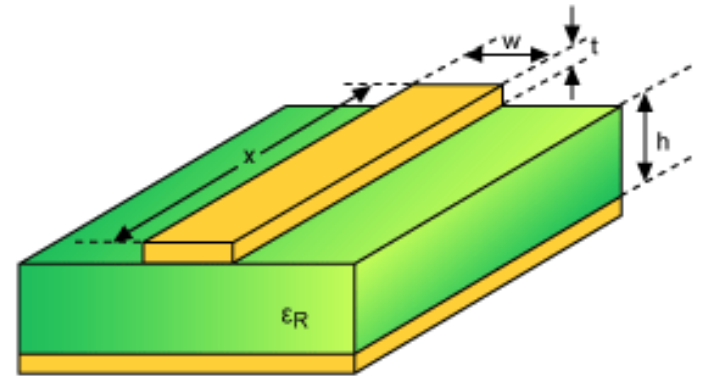
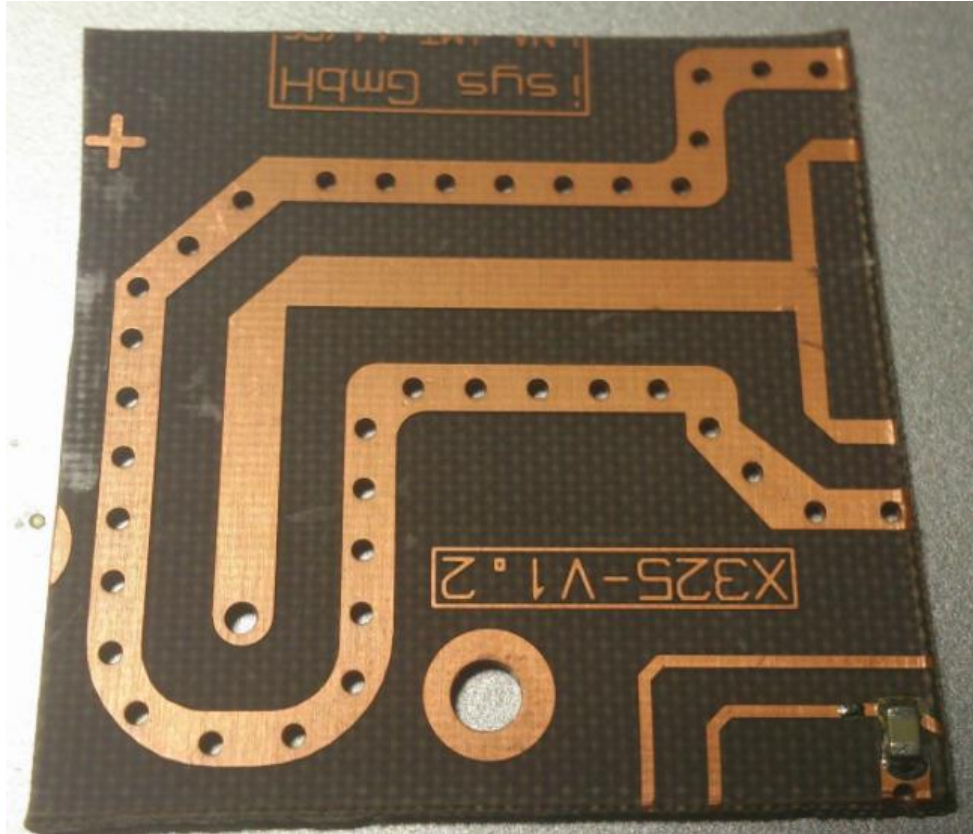


High-Speed Serial Interface Circuits and Systems

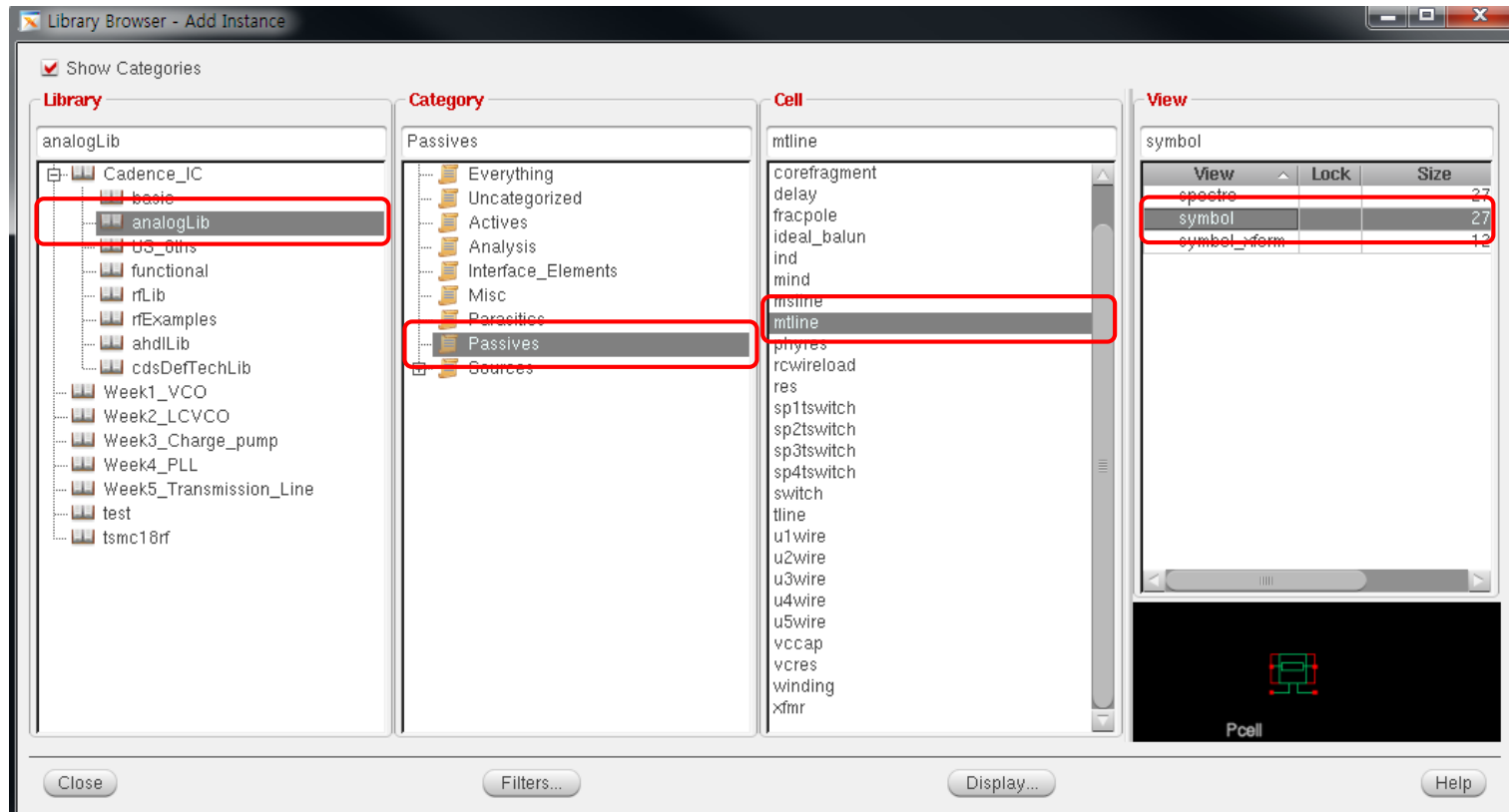
Design Exercise5 –
TDR & S-parameter

PCB Microstrip Line



mtline Setting

- mtline selection
 - Cadence_IC → analogLib → Passives → mtline → symbol



mtline Setting

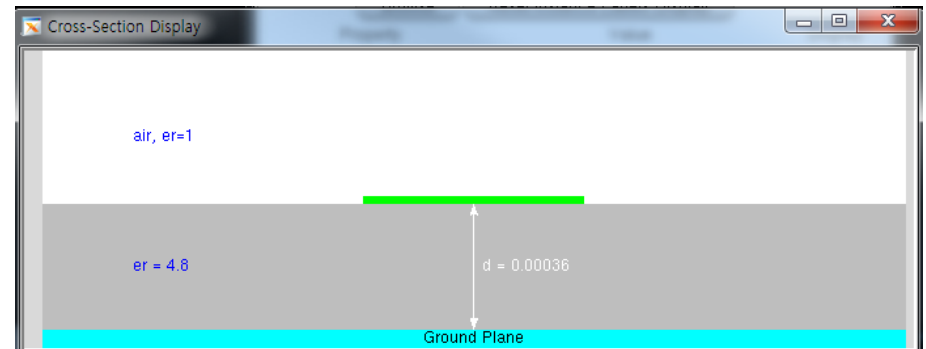
mtline setting

– Micro-stripe transmission line type

Num of lines (excluding ref.)	1	off
Model name		off
Physical length	150m M	off
Multiplicity factor	1	off
Max signal frequency		off
Type of Input	FieldSolver	off
Generate noise?	no	off
Transmission line type	microstrip	off
Model type	wideband	off
Rel dielectric const of layers(er)	4.8	off
Dielectric layer thickness (d)	360u	off
Signal line width	625u	off
Signal line thickness	17.78u	off

