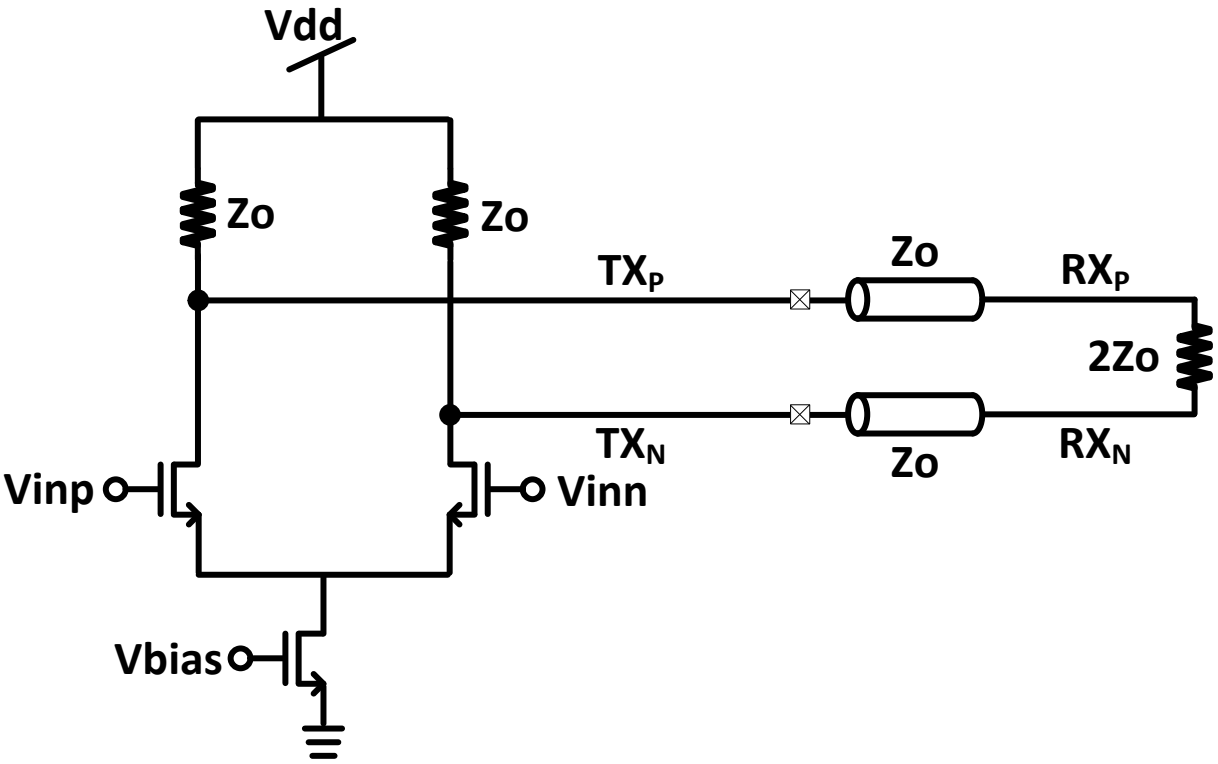
High-Speed Serial Interface Circuits and Systems

Design Exercise6 –

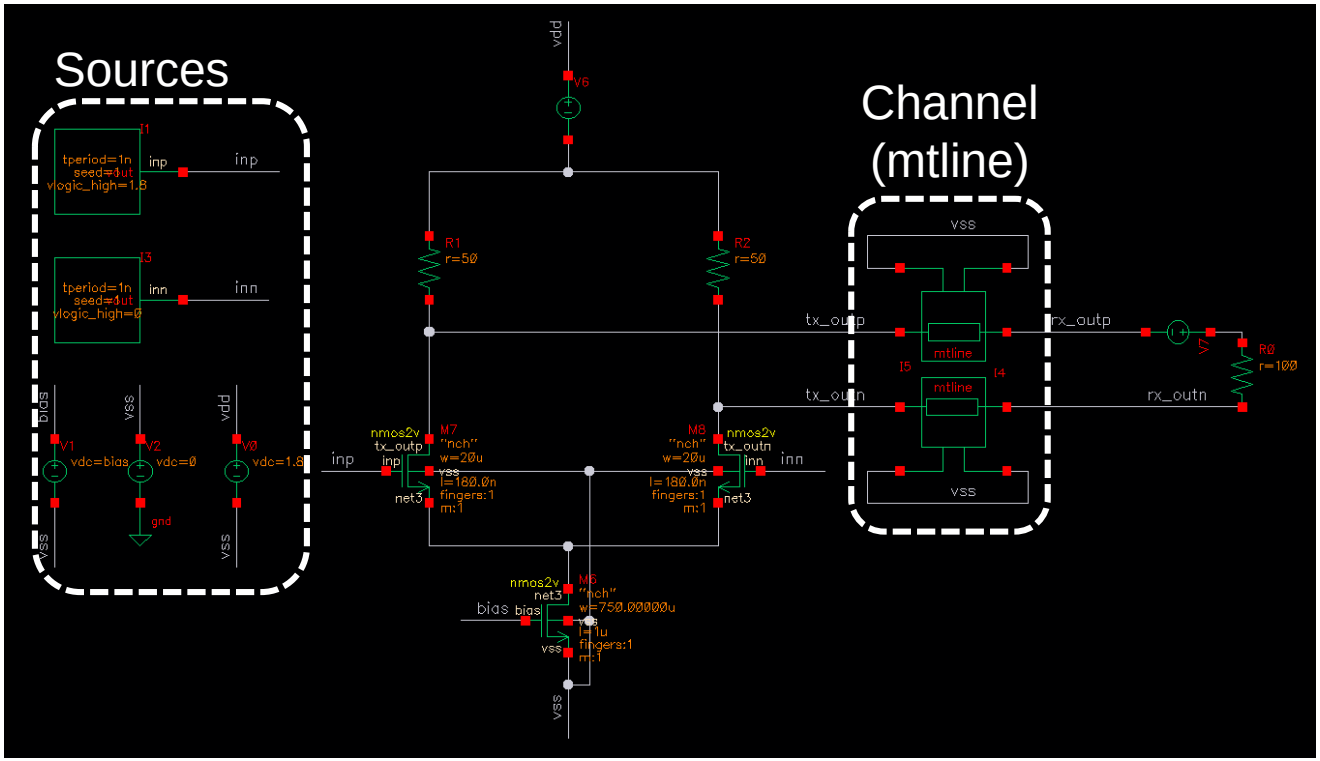
TX Drivers

Current-Mode Logic (CML) Driver



- Current Steering
- Both sides are terminated by 50Ω
- Basic structure in high-performance serial link

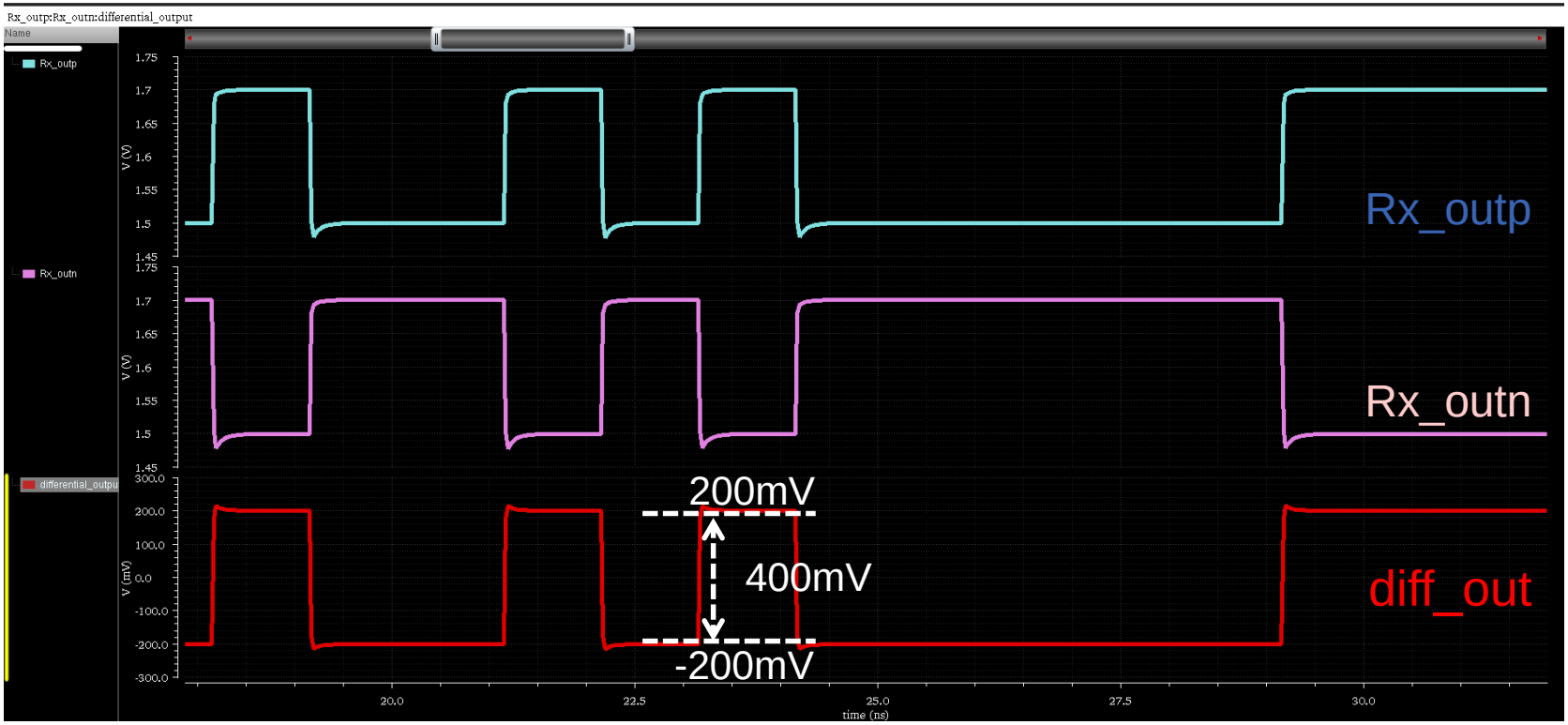
CML Driver



- Output driver Specification
  - 50Ω
  - V_outp = V_outn = 200mV
  - Vdiff_pk_pk = 400mV

