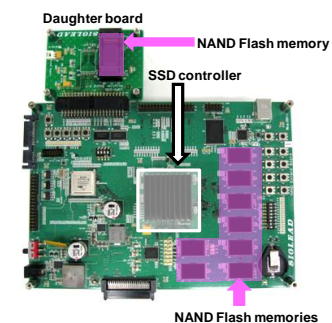
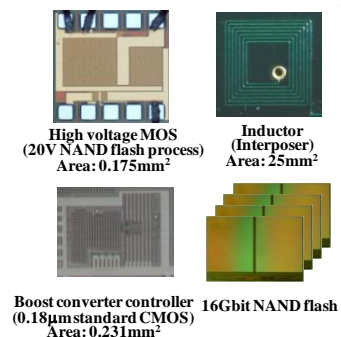
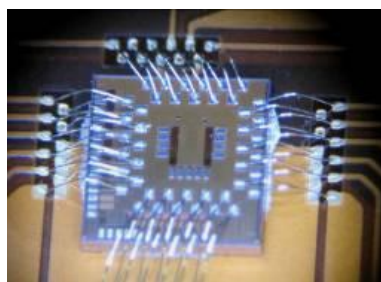
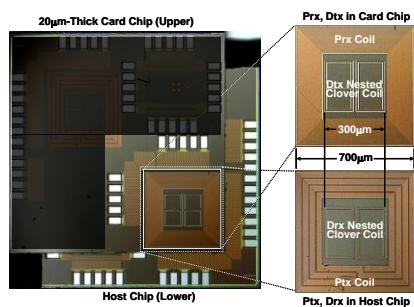
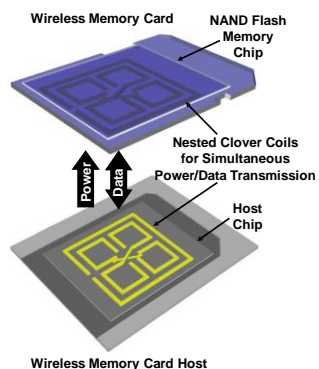


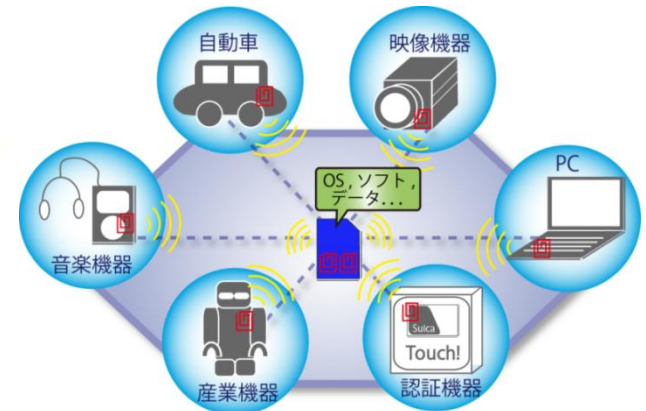
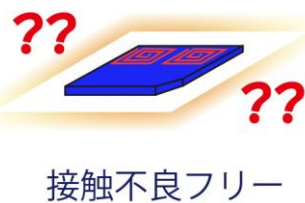
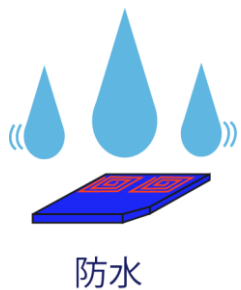
Dependable Wireless Solid-State Drive (SSD)



Ken Takeuchi, Chuo University
Tadahiro Kuroda, Keio University
Hiroki Ishikuro, Keio University

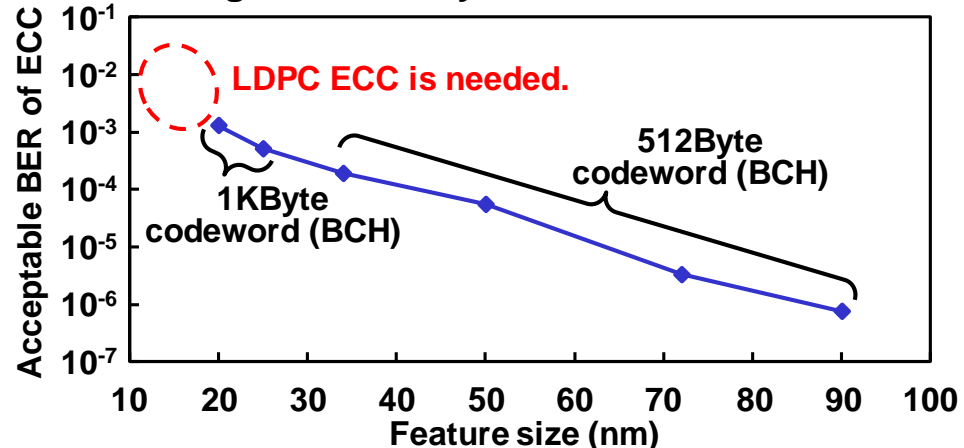
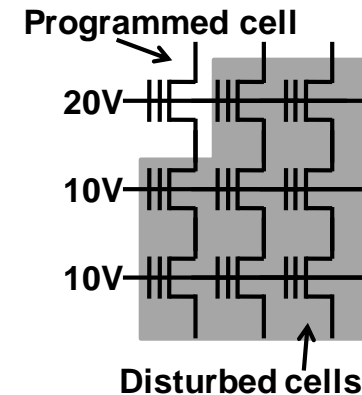
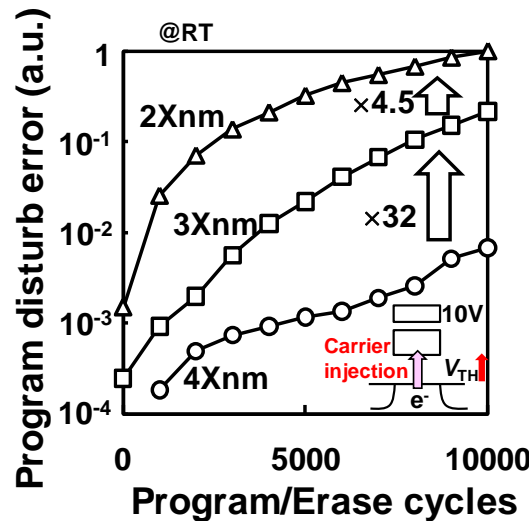
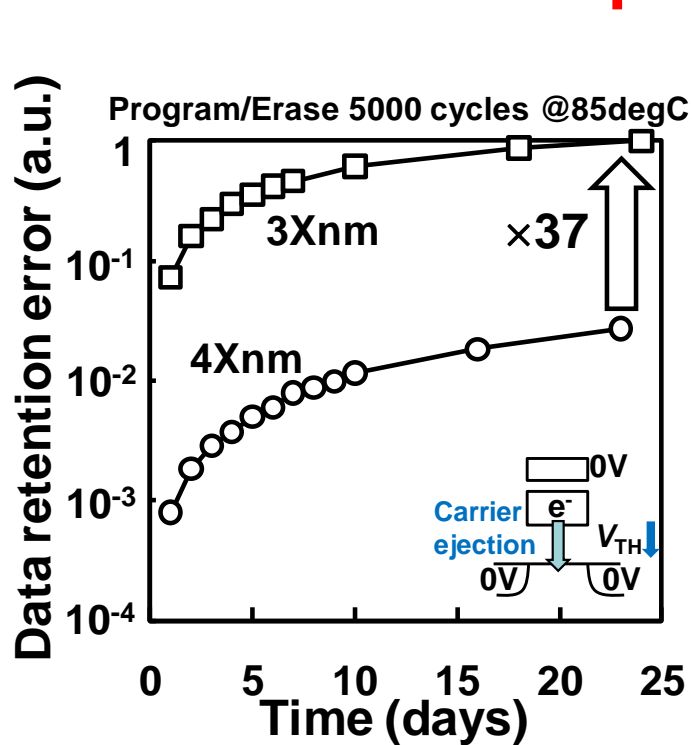
Objectives of Research

- **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)

