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Test Method for Coaxial Cable Impedance

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1. Introduction

1.1. Scope

The purpose of this procedure is to provide instructions for measuring coaxial cable impedance.

The cable impedance as a function of frequency is calculated from a vector (magnitude and phase) return loss. The average of this impedance across the desired frequency range is the cable impedance. This may be automated, but requires a vector network analyzer, and may be subject to errors due to the cable connection.

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3. Abbreviations and Definitions

3.1. Definitions

Return Loss:	The ratio of reflected signal to incident signal, expressed in dB
Network Analyzer	An instrument used to measure the swept frequency response of a cable

4. Test Samples

Cable impedance is typically tested on whole reels of coaxial cable and two (2) tests are performed, one from each end of the cable. The cable to be tested must be terminated with a precision connector and a fixed, precision 75 ohm load for normal cable lengths. The effect of reflection from the end termination is reduced by twice the cable loss, such that for long lengths of cable, the precision of the end termination is not significant. For shorter lengths of cable, the end termination return loss plus twice the cable loss must be included in error analysis.

The input cable connector must be a good impedance match to the cable impedance or the measurement results will be affected. The cable must be prepared according to both the cable and connector manufacturer's instructions. Improper cable preparation can be a major source of error in impedance measurements.

5. Equipment

Network analyzer with impedance measuring capability, such as Agilent ENA Series, including fixed impedance (75 ohm) test bridge or equivalent

Calibration kit, such as Agilent 85036B or equivalent

Computer or built in analyzer functions to process fixed impedance data

Termination (75 ohm load) for far end cable termination (the load in the calibration kit may be used)

Two (2) test port to cable precision adapters for the size of cable under test

Equipment setup is shown in Figure 1

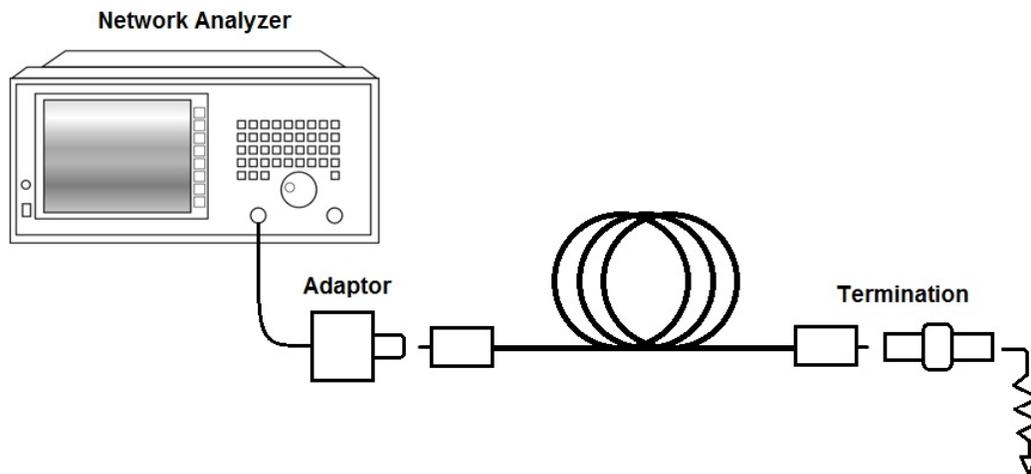


Figure 1 - Test Setup for Fixed Bridge Method

6. Measurement methodology – fixed bridge

Set up the network analyzer by setting the start frequency to 5 MHz. Set the stop frequency such that the input connector does not overwhelm the measurement. At high frequencies, the return loss of the input connector can distort the cable response. A recommended stop frequency of 210 MHz is to be used unless a higher frequency is required by specific customer applications. At higher test frequencies, connector compensation techniques may be required. Consult specific manufacturer's instructions for more details on connector compensation.

Perform a calibration (error correction) following the manufacturer's instructions. Using a vector network analyzer, this is a 1-port open/short/load calibration.

Connect the cable under test to the network analyzer test port. Terminate the far end of the cable in fixed, 75 ohm precision termination. Measure the return loss over the frequency span.

Using a computer or built in analyzer function, calculate the average impedance over the frequency range. This is done by calculating the sum of the real parts (R) divided by the number of data points collected, and the sum of the imaginary parts (jX) divided by the number of data points collected. Then calculate the magnitude of the resulting average impedance (Z). Ideally, the imaginary part (jX) should be zero; if the imaginary part is not near zero, it indicates that the input connector may be affecting the result.

