

Coaxial Cables

W5IFQ

7 SEP 2025

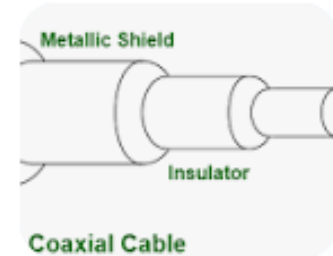
PURPOSE

- Provide information to allow the selection of the correct coaxial cable for your station.
- Prevent improper cable performance that can result in unexpected cable radiation and poor antenna performance.
- Introduce two coaxial cable performance parameters:
 - Characteristic impedance
 - Attenuation (frequency dependent)

Description of Coaxial Cable

Coaxial cable theory states that an electromagnetic wave propagates along an inner conductor, surrounded by an insulator and an outer conductor, with equal and opposite currents creating a TEM wave whose fields are contained within the cable.

This design confines the signal, preventing interference and radiation, making coaxial cables ideal for transferring Radio Frequency (RF) energy with minimal loss or external effects.



Structure and Function

- **Inner Conductor:** The central wire, typically copper, that carries the electrical signal.
- **Insulator (Dielectric):** A layer of non-conducting material surrounding the inner conductor, which maintains the spacing and signal integrity.
- **Outer Conductor (Shield):** A braided or solid metallic layer that encircles the insulator and serves as a return path for the current.
- **Outer Jacket:** A protective outer layer of insulation that shields the entire cable.

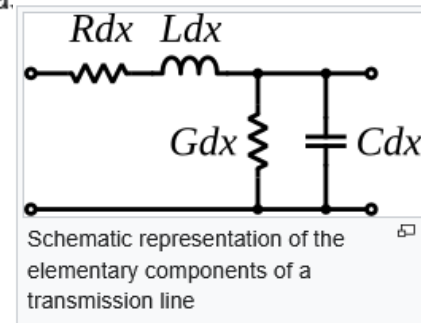
THEORY page 1

- Length of the cable, ℓ .
- Outside diameter of *inner* conductor, d .
- Inside diameter of the shield, D .
- **Dielectric constant** of the insulator, ϵ . The dielectric constant is often quoted as the relative dielectric constant ϵ_r referred to the dielectric constant of free space ϵ_0 : $\epsilon = \epsilon_r \epsilon_0$. When the insulator is a mixture of different dielectric materials (e.g., polyethylene foam is a mixture of polyethylene and air), then the term effective dielectric constant ϵ_{eff} is often used.
- **Magnetic permeability** of the insulator, μ . Permeability is often quoted as the *relative* permeability μ_r referred to the permeability of free space μ_0 : $\mu = \mu_r \mu_0$. The relative permeability will almost always be 1.
- Shunt **capacitance** per unit length, in **farads** per metre.^[9]

$$C = \frac{2\pi\epsilon}{\ln\left(\frac{D}{d}\right)} = \frac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{D}{d}\right)}$$

- Series **inductance** per unit length, in **henries** per metre, considering the central conductor to be a thin hollow cylinder (due to **skin effect**).

$$L = \frac{\mu}{2\pi} \ln\left(\frac{D}{d}\right) = \frac{\mu_0\mu_r}{2\pi} \ln\left(\frac{D}{d}\right)$$



THEORY page 2

The parameters L and C are determined from the ratio of the inner (d) and outer (D) diameters and the **dielectric constant** (ϵ). The characteristic impedance is given by^[11]

$$Z_o = \frac{1}{2\pi} \sqrt{\frac{\mu}{\epsilon}} \ln\left(\frac{D}{d}\right) \approx \frac{59.96 \Omega}{\sqrt{\epsilon_r}} \ln\left(\frac{D}{d}\right) \approx \frac{138 \Omega}{\sqrt{\epsilon_r}} \log_{10}\left(\frac{D}{d}\right).$$

- **Attenuation (loss)** per unit length, in **decibels** per metre. This is dependent on the loss in the dielectric material filling the cable, and resistive losses in the centre conductor and outer shield. These losses are frequency dependent, the losses becoming higher as the frequency increases. Skin effect losses in the conductors can be reduced by increasing the diameter of the cable. A cable with twice the diameter will have half the skin effect resistance. Ignoring dielectric and other losses, the larger cable would halve the dB/metre loss. In designing a system, engineers consider not only the loss in the cable but also the loss in the connectors.
- **Velocity of propagation**, in metres per second. The velocity of propagation depends on the dielectric constant and permeability (which is usually 1).

$$v = \frac{1}{\sqrt{\epsilon\mu}} = \frac{c}{\sqrt{\epsilon_r\mu_r}}$$

Large Coaxial Cables



1 $\frac{5}{8}$ in (41 mm) flexible
line with (mostly) air dielectric

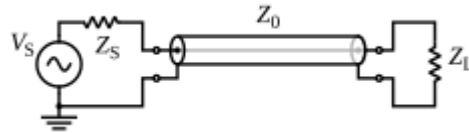


1 $\frac{5}{8}$ in (41 mm) Heliax
coaxial cable with FPE
foamed polyethylene
dielectric

Characteristic Impedance, Z_0


- The Characteristic Impedance of a cable is simply that resistance, when placed across the end of the transmission line, results in no reflected wave back to the source.

$$Z_s = Z_l = Z_0$$



- When a different impedance is present, the resultant reflected wave amplitude can be expressed as Voltage Standing Wave Ratio or VSWR.

