



Transmission Line Equation and Antenna Impedance Quick App Tool

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Coax Characteristics

Physical length	Velocity Factor
100 ft	1
Zo 50	
RCopper 0 ohm/100 ft	C 20 pf/ft
nepers/100 ft 0	db/100 ft 0
- v	Use Selected Coax

Estimated Cable Impedance at Test Frequency

Zo(f) = Ro 50 +j Xo 0

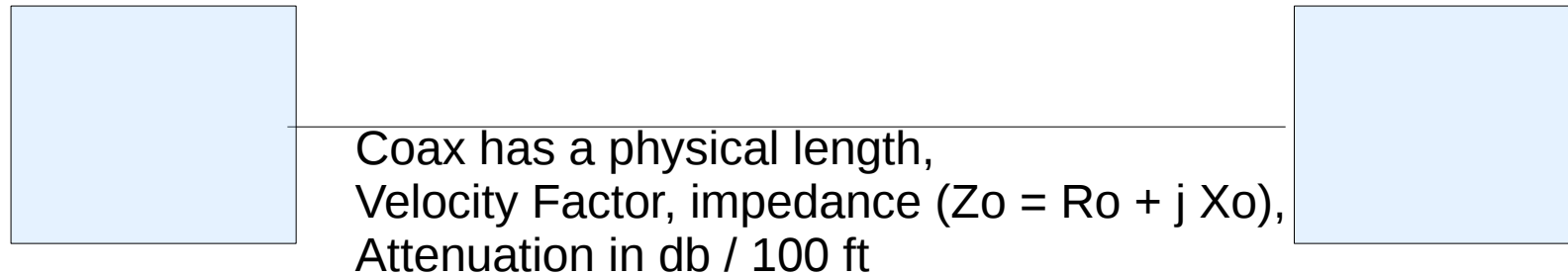
Measurement at XMTR end

Zin = RIN 50 +j XIN 0

What is it?

- The eightolives Transmission Line / Antenna Impedance QuickApp is a web-based calculator tool.
- The tool implements the Transmission Line equation used to relate the impedance at the source end (transmitter) of a (coax) transmission line to the impedance at the load (antenna)

http://www.eightolives.com/docs/Mobile/js_tools/antimp.htm



Source end,
Transmitter or
Measuring device

Load end,
Antenna

Test Frequency

Impedance $Z_L = R_L + j X_L$

Impedance $Z_{in} = R_{in} + j X_{in}$

Typical use is to compute Load Impedance after measuring Z_{in} .

Alternatively, for a known load, estimate the impedance at the source.

The screenshot shows a web-based calculator interface with four main sections, each highlighted with a different color:

- Coax Characteristics (Green):** Contains input fields for Physical length (100 ft), Velocity Factor (0.85), Zo (50), RCopper (0.1 ohm/100 ft), C (23.7 pf/ft), neper/100 ft (0.054110062), and db/100 ft (0.47). It also has a dropdown menu for coax type (RG-58) and a "Use Selected Coax" button.
- Estimated Cable Impedance at Test Frequency (Yellow):** Displays the calculated impedance as $Z_o(f) = R_o + j X_o$, with values 49.99959679 and 0.200800061.
- Measurement at XMTR end (Blue):** Contains input fields for $Z_{in} = R_{IN} + j X_{IN}$ (26.973 and 0.203), Test Frequency (2.09015 MHz), and buttons for "Set F to 1/4 wv" and "Set Lp to 1/4 wv".
- Antenna Load (Pink):** Contains input fields for $Z_L = R_L + j X_L$ (100 and 0).

The tool has four interactive sections:

The Coax Characteristics include physical length, velocity factor, impedance, copper resistance, capacitance and attenuation expressed as db/100 feet or in nepers / 100 feet. When coax "--" is selected, you can manually enter these parameters. You can also select a common coax type for typical values for that type.

An estimate of the cable impedance at the specified Test Frequency is calculated.

At the source or measurement end you can specify Test Frequency and complex impedance. Special buttons are provided to either set the Test Frequency to be $\frac{1}{4}$ wavelength for the given physical length or set the physical length to be $\frac{1}{4}$ wavelength for the given frequency.

The Antenna Load impedance is displayed. If you set the impedance values, then source impedance Z_{in} is updated.

Scrolling down from the entry areas, you find the calculator keys and a Report area which summarizes the last computation.

Like other QuickApp tools, the calculator uses Reverse Polish Notation.

Data in the entry text boxes can be entered by either selecting the text box and editing the value or by entering the value from the calculator keys and clicking the button associated with the text box.

The screenshot shows a web browser window with the address bar displaying `http://www.eightolives.com/edance`. The browser title is "SeaMonkey". The main content area contains a calculator interface with a grid of buttons. The buttons are arranged in a 4x4 grid for the top section, followed by a larger section with buttons for mathematical functions. The bottom section contains a text area with the following text:

```
Transmission Line / Antenna Impedance
Calculation

Coax:  --
  Physical length = 100 ft
  Velocity Factor = 1
  Electrical length = 100 ft
  Attenuation = 0 db / 100 ft
             (0 nepers/100 ft)
  Zo = 50 j0 ohms

Test Frequency = 10 MHz

At XMTR / Measurement End of Cable:
  Zin = 50 + j0 ohms
      (50 ohms)

At Antenna / Load End of Cable:
  ZL = 50 + j0 ohms
      (50 ohms)
```

The browser's status bar at the bottom shows the "Done" button and several icons.