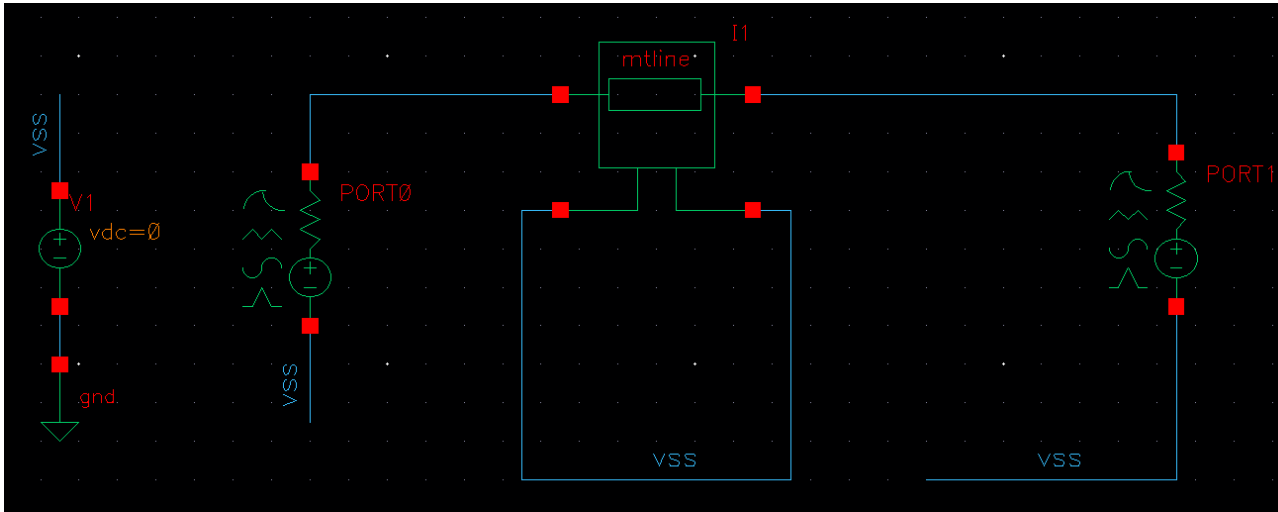
- Physical length: 0.15m → ~1n delay
- Type of Input : FieldSolver
- Transmission line type : microstrip
- Model type : wideband
- Real dielectric const of layers : 4.8 (FR4)
- Dielectric layer thickness : 360u (H)
- Signal line width : 625u (W)
- Signal line thickness : 17.78u (T)
- Display Cross-section

$$Z_0 \approx \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln \left(\frac{5.98H}{0.8W + T} \right) \Omega$$



S-Parameter

- Simulation condition



- Simulation setting
 - Analysis : sp
 - Ports : Port0 and Port1 choice
 - Sweep variable : frequency
 - Sweep range : 10M ~ 20G
 - Sweep type : Linear (Step size : 10M)
- Direct plot from
 - S11 dB20 & S21 dB20 & S11 Z-chart
 - Sweep : length (30m ~ 150m)*

Analysis

<input type="radio"/> tran	<input type="radio"/> dc	<input type="radio"/> ac	<input type="radio"/> noise
<input type="radio"/> xf	<input type="radio"/> sens	<input type="radio"/> dcmatch	<input type="radio"/> stb
<input type="radio"/> pz	<input checked="" type="radio"/> sp	<input type="radio"/> envlp	<input type="radio"/> pss
<input type="radio"/> pac	<input type="radio"/> pstb	<input type="radio"/> pnoise	<input type="radio"/> pxf
<input type="radio"/> psp	<input type="radio"/> qpss	<input type="radio"/> qpac	<input type="radio"/> qpnoise
<input type="radio"/> qpxf	<input type="radio"/> qpdp	<input type="radio"/> hb	<input type="radio"/> hbac
<input type="radio"/> hbnoise	<input type="radio"/> hbsp		

S-Parameter Analysis

Ports

/PORT0 /PORT1

Sweep Variable

☒ Frequency

☐ Design Variable

☐ Temperature

☐ Component Parameter

☐ Model Parameter

Sweep Range

☒ Start-Stop Start Stop

☐ Center-Span

Sweep Type

☒ Linear ☐ Step Size

☐ Number of Steps

Add Specific Points ☐

Do Noise

☐ yes

☒ no

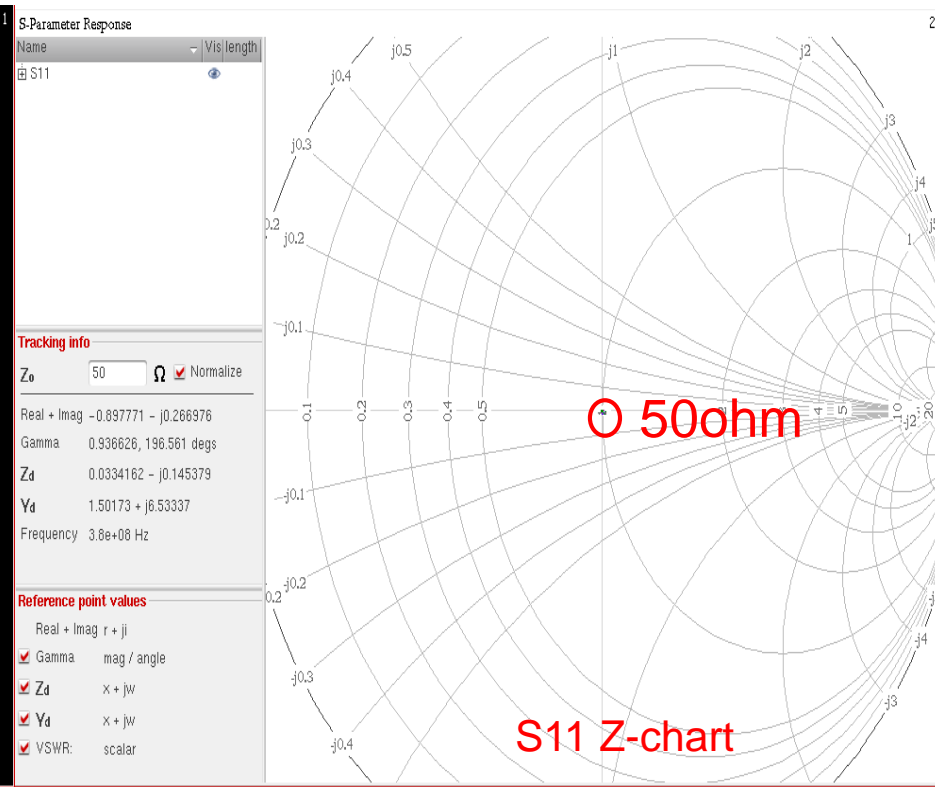
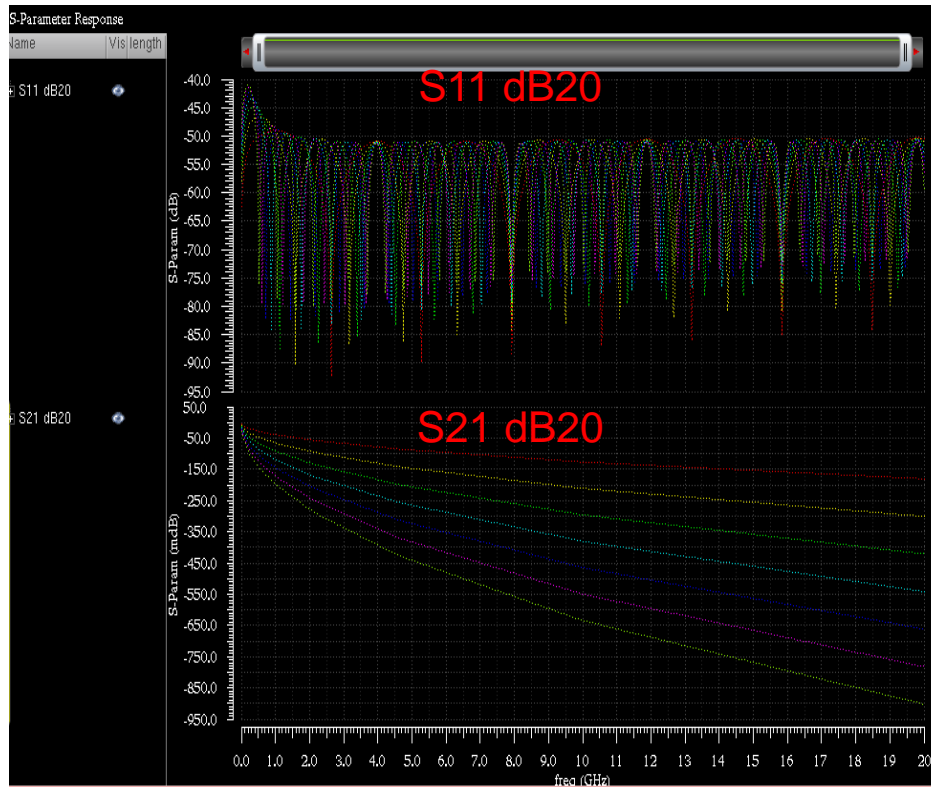
Mode

