Returnloss Measurements and Simulations

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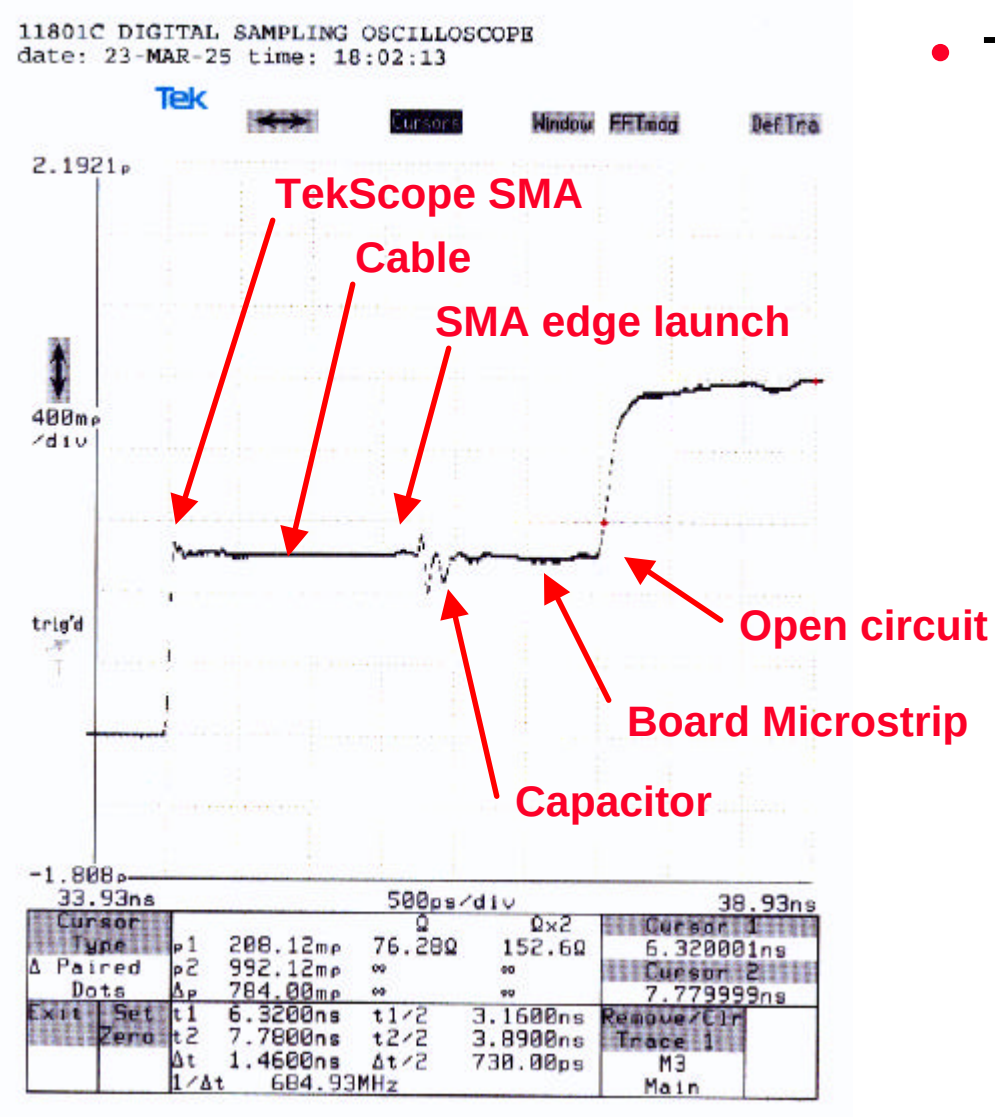
Causes

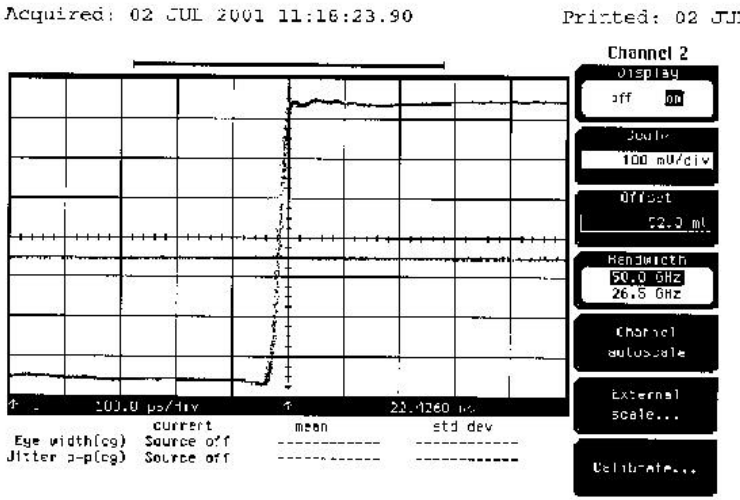
- **Driver / Receiver:**
  - Total capacitance: 1.4pF+
    - Driver / Receiver = 500fF+
    - Pad / ESD = 900fF+
- **Package:**
  - Package was designed with 100 Ohm differential lines and short bondwires (1mm)
  - However, package-only returnloss sims already show <10dB returnloss above 2GHz (assuming ideal 50 Ohm terminations inside/outside package)
- **Board:**
  - Board has 50 Ohm traces, but:
  - Via underneath BGA ball adds about 1.5pF load reducing impedance
  - Socket adds significant load (risetime goes from 100ps to 130ps with socket), but even soldered down part still has problems
  - AC decoupling caps cause significant impedance change
  - Current board has poor edge launch SMA

Measurements (time)