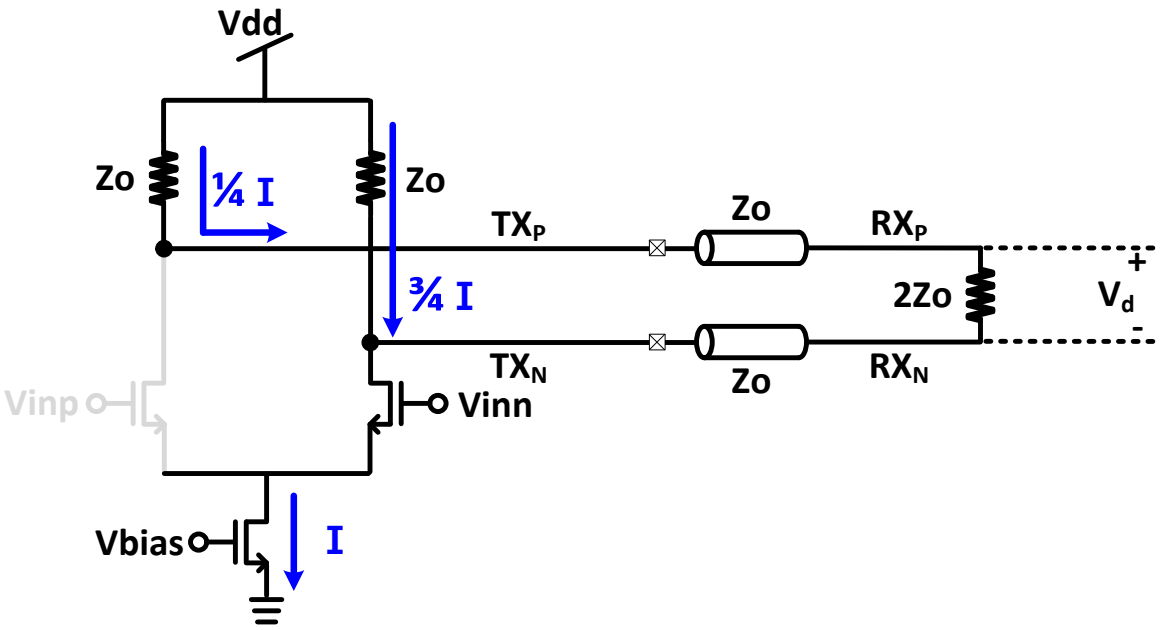
- Input MOSFET
  - Length : 180n
  - Width : 20u
- Source MOSFET
  - Length : 1u
  - Width : 750u
- Vbias
  - Voltage : 0.7
- Input_source
  - rand_bit_stream
  - Tperiod : 1n
  - Seed : 1
  - Vlogic _high : 1.8
  - Vlogic _low : 0
  - Vrise : 20p
  - Vfall : 20p
- Mtline
  - Type of Input : Tline
  - Impedance : 50ohm
  - Delay Time : 150p

CML Driver Simulation Results



CML Driver Current

- Differential termination
  - Impedance matching with differential termination : $2Z_O$



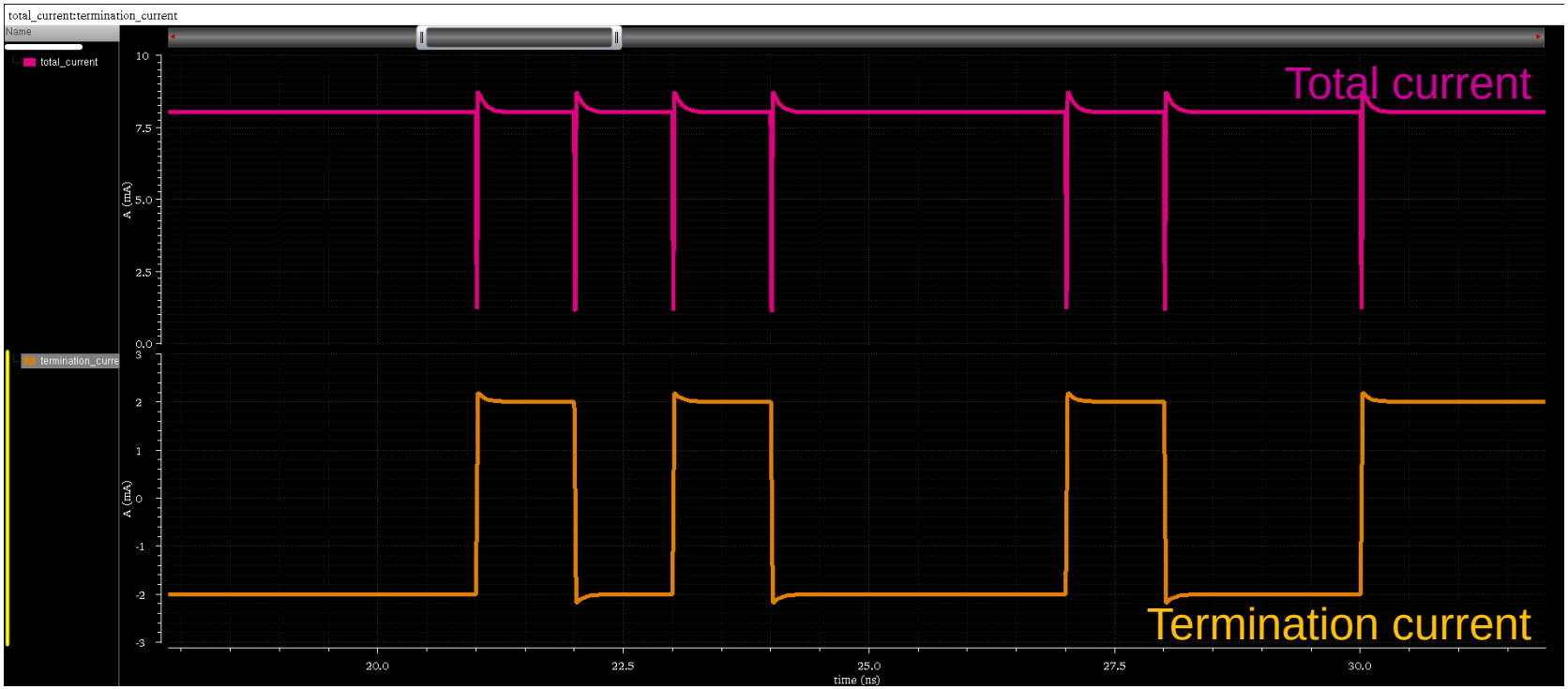
$$V_{d\_1} = (I/4)(2R)$$

$$V_{d\_0} = -(I/4)(2R)$$

$$V_{d\_pp} = IR$$

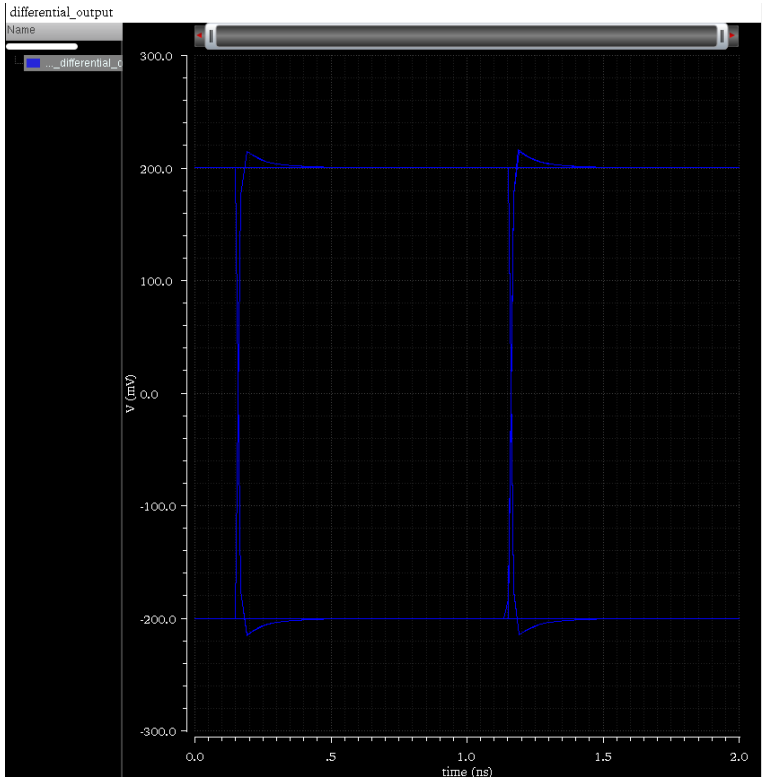
$$I = \frac{V_{d\_pp}}{R}$$

Simulation Results (Current)

