ENGINEERING REPORT	Report Number ER 8559	
	Report Date 1/14/99	Page 1 of 25
Amphenol Corporation — Aerospace Operations		Sidney, NY 13838
TITLE: Preliminary Results - EM Modeling and SPICE Simulation of 472 LRM Connector.	Report Type PRELIMINARY	
	Project No.	EWOM

NOTE: This characterization does not include the parasitic capacitance (1-2 pf typical) associated with surface mount solder pads.

PRELIMINARY

This report shall be considered preliminary due to the fact that no verification testing has been done at this time. Once such testing has been completed, the report will be revised to include the results of the testing.

Prepared by:	Noted by:	Approved by:

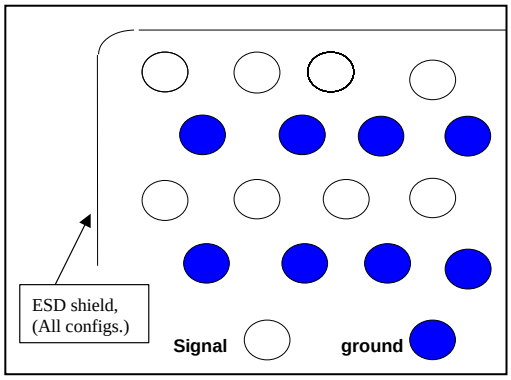
INTRODUCTION:

This report gives preliminary results of electromagnetic modeling and subsequent SPICE simulations of some representative ground - signal arrangements for the 472 LRM connector. The results will be in the form of inductance / capacitance matrices for the selected patterns, and both a simple, lumped L-C SPICE model and a more complex transmission line model for selected contacts within each pattern.

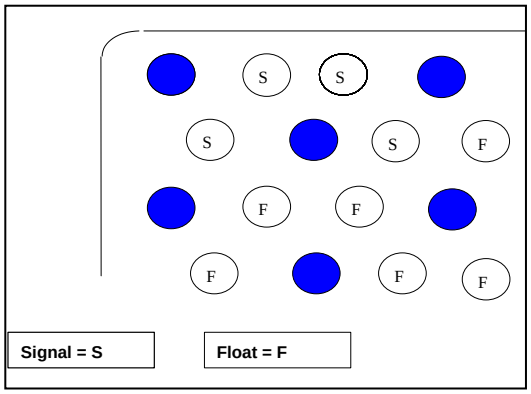
MODELING METHOD:

Electrical models were obtained from a section of the connector encompassing four rows consisting of five contacts per row located in a corner of the connector body. Three ground - signal configurations have been modeled:

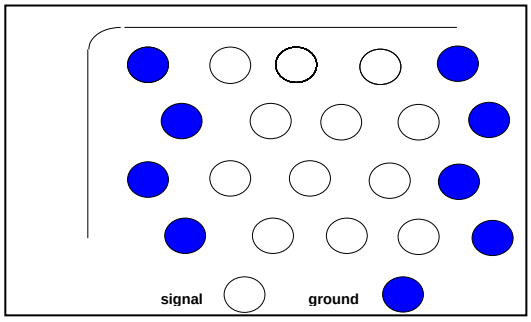
Configuration 1:



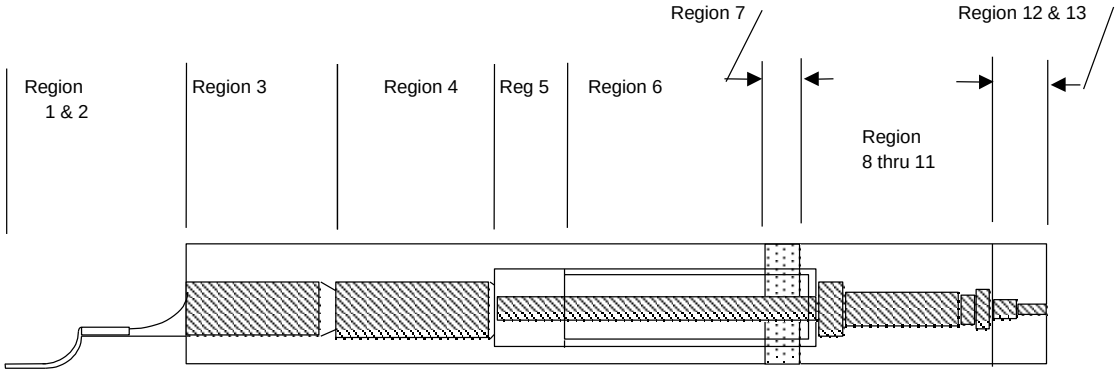
Configuration 2:



Configuration 3:



The connector length is divided into a number of sections, or "slices", each slice representing a major change in cross - sectional geometry of the contacts, as shown in the following figure:



In order to reduce complexity, some of the regions shown above have been combined by using an average contact diameter. Comparisons of averaged and non-averaged results show little or no difference in results. Each "slice" is then modeled using a static 2D electromagnetic field solver to extract the capacitance, inductance, and characteristic impedance for that slice. Please note that models are based on early versions of the 472 LRM connector using Ultem for the insert material. (e_r = 3.15). Production versions will use Vectra, which has a higher dielectric constant. (e_r = 3.70 This will increase capacitance and reduce characteristic impedance by approximately 15%.

The PCB tails have been modeled with a generic PCB with ground plane in place. (Board is 0.037 in. thick.) Surface mount pads are not taken into account.

SPICE MODEL:

Depending on intended signal speed and risetime, various degrees of complexity can be used in creating the SPICE model. For this preliminary study, the more complex model was created in order to best match and compare to actual TDR measurements. Each section (or combined sections) was modeled as SPICE transmission lines in series, each line section being assigned the appropriate impedance and propagation delay (based on electrical length).

By adding up the serial transmission line impedances and delays, a simplified lumped element model for each contact can also be used for slow signal speed simulations. (A good rule of thumb is if propagation delay is less than risetime / 10, the simple lumped element approach will be valid.) Intermediate degrees of complexity between the full transmission line model and the simple L-C model can be derived, but were not used for this study.

VERIFICATION:

The SPICE simulations were setup to mimic a standard bench TDR. A step input with a risetime matching that of the TDR (35 ps in this case) was injected at the PCB tail end of the contact of interest and the resulting reflection was observed at the input end, and compared to the actual Lab TDR results. Because of excessive mismatch between the test board traces and the SMA input connectors, previously measured results look much better than the simulated results. Those results will not be presented here. More verification work will be done after the test fixturing mismatches have been reduced or eliminated.