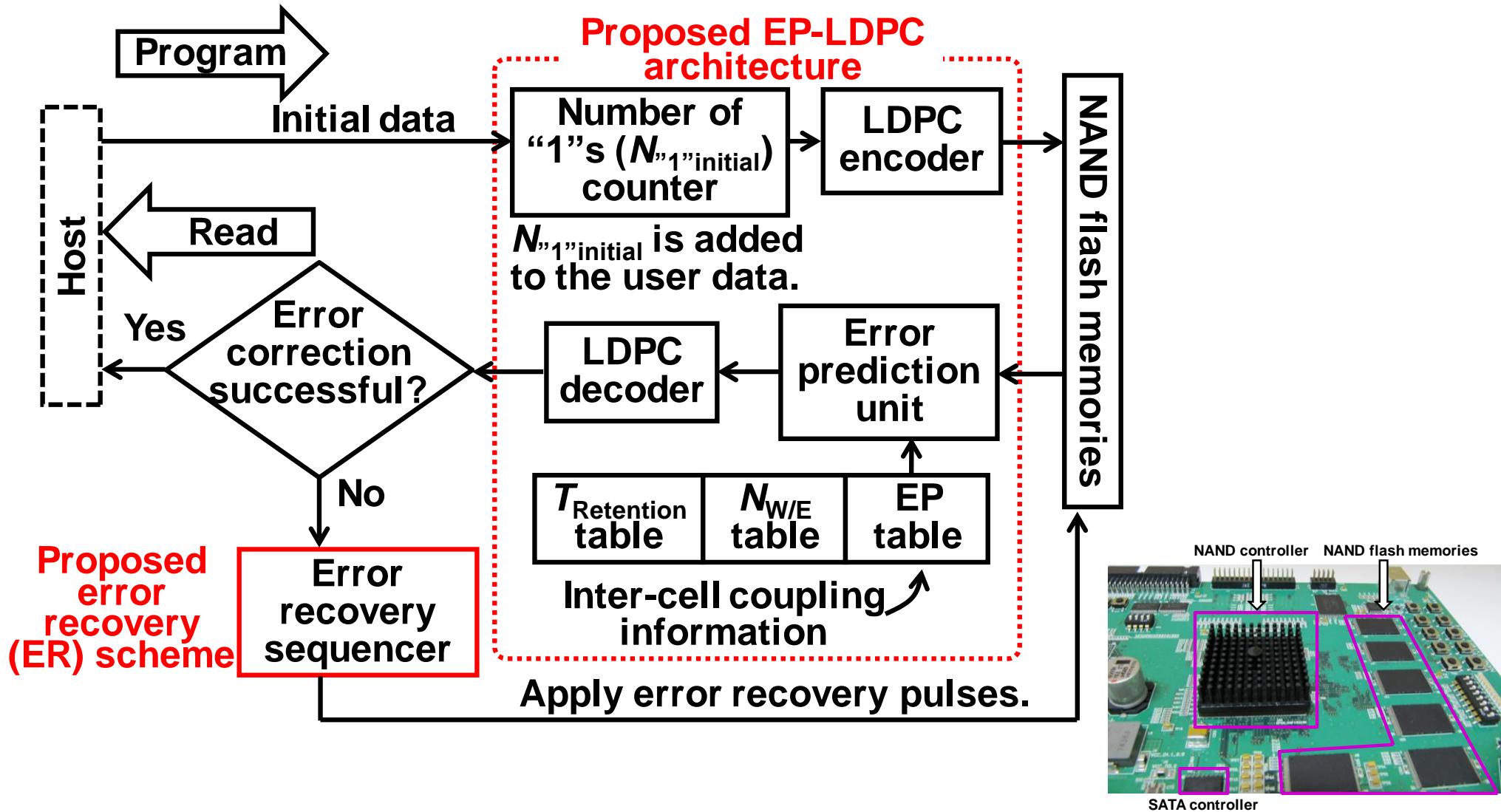


Dependable Memory System

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

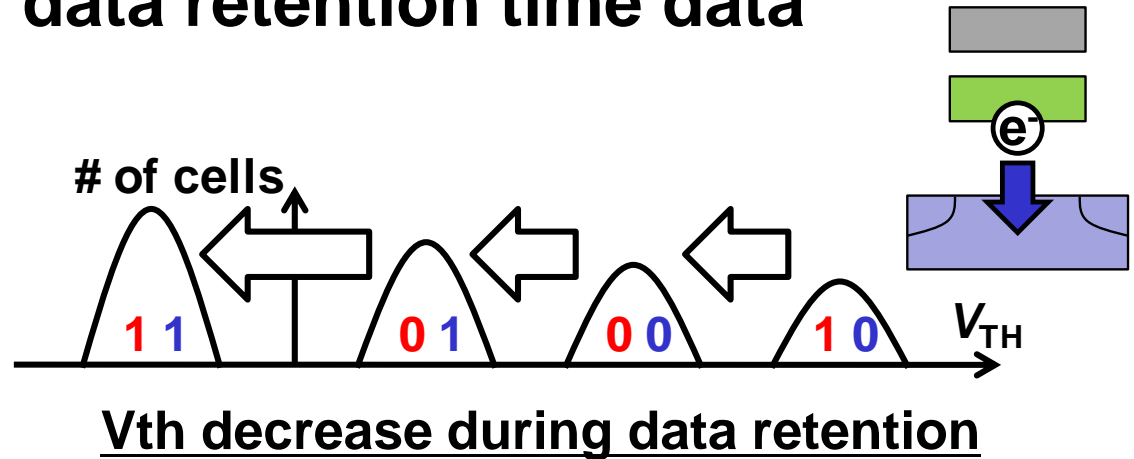
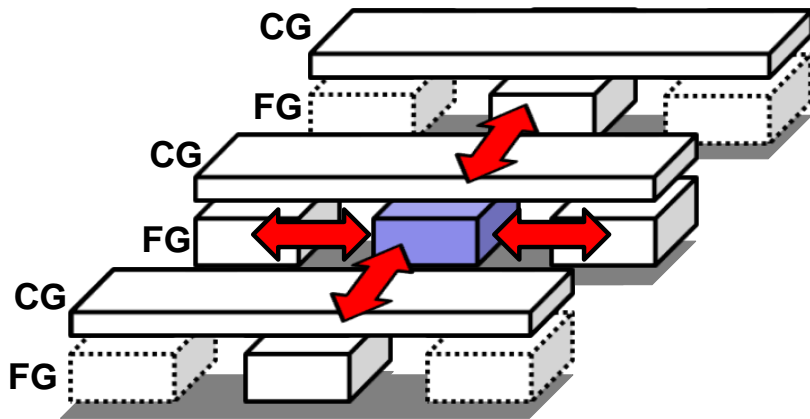


Dependable SSD System (ISSCC 2012)

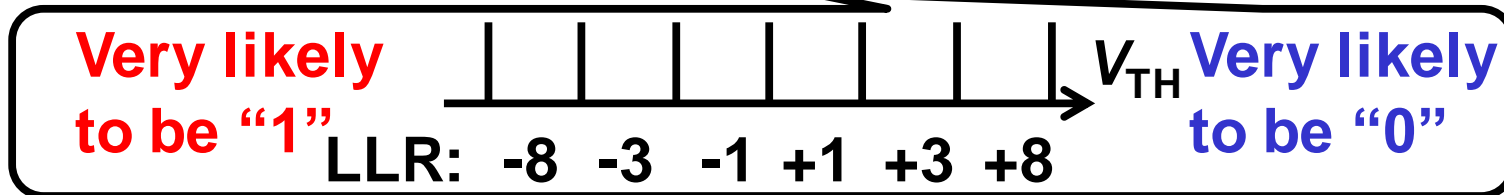
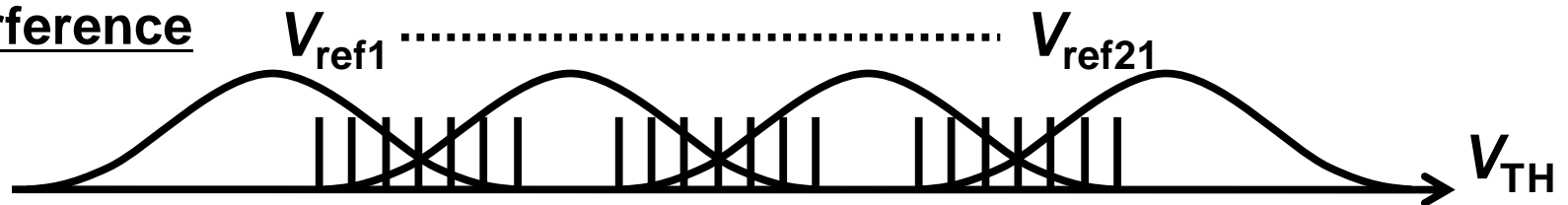


Error Predicting LDPC

- Compensate the capacitive interference by using the neighboring cell data
- Compensate the V_{th} decrease during data retention by write/erase cycles and data retention time data

