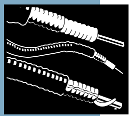


Coaxial Transmission Line Technical Data

Load VSWR Effect on Total Transmission Loss

When the transmission line is attached to a load, such as an antenna, the VSWR of the load increases the total transmission loss of the system. This effect is quite small for normal conditions. Figure 2 on page 631, shows the minimum increase in loss with load VSWR, assuming a VSWR of 1.0 at the input of the transmission line. This requires use of an input matching device.

Power Rating Considerations

Both peak- and average-power ratings are required to fully describe the capabilities of a given transmission line. Typically, peak-power ratings limit usage with amplitude modulation at medium frequencies (530-1610 kHz) or pulsed usage, while average-power ratings limit the high frequency usage.

Peak-Power Rating

The peak-power rating of a transmission line is limited by voltage breakdown between the inner and outer conductors.

Voltage breakdown is essentially independent of RF frequency, but varies with line pressure and type of pressurizing gas. Peak-power ratings are, therefore, generally stated for the following standard conditions: VSWR = 1.0, zero modulation and one atmosphere absolute dry air pressure (0 lb/in^2 or 0 kPa gauge) at sea level.

The peak-power rating of the selected cable must be derated for modulation technique and VSWR, as follows:

Peak Power Derating for Modulation and VSWR

Modulation	Peak Power Derating Calculation
AM	$P_{MAX} = \dfrac{P_{PK}}{(1+M)^2\ VSWR}$
FM and DTV	$P_{MAX} = \dfrac{P_{PK}}{VSWR}$
Analog TV	$P_{MAX} = \dfrac{P_{PK}}{(1+AU+2\sqrt{AU})\ VSWR} = \dfrac{P_{PK}}{(2.09)\ VSWR}$

Where:

P_{MAX} = Derated peak power
P_{PK} = Peak power rating of cable
M = Amplitude modulation index (100% = 1.0)
VSWR = Voltage standing wave ratio
AU = Aural to visual ratio (20% Aural: AU = 0.2)
2.09 = Modulation derating factor for TV, for AU=0.2

Rated transmitter power must be less than calculated derated peak power of the cable for safe operation. For digital TV (DTV), peak power is typically 7dB higher than average power.

From derating expressions, it can be seen that 100% amplitude modulation increases the peak power in the transmission line by a factor of 4. Also, the peak power in the transmission line increases directly with VSWR.

The transmission line peak-power rating can be significantly increased by pressurization. See page 633 for details.

An adequate safety factor on peak power is necessary to safeguard against voltage breakdown which can result in permanent damage to the transmission line. All HELIAX semiflexible coaxial cables are high-voltage tested to the equivalent of 200% of their rated peak powers (safety factor of 1.4 on voltage), and all rigid coaxial lines to the equivalent of 400% of rated peak powers (safety factor of 2.0 on voltage). These safety factors are intended as a provision for transmitter transients, lightning induced transients, and high voltage excursions due to other unforeseen causes. Andrew is known for its conservative specifications that insure long term, reliable performance. We continue to hold this commitment to our customers by maintaining the highest level of quality and performance.

HELIAX® peak-power ratings are determined according to the relation:

$$P_{PK} = \frac{\left(\dfrac{E_P \times 0.707 \times 0.7}{SF}\right)^2}{Z_C}$$

Where:

P_{PK} = Cable power rating, standard conditions
E_P = dc production test voltage
0.707 = RMS factor
0.7 = dc to RF factor (empirically verified)
SF = Safety factor on voltage
= 1.4 for HELIAX semiflexible cables
= 2.0 for rigid coaxial lines
Z_C = Characteristic impedance

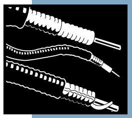
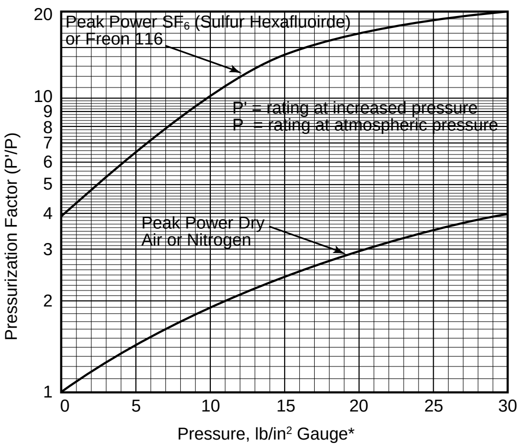
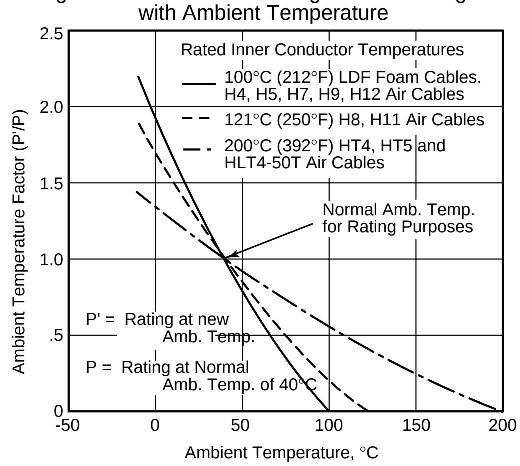


