SCTE® | STANDARDS

Interface Practices Subcommittee

AMERICAN NATIONAL STANDARD

ANSI/SCTE 05 2022

Test Method for "F" Connector Return Loss In-Line Pair

NOTICE

The Society of Cable Telecommunications Engineers (SCTE) Standards and Operational Practices (hereafter called “documents”) are intended to serve the public interest by providing specifications, test methods and procedures that promote uniformity of product, interoperability, interchangeability, best practices, and the long term reliability of broadband communications facilities. These documents shall not in any way preclude any member or non-member of SCTE from manufacturing or selling products not conforming to such documents, nor shall the existence of such standards preclude their voluntary use by those other than SCTE members.

SCTE assumes no obligations or liability whatsoever to any party who may adopt the documents. Such adopting party assumes all risks associated with adoption of these documents and accepts full responsibility for any damage and/or claims arising from the adoption of such documents.

NOTE: The user’s attention is called to the possibility that compliance with this document may require the use of an invention covered by patent rights. By publication of this document, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer. SCTE shall not be responsible for identifying patents for which a license may be required or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Patent holders who believe that they hold patents which are essential to the implementation of this document have been requested to provide information about those patents and any related licensing terms and conditions. Any such declarations made before or after publication of this document are available on the SCTE web site at https://scte.org.

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

Release	Date
SCTE 05 1999	*8/20/1999*
SCTE 05 2008	*6/27/2008*
SCTE 05 2014	*5/30/2014*

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.

Table of Contents

List of Figures

1. Introduction

1.1. Executive Summary

The purpose of this procedure is to provide instructions to measure the return loss characteristics of a pair of type "F" connectors and the cable interface, inserted in the middle of a cable, from 5 MHz to 3000 MHz.

This test method makes use of the time domain gating feature of the network analyzer to remove the near end and far end test set connector effects from type "F pair" in the middle of the cable, joined by a type "F" (female) - type "F" (female) adapter.

1.2. Scope

The purpose of this procedure is to provide instructions to measure the return loss characteristics of a pair of type "F" connectors and the cable interface, inserted in the middle of a cable, from 5 MHz to 3000 MHz. This test method makes use of the time domain gating feature of the network analyzer to remove the near end and far end test set connector effects from a type "F" pair in the middle of the cable, joined by a type "F" (female) – type "F" (female) adapter.

Return loss specifications may require a tiered specification over the frequency range due to technological implications.

1.3. Benefits

Devices which have a poor return loss and voltage standing wave ratio (VSWR) result in loss of signal power or degradation of signal information

Return loss is a way to characterize impedance mismatches. There are two major causes of return loss degradation in a network: discontinuities and impedance mismatches. Discontinuities occur at connections where cable is terminated to plugs or jacks and within the plug/jack connection itself. A discontinuity can also occur if a cable is bent too much, kinked or otherwise damaged.

Components need to have acceptable return loss in order to assure proper network operation.

1.4. Intended Audience

The intended audience for this document is for development/design engineers, technical operations and installers.

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. At the time of Subcommittee approval, the editions indicated were valid. 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. 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

[SCTE 74] ANSI/SCTE 74 2011 Specification for 75 ohm Braided Flexible RF Coaxial Drop Cable

[SCTE 123] ANSI/SCTE 123 2011 Specification for "F" Connector, Male, Feed-Through

[SCTE 123] ANSI/SCTE 124 2011 Specification for “F” Connector, Male, Pin Type

3.2. Standards from Other Organizations

No informative references are applicable.

3.3. Published Materials

[Broadband] https://broadbandlibrary.com/return-loss/

[Return] https://training.ti.com/why-return-loss-matters

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 weighted 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*" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
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. Abbreviations and Definitions

5.1. Abbreviations

SCTE	Society of Cable Telecommunications Engineers
VNA	vector network analyzer
VSWR	voltage standing wave ratio

5.2. Definitions

gating	Technique used for selectively isolating the response of a connector for return loss measurements
directivity	The figure of merit for how well a coupler separates forward and reverse waves is directivity; the greater the directivity of the device, the better the signal separation. System directivity is the vector sum of all leakage signals appearing at the analyzer receiver input. The error contributed by directivity is independent of the characteristics of the test device and it usually produces the major ambiguity in measurements of low reflection devices.
return loss:	The ratio of incident signal to reflected signal, expressed in dB
network analyzer	An instrument used for measuring the swept frequency response of a cable or cable/connector combination

6. Background

Media impedance is measured by return loss. Return loss is the ratio, in decibels, of the incident signal to the reflected signal. This ratio should be as high as possible. When more signal is reflected, less signal is delivered to the load. Signal reflection is due to the discontinuity of the transmission line.

