# *Ultra-Low Swing Transceiver for Energy Efficient Communiction in 2.5-D Integrated Systems*

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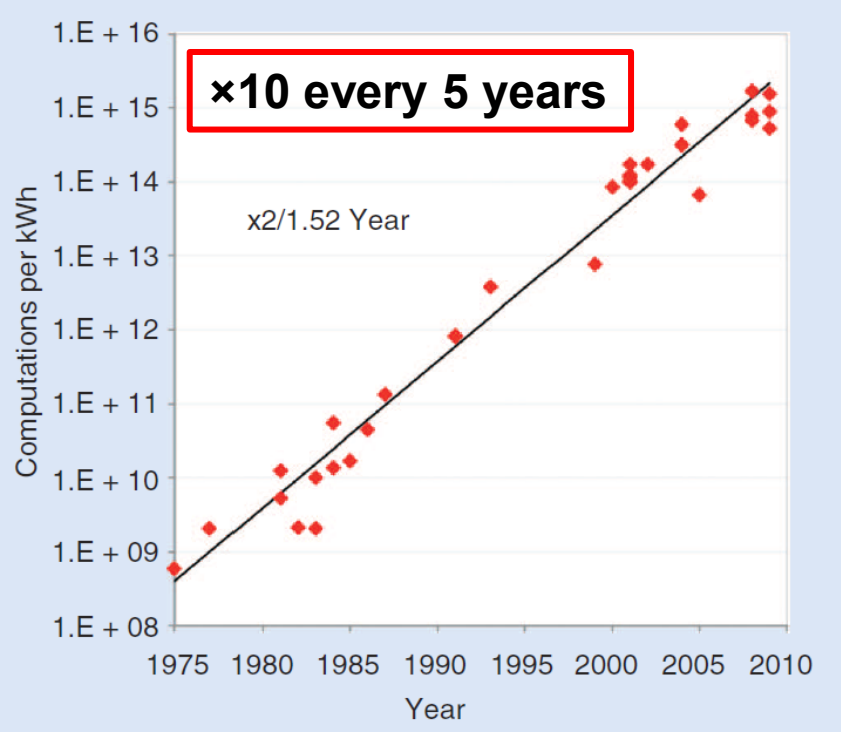
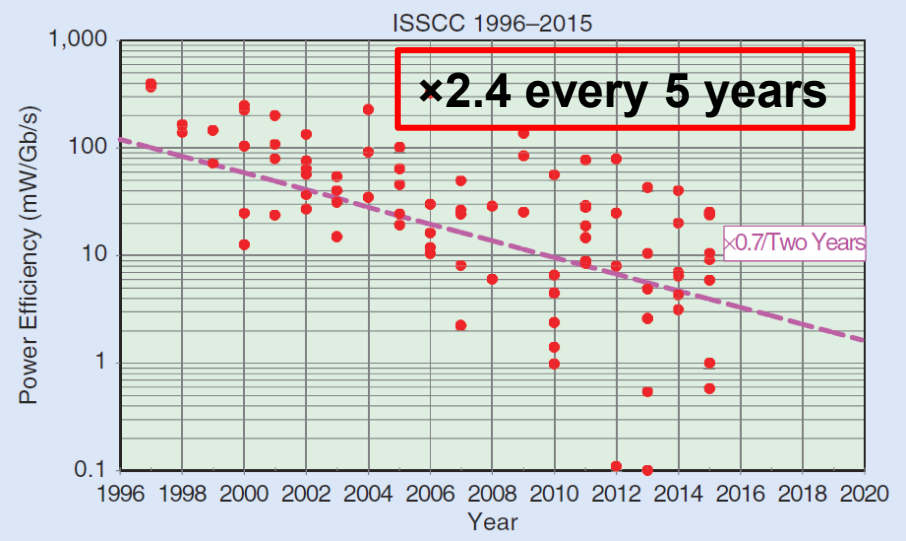
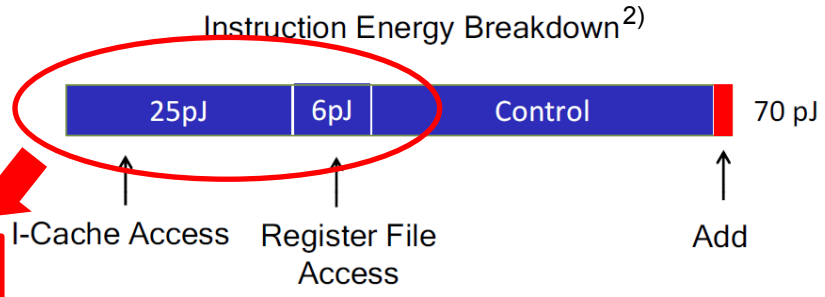
# Why Communication matters?

*Computation energy efficiency trend* [1)]




*Communication energy efficiency trend* [1)]

