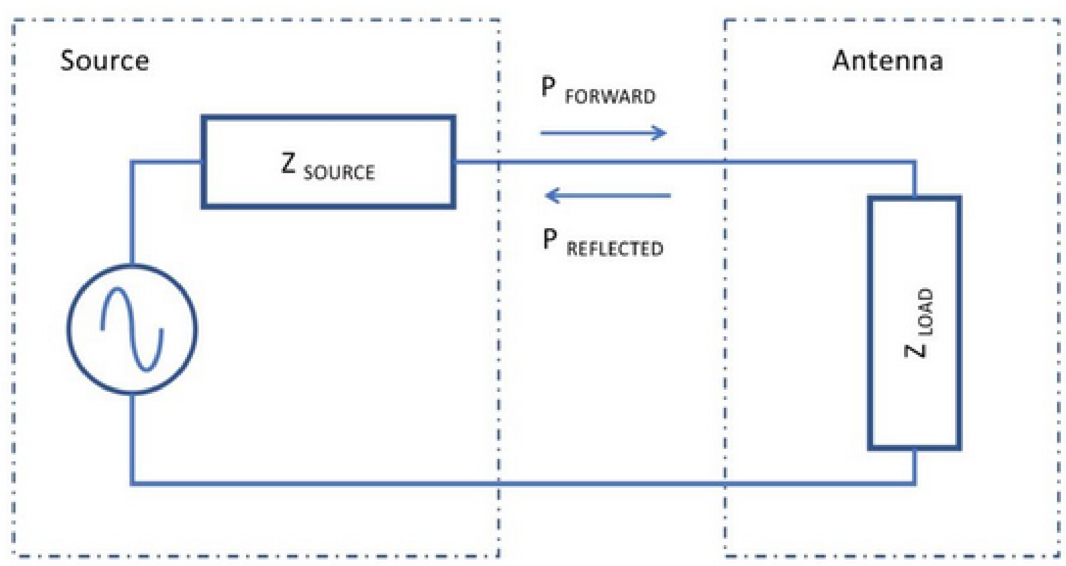
Consider the two rows highlighted in yellow. These are useful to remember and provide an important guiding principle when reviewing antenna performance:

- **6 dB return loss**
- **10 dB return loss**

The ratio of a sinusoidal signal reflected back from the load to the incident signal is called return loss. The term 'forward power is synonymous with powered deliver to the load, or thru power. Thus with ~ 25% reflected power:

**Return Loss = -10 x Log [ 100/25.12] = 6 dB**

Note: The historical definition of return loss results in a negative sign. More recently this has been dropped/corrected as seen in the table provided here.




## Reflected Power

When the source and antenna load impedance are identical, 100% of the source power transferred to the load and there are no mismatch losses. If the antenna has a for example 100 Ohm input impedance and the source a 50 Ohm impedance then there is a mismatch and power is reflected from the antenna. Here we characterize this impedance mismatch in terms of return loss:

**Return Loss = 20*log [100/50] = 6 dB**

Clearly, the power reflected back from the antenna to the source should be minimized as far as possible. But due to antenna bandwidth constraints such as those posed by wideband antennas such as LTE, a lower limit of 6 dB is the commonly accepted worst-case value. In other words, more than 25% reflected power is generally unacceptable and in terms of PTCRB makes carrier TRP compliance perhaps very difficult.

## Mismatch Loss

The mismatch loss is another way of representing reflected power. It is caused by any difference between the source and load impedance. For example, in the case of a modular cellular power amplifier, this generally requires a 50 Ohm load for maximum power transfer. Mismatch loss should be minimized in cascaded RF system calculations and can represent a significant loss of power delivered to the antenna. Consider the 6dB antenna return loss case discussed here with ~ 1.25 dB mis-match loss.

**Mismatch loss (%) = 100 x $[1-10^{(-0.5/10)}]$ ~ 25%**

## Maximum Power Transfer

The maximum power transfer from source to load occurs when the source impedance is equal to the load impedance. For example, a 1 Watt power amplifier (source) optimized for use in a 50 Ohm system will deliver 0.75W into an antenna with a 6 dB return loss.

**Power = Source Power (W) x Forward Power (%) = 1W x 75% = 0.75W**