098-219r2

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1. REQUIREMENTS FOR SPI-3 CABLES

This clause specifies the electrical performance requirements for shielded and unshielded cables.

Five parameters are required to specify the electrical requirements: Transmission line impedance (Zo), capacitance per unit length, propagation velocity, propagation velocity skew, and signal attenuation. Each parameter is specified for both SE and Diff applications.

This clause also specifies methods for executing the testing for extracting these parameters.

Two methods are specified for the transmission line impedance: time domain and frequency domain. The capacitance is extracted from the frequency domain measurements for transmission line impedance. The propagation velocity and propagation time skew is based on a time domain measurement. The attenuation is derived from a frequency domain measurement.

1.1 General Notes for Testing

To minimize discontinuities and signal reflections, the use of cables with different impedances in the same bus should be minimized. Implementations may require trade-offs in shielding effectiveness, cable length, the number of loads, transfer rates, and cost to achieve satisfactory system operation. To minimize discontinuities due to local impedance variation, a flat cable should be spaced at least 1,27 mm (0,050 in) from other cables, any other conductor, or the cable itself when the cable is folded. Also, use of 26 AWG wire in 1,27 mm (0,050 in) pitch flat cable will more closely match impedances of many round shielded cables, resulting in fewer impedance discontinuities and therefore, improved signal quality. When mixing devices of different widths, particular care should be taken to not exceed the skew allowances provided by the cable skew delay and the system skew delay. These timing parameters may be lowered by reducing SCSI device input capacitance, SCSI device stub length, and the number of SCSI devices attached to the bus. The same precautions should be taken on busses with single-ended devices using fast synchronous data transfers in order to maintain system integrity.

Parameter	Section	measurement domain	test conditions	sample style	Active equipment
Diff Local Zo	2.1.1	time	Rise times at 0.5 and 3 ns	(A) details TBD 6 meters long	Diff TDR

	2.1.2	Freq.	sweep between 1 MHz and 1 Gig	(B) details TBD tune length to eliminate resonance	HP 4291B Z anal or Equiv.
Diff Extended Distance (Balanced) Zo	2.1.3	Freq.	sweep between 1 MHz and 1 Gig	C	HP 8753E network anal or Equiv.
SE C	Deleted	Freq.	sweep between 1MHz and 120 MHz	D	HP 4291B Z anal or Equiv.
Diff C	2.2.1	Freq.	sweep between 1 MHz and 1 Gig	E	HP 4291B Z anal or Equiv.
Diff (Tp) Propagation Time per meter Note: Tp is 1/Vp	3.1.1	time	Pattern:20 MHz 50% duty cycle…any rise time between 0.5 ns to 5 ns		signal gen (with balun possibly) + scope (?? Equip)
Diff Propagation Time skew	4.1	time	Difference between the min. and max Tp of all pairs.		NA
Diff attenuation (Balanced)	5.3	Freq.	low freq. shelf to 1 Gig	G leave all other lines open - long enough to produce at least 6dB at the low freq. shelf (typically > 30 m)	HP 8753E network anal or Equiv.
Possible future considerations…					
Cross-Talk NEXT Diff (Balanced)		Freq. Stated in dB loss	Low freq. Shelf to 1 Gig	I	HP 8753E or Equiv.
Cross-Talk FEXT Diff		Freq. Stated in dB loss	Low freq. Shelf to 1 Gig	J	HP 8753E or Equiv.

2. Transmission line impedance (time domain)

This requirement is necessary to allow the cable media to interface to devices and terminators without inducing excessive signal reflections.

2.1 Differential Impedance

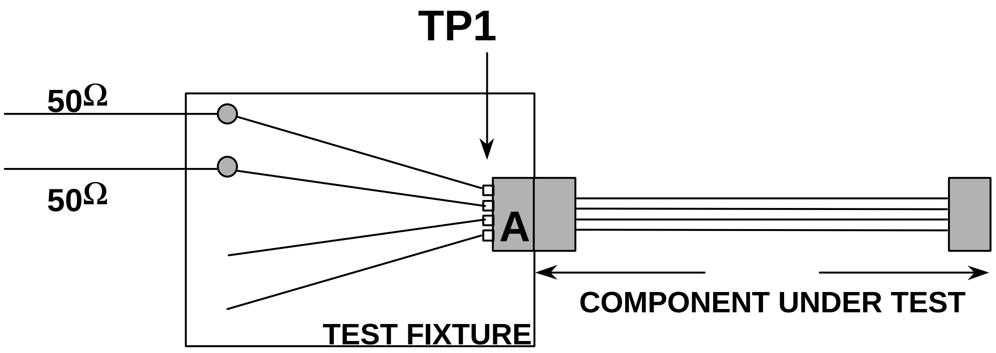
2.1.1 Time Domain Measurement

2.1.1.1 Sample Type A Setup

The following procedure prepares the cable sample for the testing of Differential Transmission Line impedance.