Figure 3 – Pressurization Factors



* For kPa, multiply by 6.895

Figure 4 – Variation of Average Power Rating with Ambient Temperature



Typical dc production test voltages for various sizes of semiflexible coaxial cable and rigid line are shown below.

Nominal size	Impedance ohms	Ep, kV Flexible cables	Ep, kV Rigid lines
7/8"	50	6	–
1-1/4"	50	9	–
1-5/8"	50	11	11
2-1/4"	50	13	–
3"	50	16	–
3-1/8"	50	–	19
4"	50	21	–
5"	50	27.5	–
6-1/8"	50, 75	–	36
7-3/16"	75	–	41.8
8-3/16"	75	–	47

Foam-dielectric cables have a greater dielectric strength than air-dielectric cables of similar size. For this reason they might be expected to have higher peak-power ratings than air cables. Higher peak-power ratings usually can not be realized, however, because the commonly used connectors for foam cables have air spaces at the cable/connector interface which limit the allowable RF voltage to “air cable” values. Andrew rates similar size foam- and air-dielectric cables alike for this reason.

Effect of Connector on Power Rating

The peak power handling capability of a cable assembly is the smaller of the values for the cable and the connectors. The following table shows power ratings for common connectors at standard conditions of VSWR = 1.0, zero modulation and one atmosphere dry air pressure (0 lb/in^2 or 0 kPa gauge) at sea level.

Connector Power Ratings

Connector Type	DC Test Voltage kV	Average Power kW*	Peak Power kW
SMA	1.0	0.1	2.5
BNC	1.5	0.1	5.6
TNC	1.5	0.3	5.6
UHF	2.0	0.3	10
N	2.0	0.6	10
HN	4.0	0.6	40
SC	4.2	1.2	44
7-16 DIN	4.0	1.3	40
4.1/9.5 DIN	2.5	1.2	16
LC	5.0	3.5	63
7/8" EIA	6.0	1.7	90
1-5/8" EIA	11	4.9	300
3-1/8" EIA	19	16	902
4-1/2" IEC	21	27	1100
6-1/8" EIA	27.5	57	1890

* Average power ratings of the connector interfaces are based on an operating frequency of 900 MHz. The values shown in this table are typical for most applications.

Increased Peak Power Ratings

Pressurization and/or the use of high-density gases with high dielectric strength can be used to increase peak-power ratings. These effects are shown in Figure 3.

For a given transmission line pressure, the increase in peak-power rating is significant. For example, a line pressure of 10 lb/in^2 (70 kPa) dry air increases the peak-power rating by a factor of 1.9. Pressurization above 30 lb/in^2 (207 kPa) is not recommended.

Average Power Rating

Average power ratings for semiflexible cables are determined by the maximum permissible inner conductor temperature. This maximum temperature depends on the type of dielectric, and is governed by considerations of the long-term life of the dielectric. Average power ratings for rigid coaxial lines are also determined by the maximum inner conductor temperature. For rigid lines this maximum temperature is set primarily by considerations of differential expansion of inner and outer conductors, and the maximum movement permissible at the joints (inner connectors).