Transmission Line Equation

$$Z_{in} / Z_0 = \frac{(Z_L \cosh(G) + Z_0 \sinh(G))}{(Z_L \sinh(G) + Z_0 \cosh(G))}$$

where

- $G = L (a + j b)$
 - $L =$ physical length in feet
 - $a =$ matched loss attenuation in nepers / unit length
1 neper = 8.686 db
 - $b =$ phase constant = $2 \pi / (VF * 983.6 / F)$
 - $VF =$ velocity factor
 - $F =$ Test frequency in MHz
- Source: ARRL Antenna Book
(22nd edition)

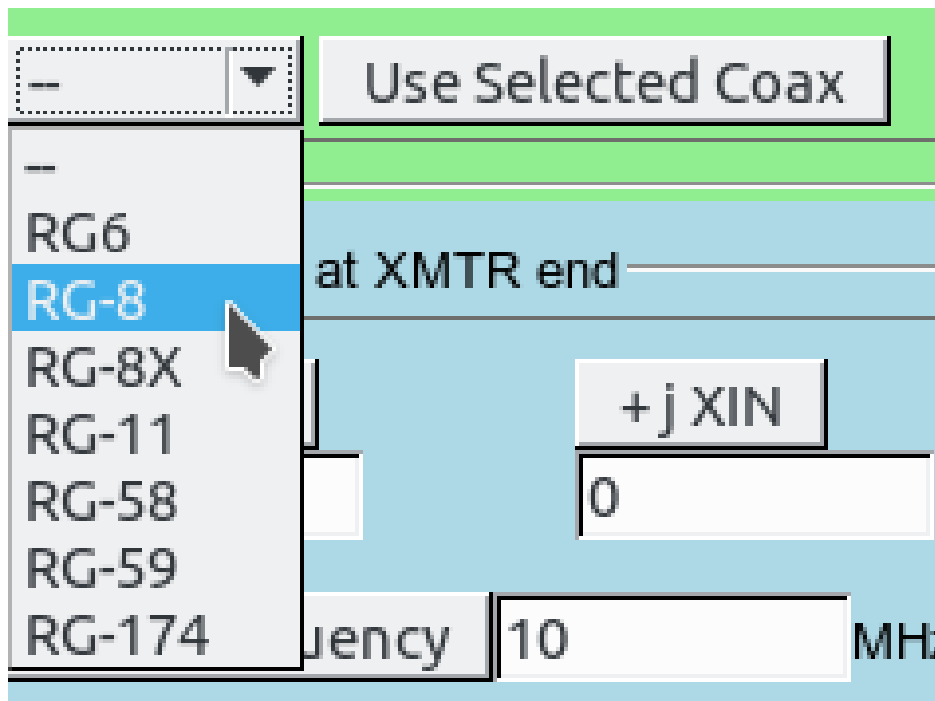
Coax Characteristics

- Coax data sheets normally specify
 - Characteristic impedance Z_0 at high frequency
 - Attenuation in db/100 ft at specified frequencies
 - Velocity Factor VF
 - Wire resistance ohms / 100 ft
 - Capacitance pf / ft
- Values can vary between manufacturers and between manufacturing lots.

Estimating Coax Impedance At Frequency

- $Z(f) = \text{Math.sqrt}(Z_0^2 - j (R_{dc} / 2 \pi f C))$
 - At high frequencies, $Z(f) = Z_0$
 - At low frequencies, $Z(f) = \text{Math.sqrt}(-j R_{dc} / 2 \pi f C)$
- The general equation is:
 - $Z(f) = \text{Math.sqrt}((R + j 2 \pi f L) / (G + j 2 \pi f C))$
 - The shunt conductance, G , is assumed to be 0
- Skin effects in the 10 – 100 kHz range are not considered in this estimate

Notes



- If you select a coax type, the values set are “typical”. Check the manufacturers data sheet for your particular cable.
- Attenuation values for a selected “typical” coax are interpolated for the test frequency used.
- To specify all values, select the default “--” coax.

Example 1 – $\frac{1}{4}$ wave Line

- The $\frac{1}{4}$ Wavelength Line has special impedance transform property such that

$$Z_{in} = Z_0^{**2} / Z_L$$

- An open circuit at the load appears as a short at the input
 - You can set R_L to 1000000 ohms to represent “open”
- A short at the load appears as an open circuit at the input

Example 2

- A 50 foot coax with velocity factor of .66 has an impedance of $50 - j 0.45$ at 7.15 MHz and a matched line loss of 0.54 db / 100 ft at that frequency.
- If an attached dipole antenna is assumed to have an impedance of $43 + j 30$ ohms, the input impedance will be $65.8 + j 32$ ohms

Source: ARRL Antenna Book 22nd Edition

Ways to measure cable length

- Use a tape measure to measure physical length.
- If you can't do that, leave the load end open and determine the lowest frequency where the impedance at the source (Z_{in}) appears to be 0.
 - This would be $\frac{1}{4}$ wavelength (electrical length)
 - Physical length = Electrical length * VF
- Alternatively, short the load end and parallel a 50 ohm resistor at the source. Then determine the lowest frequency where the impedance $Z_{in} = 50$ ohms
 - This would be $\frac{1}{4}$ wavelength (electrical length)

For more information

- Visit <http://www.eightolives.com>