RF Coax Cable for Amateur Radio

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AE5AS

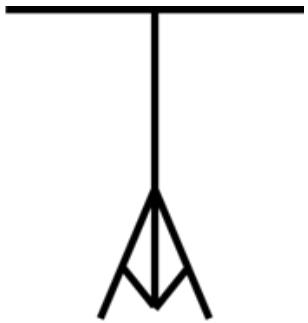
Four Required Elements of an Amateur Radio System

- **A Radio Operator**

Four Required Elements of an Amateur Radio System

- A Radio Operator
- A Radio

Four Required Elements of an Amateur Radio System



- A Radio Operator
- A Radio
- An Antenna

Four Required Elements of an Amateur Radio System

- A Radio Operator
- A Radio
- An Antenna
- A Transmission Line

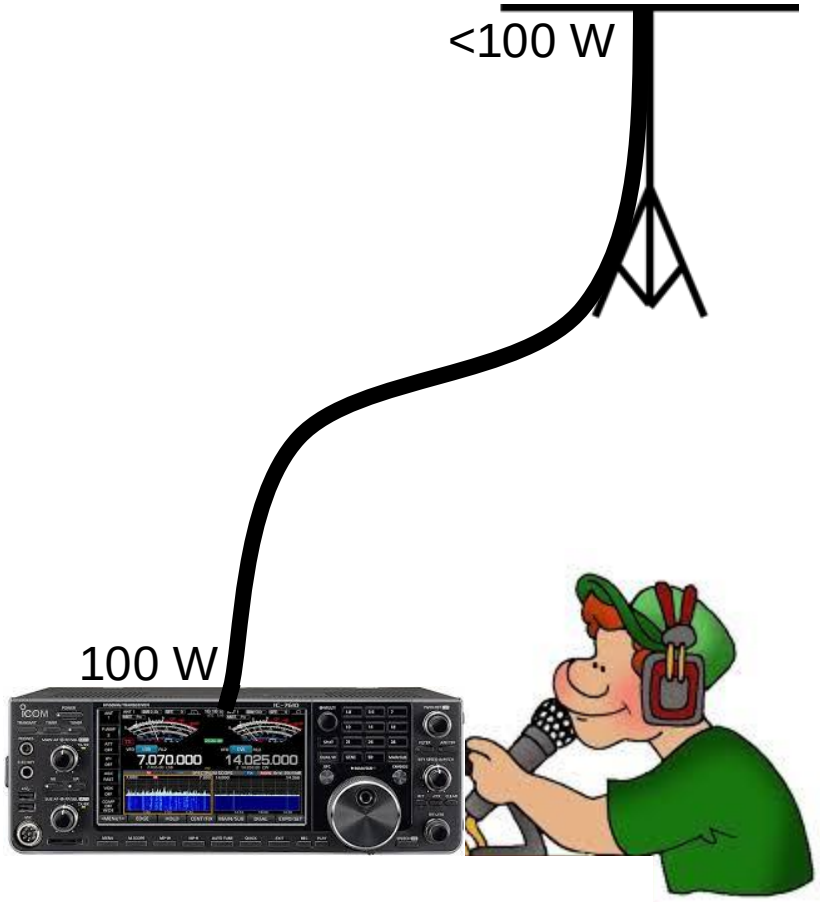
Transmission Line Types

Broadly speaking, there are four (4) transmission line types:

- **Radio Frequency (RF) Coaxial (Coax) Cable**
- **Window Line**
- **Heliax Cable**
- **Hardline**

