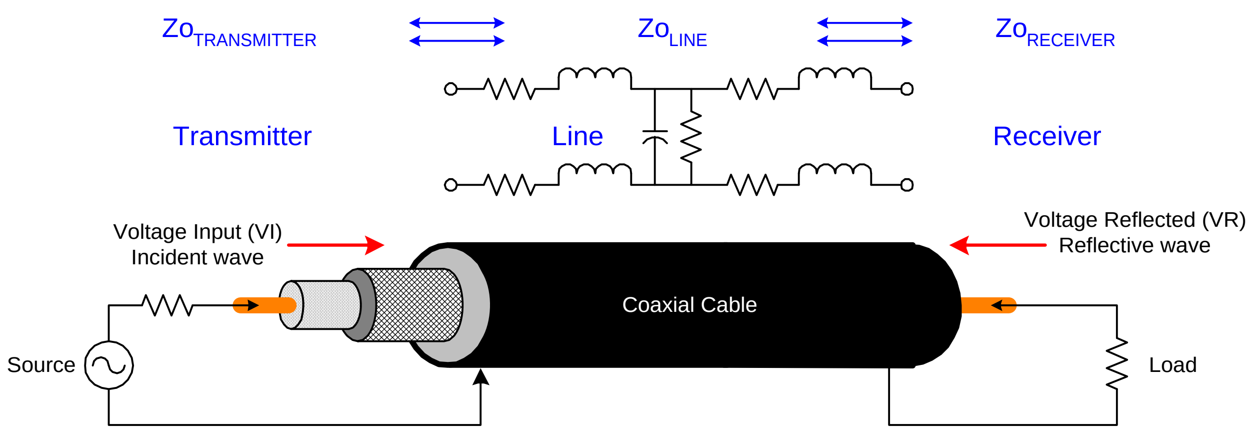
Application Note

Characteristic Cable Impedance

Characteristic cable impedance (Zo) is a very important measurement in determining a cable’s transmission capability. Maximum power is transmitted when the source has the same impedance as the load. Therefore the cable (line) should have the same characteristic impedance as the transmission equipment. The Zo of the transmitting equipment drives the maximum signal into the line and in turn the Zo of receiving equipment determines the maximum signal out of the line. Ideally, $Zo_{TRANSMITTER} = Zo_{LINE} = Zo_{RECEIVER}$. When the characteristic impedances do not match, part of the signal is reflected back to the source degrading the transmission path.



Maximum Signal Transmission (power transfer) occurs when $Z_{LINE} = Z_{LOAD}$

Figure 1: Maximum Signal Transmission

Although it can be represented in terms of inductors, capacitors and resistors, characteristic impedance is a complex number that is highly dependent on the frequency of the applied signal. Zo is not a function of the cable length. At high frequencies (> 100kHz), the characteristic impedance is almost purely resistive. At mid-range frequencies (1kHz), Zo is affected by capacitance (wC) and at low frequencies (DC – 100Hz), Zo is influenced by conductance (G).

Complex Equation	Resistive Measurement
$Zo = \sqrt{\dfrac{R + j\omega L}{G + j\omega C}}$	$Zo = \sqrt{Zoc \quad Zsc}$

frequency:	f = DC - 100Hz	f = 1kHz	f = 100kHz
Zo:	$Zo = \sqrt{\dfrac{R}{G}}$	$Zo = \sqrt{\dfrac{R}{\omega C}}$	$Zo = \sqrt{\dfrac{L}{C}}$

Figure 2: Characteristic Impedance Formulas

IET LABS, INC.
534 Main Street, Westbury, NY 11590
www.ietlabs.com
TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

Application Note

Measuring Characteristic Cable Impedance

Yet, how does a cable manufacturer realistically measure the characteristic impedance of his product? In other words, what is the cable's Zo, the Z_{LINE} that must be equated to the transmitter and receiver? The characteristic impedance of coaxial cable can be determined from the formula:

$$Z_O = \sqrt{Z_{OC}\, Z_{SC}}$$

Z_O is the Characteristic Impedance
Z_{OC} is the Open Circuit Impedance
Z_{SC} is the Short Circuit Impedance

To measure a coaxial cable (in the frequency range 10 Hz to 2 MHz) on the IET Labs 7600 Plus.