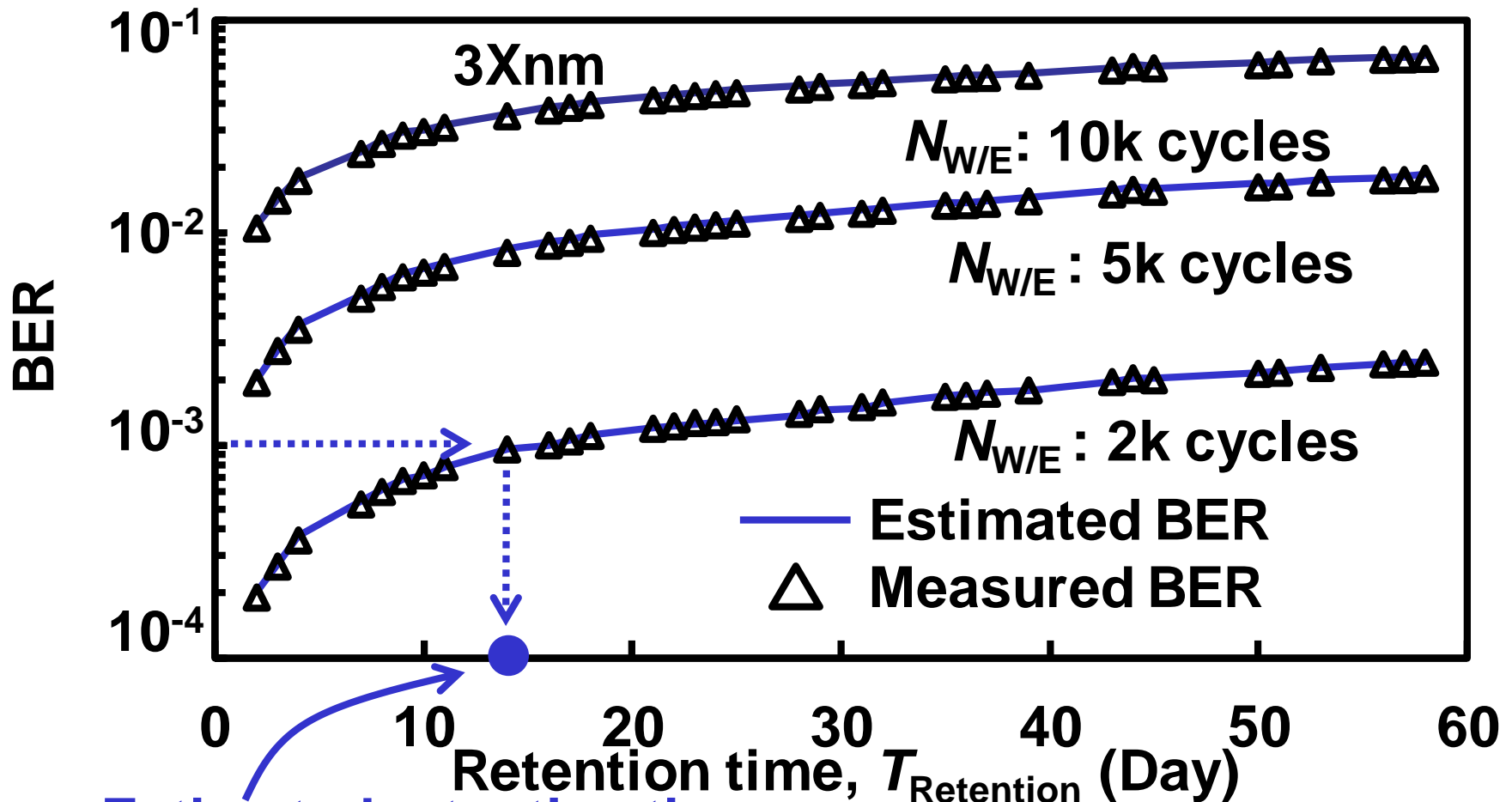


FG-FG interference



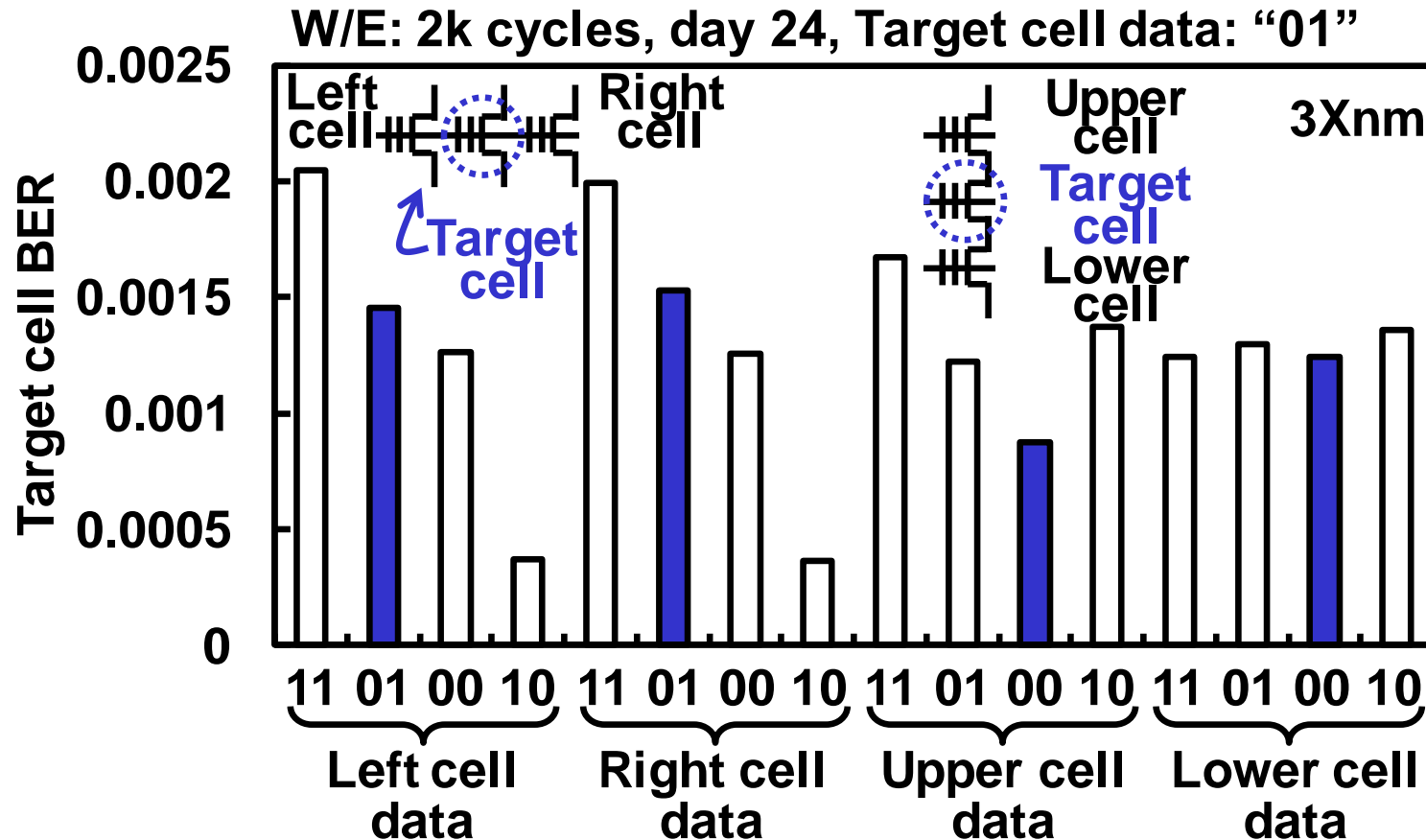
Error Predicting LDPC

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



Error Predicting LDPC

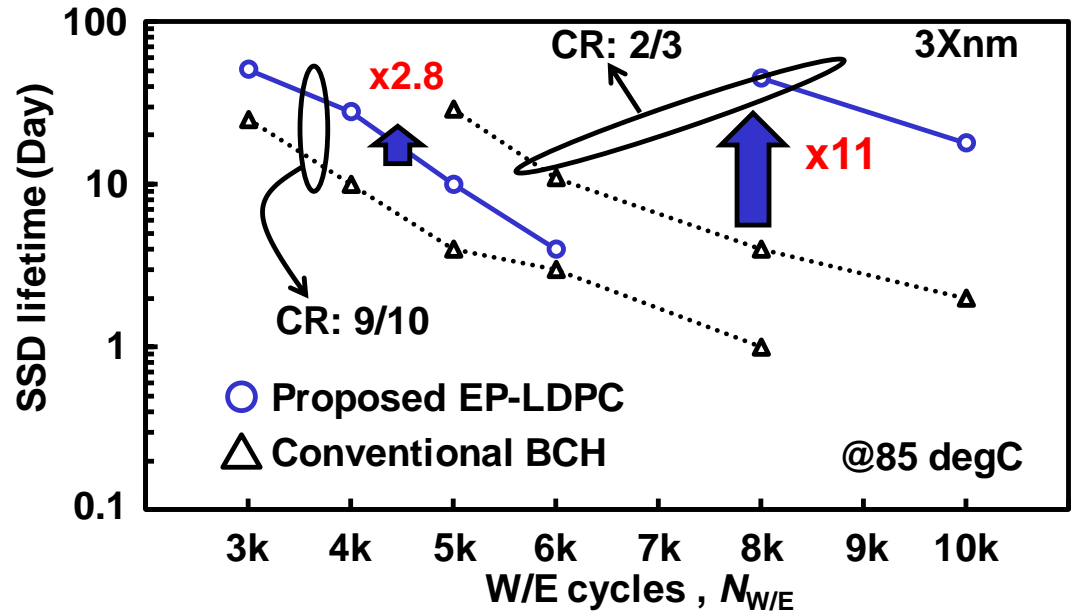
- Predict BER by the write/erase cycles, data retention time, neighboring cell data and pre-recorded tables



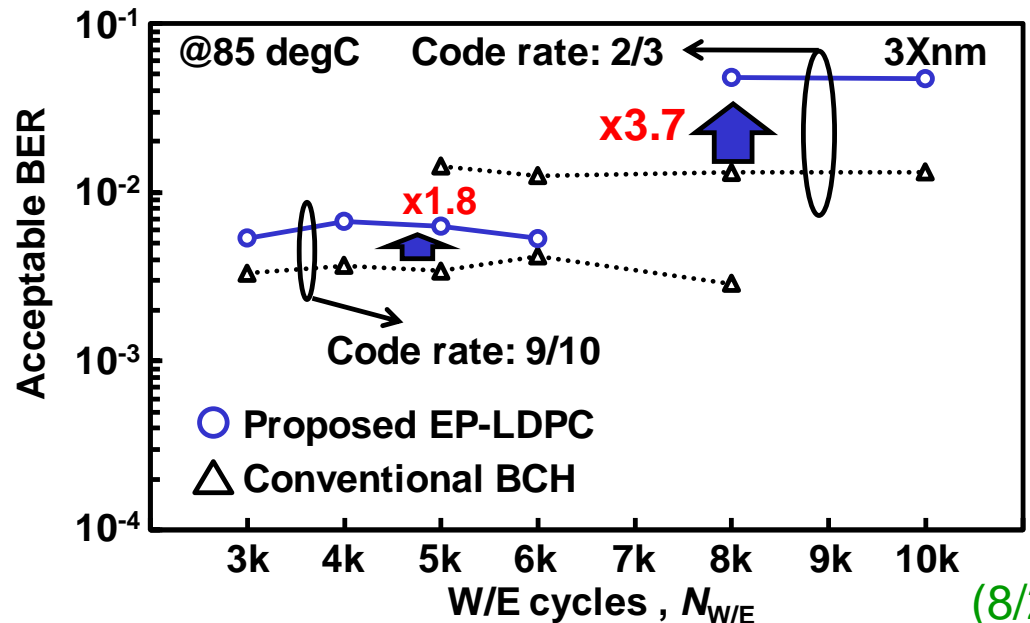
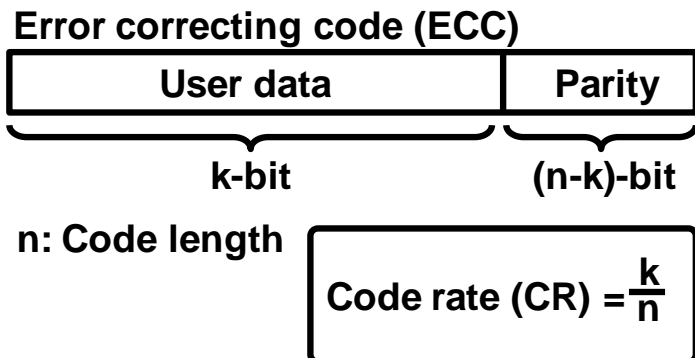
$$\begin{aligned}
 \text{BER}_{\text{Target Cell}} &\sim (\text{BER}_{\text{Left_}''01''} + \text{BER}_{\text{Right_}''01''} + \text{BER}_{\text{Upper_}''01''} + \text{BER}_{\text{Lower_}''01''}) / 4 \\
 &= (0.0015 + 0.0015 + 0.0012 + 0.0013) / 4 = 0.0014
 \end{aligned}$$