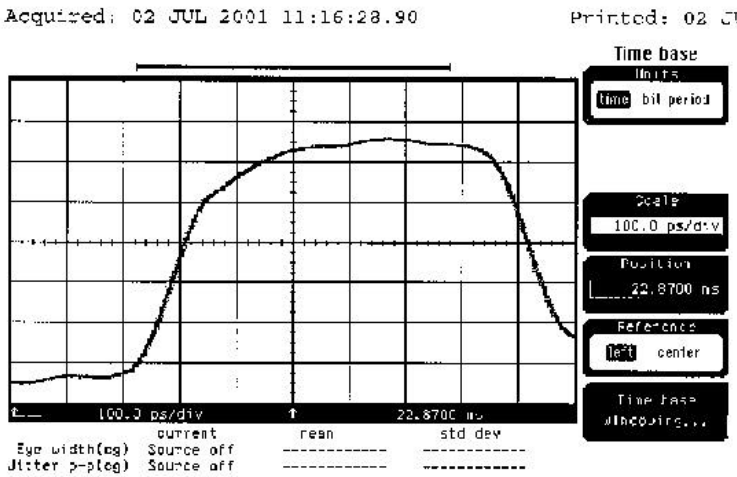


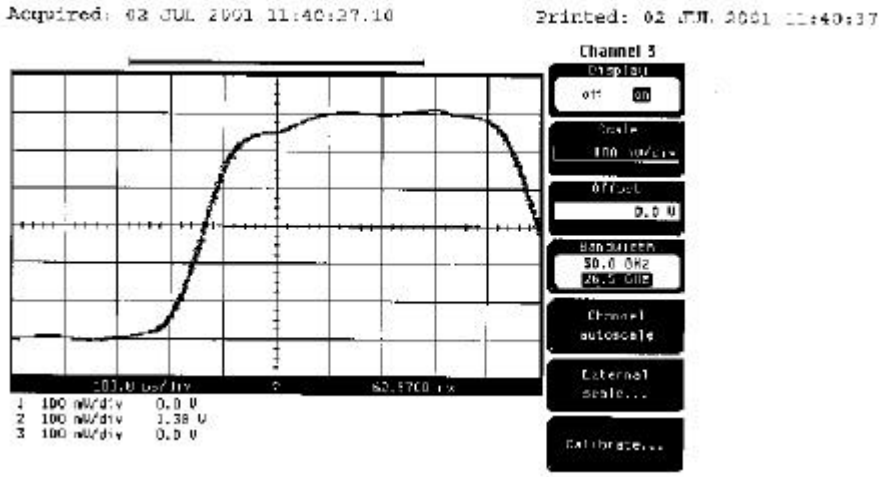
- **TDR – Board only**
  - 50ps rise time
  - contains: scope SMA, cable, SMA egde launch, decoupling cap and board trace.
  - Shows poor SMA edge launch and effect of decoupling capacitor
  - 500ps /div

Measurements (time)



- **TDT – Bare Substrate soldered**
  - In through tdp, out through tdn
  - 100ps / div plots
  - Upper left: input = 20ps rise time
  - Bottom left: TDT with bondwire
  - Bottom right: TDT with solderdot
  - Same reduction in slope

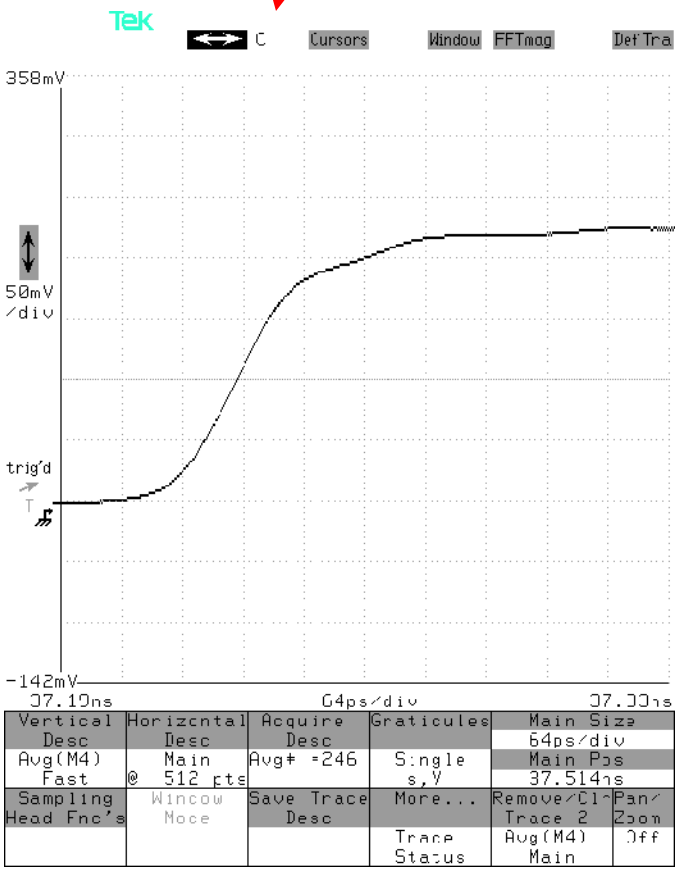




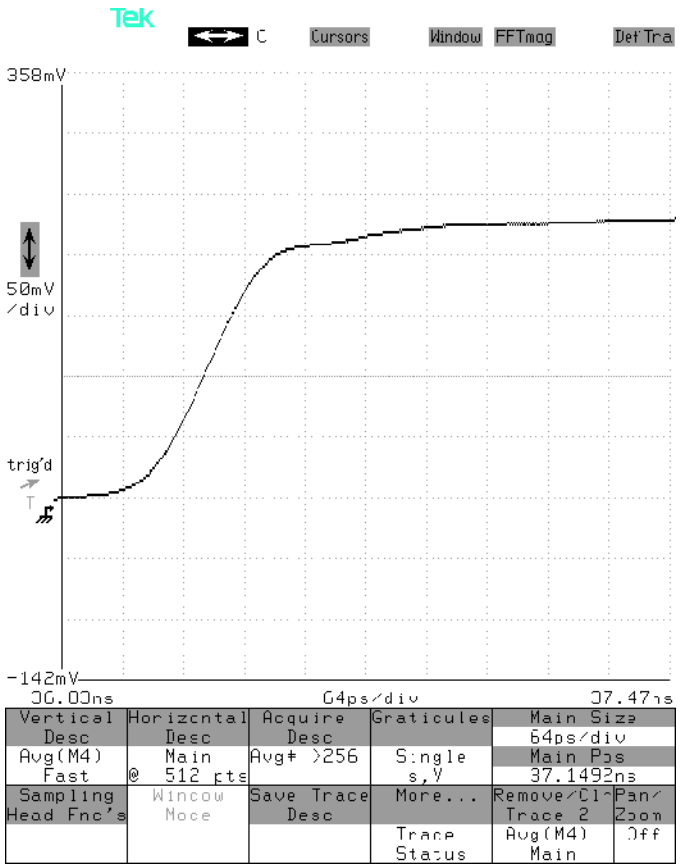
Measurements (time)