a) Cut sample cable length to 6 m.
b) Remove 5,0 cm of outer jacket at each end of the cable sample.
c) Comb out braid wire strands to form a pigtail.
d) Trim filler and tape materials.
e) Strip insulation from all conductors at both cable ends 0,6 cm.
f) Tie all grounds and shield together.

2.1.1.2 Test Fixture



A = TERMINATION POINT ON THE TEST FIXTURE

TEST FIXTURE / MEASUREMENT PROCESS IS CALIBRATED TO REPORT VALUES AT TP1

2.1.1.3 Calibration Procedure

Calibrate the TDR so that the skew between the channels is minimized as much as possible before the fixture is connected and after the fixture is connected. The maximum skew between the channels with the fixture in place is 7 ps. Calibrate the system using a short and a load connected at the point on fixture where the sample will be connected keeping the standards as absolutely close to the edge of the edge of the test fixture. The resistance standard used must have a maximum tolerance of 1%.

2.1.1.4 Measurement Procedure

On a 6 m (20 ft) cable sample length, select the pair to be measured. Tie all other wires and the shield together. Using a time domain reflectometer with a 0.5 and 3 ns rise time. The Impedance will be averaged between 2 ns and 4 ns from the test fixture/cable interface.

2.1.1.5 Acceptable Values

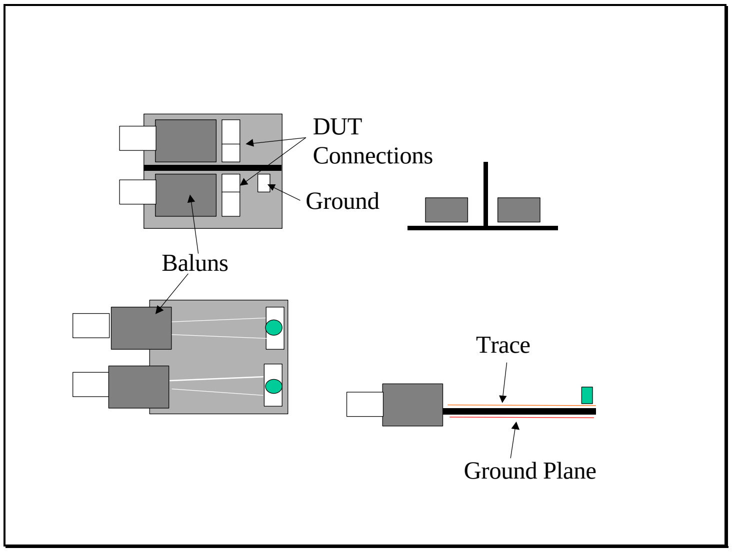
TBD

2.1.2 Frequency Domain Measurement of Differential Impedance (HP 4291A)

2.1.2.1 Sample Type B Setup

a) The cable sample shall be cut to a length such that resonance does not occur. The ends shall be prepared in such a manner that as little disturbance as possible to the original cables physical structure exists not to exceed one inch on either end.

2.1.2.2 Test Fixture



2.1.2.3 Calibration Procedure

The analyzer will be set to perform a S11 measurement with the power set at a minimum of 6dbm, the number of points set to a minimum of 401, the band width at a maximum of 200HZ, averaging at a minimum of 2 averages, and the start / stop frequencies per the table. The calibration will be of the open, short, load method keeping the leads as short as possible on the standards. The load standard will match the impedance of the secondary of the balun and have a maximum tolerance of 1%.

2.1.2.4 Measurement Procedure

a) Hewlett Packard 4291B RF Impedance / Material Analyzer or equivalent. Test fixture and an impedance matching balun unbalanced to balanced.

b) Hewlett Packard 8753E Network Analyzer or equivalent test fixture and an impedance matching balun unbalanced to balanced.