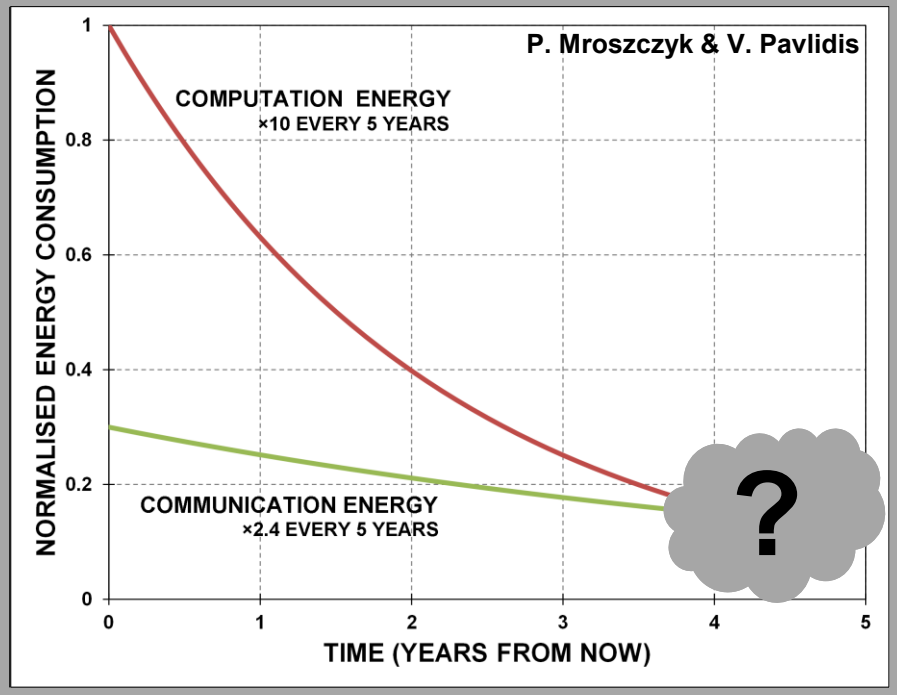


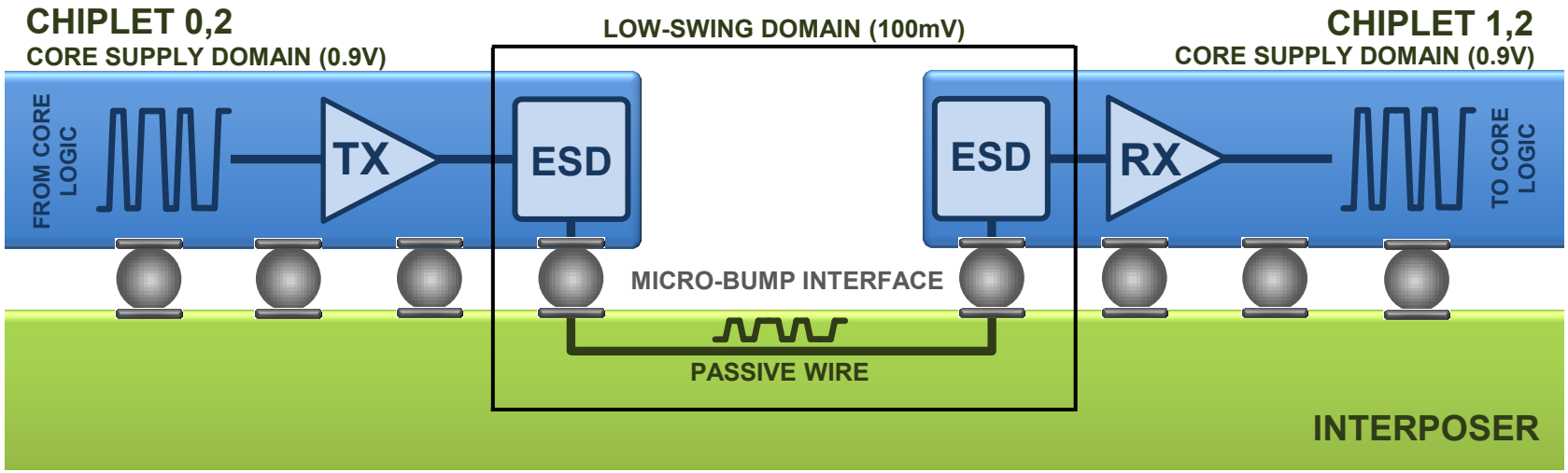

**~30% of energy for communication**


1) H. Tamura, "Looking to the Future: Projected Requirements for Wireline Communications Technology", IEEE Solid-State Circuits Magazine, Vol. 7, No 4, pp. 53 – 62, 2015.
2) M. Horowitz, "Computing's energy problem (and what we can do about it)", IEEE International Solid-State Circuits Conference, pp. 10 – 14, Mar. 2014

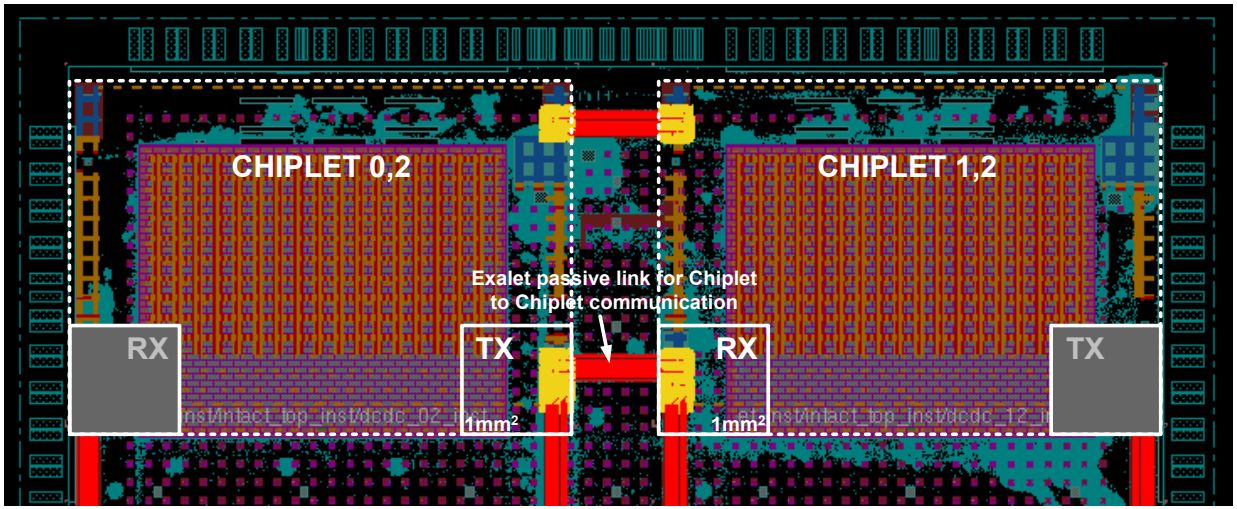
# Why Communication matters?