Error Predicting LDPC

■ x11 lifetime

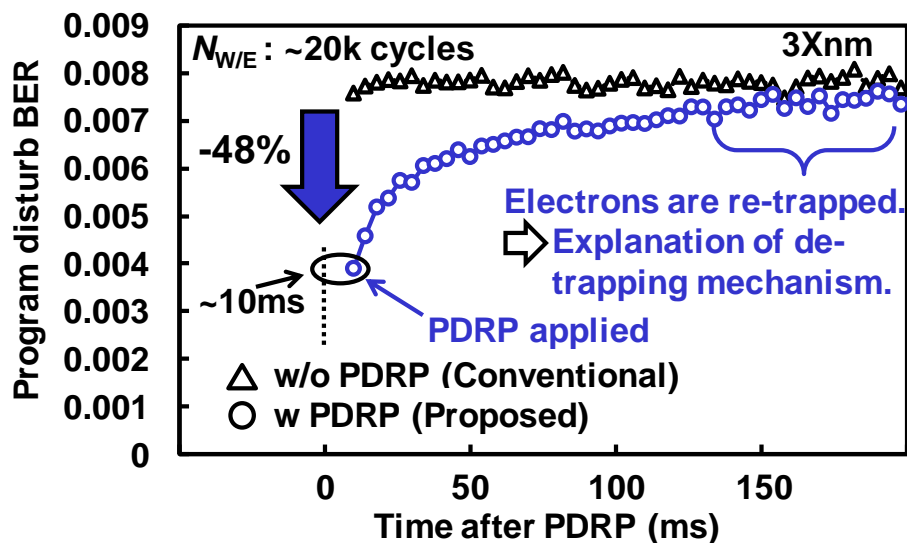
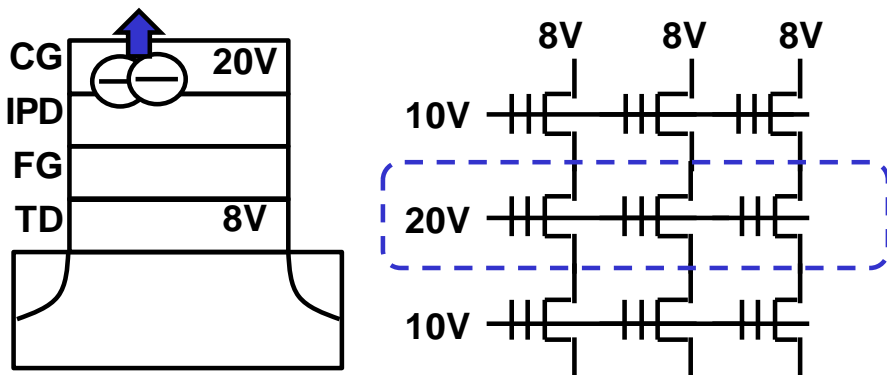


■ x3.7 acceptable BER

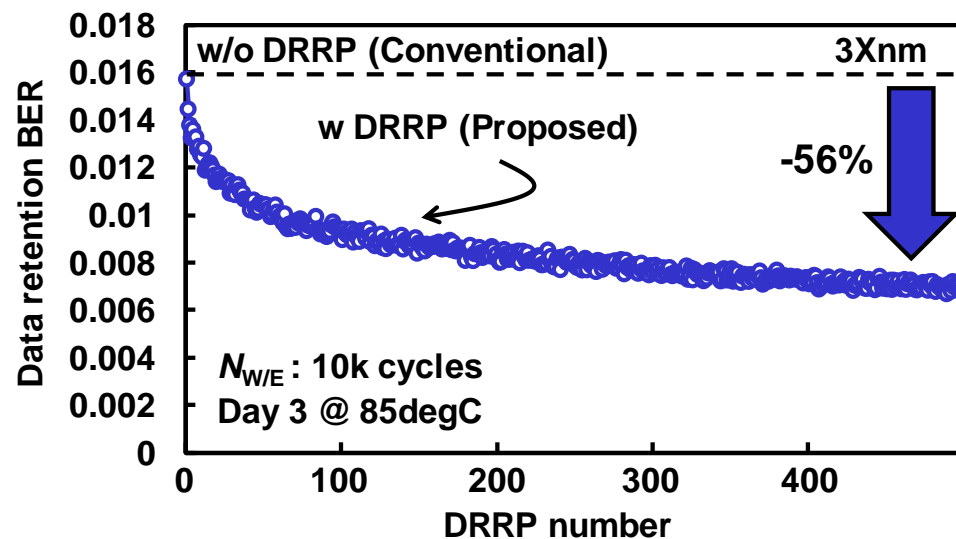
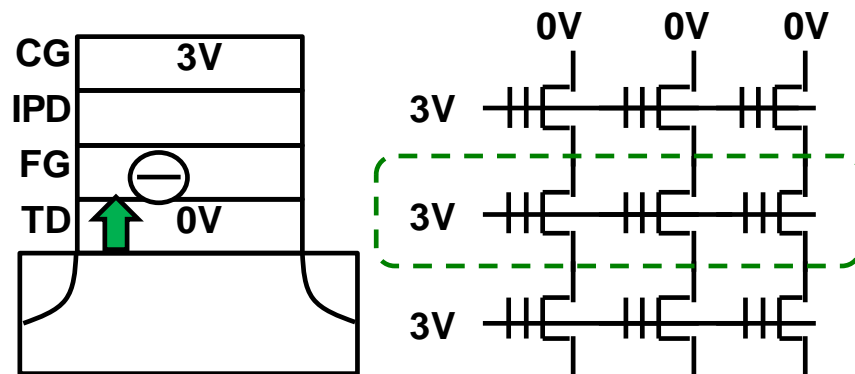


Error Recovery Scheme

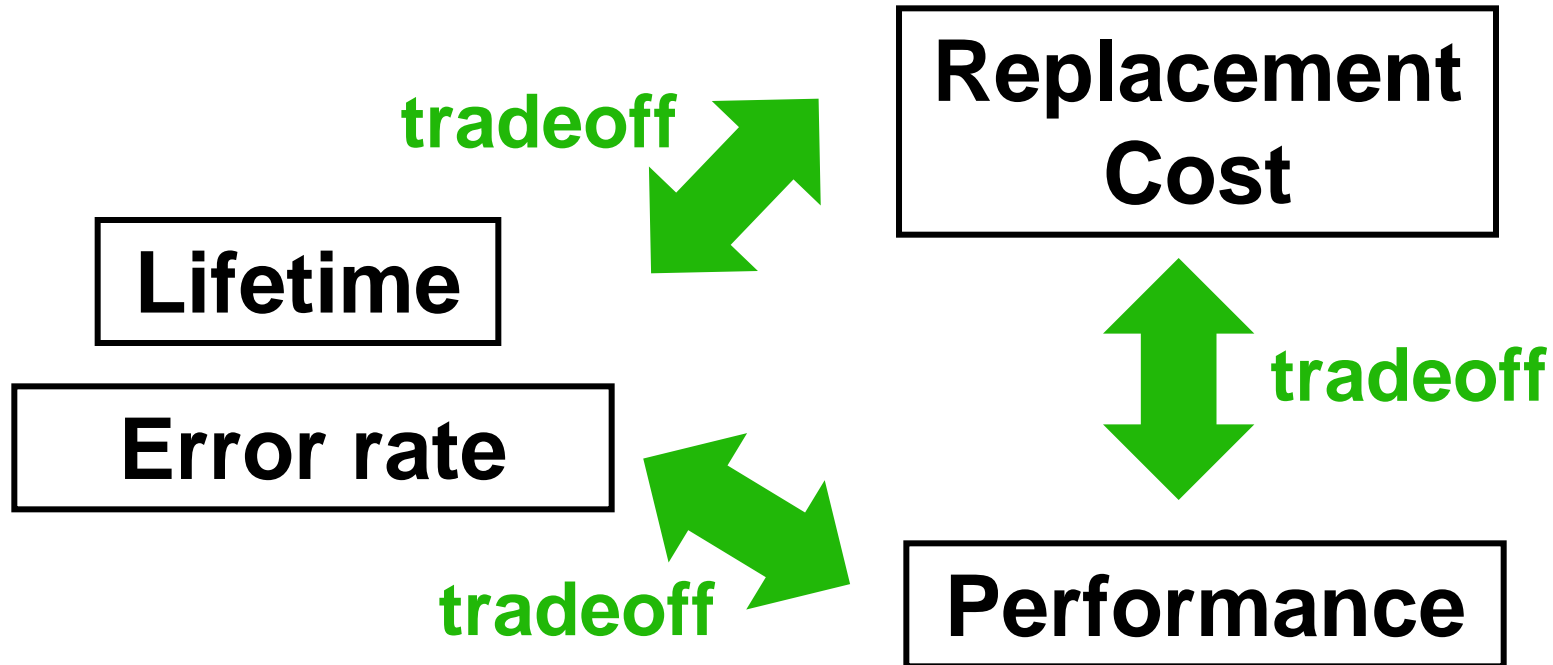
Recovery of program disturb error



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)

