Notes on Spice Simulations

These notes are intended to help you do the Spice simulation work required for the class project.

Xcede+ Connector Model

The connector to be used in the project is the Amphenol Xcede+ connector. The connector is offered in two versions: a standard back/midplane version and an orthogonal midplane version. For the project, the available sizes are:

- 4x8 Midplane
- 4x8 Orthogonal
- 6x8 Midplane
- 6x12 Midplane
- 6x12 Orthogonal

There are different models for each of these versions These are s-parameter models in Touchstone file format. The Touchstone files, Spice TDR test files, and connector elements modeled for these connectors are:

- 4x8 Midplane
  - `XCedePlus_4pr_97ohm_1p85mm_With_Extra_GND_2mm_Sig_3mm_GND_Wipe.s32p`
  - `xcede_4x8mp_test.sp`
  - `Models a daughter card plug joined to a midplane socket`
- 4x8 Orthogonal
  - `Orthogonal_rev12_Full_Final.s24p`
  - `xcede_4x8ortho_test.sp`
  - `Models a daughter card socket to midplane socket pair to daughter card socket connector stack`
- 6x8 Midplane
  - `Xcede_plus_6pr_85ohm_1p85mm_20120503_Extra_GND_2mm_Sig_3mm_GND_Wipe.s48p`
  - `xcede_6x12mid.sp`
  - `Models a daughter card plug joined to a midplane socket`
- 6x12 Midplane
  - `Xcede_plus_6pr_85ohm_1p85mm_20120503_Extra_GND_2mm_Sig_3mm_GND_Wipe.s48p`
  - `xcede_6x12ortho_test.sp`
  - `Models a daughter card plug joined to a midplane socket`
- 6x12 Orthogonal
  - `XCedeplus_100ohm_2p68_Ortho_2mm_Sig_3mm_GND_Wipe_EF_GHpairs_Only_20144301_IdEM.s32p`
  - `xcede_6x8mid.sp`
  - `Models a daughter card plug joined to a midplane socket`

The characters after the dot indicate the number of ports. For example, the .s32p file extension means “s-parameters, 32 ports”. The comment banner at the head of each model file gives a connection map; for the 4x8 midplane connector, it looks like this:

```
! *   DAUGHTER CARD SIDE OF CONNECTOR, NODE(PIN LOCATION):
! *  ------------------------------------------------------------------------------------
! *  | Terminated Wafer|  Wafer A        |  Wafer B        | Terminated Wafer|
! *  ------------------------------------------------------------------------------------
! *  |     GND         |     GND         |     GND         |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |     GND         |  Port 15 Pin H) |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 31(Pin H) |  Port 13(Pin G) | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 29(Pin G) |     GND         | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |     GND         |     GND         |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |     GND         |  Port 11(Pin F) |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 27(Pin F) |  Port 9 (Pin E) | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 25(Pin E) |      GND        | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |     GND         |      GND        |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |     GND         |  Port 7  Pin D) |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 23(Pin D) |  Port 5 (Pin C) | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 21(Pin C) |      GND        | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |      GND        |      GND        |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |      GND        |  Port 3(Pin B)  |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 19(Pin B) |  Port 1(Pin A)  | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 17(Pin A) |      GND        | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     -           |     GND         |      -          |     GND         |
! *  ------------------------------------------------------------------------------------

! *   BACKPLANE SIDE OF CONNECTOR, NODE(PIN LOCATION):
! *  ------------------------------------------------------------------------------------
! *  | Terminated Wafer|  Wafer A        |     Wafer B     | Terminated Wafer|
! *  ------------------------------------------------------------------------------------
! *  |     GND         |     GND         |     GND         |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |     GND         |  Port 16 Pin H) |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 32(Pin H) |  Port 14(Pin G) | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 30(Pin G) |     GND         | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |     GND         |     GND         |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |     GN D        |  Port 12(Pin F) |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 28(Pin F) |  Port 10(Pin E) | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 26(Pin E) |     GND         | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |     GND         |     GND         |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |     GND         |  Port 8  Pin D) |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 24(Pin D) |  Port 6 (Pin C) | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 22(Pin C) |      GND        | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |      GND        |      GND        |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |      GND        |  Port 4(Pin B)  |     GND         |
! *  ------------------------------------------------------------------------------------
! *  |  TERMINATED-Z0  |  Port 20(Pin B) |  Port 2(Pin A)  | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     GND         |  Port 18(Pin A) |      GND        | TERMINATED-Z0   |
! *  ------------------------------------------------------------------------------------
! *  |     -           |      GND        |      -          |     GND         |
! *  ------------------------------------------------------------------------------------
```

