

measuring coax cable loss with an SWR meter

One solution to
the high cost
of exotic test equipment
for measuring
transmission-line losses

Have you ever wondered how much loss a piece of coaxial cable has at a particular frequency? You could consult a chart or graph in a reference book. However, that would only tell you the *approximate* loss for coax from the manufacturer who supplied data to the editor of the book. Age and environment affect cable loss. Does the chart in the book include an age factor? The easiest way to determine loss in a piece of coax is by measuring it. You don't need

expensive test equipment to do this. All you need is a) an SWR meter or a bidirectional wattmeter, b) a transmitter, and c) the desire to perform a few simple calculations.

determining cable loss

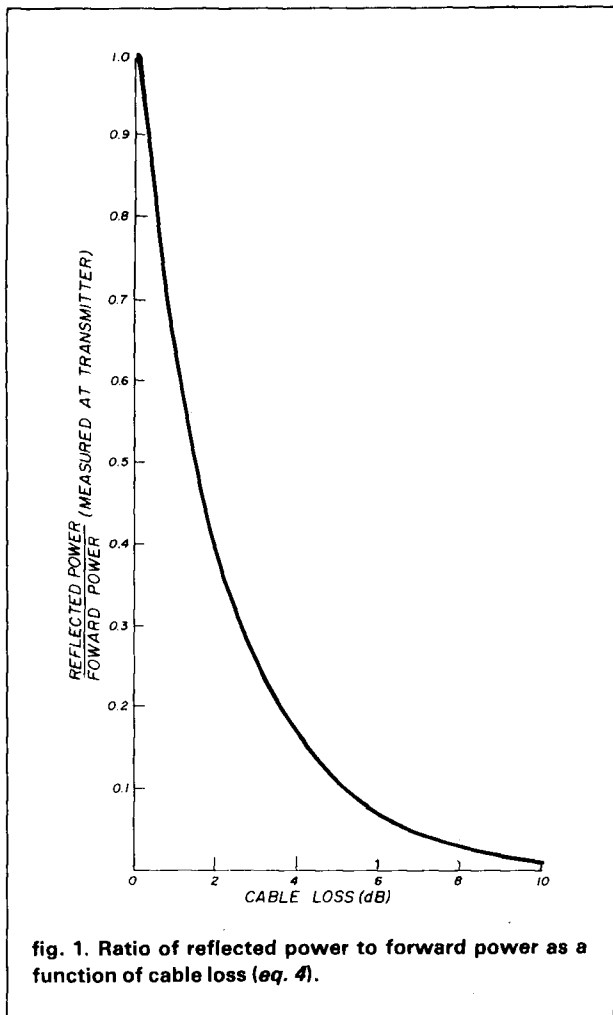
The loss in coaxial cable can be determined by connecting it to a source of rf (the transmitter) and measuring the SWR at the transmitter when the far end of the line is an open circuit. At first this method may sound too simple to work, but it does, and here's why.

Transmission line theory tells us that the SWR will be:

$$SWR = \frac{R}{Z} \quad (1)$$

where R is the load resistance, and Z is the line impedance.¹ An open circuit would present an infinite load resistance and therefore an infinite SWR. Trans-

By John W. Frank, WB9TQG, P.O. Box 5113,
Madison, Wisconsin 53705



mission line theory also tells us that the reflection coefficient² will be:

$$K = \frac{SWR - 1}{SWR + 1} \quad (2)$$

Since the SWR of an open circuit will be infinite, the reflection coefficient will be, for all practical purposes, unity (100 per cent). Therefore, all the power reaching the end of the line will be reflected to the source.

However, not all the power from the source reaches the end of the line; some is lost along the way. And not all the reflected power returns to the source; some of it is also lost along the way.