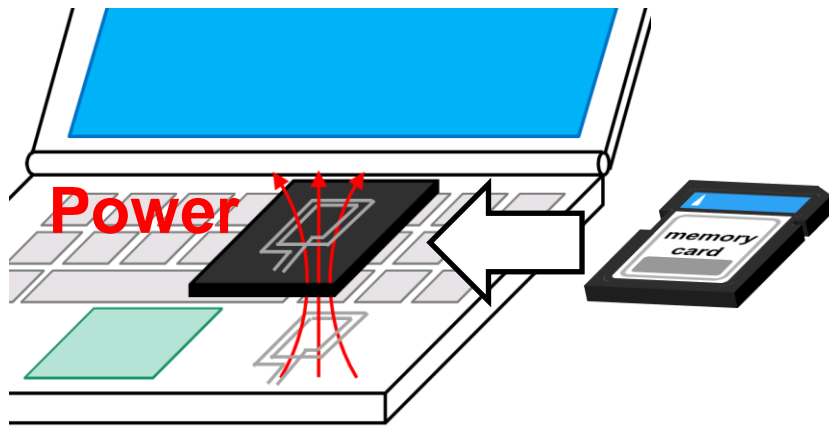
Wireless Power and Data Transfer

■ Dependability Issues

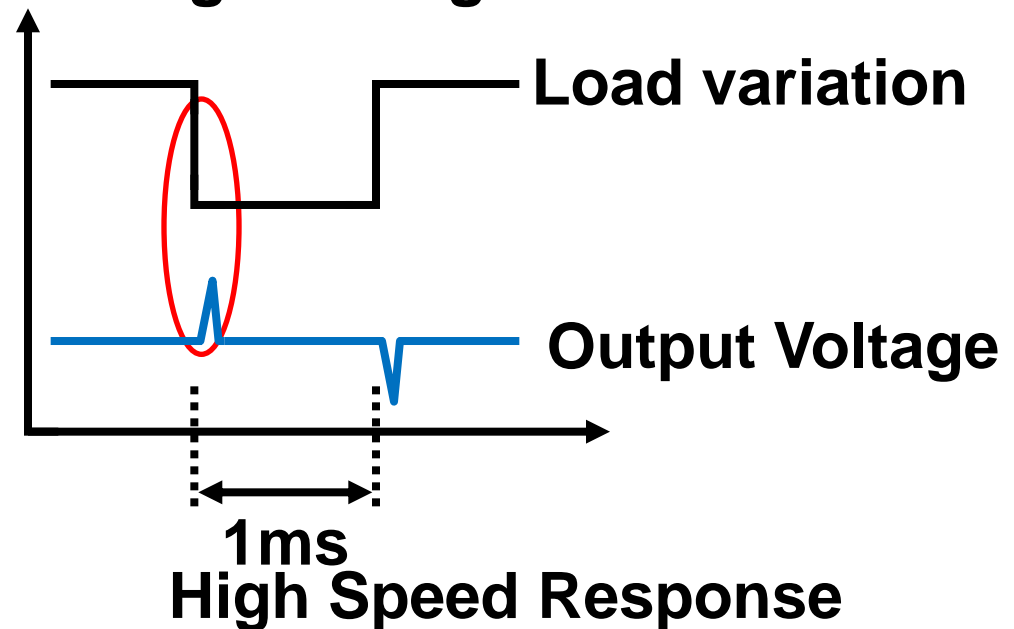
- Voltage and thermal stress in memory card (Rapid load change in battery-less system)
- Electro-magnetic interference (EMI) between power, data channel, and other electronic system.

■ Keyword

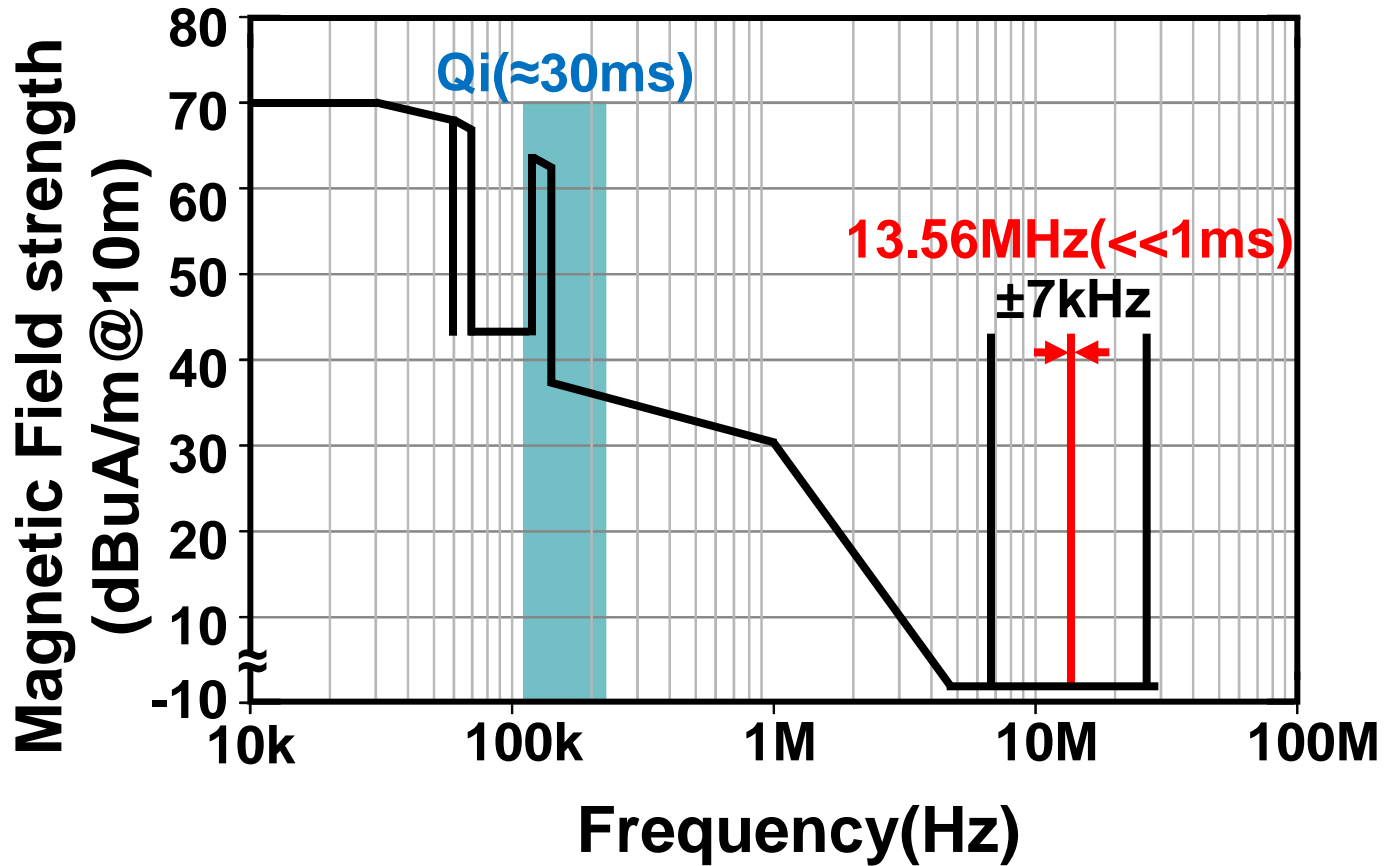
- Wideband near-field electro-magnetic signal



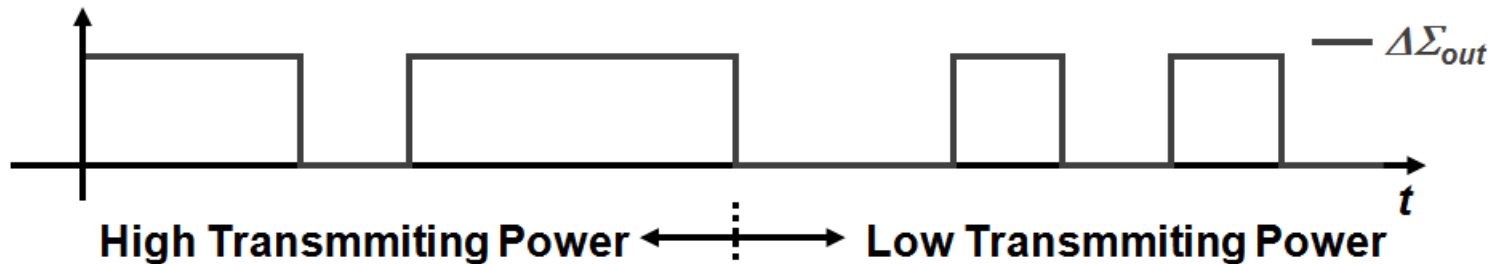
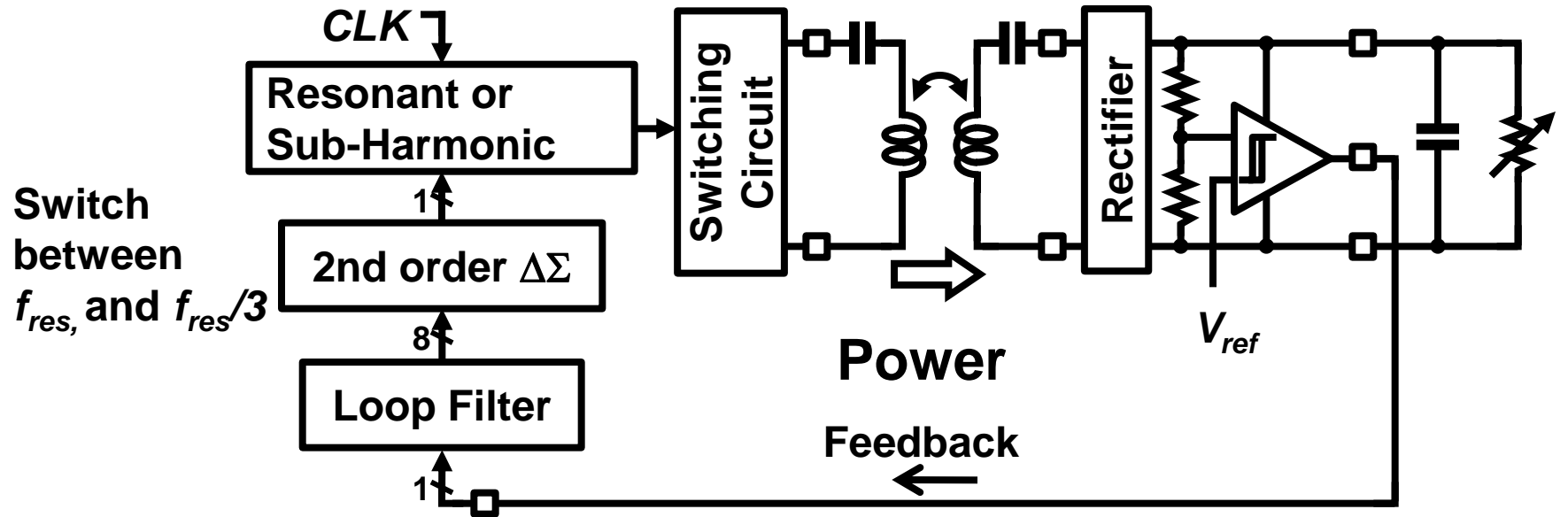
Contactless Memory Card