Coaxial Cable Absorption Losses

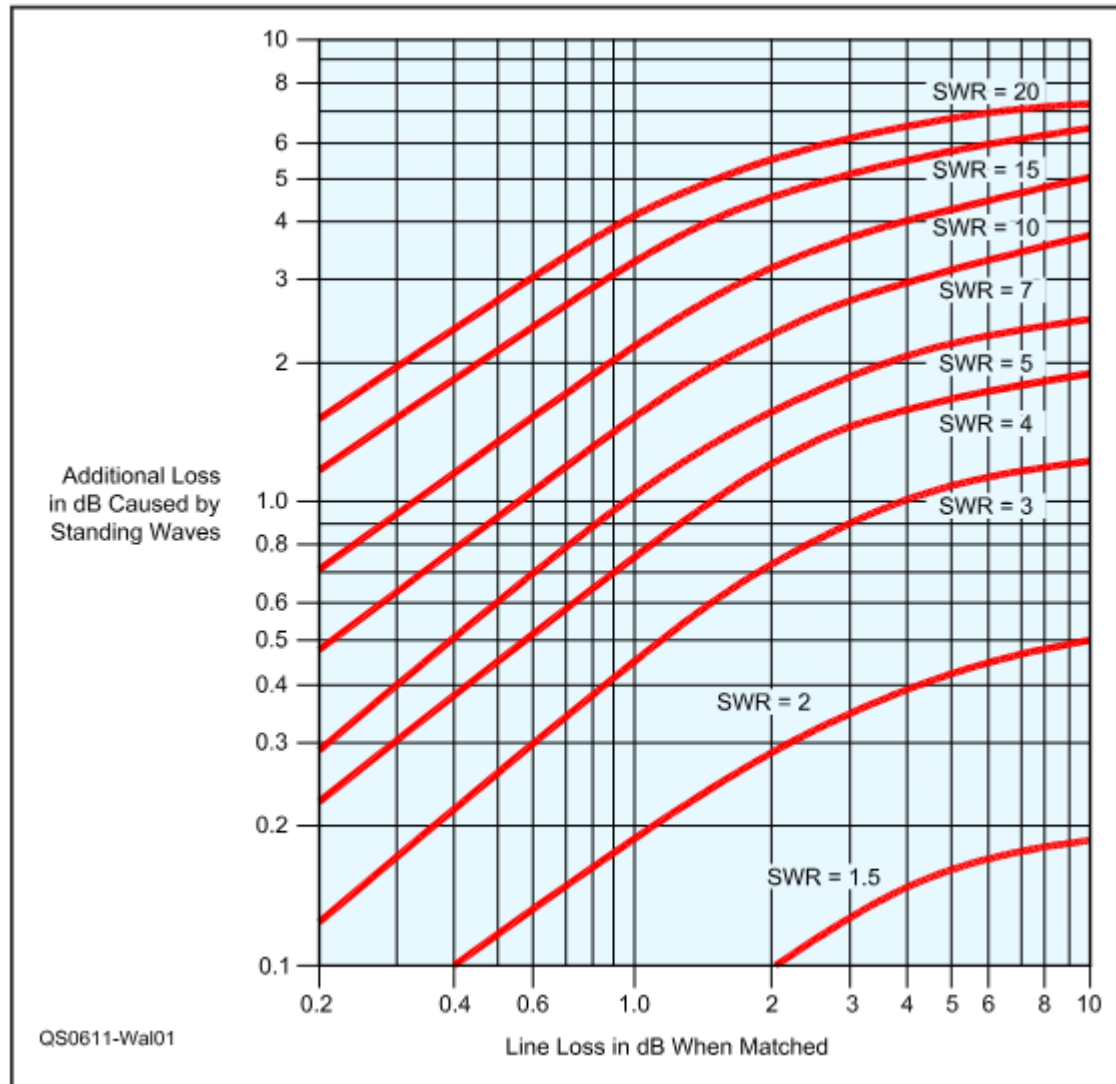
Coaxial cable absorption losses, or dielectric losses, occur when the insulating material (the dielectric) between the center conductor and outer shield absorbs energy from the signal, converting it into heat. This loss mechanism is more pronounced at higher frequencies and with certain dielectrics, such as foam polyethylene, which can absorb moisture, leading to degradation and increased loss over time. Factors like cable length, material properties, signal frequency, moisture ingress, and physical damage (like sharp bends) all contribute to the overall attenuation, or loss, of the signal in a coaxial cable. 