Solderdot short

Bondwire short

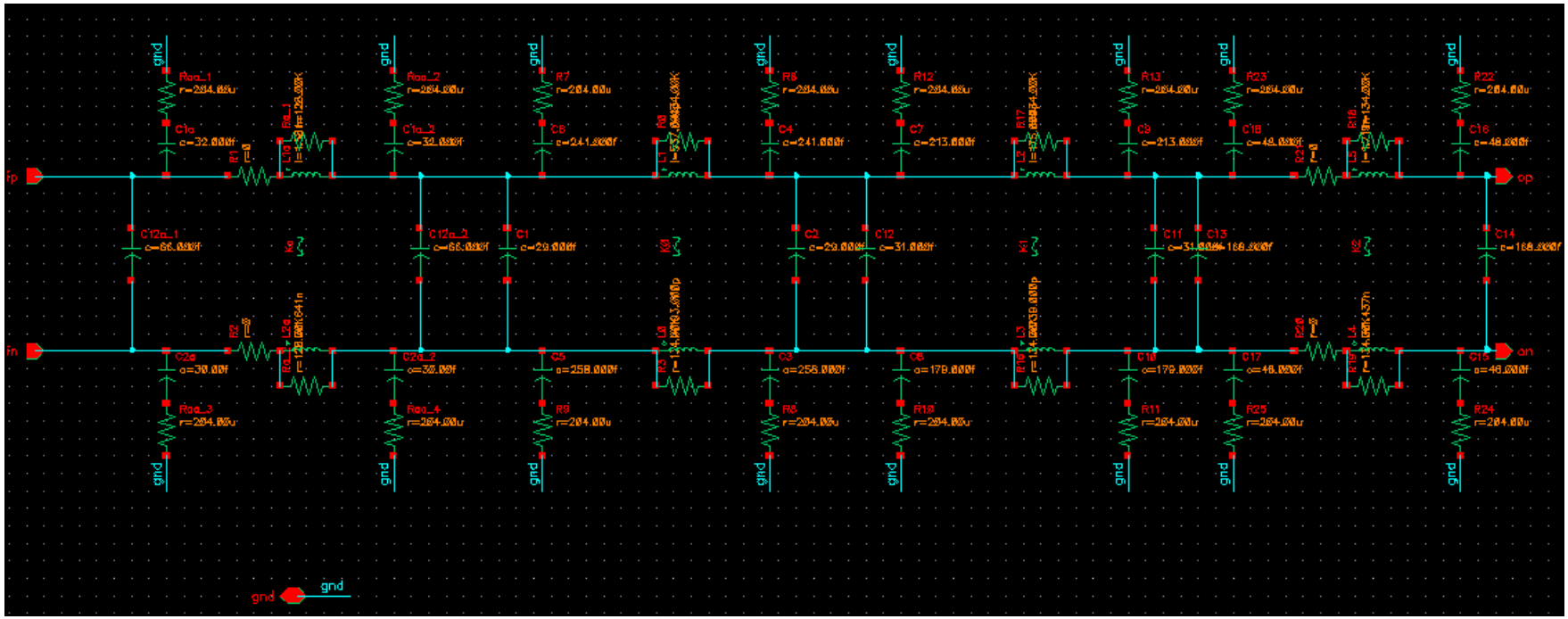


- **TDT – Bare Substrate soldered**
  - In through tdp, out through tdn
  - 64ps / div plots
  - Now with TekScope