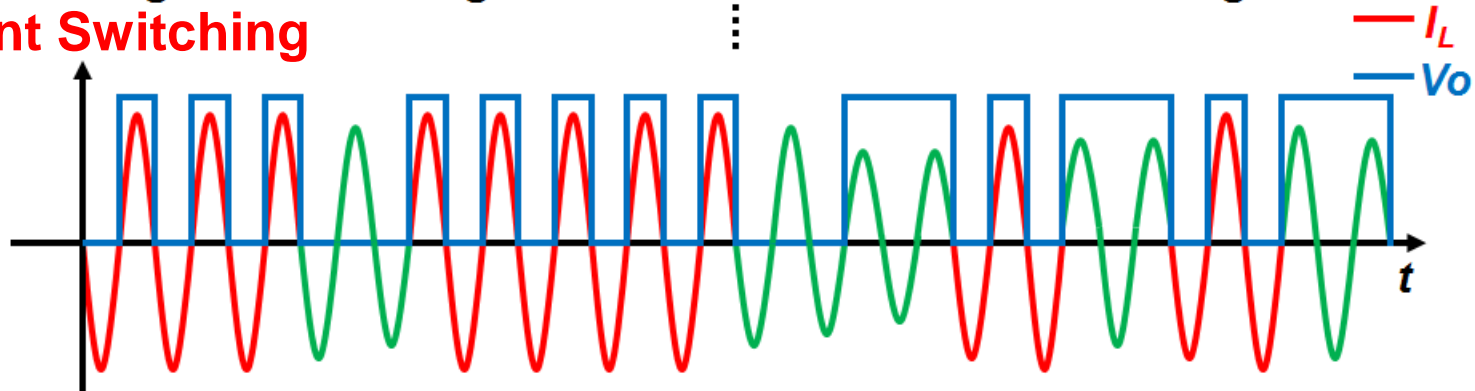
EMI regulation



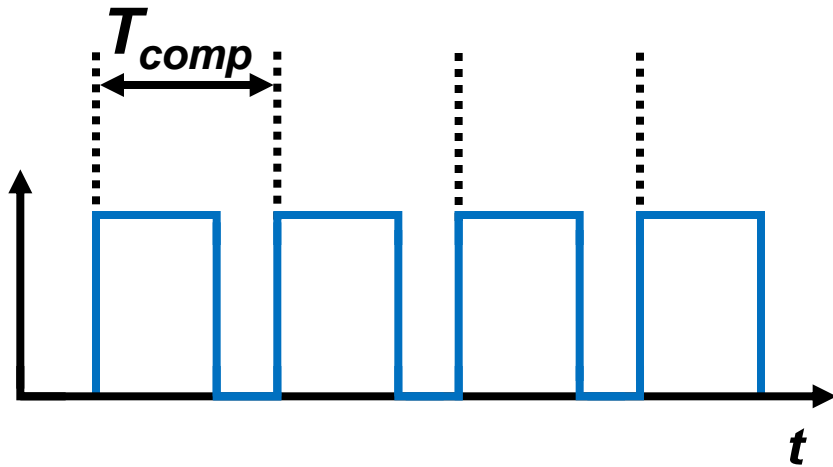
Fast Power Control by $f_{res} - f_{res}/3$ Switching



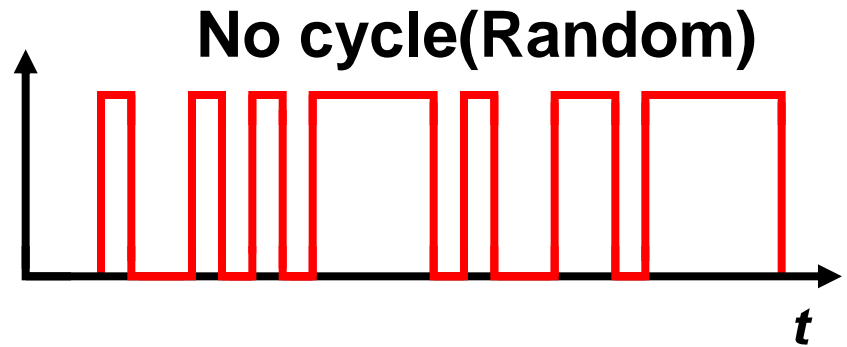
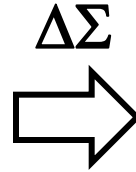
Zero Current Switching
Low EMI



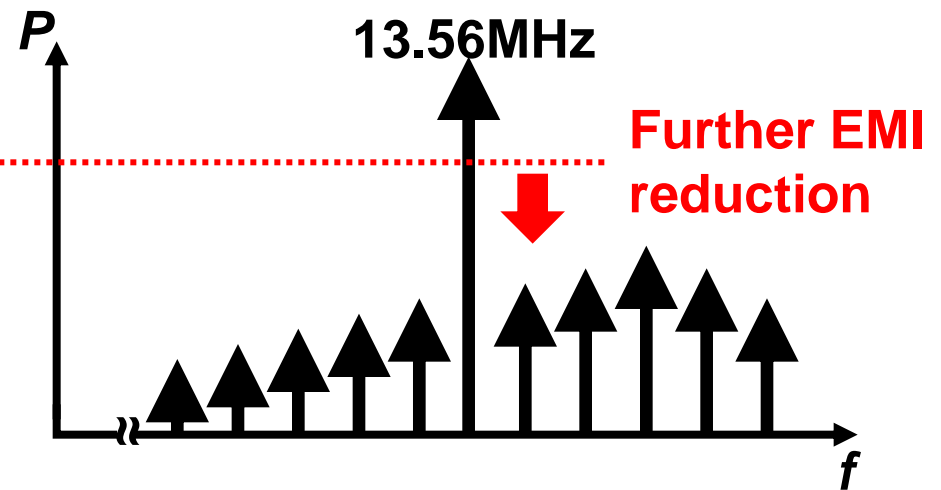
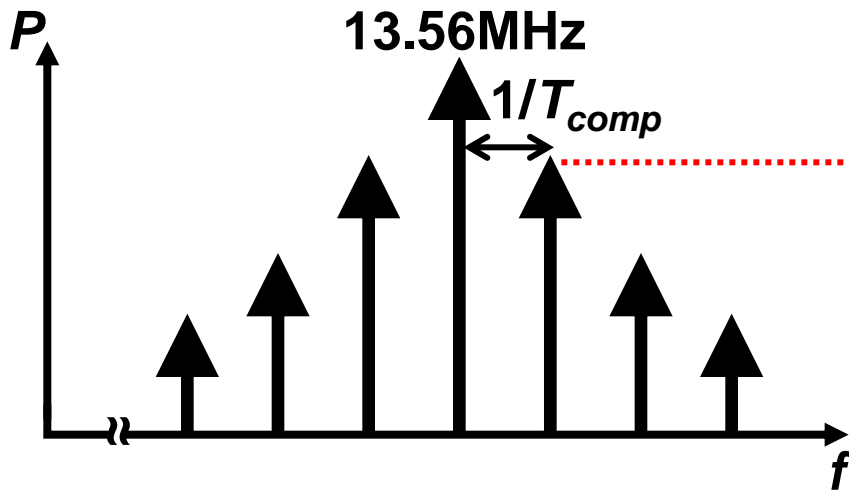
EMI Reduction by $\Delta\Sigma$ Modulation



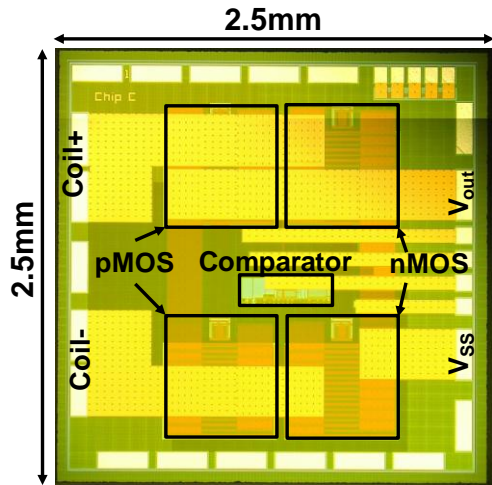
Without $\Delta\Sigma$ -Modulator



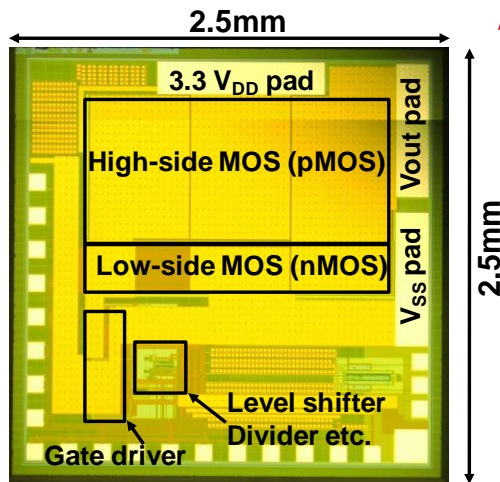
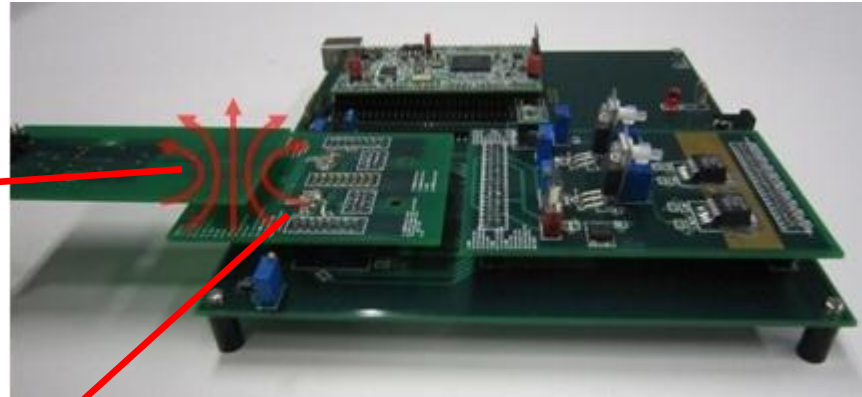
With $\Delta\Sigma$ -Modulator



