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VSWR Calculation

SWR Nomographs (1) and (2) show the proportion between forward and reflected power.

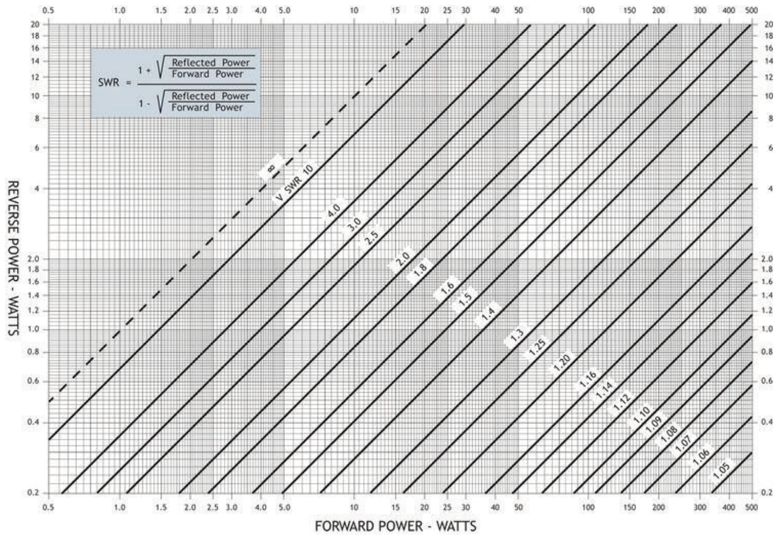
When installing communications systems, and thereby also antenna systems, it would be useful to be able to check that the systems work as they should. Which means that as much power as possible is dissipated in the antenna.

For this purpose you can use SWR Nomographs, which from the forward power and reflected power show the SWR that the transmitter can "see".

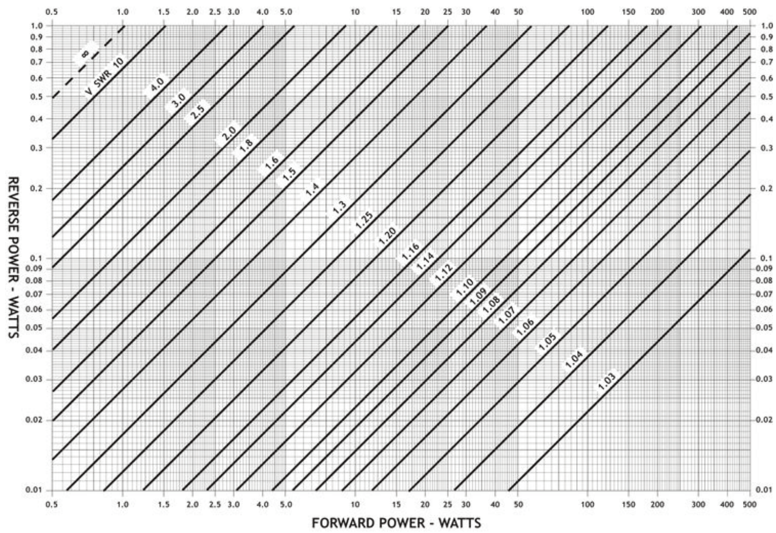
SWR Nomograph (1) and (2) show the proportion between forward and reflected power. By entering these into a double logarithmic system of co-ordinates a linear SWR sequence is shown. The forward power is the power being transmitted into a system whereas the reflected power is the power being reflected because of a mismatch at the load.

The SWR can be found by using the SWR Nomographs if the forward power and reflected power are known.

- **SWR Nomograph (1) covers the forward power from 0.5 to 500 W and the reflected power at 0.2 – 20 W.**
- **SWR Nomograph (2) covers the forward power from 0.5 to 500 W and the reflected power at 0.01 – 1 W.**