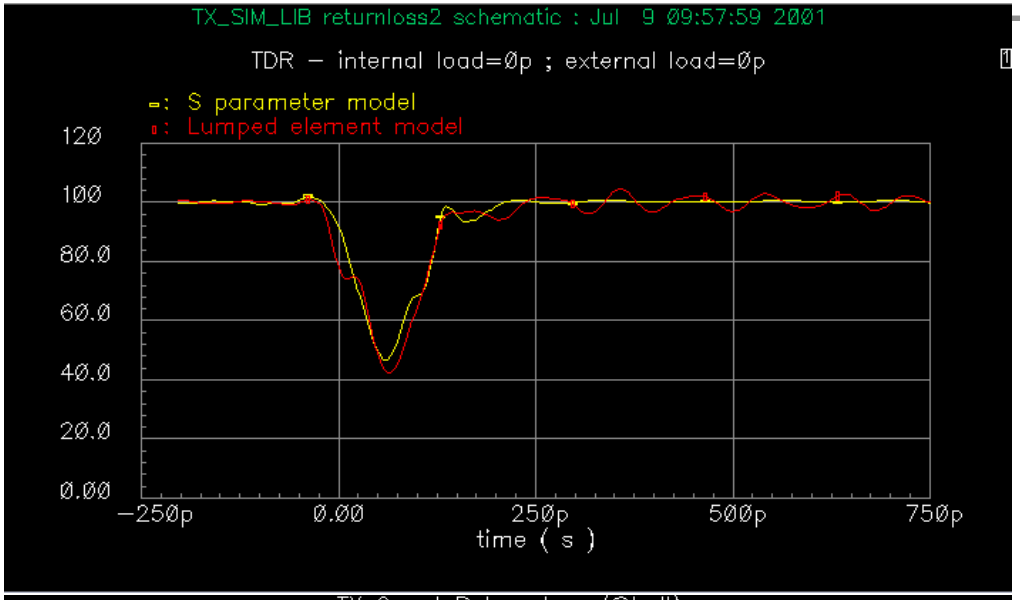


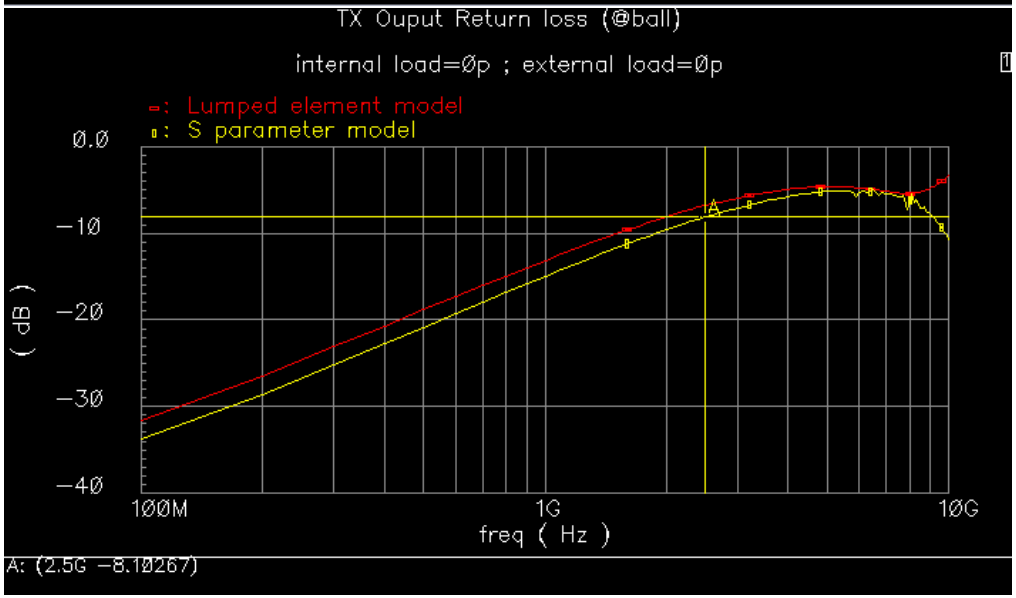
Simulations

- **Several simulations**
  - TDR Simulations
  - Returnloss simulations
  - Transient (pulse response) simulations
- **Models**
  - S parameter model (3D – HFSS)
  - Lumped element model (fitted)



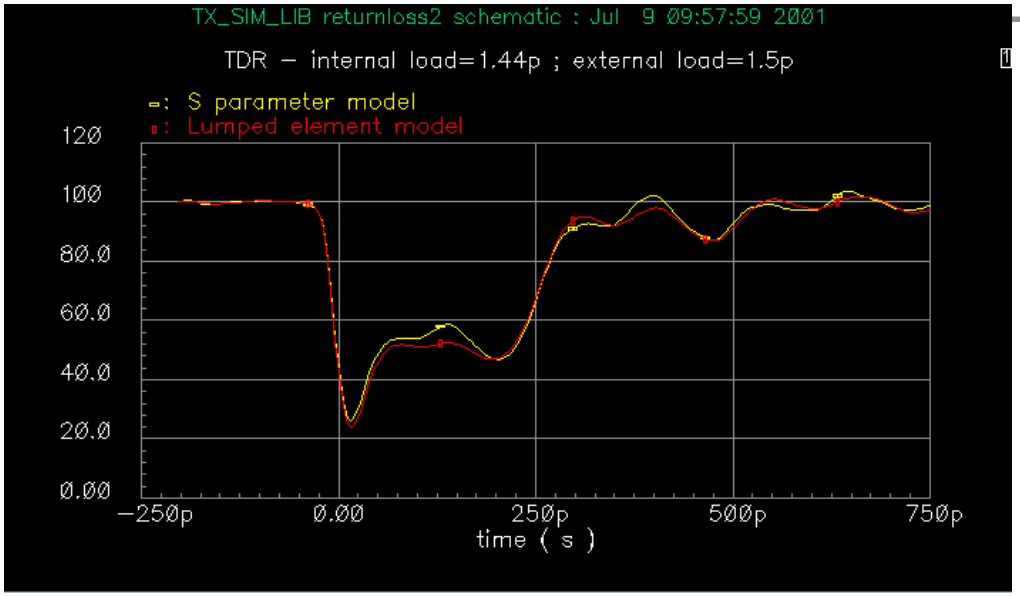
Simulations (TDR / RL)

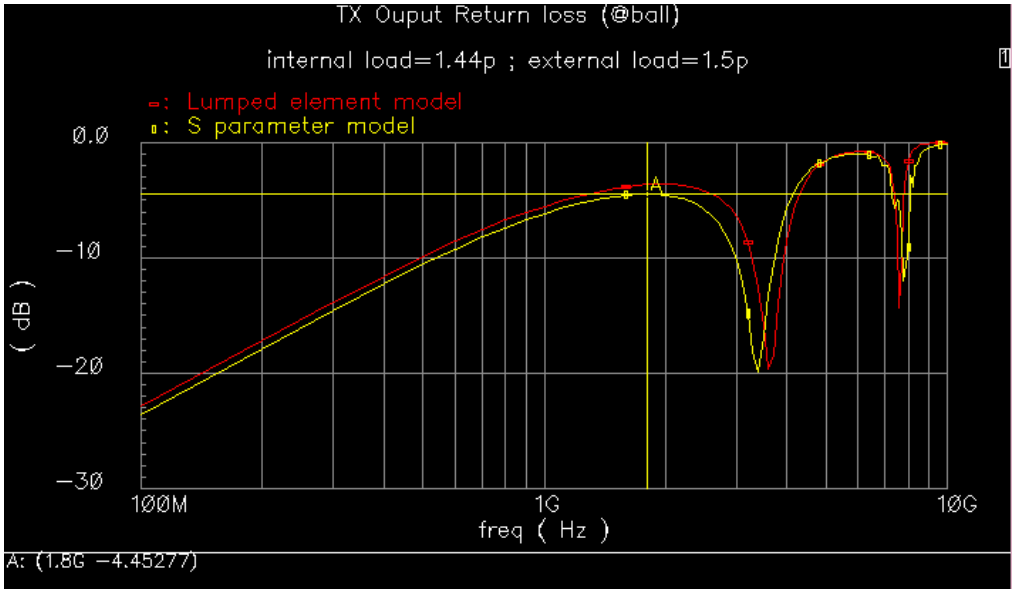




- **Package only**
  - Always fully differential simulation set-up
  - Always proper 100 Ohms source / load terminations
  - Internal and external capacitances varied
  - Here: no capacitive loads
  - Impedance drops below 50 Ohms
  - Returnloss @ 2.5GHz = 8.1dB