Importance of Minimizing Reflections

- Coaxial Cable Additional Loss factor, next slide.
- VSWR output power “fold-back” in solid state rigs. Typically complete shut down when VSWR reaches 3:1.

Additional Cable Loss due to SWR

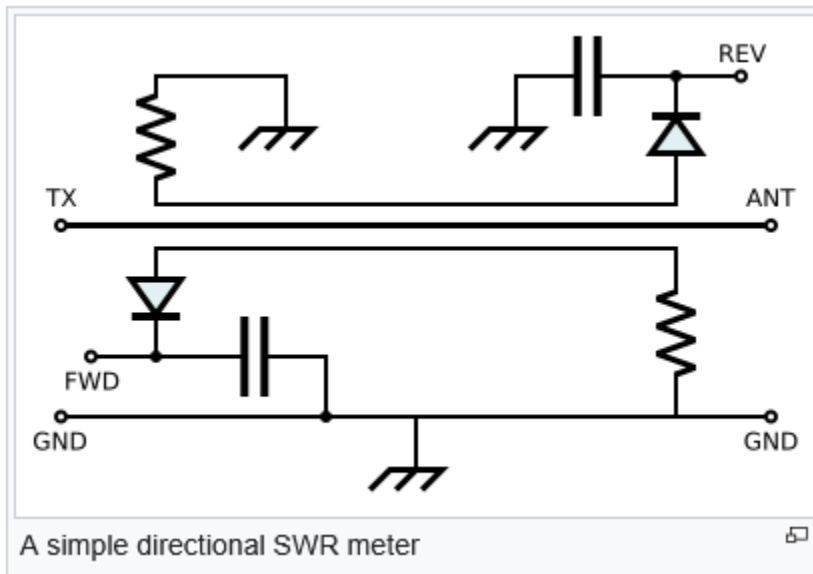


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SWR Measurement

Since the power of the forward and reflected waves are proportional to the square of the voltage components due to each wave, SWR can be expressed in terms of forward and reflected power:

$$\text{SWR} = \frac{1 + \sqrt{P_r/P_f}}{1 - \sqrt{P_r/P_f}} \quad \text{VSWR} = \frac{|V_{\text{max}}|}{|V_{\text{min}}|}$$



Measurement of Cable Loss

- A number of antenna analyzers can measure the absorption loss versus frequency for a known length, this can then be compared with the manufacturer's specifications to detect deterioration of the cable.
- Example of why this could be important:
- K5GM noticed a significant change in his Mosley TA-33 trap yagi performance. After careful analysis, the braid in a short section of the RG-213 coaxial cable had deteriorated due to water incursion. Maybe earlier absorption testing might have caught this pending failure?




Use of The NanoVNA For Antenna Measurements

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15 AUG 2021

Using the RigExpert AA-230 Zoom To Measure Cable Loss

To measure cable loss with the RigExpert AA-230 Zoom, connect the cable to the analyzer's connector, then select the Tools menu (F8) to find the Cable Loss option, or use the Return Loss function with a shorted cable end to measure the reflected signal and calculate energy lost. The TDR (Time Domain Reflectometer) mode can also locate faults along the cable that contribute to loss. 



See Review article: ARRL QST March 2016

Using the MFJ-259B To Measure Cable Loss

To measure cable loss with an MFJ-259B, connect the cable's far end as an open circuit, tune the analyzer to a known frequency, then find the frequency where the impedance reads as a short (0 ohms), and record the reactance (X). Repeat for a known short, but find the frequency of the open. The difference between the two X values, divided by the cable's measured length (in feet) and the analyzer's frequency, gives you the loss per 100 feet of cable in dB.



