6G SAS Reference TX & RX Termination Networks

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Objective

- Design termination networks to reasonably recreate worst case SDD11, SDD22, SCC11, SCC22, SCD11 & SCD22
But 1\textsuperscript{st}... where is this going?

- Three applications:
  1. Validation of channels
  2. Validation of TX
  3. Validation of RX
- 1\textsuperscript{st} two applications are software, but 3\textsuperscript{rd} application requires hardware implementation of reference TX
- Problem: lab equipment cannot emulate worst case return loss
Proposed Solution

• Since 3rd application (RX validation) always uses 10 meter SAS cable, TX return loss affects far end waveform very little.

• Termination networks should be applied only to software ref. TX & RX
Return Loss Spec Format

\[ LF = \frac{tol}{2+tol} \]
\[ \sim \frac{tol}{2} \]

\[ F_Z = \frac{tol}{2\pi RC(1+tol)} \]
\[ \sim \frac{tol}{2\pi RC} \]

\[ F_P = \frac{2+tol}{2\pi RC(1+tol)} \]
\[ \sim \frac{1}{\pi RC} \]

\[ \left| S_{11} \right| \text{ (log scale)} \]

20 dB/decade
Model #1

\[ R_1 = R_1^* \parallel \text{Zo}, \quad R_2 = R_2^* \parallel \text{Zo}, \quad R_1 C_1 = R_2 C_2 = R_3 C_3 = \tau \]

\[ S_{11} = \frac{[(2/\text{Zo}) \times (R_1 \parallel (R_2 + R_3)) - 1 - s\tau]}{[1 + s\tau]} \]

\[ S_{12} = \frac{[(2/\text{Zo}) \times (R_1 R_2 / (R_1 + R_2 + R_3))]}{[1 + s\tau]} \]

\[ S_{22} = \frac{[(2/\text{Zo}) \times (R_2 \parallel (R_1 + R_3)) - 1 - s\tau]}{[1 + s\tau]} \]
Normalizing resistors to $Z_0$: $r_1 = R_1/Z_0, \ r_2 = R_2/Z_0, \ r_3 = R_3/Z_0$

$$S_{11} = -[(1 - 2(r_1||(r_2+r_3))) + s\tau] / [1+s\tau]$$

$$S_{12} = [2(r_1r_2 / (r_1+r_2+r_3))] / [1+s\tau]$$

$$S_{22} = -[(1 - 2(r_2||(r_1+r_3))) + s\tau] / [1+s\tau]$$

$$S_{Dnn} = [S_{11} + S_{22} - 2 S_{12}] / 2$$

$$= -[(1 - r_3||(r_1+r_2)) + s\tau] / [1+s\tau]$$

$$S_{Cnn} = [S_{11} + S_{22} + 2 S_{12}] / 2$$

$$= -[(1 - [4r_1r_2+r_1r_3+r_2r_3]/[r_1+r_2+r_3]) + s\tau] / [1+s\tau]$$

$$S_{Dnn} = [S_{11} - S_{22}] / 2$$

$$= [ (r_1-r_2)r_3 / (r_1+r_2+r_3) ] / [1+s\tau]$$
Model #1 Values

<table>
<thead>
<tr>
<th>Model #1 Values</th>
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<tbody>
<tr>
<td>r1 0.65</td>
</tr>
<tr>
<td>r2 0.6</td>
</tr>
<tr>
<td>r3 10</td>
</tr>
<tr>
<td>tau 25</td>
</tr>
<tr>
<td>R1* 93</td>
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<tr>
<td>R2* 75</td>
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<tr>
<td>R3 500</td>
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<tr>
<td>Zo 50</td>
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</tbody>
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<thead>
<tr>
<th>Model #1 Values</th>
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<tbody>
<tr>
<td>Values</td>
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<tr>
<td>SCC11</td>
</tr>
<tr>
<td>SDD11</td>
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<tr>
<td>SCD11</td>
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</tbody>
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Model #2

\[ ZoC_1/2 = \tau_1 \]

\[ ZoC_2/2 = \tau_2 \]

\[ S_{11} = -s\tau_1 / (1+s\tau_1) \]

\[ S_{12} = 0 \]

\[ S_{22} = -s\tau_2 / (1+s\tau_2) \]

\[ S_{DD_{nn}} = S_{CC_{nn}} = [S_{11} + S_{22}] / 2 \]

\[ S_{CD_{nn}} = [S_{11} - S_{22}] / 2 \]
Model #2 Values

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>tau1</th>
<th>tau2</th>
<th>Zo</th>
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<tbody>
<tr>
<td>2</td>
<td>0.5</td>
<td>50</td>
<td>12.5</td>
<td>50</td>
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<tr>
<td>pF</td>
<td>pF</td>
<td>ps</td>
<td>ps</td>
<td>ohms</td>
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</tbody>
</table>

GHz

SCC11
SDD11
SCD11
SCC11 Limit
SDD11 Limit
SCD11 Limit

dB

0.10 1.00 10.00

GHz
Conclusions

• Since model #2 does a much better job of emulating worst case SCD11, it is chosen as the termination model

• \textit{TxRefTerm.s4p} & \textit{RxRefTerm.s4p} uploaded in \textit{07-267r0.zip} are cascaddable 4-port models
  
  • \textit{TxRefTerm}: 2pF to GND on ports 1(in) & 2(out) and 0.5pf to GND on ports 3(in) & 4(out)
  
  • \textit{RxRefTerm} is identical, but with 2pF and 0.5pF reversed