The reflection coefficient, S_{11}, is similar to return loss and is defined as the ratio of reflected voltage $E_{Reflected}$ to incident voltage $E_{Incident}$ as measured at port 1 of a network or device. When the reflected voltage is less than the incident voltage, S_{11} will be a ratio less than one. Thus, in dB terms, S_{11} will be represented by a negative number.

If S_{11}=0 dB, then all the power is reflected from the device and nothing is transmitted.

It important to note that return loss is the inverse of S_{11}. Many models of test equipment display results as a log magnitude (dB) representation of S_{11}. Thus, good performance is indicated by large negative numbers. Since return "loss" is the inverse of S_{11} and is designed to show the "loss" of energy between the incident and reflected signals, good performance is indicated by large positive numbers.

Return loss is related to S_{11} by the following equation:

$$Return\ Loss = -20 \times \log_{10}|(S_{11})| \tag{1}$$

In this procedure, the S_{11} trace displayed on the test equipment will be called "return loss," even though it technically is a log magnitude display of S_{11}, which is the inverse of return loss.

7. Equipment

1. RF vector network analyzer (VNA) with the following minimum features[1]:
    a. Minimum RF frequency range of 300 kHz to 3 GHz
    b. 75 ohm impedance
    c. Dynamic range at least 10 dB better than the required perforamance
    d. Integrated S-parameter test set
    e. Time domain capability
2. Type "F" 75 ohm calibration kit with minimum RF frequency range of 300 kHz to 3 GHz [2]:
3. Flexible precision test cable(s) with minimum RF frequency range of 300 kHz to 3 GHz [3]:
4. Type N female to "F" male adapter
5. Type N male to "F" female adapter
6. Type "F" female to "F" female adapter
7. Flexible RF coaxial cable and "F" male connectors as required

Figure 1 illustrates a typical test set up.

[1] Devices that may be compliant include Keysight ENA Series with time domain option and 75 ohm option or the equivalent. This identification of products or services is not an endorsement of those products or services or their suppliers.
[2] Devices that may be compliant include Keysight 85039B or the equivalent. This identification of products or services is not an endorsement of those products or services or their suppliers.
[3] Devices that may be compliant include Keysight 11857B or the equivalent. This identification of products or services is not an endorsement of those products or services or their suppliers.

8. Test Samples

8.1. The connector to be tested shall be installed on the near end of a 10' ± 0.25" length of cable. The connector and cable shall be installed per manufacturer's instructions.

8.2. The far end of the cable shall be terminated in a precision 75 ohm load. A second connector may be installed at the far end to allow proper termination.

8.3. Before performing the tests, visually inspect the cable and connectors to insure that there are no problems such as cracks, punctures, bruises, dents, or poor contacts which could affect the accuracy of the test.