2.1.2.5 Acceptable Values

TBD

2.1.3 Extended Distance Differential Impedance (Optional)

2.1.3.1 Sample Setup C

2.1.3.2 Test Fixture

Reference: 2.1.1.2 for appropriate test fixtures

2.1.3.3 Calibration Procedure

Reference 2.1.2.3 for calibration requirements.

2.1.3.4 Measurement Procedure

Connect the near end of the sample to the out put balun on the test fixture using keeping the leads as short as possible to eliminate inductance problems and terminate the far end of the sample in the impedance of the cable. Perform a swept test for the bandwidth as required by table.

2.1.3.5 Acceptable Values

TBD

2.2 Differential Capacitance

2.2.1 Sample setup E

2.2.2 Test Fixture

Reference: 2.1.1.2 for appropriate test fixtures

2.2.3 Calibration Procedure

Reference 2.1.2.3 for requirements

2.2.4 Measurement Procedure

The measurement will be performed using the Equivalent Circuit method adjusting the open and short values of the capacitance and inductance so that the traces over lay as closely as absolutely possible.

2.2.5 Acceptable Values

TBD

3. Velocity of Propagation

3.1 Differential Velocity of Propagation

3.1.1 Sample Setup F

3.1.2 Test Fixture

Reference: 2.1.1.2 for appropriate test fixtures

3.1.3 Calibration Procedure

The analyzer will be set to perform a S12 measurement with the power set at a minimum of 6dbm, the number of points set to a minimum of 401, the band width at a maximum of 200HZ, averaging at a minimum of 2 averages, and the start / stop frequencies per the table. Perform a transmission calibration using a sample of the cable to be tested keeping the sample as short as possible .

3.1.4 Measurement Procedure

With the analyzer set up in the Delay Mode connect one end of the sample to the balun on the out put port and the opposite end to the balun on the input port With the markers turned on record the minimum and maximum delay across the band width as listed in the table.

3.1.5 Acceptable Values

TBD

4. Deley Skew

4.1 Diff. Skew

4.1.1 Calculated

Maximum Delay minus the minimum Delay renders the overall Delay Skew of the pair under test.

4.1.2 Acceptable Values

5. Attenuation

5.1 Theory

Attenuation is a measurement of the dissipative losses on a balanced transmission line. The series resistive loss of the conductors (copper) and the shunt loss due to the dissipation factor of the dielectric covering the conductors dominate these losses. At higher frequencies, the conductor loss increases due to skin effect. Skin effect is where the current crowds towards the outer “skin” of the conductor and effectively reduces the conductor area that current flows through. The attenuation for a given balanced transmission line will be due to a delicate balance of conductor metal composition and wire size and the composition, uniformity, and thickness of the dielectric that surrounds the conductors.

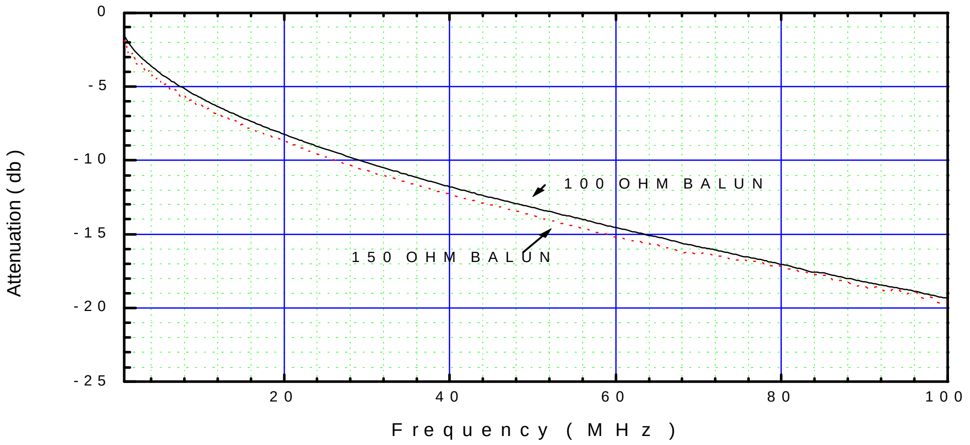
Attenuation can only be measured directly with an ideal test system that is perfectly matched to the balanced transmission line to be tested. In a practical test system, the quantity that is actually measured is insertion loss. Insertion loss is comprised of a component due to the attenuation of the balanced transmission line, a component due to the mismatch loss at the input or near end side of the transmission line and a component due to the mismatch loss at the output or far end side of the transmission line. There will be a mismatch loss component at any interface where the impedances are not perfectly matched at either side of the interface. The amount of mismatch loss that will be experienced at each interface is:

$$\textbf{Mismatch Loss (dB)} = (-\,10\ \mathrm{LOG}_{10}\ (1 - |\quad|^2\ ))\ \mathrm{dB}$$

