Circuit Modeling of 30AWG LVD SCSI Cable

Andrew Bishop - Quantum

Michael Karg - Madison Cable Co.

Jie Fan - Madison Cable Co.

RLGC - Model Parameters

- Given analytical expressions for RLGC model parameters:

$$R = K0 + K1 * f^{a1} + K2 * f^{a2} + K3 * f^{a3}$$

$$L = L1 + L2 * \exp(f)$$

$$G = G1 * f$$

$$C = C1$$

- Grouping terms that are frequency dependant we may write:

$$R' = R_o + R(f)$$

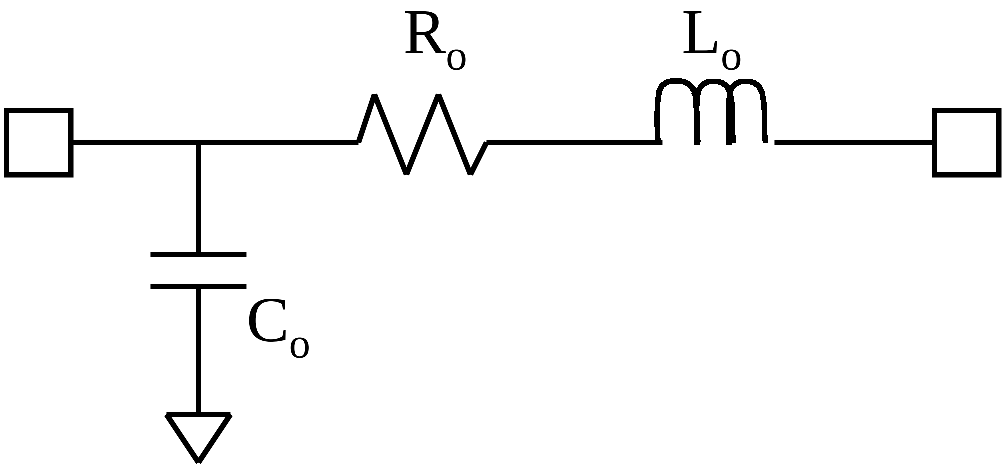
$$L' = L_o + L(f)$$

$$G' = 0$$

$$C' = C_o$$

RLGC Circuit Model

- 1st Order model section (single-ended version):