The reflected power measured at the source represents twice the loss of the coax: the loss forward and loss reflected. The standard formula for calculating the dB loss or gain³ is:

$$dB = 10 \log \frac{P_1}{P_2} \quad (3)$$

In this application, eq. 3 would tell us the loss for the round trip. Since we are interested in the loss in only one direction, and since the loss forward should be the same as the loss reflected, eq. 3 becomes:

$$dB = 5 \log \frac{\text{reflected}}{\text{forward}} \quad (4)$$

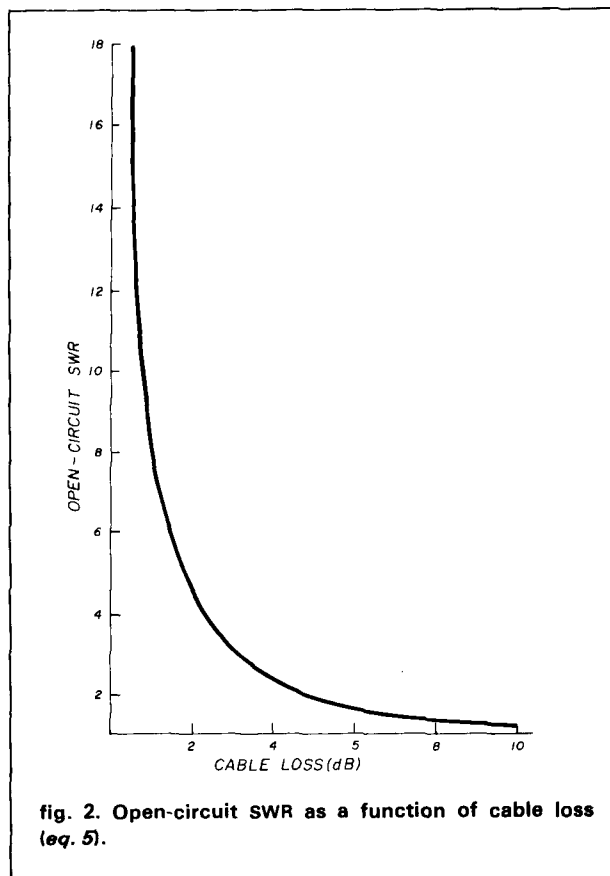
Eq. 4 is fine if you have a bidirectional wattmeter. Since many low-priced SWR meters measure SWR *without* indicating actual power in watts, and since SWR is a function of forward and reflected power, eq. 4 can be transposed:

$$dB = 5 \log \left(\frac{SWR - 1}{SWR + 1} \right)^2 \quad (5)$$

Eq. 4 is shown graphically in fig. 1. Eq. 5 is shown in fig. 2.

examples

Before going any further, let's consider two simple hypothetical examples. A transmitter feeds 100 watts of rf power into a length of RG-58 cable. A bidirectional wattmeter at the transmitter indicates a reflected power of 25 watts. From eq. 4 we can calculate



ANTENNA COMPONENTS

Antenna wire, stranded #14 copperweld.....	\$.08 ft.
75, 100, 130, 150, 300, or 1,000 ft. rolls	
Antenna Wire, stranded #15 copperweld.....	.06 ft.
75, 100, 130, 150, 200, or 300 ft. rolls	
Antenna wire, stranded #16 copperweld.....	.05 ft.
75, 100, 130, 150, 200, or 300 ft. rolls	
Van Gorden HI-Q Baluns, 1:1 or 4:1.....	10.95 ea.
Unadilla/Reyco, W2AU Baluns, 1:1 or 4:1.....	14.95 ea.
Van Gorden HI-Q center insulators.....	5.95 ea.
Ceramic "Dogbone" end insulators, pair.....	.98
Van Gorden plastic end insulators, pair.....	4.95
Nylon guy rope, 450 lb. test, 100' roll.....	3.49
Unadilla/Reyco W2VS Traps, KW-10 thru KW-40.....	21.95 pr.
Belden 8214 RG-8U type foam coax.....	.30 ft.
50, 60, 75, 100, and 125 ft. rolls	
Belden 8219 RG-58 A/U foam coax.....	.12 ft.
50, 60, 75, 100, 125, 200, 300 and 1,000 ft. rolls	
Berk-Tex 6211 RG-8X foam coax, Ultraflexible.....	.16 ft.
50, 60, 75, 100, 125, 200, 300, and 500 ft. rolls	
Amphenol 83-1SP PL-259 connectors.....	.75 ea.
Amphenol UG-175/U adapters (RG-58).....	.25 ea.
Amphenol UG-176/U adapters (RG-8X, RG-59).....	.25 ea.
Amphenol PL-258, straight adapter.....	1.07