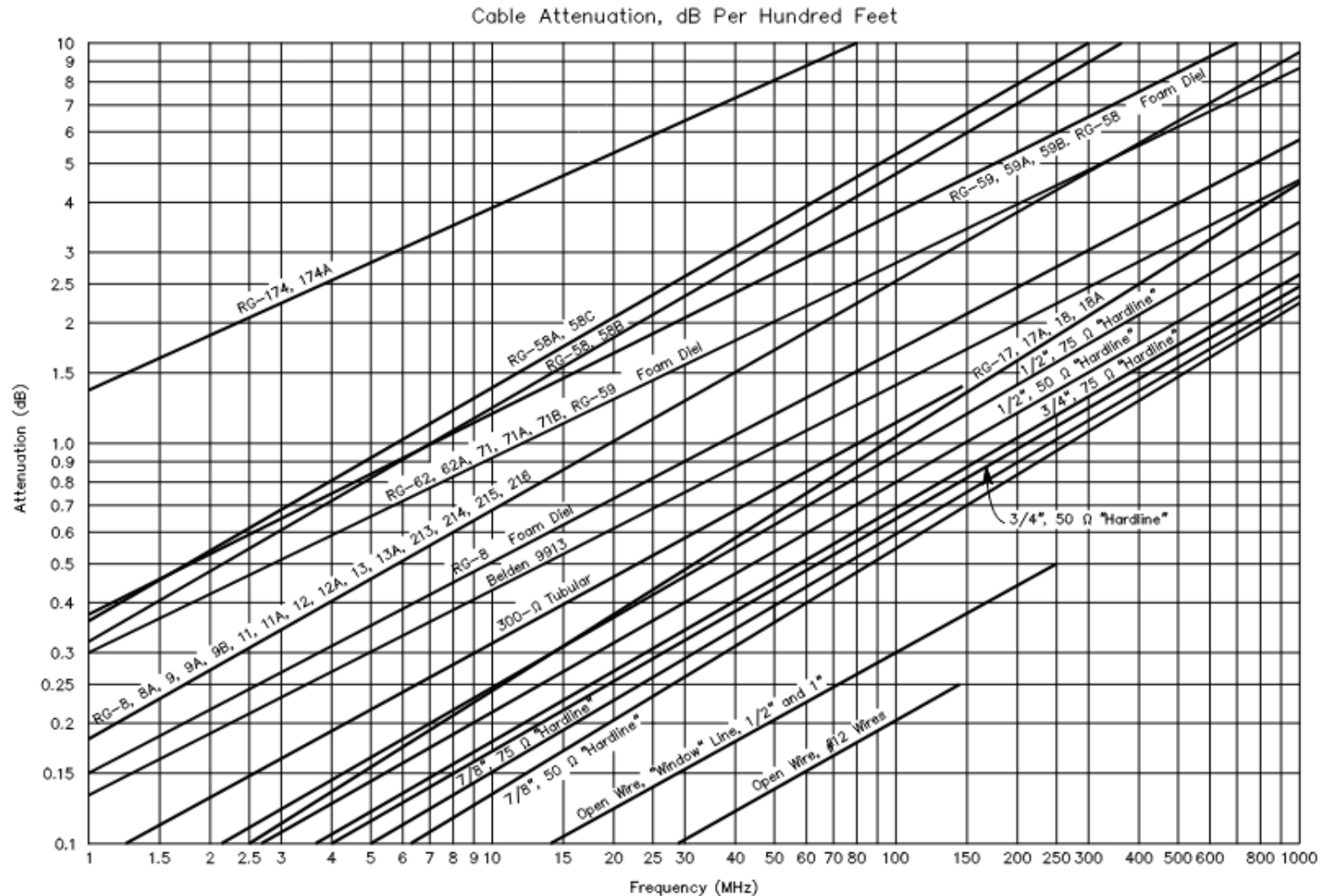
History of Coaxial Cable Impedance

- The best coaxial cable impedances were experimentally determined at [Bell Laboratories](#) in 1929 to be 77 Ω for low-attenuation, 60 Ω for high-voltage, and 30 Ω for high-power. For a coaxial cable with air dielectric and a shield of a given inner diameter, the attenuation is minimized by choosing the diameter of the inner conductor to give a characteristic impedance of 76.7 Ω .^[14] When more common dielectrics are considered, the lowest [insertion loss](#) impedance drops down to a value between 52 and 64 Ω . Maximum power handling is achieved at 30 Ω .^[15]

Optimum Cable Zo

- The [arithmetic mean](#) between 30 Ω and 77 Ω is 53.5 Ω ; the [geometric mean](#) is 48 Ω . The selection of 50 Ω as a compromise between power-handling capability and attenuation is in general cited as the reason for the number.[\[14\]](#) 50 Ω also works out tolerably well because it corresponds approximately to the feedpoint impedance of a half-wave dipole, mounted approximately a half-wave above "normal" ground.

Cable Attenuation by Type



Popular HF Coaxial Cables – 100 watts

RG-58 A/U

CABLE SPECIFICATIONS

PART NUMBER COA5800	CONDUCTOR	INSULATION	OUTER SHIELDING	OUTER JACKET
Material	Tinned Copper	Solid Polyethylene	Tinned Copper	Polyvinyl Chloride (PVC)
Size / Misc.	20AWG	N/A	95% Coverage	Black Color
Stranding	19X33	N/A	Braid	N/A
Outside Diameter	Ø 0.035"	Ø 0.116"	N/A	Ø 0.192" - Ø 0.196"

TECHNICAL DATA	
Nominal Impedance	50Ω
Nominal Inductance	0.092 μH/Ft
Nominal Capacitance	30.8 Pf/Ft
Velocity of Propagation	66%
Conductor DC Resistance @20° C	10.8 Ω/1000 ft.
Outer Shield DC Resistance	4.1 Ω/1000 ft.
Operating Temperature	-40°C to +75°C

ATTENUATION TABLE	
Frequency (MHz)	Nominal Attenuation (dB/100ft.)
1	0.4
10	1.5
50	3.7
100	5.4
200	8.1
400	12.4
700	17.7
900	21.1
1000	22.8