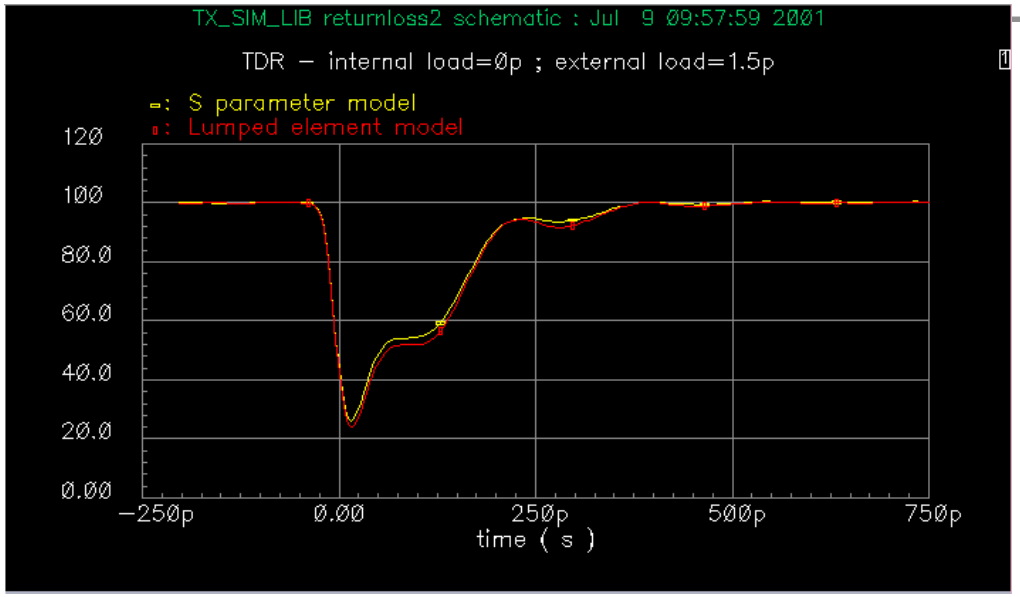
Simulations (TDR / RL)

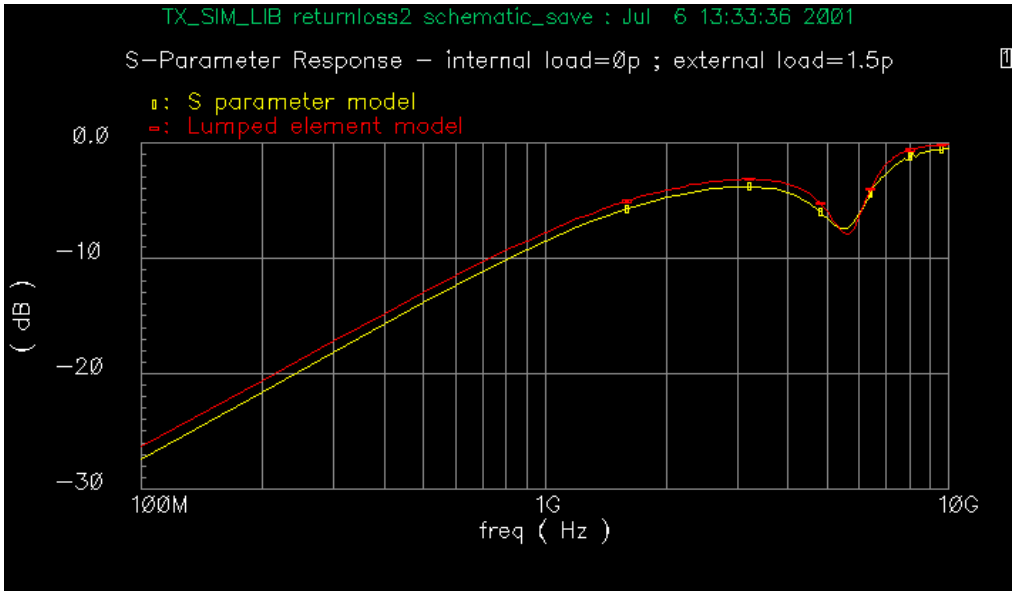




- **Full Capacitive load**
  - Internal = Pad + Driver
  - External = Via + Trace
  - Impedance drops below 30 Ohms
  - Returnloss @ 1.8GHz = 4.5dB
  - TDR pulse is over 2x wider

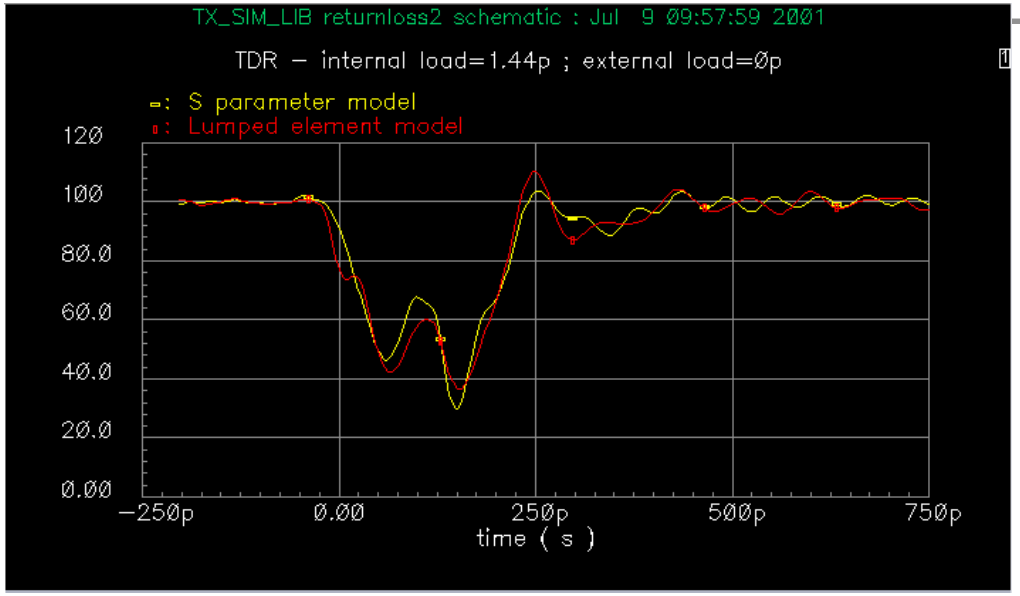
Simulations (TDR / RL)