☒ Single-Ended ☐ Mixed In/Out ☐ Other

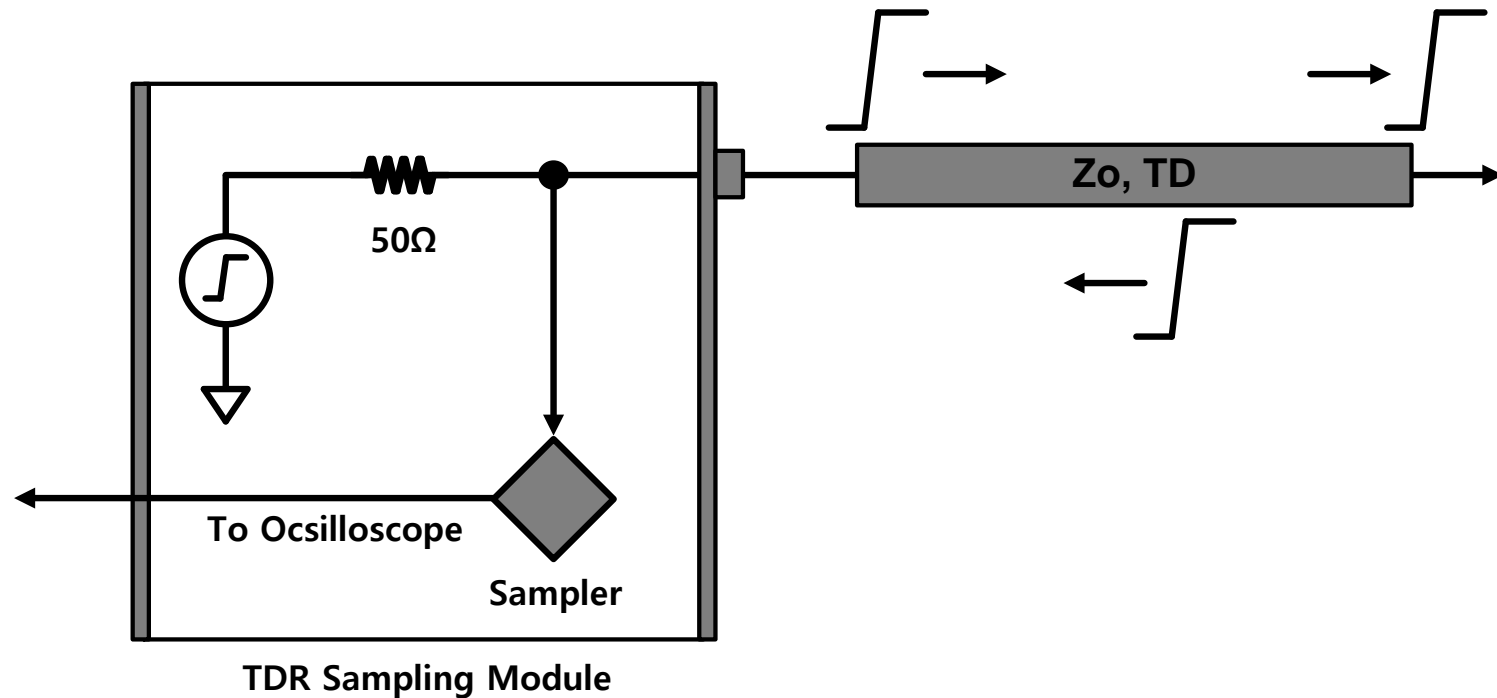
Enabled ☒

S-Parameter

- Simulation result
 - Length \uparrow - loss \uparrow
 - Impedance match



TDR (Time-Domain Reflectometer)

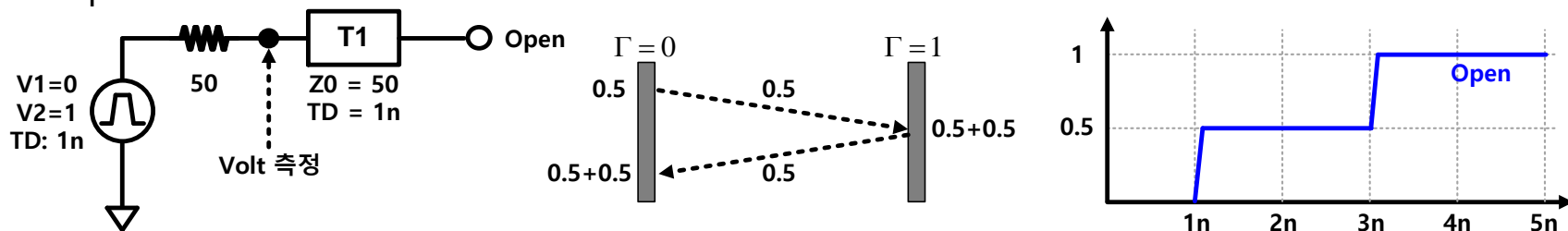


- Pulse generator produces step input with very large period.
- Scope measures the pulse shape.
- Analysis of transmission line characteristic.

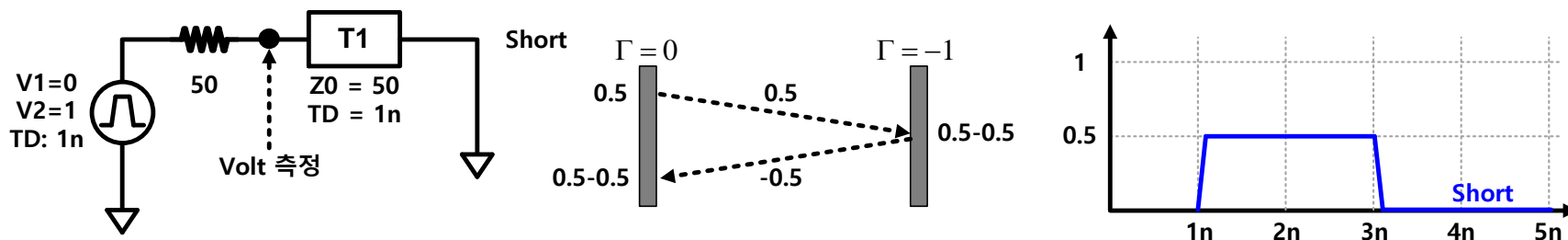
TDR Load Condition 1

- TDR application : resistor load

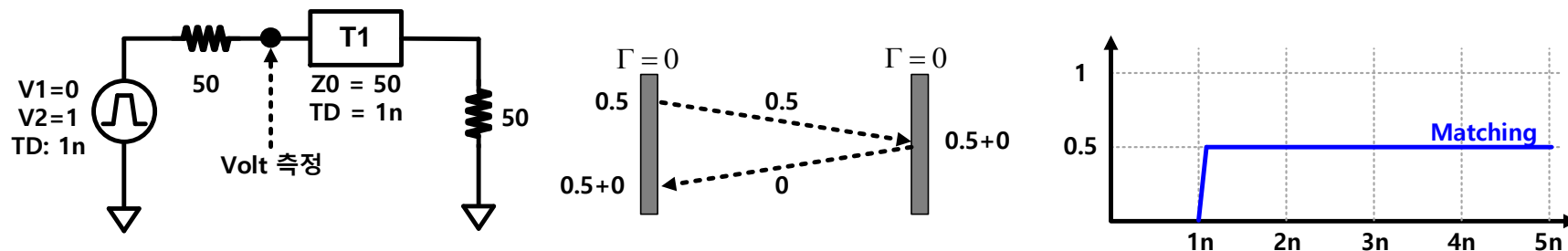
- Open



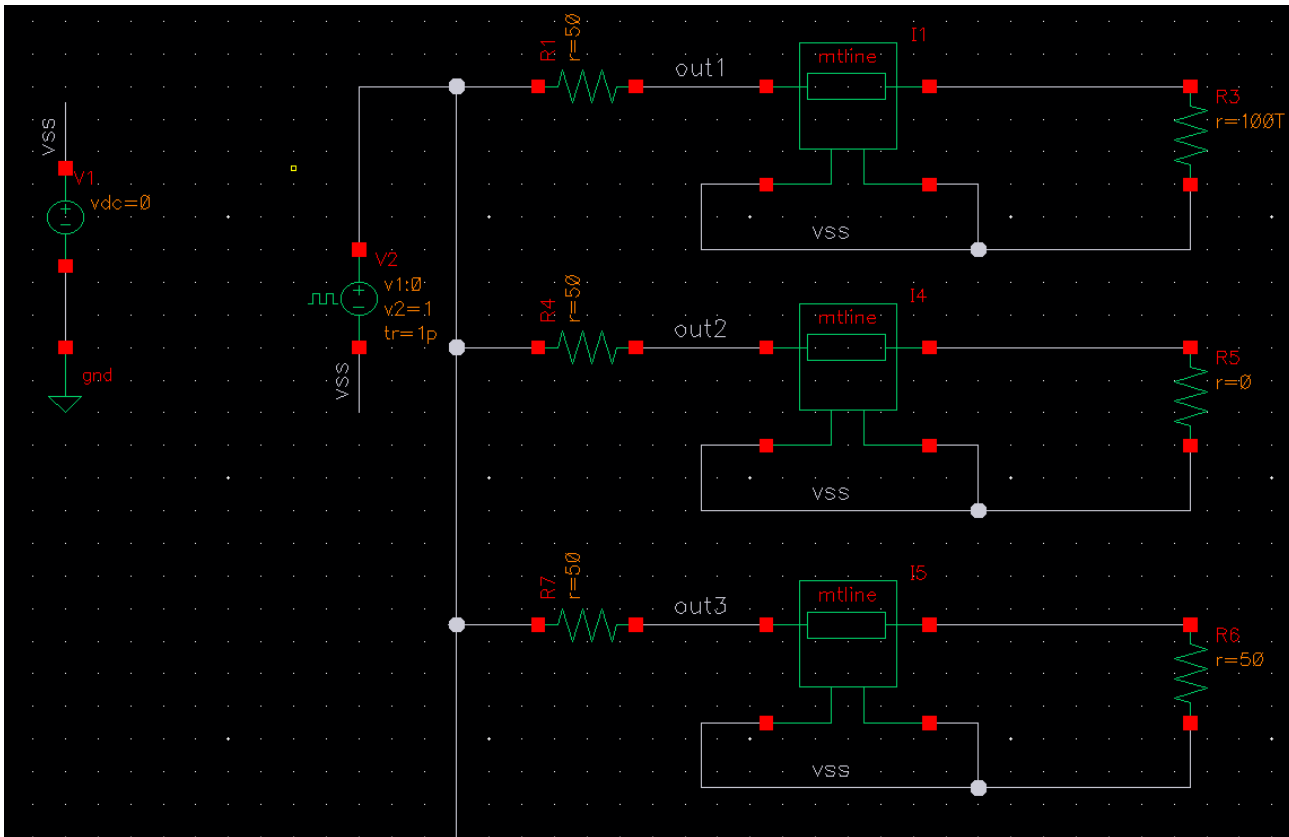
- Short



- Matching



TDR Load Condition 1



- V-pulse setting
 - Voltage1 : 0V
 - Voltage2 : 1V
 - Period : 10n
 - Delay: 1n
 - Rise time : 1p
 - Fall time : 1p
 - Pulse width : 5n

Voltage 1	0 V
Voltage 2	1 V
Period	10n s
Delay time	1n s
Rise time	1.0p s
Fall time	1.0p s
Pulse width	5n s

