Date: 9/9/08

To: T10 Committee (SCSI)

From: George Penokie (LSI)

Subject: SAS-2: Making 07-267 into an Annex

1 Overview

This is the re-creation of 07-267r1 putting it into a form that can be placed into the SAS-2 standard as an informative annex.

2 SAS-2 changes

2.0.0.0.1 Reference transmitter device characteristics

The reference transmitter device is a set of parameters defining the electrical performance characteristics of a transmitter device to be used in simulation to determine compliance of an TxRx connection.

The following Touchstone file containing the S-parameters of the reference transmitter device is included:

   a)   TxRefTerm.s4p.

See Annex A.2 for ~~A~~an S-parameter model of the reference transmitter device. ~~is included with this standard. The following files are included:~~

   b)   ~~07-267r0_TxRx_RefTermModels.pdf describes how the reference transmitter device and reference receiver device models were created; and~~
   c)   ~~07-267r0_TxRefTerm.s4p is a Touchstone® file containing the S-parameters of the reference transmitter device.~~

   NOTE 1 - ~~Touchstone® is a registered trademark of Agilent Corporation.~~

Table 1 defines the reference transmitter device characteristics.

Table 1 — Reference transmitter device characteristics at IT and CT

Characteristic	Units	Value
Peak to peak voltage (V_{P-P}) [a]	mV(P-P)	1 000 [b]
Transmitter equalization [a]	dB	2
Maximum rise/fall time [c]	UI	0.41 (68.$\overline{3}$ ps)
RJ	UI	0.15 (25 ps)
DJ	UI	0.15 (25 ps)

[a]   See 5.3.6.5.5 for measurement method.
[b]   This is a higher value than the minimum required transmitter voltage defined in table 61 (see 5.3.6.5.1).
[c]   Rise/fall times are measured from 20 % to 80 % of the transition with a repeating 01b or 10b pattern (e.g., D10.2 or D21.5)(see table 237 in 10.2.9.2).

2.0.0.0.2 Reference receiver device

The reference receiver device is a set of parameters defining the electrical performance characteristics of a receiver device to be used in simulation to determine compliance of a transmitter device or TxRx connection.

The following Touchstone file containing the S-parameters of the reference receiver device is included:

   a)   TxRefTerm.s4p.

See annex A.2 for an ~~An~~ S-parameter model of the reference receiver device. ~~is included with this standard. The following files are included:~~

b) ~~07-267r0_TxRx_RefTermModels.pdf describes how the reference transmitter device and reference receiver device models were created; and~~

c) ~~07-267r0_RxRefTerm.s4p is a Touchstone® file containing the S-parameters of the reference receiver device.~~

NOTE 2 - ~~Touchstone® is a registered trademark of Agilent Corporation.~~

The reference receiver device includes a 3 tap decision feedback equalizer (DFE) with infinite precision taps and unit interval tap spacing. The reference coefficient adaptation algorithm is the least mean square (LMS) algorithm. The DFE may be modeled at the center of the eye as:

$$y_k = x_k - \sum_{i=1}^{3} d_i \times \text{sgn}(y_{k-i})$$

where:

y	equalizer differential output voltage
x	equalizer differential input voltage
d	equalizer feedback coefficient
k	sample index in UI

The reference receiver assumes the ~~equilizer~~equalizer feedback coefficients (i.e., d_i) are positive and their magnitudes are less than 0.5.

NOTE 3 - For more information on DFE and LMS, see John R. Barry, Edward A. Lee, and David G. Messerschmitt. *Digital Communication - Third Edition*. Kluwer Academic Publishing, 2003. See http://users.ece.gatech.edu/~barry/digital.

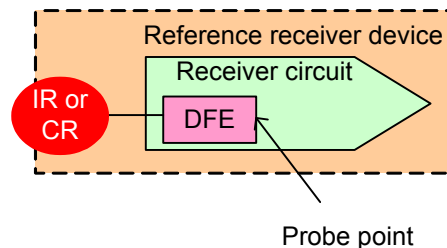Figure 1 shows a reference receiver device.