To interpret this, note that Pin A in Wafer A on the daughter card side connects to Pin A in Wafer A on the backplane side, and similarly for the other pins in Wafers A and B. The differential pairs are A/B, C/D, E/F and G/H. But notice that there are also port numbers that are unique: Port 1 through Port 32. The odd numbers are on the daughter card side and the even numbers are on the backplane side: 1 pairs with 2, 3 pairs with 4 and so on. You can ignore the "Terminated Wafers". These simply indicate that when the model was extracted, the pins adjacent to pin ports 1–32 were terminated in the connector's reference impedance, rather than left floating. This is a more accurate representation of the connector in a real system. The Spice statement that instantiates this connector is:

```
S1    1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16
+    17  18  19  20  21  22  23  24  25   26   27   28   29   30   31   32  MNAME=s_model
```

The model definition that must accompany this is:

```
.MODEL s_model S TSTONEFILE='./XCedePlus_4pr_97ohm_1p85mm_With_Extra_GND_2mm_Sig_3mm_GND_Wipe.s32p'
```

Figure 1 below shows the port connections for this model. Connector model test bench decks for all the connectors are provided on the class website under each connector's sub-directory. These allow you to put a differential step into one of the connector pairs and observe both the output signal and the crosstalk induced at other connector ports. To change where the differential step is applied, change the port number in the Rp and Rn statements:

```
Rp  inp 1    50
Rn  inn 3    50
```

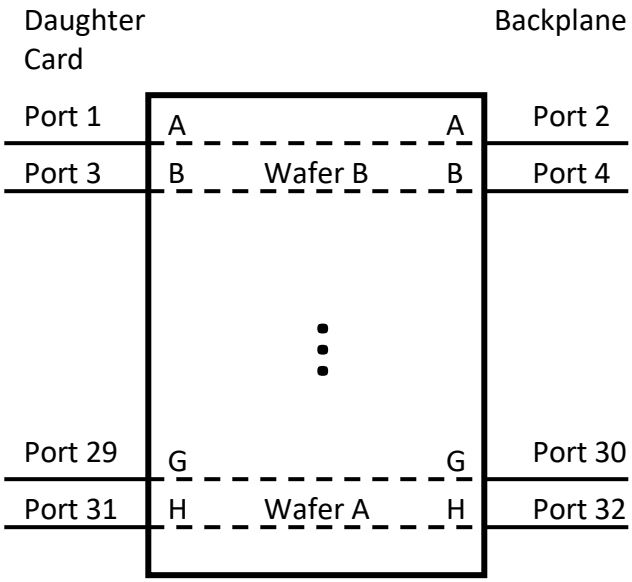

Figure 1

Then comment out the appropriate input terminating resistors. For example:

```
* Daughter Card Side Terminations *
*R1     1 0  rterm
*R3     3 0  rterm
 R5     5 0  rterm
 R7     7 0  rterm
 R9     9 0  rterm
 R11   11 0  rterm
 R13   13 0  rterm
```

```
R15   15  0   rterm
R17   17  0   rterm
R19   19  0   rterm
R21   21  0   rterm
R23   23  0   rterm
R25   25  0   rterm
R27   27  0   rterm
R29   29  0   rterm
R31   31  0   rterm
```

To change the Xcede connector pin connections in the channel simulation decks (see below), follow this same procedure in the included file `xcede_plus.inc`.

Channel Simulation Templates

A generic simulation template, `reference_channel_2020.sp`, is on the class website. You will need to modify this template to customize it to your design. Comment fields identify the places where this should be done.

The structures of the backplane (also coplanar midplane) and orthogonal midplane channels are shown in Figure 2 and Figure 3 below.