# 2.5-D Chiplet to Chiplet Physical Interconnect




*Cross section of the interconnect with single-ended low swing I/O interface*



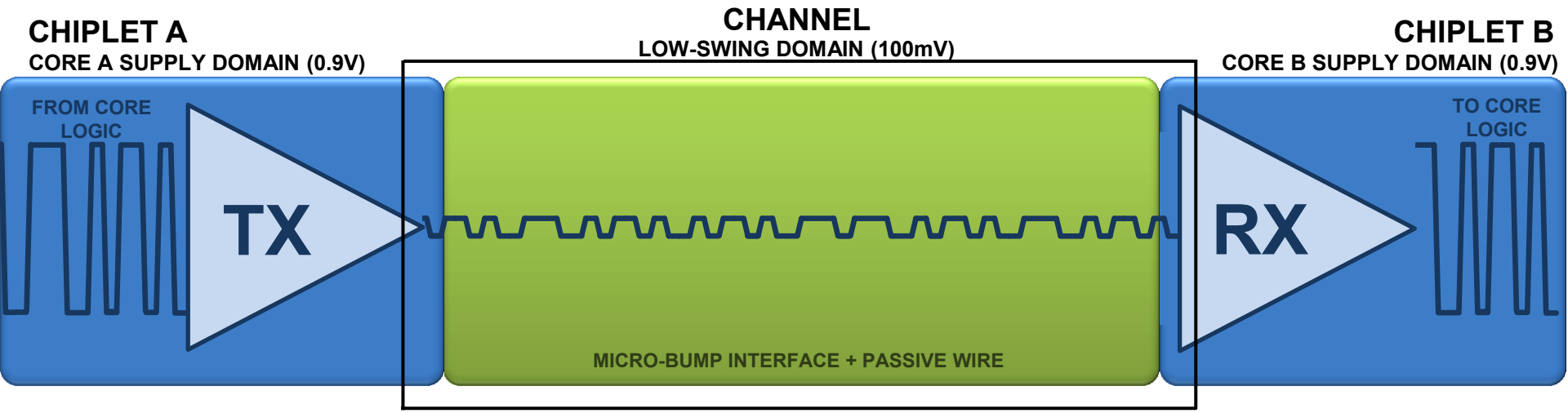

*Physical view of the interposer with the projected location of the transceiver and the passive link*