Popular HF Coaxial Cables – 250 watts RG-8X (Belden 9258)

ELECTRICAL CHARACTERISTICS:

Nom. Characteristic Impedance	50 Ohms
Nom. Inductance	.065 μ H/ft
Nom. Capacitance Conductor to Shield	24.8 pF/ft
Nominal Velocity of Propagation	82 %
Nominal Delay	1.2 ns/ft
Nom. Conductor DC Resistance @ 20 Deg. C	4.3 Ohms/1000 ft
Nominal Outer Shield DC Resistance @ 20°C	3.3 Ohms/1000 ft

Nom. Attenuation :

Description	Frequency (MHz)	Start Frequency (MHz)	Stop Frequency (MHz)	Nom. Attenuation (dB/100 ft.)
	1			.3
	10			.9
	50			2.1
	100			3.1
	200			4.5
	400			6.6
	700			9.1
	900			10.7
	1000			11.2

Max. Power Rating :

Popular HF Coaxial Cables – 1000 watts

RG-8U and RG-213

DXE-8U Low-Loss 50-ohm Foam Dielectric Cable

95-97% Coverage Bare Copper Shield
Gas-Injected Foam Polyethylene Dielectric
11-Gauge Stranded Copper Center
Black PVC Jacket

Gas-Injected Foam Won't Absorb Water

- Low-loss, gas-injected foam polyethylene dielectric
- .405" high-flex PVC jacket
- Low-loss foam dielectric
- Braided copper shield

Attenuation/ 100 ft.	Power Rating	Efficiency Approximate
0.3 dB @ 5 MHz	5.4 kW	93 %
0.6 dB @ 10 MHz	3.4 kW	87 %
1.0 dB @ 30 MHz	2.0 kW	79 %
1.3 dB @ 50 MHz	1.5 kW	73 %
2.2 dB @ 150 MHz	1.0 kW	60 %

NOT Recommended for Rotator Loops

Velocity Factor: 81% (0.81)
Minimum Bend Radius: 2.5"

DXE-213U 50-ohm Cable

96-97% Coverage Bare Copper Shield
Solid Polyethylene Dielectric
13 AWG Stranded Copper Center
UV-Resistant, Non-Contaminating, Black PVC Jacket

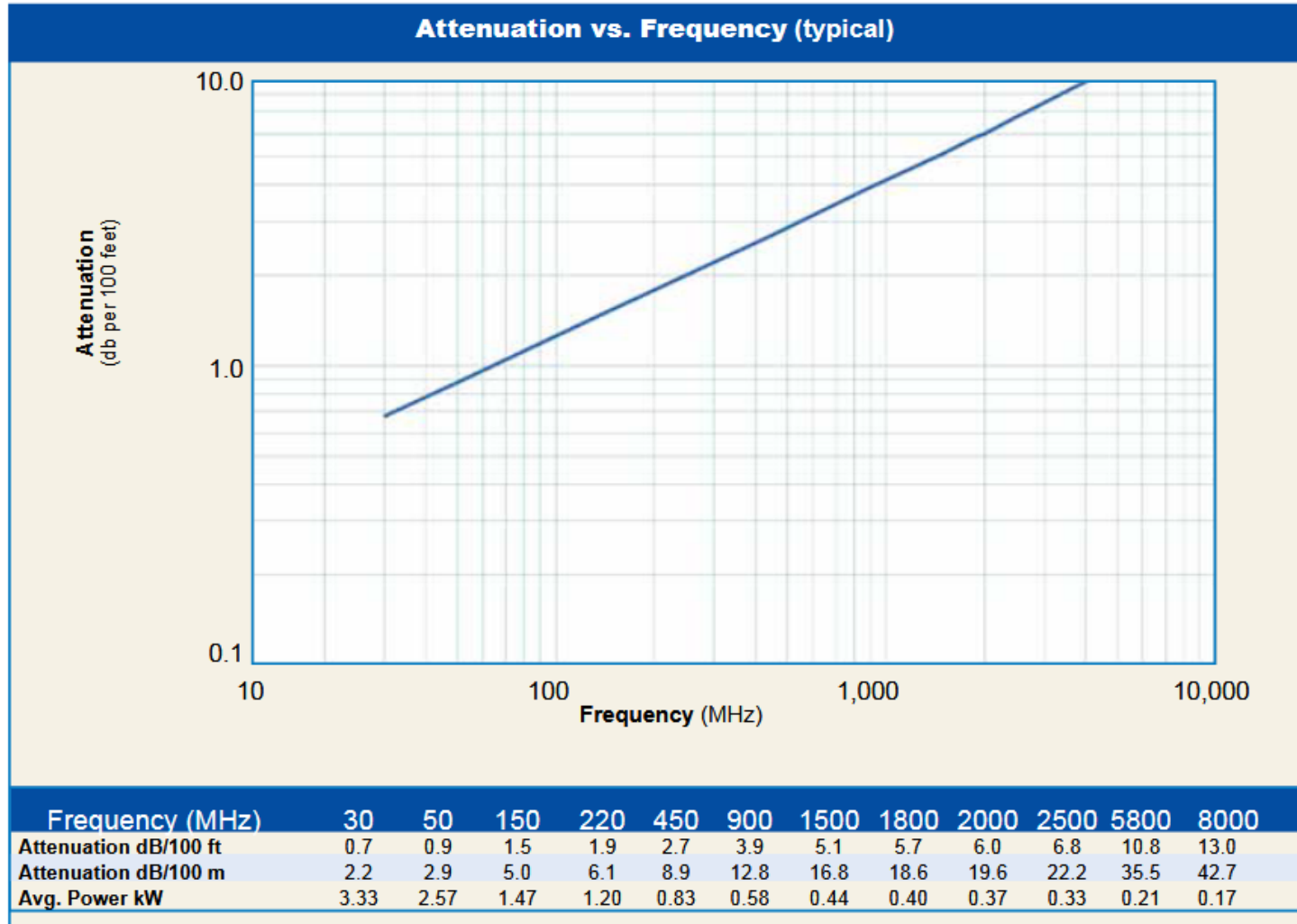
- Solid Polyethylene Dielectric
- Okay for repeated bending
- Recommended for Rotator Loops
- .405" Type II jacket is non-contaminating and UV-resistant, suitable for outdoor use
- Direct-bury
- Braided copper shield

