From April 2008 *High Frequency Electronics*
Copyright © 2008 Summit Technical Media LLC

Return Loss, Reflection Coefficient and VSWR

Here is a brief review of three related RF transmission parameters, along with a reference table of their values.

At high frequencies, the actual voltages, currents and phase relationships that define an impedance are difficult to measure directly. Instead, we use steady-state measurements of the traveling waves in transmission lines, which can be separated by a directional coupler into those traveling in "forward" and "reverse" (or "reflected") directions.

Return loss, *reflection coefficient* and *voltage standing wave ratio* are different numerical values for these radio frequency transmission measurements. Although they are related mathematically, each refers to a different means of measurement or analysis.

Reflection coefficient (Γ) is the fraction of a forward traveling wave that is reflected from a mismatched load, expressed in polar coordinates ($|\Gamma| \angle \theta$). The magnitude has no units, since it is a ratio, and is also referred to as rho (ρ). The phase angle may be given as 0 to 360 degrees or +180 to –180 degrees, depending on the analytical system that will use the data.

Return loss (RL) is the ratio of the magnitude of the forward and reverse traveling waves, squared to represent power and converted to dB. Thus, it is related to reflection coefficient by

$$RL = 10 \log (|\Gamma|^2)$$

Voltage standing wave ratio (VSWR) dates to the time when slotted lines were the primary means of transmission line measurements. VSWR is simply the ratio of the standing wave maxima and minima, as measured by moving the probe along the line. Being a voltage measurement, it is related to Γ by

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{V_{fwd} + V_{ref}}{V_{fwd} - V_{ref}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

VSWR is typically used with installed systems such as transmitter and antenna installations. RL and Γ are more common in laboratory practice.

The accompanying table is a handy reference to equivalent values of RL, VSWR and $|\Gamma|$ over a range of RL values from 1 to 60 dB.

Return Loss (dB)	VSWR	Reflection Coefficient Magnitude	Return Loss (dB)	VSWR	Reflection Coefficient Magnitude
60.00	1.002	0.001	14.00	1.499	0.200
55.00	1.004	0.0018	13.50	1.536	0.211
50.00	1.006	0.0032	13.00	1.577	0.224
45.00	1.011	0.0056	12.50	1.622	0.237
40.00	1.02	0.01	12.00	1.671	0.251
37.00	1.029	0.0141	11.50	1.70	0.266
34.00	1.041	0.020	11.00	1.75	0.282
31.00	1.058	0.0282	10.50	1.785	0.299
30.00	1.065	0.0316	10.00	1.851	0.316
29.00	1.074	0.0355	9.50	2.007	0.335
28.00	1.083	0.0398	9.00	2.10	0.355
27.00	1.094	0.0447	8.50	2.15	0.376
26.00	1.106	0.0501	8.00	2.323	0.398
25.00	1.119	0.0562	7.50	2.458	0.422
24.00	1.135	0.0631	7.00	2.615	0.447
23.00	1.152	0.0708	6.50	2.796	0.473
22.00	1.173	0.0794	6.00	3.10	0.501
21.00	1.196	0.0891	5.50	3.263	0.531
20.00	1.222	0.1	5.00	3.57	0.562
19.00	1.253	0.112	4.50	3.946	0.596
18.00	1.288	0.126	4.00	4.419	0.631
17.00	1.329	0.141	3.50	5.030	0.668
16.50	1.352	0.150	3.00	5.848	0.707
16.00	1.377	0.159	2.50	7.00	0.750
15.50	1.404	0.168	2.00	8.724	0.794
15.00	1.433	0.178	1.50	11.610	0.841
14.50	1.464	0.188	1.00	17.391	0.891