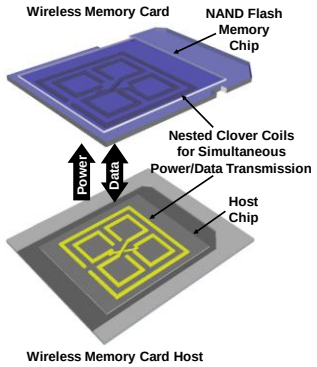
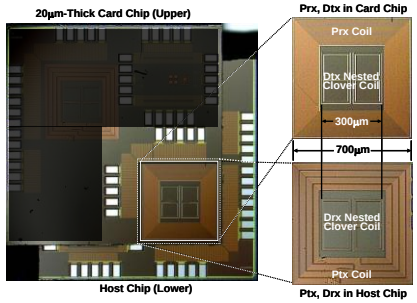
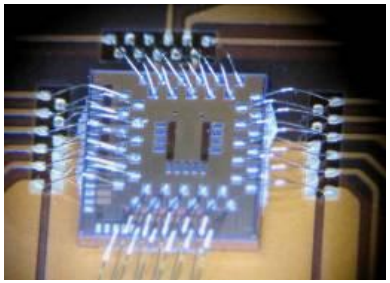
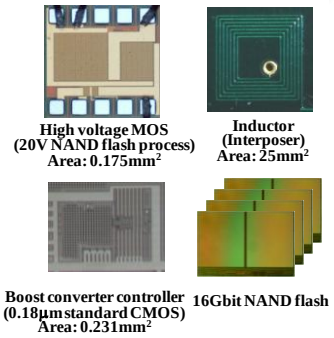
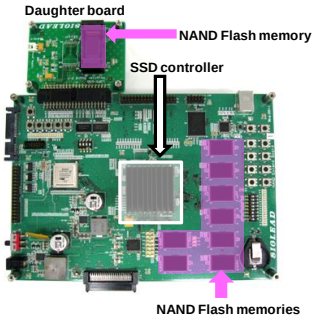
Dependable Wireless Solid-State Drive (SSD)











Ken Takeuchi, Chuo University
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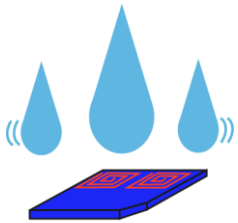
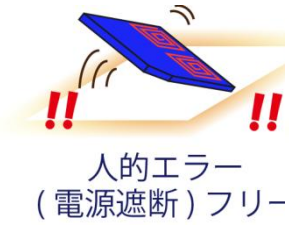
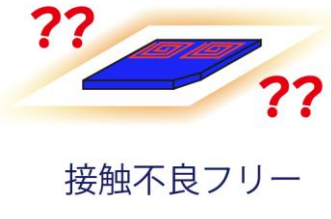
Hiroki Ishikuro, Keio Univesersity

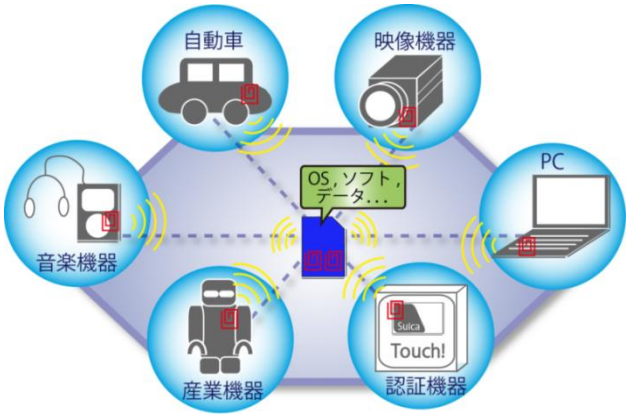
Objectives of Research

- **Wireless SSD/Memory card and its host system**
- **Robust against memory cell error, contact error, ESD, EMI and waterproof**
- **High-speed near field wireless communication**
  - **Target : 10Gbps (2012), 50Gbps (2014) at 1mm distance**
- **Wireless power delivery with MHz load variability**
  - **Target : 1-3W (2012-2014)**



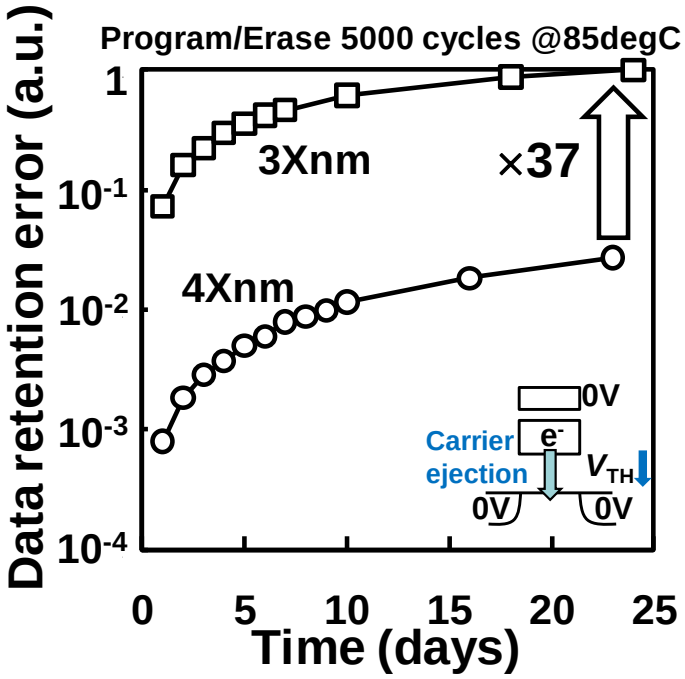


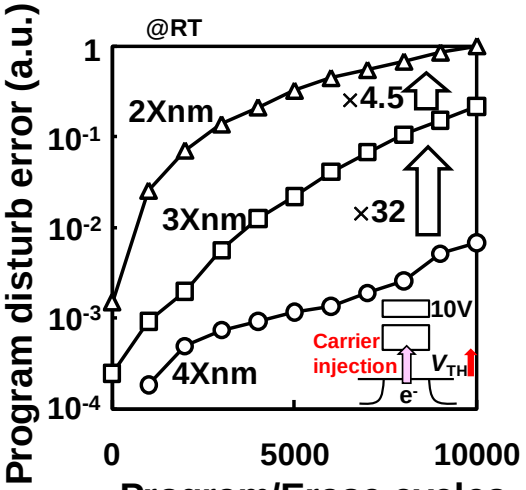


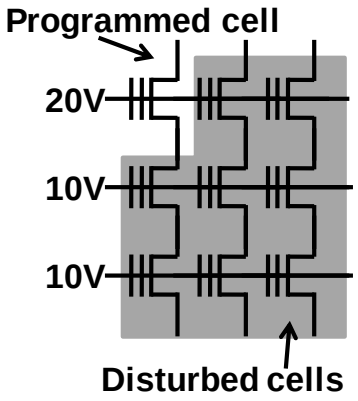


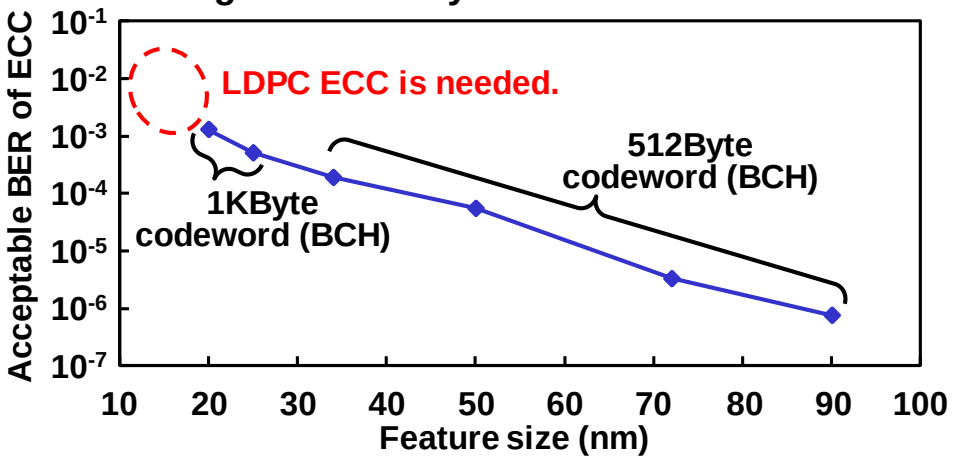
Dependable Memory System

- **Data retention error and program disturb error become worse as the memory cell is scaled.**
- **ECC should be improved with the device scaling.**