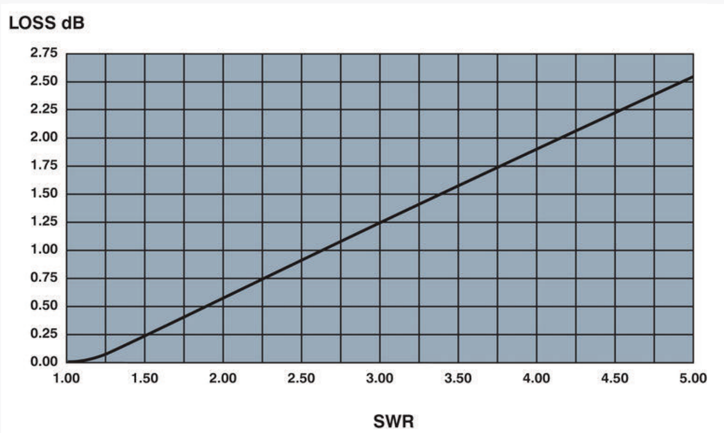


SWR Nomograph (1)



SWR Nomograph (2)

VSWR Mismatch Loss



Antennas, transmission lines and RF equipment will never have perfect 1:1 VSWR - so some power will always be lost as reflected power.

From this chart, the loss due to mismatch can be read if the VSWR is known.

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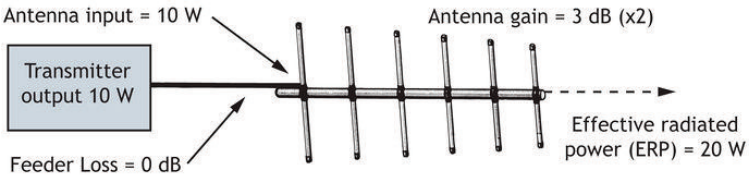
Field Strength Versus Radiated Power

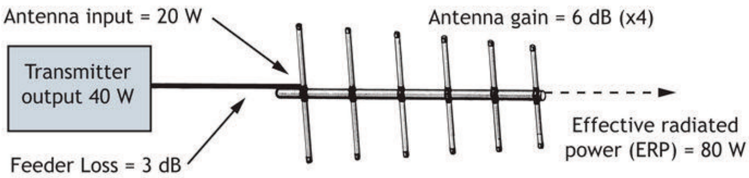
Effective radiated power (ERP) represents the total power in watts that would have to be applied to a half-wave dipole antenna in order to achieve the same radiation intensity as the antenna in question at it's maximum gain location.

When using an antenna with gain over a half-wave dipole, it is a useful measure of how much RF power is added in the main direction.

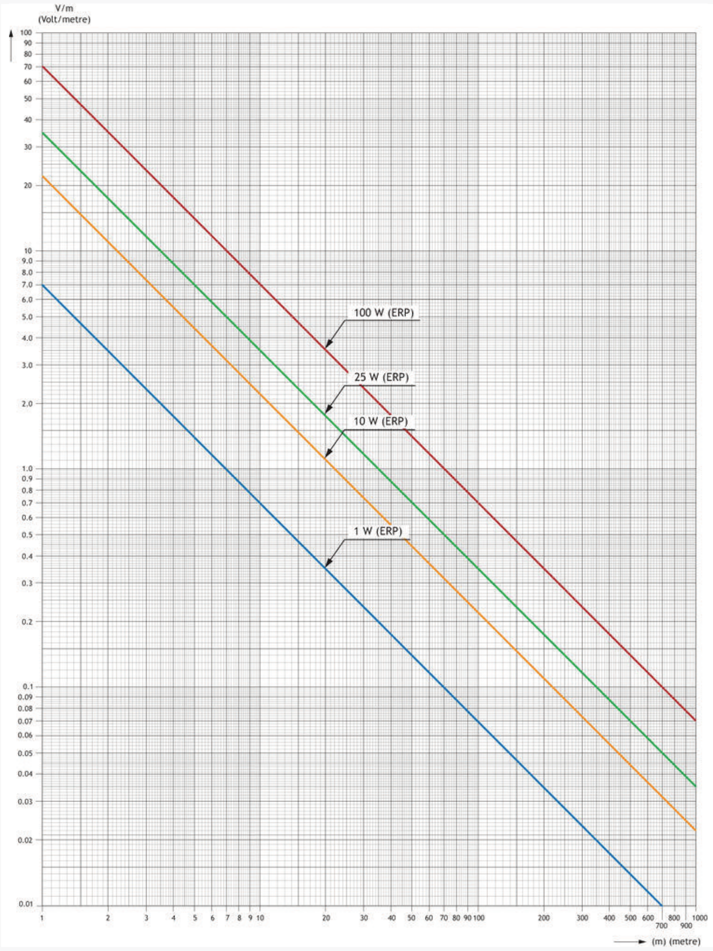
The table shows how much ERP can be obtained in the main beam direction of an antenna when the input power is 1, 10 and 100 watt. Note that mismatch loss is not accounted for in these calculations.