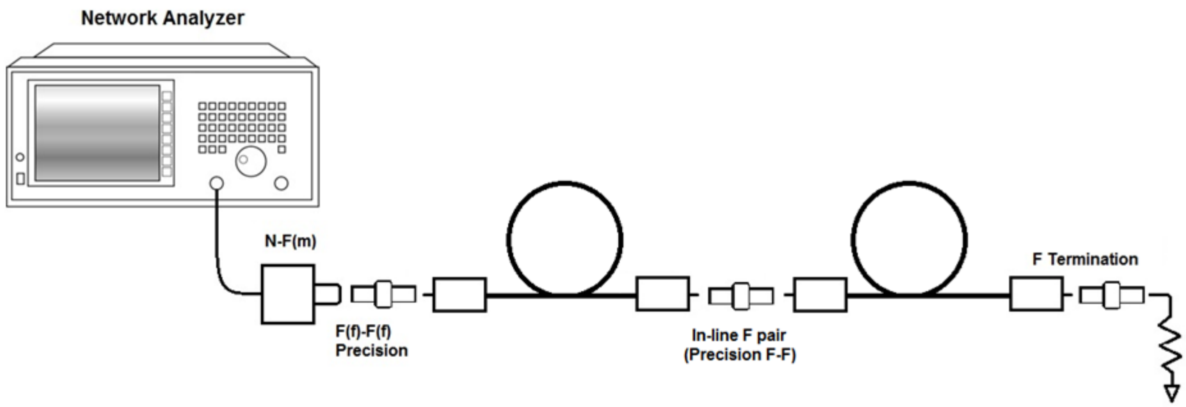

Figure 1 - Equipment Setup

9. Measurement Methodology

9.1. Per the test equipment manufacturers recommended instructions, follow any pre-calibration requirements, including adequate warm-up and stabilization time. Insure that the instrument is properly grounded and that anti-static precautions are maintained at all times.

9.2. Perform a 1-port calibration (error correction), using the type "F" calibration kit. Measure the open, short and load when prompted by the analyzer. When done, save this instrument state, if desired.

9.3. Place N Female to F Male adapter on Port 1 cable

9.4. Place F-81 F Female to F Female adapter on N Female to F Male adapter

9.5. Place 1st 10-foot cable on F-81 adapter

9.6. Connect 2nd 10-foot cable to 1st 10-foot cable with a F-81 adapter

9.7. Place F Female to N Male adapter on 2nd 10-foot cable

9.8. Place Load on F Female to N Male adapter

9.9. Set up the vector network analyzer (VNA) for a reflection measurement as per the manufacturer's instructions. Set the start frequency at 300 kHz; set the stop frequency at 3000 MHz, set the number of point to 1601. Check to see that cal kit selected is type "F". If not, select the user cal kit, which should have the type "F" kit loaded.

9.10. Connect the cable to the network analyzer. Be sure to properly dress the center conductor to avoid damage to the precision "F" test adapter. Be sure a proper termination is applied at the far end of the cable. Check the reflection trace, there should be a ripple pattern in the return loss indicating the beat pattern of the near end cable connection and the far end termination. A typical trace is shown in the upper part of Figure 2. Under the Transform menu, the time domain transform can be turned ON to see the time domain response of the cable and connections. With time domain on, set the start time to –5 ns, and the stop time to 30 ns. You should see two returns, one from the near end, and one from the far end. Any returns from the cable should be less than 0.03 reflection coefficient (-30 dB), and the near and far end returns should be less than 0.1 (-20 dB). Any defects in the cable or the connections greater than these values may degrade the measurement. The lower trace of Figure 2 shows a typical domain trace. This pre-test ensures that the cable and end connectors are of sufficient quality to test the in-line "F" connectors. Turn the TRANSFORM OFF when the pre-test is complete.

9.11. Connect test sample to the network analyzer. The reflection trace should show a ripple pattern, which is a beat pattern from both ends and the middle connector, as seen in the upper trace in Figure 2.