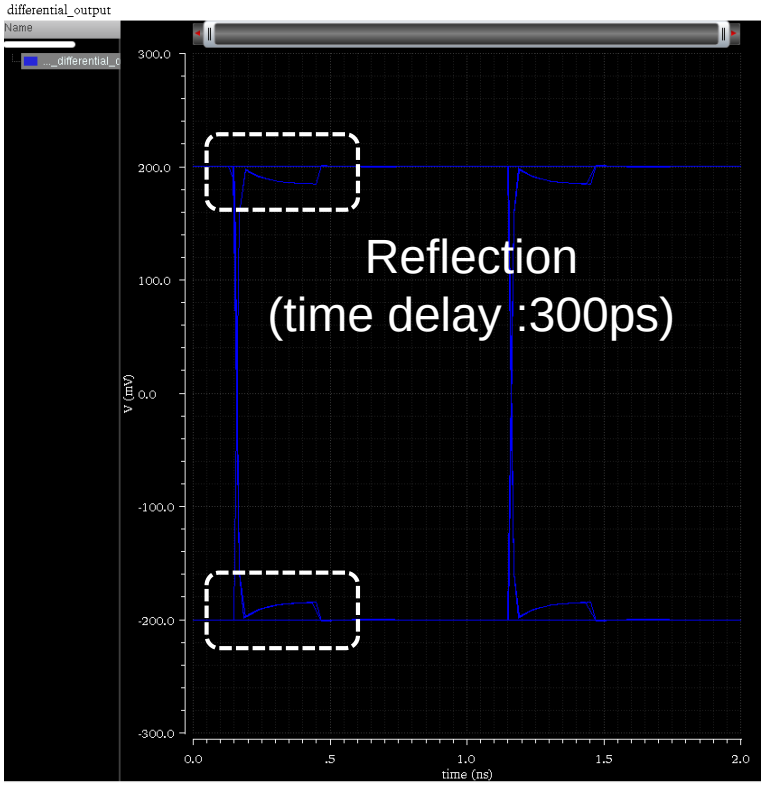


- Total RMS current : 8.0 mA (V_{diff_pp} 400mV condition)
- Termination RMS current : 2.0 mA (V_{diff_pp} 400mV condition)

Simulation Results (Different Z_0)