ERP	GAIN (dB)						
Power input Factor	0 (1)	3 (2)	6 (4)	10 (10)	13 (20)	16 (40)	20 (100)
1 W	1	2	4	10	20	40	100
10 W	10	20	40	100	200	400	1000
100 W	100	200	400	1000	2000	4000	10000





Field Strength Versus Radiated Power and Distance



The graph shows the proportion between field strength (y-axis), distance (x-axis) and ERP (the curve). The graph illustrates how high the field strength is at a given distance from the antenna when ERP is 1, 10, 25 and 100 watt, respectively.

Because antennas are often directional it has to be clear how high the ERP is in the direction required. After this the graph can be used from 1-1000 m away from the antenna. How to use the graph is illustrated below by an example.

Example

How high is the field strength 30 m away from the antenna when the radiation of the antenna is 10 watt ERP. 30 metres is found on the x-axis and the readings are made where the yellow graph indicates 10 watt ERP. Readings on the y-axis show 0.75 V/m.

The graph can also be used if a field strength of 1 V/m – 20 m away from the antenna is required and where the ERP power to be used is unknown. Here the point is found in the graph - notice that the green line indicating 25 watt passes through this point.

As readings indicate in the graph the field strength is very low on 1000 m even at 100 watt ERP. This shows that a high ERP is needed on 1000 m before the field strength becomes important at this distance.

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Conversion Tables

Power - dBm - Voltage in 50 Ω / Voltage - dB µV

Power → dBm → Voltage in 50 Ω

dBm = 10 log (P/P_{Ref})
where P_{Ref} = 1 mW
$V_{RMS} = \sqrt{P \times 50}$

Power	dBm	Voltage (RMS) in 50 Ω
1 kW	+ 60	224 V
100 W	+ 50	70.7 V
10 W	+ 40	22.4 V
1 W	+ 30	7.07 V
100 mW	+ 20	2.23 V
10 mW	+ 10	707 mV
1 mW	0	224 mV
100 µW	- 10	70.7 mV
10 µW	- 20	22.4 mV
1 µW	- 30	7.07 mV
100 nW	- 40	2.23 mV
10 nW	- 50	707 µV
1 nW	- 60	224 µV
100 pW	- 70	70.7 µV
10 pW	- 80	22.4 µV
1 pW	- 90	7.07 µV
100 fW	- 100	2.23 µV
10 fW	- 110	0.71 µV
1 fW	- 120	0.22 µV

Voltage → dB µV

dB µV = 20 log (V_{RMS}/V_{Ref})
where V_{Ref} = 1 µV

Voltage (RMS)	dB µV
10.0 V	140
3.16 V	130
1.00 V	120
316 mV	110
100 mV	100
31.6 mV	90
10.0 mV	80
3.16 mV	70
1.00 mV	60
316 µV	50
100 µV	40
31.6 µV	30
10.0 µV	20
3.16 µV	10
2.00 µV	6
1.41 µV	3
1.00 µV	0
0.708 µV	- 3
0.501 µV	- 6
0.316 µV	- 10
0.100 µV	- 20