Attenuation/ 100 ft.	Power Rating	Efficiency Approximate
0.4 dB @ 5 MHz	4.9 kW	91 %
0.6 dB @ 10 MHz	3.4 kW	87 %
1.0 dB @ 30 MHz	2.0 kW	79 %
1.3 dB @ 50 MHz	1.5 kW	73 %
2.4 dB @ 150 MHz	0.9 kW	57 %

Recommended for Rotator Loops

Velocity Factor: 66% (0.66)
Minimum Bend Radius: 5"

Popular VHF/UHF Coaxial Cable LMR-400



Popular HF QRP Coaxial Cable



\$28.65

DX Engineering RG-174 50-ohm Hi-Viz Orange Mini Coaxial Assemblies >

Coaxial Cable, RG-174, 26 AWG Copper, Orange PVC Jacket, BNC Male, 35 ft. Length, Each

Note: Use of BNC connectors rather than standard PL-259 connectors

RG-174V Loss Chart

DX Engineering RG-174V Mini-Coaxial Cable Assemblies Loss Chart

Approx. RF Loss, dB	DXE-174V Cable Assembly Length					
	1.5 ft	3 ft	6 ft	25 ft	35 ft	50 ft
1.8 MHz	0.01 dB	0.03 dB	0.06 dB	0.23 dB	0.32 dB	0.47 dB
3.5 MHz	0.02 dB	0.04 dB	0.08 dB	0.35 dB	0.49 dB	0.70 dB
7 MHz	0.03 dB	0.06 dB	0.12 dB	0.51 dB	0.72 dB	1.03 dB
10.1 MHz	0.03 dB	0.07 dB	0.14 dB	0.60 dB	0.84 dB	1.20 dB
14 MHz	0.04 dB	0.09 dB	0.18 dB	0.73 dB	1.02 dB	1.47 dB
18.07 MHz	0.05 dB	0.10 dB	0.20 dB	0.83 dB	1.17 dB	1.67 dB
21 MHz	0.05 dB	0.11 dB	0.22 dB	0.90 dB	1.26 dB	1.80 dB
24.89 MHz	0.05 dB	0.12 dB	0.23 dB	0.97 dB	1.36 dB	1.94 dB
28 MHz	0.06 dB	0.12 dB	0.25 dB	1.04 dB	1.47 dB	2.10 dB
50 MHz	0.08 dB	0.17 dB	0.34 dB	1.44 dB	2.01 dB	2.87 dB
146 MHz	0.14 dB	0.30 dB	0.59 dB	2.47 dB	3.46 dB	4.94 dB
430 MHz	0.26 dB	0.54 dB	1.07 dB	4.46 dB	6.25 dB	8.93 dB

3dB Loss is one-half of your transmit power

Coaxial Cable Connectors – RG-58 A/U & RG-8X



PL259 UHF Male Crimp Connectors for RG58

Connector Material:

- Outer shell: Copper nickel plated
- Inner needle: Brass gold plated
- Insulator: Teflon (PTFE)



XRDS -RF RG8X PL259 Connector 10PCS, UHF PL259 Male Connector for RG8X, LMR240, KMR240, 4D-FB Cables, Compatible with CB Radios, HAM Radios, Antennas, and RF Applications

[Visit the XRDS -RF Store](#)

4.6 ★★★★★ 20 ratings

Amazon's Choice

\$21⁹⁹

Get Fast, Free Shipping with Amazon Prime

Get \$80 off instantly: Pay \$0.00 upon approval for the Amazon Store Card.