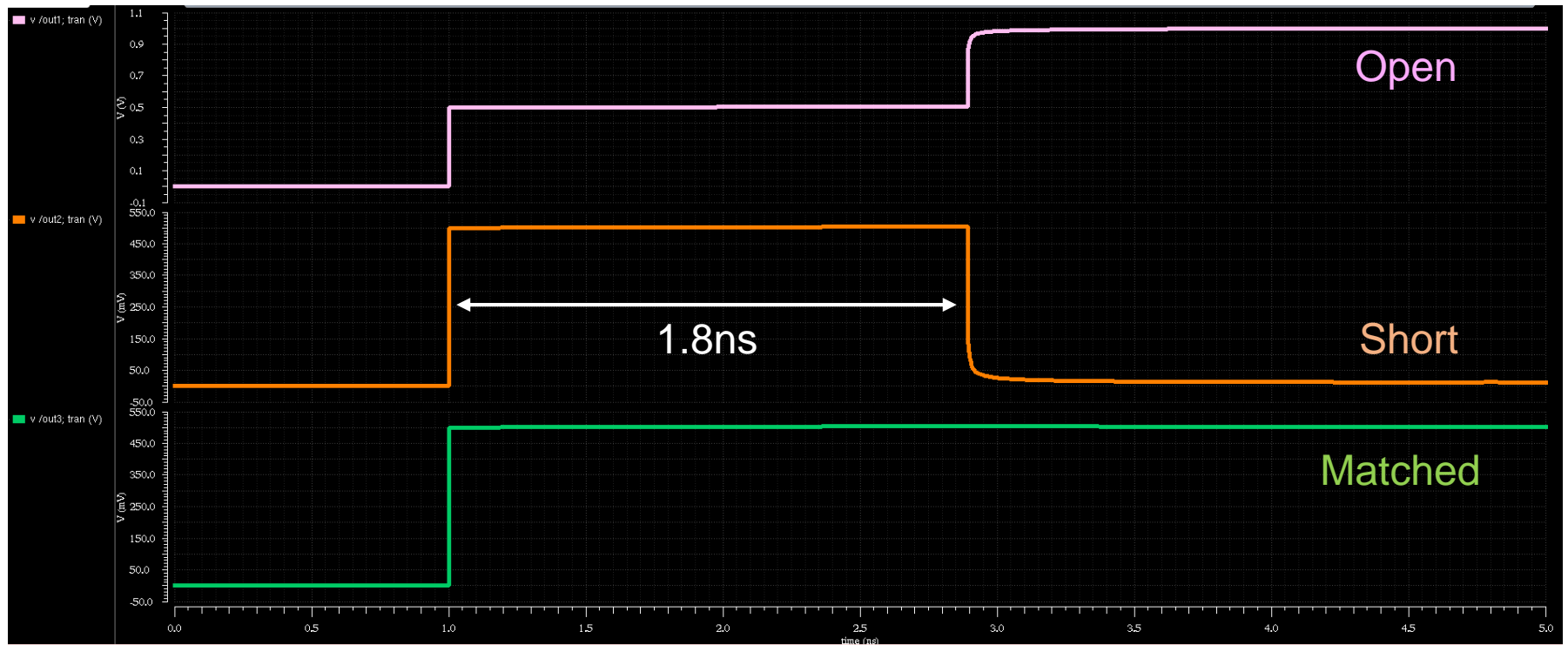
- Simulation setting

- Trans
- 5n

Analyses		
Type	Enable	Arguments
1 tran	<input checked="" type="checkbox"/>	0 5n

TDR Load Condition 1

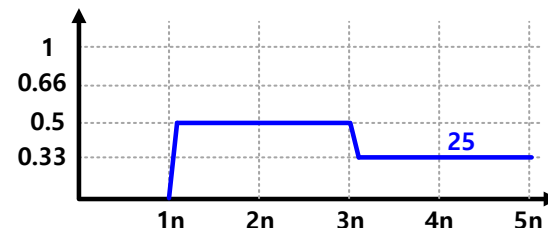
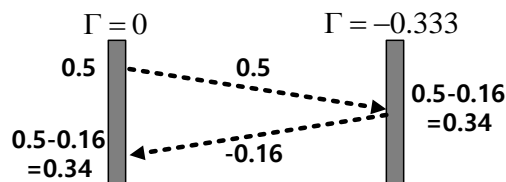
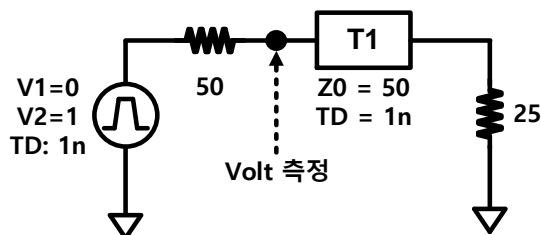
● Simulation result



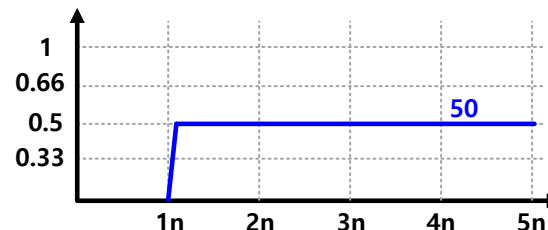
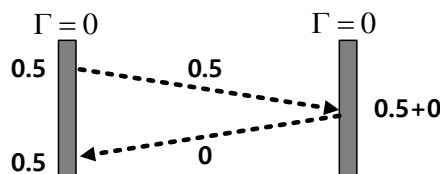
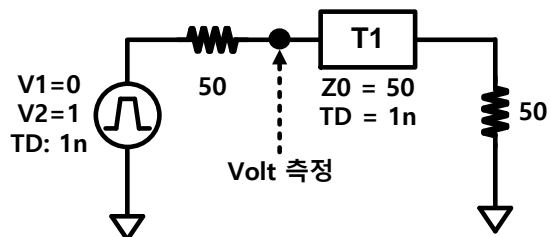
TDR Load Condition 2

TDR application : resistor load

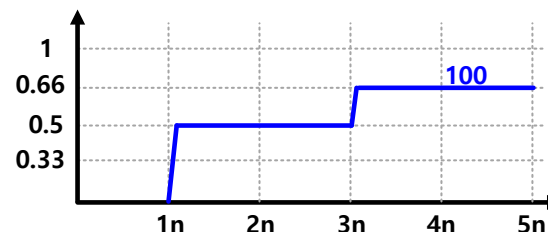
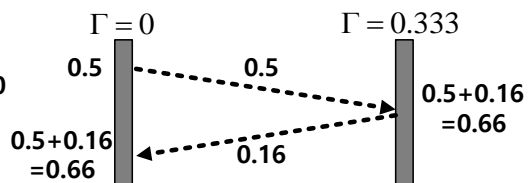
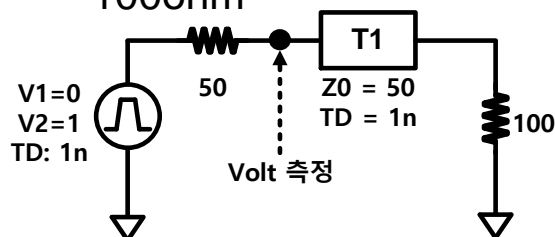
– 25ohm