# Low Swing Signaling Scheme

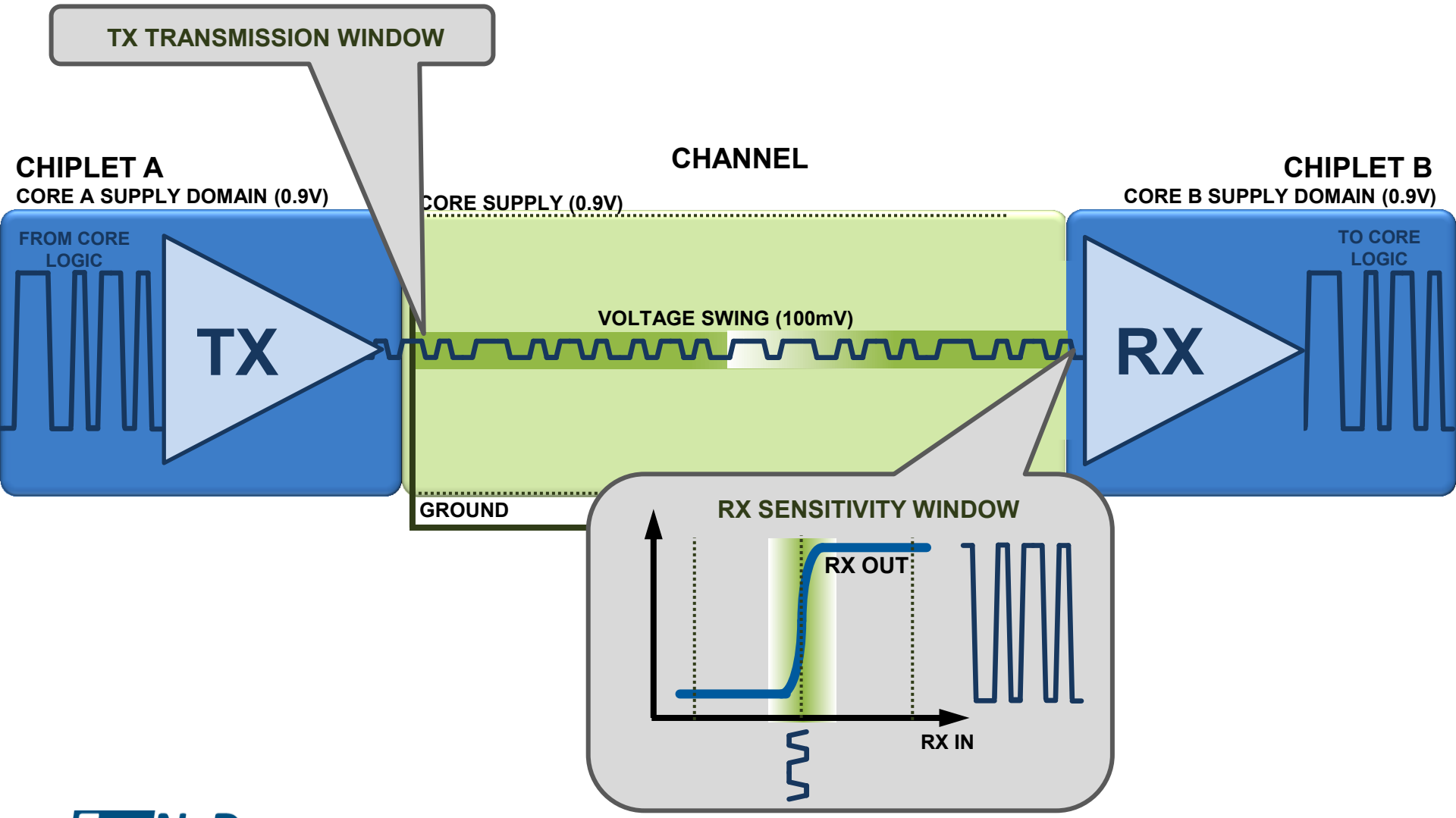
**ENERGY ~ DISTANCE × VOLTAGE²**

ExaNoDe

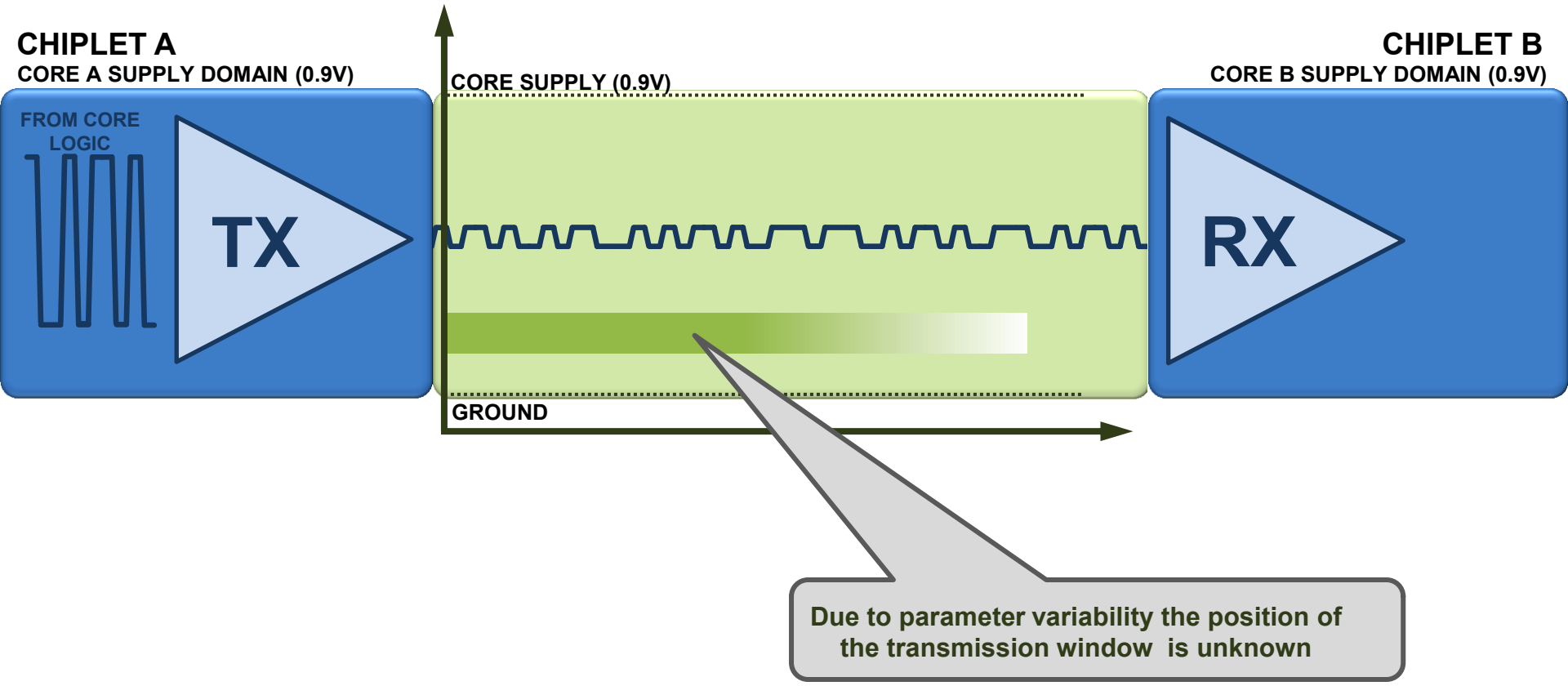
Low Swing



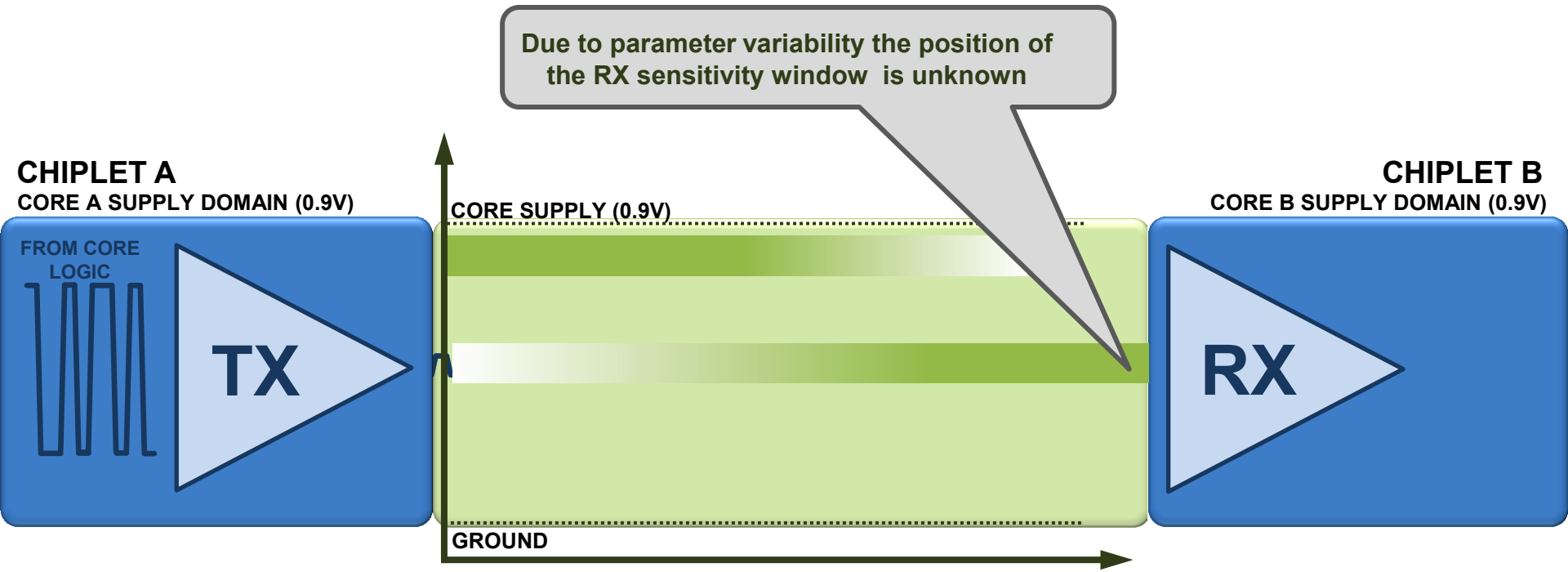
# Transmitter and Receiver Design



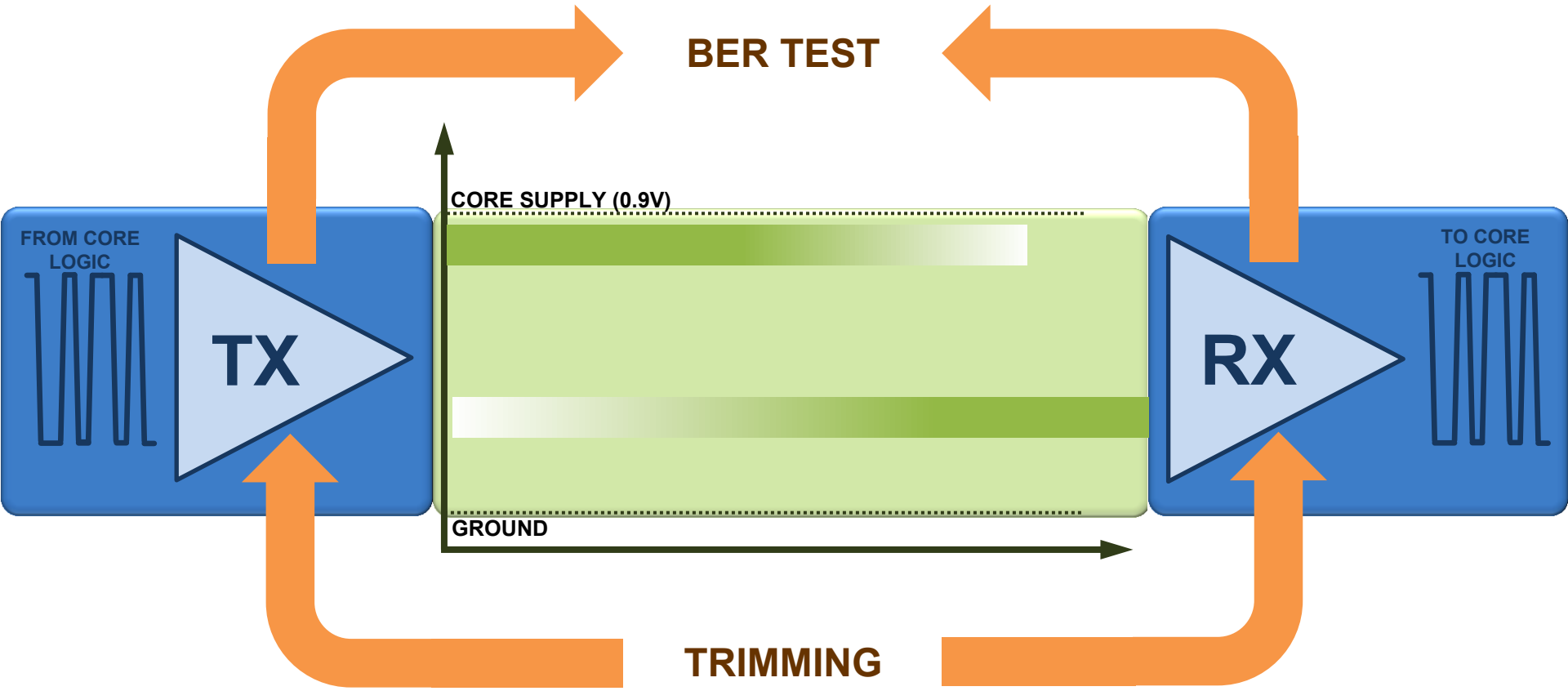
