Transmission Lines
An Overview

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What is a Transmission Line?

- RF transmission lines are used to transfer or guide RF energy from one place to another with a minimum loss of power
  - Antenna to receiver
  - Transmitter to antenna
  - Connecting link between equipment

Types of Transmission Lines

- Open Wire
- Twin-lead (Ribbon)
- Twisted Pair
- Coaxial
  - Flexible
  - Rigid
- Waveguide

Transmission Line Characteristics

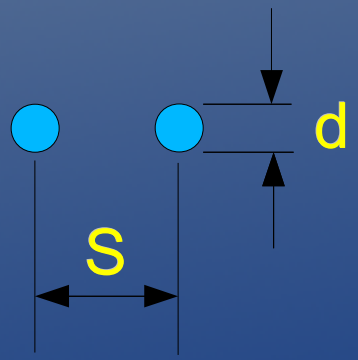
- All transmission lines share the same basic properties:
  - Resistance
  - Capacitance
  - Inductance
  - Physical Construction
- These basic properties determine typical usage parameters

Transmission Lines

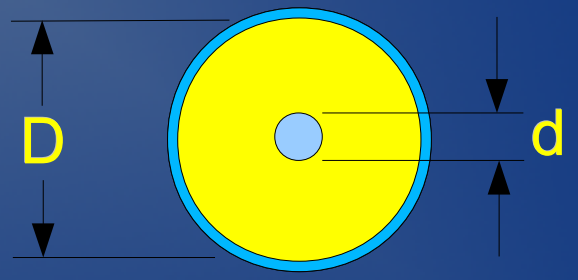
- Basic properties determine characteristics:
  - Impedance (Z_O)
  - Attenuation (dB)
  - Velocity Factor (%)
  - Power Limitations (Max. W)

Transmission Lines

- Impedance (Z_O)
  - Determined by Physical Properties
  - Frequency Independent
  - Material Independent
  - Length Independent



$$z_0 = 276 \log_{10} \frac{2S}{d}$$



$$z_0 = 138 \log_{10} \frac{D}{d}$$

Transmission Lines

- Attenuation (dB/Length)
  - Power or Signal Loss for given Length
  - Determined by:
    - Size of conductors
    - Dielectric material
    - Length

Transmission Lines

- Velocity Factor (%)
  - Time required for signal to propagate from one point to another in a transmission line as compared to propagation of the same distance in free space
    - Dielectric Material Dependent
    - Frequency Independent

$$\lambda = \frac{V}{F} \qquad \lambda_{meters} = \frac{300,000,000}{F}$$

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Transmission Lines

- Power Limitations
  - Maximum Power Limit to a Matched Line
    - Dielectric Dependent
    - Frequency Dependent
    - Impedance Dependent

Coaxial Transmission Line

- Most often used by Hams
  - Convenient
  - Cost effective
  - Many different types available

- OK! - But, which one?
  - Regardless of operating frequency, all transmission lines should have the smallest possible loss for maximum signal/power transfer
  - Must be matched to characteristic Impedance

Coaxial Transmission Line

OK, that was an infantile, evasive answer –

- How do I choose a coax cable for my station?
  - What is the application?
    - What frequency - below 30 MHz or above?
    - What power level – a few watts or legal limit?
    - How long is the cable?
  - Choose from a catalog or data book (on-line)