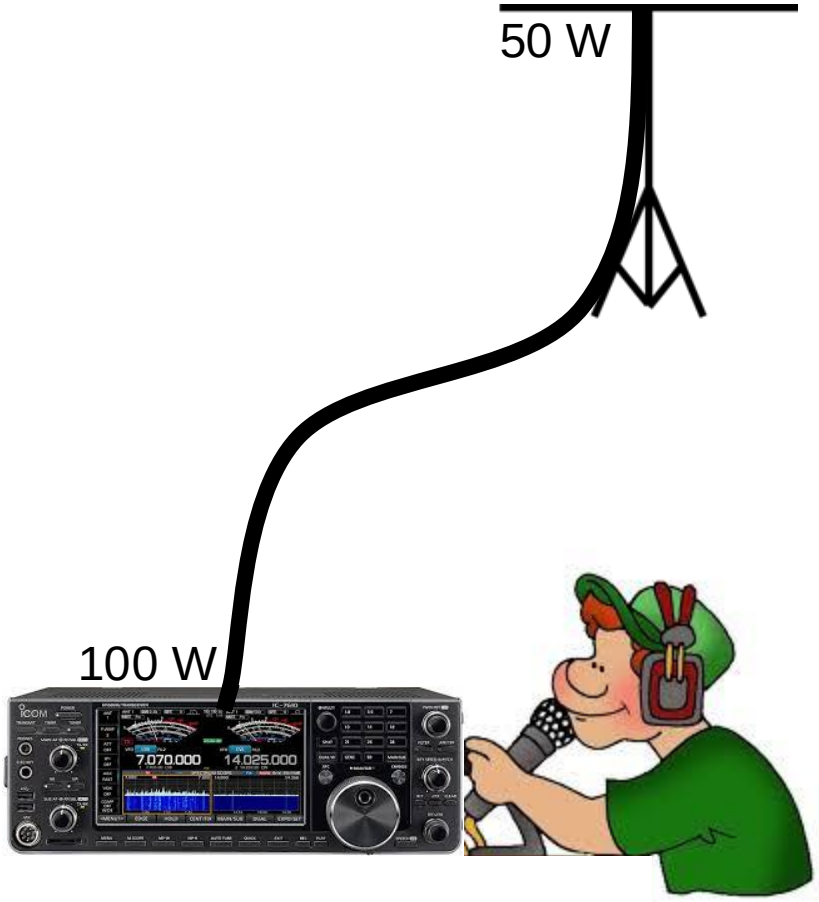
End Wire antennas do not really have transmission lines

Transmission Lines Have Losses in Power



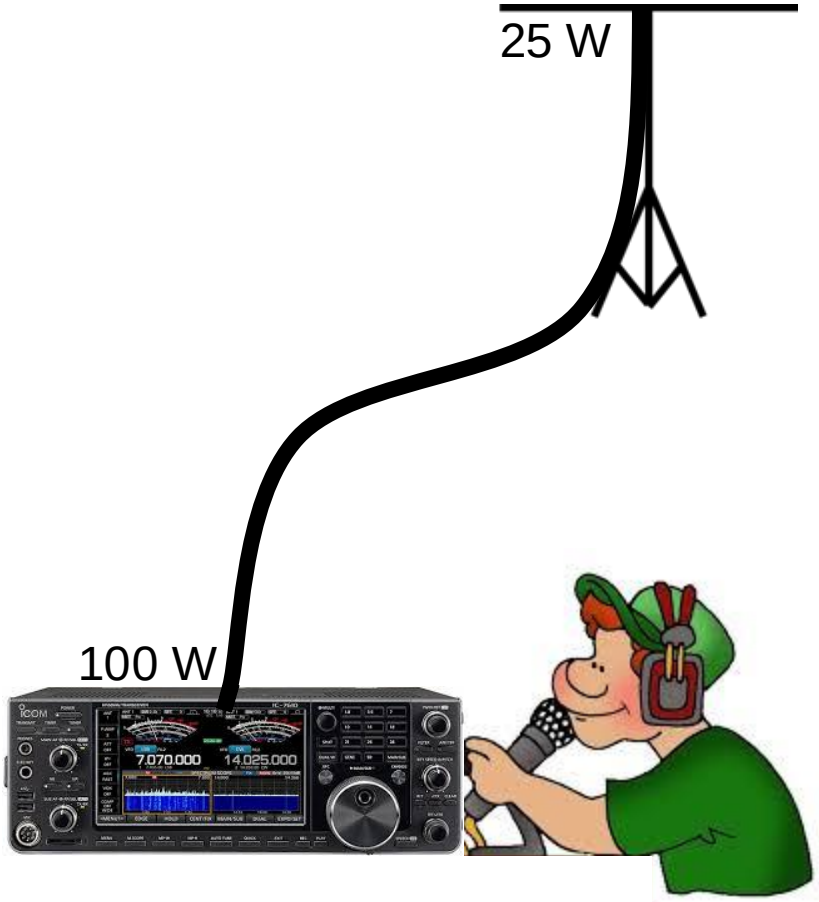
- **Usually measured in db**

Transmission Lines Have Losses in Power



- **Usually measured in db**
- **If Transmission Line has a 3 db loss, then power is cut to 50% at the antenna**