# Parameter Variability in TX



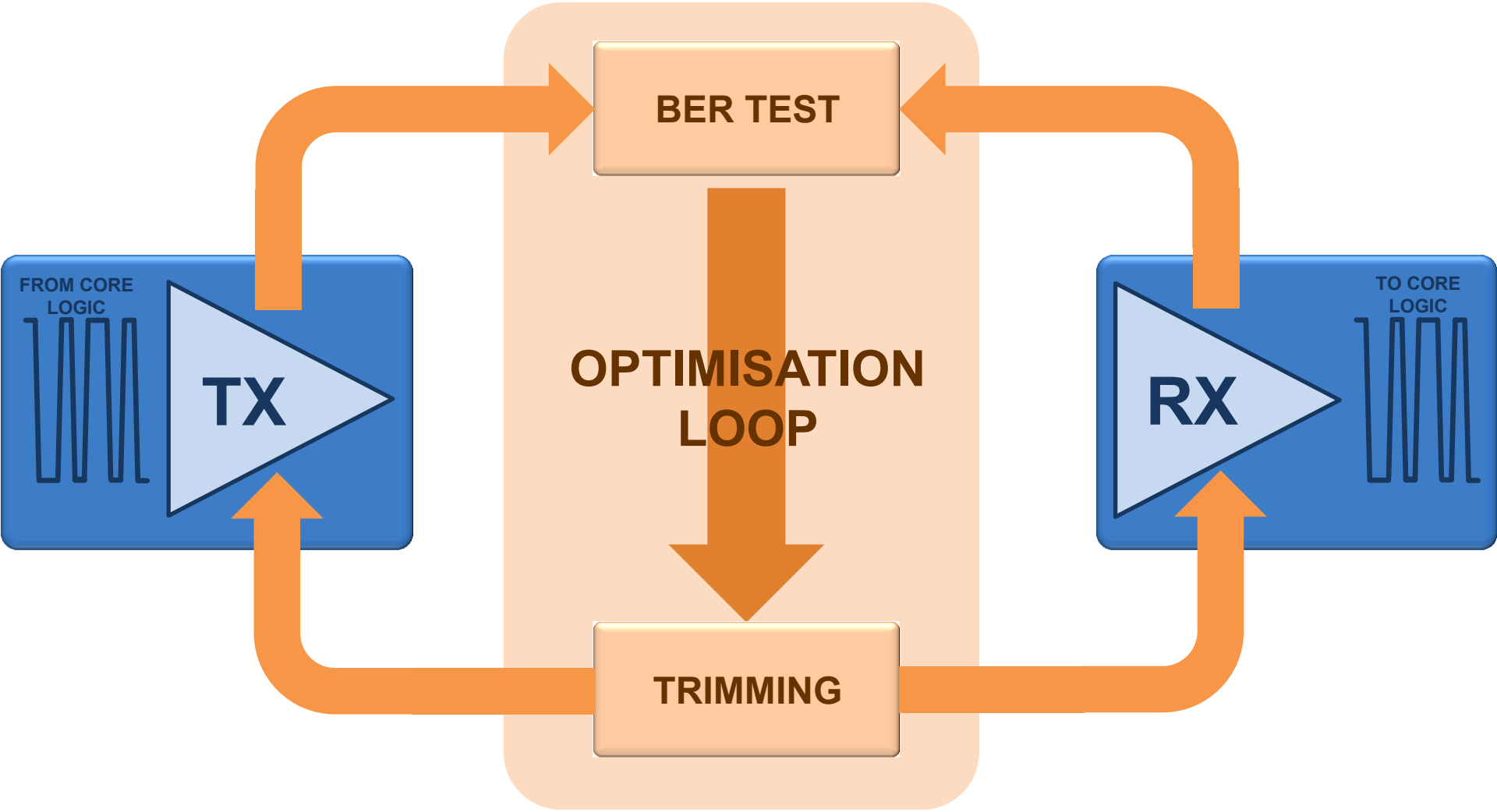
# Parameter Variability in RX



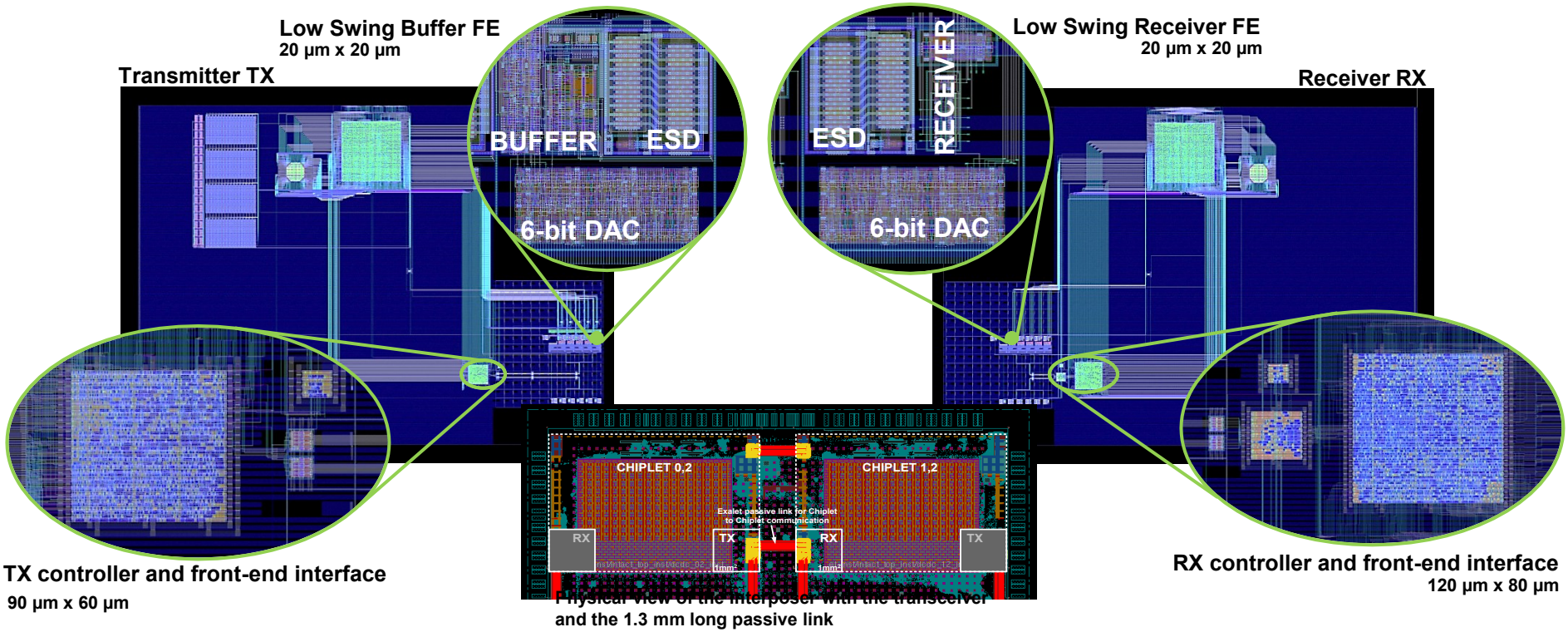
# Transceiver Trimming



# Transceiver Optimization



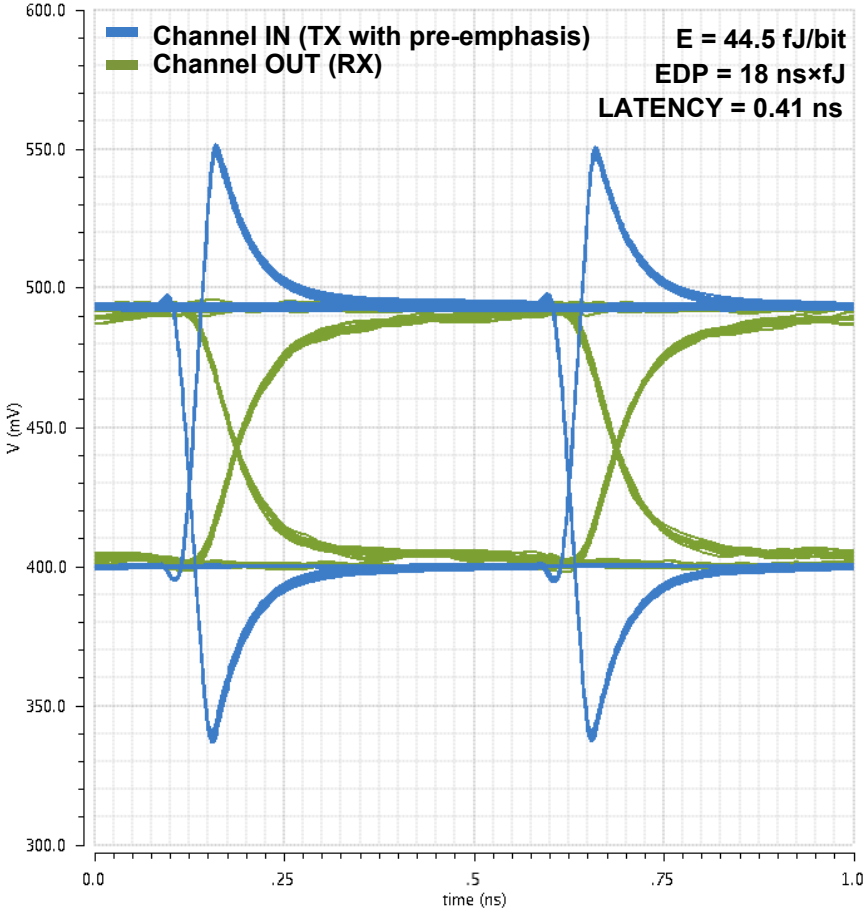
# EMI v1.0 Transceiver in 28nm FDSOI

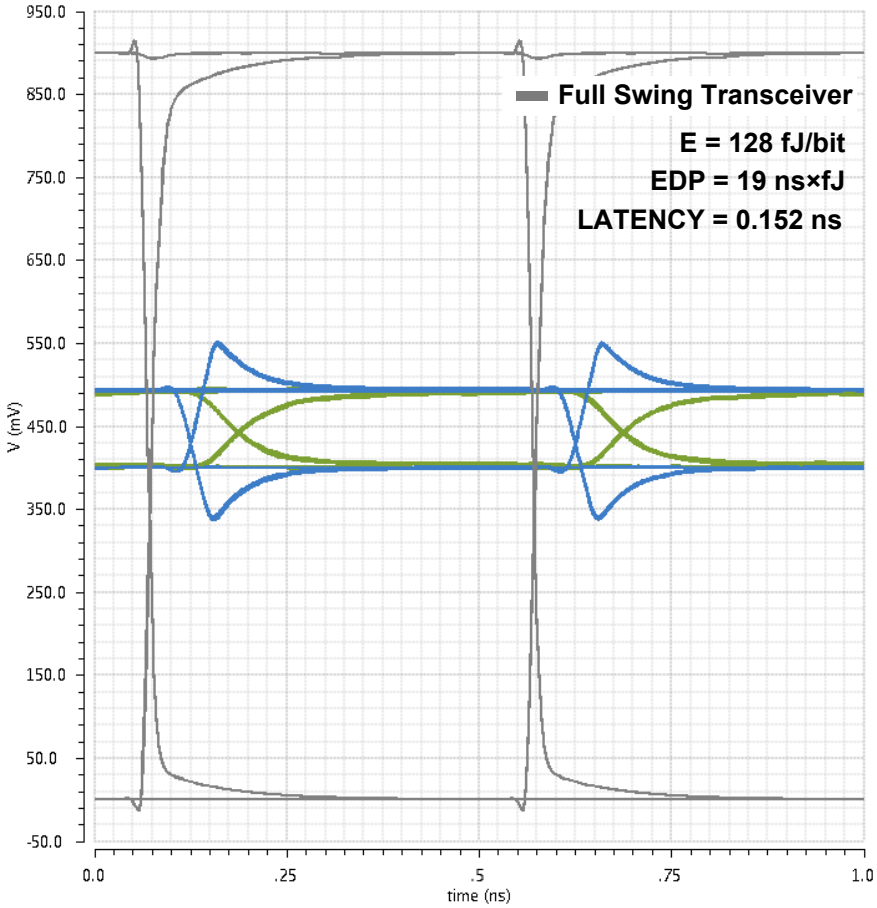



