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Interface Practices Subcommittee

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Test Method for Coaxial Cable Impedance

NOTICE

Document Types and Tags

Document Type: Specification

Document Tags:

☒ Test or Measurement	☐ Checklist	☐ Facility
☐ Architecture or Framework	☐ Metric	☐ Access Network
☐ Procedure, Process or Method	☐ Cloud	☐ Customer Premises

Document Release History

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SCTE 66 2003	*11/7/2003*
SCTE 66 2008	*2/29/2008*
SCTE 66 2016	*8/22/2016*

Note: Standards that are released multiple times in the same year use: a, b, c, etc. to indicate normative balloted updates and/or r1, r2, r3, etc. to indicate editorial changes to a released document after the year.

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1. Introduction

1.1. Executive Summary

This procedure defines a test method for measurement of coaxial cable characteristic impedance, Z_0. Throughout this document the shorter term cable impedance may be used.

1.2. Scope

The purpose of this procedure is to provide instructions for measuring 75 ohm coaxial cable impedance.

The cable input impedance as a function of frequency is calculated from a vector (magnitude and phase) return loss. The average of this input impedance across the desired frequency range is the cable impedance. This calculation may be automated using a computer connected to the vector network analyzer or the analyzer may have this function built in.

1.3. Benefits

When the cable impedance is near 75 ohms, input and output reflections are minimized improving system performance.

1.4. Intended Audience

This is a laboratory test procedure used for verification at the point of cable manufacture or to inspect finished cable performance.

1.5. Areas for Further Investigation or to be Added in Future Versions

None

2. Normative References

The following documents contain provisions which, through reference in this text, constitute provisions of this document. The editions indicated were valid at the time of subcommittee approval. All documents are subject to revision and, while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

No normative references are applicable.

2.2. Standards from Other Organizations

No normative references are applicable.

2.3. Other Published Materials

No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

No informative references are applicable.

3.2. Standards from Other Organizations

No informative references are applicable.

3.3. Other Published Materials

No informative references are applicable.

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified ***shall*** never be used.
should	This word or the adjective "*recommended*" means that there *may* exist valid reasons in particular circumstances to ignore this item, but the full implications *should* be understood and the case carefully weighed before choosing a different course.
should not	This phrase means that there *may* exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications *should* be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" indicate a course of action permissible within the limits of the document.
deprecated	Use is permissible for legacy purposes only. Deprecated features *may* be removed from future versions of this document. Implementations *should* avoid use of deprecated features.

5. Definitions

5.1. Abbreviations

MHz	megahertz
SCTE	Society of Cable Telecommunications Engineers

5.2. Definitions

Definitions of terms used in this document are provided in this section. Defined terms that have specific meanings are capitalized. When the capitalized term is used in this document, the term has the specific meaning as defined in this section.

Return Loss:	The ratio, in decibels, of the power incident upon an impedance discontinuity to the power reflected from the impedance discontinuity. Note: When $P_{reflected} < P_{incident}$ return loss is a positive number.
Vector Network Analyzer	An instrument used to measure the swept frequency response (phase and magnitude) of a cable

6. 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.

7. Equipment

Vector network analyzer with impedance measuring capability[1]

Calibration kit[2]

Computer or built in analyzer functions to process 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*

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[1] An analyzer that may be used are Keysight ENA Series, including fixed impedance (75 ohm) test bridge or the equivalent. This identification of products or services is not an endorsement of those products or services or their suppliers."

[2] A kit that may be used is Keysight 85036B or the equivalent. This identification of products or services is not an endorsement of those products or services or their suppliers.