Coaxial Transmission Line

Table 1

Nominal Characteristics of Commonly Used Transmission Lines

RG or Type	Part Number	Nom. Z_0 W	VF %	Cap. pF/ft	Cent. Cond. AWG	Diel. Type	Shield Type	Jacket Matl	OD Inches	Max V (RMS)	Matched Loss (dB/100) 1 MHz	10	100	1000
RG-6	Belden 1694A	75	82	16.2	#18 Solid BC	FPE	FC	P1	0.275	600	0.2	0.7	1.8	5.9
RG-6	Belden 8215	75	66	20.5	#21 Solid CCS	PE	D	PE	0.332	2700	0.4	0.8	2.7	9.8
RG-8	Belden 7810A	50	86	23.0	#10 Solid BC	FPE	FC	PE	0.405	600	0.1	0.4	1.2	4.0
RG-8	TMS LMR400	50	85	23.9	#10 Solid CCA	FPE	FC	PE	0.405	600	0.1	0.4	1.3	4.1
RG-8	Belden 9913	50	84	24.6	#10 Solid BC	ASPE	FC	P1	0.405	600	0.1	0.4	1.3	4.5
RG-8	CXP1318FX	50	84	24.0	#10 Flex BC	FPE	FC	P2N	0.405	600	0.1	0.4	1.3	4.5
RG-8	Belden 9913F7	50	83	24.6	#11 Flex BC	FPE	FC	P1	0.405	600	0.2	0.6	1.5	4.8
RG-8	Belden 9914	50	82	24.8	#10 Solid BC	FPE	FC	P1	0.405	600	0.2	0.5	1.5	4.8
RG-8	TMS LMR400UF	50	85	23.9	#10 Flex BC	FPE	FC	PE	0.405	600	0.1	0.4	1.4	4.9
RG-8	DRF-BF	50	84	24.5	#9.5 Flex BC	FPE	FC	PE	0.405	600	0.1	0.5	1.6	5.2
RG-8	WM CQ106	50	84	24.5	#9.5 Flex BC	FPE	FC	P2N	0.405	600	0.2	0.6	1.8	5.3
RG-8	CXP008	50	78	26.0	#13 Flex BC	FPE	S	P1	0.405	600	0.1	0.5	1.8	7.1
RG-8	Belden 8237	52	66	29.5	#13 Flex BC	PE	S	P1	0.405	3700	0.2	0.6	1.9	7.4
RG-8X	Belden 7808A	50	86	23.5	#15 Solid BC	FPE	FC	PE	0.240	600	0.2	0.7	2.3	7.4
RG-8X	TMS LMR240	50	84	24.2	#15 Solid BC	FPE	FC	PE	0.242	300	0.2	0.8	2.5	8.0
RG-8X	WM CQ118	50	82	25.0	#16 Flex BC	FPE	FC	P2N	0.242	300	0.3	0.9	2.8	8.4
RG-8X	TMS LMR240UF	50	84	24.2	#15 Flex BC	FPE	FC	PE	0.242	300	0.2	0.8	2.8	9.6
RG-8X	Belden 9258	50	82	24.8	#16 Flex BC	FPE	S	P1	0.242	600	0.3	0.9	3.1	11.2
RG-8X	CXP08XB	50	80	25.3	#16 Flex BC	FPE	S	P1	0.242	300	0.3	0.9	3.1	14.0
RG-9	Belden 8242	51	66	30.0	#13 Flex SPC	PE	SCBC	P2N	0.420	5000	0.2	0.6	2.1	8.2
RG-11	Belden 8213	75	84	16.1	#14 Solid BC	FPE	S	PE	0.405	600	0.2	0.4	1.3	5.2
RG-11	Belden 8238	75	66	20.5	#18 Flex TC	PE	S	P1	0.405	600	0.2	0.7	2.0	7.1
RG-58	Belden 7807A	50	85	23.7	#18 Solid BC	FPE	FC	PE	0.195	300	0.3	1.0	3.0	9.7
RG-58	TMS LMR200	50	83	24.5	#17 Solid BC	FPE	FC	PE	0.195	300	0.3	1.0	3.2	10.5
RG-58	WM CQ124	52	66	28.5	#20 Solid BC	PE	S	PE	0.195	1400	0.4	1.3	4.3	14.3
RG-58	Belden 8240	52	66	28.5	#20 Solid BC	PE	S	P1	0.193	1900	0.3	1.1	3.8	14.5
RG-58A	Belden 8219	53	73	26.5	#20 Flex TC	FPE	S	P1	0.195	300	0.4	1.3	4.5	18.1
RG-58C	Belden 8262	50	66	30.8	#20 Flex TC	PE	S	P2N	0.195	1400	0.4	1.4	4.9	21.5
RG-58A	Belden 8259	50	66	30.8	#20 Flex TC	PE	S	P1	0.192	1900	0.4	1.5	5.4	22.8
RG-59	Belden 1426A	75	83	16.3	#20 Solid BC	FPE	S	P1	0.242	300	0.3	0.9	2.6	8.5
RG-59	CXP 0815	75	82	16.2	#20 Solid BC	FPE	S	P1	0.232	300	0.5	0.9	2.2	9.1
RG-59	Belden 8212	75	78	17.3	#20 Solid CCS	FPE	S	P1	0.242	300	0.6	1.0	3.0	10.9
RG-59	Belden 8241	75	66	20.4	#23 Solid CCS	PE	S	P1	0.242	1700	0.6	1.1	3.4	12.0
RG-62A	Belden 9269	93	84	13.5	#22 Solid CCS	ASPE	S	P1	0.240	750	0.3	0.9	2.7	8.7
RG-62B	Belden 8255	93	84	13.5	#24 Flex CCS	ASPE	S	P2N	0.242	750	0.3	0.9	2.9	11.0
RG-63B	Belden 9857	125	84	9.7	#22 Solid CCS	ASPE	S	P2N	0.405	750	0.2	0.5	1.5	5.8
RG-142	CXP 183242	50	69.5	29.4	#19 Solid SCCS	TFE	D	FEP	0.195	1900	0.3	1.1	3.8	12.8
RG-142B	Belden 83242	50	69.5	29.0	#19 Solid SCCS	TFE	D	TFE	0.195	1400	0.3	1.1	3.9	13.5
RG-174	Belden 7805R	50	73.5	26.2	#25 Solid BC	FPE	FC	P1	0.110	300	0.6	2.0	6.5	21.3
RG-174	Belden 8216	50	66	30.8	#26 Flex CCS	PE	S	P1	0.110	1100	1.9	3.3	8.4	34.0
RG-213	Belden 8267	50	66	30.8	#13 Flex BC	PE	S	P2N	0.405	3700	0.2	0.6	1.9	8.0
RG-213	CXP213	50	66	30.8	#13 Flex BC	PE	S	P2N	0.405	600	0.2	0.6	2.0	8.2
RG-214	Belden 8268	50	66	30.8	#13 Flex SPC	PE	D	P2N	0.425	3700	0.2	0.6	1.9	8.0
RG-216	Belden 9850	75	66	20.5	#18 Flex TC	PE	D	P2N	0.425	3700	0.2	0.7	2.0	7.1
RG-217	WM CQ217F	50	66	30.8	#10 Flex BC	PE	D	PE	0.545	7000	0.1	0.4	1.4	5.2
RG-217	M17/78-RG217	50	66	30.8	#10 Solid BC	PE	D	P2N	0.545	7000	0.1	0.4	1.4	5.2
RG-218	M17/79-RG218	50	66	29.5	#4.5 Solid BC	PE	S	P2N	0.870	11000	0.1	0.2	0.8	3.4