Figure 5 – Derating Factor for Average Power Due to VSWR

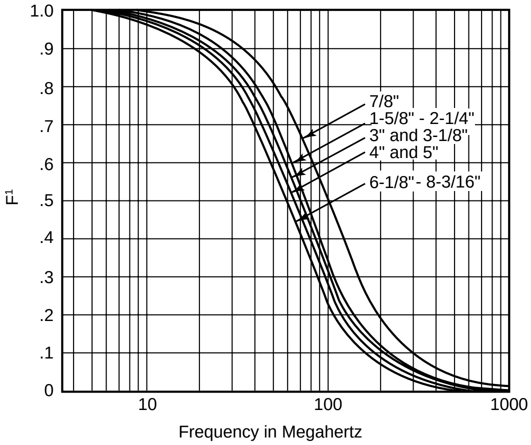
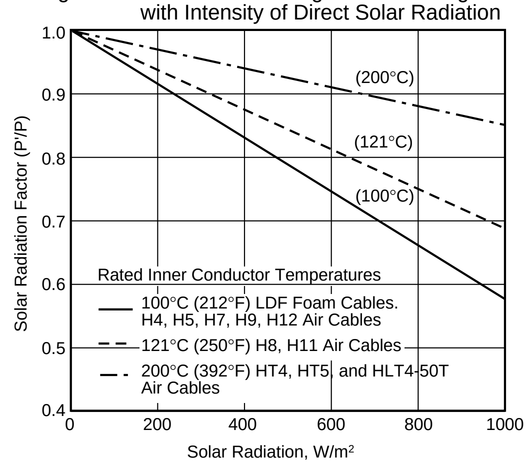


Figure 6 – Variation of Average Power Rating with Intensity of Direct Solar Radiation



Andrew average power ratings are based on a VSWR of 1.0, atmosphere pressure and ambient temperature of 40˚C (104˚F).

Derating Average Power for Modulation Condition

To convert rated transmitter power to average power for analog television transmission, multiply by 0.8 (totally black picture + aural signal). For FM radio and digital television (DTV), the factor is 1.0. Transmission lines for AM radio at MF frequencies (530-1610 kHz) are usually peak power limited. At higher (HF) frequencies, the limitation is average power capability and the required derating factor, D.F., is:

$$\text{D.F.} = 1 + \frac{M^2}{2}$$

where M is the modulation depth (100% = 1.0), expressed decimally.

Average Power Rating Adjustment for Ambient Temperature

The baseline power rating can be adjusted to meet the actual usage conditions. Figure 4 shows the variation of average power rating with ambient temperature.

Derating Average Power for VSWR

The derating factor (D.F) is calculated from the following formula:

$$\text{D.F.} = \frac{2\,(\text{VSWR})}{\text{VSWR}^2\,(1 + F^1) + 1 - F^1}$$

where F^1 is a factor that varies with frequency and line size. This calculation of derating factor is conservative in that it assumes all reflected power is re-reflected at the transmitter and absorption of the reflected signal by the line attenuation is small. Select the factor from the applicable curve in Figure 5, calculate factor D.F., and multiply by the average power from the cable characteristics table.

For example: Calculate power rating for 3" HJ8-50B cable operating at 100 MHz with VSWR = 1.1, F1 (from Figure 5) = 0.33:

$$\text{D.F.} = \frac{2 \times 1.1}{1.1^2 \times (1 + 0.33) + 1 - 0.33} = 0.965$$

Average Power Rating at 1.00 VSWR = 42.4 kW (from page 566)

Average Power Rating at 1.1 VSWR = 42.4 x 0.965 = 41.0 kW

Derating Average Power for Direct Solar Radiation

The average power handling capability of a cable exposed to direct solar radiation will be reduced. The appropriate derating factors for the different cable types are shown in Figure 6.

The average radiation intensity for moderate climates is 200 W/m^2 or less. Hot, dry climates give solar radiation intensities which at the hottest time of the day can be 1,000 W/m^2 or higher. The mean value over the day, which is applicable to average power derating calculations provided absolute maximum temperatures are not exceeded, is up to 400 W/m^2. These hot, dry locations are also subject to elevated ambient temperatures, which must also be considered (Figure 4).