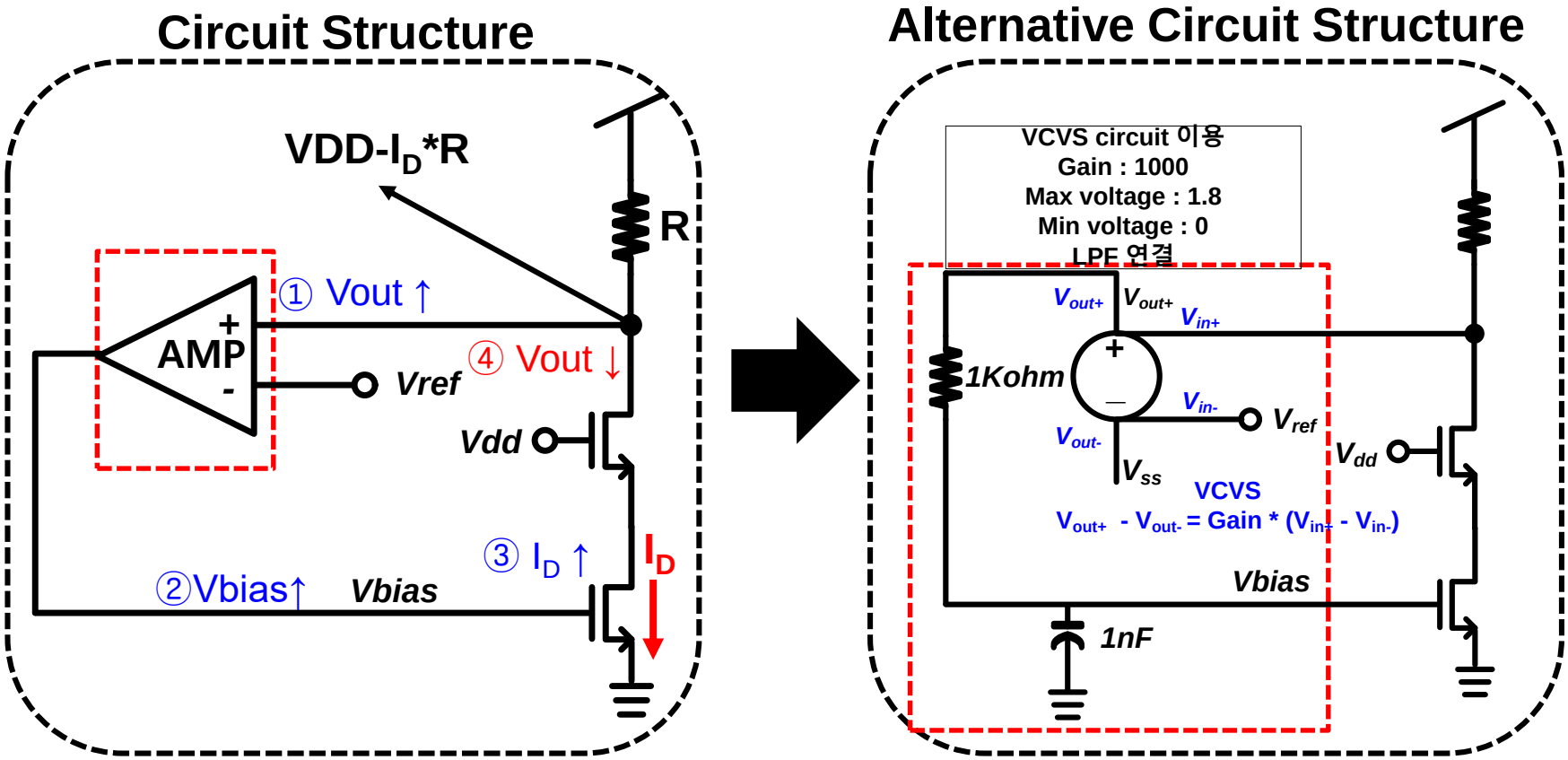
Transmission Line : 50ohm



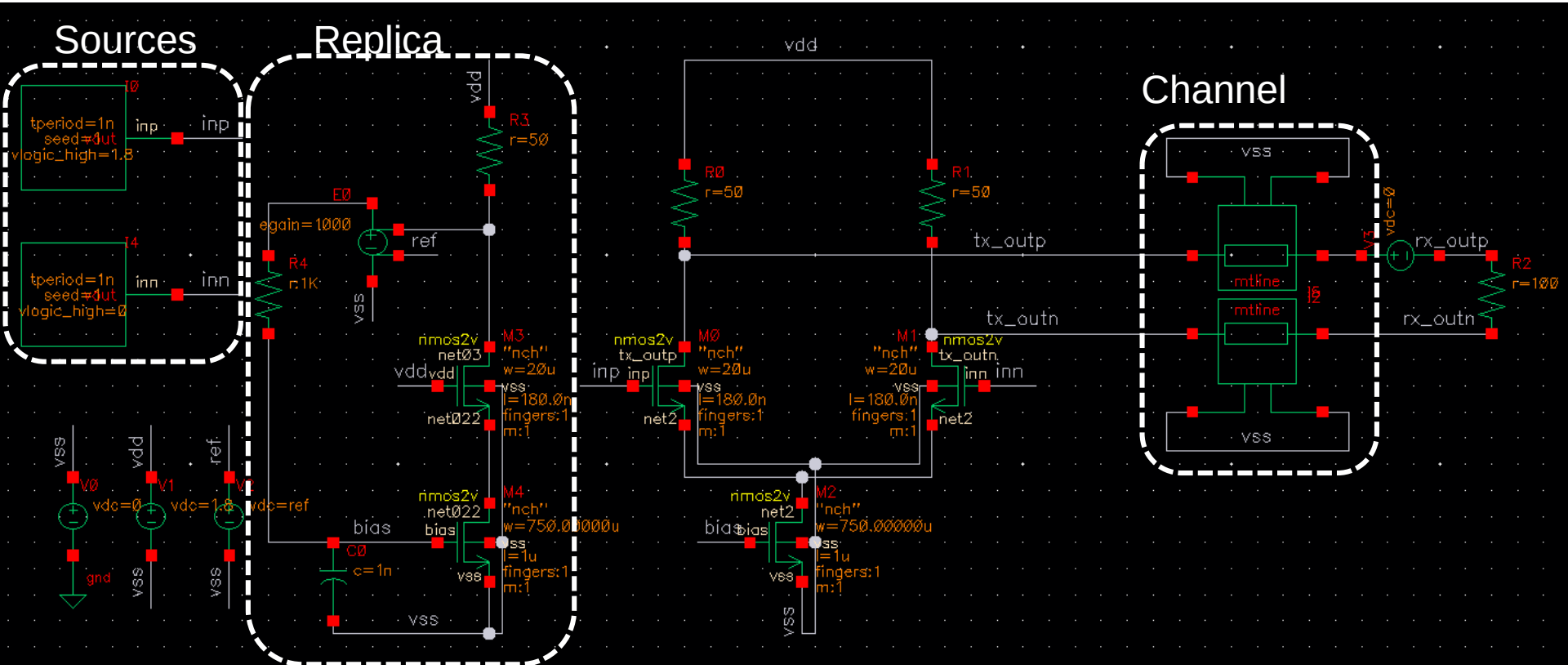
Transmission Line : 75ohm

Replica Circuit for Output Swing

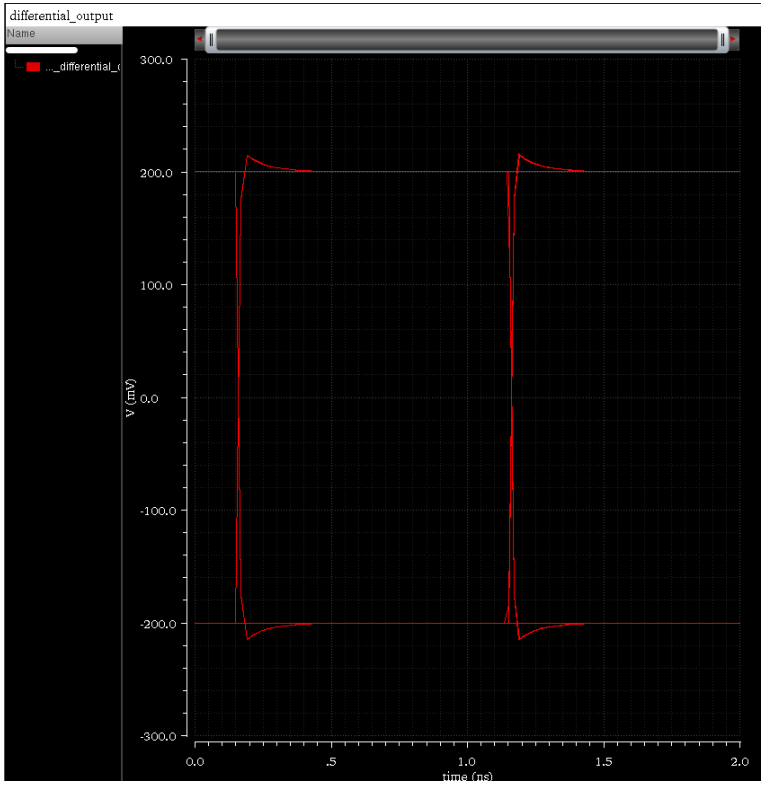
- Output swing voltage control
- Negative feedback