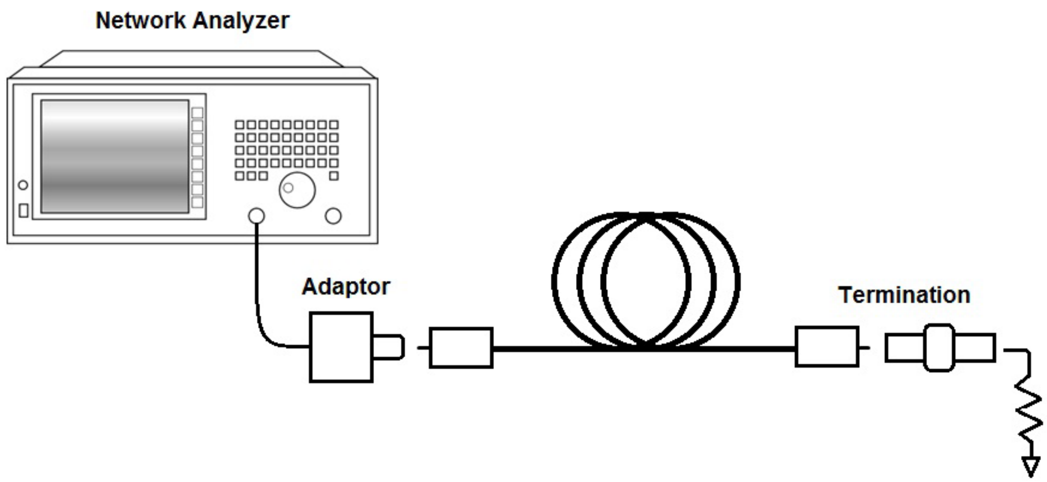

Figure 1 - Test Setup

8. Measurement methodology

Set up the network analyzer by setting the start frequency to 5 MHz. Set the stop frequency to 210 MHz minimum. 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. 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 with a 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.

9. 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.

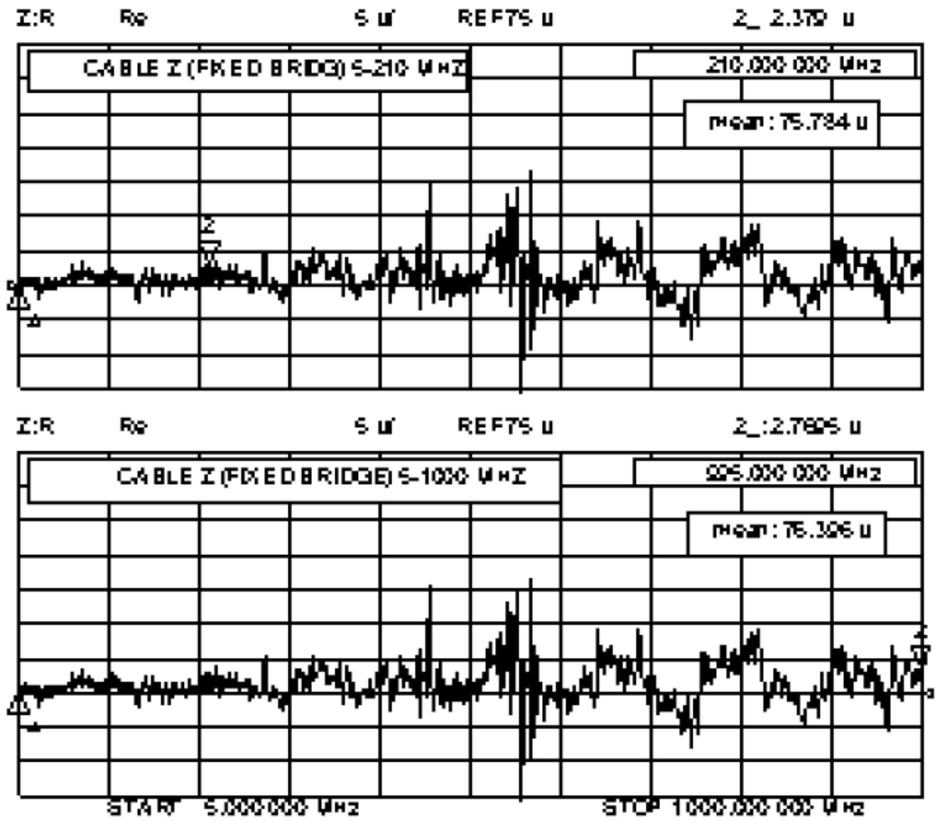

Figure 2 - Average Impedance Comparison between Markers

10. Report

TESTER: ______________________________ DATE: ______________________

MANUFACTURER: ____

CABLE TYPE/SIZE: ____

LENGTH (FEET): ____

CABLE IMPEDANCE: ____

STOP FREQUENCY FOR AVERAGING: _______________________________

11. 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:

$$P_{er} = 10\text{^}(-Directivity_{dB}/20) + 10\text{^}(-Connector\ Return\ Loss_{dB}/20)$$

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

Impedance error:

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

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.