- **Exascale Manchester Interconnect (EMI) v1.0:**
  - Energy: **44.5 fJ/bit**, Speed: **2 Gb/s/wire** (SDR), bandwidth: **256 Gb/s** (128-wire link), **5 Tb/s/mm²**
  - Advanced body biasing scheme for parameter variability trimming
  - Up to **3× less power consumption** compared to a standard full swing solution (< 0.1 pJ/bit)
  - Over **5× less switching noise** compared to a standard full swing solution
  - Latency: 2 clock cycles from TX to RX (0.41 ns for level conversion and signal prapagation)

# EMI v1.0 in 28nm FDSOI with ExaLet (1.3mm)

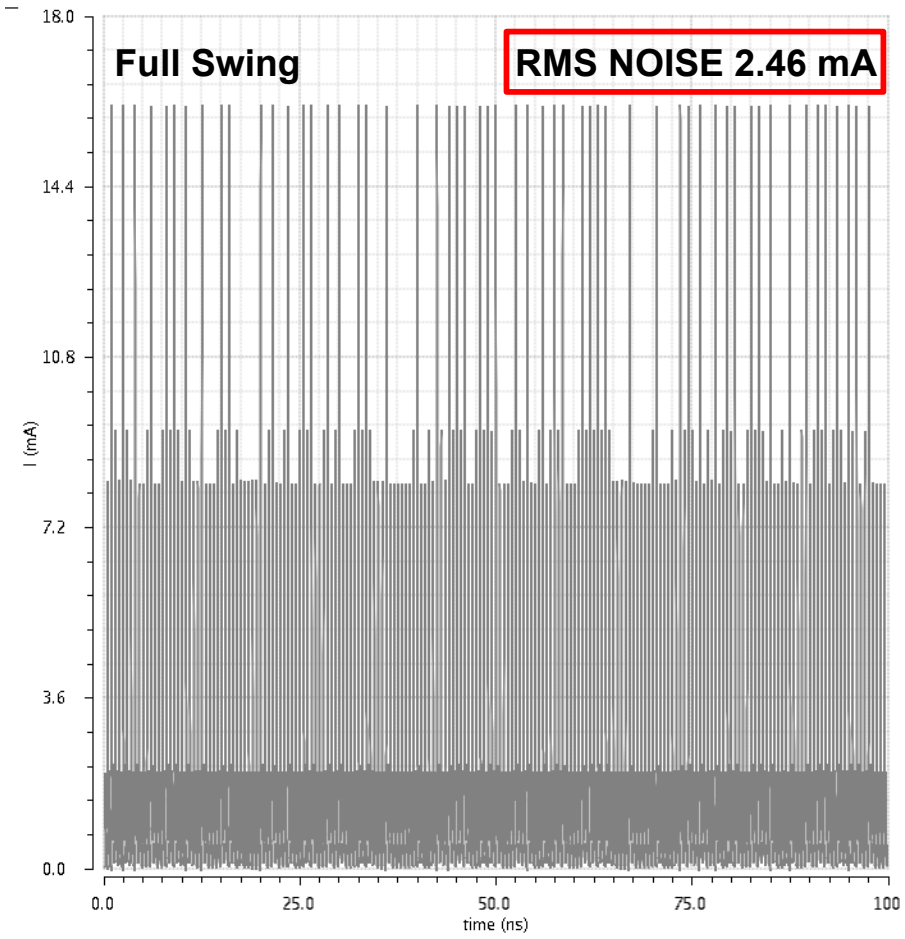
## 1-bit line @ 2 Gb/s (clock shielding) – EYE DIAGRAM