7. Inspection

Figure 2 shows the result of a measurement of real part of impedance vs. frequency. The marker function calculates the average value of impedance between the two markers shown. The upper plot shows the impedance value for this trace calculated over the 5 MHz to 210 MHz span, as recommended in this test procedure. The lower plot shows the impedance value for the same trace calculated over the 5 MHz to 1002 MHz span; note that the impedance vs. frequency starts to vary at high frequency. Inspection of the imaginary part of the impedance reveals that it becomes large at these points, indicating errors due to connector response.

Record the value of the average impedance, as well as the stop frequency for the average calculation, if other than 210 MHz.

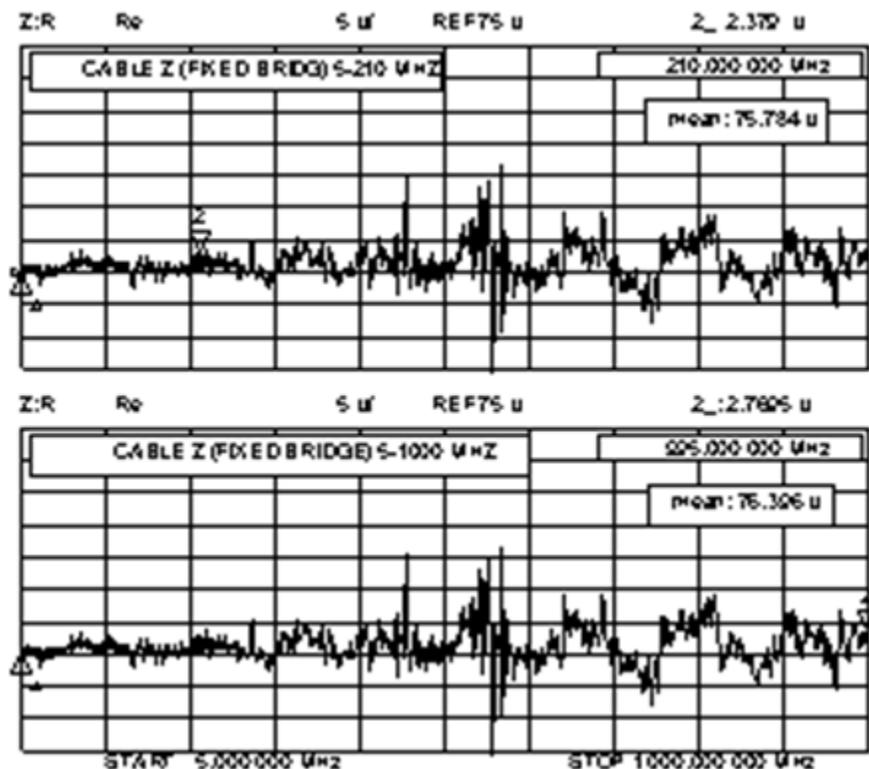


Figure 2 - Average Impedance Comparison Between Markers (Fixed Bridge Method)

8. Report

TESTER: _____ DATE: _____

MANUFACTURER: _____

CABLE TYPE/SIZE: _____

LENGTH (FEET): _____

CABLE IMPEDANCE: _____

STOP FREQUENCY FOR AVERAGING: _____

9. Error Analysis

The major source of error in this measurement is the directivity of the test system and the impedance mismatch of the test port adapter. These two error terms combine to give a total error in the return loss measurement. An example of typical errors and their effect on the impedance measurement is shown below:

	Directivity (dB)	Directivity (linear)	Connector (dB)	Connector (linear)	Total Error (Dir + Conn)	Error Effect on Z
Fixed Bridge	49	0.0035	52	0.0025	0.0060	0.9 ohms

First convert each return loss term (in dB) to linear terms and sum up the reflection error.

Reflection error:

$$P_{er} = 10^{(\text{Directivity}/20)} + 10^{(\text{Connector Return Loss}/20)}$$

Finally, calculate the error in impedance caused by the return loss error.

Impedance error:

$$Z_{er} = 75 \cdot \frac{1 + p_{er}}{1 - p_{er}} - 75$$

On short lengths of cable, the far end termination effect must be added to the reflection error. It is treated in the same way as the near end connector return loss, but the value of return loss may be reduced by twice the loss of the cable, before converting it to linear terms.

These are only example values. Consult with the equipment manufacturer to determine the actual error values, which may be much better over the 5 MHz to 210 MHz range for this procedure.