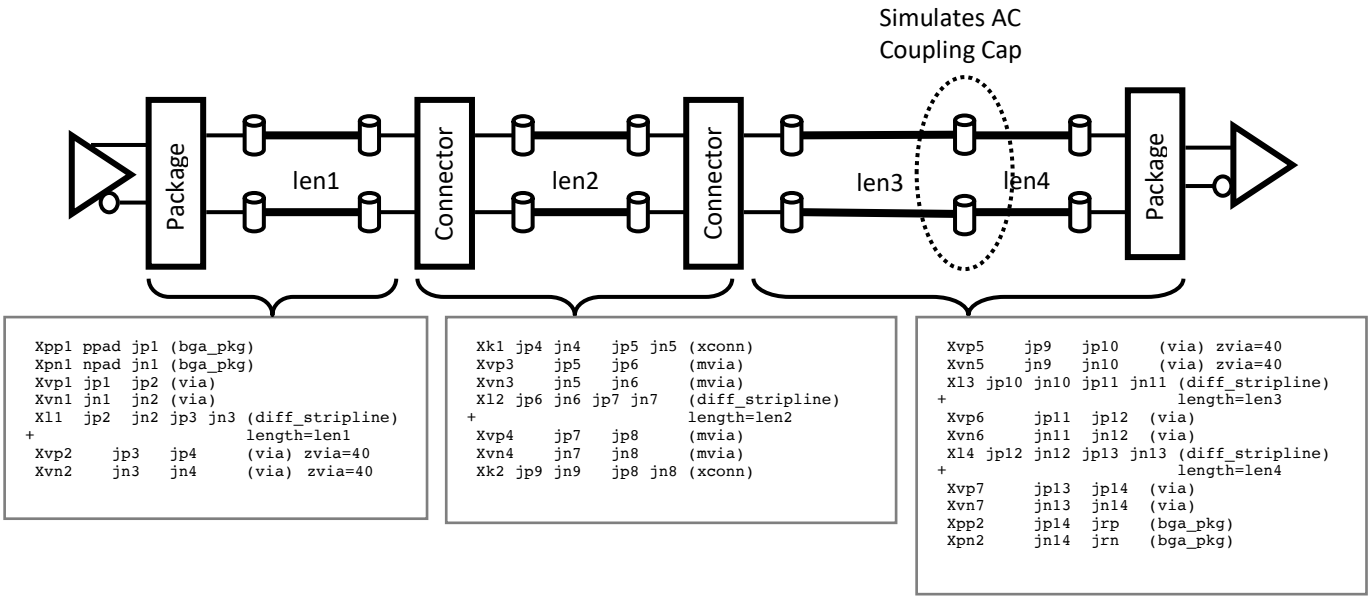

Figure 2 – Backplane Channel

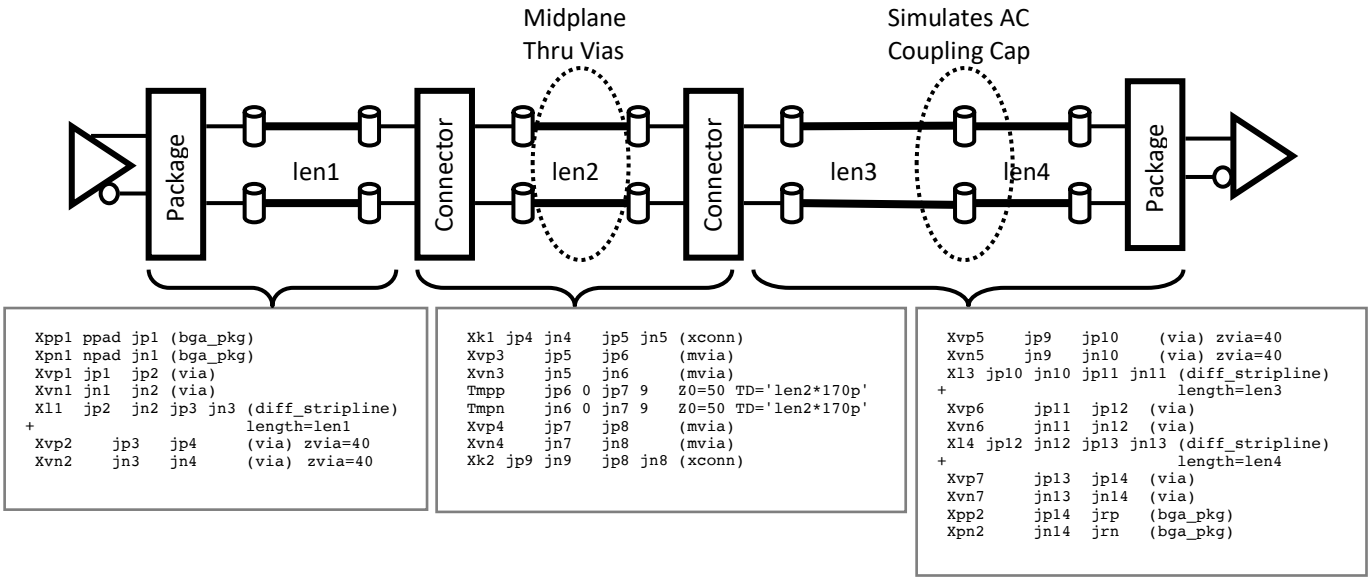

Figure 3 – Orhogonal Midplane Channel

The PRBS7 data eye simulations can be quite long (e.g. 30 minutes), so it is best to first determine the correct equalization using the single pulse simulations before running the data eye simulations with these settings.

All of the user alterable parameters are defined at the top of the .sp files, and their meanings are defined in the associated comment fields. Here is an example, taken from the `diff_channel_single_pulse.sp` file:

```
*************************************************************************
*************************************************************************
*                                                                       *
*                 User Parameter Definitions                            *
*                                                                       *
*     ADJUST THE FOLLOWING PARAMETERS TO SET SIMULATION RUN TIME        *
*     AND TO SET DRIVER PRE-EMPHASIS LEVELS.                            *
*                                                                       *
*     PLOT THE SIGNAL rx_diff TO GET THE DIFFERENTIAL RECEIVE SIGNAL.   *
*                                                                       *
*************************************************************************
*************************************************************************
* Transmitter Bit Rate *
*.PARAM bps = 6.25g           * Bit rate, bits per second
 .PARAM bps = 10.7g           * Bit rate, bits per second

* Simulation Run Time *
 .PARAM simtime   = '100/bps' * USE THIS RUNTIME FOR PULSE RESPONSE