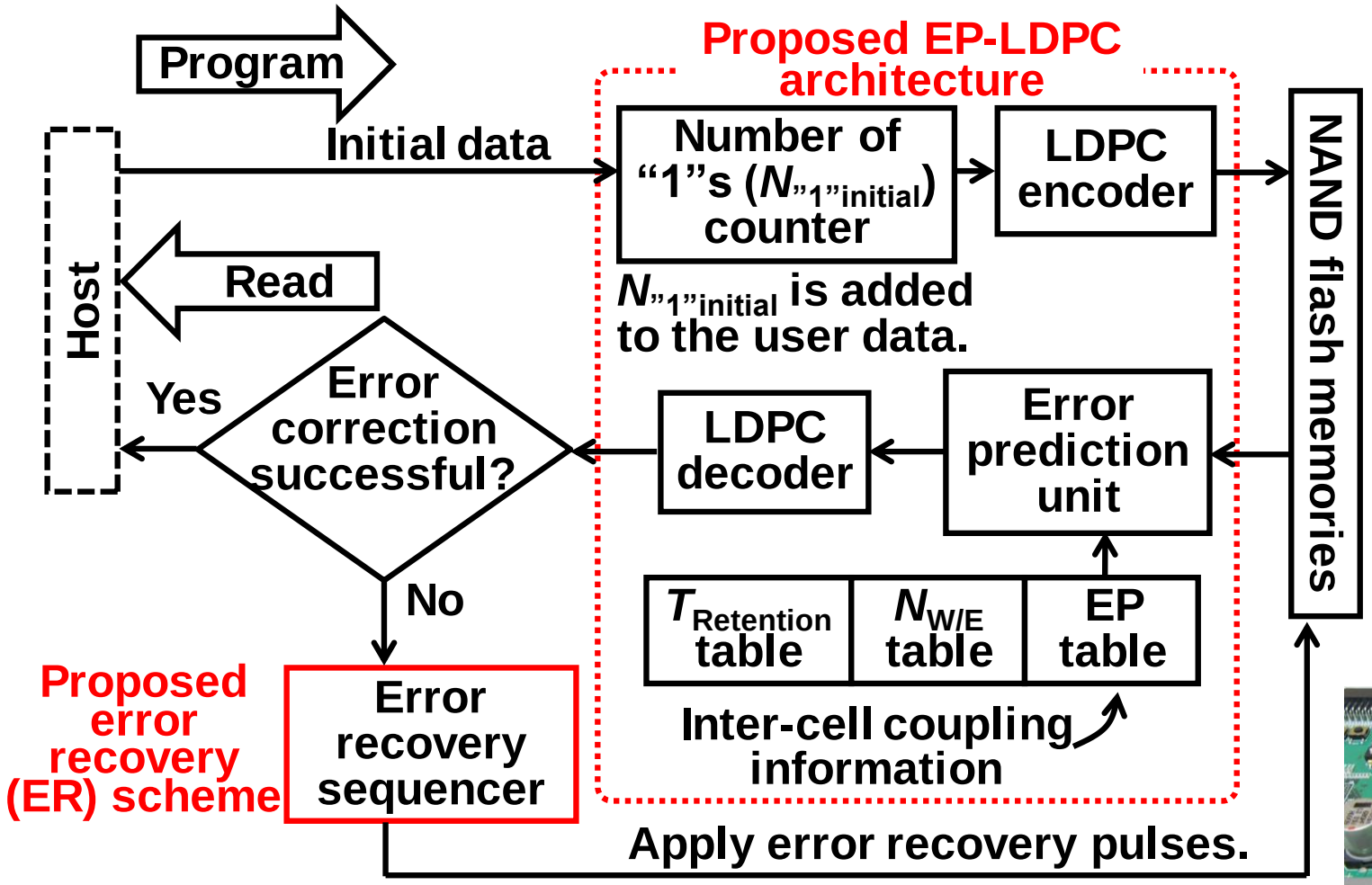


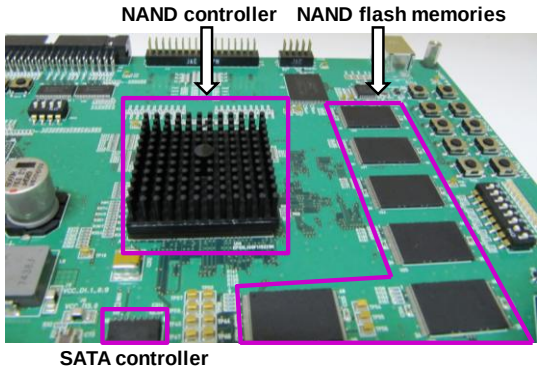






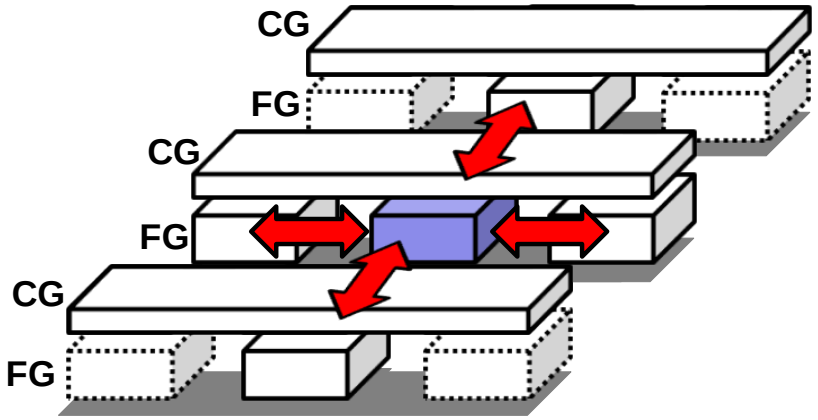
Dependable SSD System (ISSCC 2012)



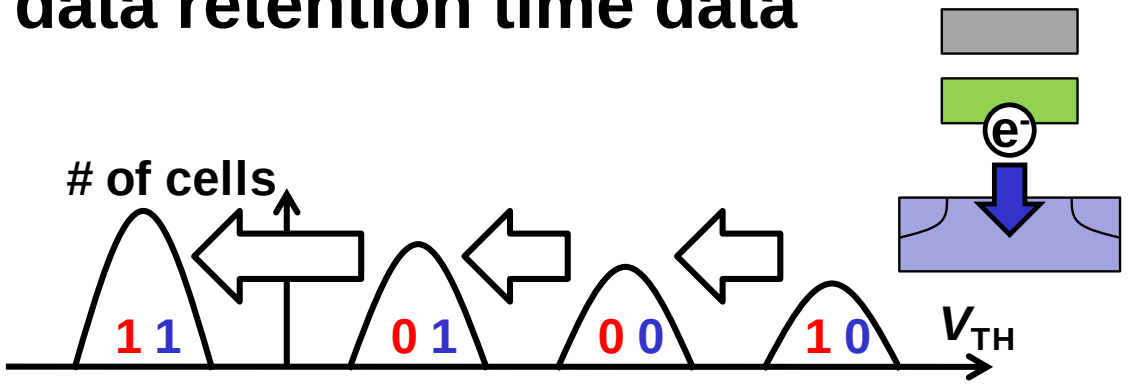


Error Predicting LDPC

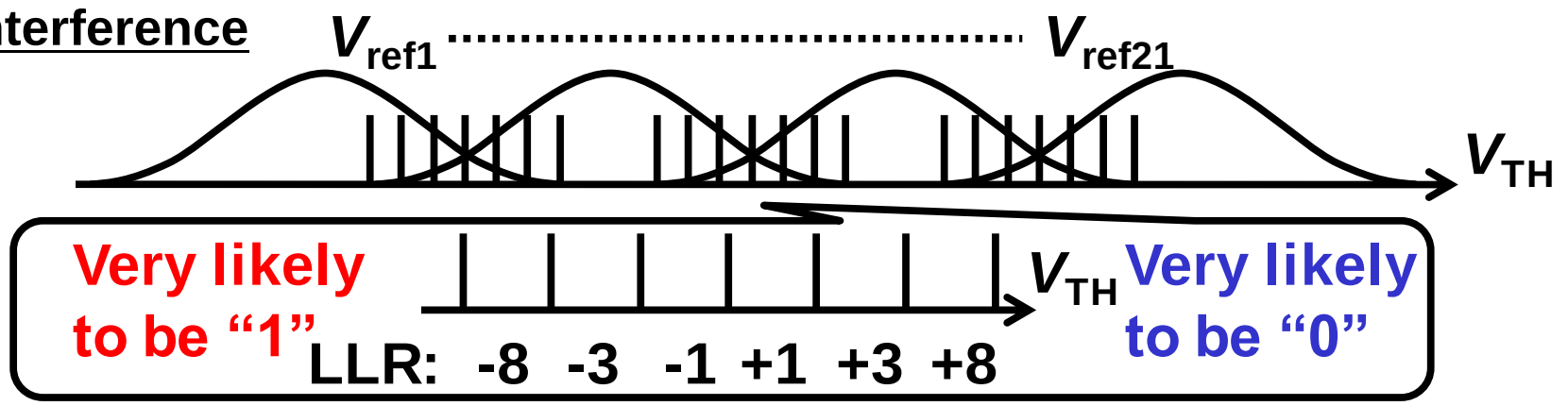
- Compensate the capacitive interference by using the neighboring cell data
- Compensate the Vth decrease during data retention by write/erase cycles and data retention time data