Transmission line models

CONFIG 1 TRANSMISSION LINE MODEL								
8-sub-section model Row 1								
REGION:	1	2	3_4	5	6	7	8_11	12_13
PIN:	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)
	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)
1	194.13	220.93	21.83	86.00	27.31	10.18	27.70	68.13
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
2	181.19	185.23	21.83	90.40	27.42	10.18	28.44	73.85
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
3	180.41	186.90	21.82	90.34	27.37	10.18	28.44	74.15
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
4	181.65	186.46	21.37	89.89	26.87	10.18	27.97	73.80
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00

CONFIG 2 TRANSMISSION LINE MODEL								
8-sub-section model								
REGION:	1	2	3_4	5	6	7	8_11	12_13
PIN:	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)
	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)
1	226.67	226.6	22.68	52.01	28.31	10.18	29.27	70.58
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
2	209.47	209.47	22.66	52.07	28.24	10.18	29.26	70.62
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
3	210.07	210.07	24.44	58.77	31.24	10.18	32.55	80.11
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
4	207.81	207.81	24.44	60.22	30.67	10.18	32.07	81.18
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00

CONFIG 3 TRANSMISSION LINE MODEL								
8-sub-section model								
REGION:	1	2	3_4	5	6	7	8_11	12_13
PIN:	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)	Zo (Ω)
	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)	Tp (ps)
1	240.1585	220.93	23.19	93.70	26.07	10.18	30.09	71.60
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
2	273.15	185.23	26.89	100.43	33.32	10.18	34.47	76.76
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
3	252.86	186.90	31.05	124.23	39.59	10.18	41.31	94.11
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00
4	256.32	186.46	32.58	129.58	41.56	10.18	43.49	98.47
	11.44	3.67	36.6	6.98	15.00	2.032	23.8	7.00

Inductance and Capacitance Matrices

The Inductance and Capacitance matrices per length are shown for each configuration, and each contact region. Four contacts for each configuration were modeled, generating a 4 by 4 matrix for each region of the three signal - ground configurations.

The main matrix diagonal represents the self-capacitance and inductance of each contact, while the off-diagonals represent the mutual L's and C's. (The coupling parameters)

REGION 1 & 2

CONFIG 1		**REGION 1/2**			
(region 1)		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		194.1326	181.1869	180.4127	181.6528
Tp =					
L matrix:	PIN 1	2.22E-09	-1.15E-10	-3.46E-11	-1.81E-11
	PIN 2	-9.82E-11	2.08E-09	-9.16E-11	-2.65E-11
	PIN 3	-3.13E-11	-9.15E-11	2.07E-09	-9.10E-11
	PIN 4	-1.67E-11	-2.68E-11	-9.11E-11	2.08E-09
C matrix:	PIN 1	5.90E-14	3.31E-15	1.16E-15	6.06E-16
	PIN 2	2.84E-15	6.32E-14	2.89E-15	9.59E-16
	PIN 3	1.04E-15	2.89E-15	6.35E-14	2.83E-15
	PIN 4	5.55E-16	9.68E-16	2.83E-15	6.30E-14

CONFIG 2		**REGION 1/2**			
		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		226.67	209.47	210.07	207.81
L matrix:	PIN 1	2.66E-09	-8.99E-11	-5.53E-10	-5.35E-11
	PIN 2	-8.70E-11	2.45E-09	-4.84E-11	-5.09E-10
	PIN 3	-5.52E-10	-2.15E-11	2.46E-09	-2.59E-11
	PIN 4	-2.06E-11	-5.11E-10	-2.48E-11	2.43E-09
C matrix:	PIN 1	5.17E-14	2.37E-15	1.17E-14	1.76E-15
	PIN 2	2.28E-15	5.59E-14	1.73E-15	1.18E-14
	PIN 3	1.16E-14	1.14E-15	5.58E-14	1.09E-15
	PIN 4	1.04E-15	1.18E-14	1.03E-15	5.63E-14

GENX_CONFIG_3 Row 1/2 Matrix (Pins 1-2, 1-3, 2-2, 2-3)

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		240.1585	273.1464	252.856	256.3194
L matrix:	PIN 1	2.83E-09	-1.66E-10	-5.28E-10	-1.03E-10
	PIN 2	-2.27E-10	3.31E-09	-7.08E-10	-7.15E-10
	PIN 3	-6.81E-10	-5.95E-10	3.05E-09	-1.81E-10
	PIN 4	-1.37E-10	-6.91E-10	-2.01E-10	3.03E-09
C matrix:	PIN 1	4.91E-14	4.95E-15	9.86E-15	3.43E-15
	PIN 2	7.07E-15	4.44E-14	1.23E-14	1.14E-14
	PIN 3	1.26E-14	1.04E-14	4.78E-14	5.72E-15
	PIN 4	4.66E-15	1.10E-14	6.40E-15	4.62E-14

REGION 3 & 4

GENX_3/4 Row 1 Matrix (Pins 1, 2, 3, & 4) (Row 2 & 4 grounded)

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		21.83105	21.83105	21.81649	21.3675
L matrix:	PIN 1	7.98E-10	-1.66E-10	1.16E-11	-8.07E-13
	PIN 2	-1.65E-10	8.15E-10	-1.65E-10	1.15E-11
	PIN 3	1.15E-11	-1.65E-10	8.14E-10	-1.63E-10
	PIN 4	-7.91E-13	1.13E-11	-1.62E-10	7.81E-10
C matrix:	PIN 1	1.68E-12	3.51E-13	4.86E-14	6.71E-15
	PIN 2	3.48E-13	1.71E-12	3.52E-13	4.86E-14
	PIN 3	4.81E-14	3.51E-13	1.71E-12	3.52E-13
	PIN 4	6.65E-15	4.84E-14	3.51E-13	1.71E-12

CONFIG 2 REGION 3/4

Pin No.		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		22.68	22.66	24.44	23.83
L matrix:	PIN 1	8.67E-10	-1.85E-10	-2.46E-10	2.15E-11
	PIN 2	-1.86E-10	8.65E-10	2.18E-11	-2.42E-10
	PIN 3	-2.55E-10	2.20E-11	9.12E-10	-6.28E-12
	PIN 4	2.15E-11	-2.49E-10	-6.18E-12	8.88E-10
C matrix:	PIN 1	1.68E-12	3.68E-13	4.45E-13	6.26E-14
	PIN 2	3.68E-13	1.69E-12	6.19E-14	4.51E-13
	PIN 3	4.64E-13	6.56E-14	1.53E-12	1.75E-14
	PIN 4	6.56E-14	4.64E-13	1.72E-14	1.56E-12

CONFIG 3 REGION 3_4

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		23.19337	26.89049	31.04675	32.5787
L matrix:	PIN 1	8.83E-10	-1.59E-10	-2.29E-10	3.05E-11
	PIN 2	-1.78E-10	1.06E-09	-2.12E-10	-2.68E-10
	PIN 3	-2.65E-10	-2.45E-10	1.23E-09	-2.47E-10
	PIN 4	1.00E-11	-3.16E-10	-2.67E-10	1.26E-09
C matrix:	PIN 1	1.64E-12	3.69E-13	3.94E-13	1.16E-13
	PIN 2	4.16E-13	1.47E-12	4.14E-13	3.85E-13
	PIN 3	4.74E-13	4.66E-13	1.28E-12	3.39E-13
	PIN 4	1.92E-13	4.66E-13	3.72E-13	1.18E-12

REGION 5

GENX_5 Row 1 Matrix (Pins 1, 2, 3, & 4) (Row 2 & 4 grounded)