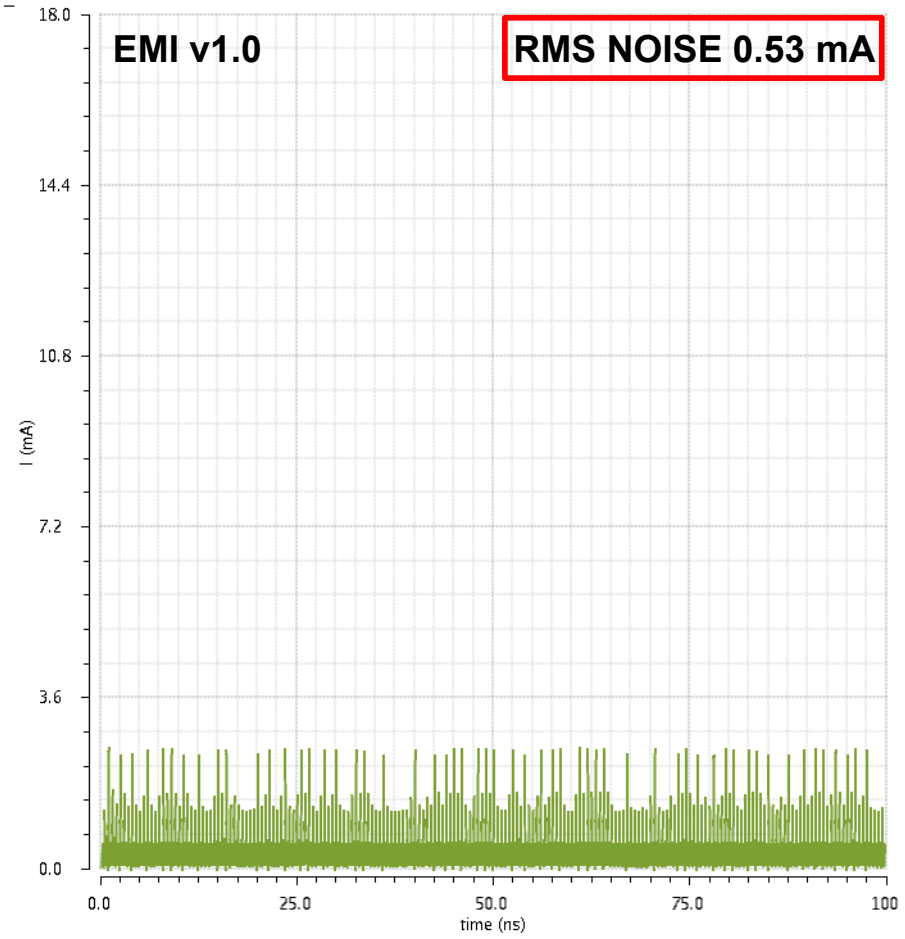


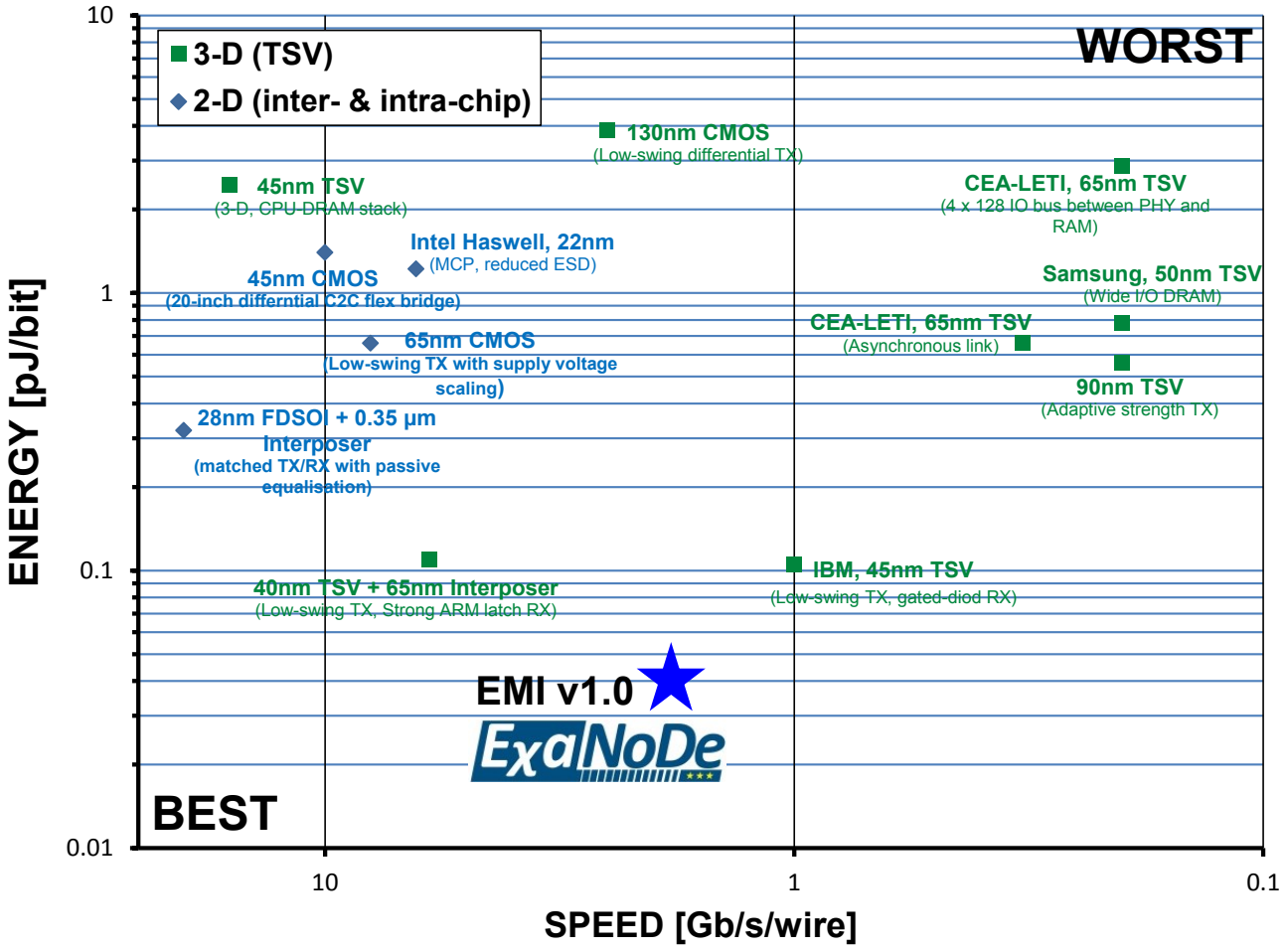
# EMI v1.0 in 28nm FDSOI with ExaLet (1.3mm)

## 1-bit line @ 2 Gb/s (clock shielding) – SWITCHING NOISE



# EMI v1.0 Energy Efficiency vs Speed



# EMI v1.0 Energy Efficiency vs Area