– 50ohm



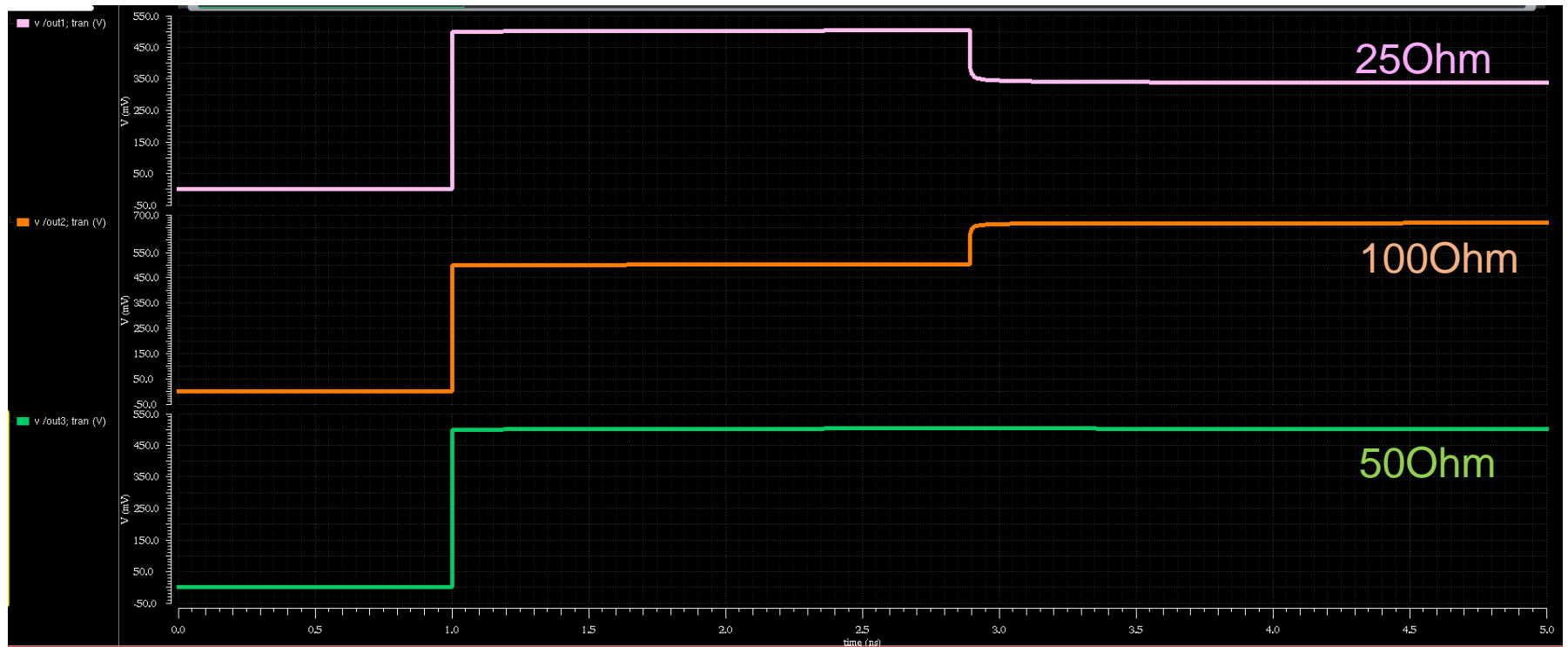
– 100ohm



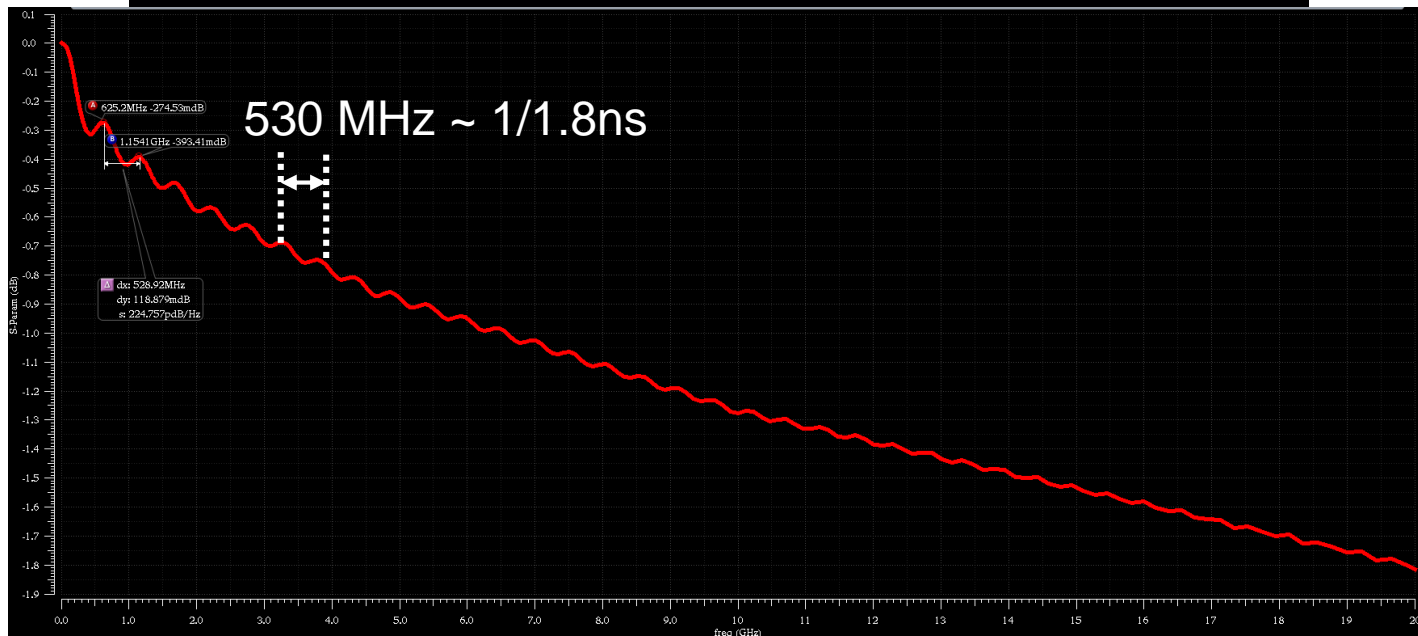
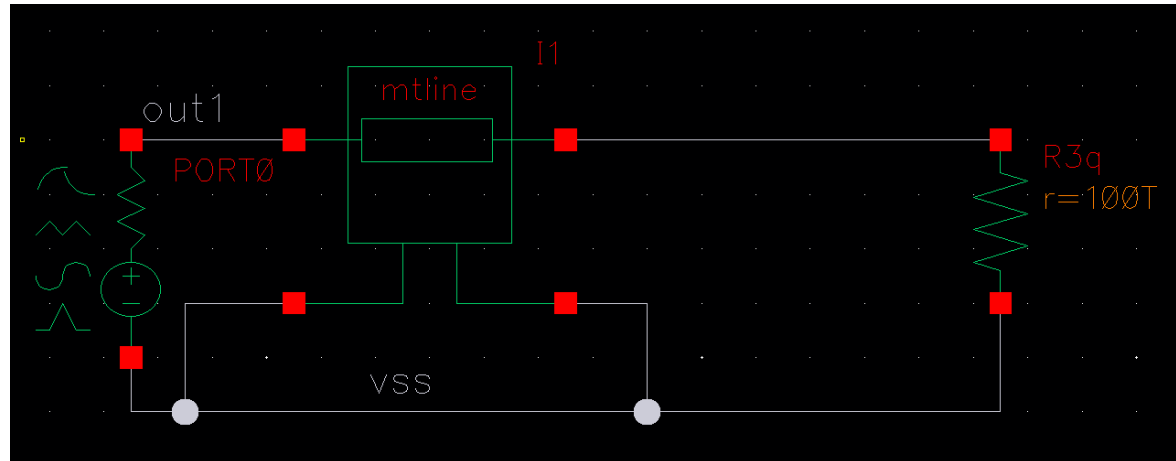
TDR Load Condition 2



Simulation result



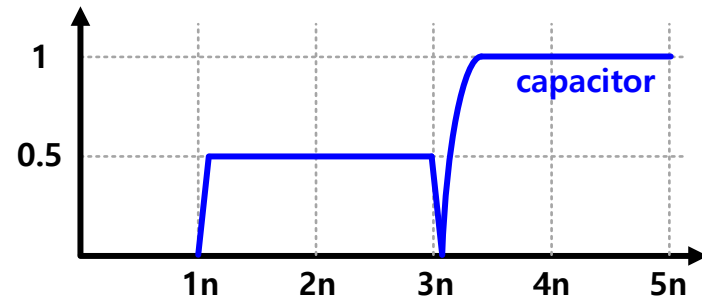
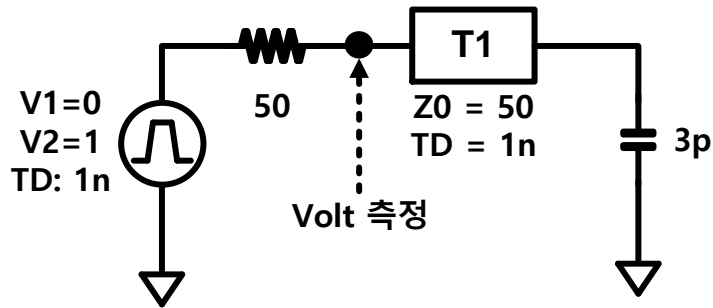
TDR S-parameter Simulation



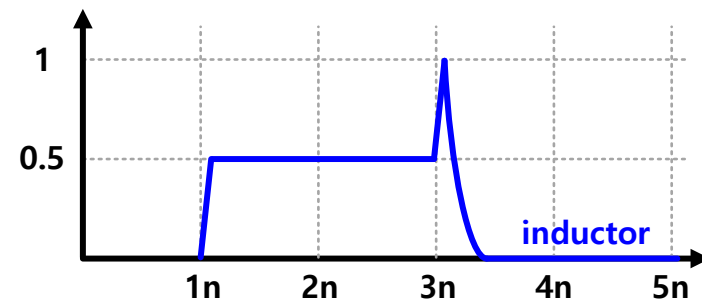
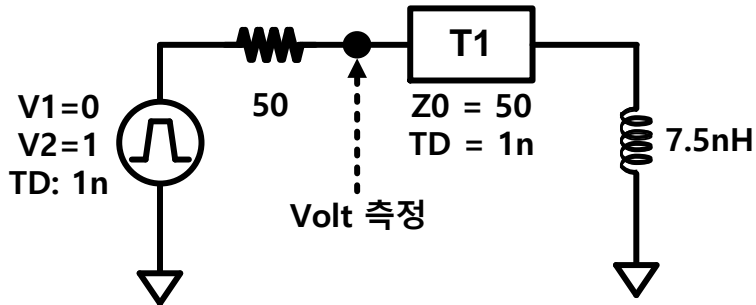
TDR Load Condition 3