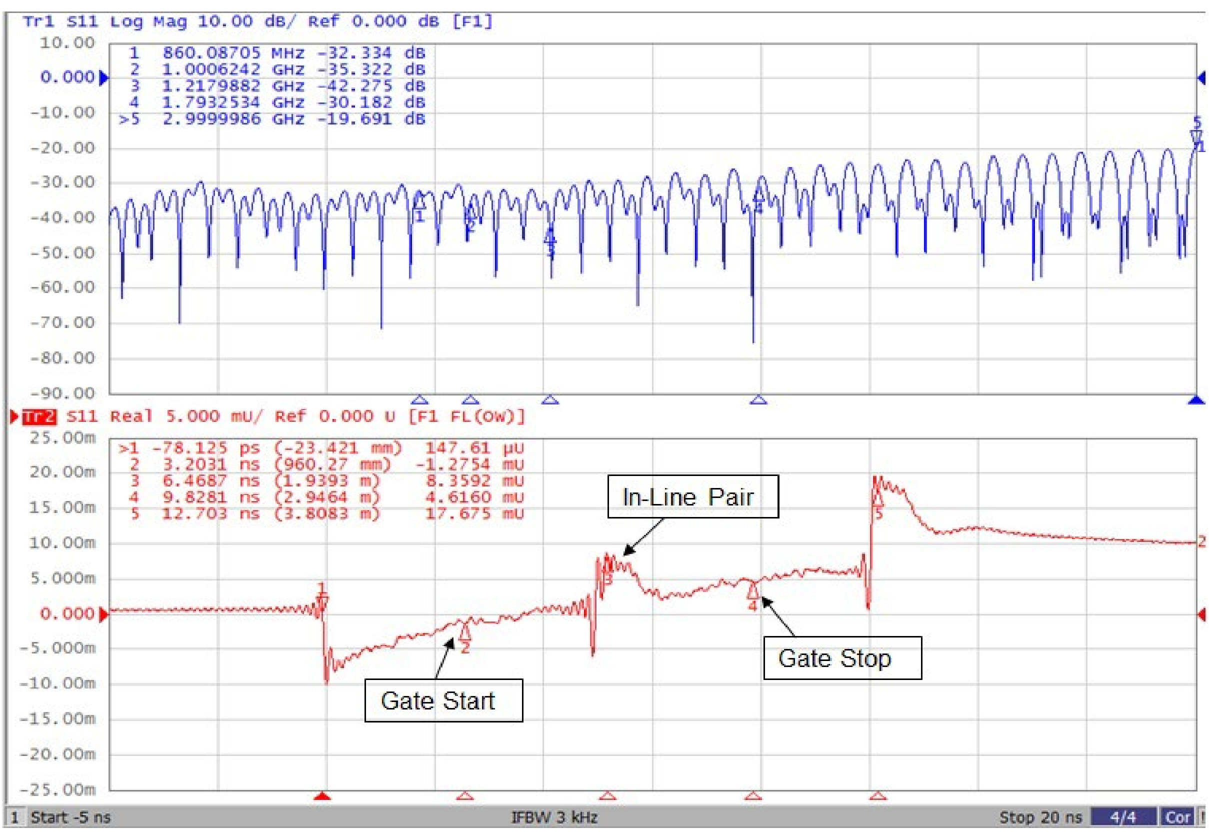

Figure 2 - Time Domain and Frequency Response Trace (no gating)

9.12. Under the System key, select the TRANSFORM menu. In this menu select the TRANSFORM ON. With time domain on, set the start time to –5 ns, and the stop time to 30 ns. You should see three returns, one from the near end, and one from the far end, and one from the middle, at approximately 12 ns. Record the value of reflection for the input connector (at time = 0 sec.). Set the gate start time to halfway between the near end return and the middle return, and the gate stop time to halfway between the middle return and the far end return.

9.13. Turn the gating ON. The time domain pattern of the return loss should change to show only the response of the middle connector. With gating ON, the near and far end return should disappear. A typical Return Loss example trace is shown in the upper part of Figure 3.