Transmission Lines Have Losses in Power



- **Usually measured in db**
- **If Transmission Line has a 6 db loss, then power is cut to 25% at the antenna**

Transmission Line Includes Everything between Radio and Antenna

- **Amplifiers**

Transmission Line Includes Everything between Radio and Antenna

- **Amplifiers**
- **Antenna Tuners**

Transmission Line Includes Everything between Radio and Antenna

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- **SWR Meters**

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Transmission Line Includes Everything between Radio and Antenna

- **Amplifiers**
- **Antenna Tuners**
- **SWR Meters**
- **RF Chokes**
- **Cable Connectors**

Try to Minimize Items in the Transmission Line

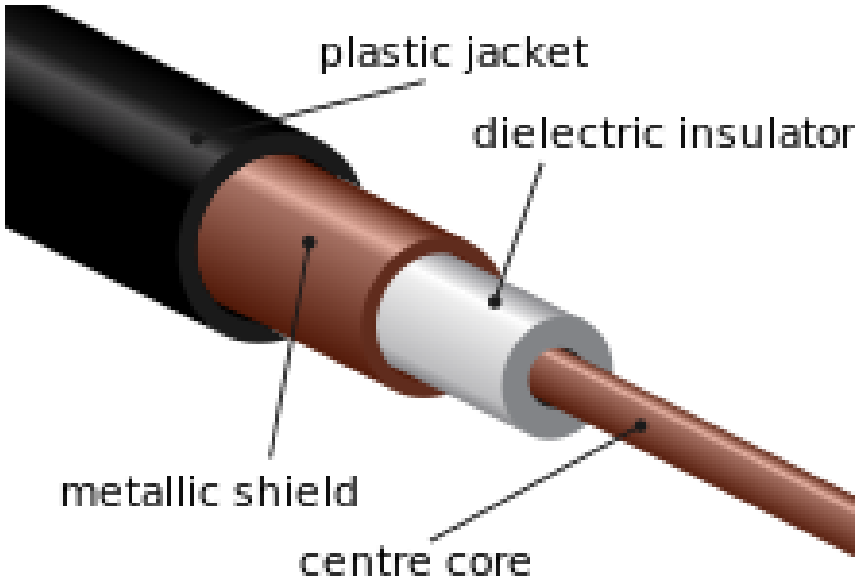
- **Amplifiers**
- **Antenna Tuners – use near resonant antennas**
- **SWR Meters – use Radio's built ins**
- **RF Chokes – use only if needed**
- **Cable Connectors – minimize by eliminating other items**

Transmission Line Stripped Down

The goal is a transmission line stripped down to:

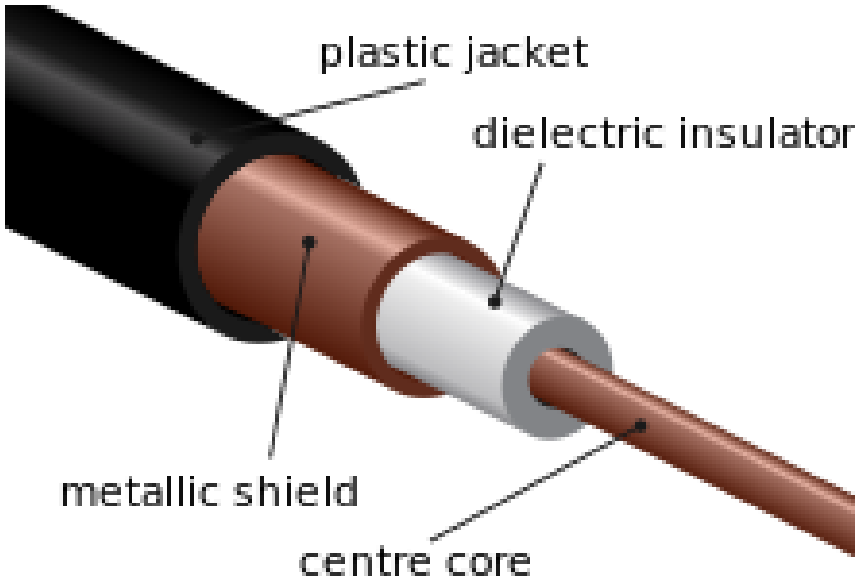
- **The RF Coax Cable itself**
- **Two connectors – one on each end**