*.PARAM simtime   = '512/bps' * USE THIS RUNTIME FOR EYE DIAGRAM

* CTLE Settings *
*.PARAM az1     = 3.125g      * CTLE zero frequency, Hz
 .PARAM az1     = 5g          * CTLE zero frequency, Hz
*.PARAM ap1     = 3.125g      * CTLE primary pole frequency, Hz
 .PARAM ap1     = 5g          * CTLE primary pole frequency, Hz
 .PARAM ap2     = 10g         * CTLE secondary pole frequency, Hz

* Driver Pre-emphais *
 .PARAM pre1      =  0.00     * Driver pre-cursor pre-emphasis
 .PARAM post1     =  0.00     * Driver 1st post-cursor pre-emphasis
 .PARAM post2     =  0.00     * Driver 2nd post-cursor pre-emphasis

* PCB Line Lengths *
 .PARAM len1      = 9         * Line segment 1 length, inches
 .PARAM len2      = 12        * Line segment 2 length, inches
 .PARAM len3      = 4         * Line segment 3 length, inches
 .PARAM len4      = 1         * Line segment 4 length, inches

* Eye delay -- In awaves viewer, plot signal rx_diff against signal eye
*              then adjust parameter edui to center the data eye.
*
 .PARAM edui      = 0.00      * Eye diagram alignment delay.
                              * Units are fraction of 1 bit time.
                              * Negative moves the eye rigth.
                              * Positive moves the eye left.

*************************************************************************
*************************************************************************
```

You will have to modify the appropriate parameter to reflect your link configuration, lengths and bit rate. Also, the transient simulation control statements are at the top of the file just below the parameter definitions, and you can edit these to implement swept simulations if you wish.