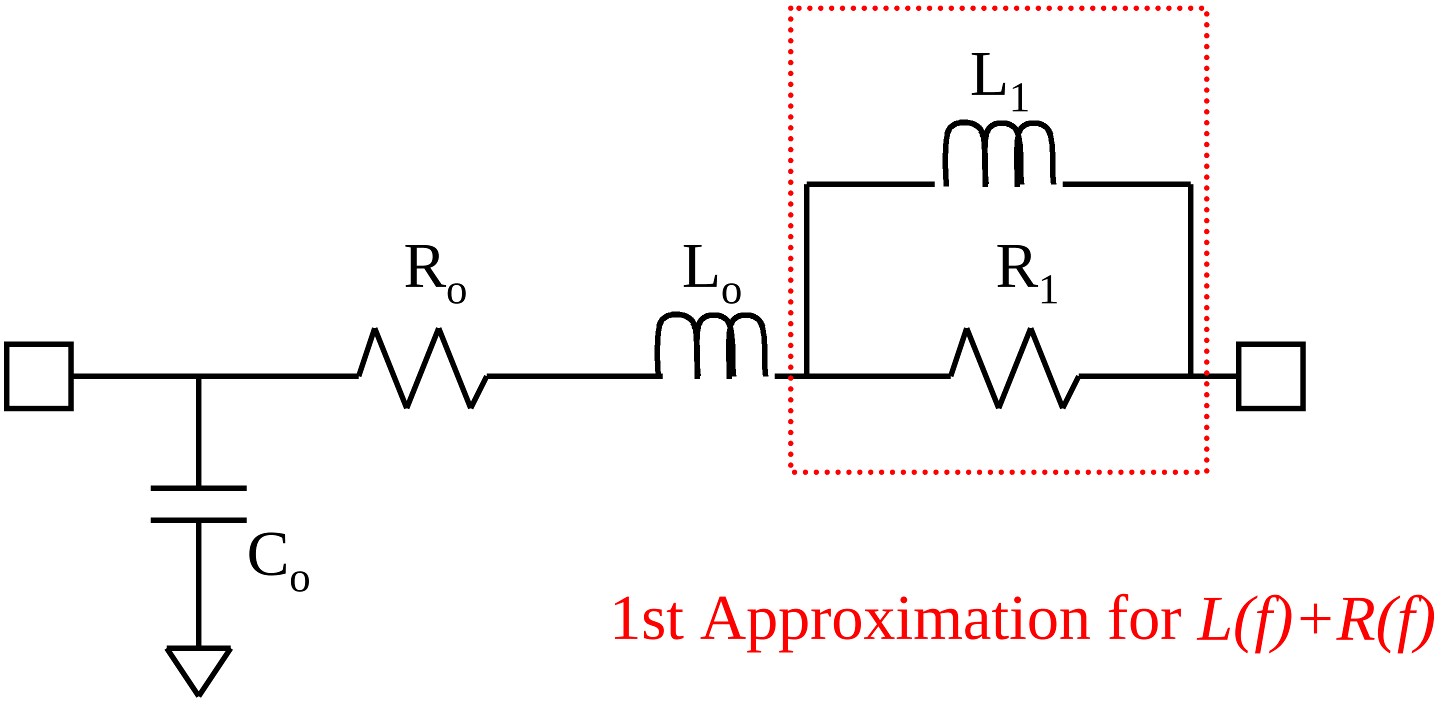


- Select section size based on bandwidth requirements.
- For a maximum frequency f_1 need to select L_o, and C_o such that:

$$f_1 \ll 1 / \left(2\pi\sqrt{L_o C_o}\right)$$

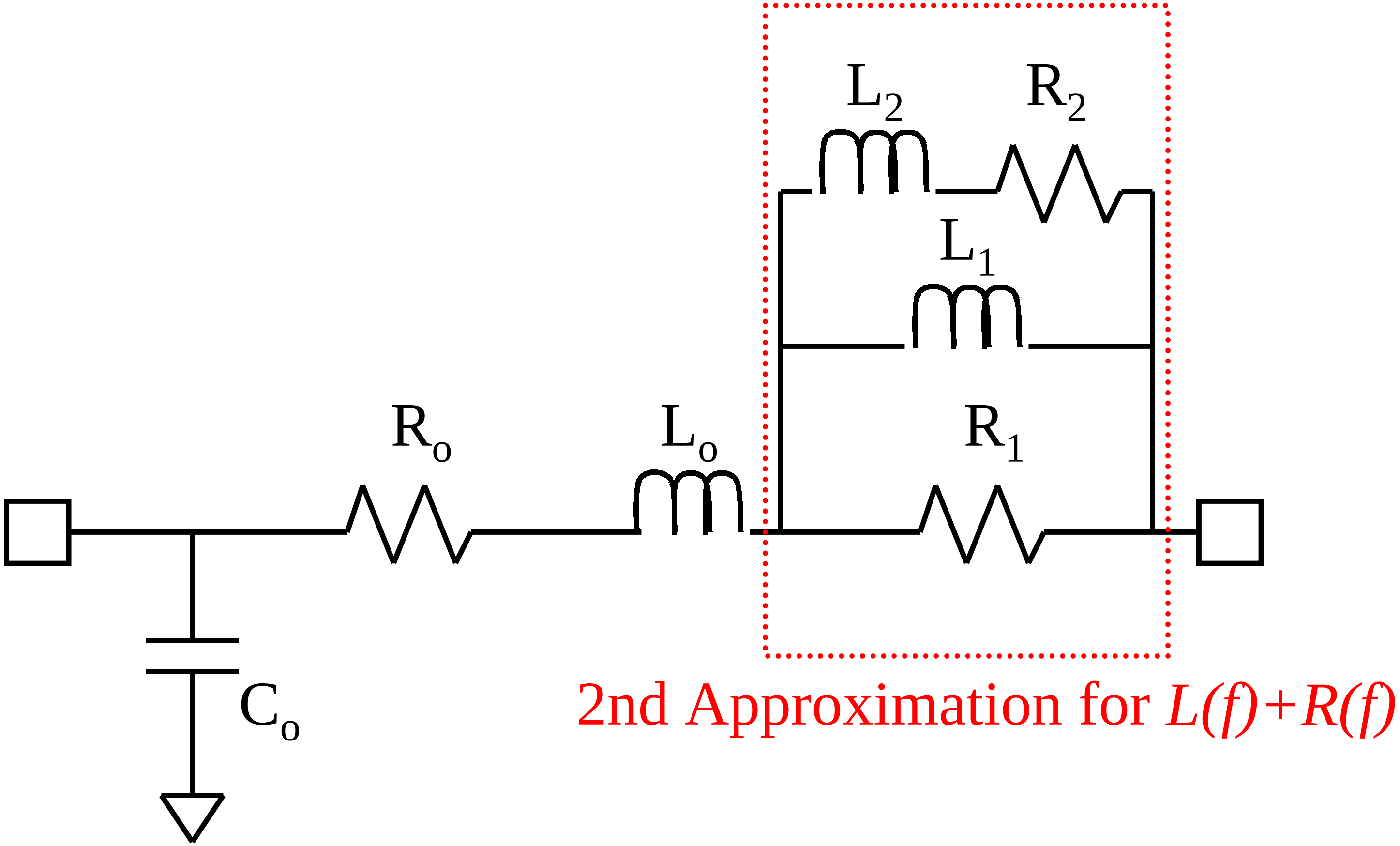
Improving RLGC Model

- 2nd Order model section



Improving RLGC Model

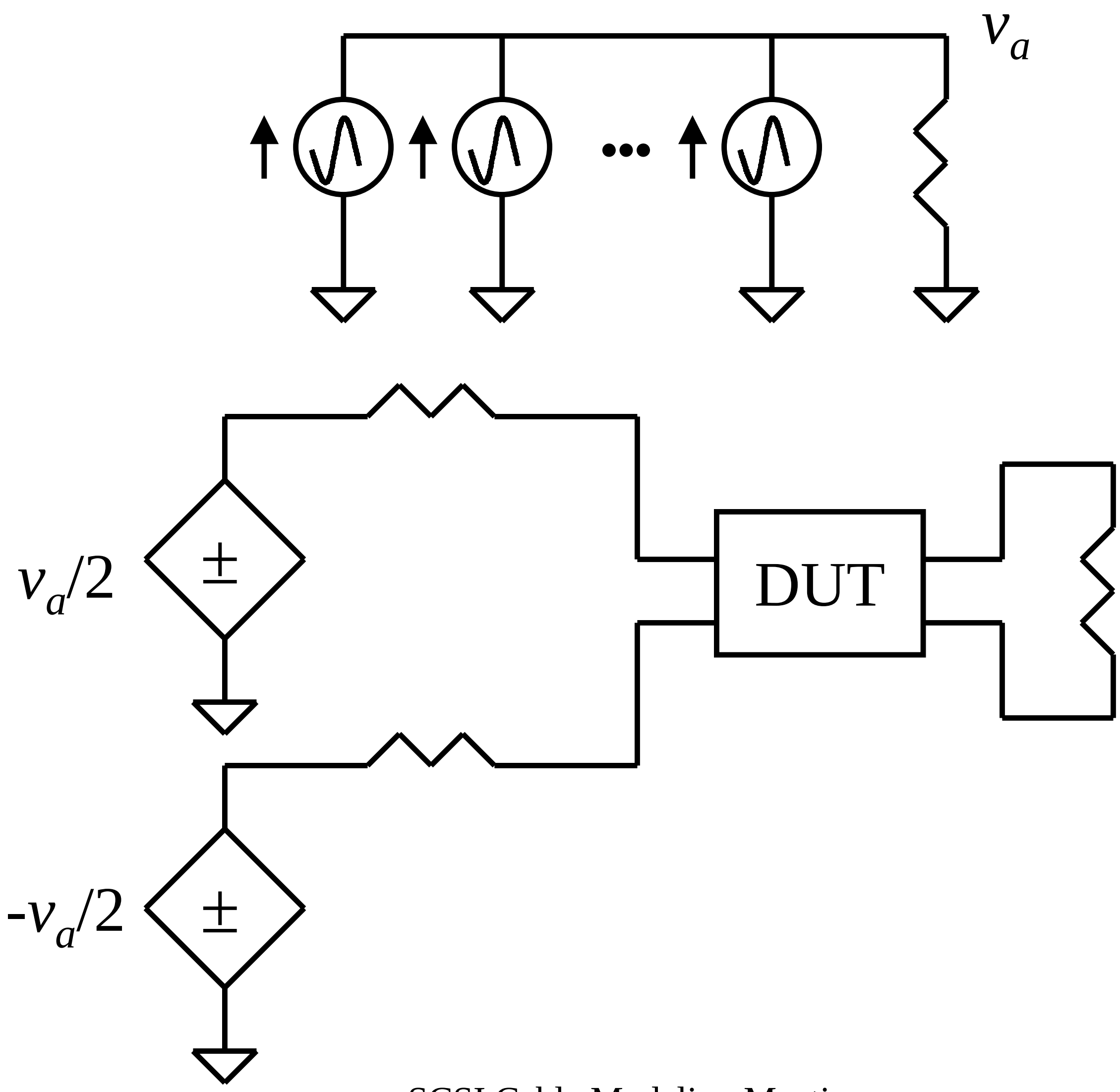
- 3rd Order model section



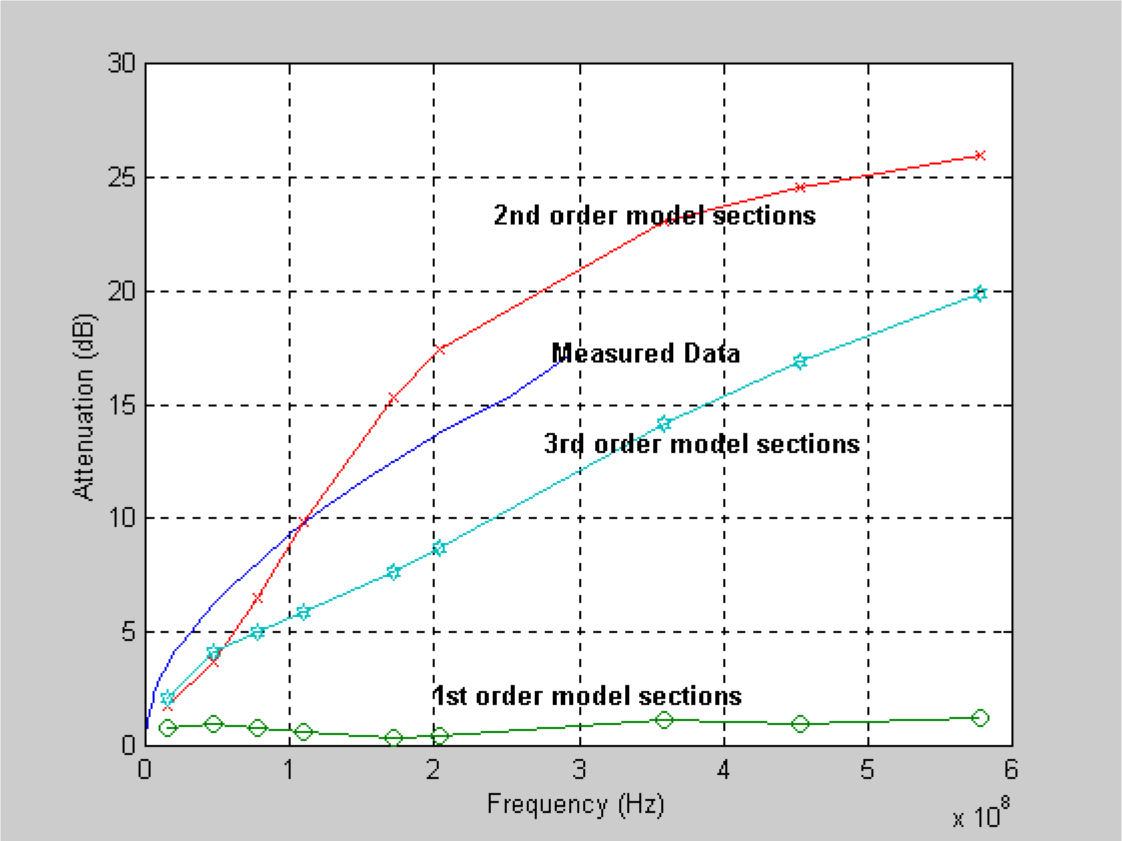
Simulating Cable Attenuation

- Simulation procedure:
  - Use a long enough transient simulation to capture several cycles of the lowest frequency of interest.