Coax Cable Construction



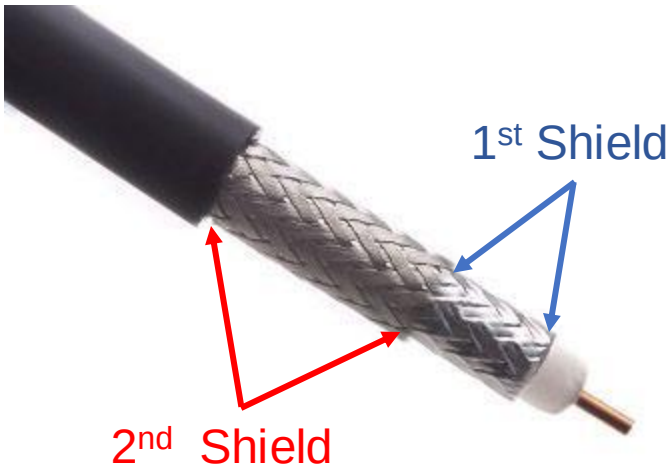
- **Center Core Conductor - solid or stranded copper**
- **Dielectric Insulator- more than one type**
- **Outer Shield – usually braided copper**
- **Outer Jacket – usually Polyethylene**

Coax Cable Construction



- **This construction includes two conductors**
- **Center core is primary conductor**
- **Outer Shield is the secondary conductor**
- **Physical geometry keeps coax cable from radiating – it is why the outer conductor is called the outer shield**
- **Dielectric Insulator- keeps conductors from shorting**
- **Different jackets – some for burying and some for fire sensitive environments**

Coax Cable Construction - Better Type



- Center Core Conductor - solid or stranded copper
- Dielectric Insulator- more than one type
- Outer Shield – usually braided copper
- Outer Jacket – usually Polyethylene
- Second Outer Shield – often aluminum

Key Coax Cable Characteristics

- **Impedance is a measure of electrical resistance and reactance to transmission – 50 ohms.**
  - **This matches the radio and antenna.**
  - **Minimizes SWR effects.**

  (75 ohm Coax requires 50/75 ohm transformers on each end if used – not recommended.)
- **Velocity Factor (VF) is a percentage measurement of how fast the electrical energy is transmitted through the coax cable – higher is better.**
- **Power Rating is a measure of how many watts it can handle –this varies by frequency and is normally not an issue**

Key Coax Cable Characteristics

- **Attenuation is expressed in –db per 100 ft.**
- **Attenuation varies by frequency**
  - **Attenuation goes up as frequency goes up**