Decibel to Ratio 0 – 19 dB

Ratio downwards (-)		dB	Ratio upwards (+)	
Power	Voltage		Voltage	Power
1.0	1.0	0	1.0	1.0
0.977	0.989	0.1	1.01	1.02
0.955	0.977	0.2	1.02	1.05
0.933	0.966	0.3	1.04	1.07
0.912	0.955	0.4	1.05	1.10
0.891	0.944	0.5	1.06	1.12
0.871	0.933	0.6	1.07	1.15
0.851	0.923	0.7	1.08	1.18
0.832	0.912	0.8	1.10	1.20
0.813	0.902	0.9	1.11	1.23
0.794	0.891	1.0	1.12	1.26
0.759	0.871	1.2	1.15	1.32
0.724	0.851	1.4	1.18	1.38
0.692	0.832	1.6	1.20	1.45
0.661	0.813	1.8	1.23	1.51
0.631	0.794	2.0	1.26	1.59
0.603	0.776	2.2	1.29	1.66
0.575	0.759	2.4	1.32	1.74
0.550	0.741	2.6	1.35	1.82
0.525	0.724	2.8	1.38	1.91
0.501	0.708	3.0	1.41	2.00
0.447	0.669	3.5	1.50	2.24
0.398	0.631	4.0	1.59	2.51
0.355	0.596	4.5	1.68	2.82
0.316	0.562	5.0	1.78	3.16
0.282	0.531	5.5	1.88	3.55
0.251	0.501	6	2.00	3.99
0.200	0.447	7	2.24	5.01
0.159	0.398	8	2.51	6.31
0.126	0.355	9	2.82	7.94
0.100	0.316	10	3.16	10.0
0.0794	0.282	11	3.55	12.6
0.0631	0.251	12	3.98	15.9
0.0501	0.224	13	4.47	20.0
0.0398	0.200	14	5.01	25.1
0.0316	0.178	15	5.62	31.6
0.0251	0.159	16	6.31	39.8
0.0200	0.141	17	7.08	50.1
0.0159	0.126	18	7.94	63.1
0.0126	0.112	19	8.91	79.4

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Conversion Tables

Decibel to Ratio 20 – 140 dB

Ratio downwards (-)		dB	Ratio upwards (+)	
Power	Voltage		Voltage	Power
10.0×10^{-3}	100×10^{-3}	20	10.0	100
6.31×10^{-3}	79.4×10^{-3}	22	12.6	159
3.98×10^{-3}	63.1×10^{-3}	24	15.9	251
2.51×10^{-3}	50.1×10^{-3}	26	20.0	398
1.59×10^{-3}	39.8×10^{-3}	28	25.1	631
1.00×10^{-3}	31.6×10^{-3}	30	31.6	1.00×10^{3}
0.631×10^{-3}	25.1×10^{-3}	32	39.8	1.59×10^{3}
0.398×10^{-3}	20.0×10^{-3}	34	50.1	2.51×10^{3}
0.251×10^{-3}	15.9×10^{-3}	36	63.1	3.98×10^{3}
0.159×10^{-3}	12.6×10^{-3}	38	79.4	6.31×10^{3}
100×10^{-6}	10.0×10^{-3}	40	100	10.0×10^{3}
63.1×10^{-6}	7.94×10^{-3}	42	126	15.9×10^{3}
39.8×10^{-6}	6.31×10^{-3}	44	159	25.1×10^{3}
25.1×10^{-6}	5.01×10^{-3}	46	200	39.8×10^{3}
15.9×10^{-6}	3.98×10^{-3}	48	251	63.1×10^{3}
10.0×10^{-6}	3.16×10^{-3}	50	316	100×10^{3}
6.31×10^{-6}	2.51×10^{-3}	52	398	159×10^{3}
3.98×10^{-6}	2.00×10^{-3}	54	501	251×10^{3}
2.51×10^{-6}	1.59×10^{-3}	56	631	398×10^{3}
1.59×10^{-6}	1.26×10^{-3}	58	794	631×10^{3}
1.00×10^{-6}	1.00×10^{-3}	60	1.00×10^{3}	1.00×10^{6}
316×10^{-9}	562×10^{-6}	65	1.78×10^{3}	3.16×10^{6}
100×10^{-9}	316×10^{-6}	70	3.16×10^{3}	10.0×10^{6}
31.6×10^{-9}	178×10^{-6}	75	5.62×10^{3}	31.6×10^{6}
10.0×10^{-9}	100×10^{-6}	80	10.0×10^{3}	100×10^{6}
3.16×10^{-9}	56.2×10^{-6}	85	17.8×10^{3}	316×10^{6}
1.00×10^{-9}	31.6×10^{-6}	90	31.6×10^{3}	1.00×10^{9}
100×10^{-12}	10.0×10^{-6}	100	100×10^{3}	10.0×10^{9}
10.0×10^{-12}	3.16×10^{-6}	110	316×10^{3}	100×10^{9}
1.00×10^{-12}	1.00×10^{-6}	120	1.00×10^{6}	1.00×10^{12}
100×10^{-15}	316×10^{-9}	130	3.16×10^{6}	10.0×10^{12}
10.0×10^{-15}	100×10^{-9}	140	10.0×10^{6}	100×10^{12}

Attenuation versus Frequency:

Cable loss in various cable types in proportion to the frequency.