Brand	XRDS -RF
Cable Type	RG8X

Crimping Tool (Amazon)



Coaxial Crimping Tool for RG Type Cable -
RG50,54,55U,58,59,62,108,142,178,301,302,
307,400, LMR195,200,240, BNC 3D-2V,4C-2V
Connectors (CRIPMER L7 WG)

[Visit the YMYP Store](#)

4.6 ★★★★★ 43 ratings

Amazon's Choice

\$22⁹⁸

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Note: RG-240 uses same crimp tool as RG 8X

Coaxial Cable Connectors – RG-8 and RG-213

Deluxe UHF Male Solder Connector - RG8 & RG213



SKU: 1211

1 Piece | 50 Ohm | Male | Nickel Plated | Twist On Type

Quantity Discount Pricing				
1-4	5-19	20-99	100-499	500+
\$10.39	\$9.00	\$7.73	\$6.71	\$5.82

Quantity Available: 25

Qty

Add to Cart

✓ In Stock
Ships today



UHF male Crimp Connector for RG-8, RG-11, RG-83, RG-213, RG-393, LMR-400, and other 0.405 Inch OD Coax



Quantity Discounts Available:

(Single Piece) Price: \$2.99 each

(10 Pack) Price: \$26.90 per pack **Save 10%**

(25 Pack) Price: \$59.75 per pack **Save 20%**

(50 Pack) Price: \$119.50 per pack **Save 20%**

(100 Pack) Price: \$209.00 per pack **Save 30%**

Coaxial Cable Connector – LMR-400

SureCall N-Male Crimp Connector for LMR® 400 Cable | SC-CN-09

☆☆☆☆☆ 0 Reviews

SC-CN-09



Currently ships in 1-2 business days.


Weather-resistant connector for cables

- High quality, low-loss connector
- Weather Resistant
- N-Connector

\$8.95

1

Add to Cart

 **FREE SHIPPING.** 60 day money back guarantee*

Building Cables

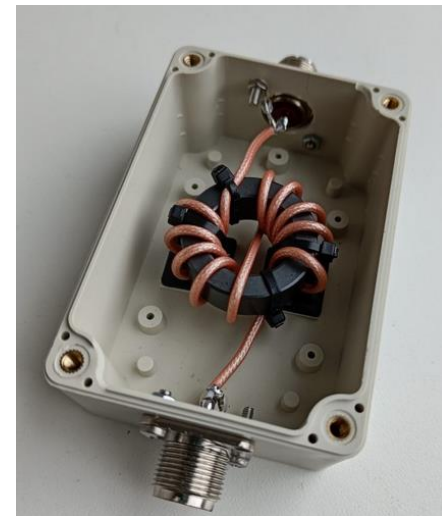
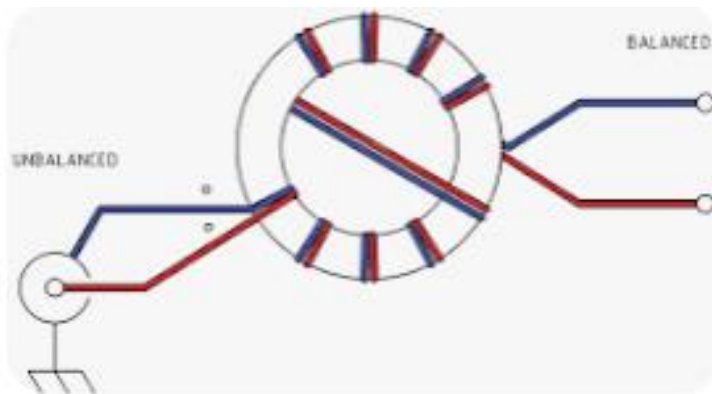
- Unless you are a good technician, I would recommend purchasing coaxial cable with connectors installed!

My Favorite Cable Companies

- Amazon
- DX-Engineering - <https://www.dxengineering.com/>
- ABR Industries - <https://abrind.com/> (custom lengths)
- Times Microwave - <https://timesmicrowave.com/>
- Belden - <https://www.belden.com/>
- Show Me Cables - <https://www.showmecables.com/>

Choke Baluns

RF choke baluns use a high-impedance inductance to block common-mode radio frequency (RF) currents from flowing on the outside of a coaxial cable's shield. This is crucial in antenna systems to prevent the coax from acting as an unwanted antenna element, which can cause RFI, noise, poor antenna performance, and potentially damage equipment. They are particularly used to isolate the antenna from the feedline, improve efficiency, and reduce interference in a radio station or nearby electronics.