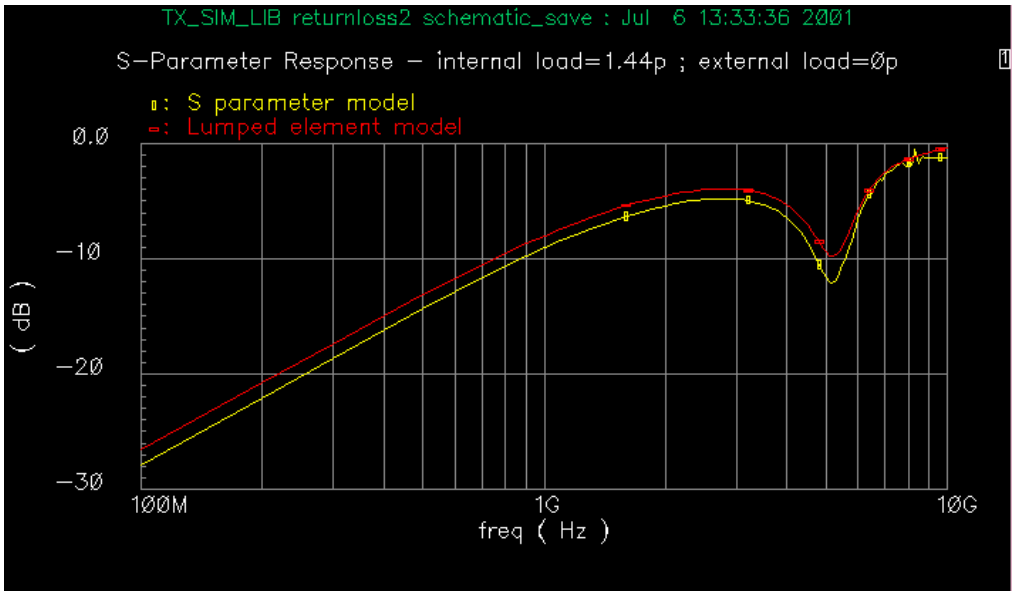




- **External load only**
  - Impedance drops below 30 Ohms
  - Returnloss @ 2.5GHz = 5dB
  - Internal load does not effect returnloss drastically when external load is present, but the TDR pulse is much shorter when no internal capacitance is present

Simulations (TDR / RL)

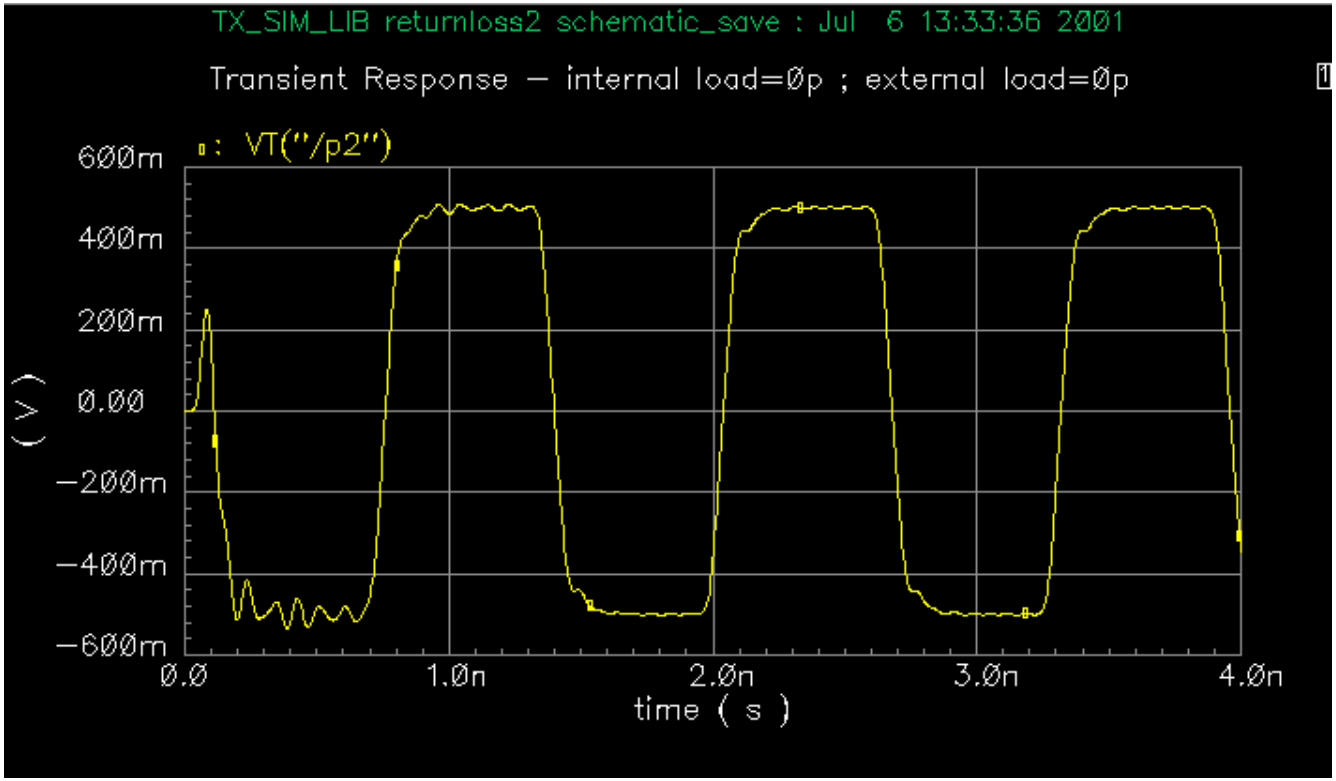




- **Internal load only**
  - Impedance drops below 40 Ohms
  - Returnloss @ 2.5GHz = 6dB
  - Internal load still has significant effect when no external load is present, but TDR has more distinctive ‘double’ bump