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		85.99872	90.39822	90.33503	89.88922
L matrix:	PIN 1	6.00E-10	-6.76E-11	2.63E-13	-1.28E-14
	PIN 2	-6.96E-11	6.33E-10	-7.05E-11	2.97E-13
	PIN 3	2.89E-13	-7.05E-11	6.33E-10	-7.08E-11
	PIN 4	-1.27E-14	3.34E-13	-7.09E-11	6.26E-10
C matrix:	PIN 1	8.11E-14	5.75E-15	5.67E-16	6.06E-17
	PIN 2	6.14E-15	7.75E-14	5.98E-15	5.95E-16
	PIN 3	6.07E-16	5.98E-15	7.75E-14	6.00E-15
	PIN 4	6.49E-17	5.94E-16	6.01E-15	7.74E-14

CONFIG 2 **REGION 5**

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		52.01	52.07	58.77	60.22
L matrix:	PIN 1	6.50E-10	-6.28E-11	-9.47E-11	-4.11E-12
	PIN 2	-6.27E-11	6.50E-10	-4.18E-12	-9.49E-11
	PIN 3	-1.07E-10	-4.93E-12	7.36E-10	-4.02E-12
	PIN 4	-5.00E-12	-1.08E-10	-4.12E-12	7.43E-10
C matrix:	PIN 1	2.40E-13	1.68E-14	2.23E-14	3.86E-15
	PIN 2	1.68E-14	2.40E-13	4.12E-15	2.13E-14
	PIN 3	2.67E-14	4.99E-15	2.13E-13	2.44E-15
	PIN 4	5.08E-15	2.73E-14	2.70E-15	2.05E-13

GENX_CONFIG_3 Row 1/2 Matrix

Zo =		93.69843	100.4261	124.2272	129.5831
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	6.64E-10	-6.77E-11	-9.42E-11	-8.33E-12
	PIN 2	-7.28E-11	7.34E-10	-1.06E-10	-1.14E-10
	PIN 3	-1.24E-10	-1.35E-10	9.12E-10	-1.46E-10
	PIN 4	-1.43E-11	-1.56E-10	-1.59E-10	9.49E-10
C matrix:	PIN 1	7.56E-14	6.56E-15	6.42E-15	2.39E-15
	PIN 2	6.90E-15	7.28E-14	7.65E-15	7.14E-15
	PIN 3	9.60E-15	1.09E-14	5.91E-14	8.38E-15
	PIN 4	3.76E-15	1.10E-14	9.08E-15	5.65E-14

REGION 6

CONFIG 1 **Region 6**

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		27.31	27.42	27.37	26.87
L matrix:	PIN 1	4.11E-10	-8.17E-11	4.94E-12	-2.94E-13
	PIN 2	-8.09E-11	4.18E-10	-8.06E-11	4.79E-12
	PIN 3	4.89E-12	-8.07E-11	4.17E-10	-7.96E-11
	PIN 4	-2.91E-13	4.81E-12	-7.97E-11	4.02E-10
C matrix:	PIN 1	5.51E-13	9.00E-14	1.13E-14	1.41E-15
	PIN 2	9.06E-14	5.56E-13	9.26E-14	1.16E-14
	PIN 3	1.14E-14	9.27E-14	5.57E-13	9.26E-14
	PIN 4	1.42E-15	1.16E-14	9.26E-14	5.57E-13

CONFIG_2 **Region 6**

Zo =		28.31	28.24	31.24	30.67
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	4.38E-10	-8.45E-11	-1.13E-10	7.30E-12
	PIN 2	-8.45E-11	4.37E-10	7.39E-12	-1.11E-10
	PIN 3	-1.18E-10	7.51E-12	4.64E-10	-2.11E-12
	PIN 4	7.31E-12	-1.15E-10	-2.04E-12	4.52E-10
C matrix:	PIN 1	5.46E-13	9.21E-14	1.11E-13	1.42E-14
	PIN 2	9.20E-14	5.48E-13	1.43E-14	1.11E-13
	PIN 3	1.19E-13	1.56E-14	4.75E-13	3.72E-15
	PIN 4	1.55E-14	1.19E-13	3.68E-15	4.81E-13

CONFIG_3 **Region 6**

Zo =		29.07	33.32	39.59	41.56
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	4.52E-10	-7.90E-11	-1.12E-10	1.28E-11
	PIN 2	-8.82E-11	5.43E-10	-1.06E-10	-1.31E-10
	PIN 3	-1.31E-10	-1.23E-10	6.27E-10	-1.21E-10
	PIN 4	2.31E-12	-1.57E-10	-1.31E-10	6.42E-10
C matrix:	PIN 1	5.35E-13	1.03E-13	1.04E-13	3.09E-14
	PIN 2	1.14E-13	4.89E-13	1.12E-13	1.04E-13
	PIN 3	1.31E-13	1.36E-13	4.00E-13	9.72E-14
	PIN 4	5.11E-14	1.36E-13	1.07E-13	3.72E-13

REGION 7:

GENX_7 Row 1 Matrix (Pins 1, 2, 3, & 4) (Row 2 & 4 grounded)

L =	2.0687E-11
C =	1.9959E-13
Zo =	10.18

Note:

Since each contact in Region 7 is surrounded by the ESD shield, there are no mutual inductances or capacitances, hence no matrix.

REGION 8 - 11

CONFIG_1 **Region8 thru 11 Row 1 Matrix**

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		27.6965	28.43895	28.44213	27.96623
L matrix:	PIN 1	6.60E-10	-1.20E-10	6.47E-12	-4.00E-13
	PIN 2	-1.21E-10	6.89E-10	-1.30E-10	8.03E-12
	PIN 3	6.19E-12	-1.22E-10	6.91E-10	-1.29E-10
	PIN 4	-3.81E-13	7.53E-12	-1.29E-10	6.68E-10
C matrix:	PIN 1	8.60E-13	1.53E-13	2.13E-14	2.77E-15
	PIN 2	1.54E-13	8.52E-13	1.63E-13	2.12E-14
	PIN 3	2.01E-14	1.53E-13	8.54E-13	8.54E-13
	PIN 4	2.62E-15	2.00E-14	1.63E-13	8.54E-13

GENX_CONFIG_2 Row 1/2 Matrix

Zo =		29.27	29.26	32.55	32.07
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	5.67E-10	-1.01E-10	-1.39E-10	7.66E-12
	PIN 2	-1.02E-10	5.67E-10	7.78E-12	-1.37E-10
	PIN 3	-1.46E-10	7.83E-12	6.20E-10	-2.48E-12
	PIN 4	7.82E-12	-1.45E-10	-2.45E-12	6.11E-10
C matrix:	PIN 1	6.62E-13	1.21E-13	1.47E-13	1.96E-14
	PIN 2	1.22E-13	6.62E-13	1.95E-14	1.47E-13
	PIN 3	1.55E-13	2.09E-14	5.85E-13	5.13E-15
	PIN 4	2.09E-14	1.55E-13	5.07E-15	5.94E-13