Use and Placement of Choke Baluns

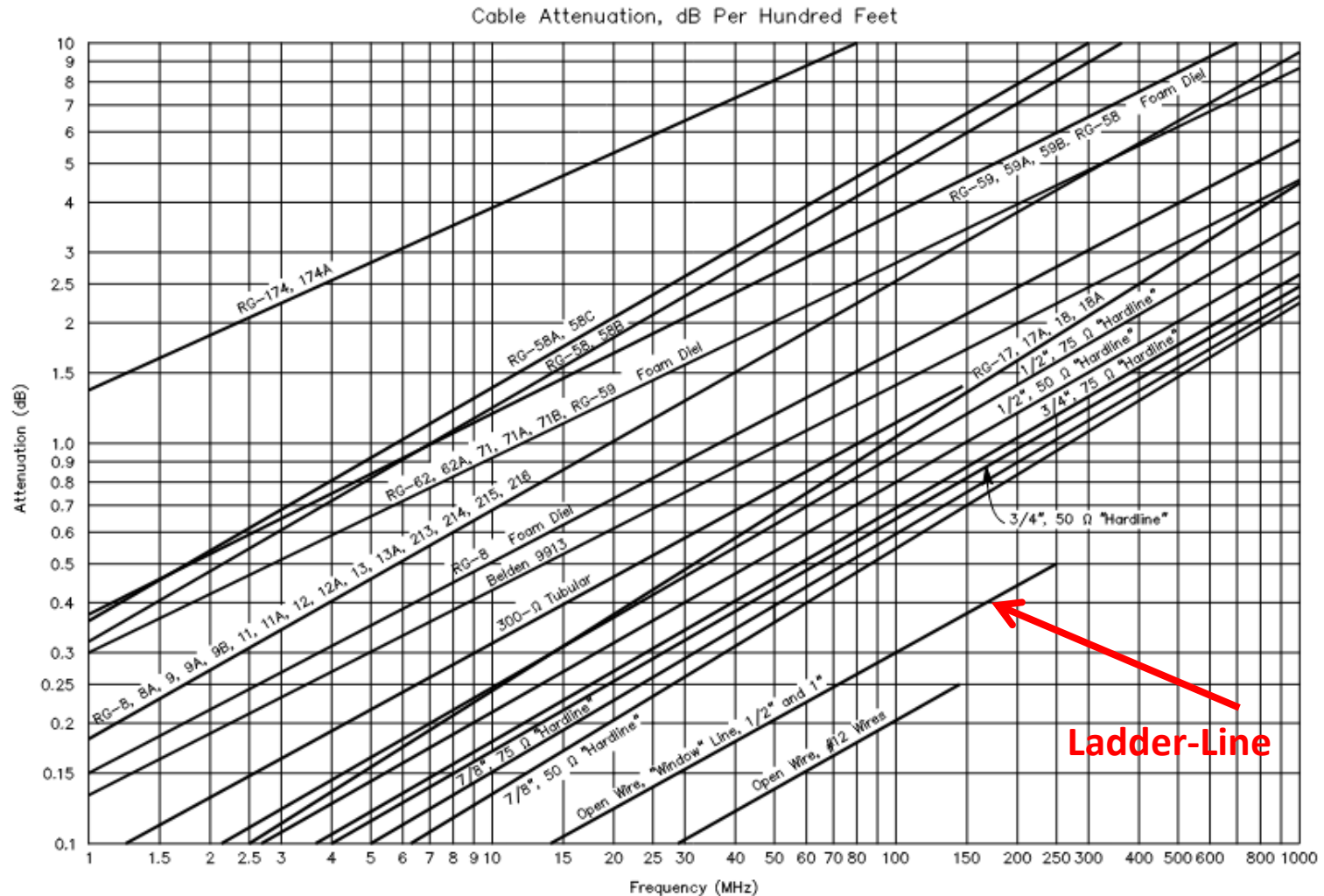
- Used when going from a balanced antenna (Dipole) to a unbalanced transmission Line (coax).
- Place at antenna feed point.
- Note: a tightly wrapped coil of coaxial cable can serve as an “air” balun, but wrapping the coaxial cable around a ferrite core is more efficient.



Non-coaxial cable transmission Lines

- Air dielectric twin-lead i.e., ladder line, is another transmission line option that has very low absorption loss at HF frequencies.
- Use of Ladder Line requires special matching networks to match its high impedance (300 to 450 ohms) to the 50 ohm output of a typical transceiver. The built-in auto-tuner in a typical amateur radio transceiver cannot match to ladder line so an external tuner (manual or automatic) is required.

Cable Attenuation of Ladder-Line



Summary

- Coaxial cable can efficiently allow your antenna to function with your amateur radio transceiver if the following rules are followed:
 - The antenna impedance must match the coaxial cable characteristic impedance, typically 50 ohms.
 - To minimize cable loss, the length and highest operating frequency will dictate cable selection.
- When using a balanced antenna (dipole), a 1:1 Choke Balun should be installed at the antenna feed point.
- To minimize transmission line losses, consider using Ladder-Line for multi-band dipole antennas.

Questions?

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