Probe point

Figure 1 — Reference receiver device

Annex A
(informative)

Simulated S-parameter model

A.1 ~~S-parameter model of the reference transmitter test load~~

A.1.1 ~~S-parameter model of the reference transmitter test load overview~~

A.1.2 ~~Equipment setup for generating S-parameters of the transmitter test load~~

A.1.3 ~~Equipment calibration~~

A.1.4 ~~S-parameter generation~~

A.2 Simulated S-parameter model

A.2.5 Simulated S-parameter model overview

The S-parameters are able to be simulated using simple circuits to represent:

    a)   a reference transmitter termination (see figure A.1);
    b)   a reference receiver termination (see figure A.1); and
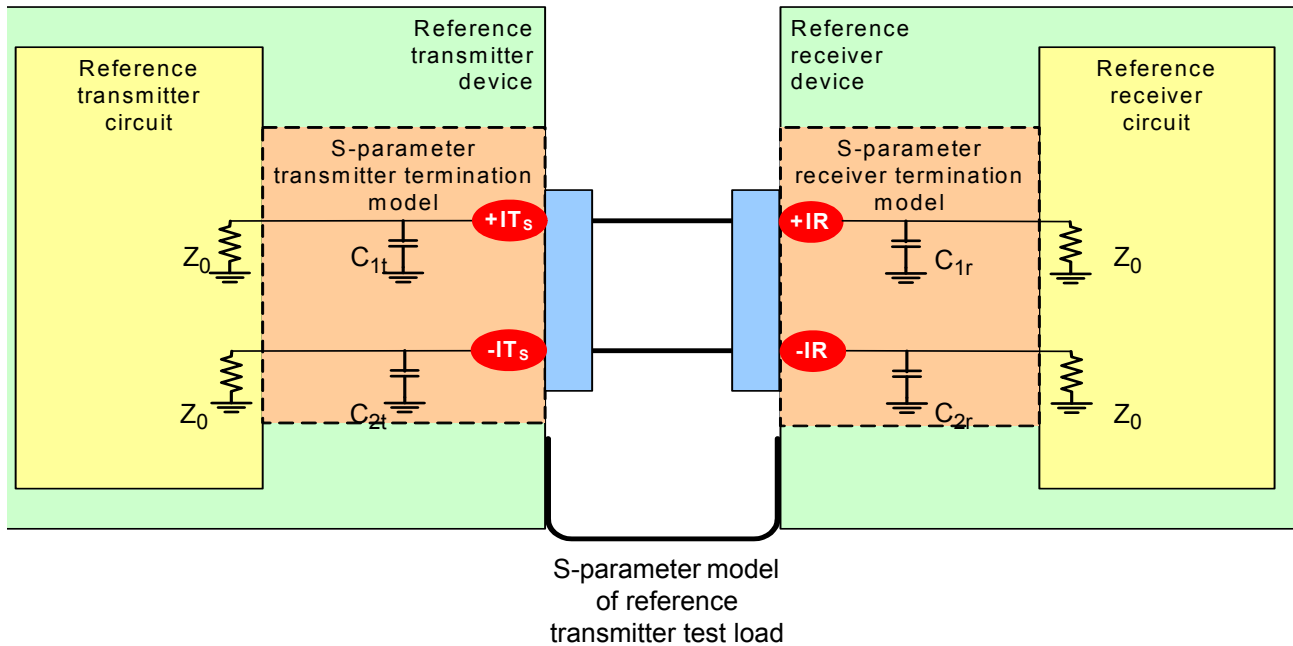   c)   the return loss (see figure A.4).

Figure A.1 — S-parameters modeling circuits for simulation

A.2.6 Simulated S-parameter model for the transmitter termination

From the simulated S-parameter transmitter termination model shown in figure A.1 a representation of the S-parameters may be derived using the following calculations:

$$\tau_1 = \frac{Z_0 \times C_{1t}}{2}$$

$$\tau_2 = \frac{Z_0 \times C_{2t}}{2}$$

$$S_{11} = \frac{-s \times \tau_1}{1 + (s \times \tau_1)}$$

$$S_{12} = 0$$

$$S_{22} = \frac{-s \times \tau_2}{1 + (s \times \tau_2)}$$

$$S_{DDij} = S_{CCij} = \frac{S_{11} + S_{22}}{2}$$

$$S_{CDij} = S_{DCij} = \frac{S_{11} - S_{22}}{2}$$

where:

τ_1 is the Tx+ termination time constant

τ_2 is the Tx- termination time constant

Z_0 is the impedance as specified by this standard (i.e., 50 ohm)