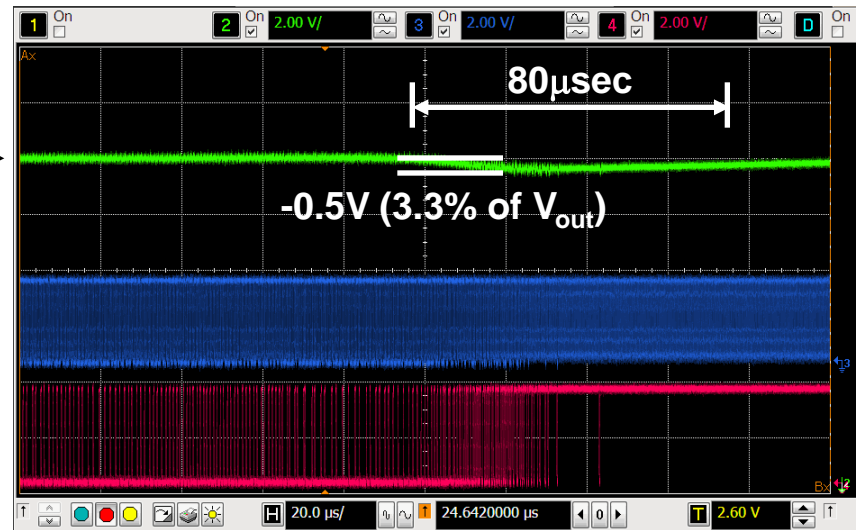
Fast Load Tracking



Rectifier chip

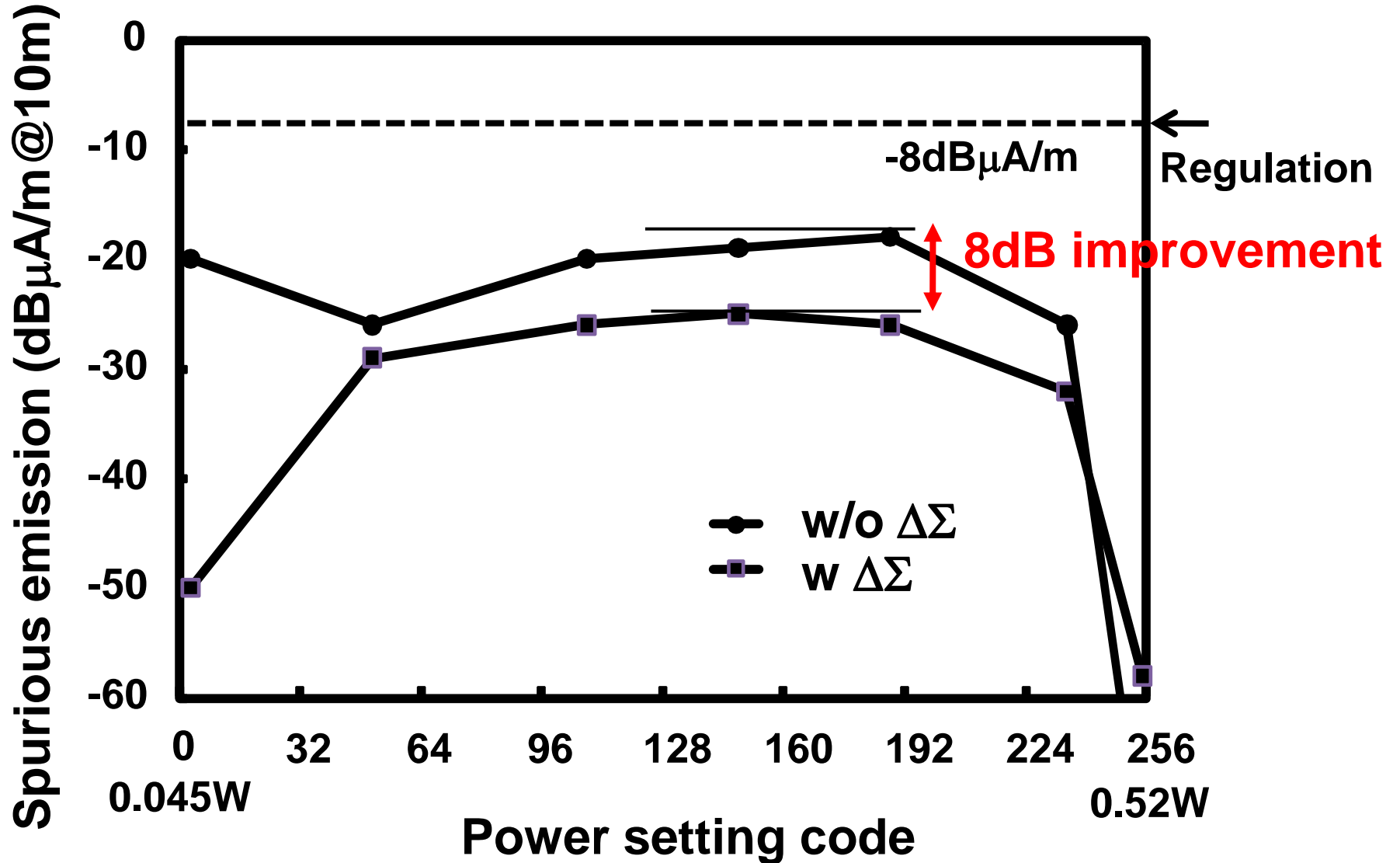


Transmitter chip



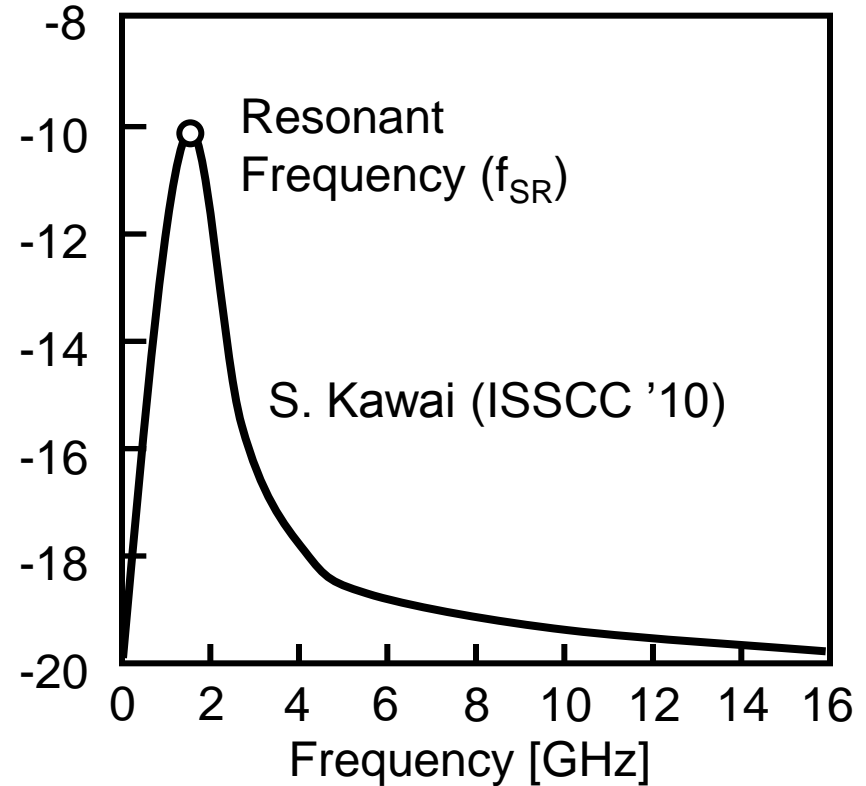
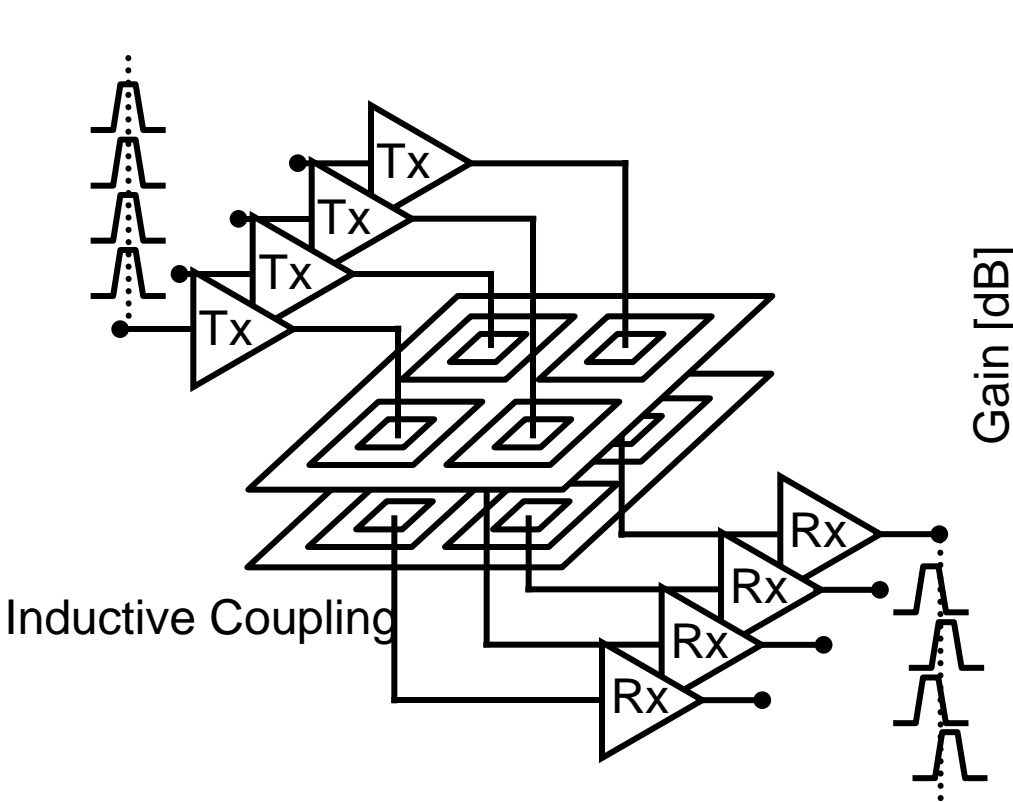
Load transition point
(From 45mW to 500mW)