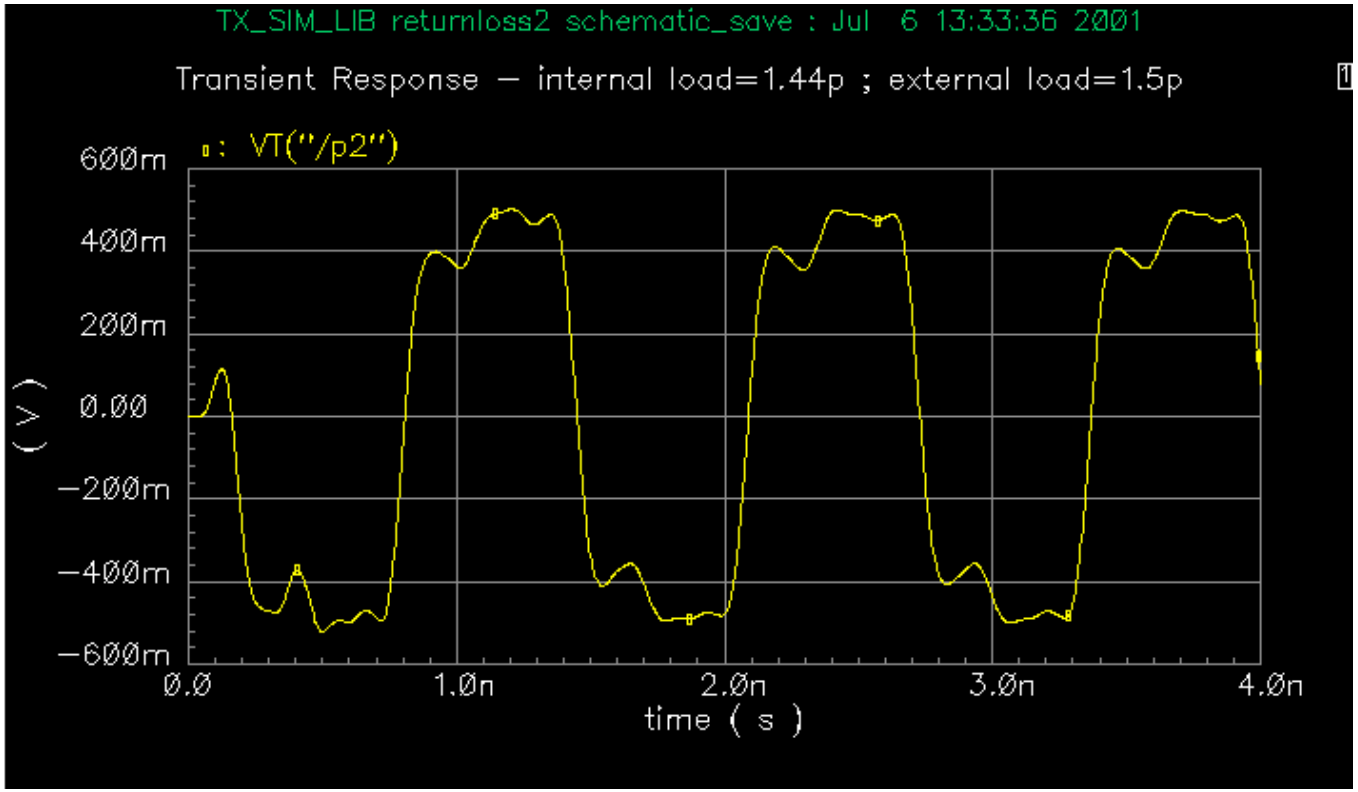
Simulations (time)

- **Package Only**
  - Output waveform with ‘111000111’ pattern
  - Very small reflection noticable at the transitions.