GENX_CONFIG_3 Row 1/2 Matrix

Zo =		30.09	34.47	41.31	43.49
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	7.43E-10	-1.23E-10	-1.79E-10	1.98E-11
	PIN 2	-1.37E-10	8.84E-10	-1.71E-10	-2.10E-10
	PIN 3	-2.12E-10	-2.05E-10	1.06E-09	-2.17E-10
	PIN 4	8.15E-12	-2.59E-10	-2.36E-10	1.09E-09
C matrix:	PIN 1	8.21E-13	1.70E-13	1.77E-13	5.28E-14
	PIN 2	1.89E-13	7.44E-13	1.90E-13	1.77E-13
	PIN 3	2.17E-13	2.23E-13	6.24E-13	1.62E-13
	PIN 4	8.55E-14	2.23E-13	1.78E-13	5.79E-13

REGION 12 & 13

CONFIG_1 **Regions 12 & 13**

		PIN 1	PIN 2	PIN 3	PIN 4
Zo =		68.13	73.85	74.15	73.80
L matrix:	PIN 1	4.77E-10	-5.50E-11	-4.22E-12	-6.67E-13
	PIN 2	-5.97E-11	5.23E-10	-6.12E-11	-4.92E-12
	PIN 3	-4.63E-12	-6.15E-11	5.26E-10	-6.22E-11
	PIN 4	-7.38E-13	-4.97E-12	-6.24E-11	5.20E-10
C matrix:	PIN 1	1.03E-13	7.63E-15	1.49E-15	3.48E-16
	PIN 2	8.44E-15	9.59E-14	8.10E-15	1.62E-15
	PIN 3	1.66E-15	8.15E-15	9.56E-14	8.11E-15
	PIN 4	3.91E-16	1.64E-15	8.15E-15	9.54E-14

CONFIG_2 Regions 12 & 13

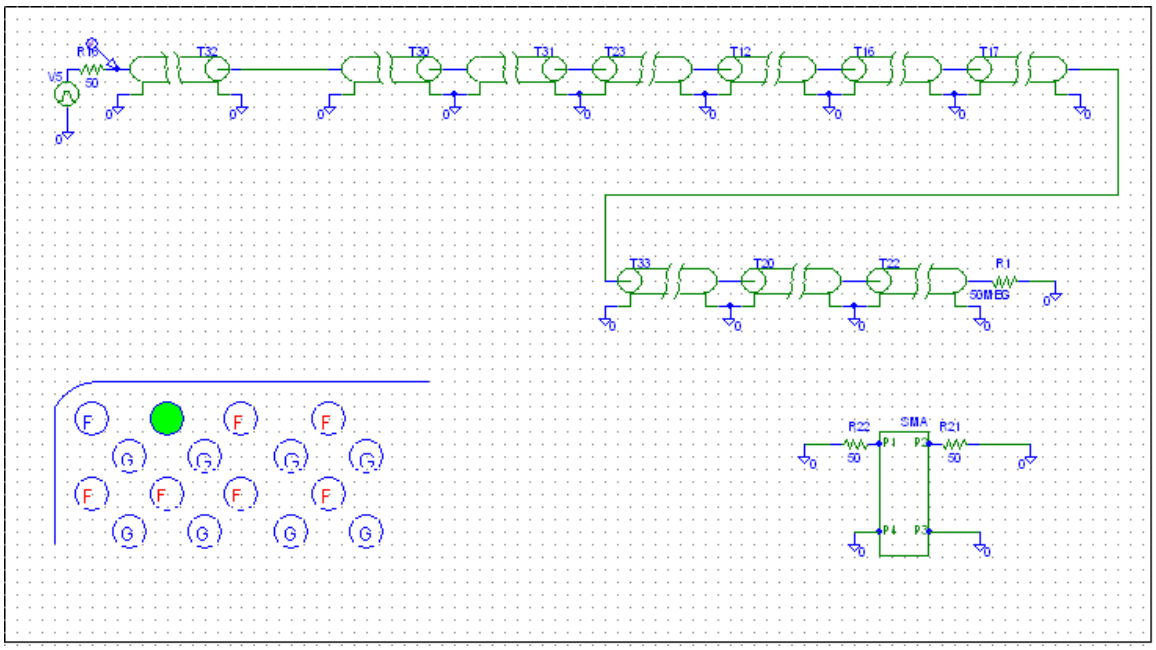
Zo =		70.58	70.62	80.11	81.18
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	4.95E-10	-4.34E-11	-6.39E-11	-3.47E-12
	PIN 2	-4.32E-11	4.95E-10	-3.49E-12	-6.41E-11
	PIN 3	-7.31E-11	-4.25E-12	5.63E-10	-2.87E-12
	PIN 4	-4.26E-12	-7.42E-11	-2.97E-12	5.68E-10
C matrix:	PIN 1	9.93E-14	6.52E-15	8.10E-15	1.45E-15
	PIN 2	6.51E-15	9.92E-14	1.49E-15	7.96E-15
	PIN 3	9.76E-15	1.84E-15	8.77E-14	8.72E-16
	PIN 4	1.86E-15	9.90E-15	9.20E-16	8.61E-14

CONFIG_3 Regions 12 & 13

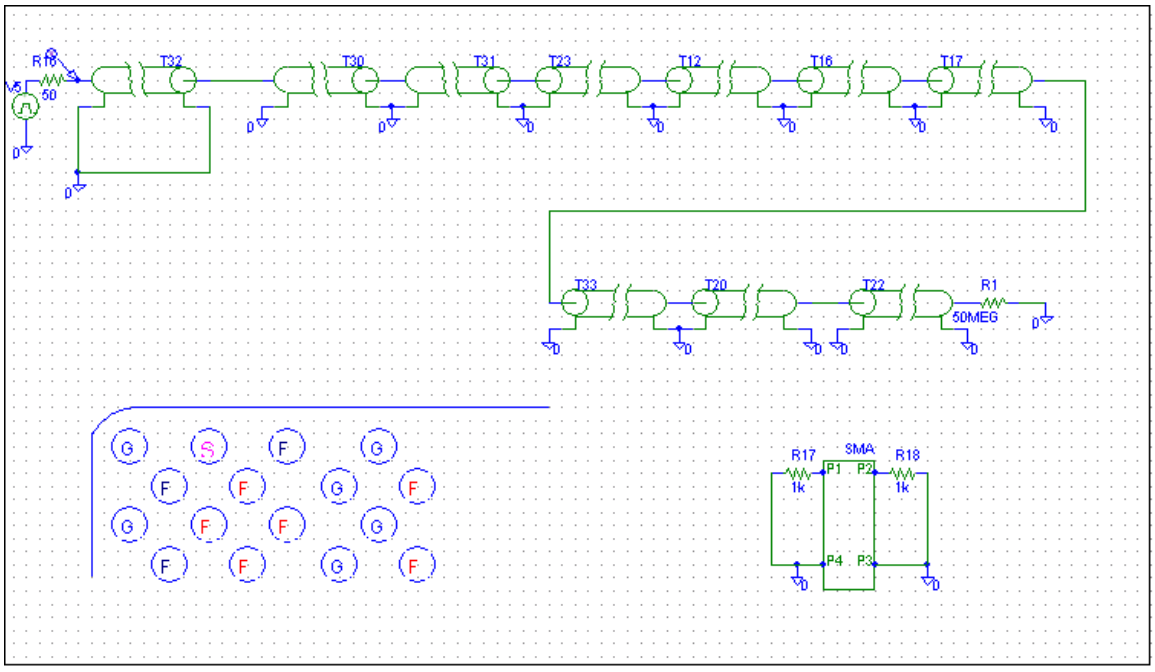
Zo =		71.60	76.76	94.11	98.47
		PIN 1	PIN 2	PIN 3	PIN 4
L matrix:	PIN 1	5.04E-10	-4.72E-11	-6.27E-11	-7.72E-12
	PIN 2	-5.14E-11	5.54E-10	-7.14E-11	-7.50E-11
	PIN 3	-8.57E-11	-9.35E-11	6.87E-10	-9.61E-11
	PIN 4	-1.32E-11	-1.09E-10	-1.05E-10	7.17E-10
C matrix:	PIN 1	9.84E-14	7.78E-15	7.43E-15	2.68E-15
	PIN 2	8.38E-15	9.40E-14	8.73E-15	8.07E-15
	PIN 3	1.11E-14	1.22E-14	7.75E-14	8.92E-15
	PIN 4	4.42E-15	1.25E-14	9.80E-15	7.40E-14