ALSO IN STOCK

Larsen Mobile Antennas • Hustler Mobile Antennas • Palomar Engineers • Centurion International Rubber Duck Antennas

WRITE FOR A FREE COPY OF OUR CATALOG

MASTER CHARGE

VISA

All items F.O.B. Lincoln, \$1.00 minimum shipping. Prices subject to change without notice. Nebraska residents please add 3% tax.

g & c Communications
730 Cottonwood Lincoln, Nebraska 68510

$$5 \log \frac{25}{100} = 5 \log 0.25$$

$$= 5(-0.602) = -3.01 \text{ dB} \quad (6)$$

The minus sign indicates a loss. To further verify eq. 4, let's consider what happened to the rf as it made its round trip through the coax. If the coax really did have 3 dB of loss, approximately 50 watts would reach the open end. When that 50 watts was reflected, the same 3 dB loss would result in 25 watts being lost in the coax. Thus, only 25 watts would be measured as reflected power at the source.

For our second hypothetical case, let's assume the use of an SWR meter that doesn't indicate forward power; the meter scale reads directly in SWR. A transmitter of unknown output is connected to a length of RG-8/U cable, and the SWR at the transmitter is 6:1. We can use eq. 5 to calculate the loss:

$$5 \log \left(\frac{6-1}{6+1} \right)^2 = 5 \log (0.714)^2 \quad (7)$$

$$= 5(-0.29) = -1.45 \text{ dB.}$$

Again, the minus sign indicates a loss.

system accuracy

This will depend on the accuracy of the SWR meter or wattmeter used to make the measurement. Several precautions must be observed:

1. Some lengths of coax at some frequencies could act as resonant circuits and cause inaccurate measurements.
2. Short lengths of good-quality coax will show a very high SWR. Make sure the transmitter used as a source of rf can withstand a high SWR.
3. The transmitter impedance must match that of the coax.
4. Measurements should be made at the frequency at which the coax will be used.

One more item must be taken into account. This system for measuring loss in coaxial cable assumes that the load will be perfectly matched to the line. Any mismatch will create standing waves that will cause additional loss.⁴

references

1. William I. Orr, W6SAI, *The Radio Handbook*, 21st edition, page 25.8.
2. *The ARRL Antenna Book*, 11th edition, page 77.
3. J. J. DeFrance, *General Electronics Circuits*, page 91.
4. *Electronics Data Book, ARRL*, pages 82-84.

ham radio

Factory Direct Only!

THE WORLD'S FIRST 1800 CHANNEL FULLY SYNTHESIZED COMPACT VHF FM MONITOR

AR-22
FACTORY DIRECT
PRICE \$125.00

This price in U.S. only

FULL BAND COVERAGE

141,000-149,995 MHz
5 KHZ Steps by digital switches.

SLIM SIZE AND LIGHT-WEIGHT.

5 1/4" (H) x 2 1/2" (W) x 1" (D)
7.1 oz with NiCd Battery Pack



COMMERCIAL BAND TYPE (151-159 MHz) IS ALSO AVAILABLE.

CREDIT CARDS/MONEY ORDER OR ANY COMMERCIAL GUARANTEED CHECK...U.P.S. COD

ACE COMMUNICATIONS, INC.

2832-D Walnut Avenue, Tustin, California 92680

Phone (714)544-8281