  - Total simulation time length, $T_{total} = 1/f_c$.
  - Simulation time step selected to ensure highest frequency of interest is not aliased and to minimize windowing effects due to sampling, $t_{step} < 1/(M \bullet f_{max})$, where $M > 1000$.
  - Apply sum of several sinusoids with incommensurate frequencies (prime multiples of a fundamental frequency f_c)
  - Perform Windowed Fourier transforms on waveform and measure spectral component amplitudes at each applied frequency, N-point FFT should be large ($N=2^{16}$). Window function can be Bartlett, Hanning, or Hamming.

Attenuation Simulation Schematic



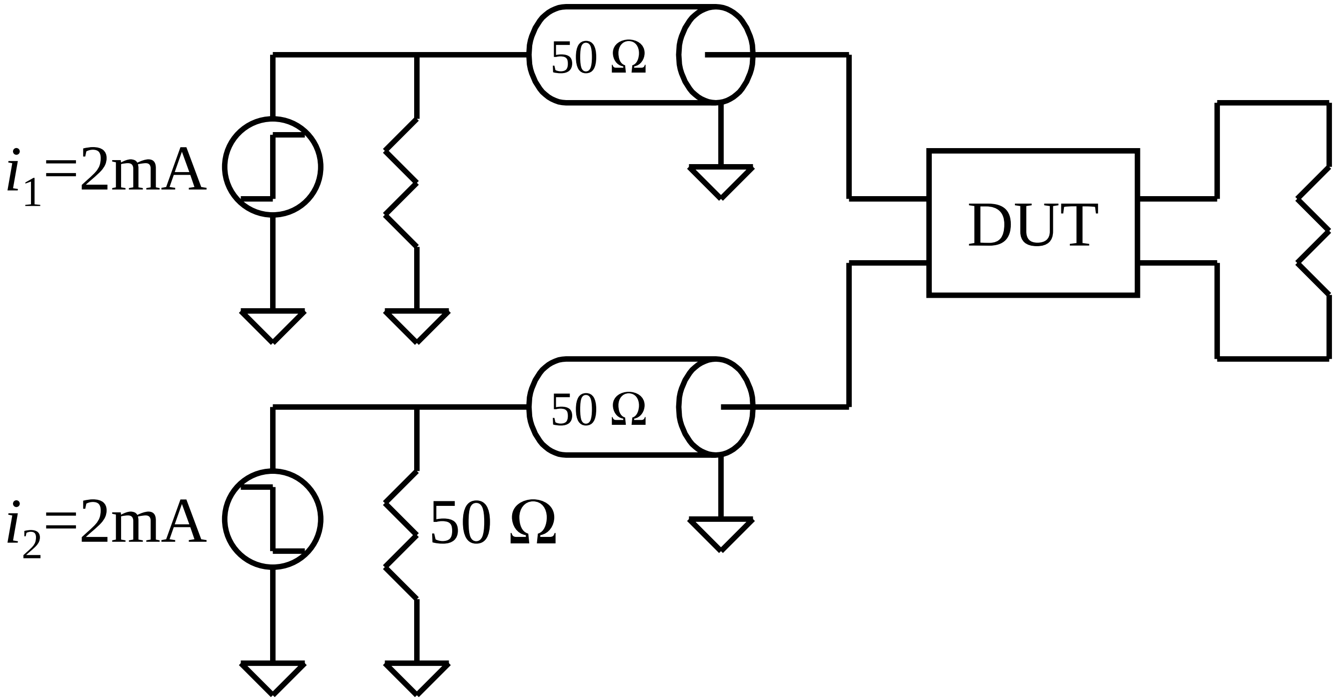
- Measured cable data versus simulation data with 1cm sections



