Society of Cable Telecommunications Engineers

ENGINEERING COMMITTEE
Interface Practices Subcommittee

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Test Procedure for Measuring Regularity of Impedance of Coaxial Cable

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1.0 SCOPE

This document outlines the procedure for determining the *regularity of impedance* for coaxial cables using telemetry methods. The *regularity of impedance* is return loss in the time domain. With basic expertise in the use of time domain reflectometers (TDR), the tester can determine return loss of discontinuities (impedance changes) at specific points along a coaxial cable.

There are two methods detailed in this document. The selection of one method over another is governed by the following criteria:

(A.) The type of TDR that is available to the tester.
(B.) The length of cable being tested.
(C.) The degree of resolution that is required.

2.0 EQUIPMENT

The equipment required to perform this type of measurement is listed as follows:

- BNC to F-Female Adapter
- F-Female Terminating Load
- (2) Pin to F-Male Adapter (if testing hardline coaxial cable)
- TDR incorporating a *Step* or *Pulse Function* stimulus
- Variable standard line
- Variable terminator

3.0 GENERAL: STEP FUNCTION RETURN LOSS

This method incorporates the use of a TDR with a *step function* stimulus. The method can be used for coaxial cables up to a maximum of 2000 feet. This type of TDR provides a high degree of resolution. The resolution of this type of TDR can distinguish discontinuities, in a short (<100 feet) length of high quality coaxial cable, up to ≈1 inch apart.

This method involves applying a *step function* (voltage) to a Cable Under Test (CUT). The ratio of the *reflected* step voltage to the *applied* step voltage is the reflection coefficient (ρ) as illustrated below:

$$\rho=V_{ref}/V_{applied}$$

Where: V_{ref}=*Reflected step voltage* by an irregularity at a distance from the cable input.
$V_{applied}$=*Applied step voltage* to the CUT.

The *step function return loss* (a_S) is calculated as follows:

$$a_S=-20\,log(\rho)$$

The rise time (t_r) determines the resolution of the measurement. The rise time is defined as the period of time to go from 10% to 90% of the step amplitude. The faster the rise time the greater the detail that can be deciphered between discontinuities in the cable. The resolution (δ) can be determined by the following:

$$\delta=(150\times10^{-6})(t_r)(V_r) \qquad \text{(Meters)}$$

Where: t_r=Rise time (picoseconds)

V_r=Velocity ratio of CUT dielectric (i.e. 0.66 for solid PE)

The t_r for TDRs using a *step function stimulus* is typically a fixed quantity that is unique to the TDR. A typical TDR will have a rise time ≤200 picoseconds.

The Characteristic Impedance (Z_0) on the ends of the cable can be determined. This is accomplished by using a standard line and a terminator that is matched to Z_0 of the CUT. The impedance of the cable ends is determined by placing a standard line between the CUT and termination at the far end of the CUT. The use of the standard line and termination makes the impedance at the ends of the CUT more easily observed.

4.0 STEP FUNCTION RETURN LOSS PROCEDURE

4.1 A TDR (i.e. Tektronix 1502C) which utilizes a *step function stimulus* should be arranged with the CUT as depicted in appendix A. The CUT (w/ F-male connectors attached) should be connected to the BNC to F (female) adapter.

Note: When testing hardline coaxial cable, a pin to F-Male adapter can be used to make connection to the TDR.

4.2 Turn "On" the power to the TDR.

4.3 Adjust *noise filtering* and *vertical scale* per the TDR manufacturer's recommendation.

4.4 Set the TDR to the *velocity of propagation* associated with the CUT.

4.5 Adjust the *distance/division* setting to view the reflected pulse (discontinuity).

4.6 Adjust the TDR to provide results in terms of decibels.

4.7 Adjust the vertical scale of the reflected pulse to be 2 divisions high.

4.8 Read and record the return loss in decibels from the TDR display.

5.0 GENERAL: PULSE FUNCTION RETURN LOSS

This method incorporates the use of a TDR with a *pulse function* stimulus. This method is used with long lengths of cable. A typical TDR that utilizes a *pulse function stimulus* can test lengths of coaxial cable up to 50,000 feet but with less accuracy as compared to the *step function* method. A δ of ≈1 foot between discontinuities, in a short (<100 feet) high quality coaxial cable, is achievable with this TDR.