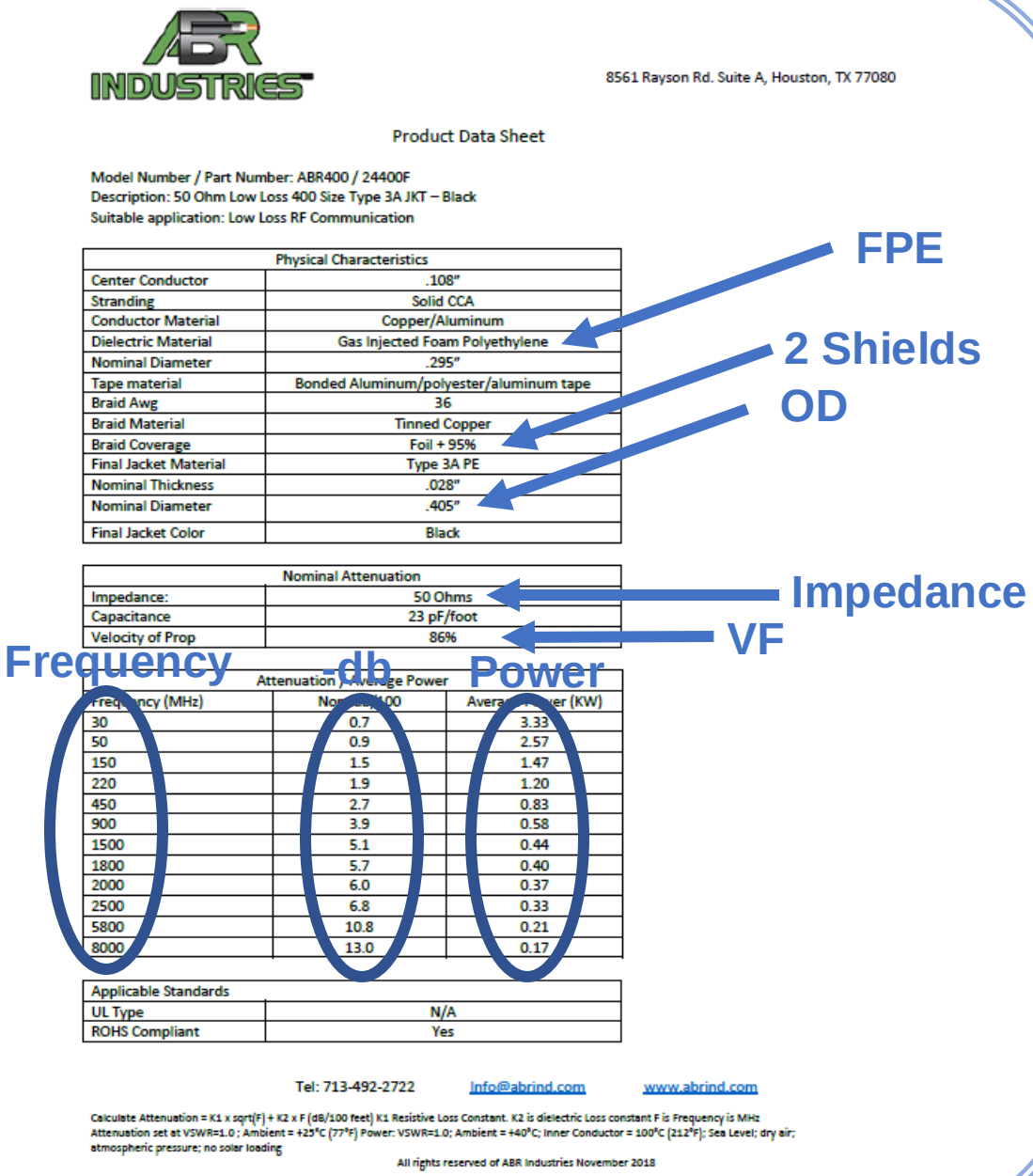
    HF < VHF < UHF

    -db < -db < -db
  - **Attenuation goes up with length such that semi-permanent installations should be cut to fit.**
- **Outside Diameter (OD) is the diameter of the coax cable.**
  - **Thicker OD is better than thin**
  - **Important when it comes to getting connectors.**

Example Coax Cable Data Sheet

This is the data sheet from ABR Industries for their LMR-400 type Coax Cable.

LMR-400 is a Trademark of Times Microwave



ABR INDUSTRIES

8561 Rayson Rd. Suite A, Houston, TX 77080

Product Data Sheet

Model Number / Part Number: ABR400 / 24400F
Description: 50 Ohm Low Loss 400 Size Type 3A JKT – Black
Suitable application: Low Loss RF Communication

Physical Characteristics	
Center Conductor	.108"
Stranding	Solid CCA
Conductor Material	Copper/Aluminum
Dielectric Material	Gas Injected Foam Polyethylene
Nominal Diameter	.295"
Tape material	Bonded Aluminum/polyester/aluminum tape
Braid Awg	36
Braid Material	Tinned Copper
Braid Coverage	Foil + 95%
Final Jacket Material	Type 3A PE
Nominal Thickness	.028"
Nominal Diameter	.405"
Final Jacket Color	Black