C_{1t} is the Tx+ termination capacitance

C_{2t} is the Tx- termination capacitance

s is the complex frequency

By setting C_{1t} to 0.5 pf τ_1 becomes 12.5 ps and C_{2t} to 2 pf τ_2 becomes 50 ps in these equations a model of the S-parameters for the transmitter termination may be generated (see figure A.2).
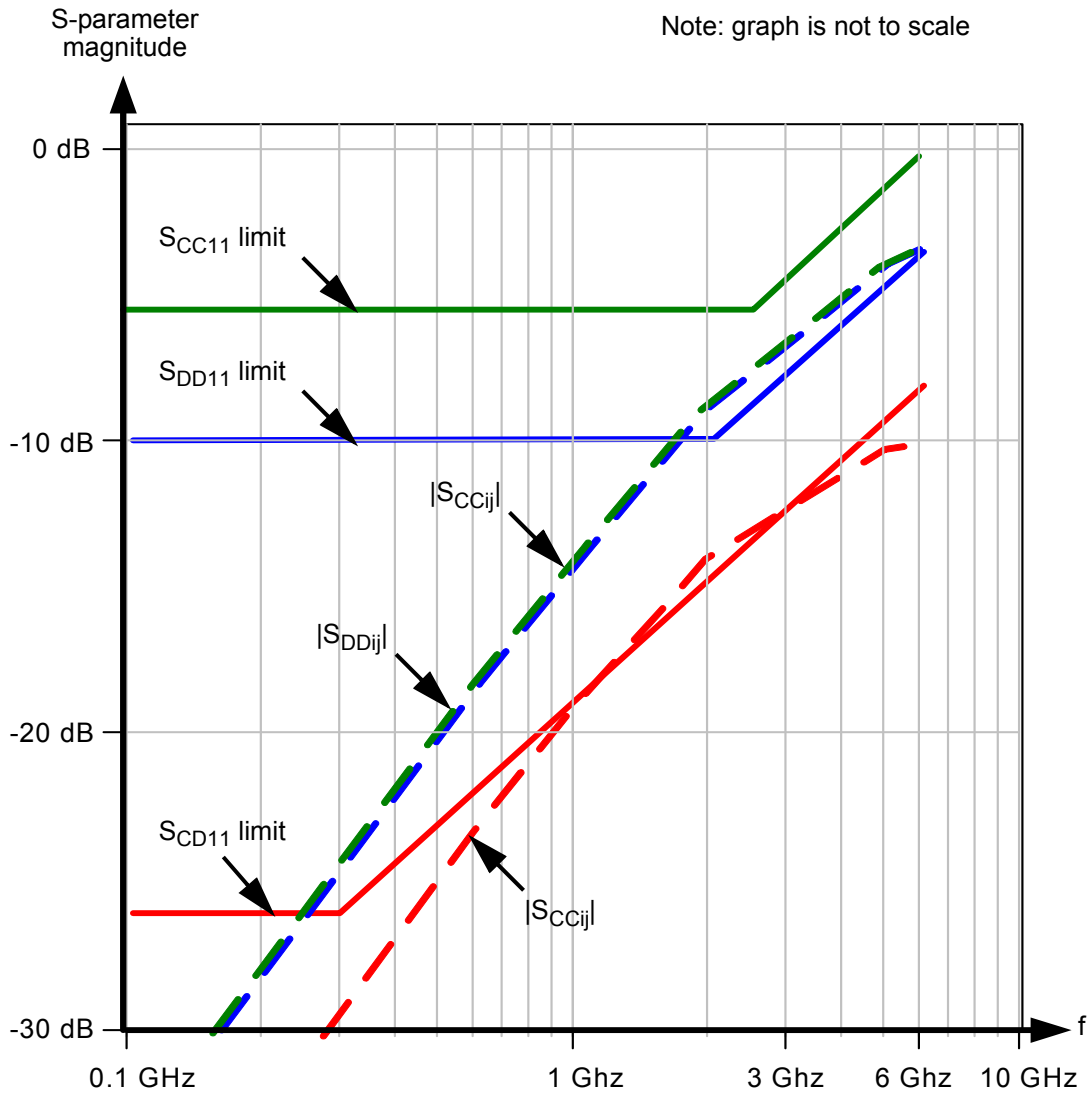
Figure A.2 — Results of simulated S-parameter Tx/Rx termination model

A.2.7 Simulated S-parameter model for the receiver termination

From the simulated S-parameter receiver termination model shown in figure A.1 a representation of the S-parameters may be derived using the following calculations:

$$\tau_1 = \frac{Z_0 \times C_{1r}}{2}$$

$$\tau_2 = \frac{Z_0 \times C_{2r}}{2}$$

$$S_{11} = \frac{-s \times \tau_1}{1 + (s \times \tau_1)}$$

$$S_{12} = 0$$

$$S_{22} = \frac{-s \times \tau_2}{1 + (s \times \tau_2)}$$

$$S_{DDij} = S_{CCij} = \frac{S_{11} + S_{22}}{2}$$

$$S_{CDij} = S_{DCij} = \frac{S_{11} - S_{22}}{2}$$

where:

τ_1 is the Rx+ termination time constant

τ_2 is the Rx- termination time constant

Z_0 is the impedance as specified by this standard (i.e., 50 ohm)

C_{1r} is the Rx+ termination capacitance

C_{2r} is the Rx- termination capacitance

s   is the complex frequency

By setting C_{1r} to 2 pf τ_1 becomes 50ps and C_{2r} to 0.5 pf τ_2 becomes 12.5 ps in these equations a model of the S-parameters for the receiver termination may be generated (see figure A.2).