This method involves applying a *pulse function* to a CUT to obtain the *pulse function return Loss* (a_p). This pulse is typically a ½ sine pulse that is unique to the TDR that is used. The tester can however modify the pulse width (t_p). The t_p is defined as the duration in time between the ½ height points of the applied pulse. The *pulse function return loss* (a_p) is defined as follows:

$$a_p = -20 \log(u_{rx}/u_s) \qquad \text{(dB)}$$

Where: u_{rx}: is the voltage of the pulse reflected by a discontinuity at a distance *x* from the input.

u_s is the voltage of the sending pulse at the input.

The *corrected pulse return loss* (a_{pc}) is the return loss measured at the input end of the cable minus the pulse attenuation from traveling to and from the measured discontinuity. The *corrected pulse return loss* is defined as follows:

$$a_{pc} = a_p - (2\alpha x/100) \quad \text{(dB)}$$

α: the attenuation constant in dB/100 meters at the frequency (f_p) which the main part of the pulse energy is concentrated.

x: is the measured distance (in meters) to the discontinuity.

f_p: frequency at which attenuation of the cable is derived from. The frequency is determined as follows:

$$f_p = 250/t_{p\,(nS)} \qquad \text{(MHz)}$$

The resolution (δ) is the minimum distance between discontinuities and can determined by:

$$\delta = 0.15 t_p V_r \quad \text{(Meters)}$$

Where t_p: is the pulse width in nanoseconds.

V_r: is the velocity ratio of the CUT (i.e. 0.66 for solid PE dielectric).

6.0 PULSE FUNCTION RETURN LOSS PROCEDURE

6.1 A TDR (i.e. Tektronix 1503C) which utilizes a *pulse function stimulus* should be assembled with the CUT in the arrangement shown in appendix A.

6.2 The CUT (w/ F-Male connectors attached) should be connected to the BNC to F-Female adapter.

Note: When testing hardline cable, a Pin to F-Male adapter can be used to make connection to the TDR.

6.3 Turn "On" the power to the TDR.

6.4 Adjust the TDR to Z_0 of CUT (i.e. 50Ω or 75Ω).

6.5 Adjust *noise filtering* per the TDR manufacturer's recommendation.

6.6 Adjust the *velocity of propagation* (V_p) to match the CUT.

6.7 Adjust the *pulse width* (t_p) in accordance with the length of the CUT.

6.8 Adjust the *distance/division* setting to see the reflected pulse.

6.9 Adjust the *standard* line and *termination* for minimum reflection of the pulse.

6.10 Note the height of the incident pulse in terms decibels (dB).

6.11 Increase the *vertical scale* (gain in dB) until the reflected pulse height equals the height noted in Step 5.10.

6.12 The additional gain necessary to match the height of the incident pulse is the *pulse return loss* in dB to be recorded.

6.13 To compensate for the pulse loss over a long length of cable, the *corrected pulse return loss* (a_{pc}) can be calculated by first determining the frequency (f_p) in which the main part of the pulse energy is concentrated. This frequency is calculated as follows:

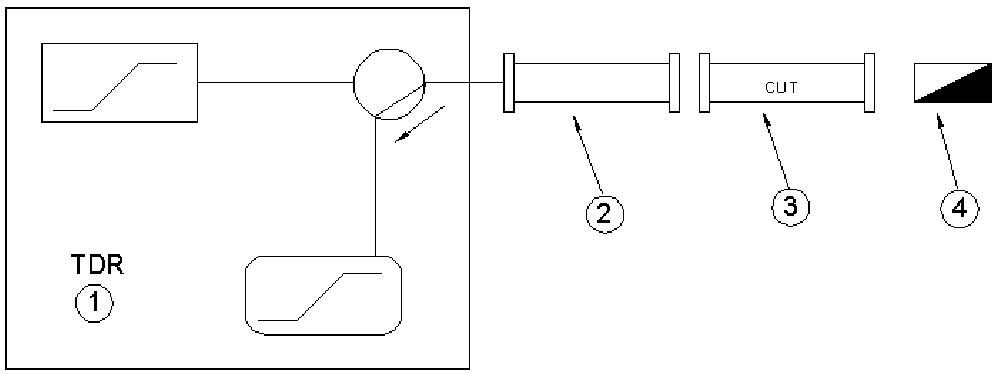
$$f_p = 250 / t_{p\,(nS)} \qquad \text{(MHz)}$$

The attenuation constant (α) in dB/100 meters is determined at this frequency. The *x* variable is the distance to the discontinuity. The corrected pulse attenuation is calculated as follows:

$$a_{pc} = a_p - (2\alpha x) \div 100 \qquad \text{(dB)}$$

7.0 APPENDIX A

Layout of Test Equipment



1 TDR
2 Standard Line (Optional)
3 Test Specimen
4 Terminating Load