FPE

2 Shields

OD

Nominal Attenuation	
Impedance:	50 Ohms
Capacitance	23 pF/foot
Velocity of Prop	86%

Impedance

VF

Frequency -db Power

Attenuation / Average Power		
Frequency (MHz)	Nominal 400	Average Power (KW)
30	0.7	3.33
50	0.9	2.57
150	1.5	1.47
220	1.9	1.20
450	2.7	0.83
900	3.9	0.58
1500	5.1	0.44
1800	5.7	0.40
2000	6.0	0.37
2500	6.8	0.33
5800	10.8	0.21
8000	13.0	0.17

Applicable Standards	
UL Type	N/A
ROHS Compliant	Yes

Tel: 713-492-2722 Info@abrind.com www.abrind.com

Calculate Attenuation = K1 x sqrt(F) + K2 x F (dB/100 feet) K1 Resistive Loss Constant. K2 is dielectric Loss constant F is Frequency is MHz Attenuation set at VSWR=1.0 ; Ambient = +25°C (77°F) Power: VSWR=1.0; Ambient = +40°C; Inner Conductor = 100°C (212°F); Sea Level; dry air; atmospheric pressure; no solar loading

Data Sheet Close Up

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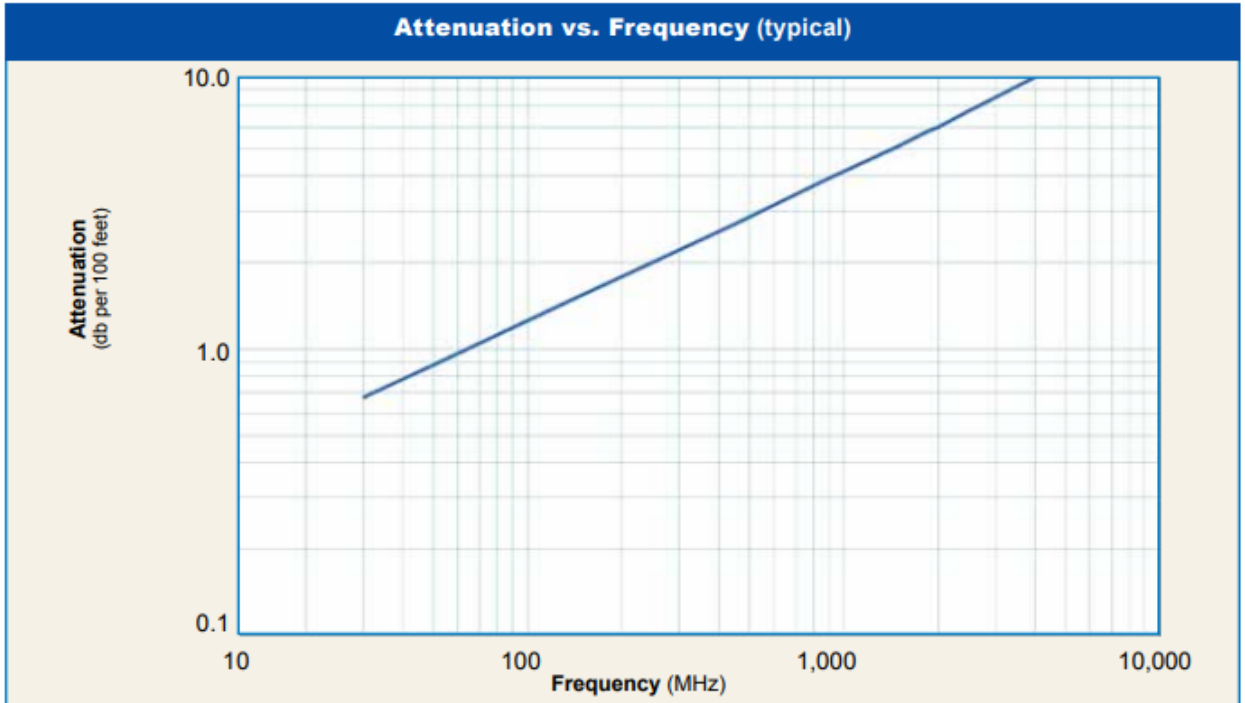
1500	5.1	0.44
1800	5.7	0.40
2000	6.0	0.37
2500	6.8	0.33
5800	10.8	0.21
8000	13.0	0.17

Pretty typical for Frequency/Attenuation/Power Charts to stop at 10M.
Note 2M and 70CM have significant –db.