● TDR application : capacitive & inductive load

– Capacitive load



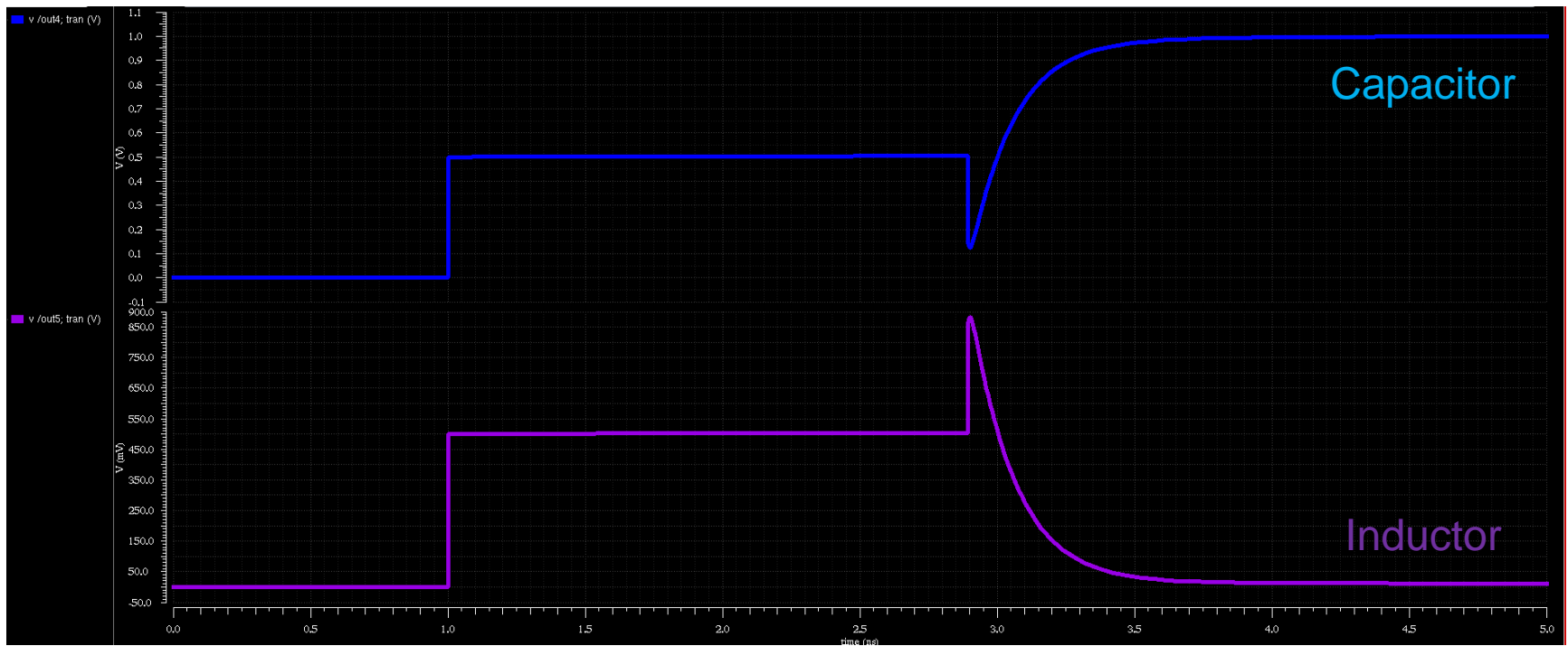
– Inductive load



TDR Load Condition 3



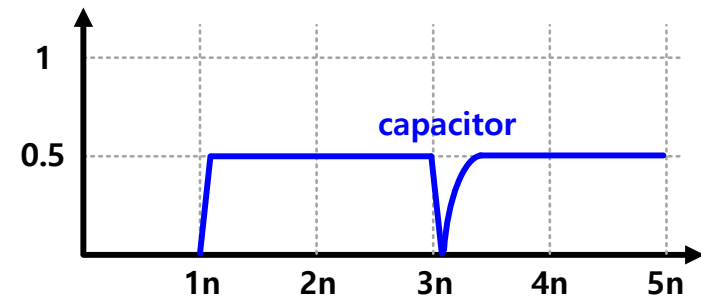
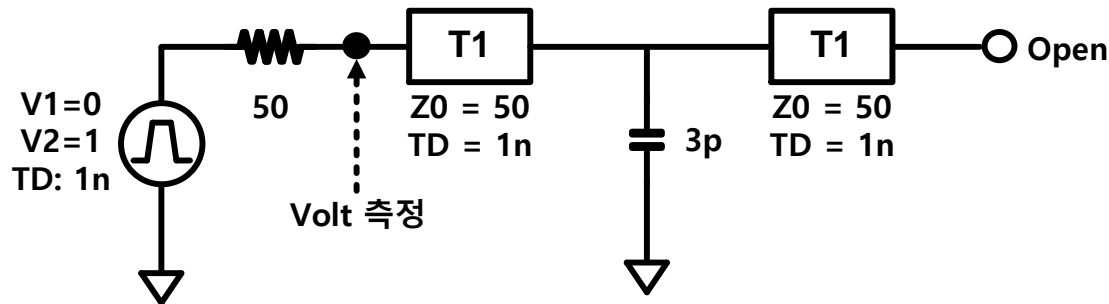
Simulation result



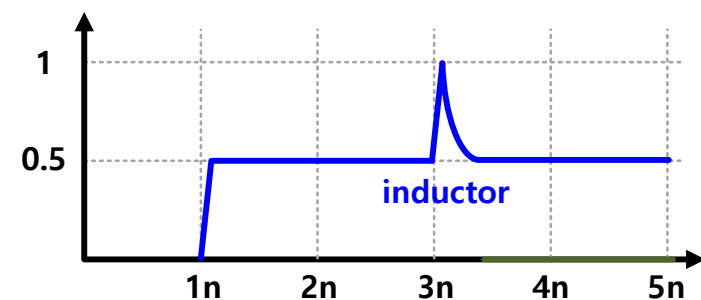
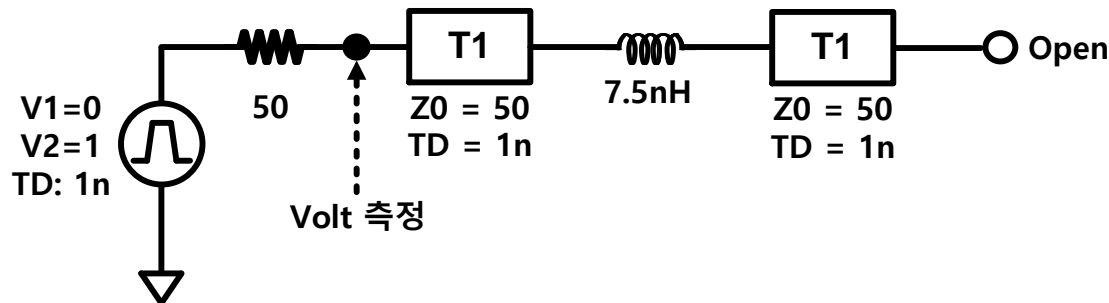
TDR Discontinuity