Coaxial Transmission Line

- For example:
  - Backpacking QRP operation – low power
  - 30 meter band
  - Coax length: ≤10 ft.
- Probably RG-174
- Why not use RG-218?

Coaxial Transmission Line

The coax to my (pick one) beam, vertical, dipole is 100 ft. long and I work 30 meters

- Should I use RG-8X or RG-8 or something better, such as Belden 9913?
  - RG-8X = 0.9 dB/100 ft. at 10 MHz
  - RG-8 = 0.6 dB/100 ft. at 10 MHz
  - 9913 = 0.4 dB/100 ft. at 10 MHz

- I think the RG-8X will be just fine –

Coaxial Transmission Line

The coax to my (pick one) beam, vertical, dipole is 100 ft. long and I work 2 meters (local repeaters)

- Should I use RG-8X or RG-8 or something better, such as Belden 9913?
  - RG-8X = 3.1 dB/100 ft. at 100 MHz
  - RG-8 = 1.9 dB/100 ft. at 100 MHz
  - 9913 = 1.3 dB/100 ft. at 100 MHz

- (xx) is a good choice –

Coaxial Transmission Line

The coax to my (pick one) beam, vertical, dipole is 100 ft. long and I work 2 meters (weak signal) at 1500 watts.

- Should I use RG-8X or RG-8 or something better, such as Belden 9913?
  - RG-8X = 3.1 dB/100 ft. at 100 MHz
  - RG-8 = 1.9 dB/100 ft. at 100 MHz
  - 9913 = 1.3 dB/100 ft. at 100 MHz

- (xx) is a good choice –

Coaxial Transmission Line

- Remember the published parameters are for Matched Lines:
  - Reduce power for miss-matched conditions

    Unless you want the magic smoke to escape!

Coaxial Transmission Line

Why is 50Ω the typical coax impedance?

- Like everything else in life – it's a compromise!
  - Desired maximum signal transfer impedance is 75Ω
    - Think center-fed, half-wave dipole
  - Desired maximum power transfer impedance is 37.5Ω
    - Think base-fed, ¼-wave, vertical dipole
  - You guessed it – 50Ω is approx. halfway!