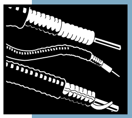
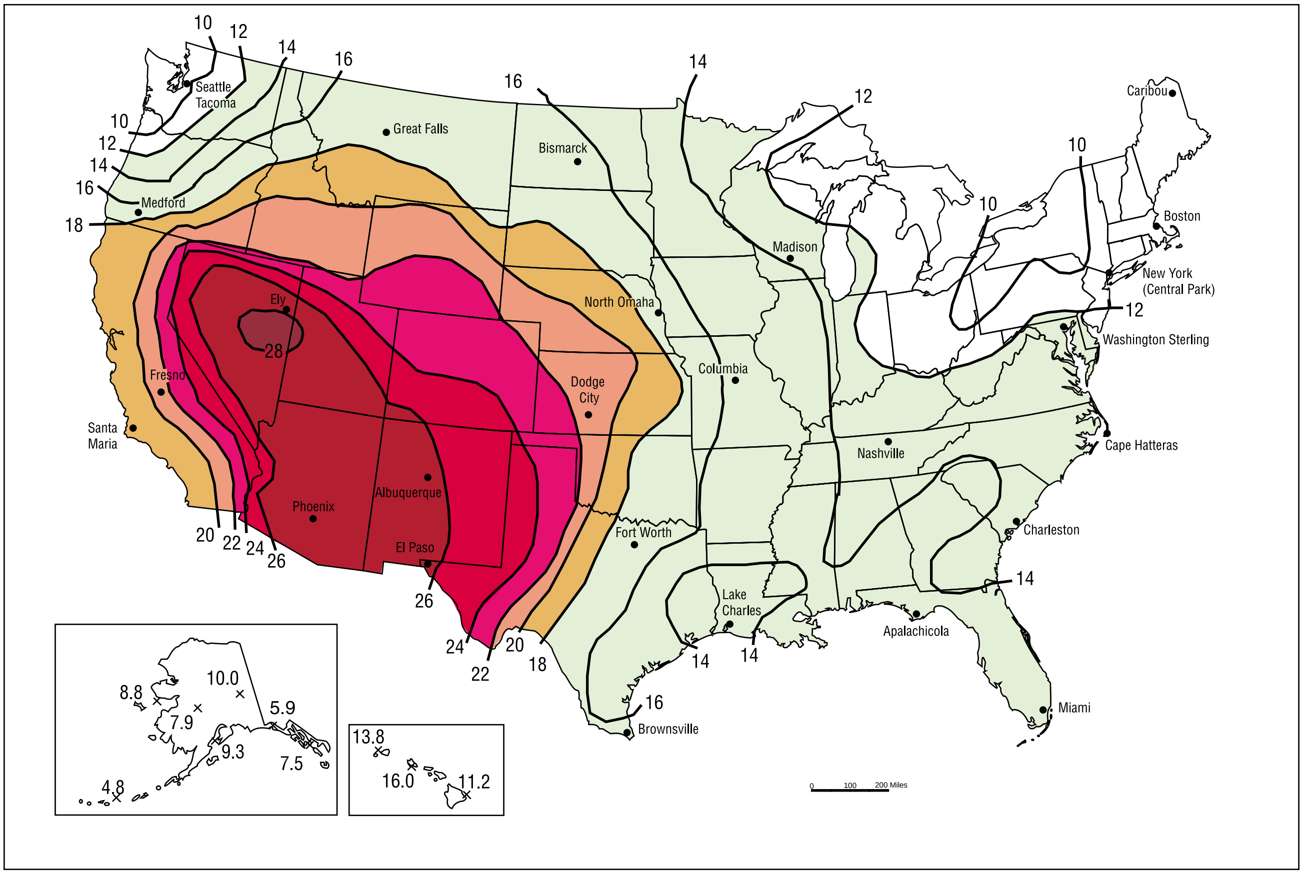


Figure 7 — Average Daily Direct Normal Solar Radiation (MJ/m²), Annual



Values for average direct solar radiation for locations in the USA are shown in Figure 7. For conversion purposes, to determine a derating factor from Figure 6 from the information by location from Figure 7, 1 MJ/m^2 over a 24-hour period is equivalent to 11.6 W/m^2.

Derating Average and Peak Powers for Altitude

Derating factors for average and peak powers with altitude are shown in the following table. These factors have been determined assuming just nominal overpressure inside the transmission line. Both average and peak powers must be derated because the lower atmospheric pressure with increasing altitude reduces both heat transfer from inner and outer conductors, and the dielectric strength of the air inside the line.

Derating Average and Peak Powers for Altitude

Altitude above Sea Level ft (m)	P1/P Average Power	P1/P Peak Power
0 (0)	1.00	1.00
5000 (1524)	0.92	0.69
8000 (2438)	0.87	0.53
10500 (3200)	0.84	0.44
15000 (4572)	0.78	0.30

Efficiency

The efficiency of a transmission line depends on its length and attenuation. The efficiency is defined as the percent of transmitter power which reaches the antenna. It can be calculated as:

$$\text{Efficiency} = \frac{100\%}{10^{\left(\frac{dB}{10}\right)}}$$

where dB is the total attenuation of the transmission line at the frequency of interest.

The remaining power is lost in the transmission line and is dissipated as heat.