The Radio Hotel – Return Loss(?)

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BVARC.org Tech-Pages Version

OK, I can hear y'all now, saying....."I finally understand what **SWR** is and how it is calculated and how it is measured and what it means and how best to ensure that it is as low as it can be in my antenna system, etc. etc. etc. And now, y'all are gonna confuse me again by using the term **Return Loss** instead of **SWR**. What the heck?"

Return Loss has surfaced in our ham world due to the new handheld antenna system analyzers like the Nano VNA and others. They will show **SWR** and **Return Loss (RL)**.

Just keep in mind that **SWR** and **Return Loss** are both indicators of the quality of the transmission line to antenna feedpoint Z match. As you know, reflected power is the result of an imperfect impedance match at the antenna (load) feed point. The greater the mis-match, the greater the reflected power. So either measurement indicator will work fine for our Ham Radio world of RF.

The Standing Wave Ratio or VSWR, with which we are most familiar, is a comparative measure of the transmission line's standing wave's maximum and minimum voltage values.

Return Loss, on the other hand, is a measure of the difference between the power forward (incident) and the power reverse (reflected). Showing, essentially, how much lower the reflected power level is versus the forward power level.

SWR is expressed as a ratio, such as 10:1 (bad match), 3:1 (OK match) or 1:1 (a perfect match).

Return Loss uses the decibel - dB scale defining a mathematical difference. Relating reflected power to the forward power. **RL** in its dB scaling allows finer quantification of matching when it gets down to the fine hairs of impedance differences. I would think that this is more applicable in the UHF and above area, *(although that is a SWAG on my part, as I have no experience in that range of RF)*.

For reference: 10:1 SWR is -2dB RL 3:1 SWR is -6dB RL and 1.01:1 SWR is -46dB RL

From here on out, you'll probably use both **SWR** and **RL** representing the same thing – the health of your antenna system's power transfer. So, a comment about the electronic / radio area where we are treading. Just as in Ohm's Law, where resistance, voltage and current are related mathematically, so are impedance and RF voltage, incident (forward) power), return (reverse) power, feed line impedance, etc. It comes down to math. Not that you need to understand the algebra and imaginary numbers involved, but just understand that it is all related and a change in one asset does affect all others.

Reflection Coefficient One other quantity that is important in the measurement of the TL and antenna match is the Reflection Coefficient. It is a simple ratio of Reflected power versus Forward Power. The reflection coefficient is a figure that quantifies the level of the incident waveform that is reflected. Similar to Return Loss, but only expressed as a ratio, not a difference in dB as in the Return Loss. Check out the chart below for comparisons of all pertinent quantities.

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More charts and web sites are referenced below. Enter at your own risk of increasing your knowledge of TL's and the measurement parameters that we use.

These two references below are excellent in providing explanations and equations for VSWR, Reflection Coefficient, etc.

https://www.electronics-notes.com/articles/antennas-propagation/vswr-return-loss/what-is-vswr.php
Just follow the bouncing ball to the various pages.

https://www.rfcafe.com/references/electrical/vswr.htm
This is an excellent web site of equations of all sorts electronics wise.

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Another tool that can be used for TL calculation is **TL Details**. A free transmission line calculation program by Dan Macguire AC6LA.

https://ac6la.com/tldetails1.html

TL Details is rich in capability for showing you the performance of your transmission lines. It can also be used to calculate SWR, if you just put in your R and j values and use 0 for the TL length it will give you the 50 ohm SWR for that Z. TL Details allows you to bypass the graphical Smith Chart, although it does give you a bit of a rough representation of the chart. It is dynamic too, as once you change anything it is immediately recalculated. This is nice as you can hit a length button up or down and keep it pressed. You will see the calculated values change as the length goes thru the half wave points and repeats as TL Z's do.