Another Data Sheet

LMR-400 Attenuation Data Sheet includes formula (VF 84%)

1.8MHz	-0.2 db
3.5MHz	-0.2 db
7.0MHz	-0.3 db
14.0MHz	-0.5 db
28.0MHz	-0.7 db



Frequency (MHz)	30	50	150	220	450	900	1500	1800	2000	2500	5800	8000
Attenuation dB/100 ft	0.7	0.9	1.5	1.9	2.7	3.9	5.1	5.7	6.0	6.8	10.8	13.0
Attenuation dB/100 m	2.2	2.9	5.0	6.1	8.9	12.8	16.8	18.6	19.6	22.2	35.5	42.7
Avg. Power kW	3.33	2.57	1.47	1.20	0.83	0.58	0.44	0.40	0.37	0.33	0.21	0.17

Calculate Attenuation =
$(0.122290) \cdot \sqrt{FMHz} + (0.000260) \cdot FMHz$ (interactive calculator available at http://www.timesmicrowave.com/cable_calculators)
Attenuation:
VSWR=1.0 ; Ambient = +25°C (77°F)
Power:
VSWR=1.0; Ambient = +40°C; Inner Conductor = 100°C (212°F); Sea Level; dry air; atmospheric pressure; no solar loading

Last Point on Data Sheets

Don’t buy coax cable without looking at the Data Sheet!

Anybody can buy junk cable and sell it on eBay or a website.

If their coax cable is so good, why don’t they have a

Data Sheet?

Transmission Line Stripped Down

What COAX to use?

- **High Velocity Factor (VF)**
  - **Foam Polyethylene (FPE)**
  - **Shield over outer braid (FC)**
- **Larger Outside Diameter (OD) Coax**
- **Lowest Attenuation on Target Frequencies**

Cable Comparison

Huge Differences at higher frequencies like 2M and 70 CM.

Still significant differences in HF band frequencies until reach lowest amateur radio frequencies.

All are 50 Ohms Impedance

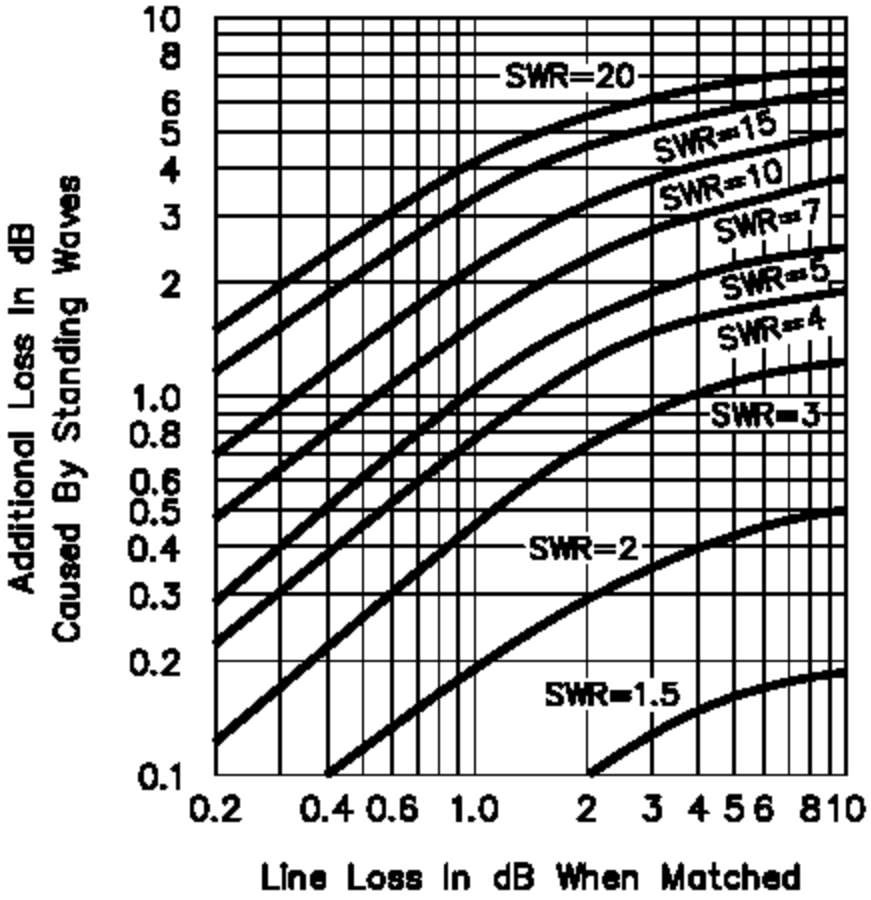
	VF	MHz			
		1	10	100	1000
OD .195 inches					
RG-58/U	66%	0.3	1.0	3.0	9.7
LMR-195	80%	0.4	1.1	3.6	11.8
OD .242 inches					
RG-8X	82%	0.3	0.9	3.7	11.2
LMR-240	84%	0.2	0.8	2.5	7.4
OD .405 inches					
RG-8/U	*				
RG-213/U	66%	0.2	0.6	1.9	8.0
LMR-400	84%	0.1	0.4	1.3	4.1
LMR-400-UF	83%	0.1	0.4	1.4	4.9