A.2.8 Simulated S-parameter model for return loss

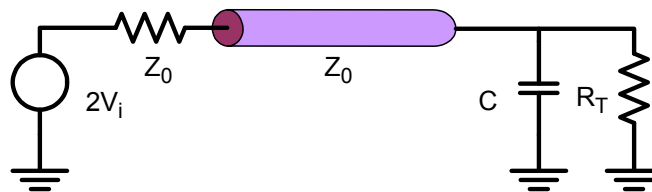Figure A.3 shows a simulated S-parameter return loss model.

Figure A.3 — Simulated S-parameter return loss model

From the simulated S-parameter return loss model shown in figure A.1, a representation of S_{11} (i.e., negative return loss) may be derived using the following calculations:

$$LF = 20 \times \log_{10}\left(\frac{tol}{2 + tol}\right)$$

$$R_T = Z_0 \times (1 + tol)$$

$$F_{zero} = \frac{tol}{(2 \times \pi \times C \times R_T \times (1 + tol))}$$

$$F_{pole} = \frac{tol + 2}{(2 \times \pi \times C \times R_T \times (1 + tol))}$$

where:

    LF   is the low frequency asymptote of magnitude S_{11}

    tol   is the tolerance of R_T

    Z_0 is the impedance as specified by this standard (i.e., 50 ohm)

    R_T is the far end load

    C   is the far end capacitance

    F_{zero} is the frequency at which the asymptotes intersect (see figure A.4)

    F_{pole} is the frequency at which the asymptotes intersect (see figure A.4)

As a result of the effects of the load on the far end not being significant the calculation may be simplified to the following:
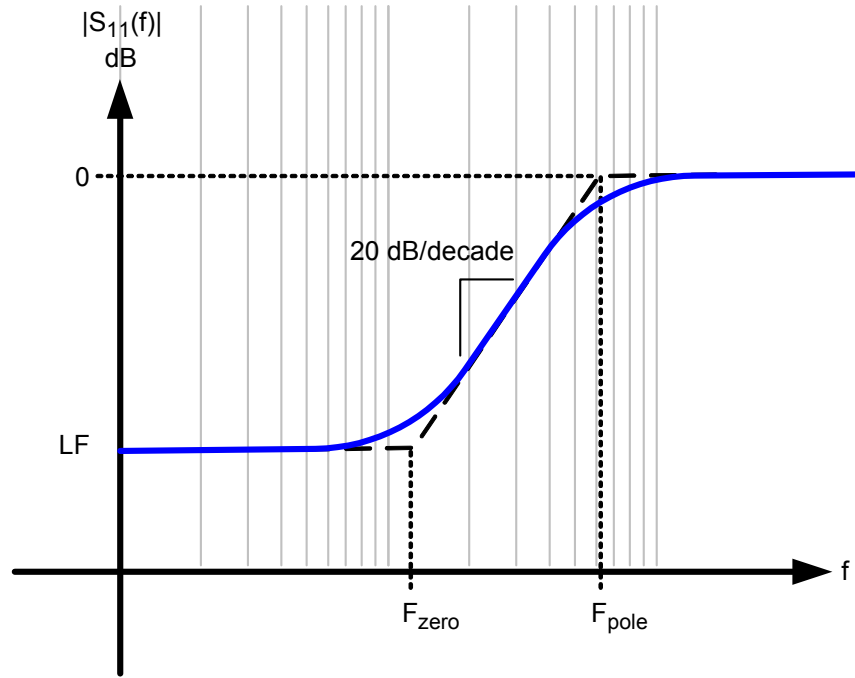
$$LF \sim 20 \times \log_{10}\left(\frac{tol}{2}\right)$$

$$F_{zero} \sim \frac{tol}{(2 \times \pi \times C \times R_T)}$$

$$F_{pole} \sim \frac{1}{(\pi \times C \times R_T)}$$

Editor's Note 1: Add the ~ symbol into the acronyms list.

Using the simplified equations a model for S_{11} (i.e., negative return loss) may be generated (see figure A.4).

Note: graph is not to scale

Figure A.4 — S-parameter return loss model plot