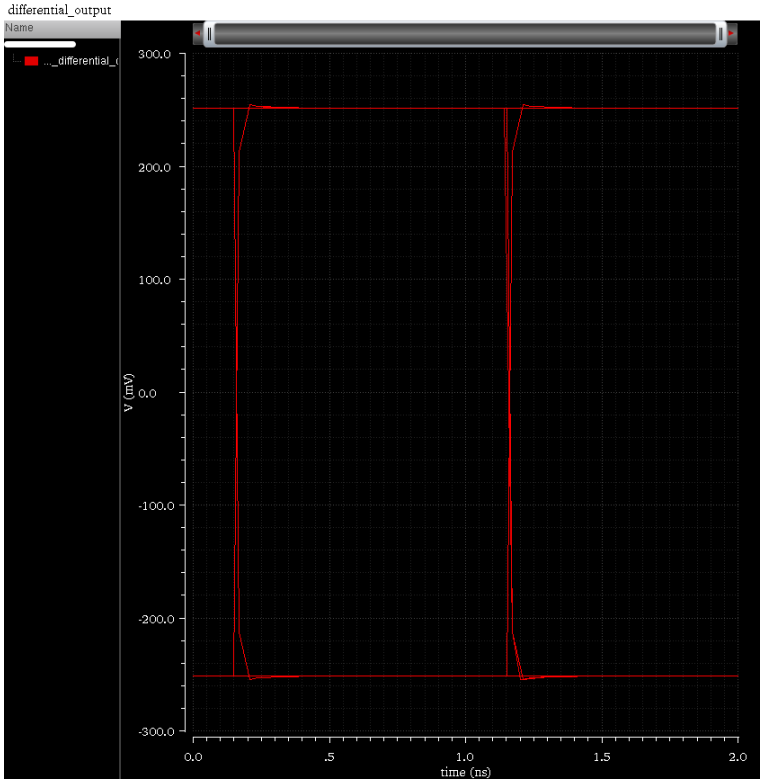
CML Driver w/ Replica



Simulation Results for Different Swing

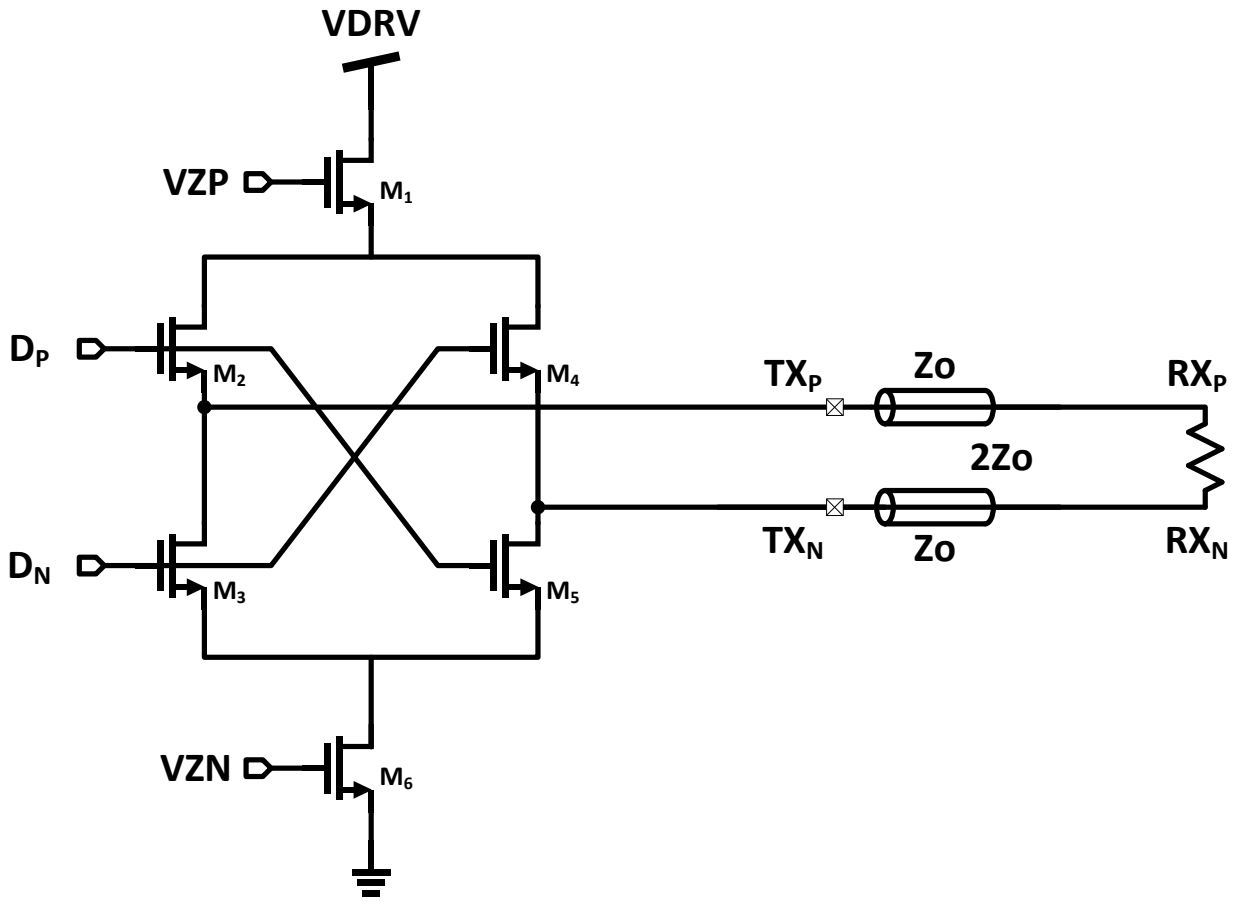


V_diff_pp : 400mV
(V_{ref} = 1.8 – 0.4 V)
Total RMS current : 16.0 mA

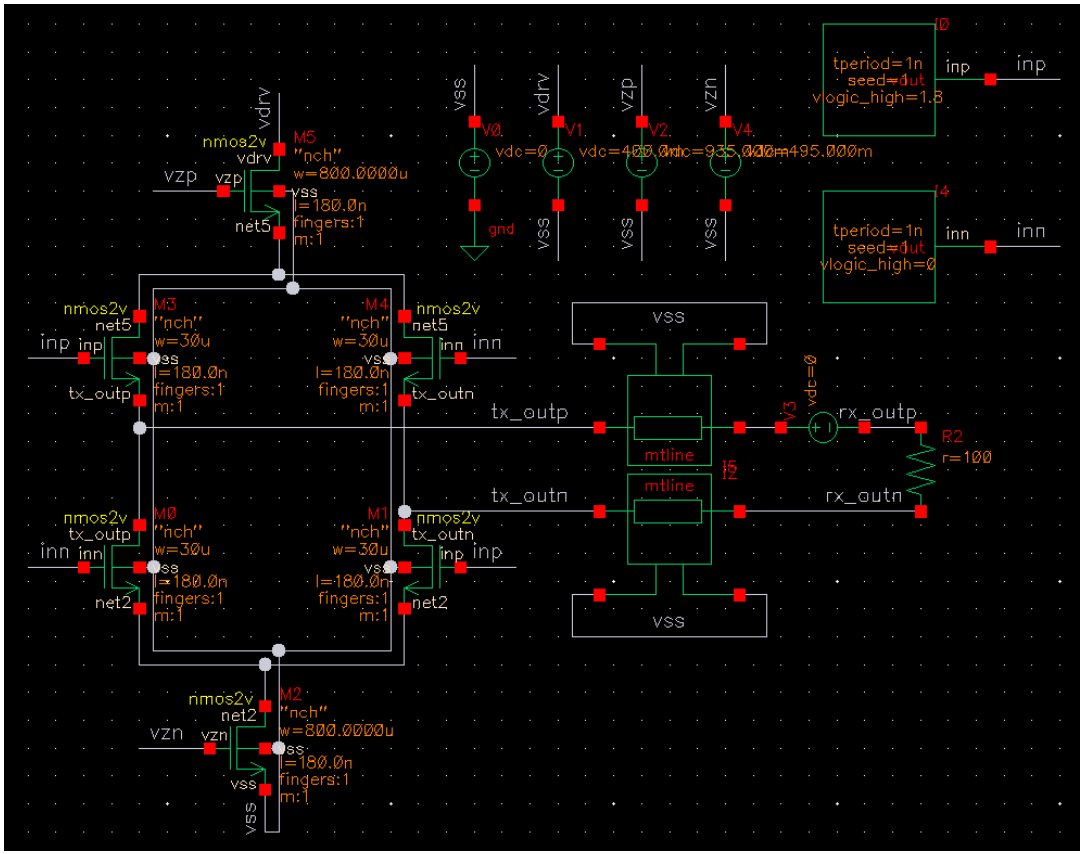


V_diff_pp : 500mV
(V_{ref} = 1.8 – 0.5 V)
Total RMS current : 20.0 mA

Voltage-Mode (VM) Driver



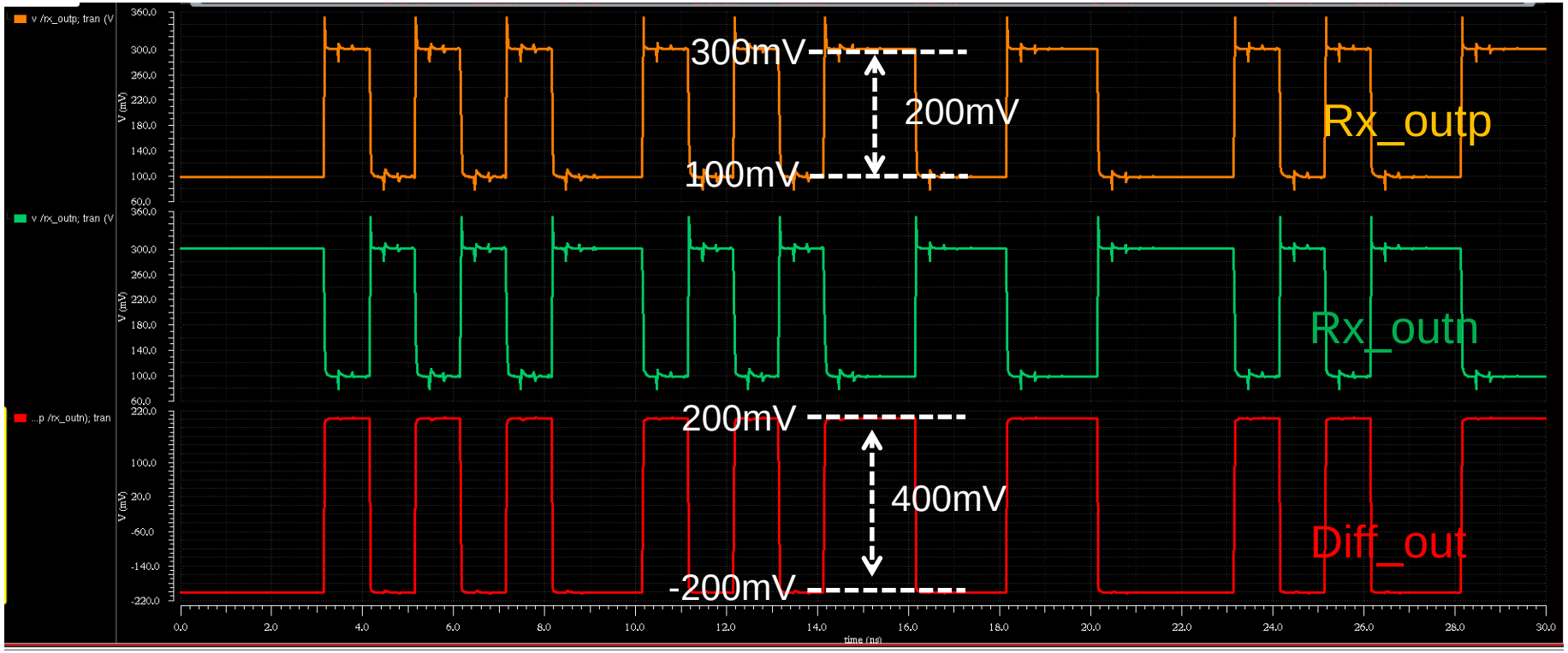
VM Driver Schematic



- Output driver Specification
  - **50Ω**
  - **Vdiff_outp = 200mV**
  - **Vdiff_pk_pk = 400mV**

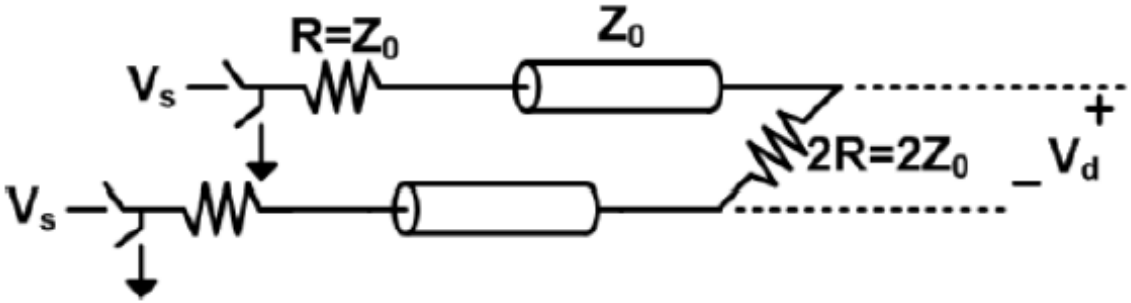
- Input MOSFET
  - Length : 180n
  - Width : 30u
- Current source MOSFET
  - Length : 180n
  - Width : 800u
- VZP bias
  - Voltage : 935mV
- VZN bias
  - Voltage : 495mV
- VDRV
  - Voltage : 400mV