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Also note, for a foundation level introduction to the subject of SWR and TL's visit
http://bvarc.org/home/tech-pages/
*Read the **SWR—Series of 8 Articles** and **SWR – Seeing Watts Reflected** presentation*

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Another example of VSWR to Return Loss calculators and charts below:

https://www.rfcafe.com/references/calculators/vswr-return-loss-conversion-calculator.htm

RL (dB)	VSWR	Γ	RL (dB)	VSWR	Γ	RL (dB)	VSWR	Γ	RL (dB)	VSWR	Γ
46.1	1.01	0.00498	25.7	1.11	0.0521	18.0	1.29	0.126	8.0	2.32	0.398
40.1	1.02	0.00990	24.9	1.12	0.0566	17.0	1.33	0.141	7.0	2.61	0.447
36.6	1.03	0.0148	24.3	1.13	0.0610	16.0	1.38	0.158	6.0	3.01	0.501
34.1	1.04	0.0196	23.7	1.14	0.0654	15.0	1.43	0.178	5.0	3.57	0.562
32.3	1.05	0.0244	23.1	1.15	0.0698	14.0	1.50	0.200	4.0	4.42	0.631
30.7	1.06	0.0291	22.6	1.16	0.0783	13.0	1.58	0.224	3.0	5.85	0.708
29.4	1.07	0.0338	21.7	1.18	0.0826	12.0	1.67	0.251	2.0	8.72	0.794
28.3	1.08	0.0385	20.8	1.20	0.0909	11.0	1.78	0.282	1.0	17.4	0.891
27.3	1.09	0.0431	20.0	1.22	0.100	10.0	1.92	0.316	0.5	34.8	0.944
26.4	1.10	0.0476	19.0	1.25	0.112	9.0	2.10	0.355	0.0	Infinity	1.00

Return Loss / VSWR / Coefficient of Reflection Equivalence Chart

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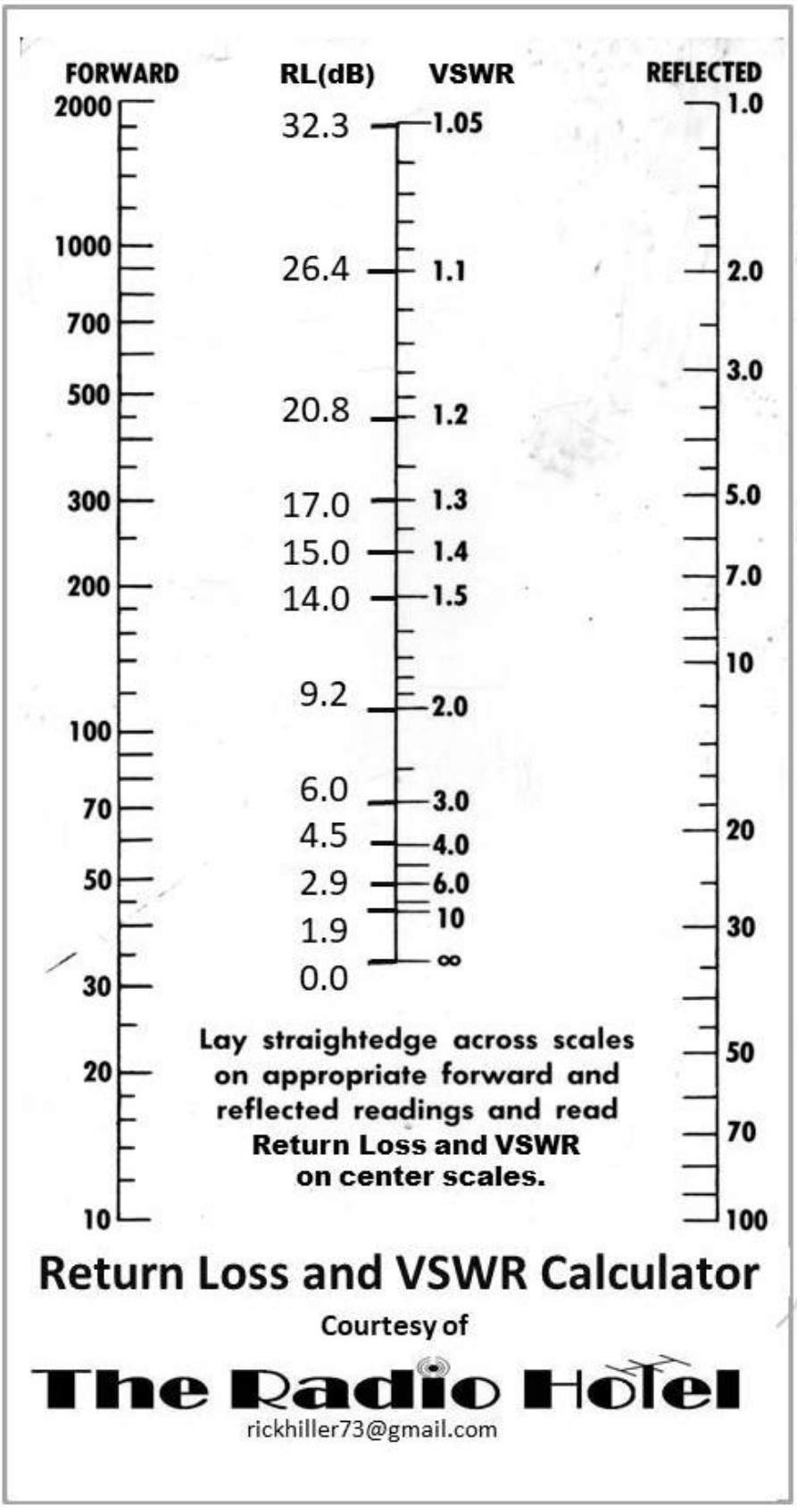
The nomograph below will allow you to determine the VSWR and Return Loss when you have measured Forward (Incident) power and Reflected power. For example, on a Bird Watt Meter, these 2 readings are all you can measure. Further result determination and analysis is done mathematically.