Simulating TDR Response

- Mimic the set-up with TDR mainframe:
  - Step generator t_{rise} = 35ps
  - 50 Ω transmission line to mainframe front panel 3.5mm connector
  - Cable from front panel connector to sample
  - DSP waveform filtering (if any)

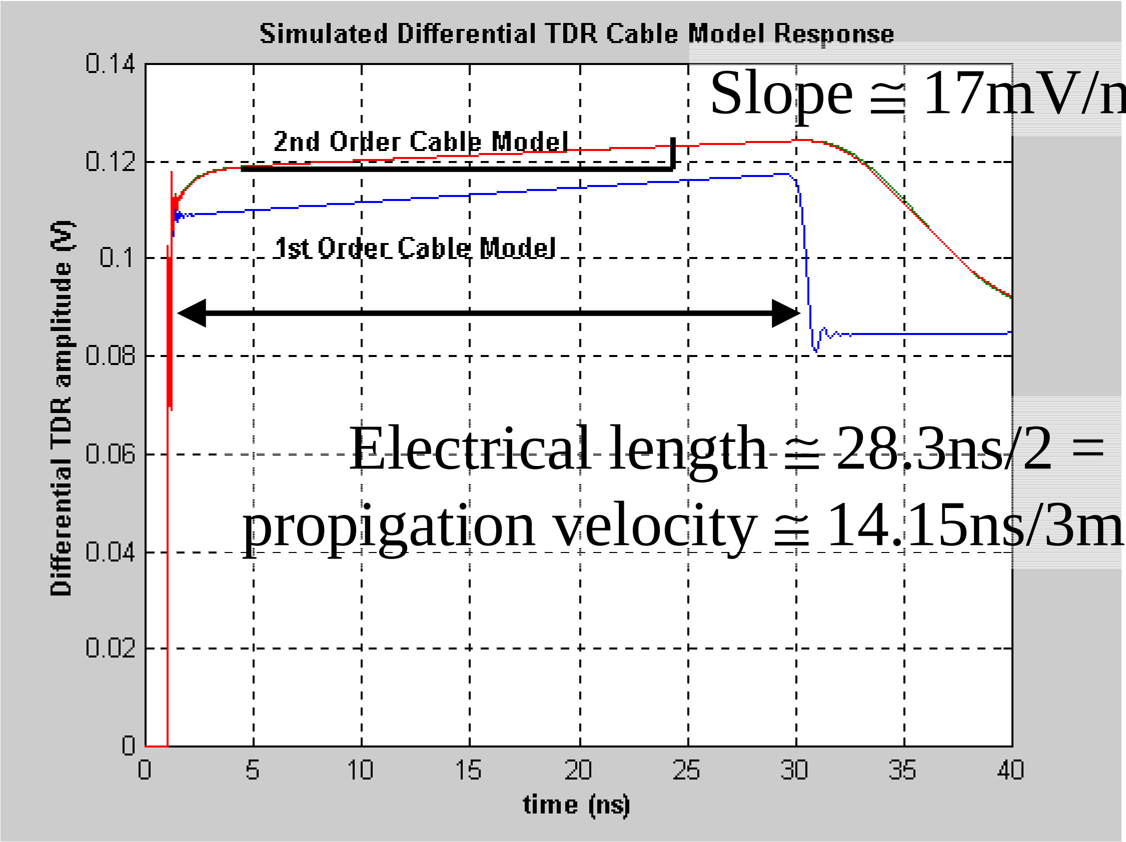
TDR Simulation Schematic



Simulated TDR Response

- Simulation of 3m section with 1cm sections

  Cable terminated with 50 Ω resistor



Slope ≅ 17mV/ns

Electrical length ≅ 28.3ns/2 = 14.15ns

propigation velocity ≅ 14.15ns/3m = 4.67ns/m