Simulation Results



VM Driver Current

- Differential termination
  - Impedance matching with differential termination : $2Z_O$



$$V_{d\_1} = (V_s / 2)$$

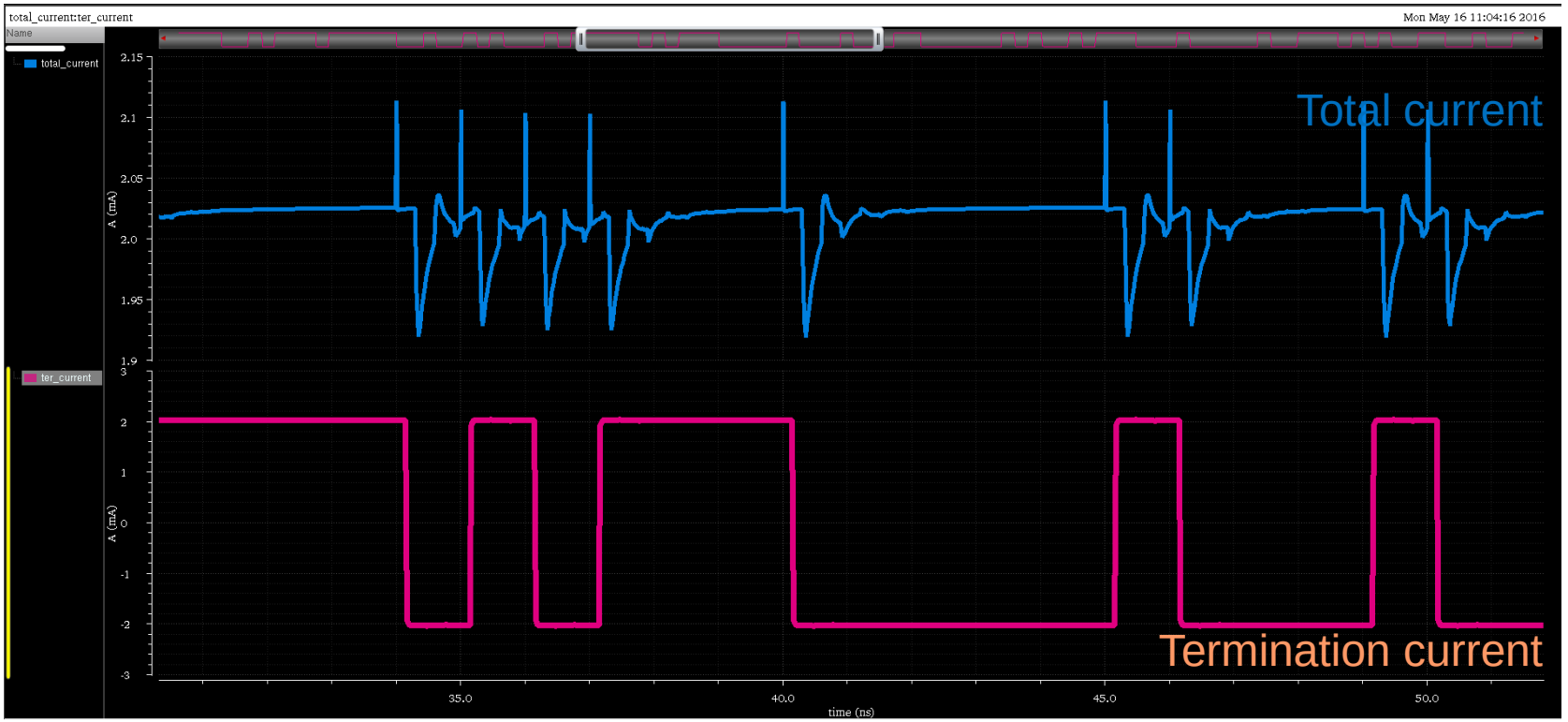
$$V_{d\_0} = -(V_s / 2)$$

$$V_{d\_pp} = V_s$$

$$I = \frac{V_{d\_pp}}{4R}$$

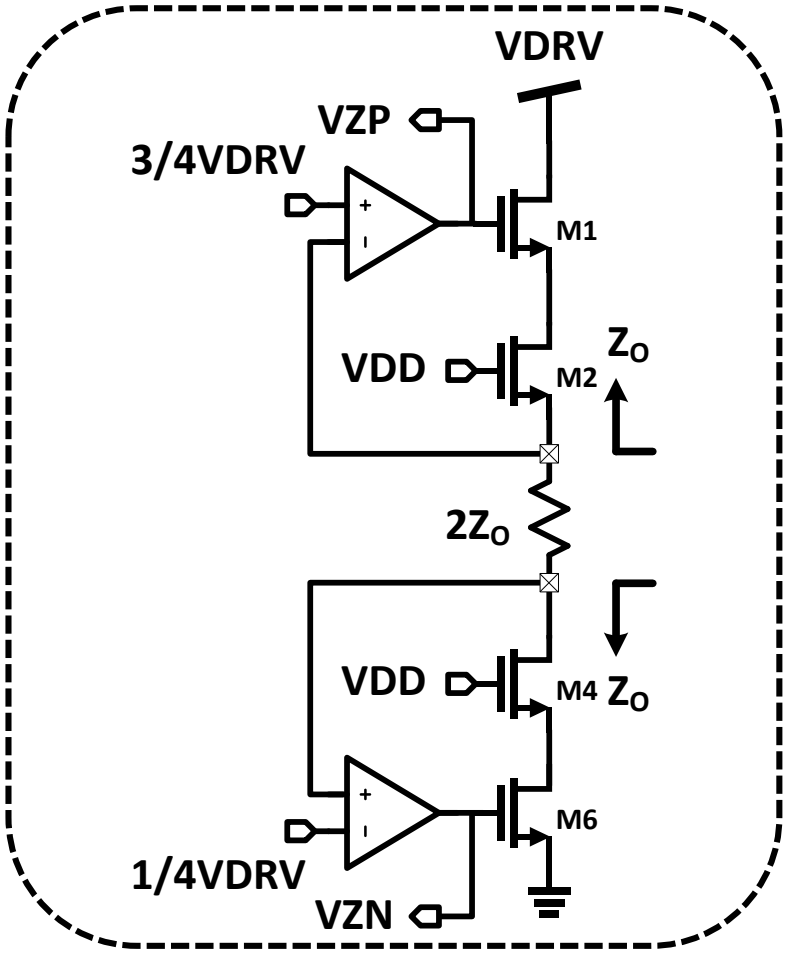
Simulation Results (Current)

- Total RMS current : 2.0 mA (V_{diff_pp} 400mV condition)
- Termination RMS current : 2.0 mA (V_{diff_pp} 400mV condition)