Another very encompassing comparison chart to give you a better feeling of the relationships of VSWR, Return Loss, Reflection Coefficient and Match Loss and Efficiency.

VSWR (:1)	Return Loss (dB)	Reflection Coefficient	Mismatch Loss (dB)	Match Efficiency (%)
1.011	45	0.006	0.000	100.00
1.020	40	0.010	0.000	99.99
1.036	35	0.018	0.001	99.97
1.065	30	0.032	0.004	99.90
1.074	29	0.035	0.005	99.87
1.08	28	0.400	0.007	99.84
1.09	27	0.045	0.009	99.80
1.11	26	0.050	0.011	99.75
1.12	25	0.056	0.014	99.68
1.13	24	0.063	0.017	99.60
1.15	23	0.071	0.022	99.50
1.17	22	0.079	0.027	99.37
1.20	21	0.089	0.035	99.21
1.22	20	0.100	0.044	99.00
1.25	19	0.112	0.055	98.74
1.29	18	0.126	0.069	98.42
1.33	17	0.141	0.088	98.00
1.38	16	0.158	0.110	97.49
1.43	15	0.178	0.140	96.84
1.50	14	0.200	0.176	96.02
1.58	13	0.224	0.223	94.99
1.67	12	0.251	0.283	93.69
1.78	11	0.282	0.359	92.06
1.92	10	0.316	0.458	90.00
2.10	9	0.355	0.584	87.41
2.32	8	0.398	0.749	84.15
2.61	7	0.447	0.967	80.05
3.01	6	0.501	1.256	74.88
3.57	5	0.562	1.651	68.38
4.42	4	0.631	2.205	60.19
5.85	3	0.708	3.021	49.88

Match Efficiency - e.g. 100 Watts Forward Power at 1.33:1 VSWR Yields 98 Watts Output (ie. 2 Watts Reflected).

The End GL and 73….W5RH