Balanced transmission lines are also susceptible to measurement errors when measuring high values of attenuation (>50 dB) due to radiated energy coupling into the transmission line. The largest source of this error is due to direct coupling of the near end side of the test system to the far end side of the test system. This coupled signal will combine with the test signal passing through the transmission line under test and cause a significant ripple error in the insertion loss measurements at the higher frequencies where the attenuation of the transmission line under test is the largest.

5.2 Balun Selection.

The impedance on the primary side of the balun must match the impedance of the network analyzer. The impedance on the secondary side of the balun must be matched as closely as possible to the nominal impedance of the cable in the balanced state to minimize reflections, which will skew the data by introducing a mismatch loss ripple component.



5.3 Attenuation Diff (Balanced)

5.3.1 Sample Setup G

Sample Length. The optimum sample length is such that you have at least ~ 6db of one way attenuation at the lowest frequency of interest. This will guarantee that there will be at least 12 dB of additional loss experienced by that portion of the test signal that reflects from the far end.

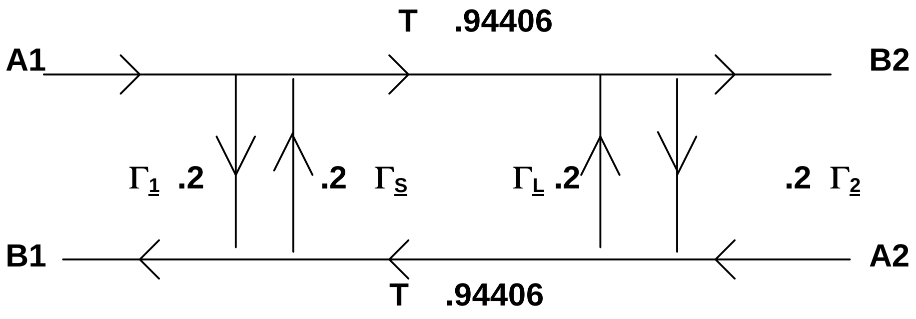
This will minimize the uncertainty caused by multiple reflections due to the far end and will result in acceptable resolution / ripple. The resultant measurements will be accurate and repeatable measurements. If you use a sample that yields an attenuation of less than 6db the mismatch ripple from the near end combined with the mismatch ripple from the far end can approach the same or greater magnitude than the attenuation at the lowest frequency. For example:

Case 1 :

Near End Balun Z = 100 Ohm
Far End Balun Z = 100 Ohm
Nominal Balanced Cable Z = 150 Ohm
Balanced Cable loss at lowest test frequency = .5 dB = .94406

$|\Gamma|$ Near End = .2 VSWR Near End = 1. 5 : 1
$|\Gamma|$ Far End = .2 VSWR Far End = 1. 5 : 1
Near End Worse case Mismatch Loss = $-10\ \mathrm{LOG}_{10}(1-|\Gamma|^2) = .177$ dB
Far End Worse case Mismatch Loss = $-10\ \mathrm{LOG}_{10}(1-|\Gamma|^2) = .177$ dB

The resultant flow graph :



Worse Case Mismatch
Loss Error dB =

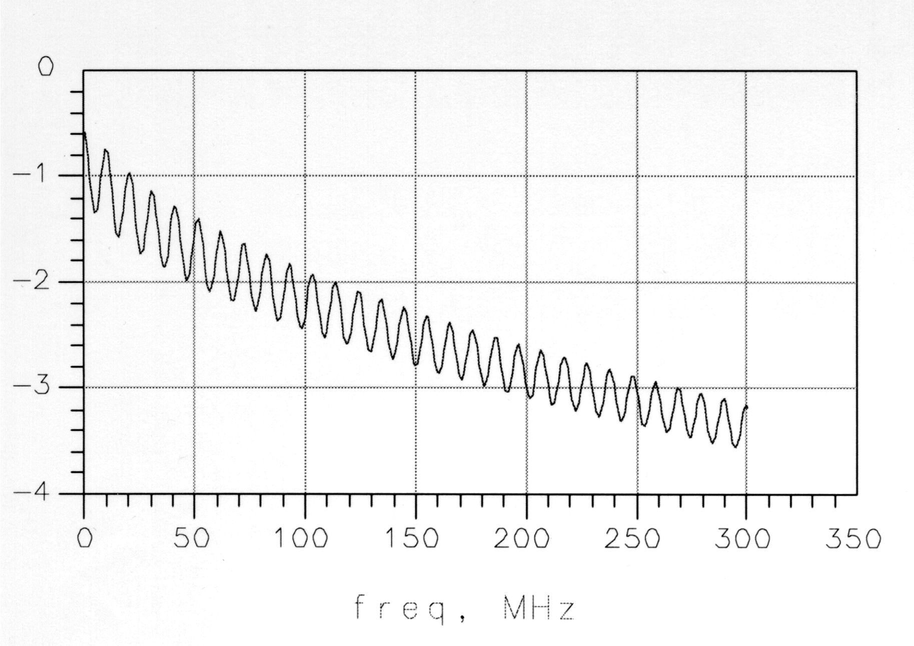
$$20\ \mathrm{LOG}_{10}\left|\frac{1-|\Gamma_s|*|\Gamma_L|)}{(1-(|\Gamma_s|*|\Gamma_1|)-(|\Gamma_2|*|\Gamma_L|)-((T)^2(|\Gamma_s|*|\Gamma_L|)+(|\Gamma_s|*|\Gamma_L||\Gamma_1|*|\Gamma_2|)}\right|$$

Worse Case Mismatch
Loss Error dB =

$$20\ \mathrm{LOG}_{10}\left|\frac{1-(.2*.2)}{(1-(.2*.2)-(.2*.2)-((.94406)^2(.2*.2)+(.2*.2*.2*.2)}\right|$$

= .6972 dB

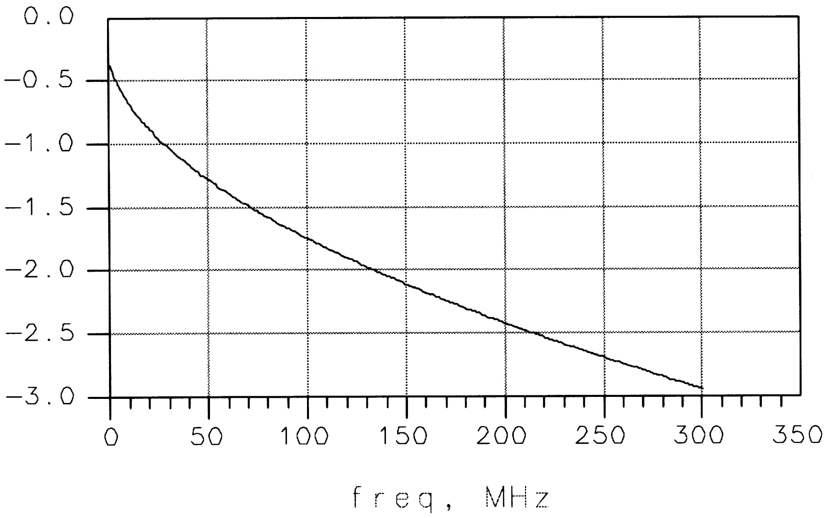
Therefore, we will be trying to measure .5dB attenuation in the presence of a ripple that will add anywhere from .354 dB to .6972dB of measurement error.



Case 2 :

Near End Balun Z = 150 Ohm
Far End Balun Z = 150 Ohm
Nominal Balanced Cable Z = 150 Ohm
Balanced Cable loss at lowest test frequency = .5 dB = .94406

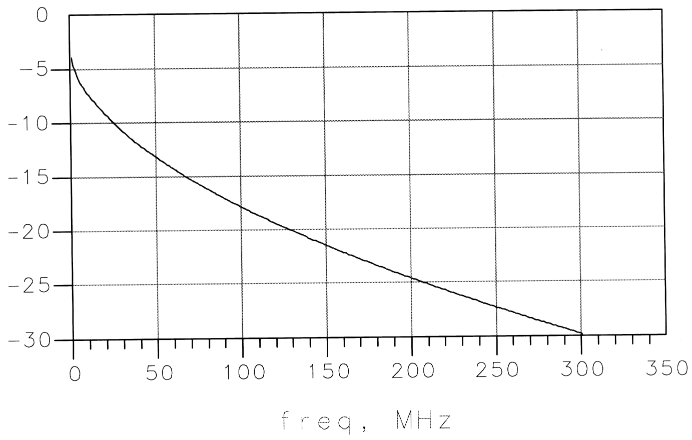
Under a matched condition, the insertion loss equals the attenuation and there is no ripple to cause measurement uncertainty.



Case 3 :

Near End Balun Z = 100 Ohm
Far End Balun Z = 100 Ohm
Nominal Balanced Cable Z = 150 Ohm
Balanced Cable loss at lowest test frequency ~ 6 dB

Under a mismatched condition, the insertion loss equals the attenuation plus the mismatch loss at the near end and at the far end. However, in this case, there is sufficient attenuation in the cable at the lowest frequency to make multiple reflections inconsequential, so there is no ripple component of measurement uncertainty. The mismatch loss error is still present, but it is ~ .3 dB out of a measured insertion loss of ~ 6 dB.



Note: The use of an attenuator for measuring shorter lengths is not acceptable because there is still mismatch loss uncertainty due to the fact that the attenuator does not have any better match than the far end test port. Also you introduce an additional uncertainty because you are trying to separate a small value (cable attenuation) from a large value, (attenuator attenuation) and you will face dynamic range issues.

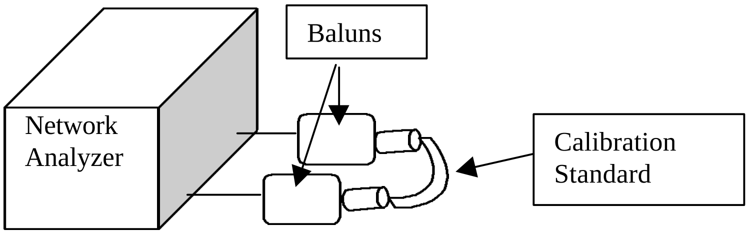
5.3.2 Test Fixture

Reference: 2.1.1.2 for appropriate test fixtures

5.3.3 Calibration Procedure

For calibration purposes you shall use a length of the cable you are actually measuring. This length of cable must be kept as short as possible and still be terminated to the secondary side of the Impedance Matching Devices connected to the Network Analyzer.

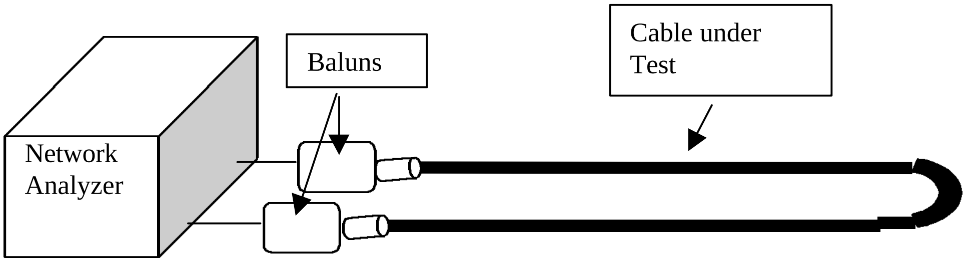
Note: *If connectors are to be used to perform the measurement, they must also be used on the calibration sample.*



5.3.4 Measurement Procedure

With the cable ends prepared such that a minimal amount of the conductors are exposed from the jacket, install connectors if required, connect the cable to the baluns and perform the tests as required. It is important to either separate or shield the baluns from each other when measuring long cable samples. When the attenuation of the cable exceeds ~50 dB or the frequency is above approximately 150 MHz, potential direct coupling from the near end to the far end balun will create an increasingly large ripple in the attenuation measurement that can cause a significant amount of measurement uncertainty.

For reference only



5.3.4.1 Equipment Required.

a) Network Analyzer (HP 87xx Series)
b) Impedance Matching Devices such as Baluns
c) Connectors for interface between cable and baluns
d) Test fixture to mount baluns

5.3.5 Acceptable Values

TBD