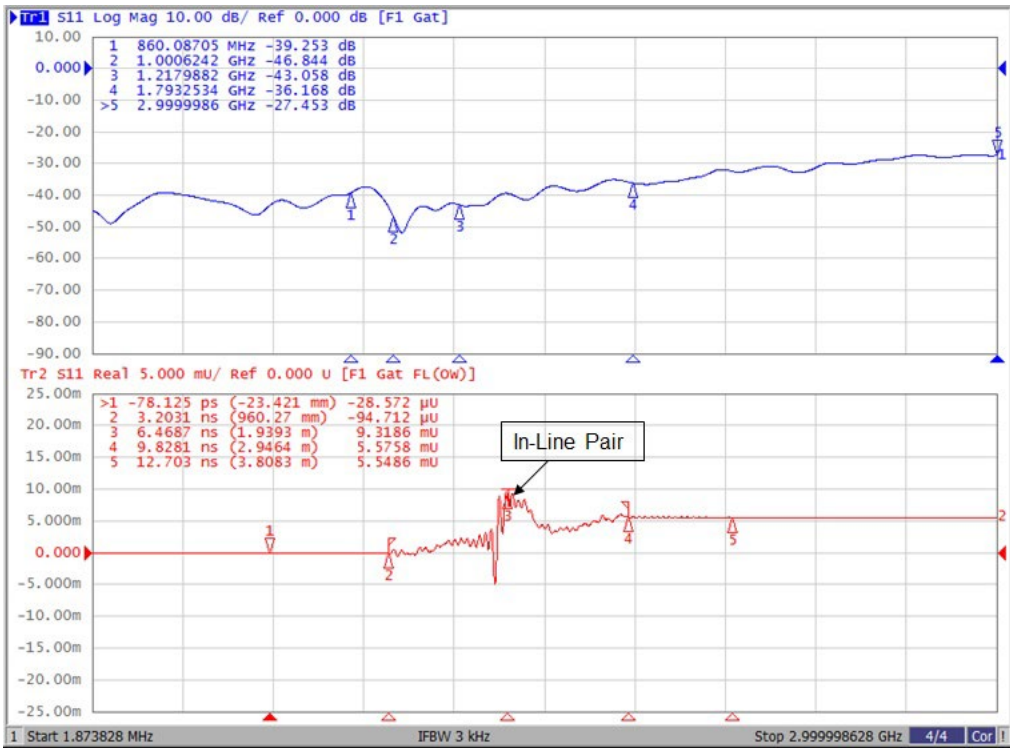

Figure 3 - Time Gated Response of In-Line "F" Connector Pair

9.14. With gating left ON, turn the transform OFF to see the time gated frequency response. The ripple pattern of Figure 3 should change to show the frequency response of only the in-line "F" connector pair. The lower track of Figure 3 shows a typical time gated frequency response. A marker is positioned at the worst-case point. Note that there may be some small edge effect at the start and stop of the trace. The Time Domain option shows the analysis capability by presenting data in the time (or distance) domain–valuable information for both the design and production engineer.

10. Inspection

10.1. After a sweep has completed, use the markers to find the worst case (highest point) of the return loss. You may wish to put the analyzer into hold sweep mode.

10.2. Record the worst-case return loss and frequency. Because the time-gated response removes the effect of reflections from the input connector, it is necessary to compensate the result for loss in signal hitting the middle connector. In general, the compensation can be calculated by:

$$p_{in} = 10^{(\text{Return Loss in dB})/20}$$

$$\text{Comp (dB)} = 20 \times (\log(1-p_{in})) \quad \text{Eq.1}$$

Where p_{in} = input connector return loss, as seen in the time domain trace of Figure 2. For example shown, $p_{in} = 10^{(-27.4/20)} = 0.043$ and the compensation value is Comp = 20 * (log(1-0.043)) = 0.37 dB. If the return loss of the input is better than 20 dB, a compensation of 1 dB is sufficient.

11. Documentation

A typical report form should include the following information as a minimum:

Test technician: _______________ Date of test: _________________

Connector: ___________________ Cable: ______________________

Test start frequency: ___________ Test stop frequency: ___________

Worse case return loss: _________ dB @ ___________ MHz

12. Error Analysis

The principal error in this measurement is the effective directivity of the measurement system. For error-corrected measurements, this is essentially equal to the return loss of the calibration load. The maximum positive error in the connector measurement is the sum of the connector return loss (expressed in linear terms) added to the effective directivity of the system, then converted back to dB.

$$Error = 20 * log(\,10^{\left(\frac{Directivity}{-20}\right)} + 10^{\left(\frac{C}{-20}\right)}) + C$$

Where:

C = Connector return loss
Directivity = Directivity of the measurement system
log = Common logarithm (base 10)

Example: A test system is calibrated and uses a 40 dB load ($10^{(40/-20)}$ = 0.01 linear.) A connector is measured and found to have 35 dB return loss ($10^{(35/-20)}$ = 0.018 linear.) What could the worst-case connector return loss be?

Error = 20*log(0.018+0.01)+(35) or *Error* = 20*log(0.028)+35 or
Error = 3.94 dB

Return loss (worse case) = C-*Error* or 35 - 3.94
Return loss (worse case) = 31.06 dB