1. Connect the cable via 7000-03 leads or fixture to the 7600 front panel output terminals.
2. Perform OPEN / SHORT zeroing on the 7000-03 leads (or your fixture).
3. Attach the cable to the 7000-03 leads (or your fixture) and measure Z_{OC}.
4. Short the cable ends and measure the Z_{SC} (cable short circuited).
5. Calculate Z_O from the formula above.

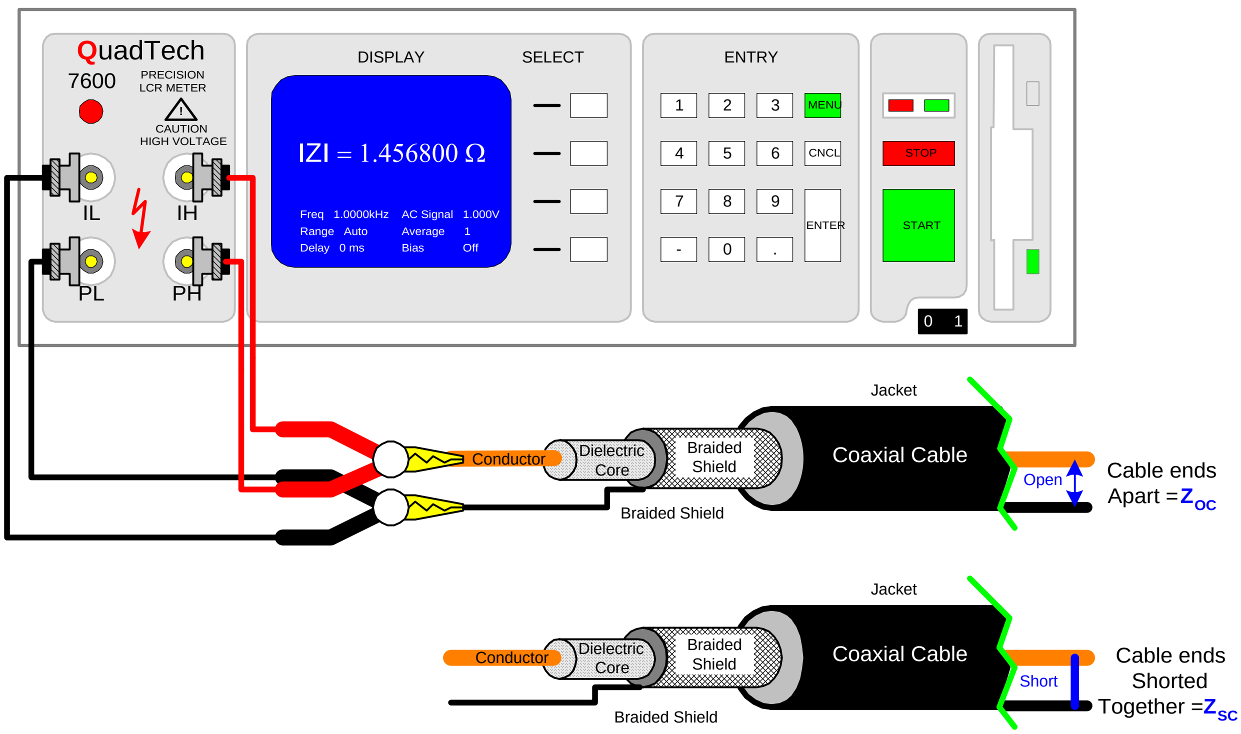


Figure 3: Coaxial Cable Impedance Measurement with 7000-03 Kelvin Leads

Zoc is made with the cable ends apart by connecting the red Kelvin lead to the conductor and the black Kelvin lead to the braided shield. Similarly, Zsc is made with the same connection, except the cable ends are shorted together.

IET LABS, INC.
534 Main Street, Westbury, NY 11590
www.ietlabs.com
TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988