* This Radio Guide MIL-STD cancelled.
Old RG-8 probably less than RG-213.

Mismatched Loss

- Transmission Line –db affected by SWR.
- Additional –db must be added for SWR.
- For example, 3 db loss with 1.5 SWR is ≈0.15 for ≈3.15 db total loss.
- For example, 3 db loss with 5.0 SWR is 2.0 db for 5 db total loss.

- Low Transmission Line loss pays dividends when SWR considered.
- Low SWR combined with low Transmission Line loss pays even more dividends.



Costs

- **LMR-400 style RF Coax Cable will cost more, but it is the best.**
- **LMR-195 style (RG-58) and LMR-240 style (RG-8X) will be cheaper than LMR-400 style.**
- **RG-213 will be cheaper than LMR-400 style, but the VF is lower.**
- **RG-58 and RG-8X will be cheaper yet than RG-213, but performance will be seriously lower for 2M and 70CM.**
- **RG-8 style has no standards. Some in this grouping will be actually LMR-400 style.**

- **Remember you only buy coax cable occasionally and the cost should be considered to be one amortized over many years – recommend go better.**

Other Considerations

- **Semi-permanent installations just about scream higher quality cable for use over many years.**
- **Portable operations from different sites from time to time may make RG-58 and RG-8X style cables desirable.**
- **Backpacking operations may make short, lighter RG-58 and RG-8X style cables pretty much mandatory.**

Coax Cable Sources

- **A lot of Ham Stores sell Coax Cable**
  - **Well Known Brands**
  - **House Brands – check Data Sheets**
- **Amazon and eBay sell Coax Cable**
  - **Well Known Brands**
  - **Other Brands and Unbranded – check Data Sheets**
- **Some vendors: HRO, Gigaparts, DX Engineering, Main Trading Company, The Wireman, R and L Electronics, MFJ, Associated Radio**
- **Some Brands:**
  - **ABR Industries**
  - **Belden**
  - **Messi & Paoloni**
  - **Times Microwave (LMR)**

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LMR RF Coax Cable defines the better RF Coax Cable market.)

Summary

- **The Transmission Line is an important element of your amateur radio operation.**
- **You should seek to minimize your line loss including mismatch loss due to SWR.**
- **Be deliberate in choosing your RF Coax Cable – check Data Sheets.**
- **Whenever all other considerations are equal, go with LMR-400 style RF Coax Cable because this group has the lowest line loss across all frequencies.**

(If you get really serious, remember there is heliax and hard line as well.)

References

- **Hallas, Joel R., W1ZR. 2012. *The Care and Feeding of Transmission Lines.* Newington, CN: ARRL.**
- **Chapter 20: Transmission Lines and Chapter 22: Component Data and References from 2014 *The ARRL Handbook for Radio Communications*. Newington, CN: ARRL.**
- ***Coaxial cable.* Wikipedia. Accessed 10 Jan 2022.**