TDR application : capacitive & inductive discontinuity

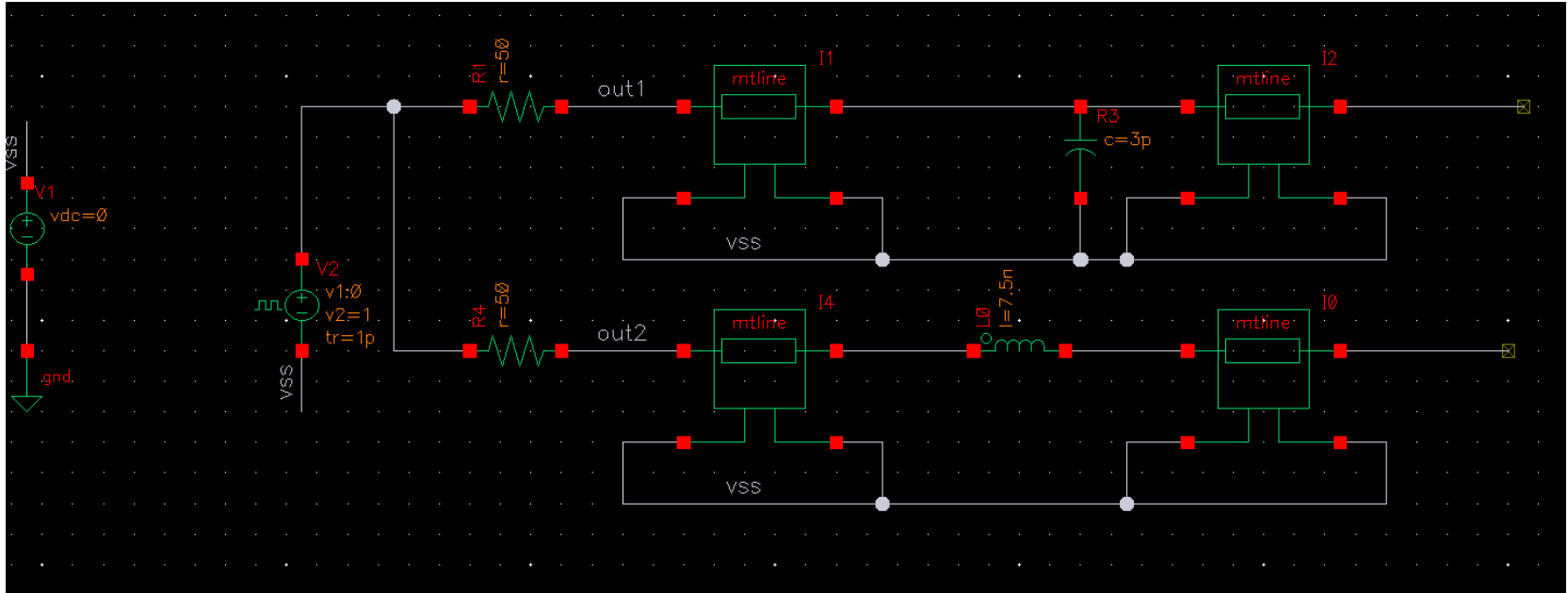
– Capacitive discontinuity



– Inductive discontinuity



TDR Discontinuity

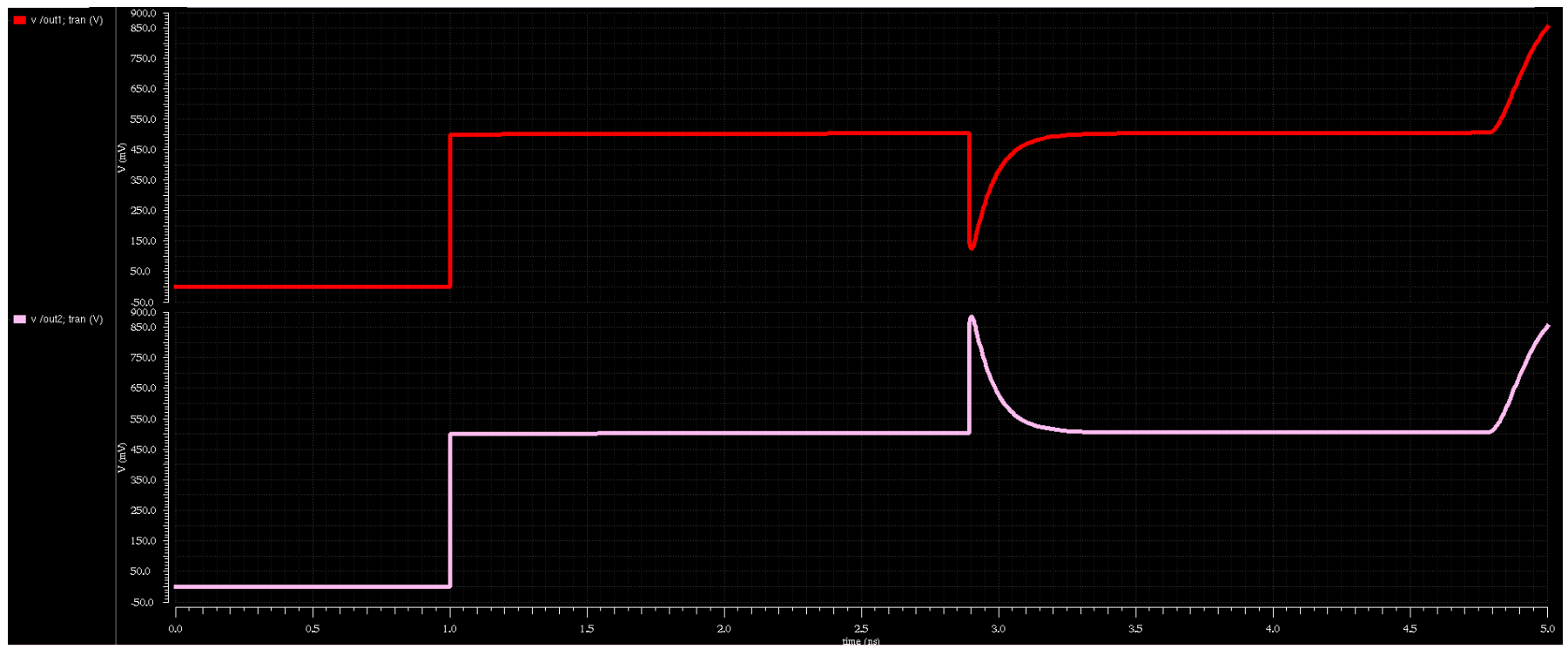


- V-pulse setting
 - Voltage1 : 0V
 - Voltage2 : 1V
 - Delay: 1n
 - Period : 10n
 - Rise time : 1p
 - Fall time : 1p
 - Pulse width : 5n
- Simulation setting
 - Trans
 - 5n
 - Conservative

TDR Discontinuity

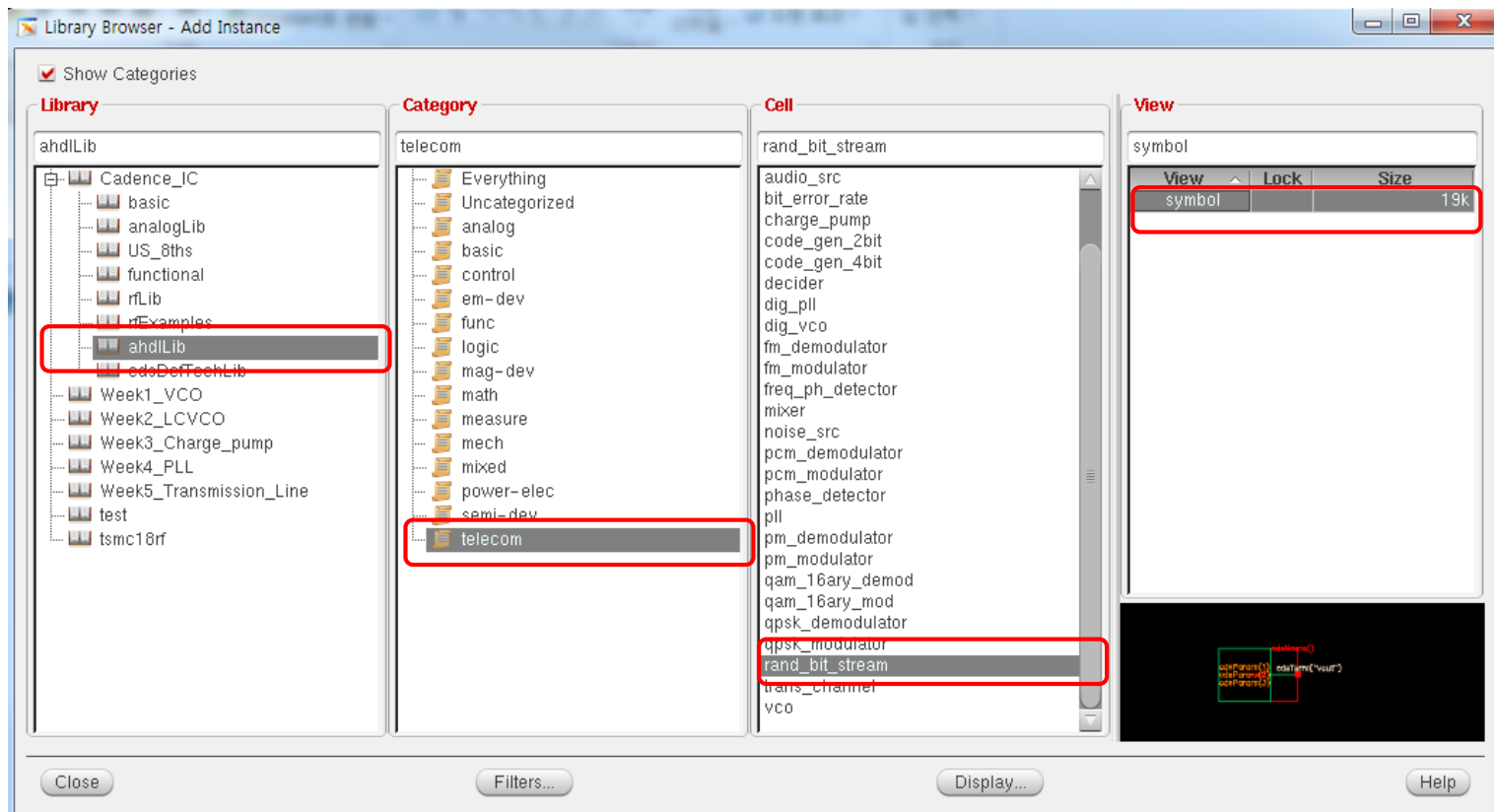


Simulation result



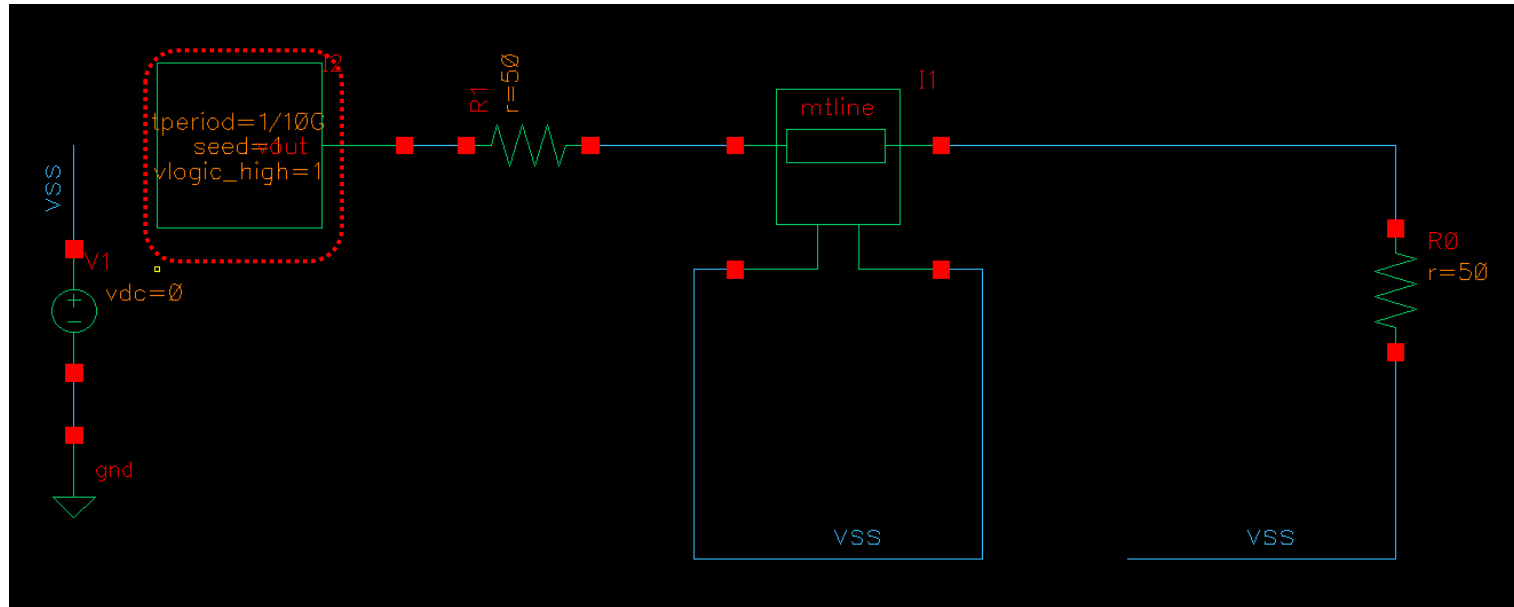
Data Transmission

- Rand-bit_stream selection
 - Cadence_IC → analogLib → telecom → rand_bit_stream → symbol



Data Transmission

Transient simulation condition

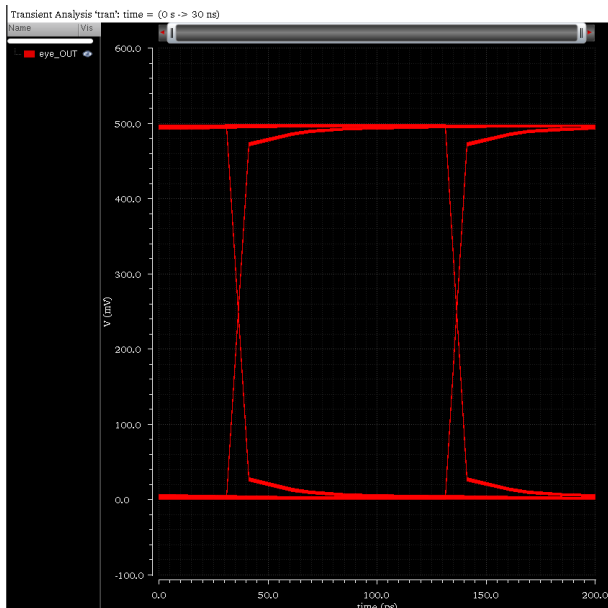


CDF Parameter of view	Use Tools Filter	Display
tperiod	1/10G	off
seed	1	off
vlogic_high	1	off
vlogic_low	0	off
tdel		off
trise	20p	off
tfall	20p	off
model		off