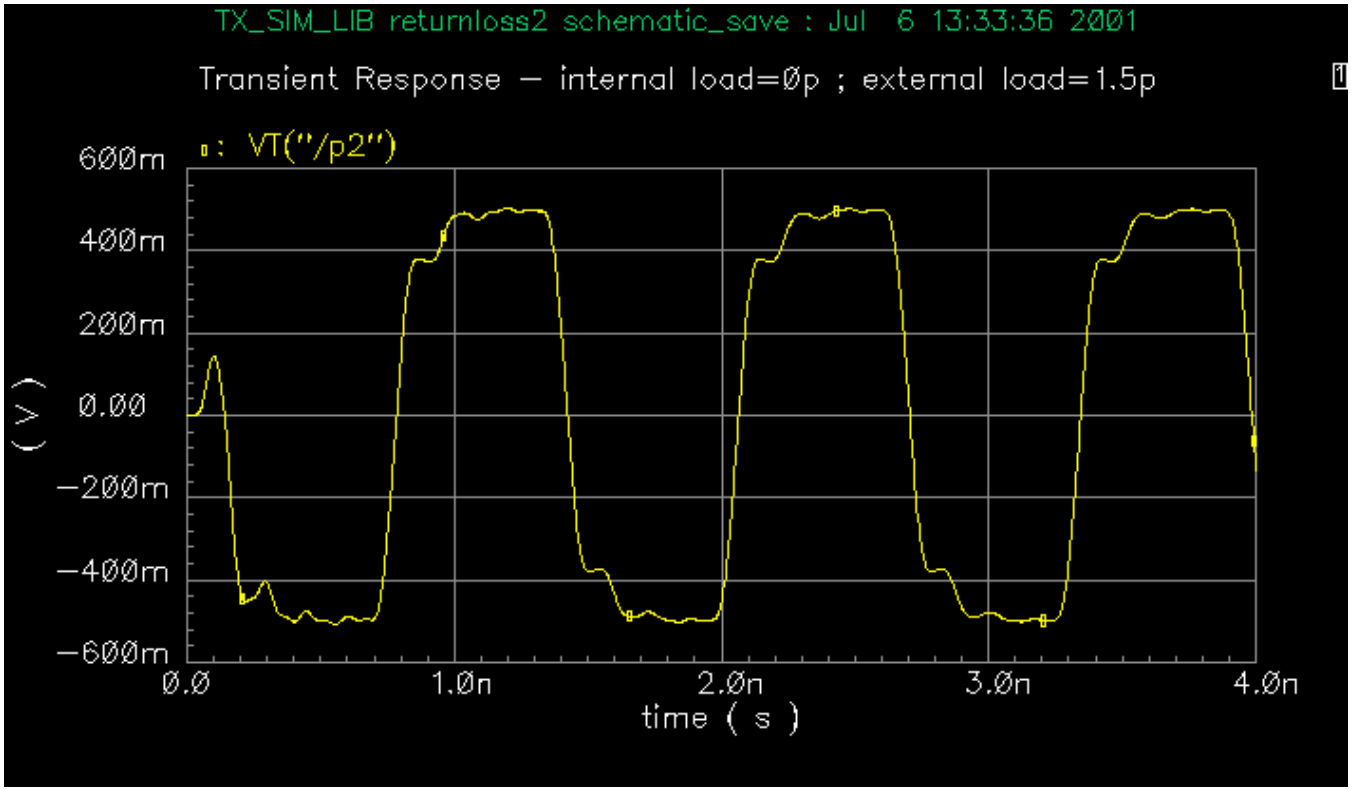
Simulations (time)

- **Full capacitive load**
  - Output waveform with ‘111000111’ pattern
  - Significant reflection (>15%) at every transistion, nearly 1 UI long
  - Reflection is more pronounced than in TDR and output measurements



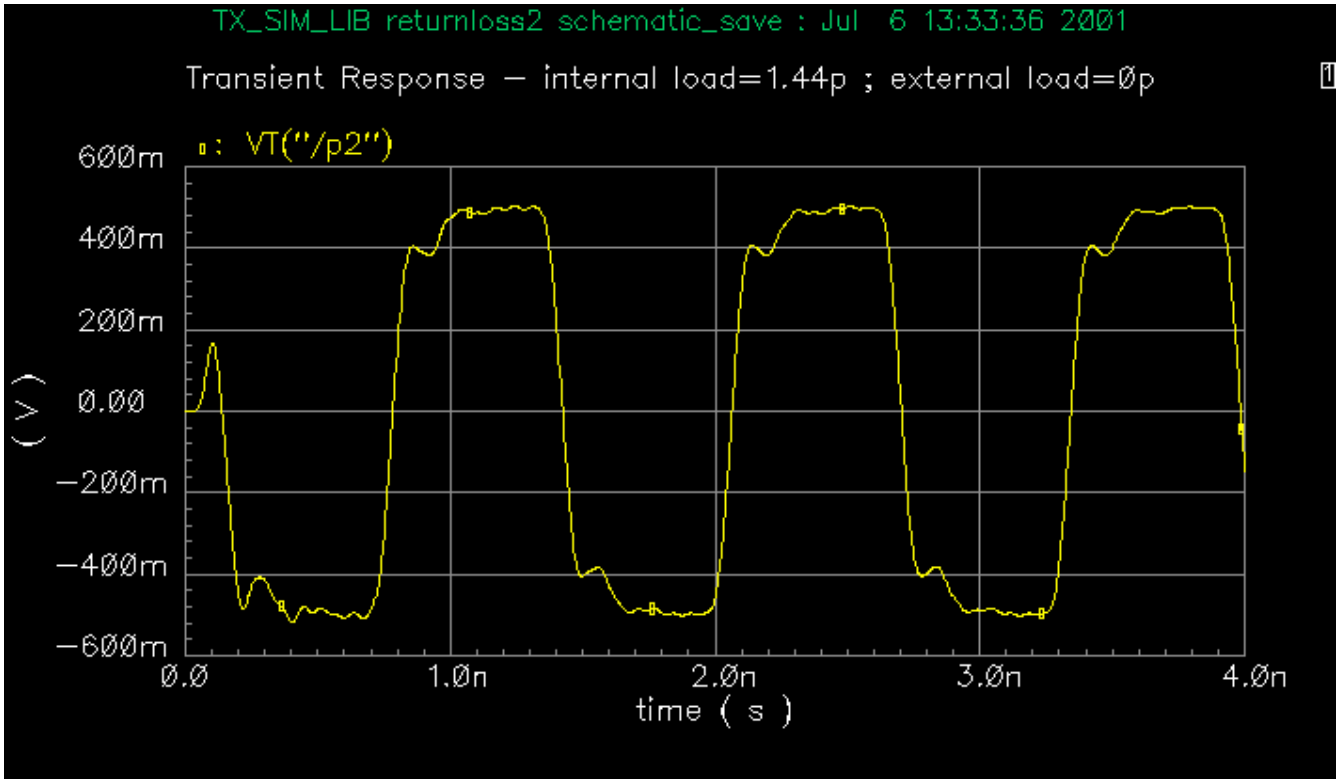
Simulations (time)

- **External load only**
  - Still significant reflection (>15%) at every transistion, but shorter than with internal capacitance
  - Flat / Step-like reflection resembles output measurements for soldered down part.



Simulations (time)

- **Internal load only**
  - Still significant reflection (>15%) at every transistion, but shorter than with full capacitive load
  - Difference between internal and external load not significant



Simulations (time)

- **Reduced capacitive load**
  - Estimate of capacitive reduction in pad and on board
  - Very little improvement compared to full capacitive load