Return Loss Bridge

BETA TRANSFORMER TECHNOLOGY CORPORATION
A subsidiary of Data Device Corporation

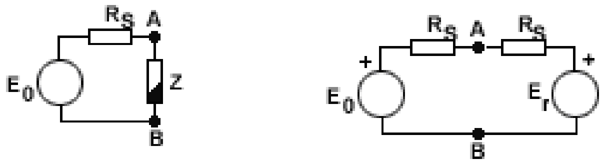
Application Note

AN/157

Return Loss

"Return Loss" is a convenient way to express the magnitude of an impedance.

In communication circuits the object is to insure maximum power transfer from a generator to a load. This occurs when the load matches the internal impedance of the generator, i.e. $Z = R_S$. The degree of mismatch or power loss is then best described by relating load impedance Z to generator impedance R_S.



Single Loop Circuit

Equivalent Circuit

Fig. 1 One-Port Load Circuit.

As shown in Fig.1, we may represent load impedance Z by an equivalent circuit consisting of a generator E_r in series with an impedance R_S equal to the internal impedance of primary generator E_0. Generator E_r creates "negative" or "reflected" power that subtracts from the "incident" power supplied by primary generator E_0, thereby reducing the power delivered to the load. The "negative" power is zero when the circuit is matched, and rises with increasing mismatch. The ratio of the generator output voltages, E_r / E_0, is known as the "reflection factor,"ρ, " and, when expressed in dB, as the "return loss," i.e.

$$\text{Return Loss} = -20 \log |\rho|$$

For example a ρ of 2% is a ratio of 0.02 and equal to roughly –34 dB. One will, however, generally use the term "return loss," which, in this case is 34 dB, the same value as ρ except for the + sign. Loss is always a positive number. A table of reflection factor, return loss and power transmission figures is found in **Application Note 155**, *Tables and Formulas for Return and Transmission Loss, and for convenience is also reproduced at the end of this application note.*

Return Loss Measurement:

There are several approaches to the measurement of return loss:

One is based on the familiar Wheatstone Bridge, shown in Fig. 2. There, impedance is measured by adjusting the upper right-hand arm of known impedances to produce a null in the detector circuit. If that arm is set to the reference value, R_S, the magnitude of the unbalance voltage measured by the detector will be proportional to the reflection factor.

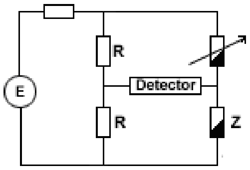


Fig. 2 Wheatstone Bridge

A second approach is the three-port hybrid circuit or return loss bridge shown in Fig. 3. The return Loss Bridge functions by permitting bi-directional power flow between A and B and A and C but blocking transmission between B and C. Ideally, none of the applied signal at B should reach C. In practice, a tiny amount of power will leak from B to C, but that should, generally, not exceed –40 dB. When all three ports are matched, power applied to port A will divide equally between B and C. However, when power is applied to port B, power will reach only A, but none will be delivered to C. When the port A termination is mismatched it will reflect power which is passed equally to ports B and C. Thus the power delivered to C will be a measure of the return loss.

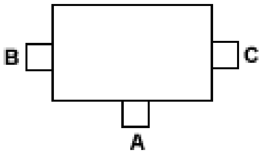


Fig. 3 Hybrid Circuit

North Hills Return Loss Bridges

Regardless of the particular design approach, a return loss bridge is a three-port device. There is a test-port which relates the DUT impedance to a reference value, and input and reflected signal output ports, designed to interface with the network analyzer.

North Hills has developed a series of Return Loss Bridges designed for 50 or 75 ohm network analyzers.

The RL series of bridges operate over the 10kHz to 300MHz frequency range and measure 50, 75 and 93 ohm unbalanced systems. The RLB series operate over the same frequency ranges but measure 75 to 150 ohm balanced networks. Given a particular network analyzer, the correct bridge for a specific application can be selected once the nominal impedance of the item under test and the frequencies of interest are known.

The series of balanced impedance bridges is particularly effective for measuring return loss characteristics of UTP cable.

All bridges read return loss without applying a correction factor.

To make a measurement set the network analyzer display to read 0 dB when the bridge test port is either left open or shorted, i.e. for 100% reflection. When the device to be tested is plugged into the test-port, the display will read return loss directly. See Fig. 4.

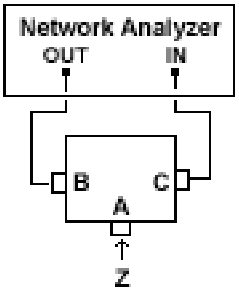


Fig. 4 Return Loss Bridge Measurement Circuit

P = REFLECTION FACTOR RL = RETURN LOSS TL
= TRANSMISSION 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	15.1$9	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	28.874	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	6.874	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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