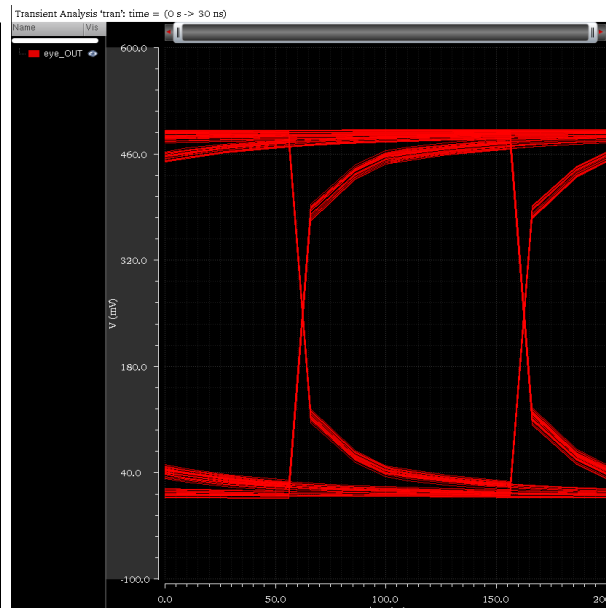
- Tperiod : 1/10G
- Seed : 1
- Vlogic_high : 1
- Vlogic_low : 0
- Trise : 10p
- Tfall : 10p

Data Transmission

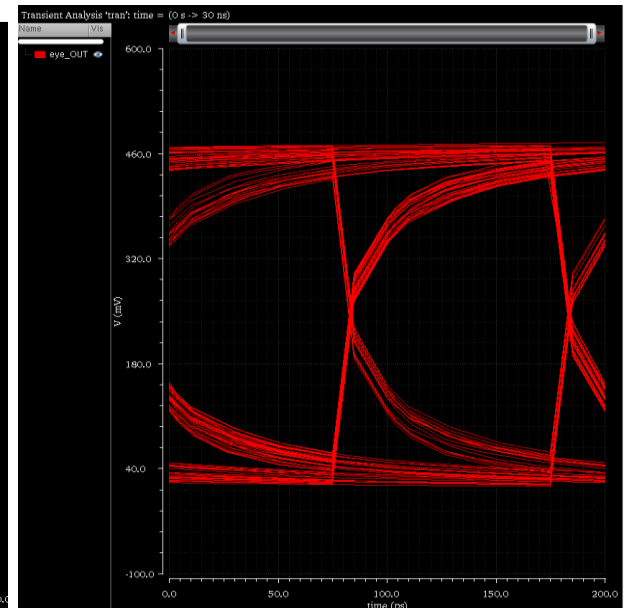
- Simulation result
 - 10Gbps datarate condition



Length : 100m



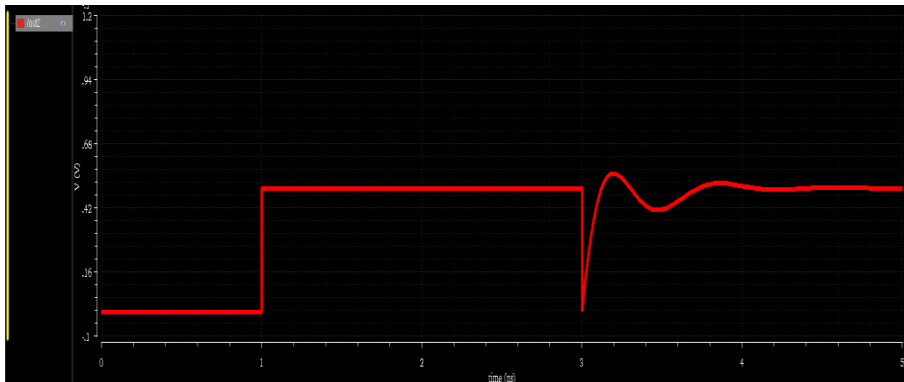
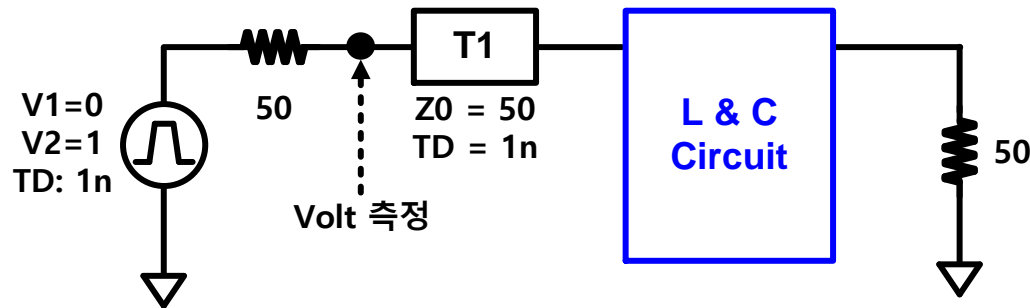
Length : 500m



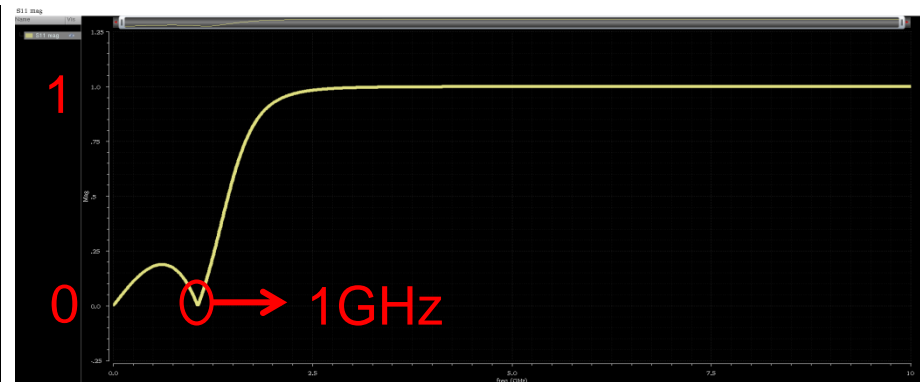
Length : 1200m

Homework 1

- TDR application : discontinuity
 - Derive L and C circuit from the given waveforms.
 - Simulate S21 and analyze characteristics of TDR & S-parameter simulation results.



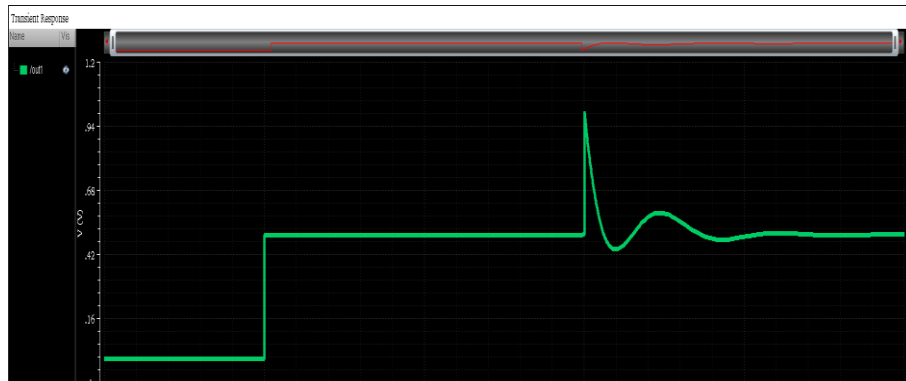
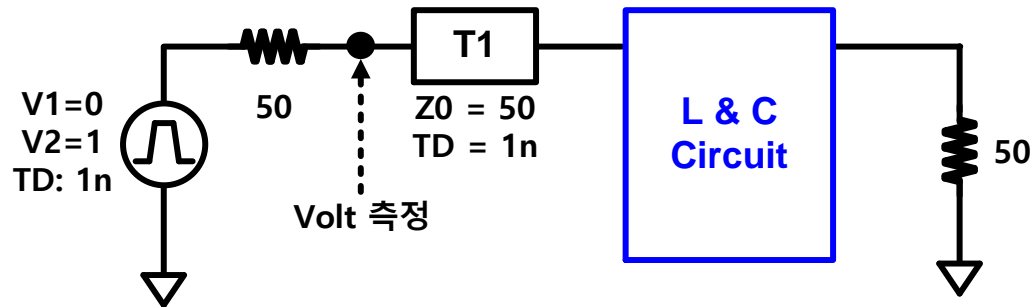
< TDR >



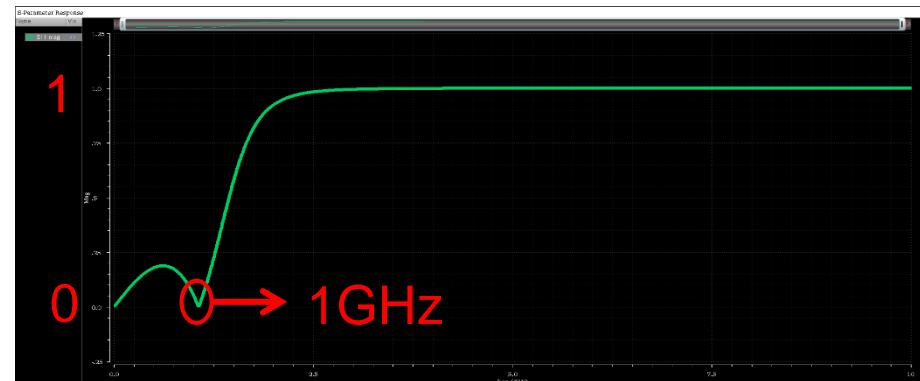
< S11 magnitude >

Homework 2

- TDR application : discontinuity
 - Derive L and C circuit from the given waveforms.
 - Simulate S21 and analyze characteristics of TDR & S-parameter simulation results.



< TDR >



< S11 magnitude >