FG-FG interference

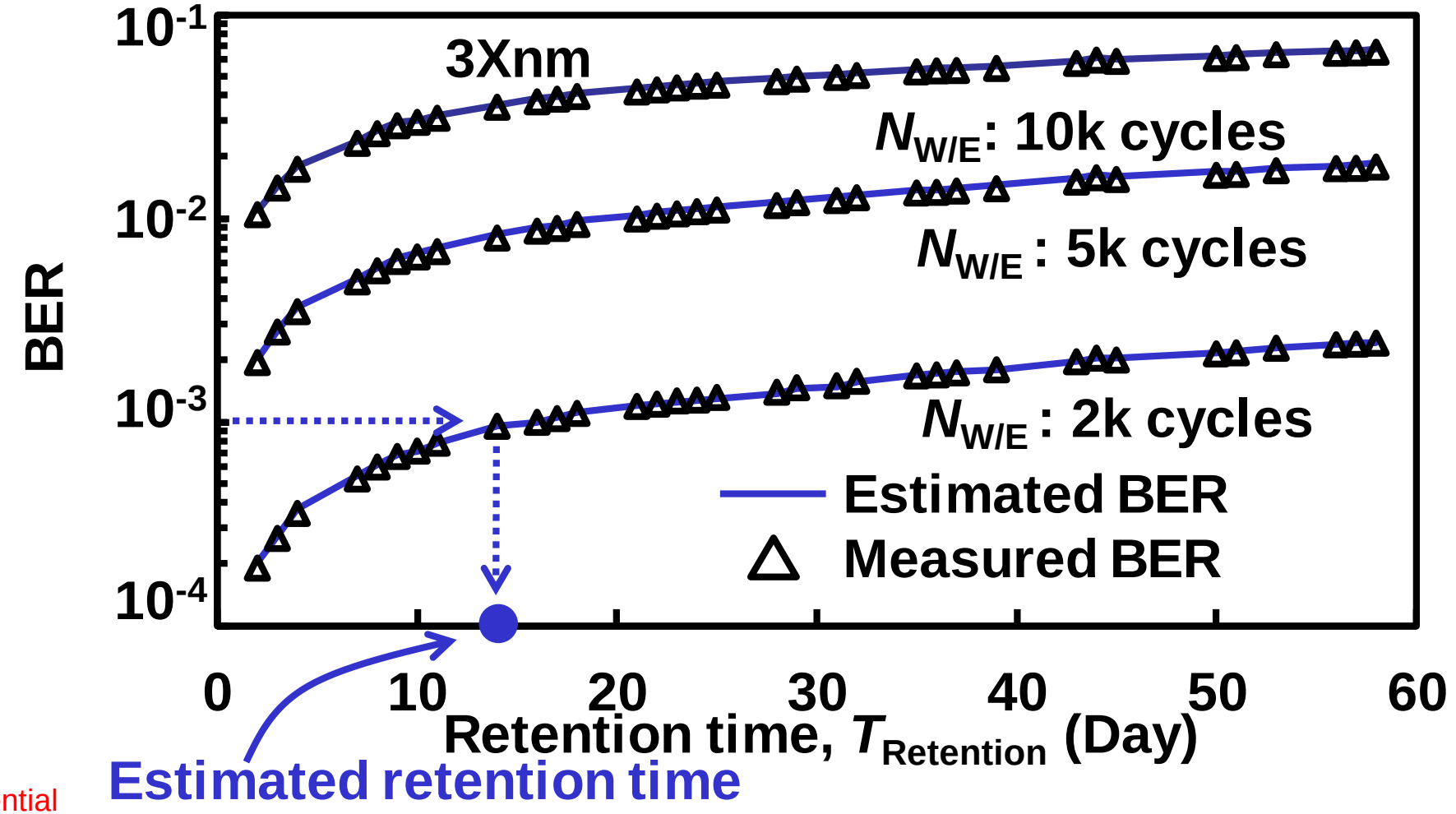


Vth decrease during data retention



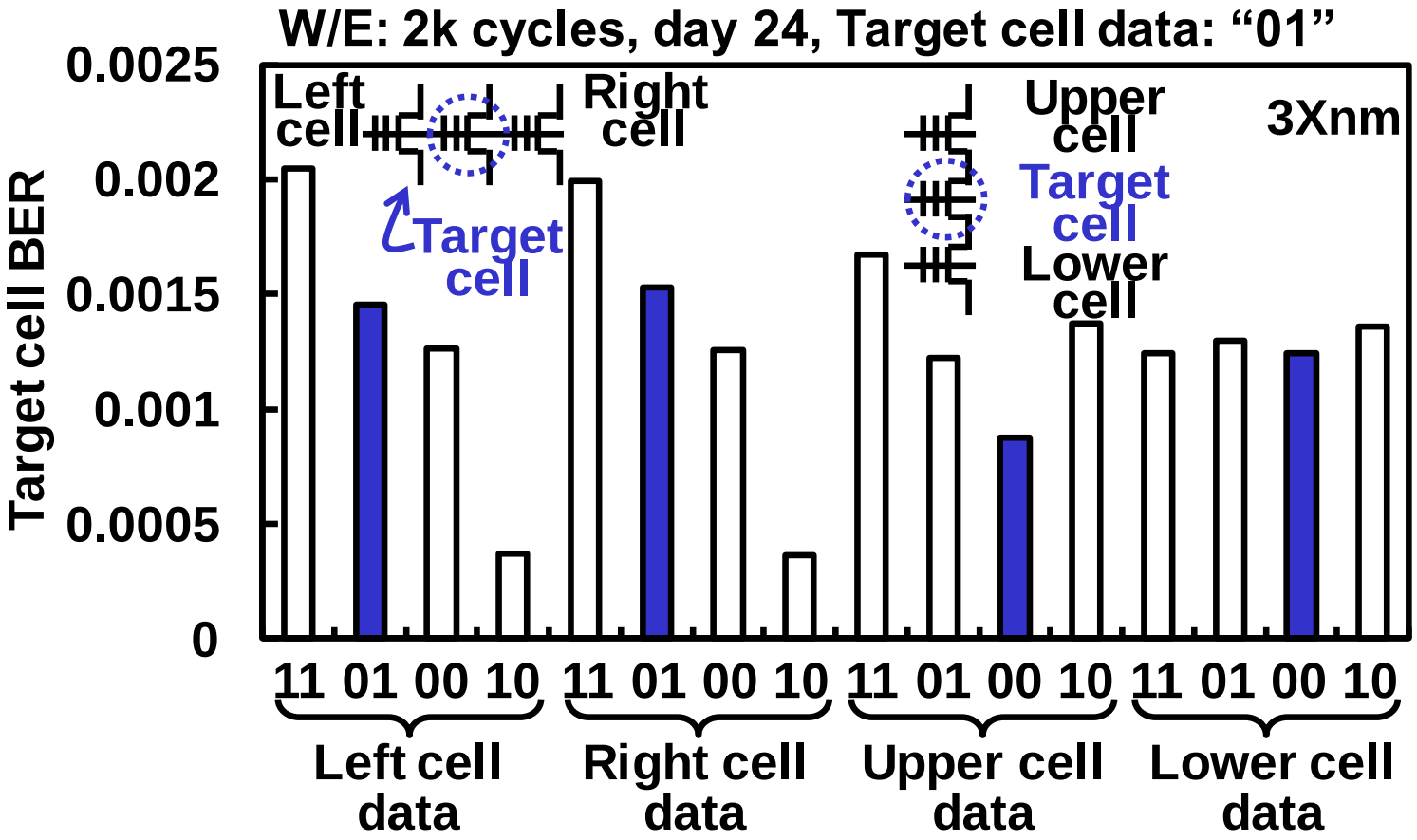
Error Predicting LDPC

- Write/erase cycles are stored in the memory block.
- Estimate the date retention time by using measured BER



Error Predicting LDPC

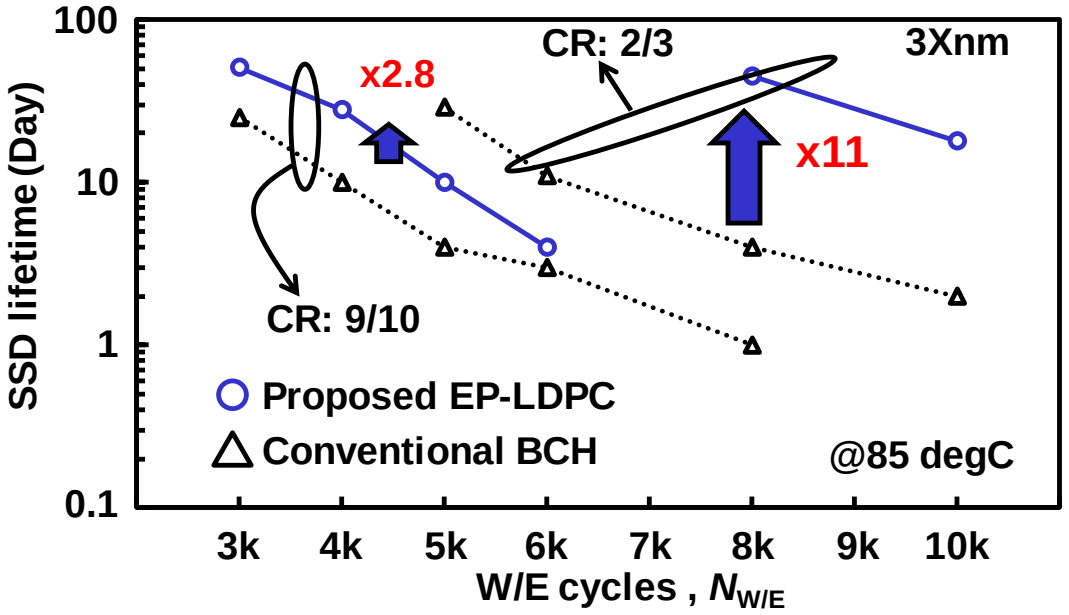
- **Predict BER by the write/erase cycles, data retention time, neighboring cell data and pre-recorded tables**



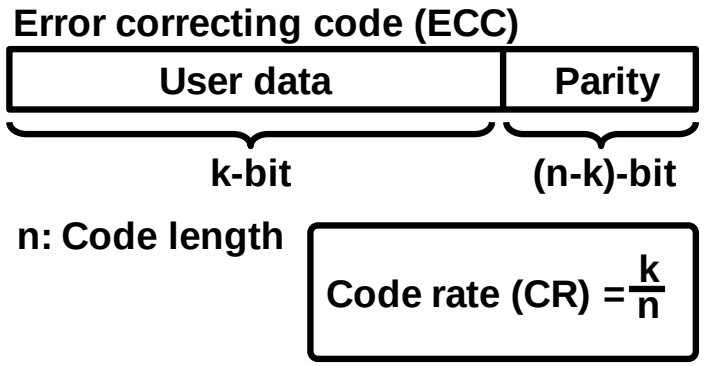
$$BER_{Target\ Cell} \sim (BER_{Left\_"01"} + BER_{Right\_"01"} + BER_{Upper\_"01"} + BER_{Lower\_"01"}) / 4$$
$$= (0.0015 + 0.0015 + 0.0012 + 0.0013) / 4 = 0.0014$$

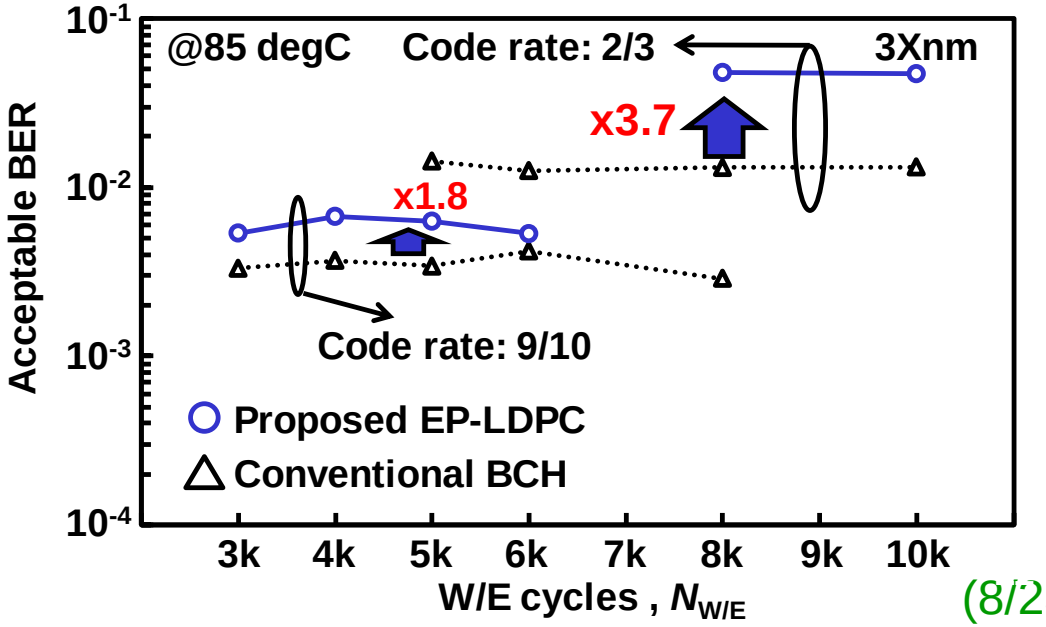
Error Predicting LDPC

- **x11 lifetime**



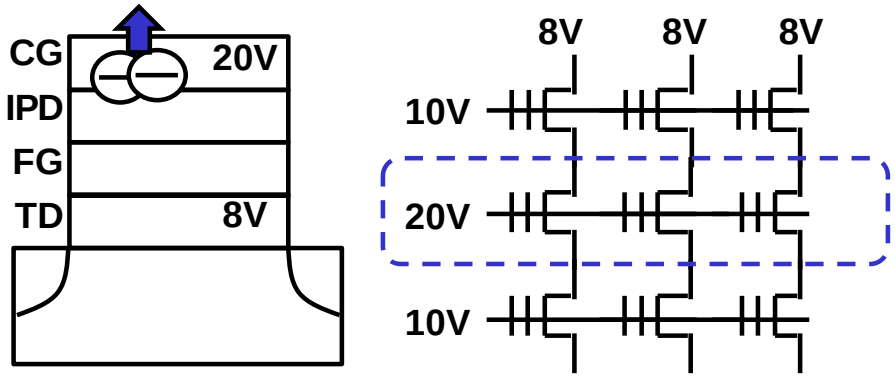
- **x3.7 acceptable BER**

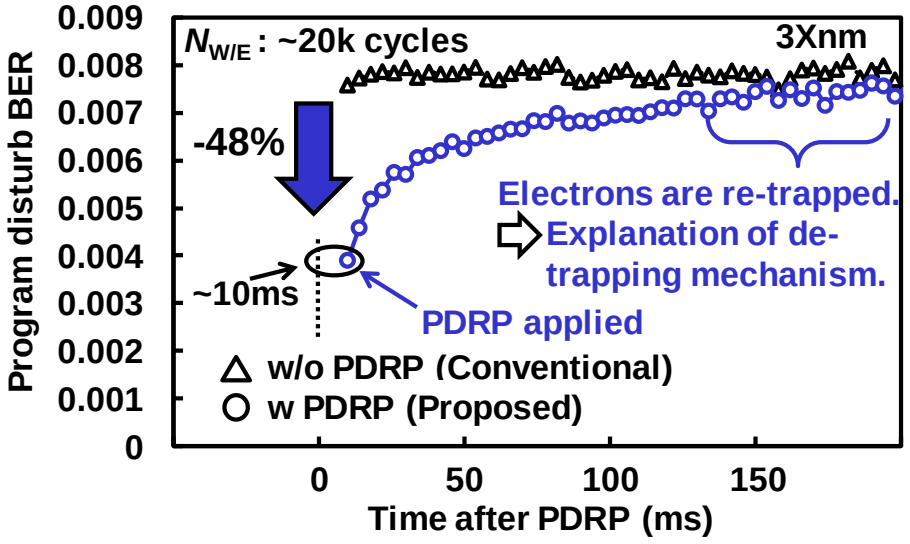




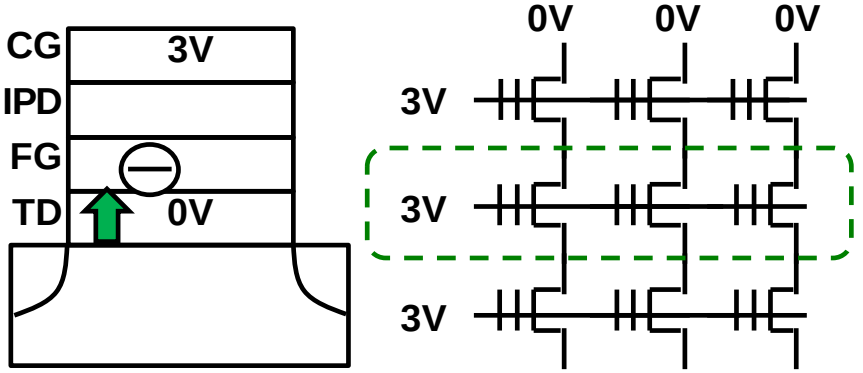
Error Recovery Scheme

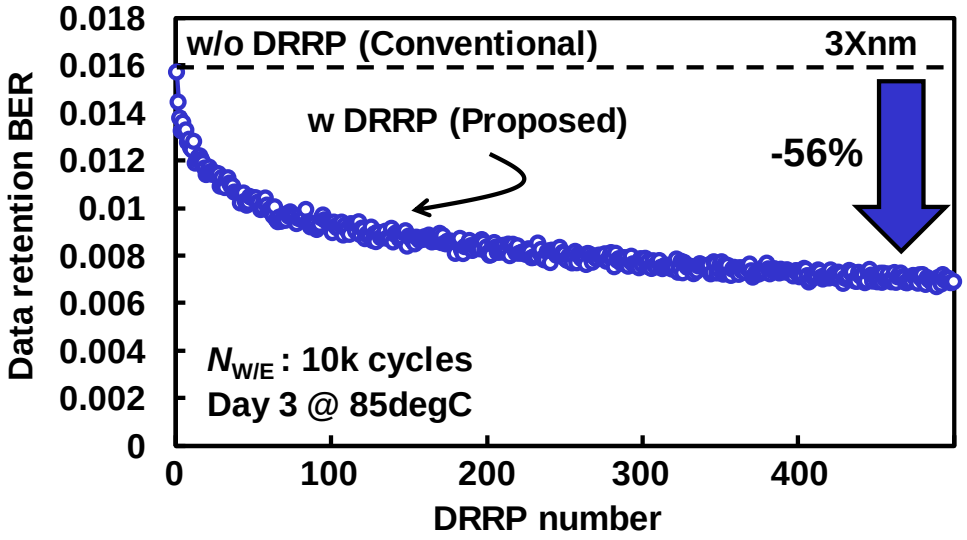
Recovery of program disturb error



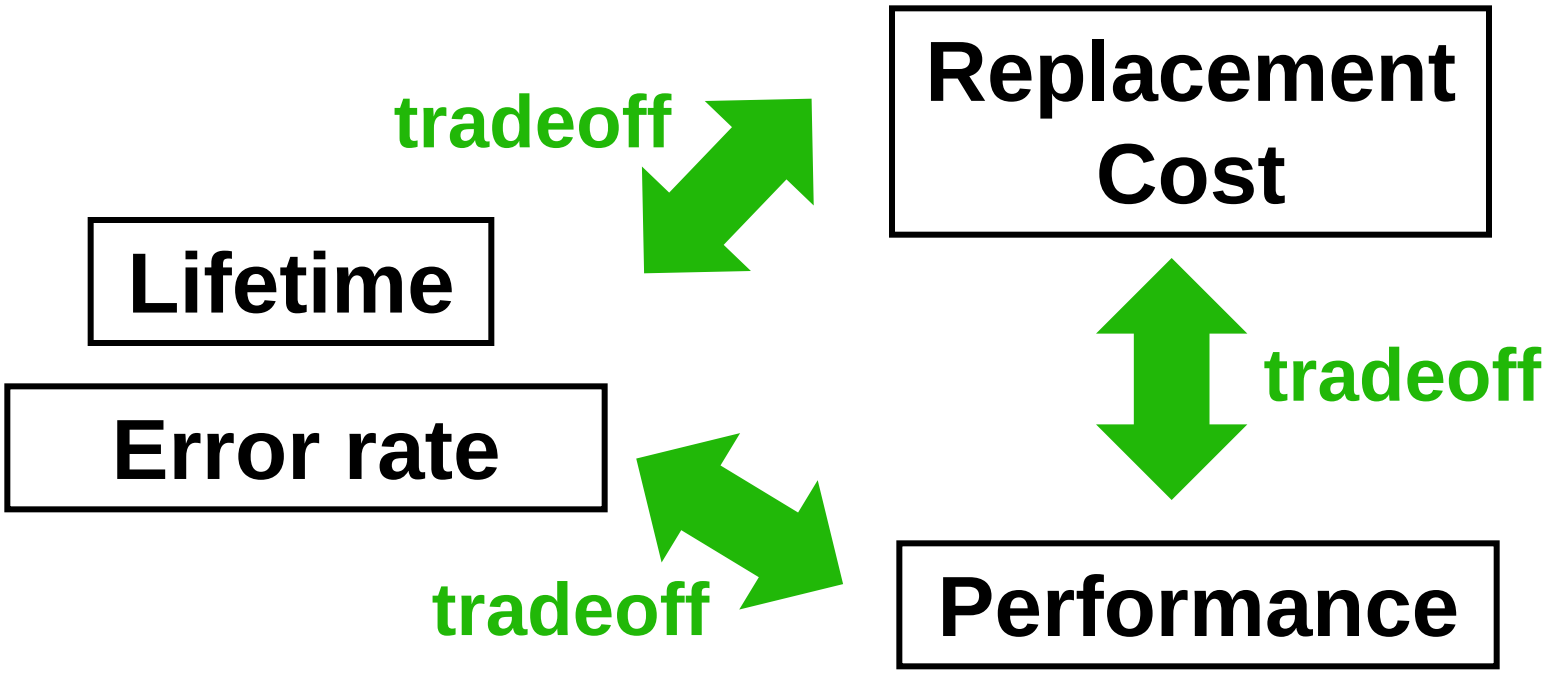


Recovery of data retention error





Dependability Metrics

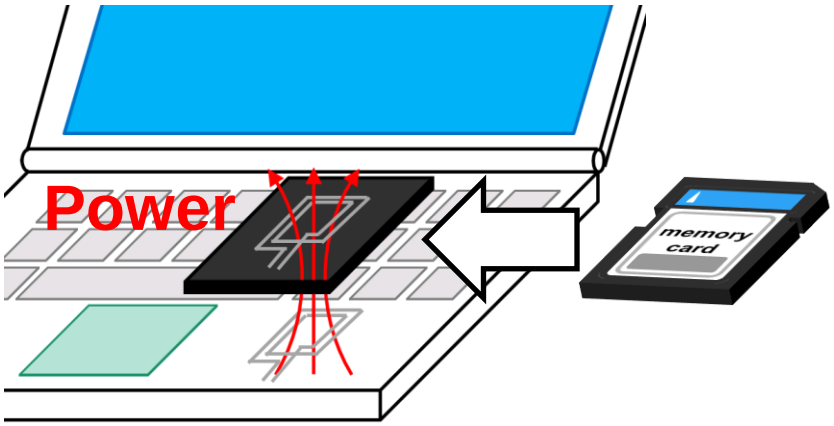


- If cost/performance is fixed, x11 lifetime or x1/4 BER.

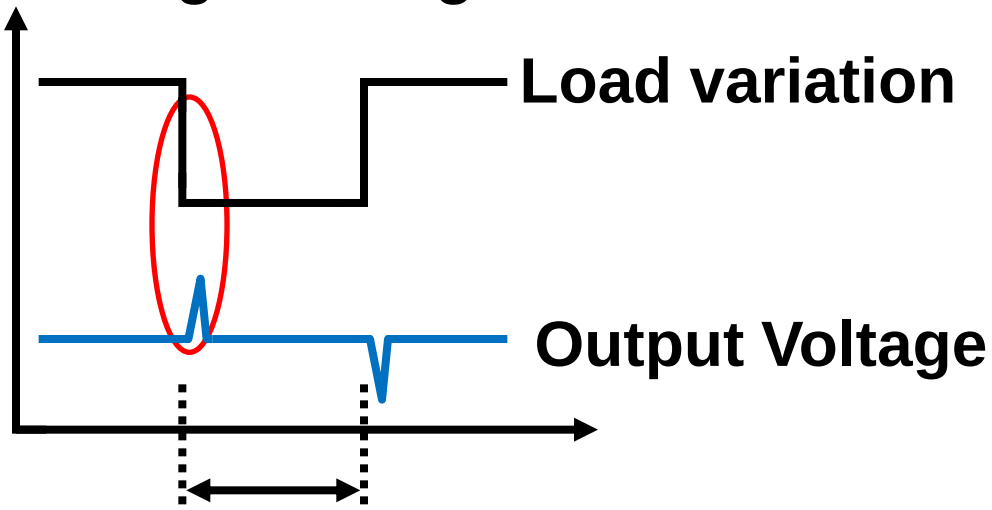
  (B2C application such as smart phone and PC)
- If reliability is fixed, x9 read performance or 1/11 lower replacement cost. (B2B application such as data center)

Wireless Power and Data Transfer

- **Dependability Issues**
  - Voltage and thermal stress in memory card (Rapid load change in battery-less system)
  - Electro-magnetic interference (EMI) between power, data channel, and other electronic system.
- **Keyword**
  - Wideband near-field electro-magnetic signal

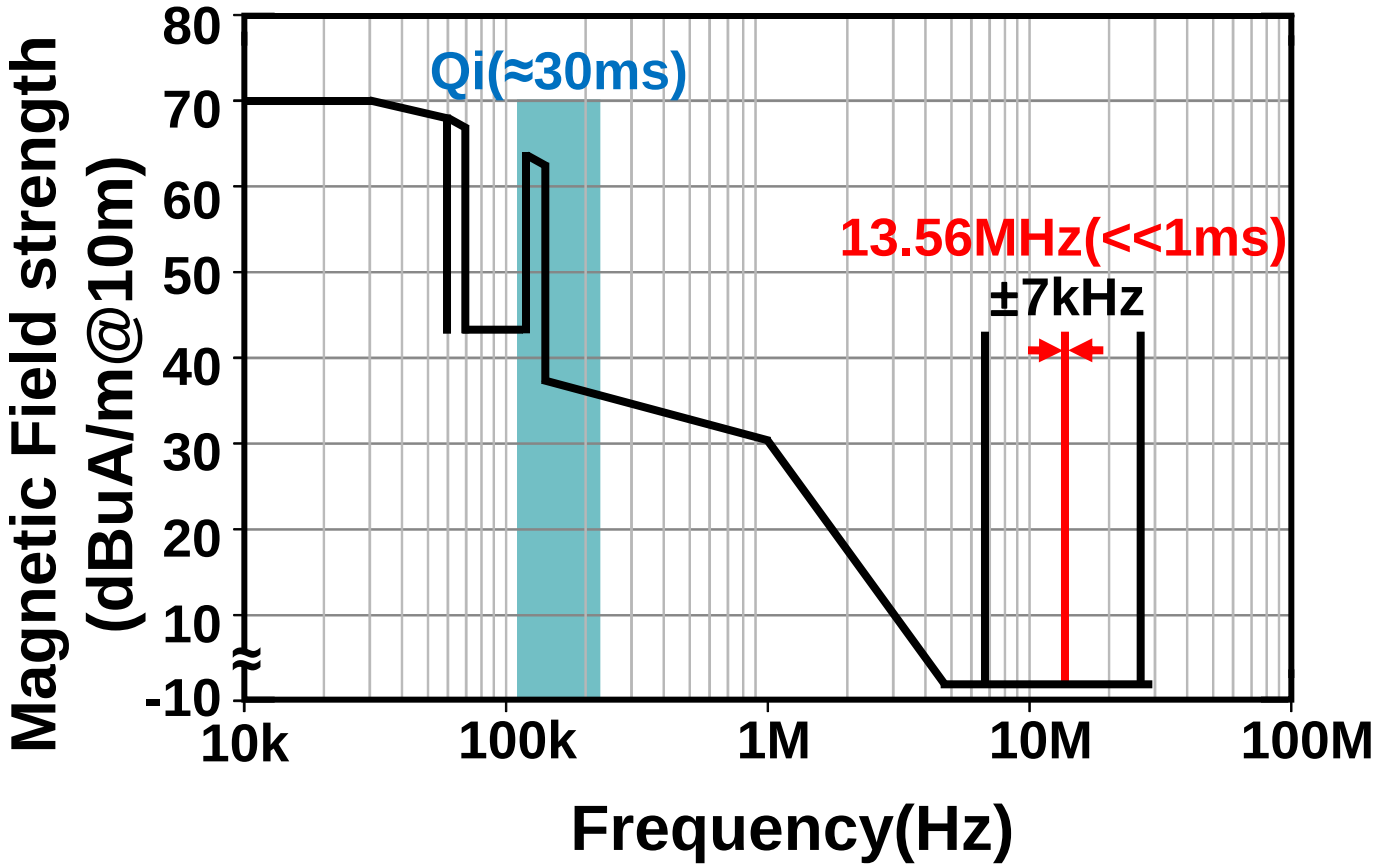


Contactless Memory Card

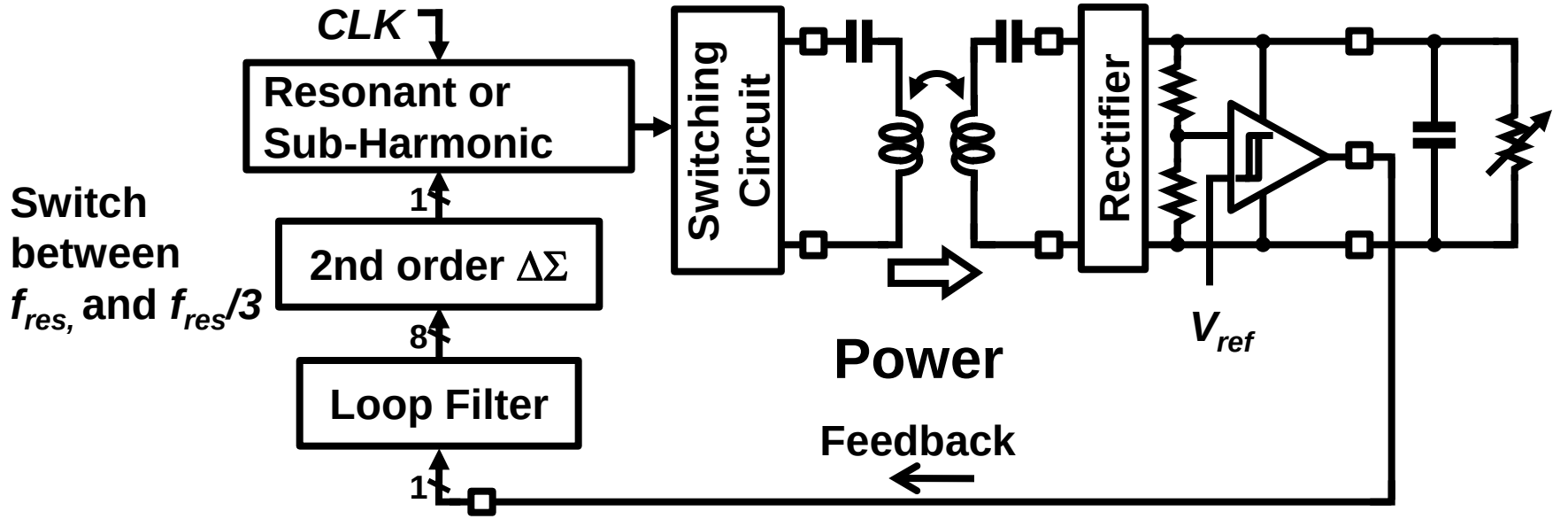


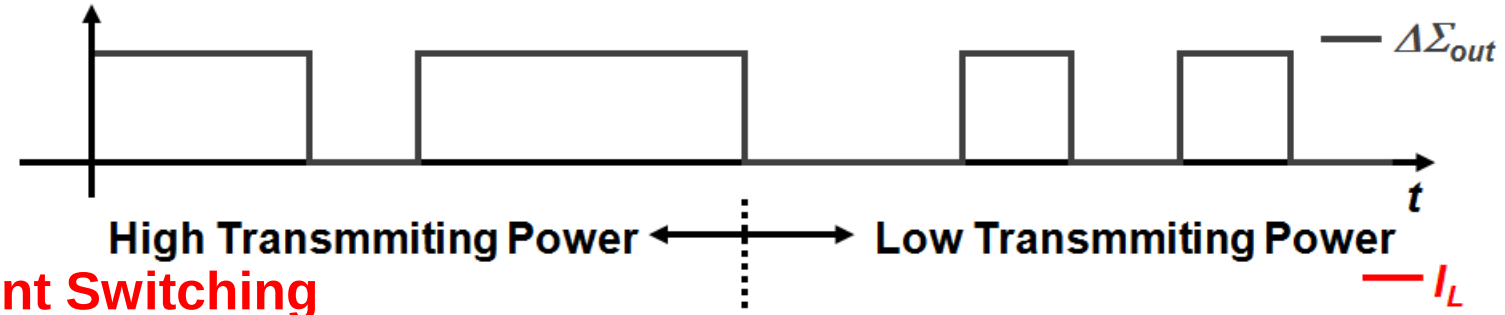
High Speed Response

EMI regulation

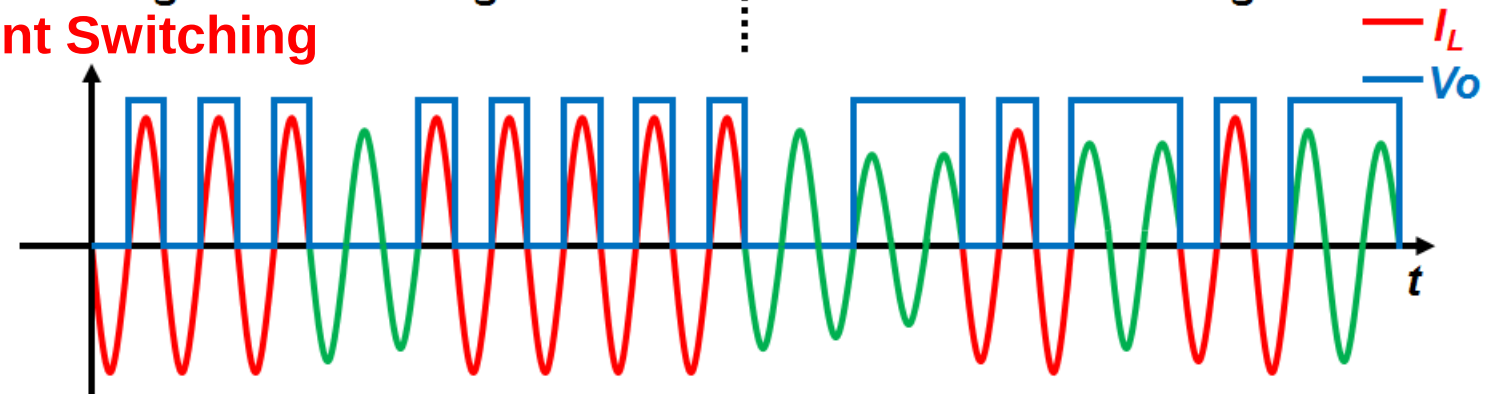


Fast Power Control by f_{res} - $f_{res}/3$ Switching

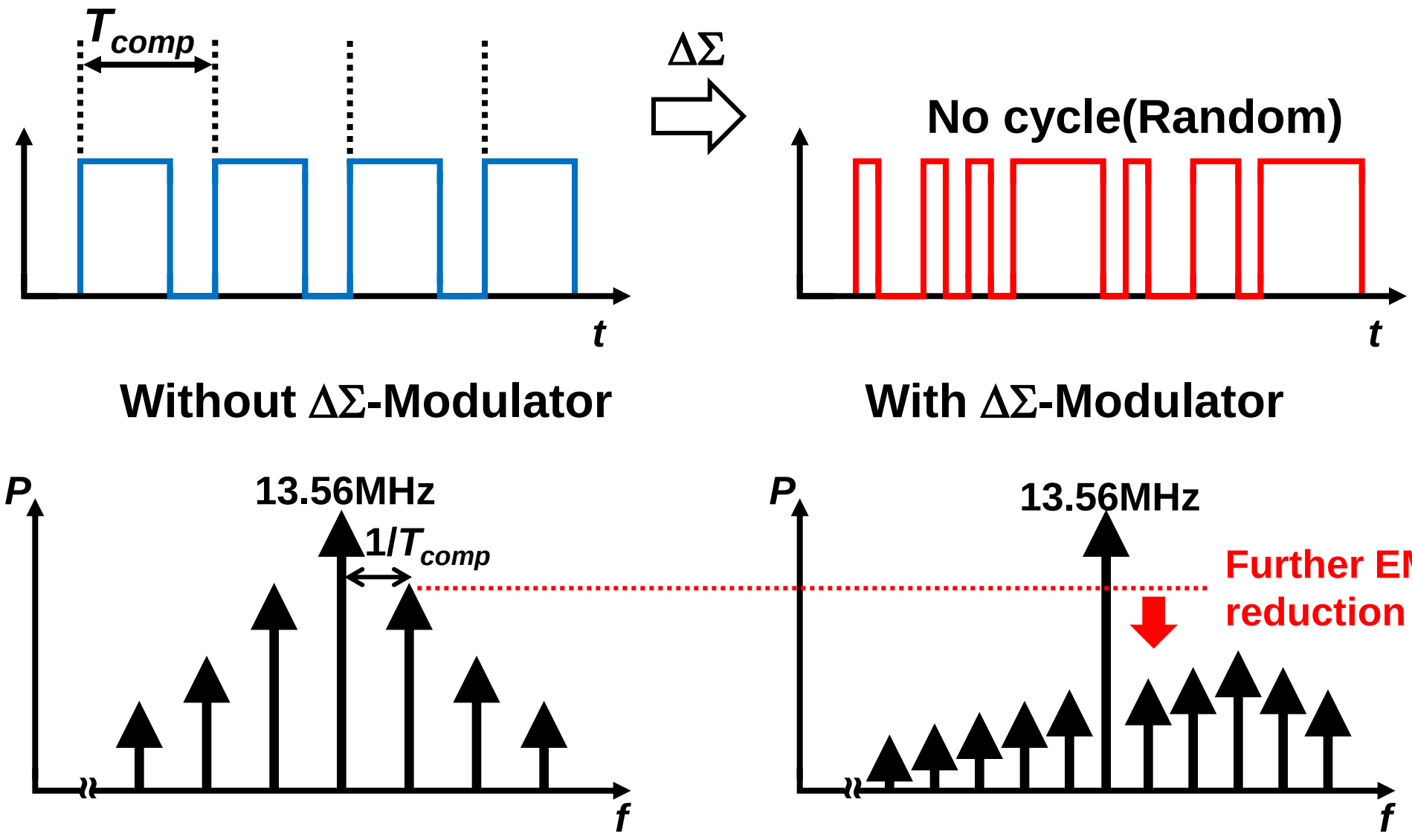




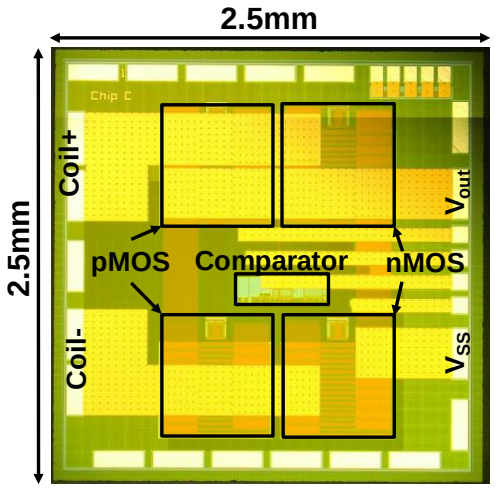
Zero Current Switching
Low EMI



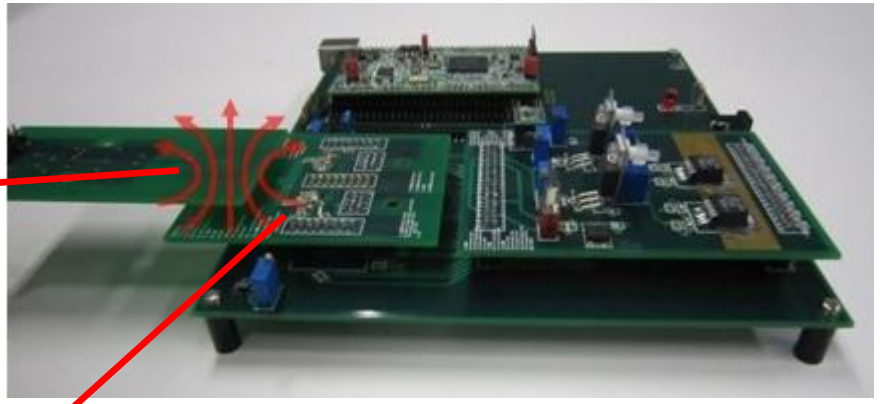
EMI Reduction by ΔΣ Modulation

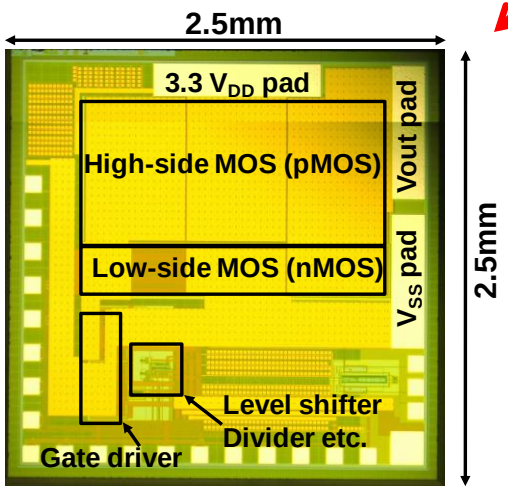


Fast Load Tracking

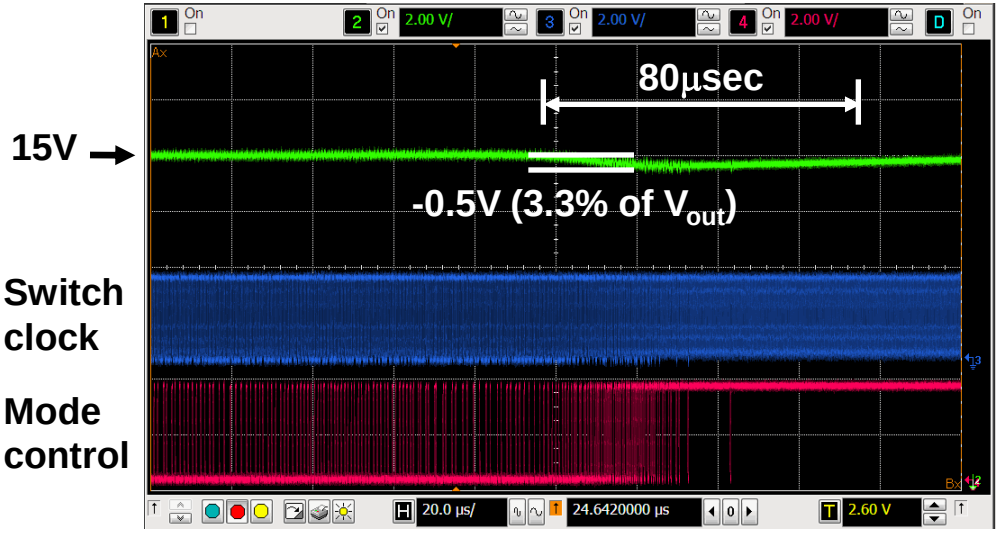


Rectifier chip



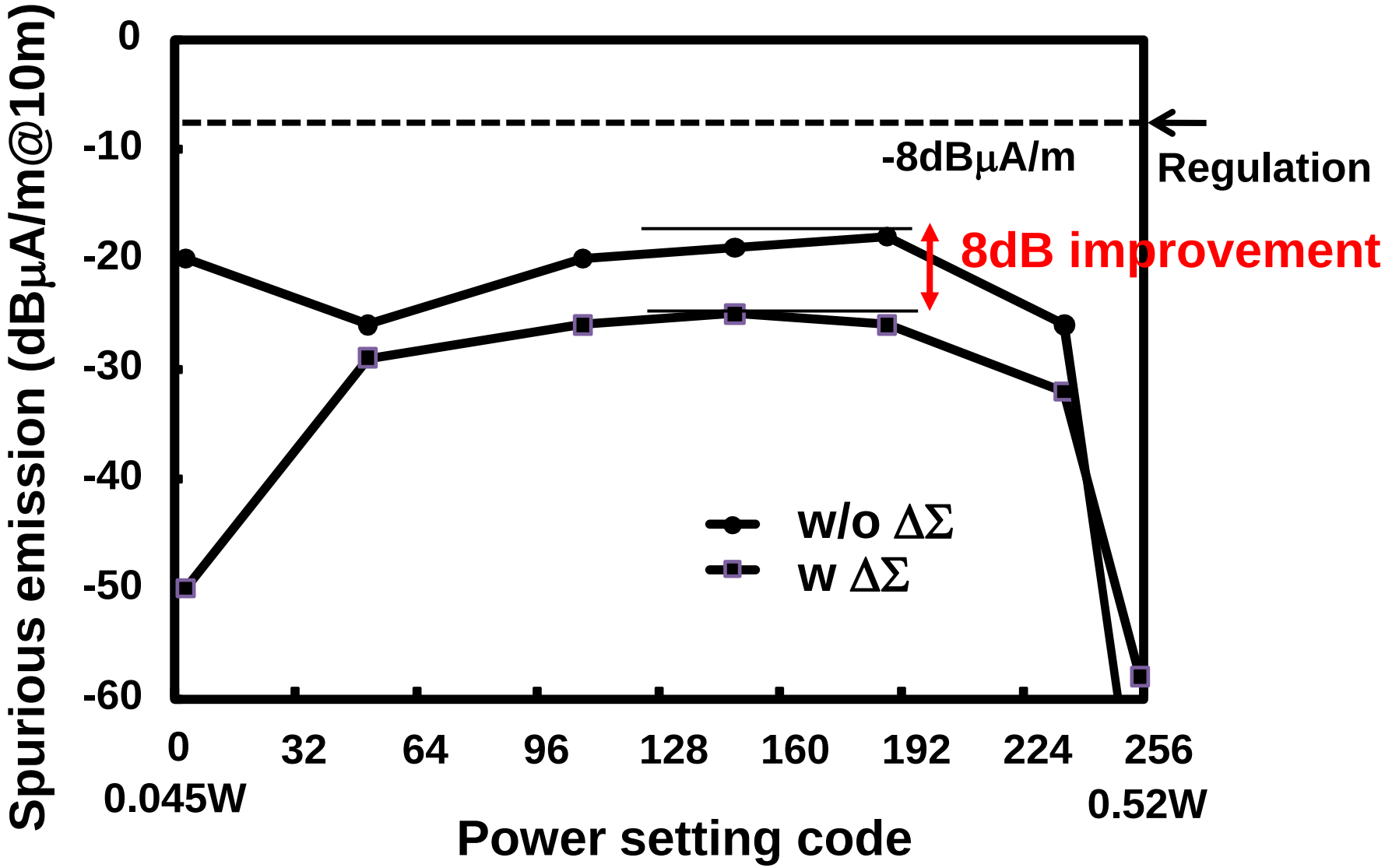


Transmitter chip



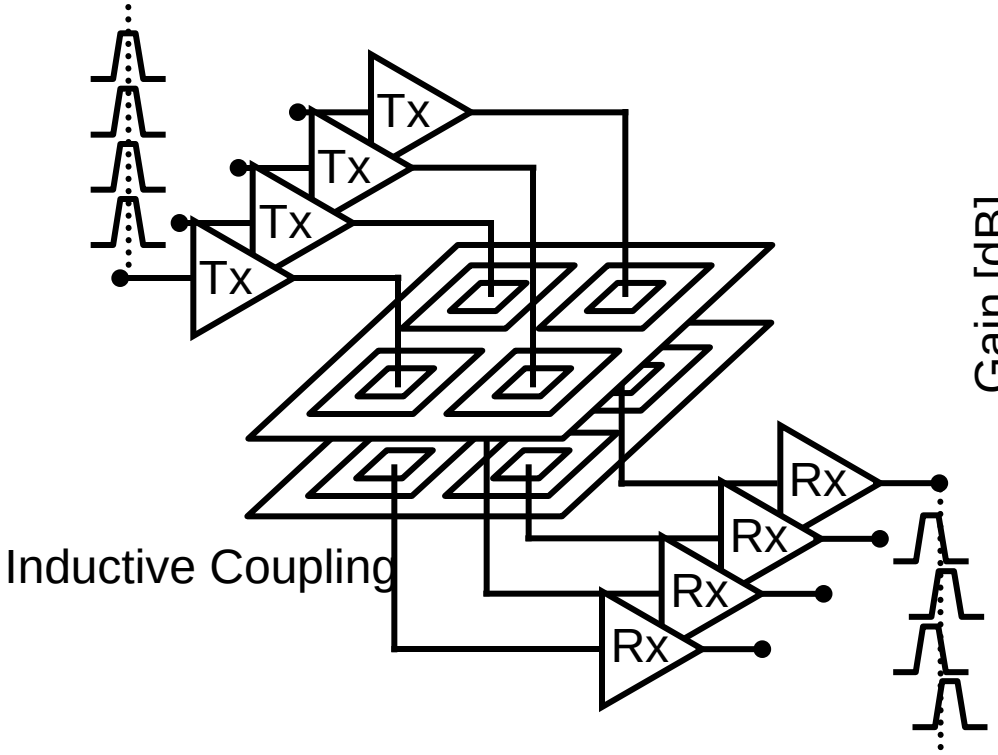
Load transition point
(From 45mW to 500mW)

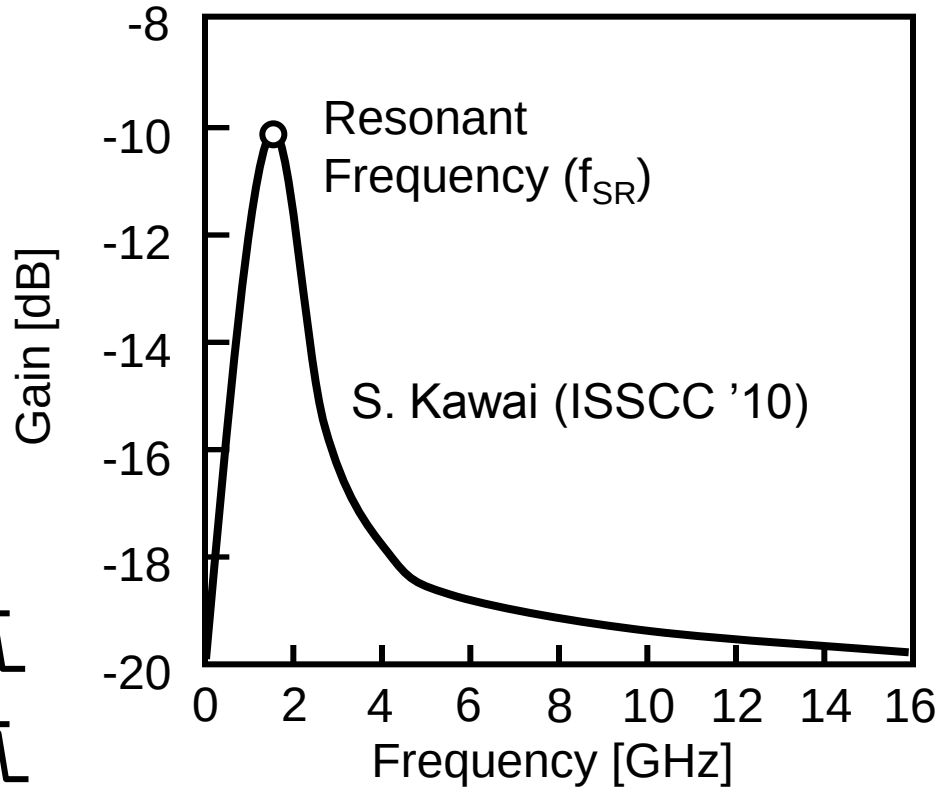
EMI Reduction



Inductive Coupling Link (Narrow Band)

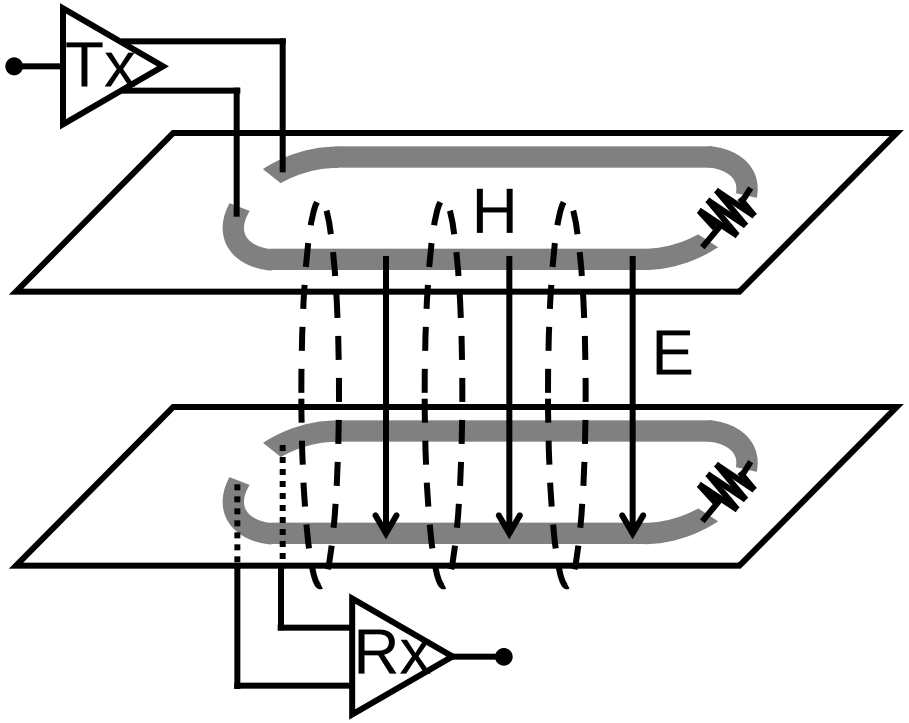
- **Inductive-coupling link**
  - **Limited bandwidth due to poor matching capability**
  - **Need parallel channels w/ skew compensation**



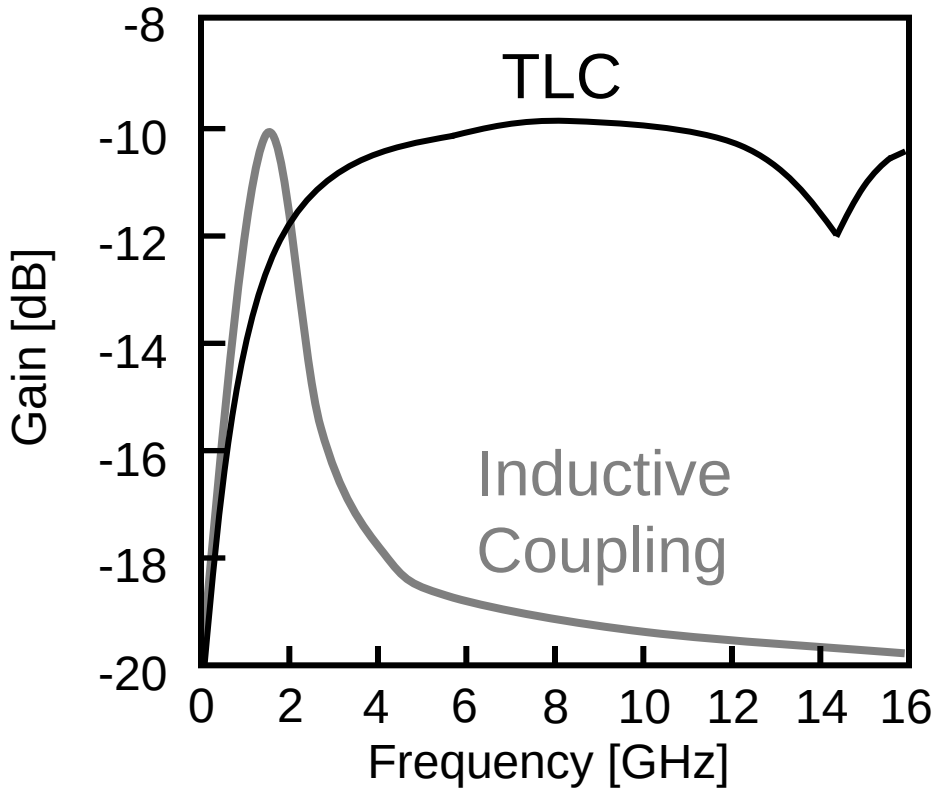


Wideband Communication with TLC

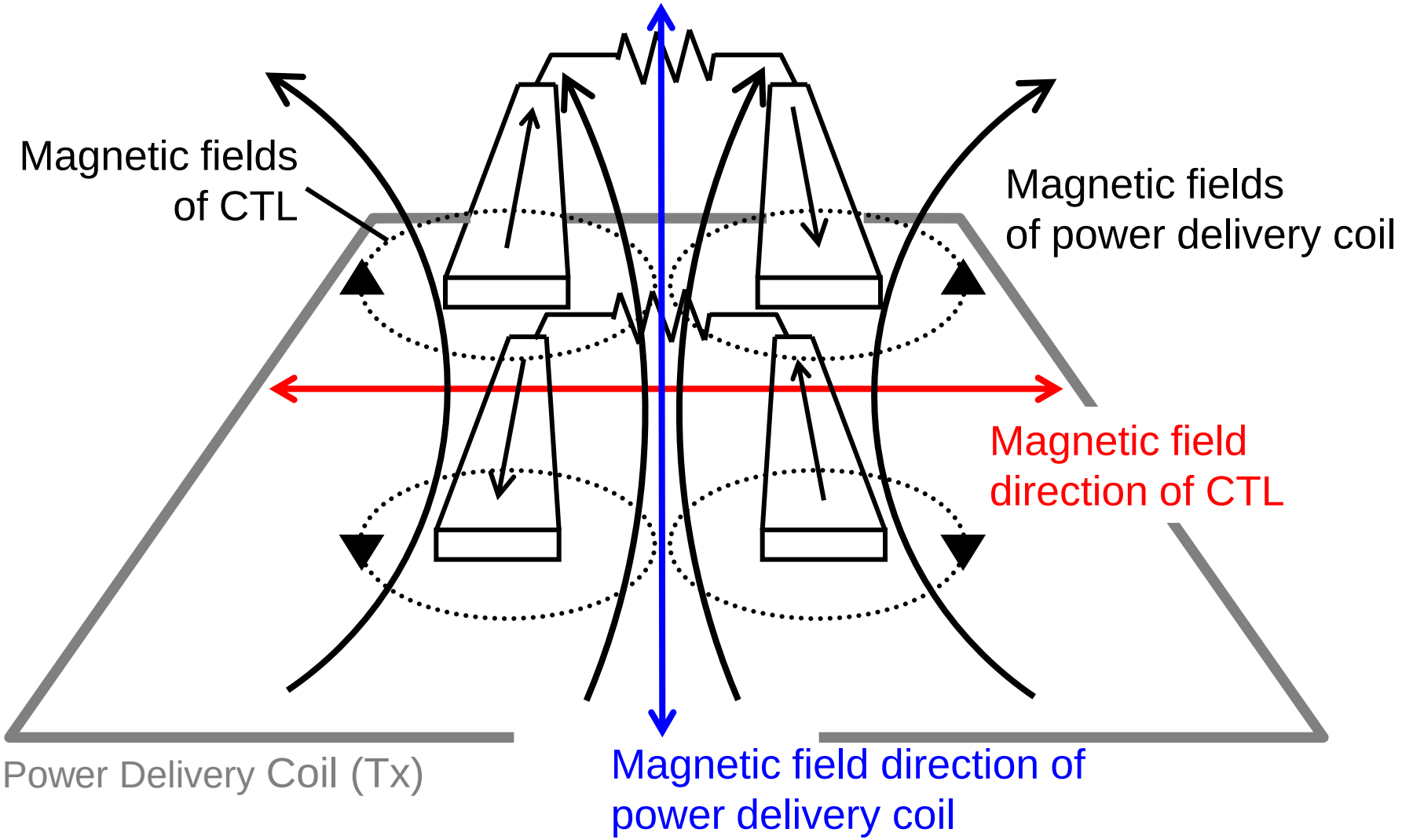
- **Transmission Line Coupler (TLC)**
  - **Good matching capability**
  - **Wide bandwidth**



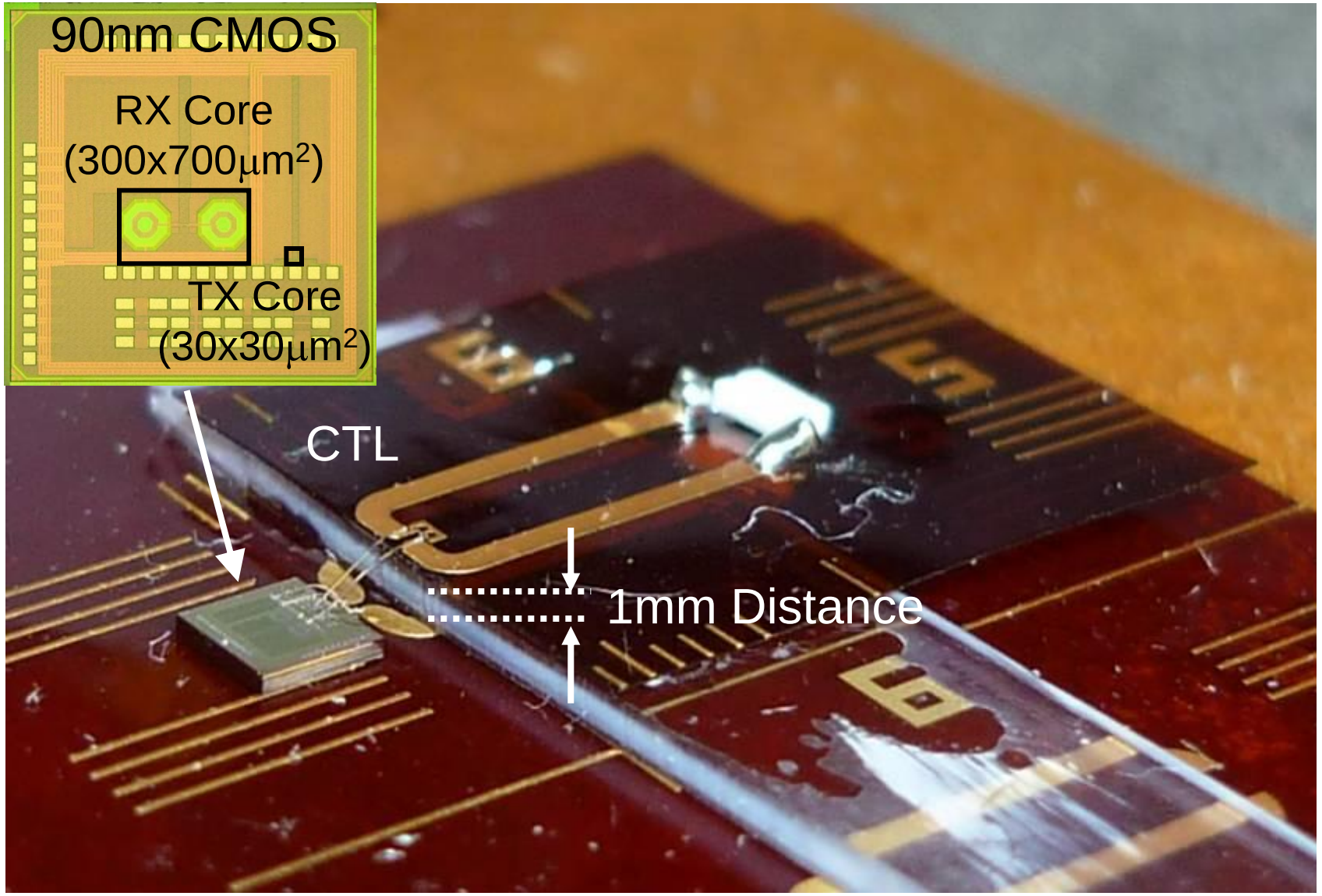
Proposed TLC



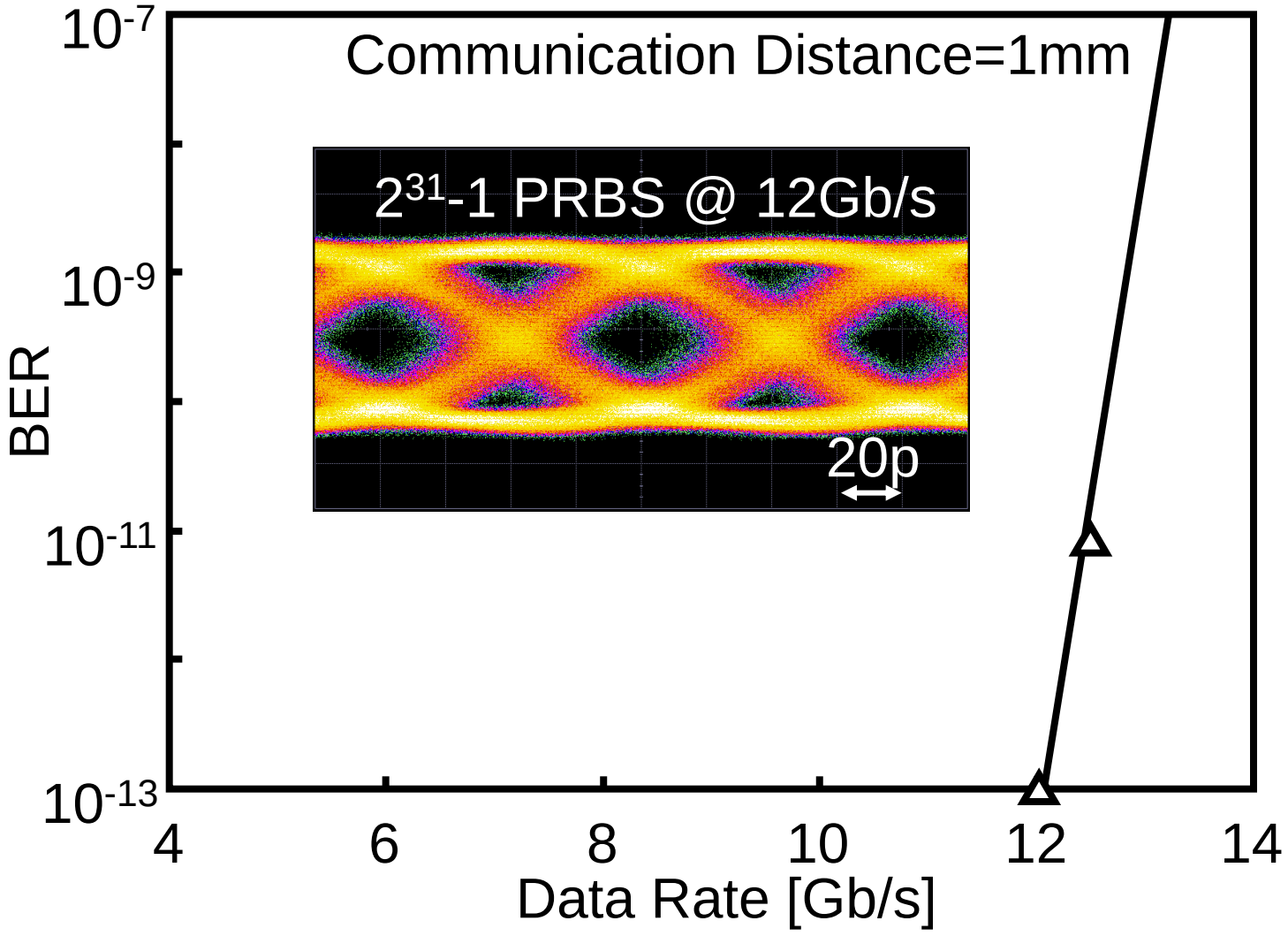
Immunity to EMI



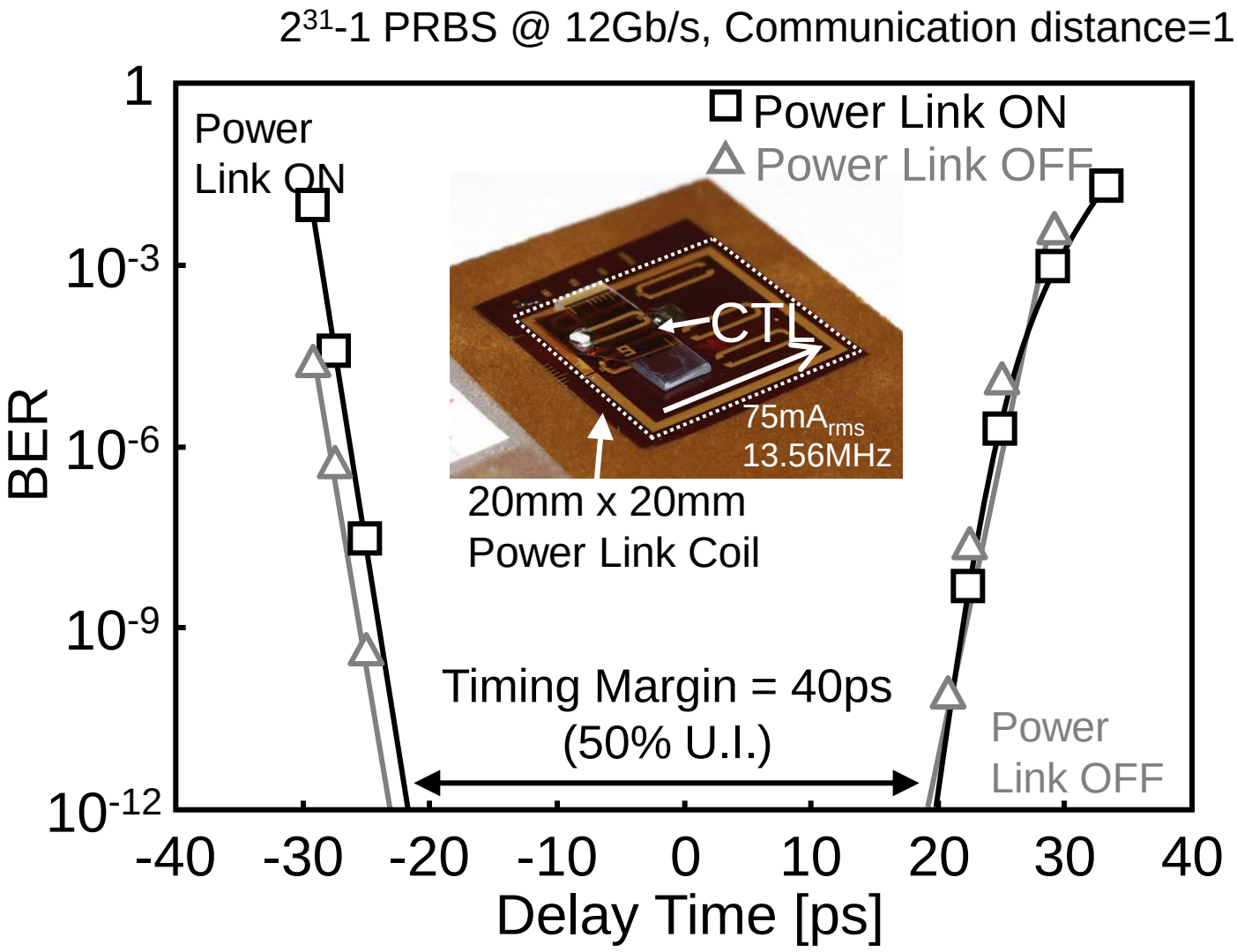
Chip Photo and Evaluation System



12Gbps Communication

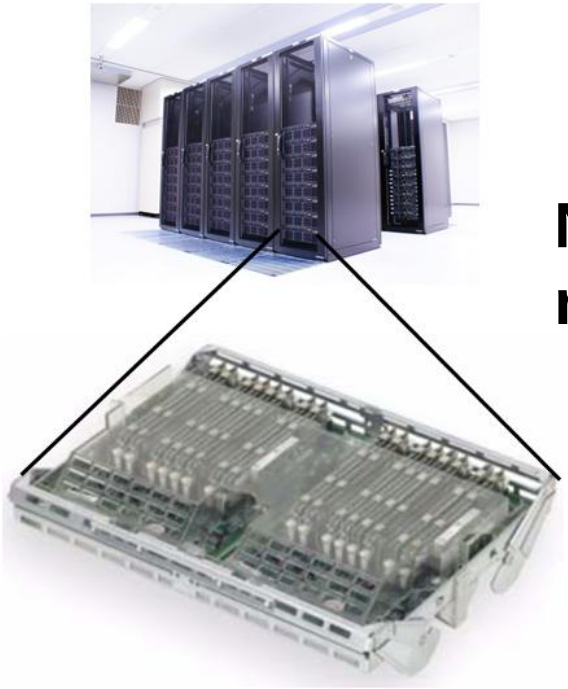


Reliable Communication in Wireless Power Delivery



Future Applications

Wireless Power transfer to battery-less EV etc.



Non-contact multi-drop bus for large volume memory system in server (Data center)