SPICE Schematics and sample results:

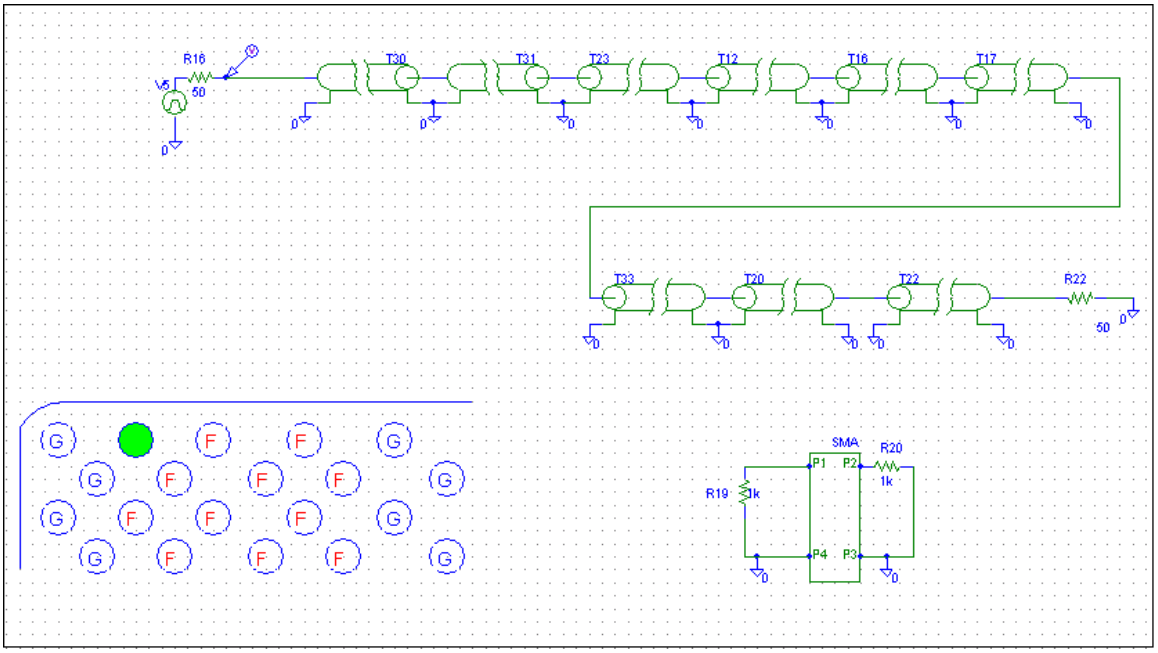
SPICE Schematic, Configuration. 1, Row 1, Pin 1:
NOTE: Impedance and electrical length values for each transmission line segment are given in Section V, "Transmission Line Models."



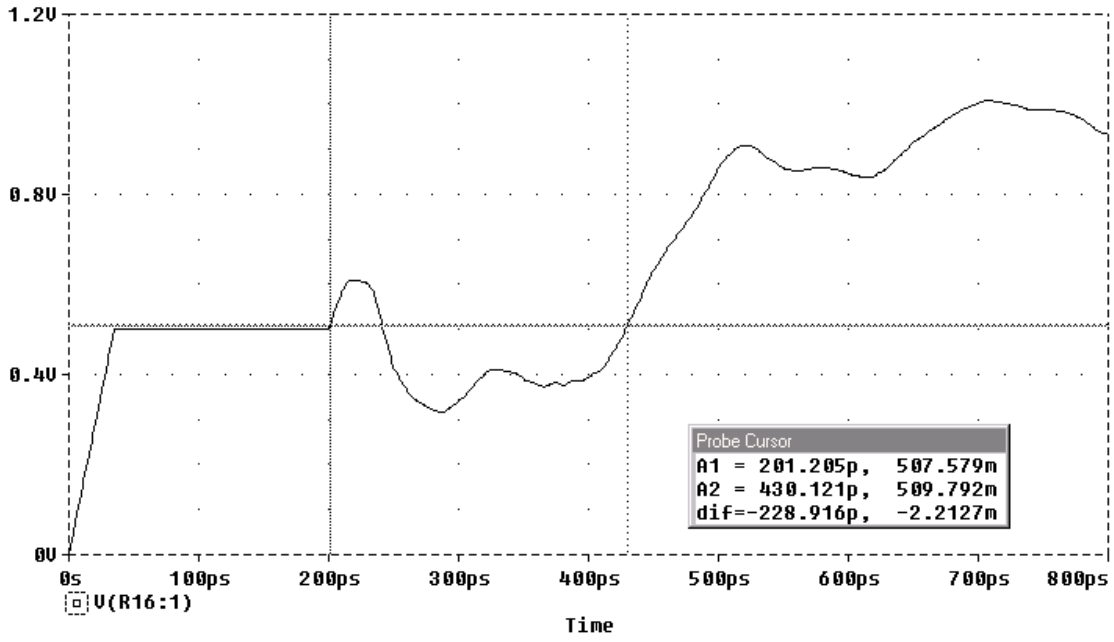
SPICE Schematic, Configuration. 2, Row 1, Pin 1:



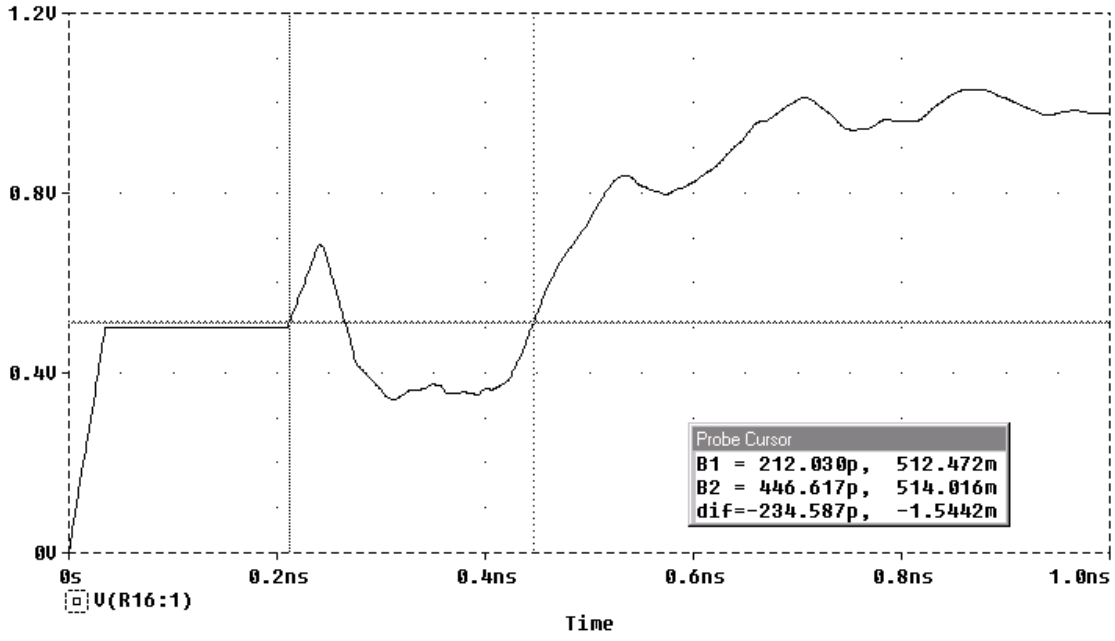
SPICE Schematic, Configuration 3, Row 1, Pin 1:



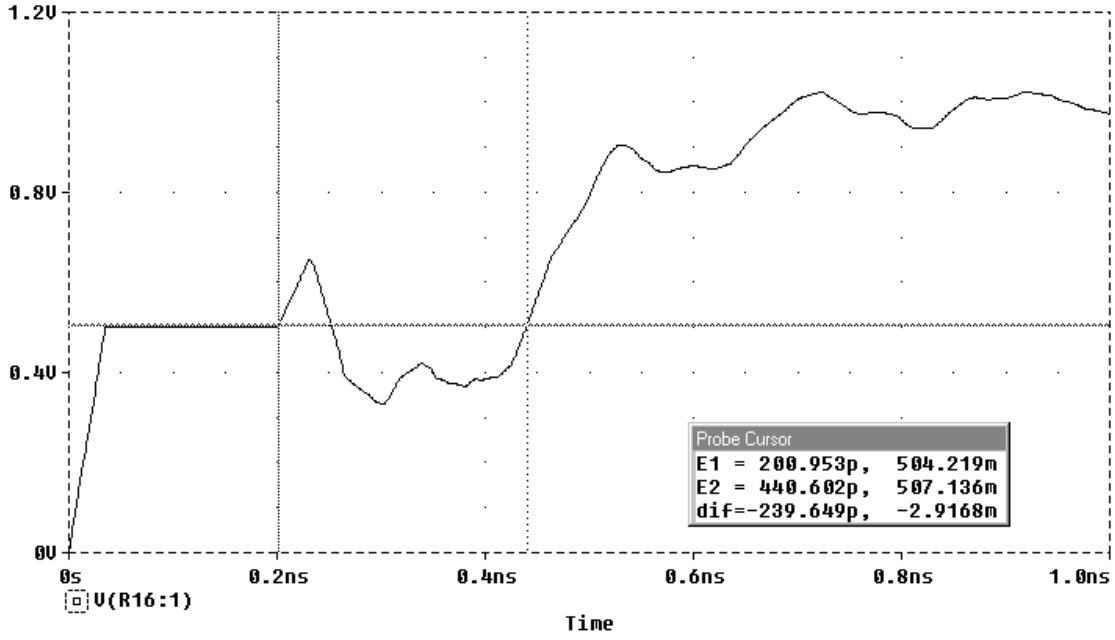
SPICE Output: 35 ps input step. (Simulated TDR input and response.)
This is PIN 1 of Configuration 1. Please note that in an attempt to duplicate actual preliminary TDR results, the impedance of the PCB tail region has been lowered to around 100 ohms. This lowers the initial inductive spike as shown below. Modeling gives approx. 200 ohms for the tail region. It is believed that test fixturing mismatches are masking the true reflection due to the PCB tails. (The plots for Configuration 2 & 3 are not modified.) Also note that the output is an open-circuit for all examples.



SPICE results, Config. 2, Pin 2:
(35 psec risetime)



SPICE results, Config 3, Pin1:
(35 psec risetime)

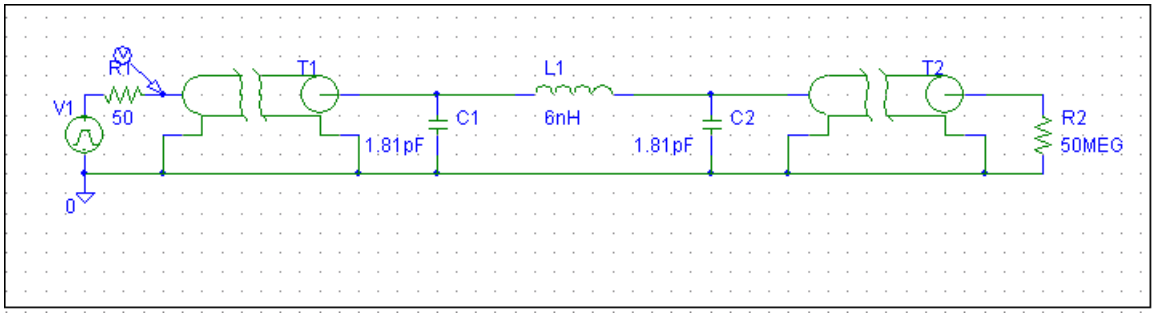


Lumped L - C Model:

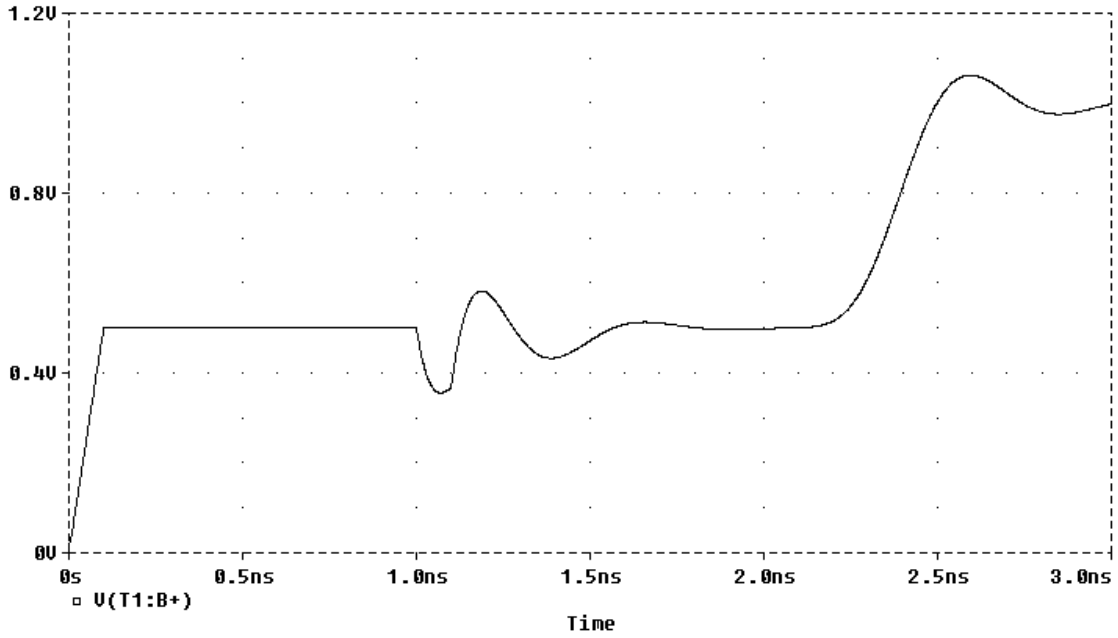
Notes:

The first sets of SPICE outputs were run at 100 psec risetime. The waveforms obviously do not resemble the transmission line models, due to the risetime being too fast compared to the connector propagation delay. A second set of SPICE results, run at 1 nsec risetime, (which meets the rule of thumb mentioned earlier) is shown for comparison. A risetime of 1 nsec is the fastest which can be considered valid for lumped element simulations of the 472 LRM connector.

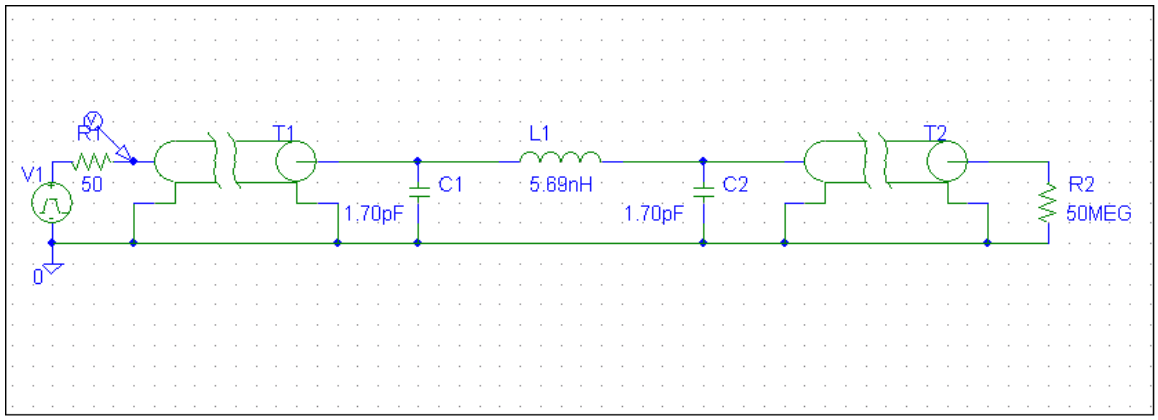
SPICE Schematic, Config. 1, Pin 1, simple lumped L - C Pi model:



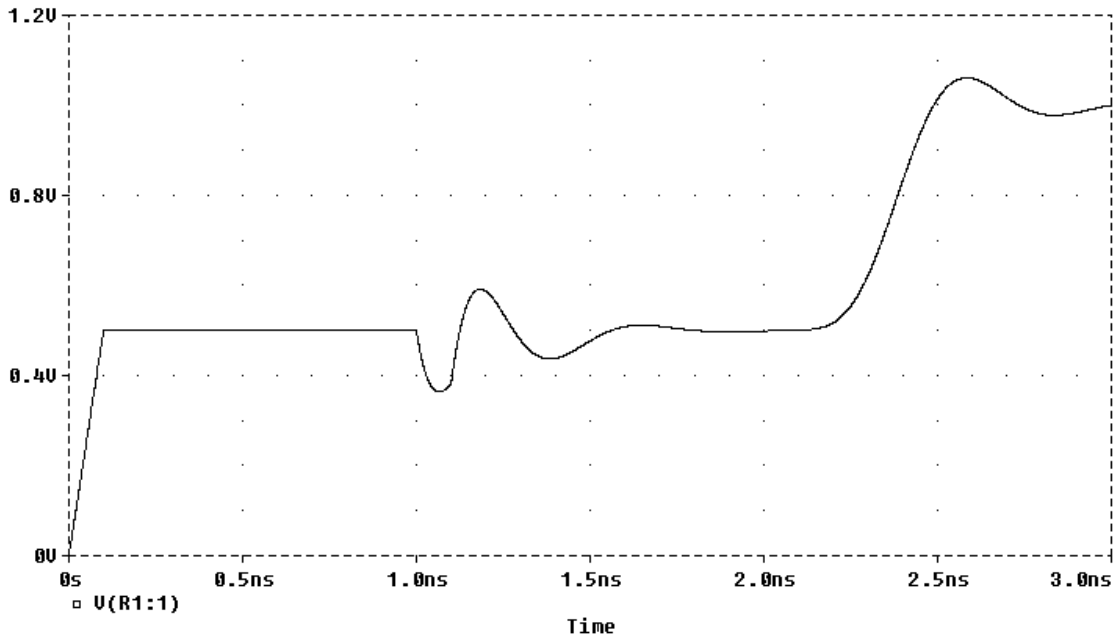
SPICE output w/100psec risetime input:



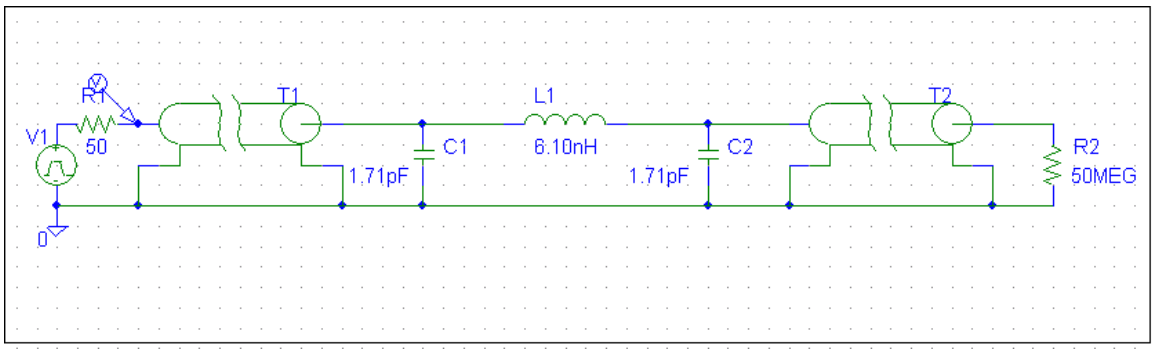
SPICE Schematic, Config. 2, Pin 1, simple lumped L - C Pi model:



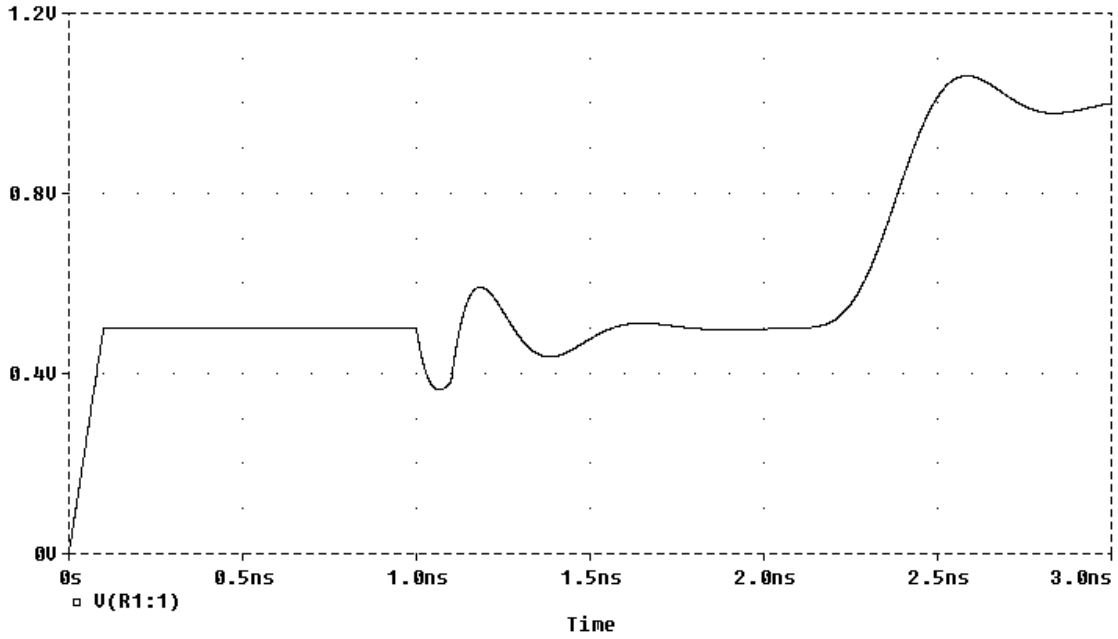
SPICE output w/100psec risetime input:



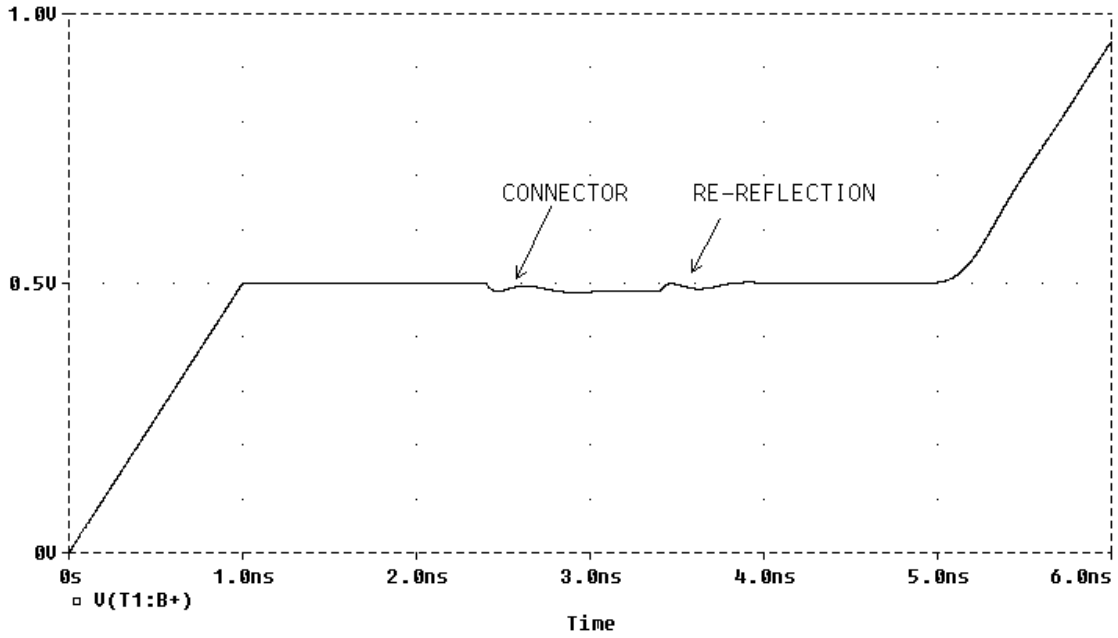
SPICE Schematic, Config. 3, Pin 1, simple lumped L - C Pi model:



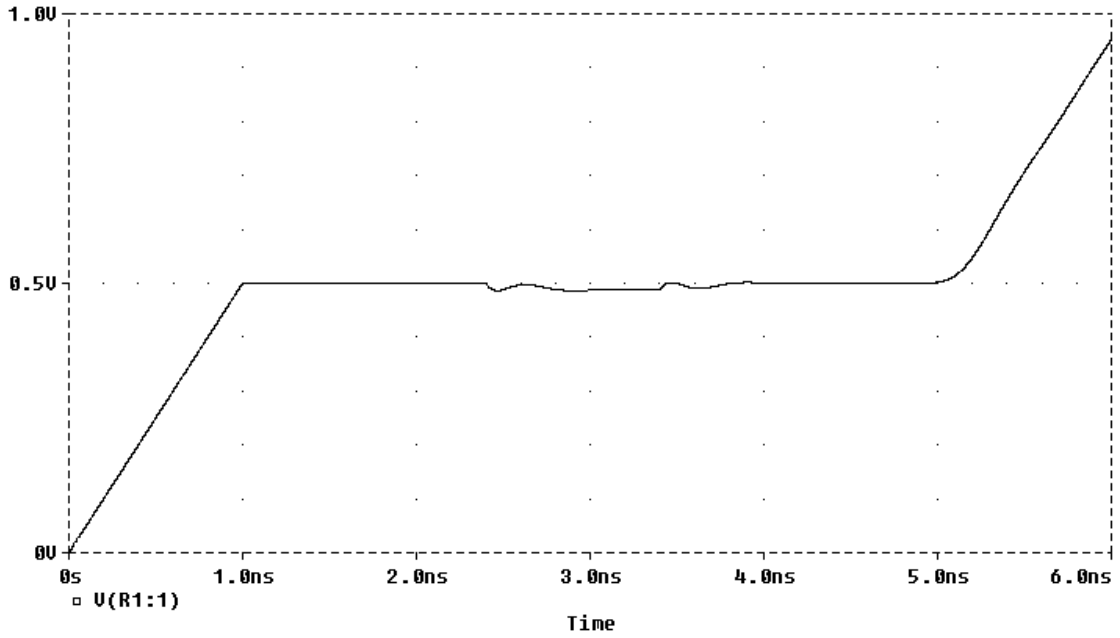
SPICE output w/100psec risetime input:



SPICE output, Config. 1, w/1 nsec input risetime:



SPICE output, Config. 2, w/1 nsec input risetime:



SPICE output, Config. 3, w/1 nsec input risetime: