

Tables and Formulas for Return and Transmission Loss

Application Note

AN/155

Fig. 1 shows a two terminal network impedance, Z, fed by a generator E with internal impedance R_s . Its equivalent circuit, shown in Fig. 2, replaces the impedance Z by a generator ρE also with internal impedance R_s . There will be equivalence, i.e. terminal voltage V_{AB} will be the same in both cases when

$$\rho = (Z - R_s) / (Z + R_s)$$

ρ is known as the reflection factor. It is a complex number whose magnitude is expressed in %. When expressed in dB, it is known as return loss.

Return loss $RL = -20 \log |\rho|$

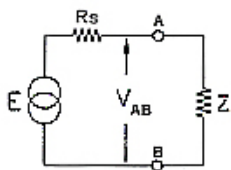


Fig. 1. Two-Terminal Circuit.

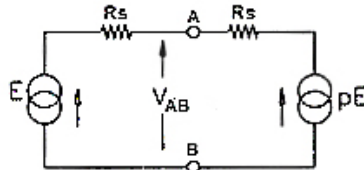


Fig. 2. Equivalent Circuit.

The power delivered to the right-hand side of terminals AB consists of positive, "incident" power from generator E and negative "reflected" power from generator ρE , where

"incident" power, $P_i = E^2 / 4R_s$
 "reflected" power, $P_r = |\rho|^2 \times P_i$
 delivered power, $P_d = P_i - P_r$

transmission ratio, $P_d/P_i = 1 - |\rho|^2$
 transmission loss, $TL = -10 \log(P_d/P_i)$
 $= -10 \log\{1 - (|\rho|^2)\}$

Since the circuit is matched in both directions, the power delivered by the generators is the maximum available.

VSWR, a term borrowed from transmission line theory, is defined as

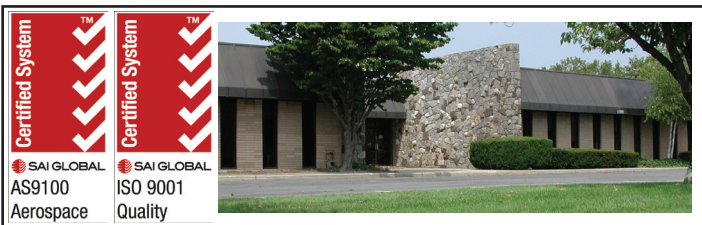
$$VSWR = Z / R \text{ and } \rho = (VSWR - 1) / (VSWR + 1)$$

The table gives equivalent values of ρ , VSWR, RL, and TL. VSWR assumes resistive loads.

ρ = REFLECTION FACTOR
TL = TRANSMISSION LOSS

RL = RETURN LOSS

ρ	VSWR	RETURN LOSS-dB	TRANSM. LOSS-dB	ρ	VSWR	RETURN LOSS-dB	TRANSM. LOSS-dB
0.1	1.002	60.000	0.000004	11.6	1.262	18.711	0.058835
0.2	1.004	53.979	0.000017	11.8	1.268	18.562	0.060896
0.3	1.006	50.458	0.000039	12.0	1.273	18.416	0.062993
0.4	1.008	47.959	0.000069	12.2	1.278	18.273	0.065126
0.5	1.010	46.021	0.000108	12.4	1.283	18.132	0.067296
0.6	1.012	44.437	0.000156	12.6	1.288	17.993	0.069502
0.7	1.014	43.098	0.000213	12.8	1.294	17.856	0.071744
0.8	1.016	41.938	0.000278	13.0	1.299	17.721	0.074023
0.9	1.018	40.915	0.000352	13.2	1.304	17.589	0.076338
1.0	1.020	40.000	0.000434	13.4	1.309	17.458	0.078690
1.1	1.022	39.172	0.000526	13.6	1.315	17.329	0.081079
1.2	1.024	38.416	0.000625	13.8	1.320	17.202	0.083505
1.3	1.026	37.721	0.000734	14.0	1.326	17.077	0.085967
1.4	1.028	37.077	0.000851	14.2	1.331	16.954	0.088466
1.5	1.030	36.478	0.000977	14.4	1.336	16.833	0.091002
1.6	1.033	35.918	0.001112	14.6	1.342	16.713	0.093575
1.7	1.035	35.391	0.001255	14.8	1.347	16.595	0.096185
1.8	1.037	34.895	0.001407	15.0	1.353	16.478	0.098832
1.9	1.039	34.425	0.001568	15.2	1.358	16.363	0.101516
2.0	1.041	33.979	0.001738	15.4	1.364	16.250	0.104238
2.1	1.043	33.556	0.001916	15.6	1.370	16.138	0.106997
2.2	1.045	33.152	0.002102	15.8	1.375	16.027	0.109793
2.3	1.047	32.765	0.002298	16.0	1.381	15.918	0.112627
2.4	1.049	32.396	0.002502	16.2	1.387	15.810	0.115498
2.5	1.051	32.041	0.002715	16.4	1.392	15.703	0.118407
2.6	1.053	31.701	0.002937	16.6	1.398	15.598	0.121354
2.7	1.055	31.373	0.003167	16.8	1.404	15.494	0.124338
2.8	1.058	31.057	0.003406	17.0	1.410	15.391	0.127360
2.9	1.060	30.752	0.003654	17.2	1.415	15.289	0.130420
3.0	1.062	30.458	0.003910	17.4	1.421	15.189	0.133519
3.2	1.066	29.897	0.004449	17.6	1.427	15.090	0.136655
3.4	1.070	29.370	0.005023	17.8	1.433	14.992	0.139829
3.6	1.075	28.774	0.005632	18.0	1.439	14.895	0.143041
3.8	1.079	28.404	0.006276	18.2	1.445	14.799	0.146292
4.0	1.083	27.959	0.006954	18.4	1.451	14.704	0.149581
4.2	1.088	27.535	0.007668	18.6	1.457	14.610	0.152909
4.4	1.092	27.131	0.008416	18.8	1.463	14.517	0.156275
4.6	1.096	26.745	0.009200	19.0	1.469	14.425	0.159680
4.8	1.101	26.375	0.010018	19.2	1.475	14.334	0.163124
5.0	1.105	26.021	0.010871	19.4	1.481	14.244	0.166606
5.2	1.110	25.680	0.011759	19.6	1.488	14.155	0.170128
5.4	1.114	25.352	0.012682	20.0	1.500	13.979	0.177288
5.6	1.119	25.036	0.013641	21.0	1.532	13.556	0.195875
5.8	1.123	24.731	0.014634	22.0	1.564	13.152	0.215456
6.0	1.128	24.437	0.015663	23.0	1.597	12.765	0.236042
6.2	1.132	24.152	0.016727	24.0	1.632	12.396	0.257647
6.4	1.137	23.876	0.017825	25.0	1.667	12.041	0.280287
6.6	1.141	23.609	0.018959	26.0	1.703	11.701	0.303977
6.8	1.146	23.350	0.020128	27.0	1.740	11.373	0.328734
7.0	1.151	23.098	0.021333	28.0	1.778	11.057	0.354575
7.2	1.155	22.853	0.022572	29.0	1.817	10.752	0.381519
7.4	1.160	22.615	0.023847	30.0	1.857	10.458	0.409586
7.6	1.165	22.384	0.025158	31.0	1.899	10.173	0.438796
7.8	1.169	22.158	0.026503	32.0	1.941	9.897	0.469172
8.0	1.174	21.938	0.027884	33.0	1.985	9.630	0.500736
8.2	1.179	21.724	0.029301	34.0	2.030	9.370	0.533513
8.4	1.183	21.514	0.030752	35.0	2.077	9.119	0.567529
8.6	1.188	21.310	0.032240	36.0	2.125	8.874	0.602811
8.8	1.193	21.110	0.033763	37.0	2.175	8.636	0.639389
9.0	1.198	20.915	0.035321	38.0	2.226	8.404	0.677292
9.2	1.203	20.724	0.036915	39.0	2.279	8.179	0.716554
9.4	1.208	20.537	0.038545	40.0	2.333	7.959	0.757207
9.6	1.212	20.355	0.040210	41.0	2.390	7.744	0.799289
9.8	1.217	20.175	0.041911	42.0	2.448	7.535	0.842837
10.0	1.222	20.000	0.043648	43.0	2.509	7.331	0.887891
10.2	1.227	19.828	0.045421	44.0	2.571	7.131	0.934495
10.4	1.232	19.659	0.047229	45.0	2.636	6.936	0.982693
10.6	1.237	19.494	0.049074	46.0	2.704	6.745	1.032530
10.8	1.242	19.332	0.050954	47.0	2.774	6.558	1.084070
11.0	1.247	19.172	0.052870	48.0	2.846	6.375	1.137350
11.2	1.252	19.016	0.054822	49.0	2.922	6.196	1.192440
11.4	1.257	18.862	0.056811	50.0	3.000	6.021	1.249390



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India +91 80 46797 0368