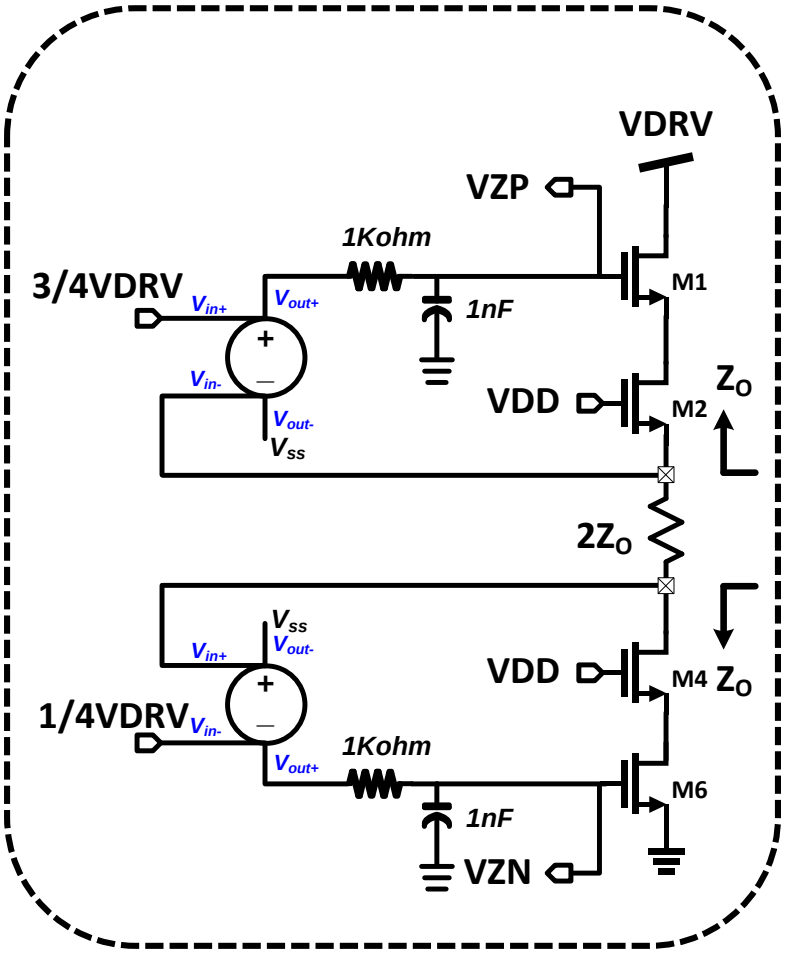


Replica Circuit for VM Driver

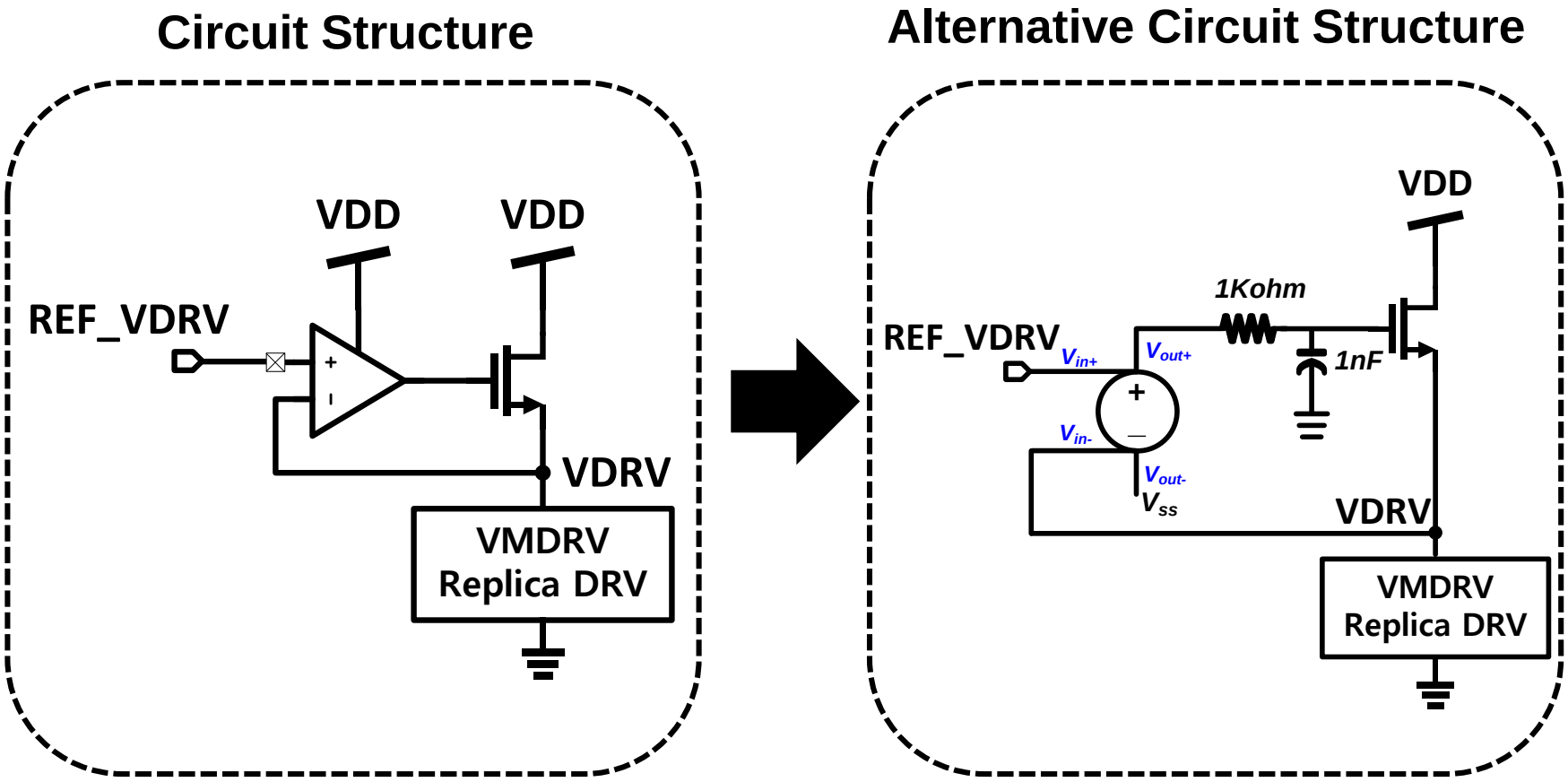
Circuit Structure



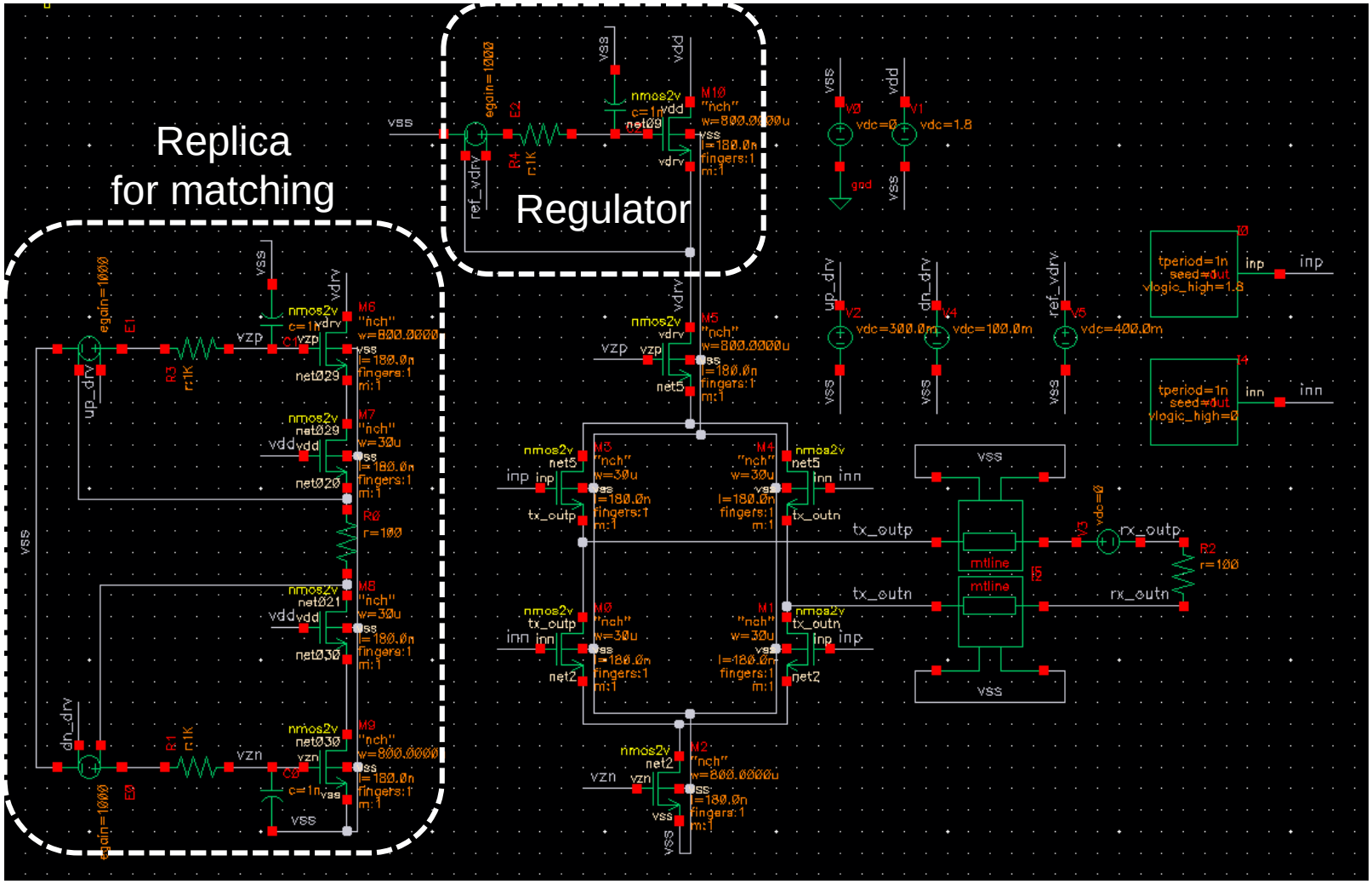
Alternative Circuit Structure



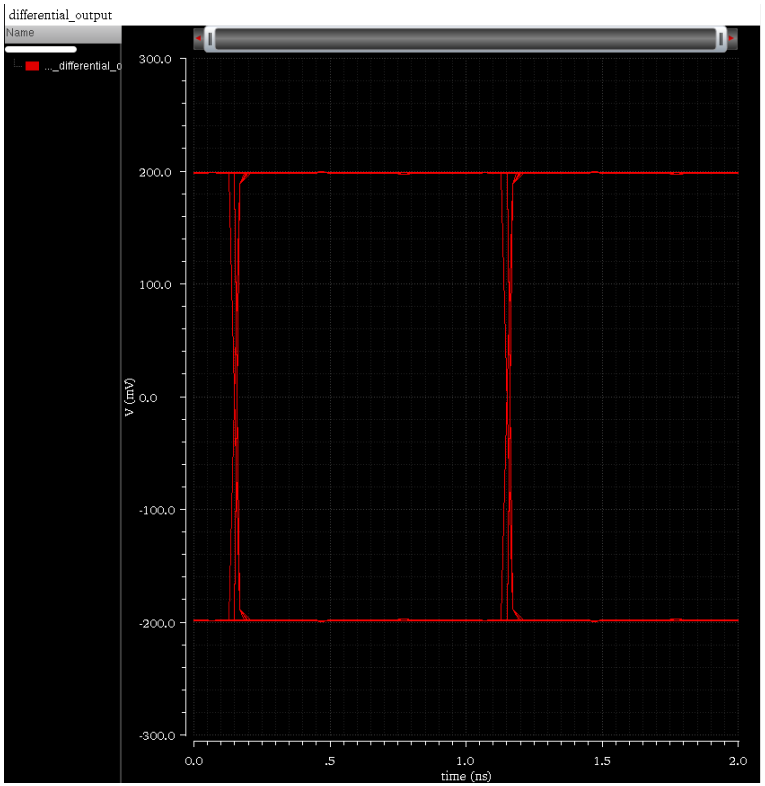
Regulator Circuit for VM Driver



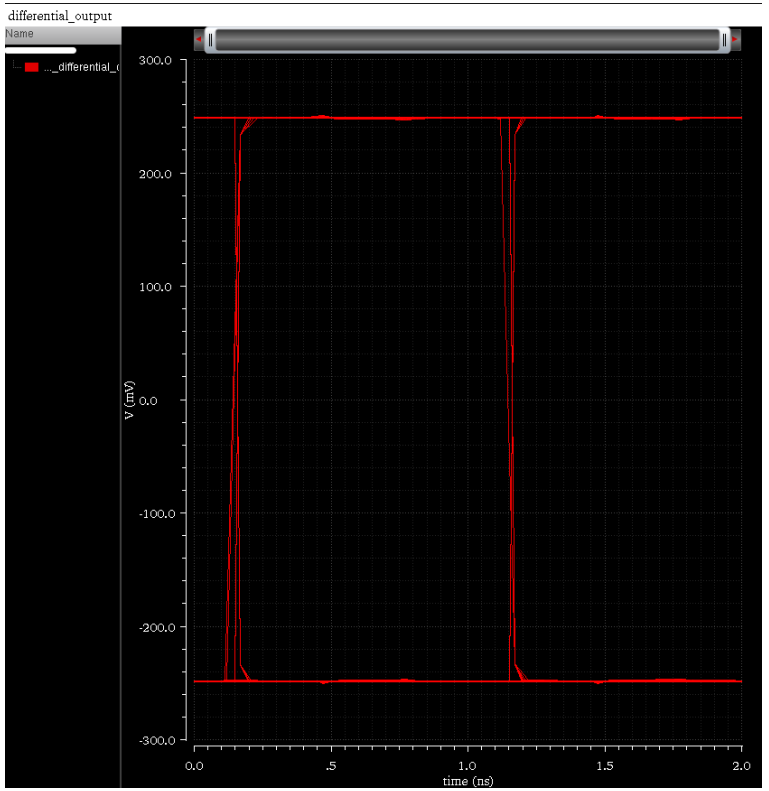
VM Driver w/ Replica



Simulation Results for Different Swing

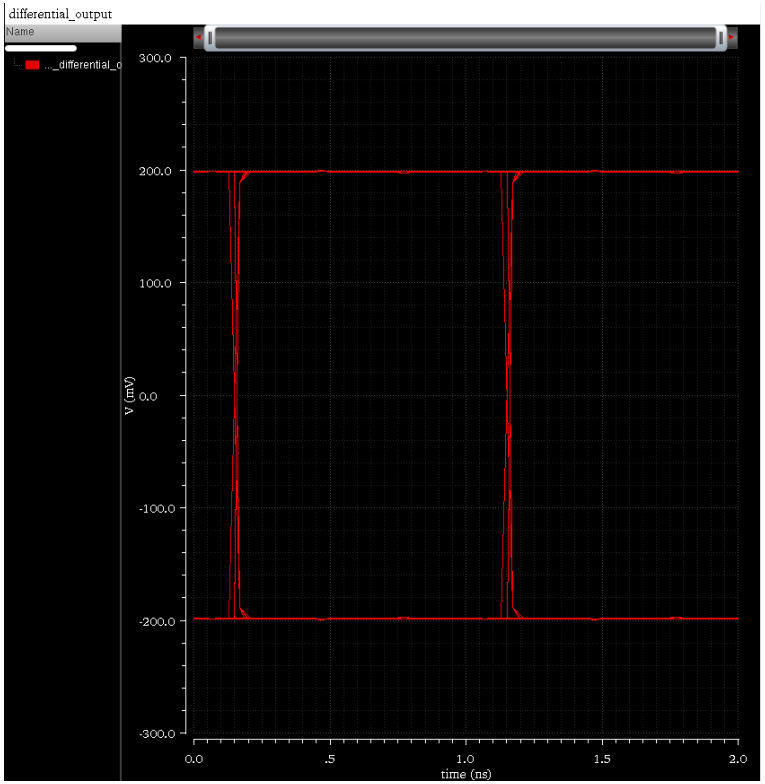


V_diff_pp : 400mV
Total RMS current : 4.0 mA

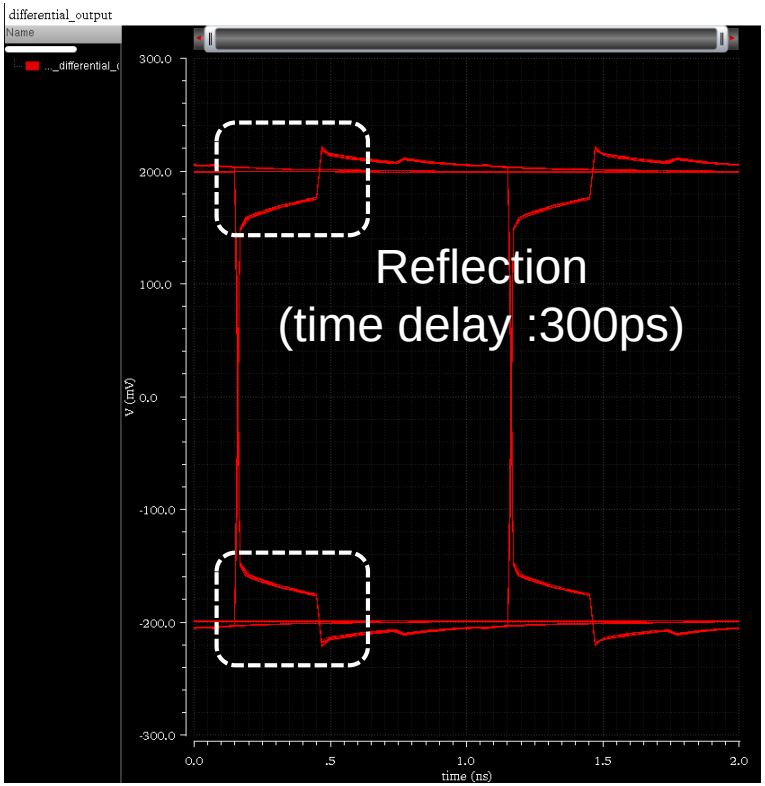


V_diff_pp : 500mV
Total RMS current : 5.0 mA

Simulation Results (Different Z_0)



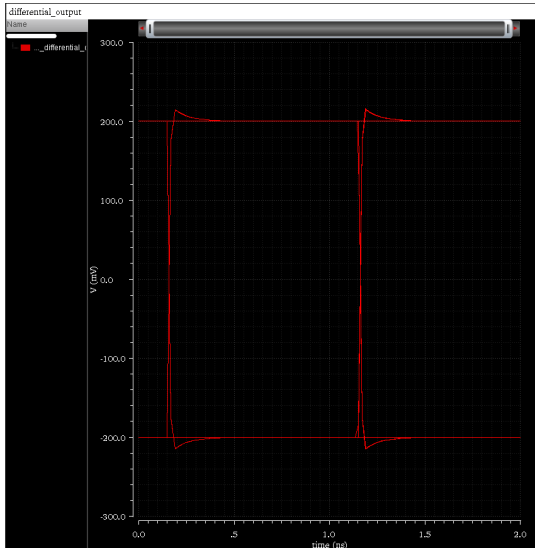
Transmission Line : 50ohm



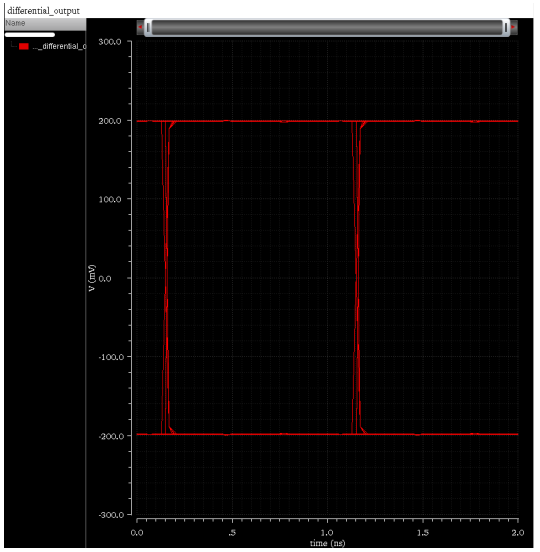
Transmission Line : 75ohm

Power Consumption Comparison

- Current mode output driver
  - RMS current : 16.0 mA (V_{diff_pp} 400mV condition)
- Voltage mode output driver
  - RMS current : 4.0 mA (V_{diff_pp} 400mV condition)



Current mode output driver



Voltage mode output driver

Homework

- Current mode and voltage mode output driver
  - Design $V_{diff,p2p}$ 600mV Current and voltage mode driver with 50ohm impedance.
    - Derive mosfet size.
    - Plot the output waveform and current waveform.
    - Compare and analyze between current mode and voltage mode output driver.
    - Plot the eye diagram in case of transmission line impedance 75ohm and 50ohm. (Differential Rx termination 50ohm condition)
    - Plot the eye diagram in case of differential Rx termination 75ohm and 50ohm. (Transmission line impedance 50ohm condition)