EMI Reduction



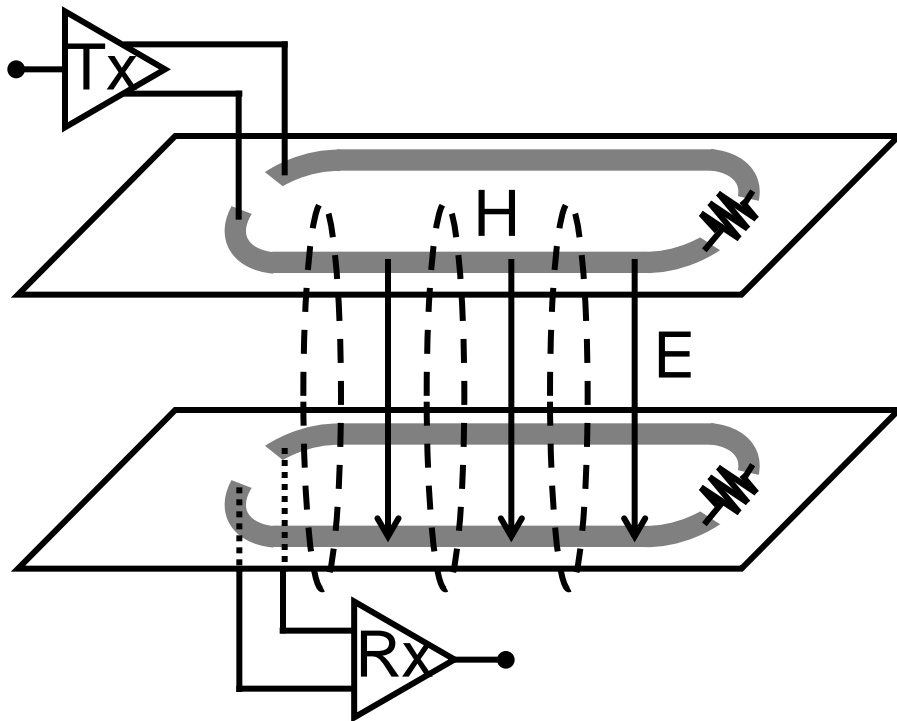
Inductive Coupling Link (Narrow Band)

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

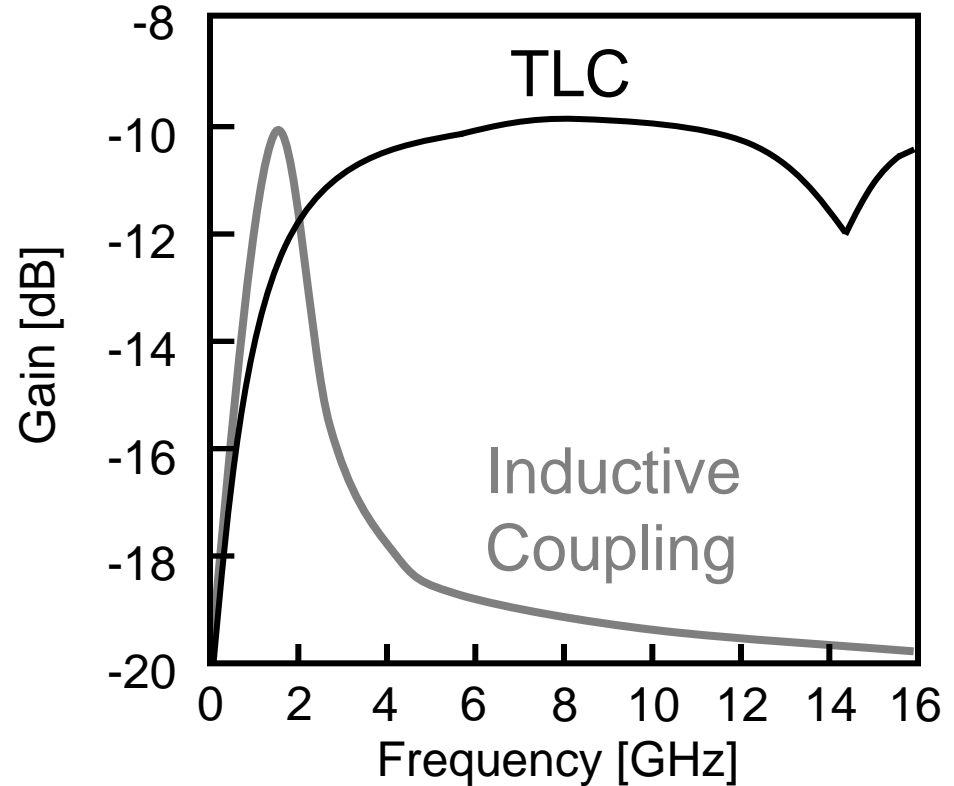


Wideband Communication with TLC

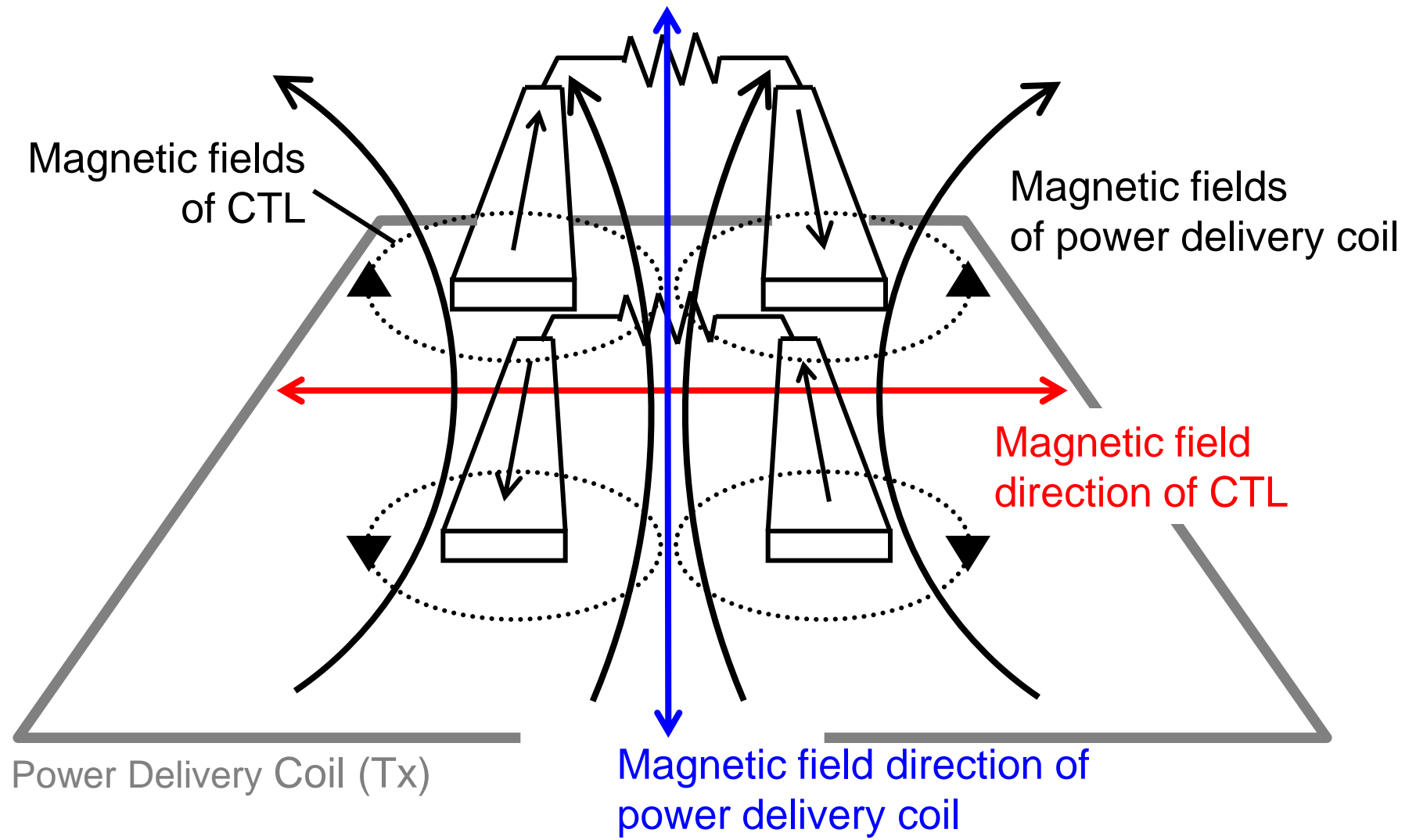
- **Transmission Line Coupler (TLC)**
 - **Good matching capability**
 - **Wide bandwidth**



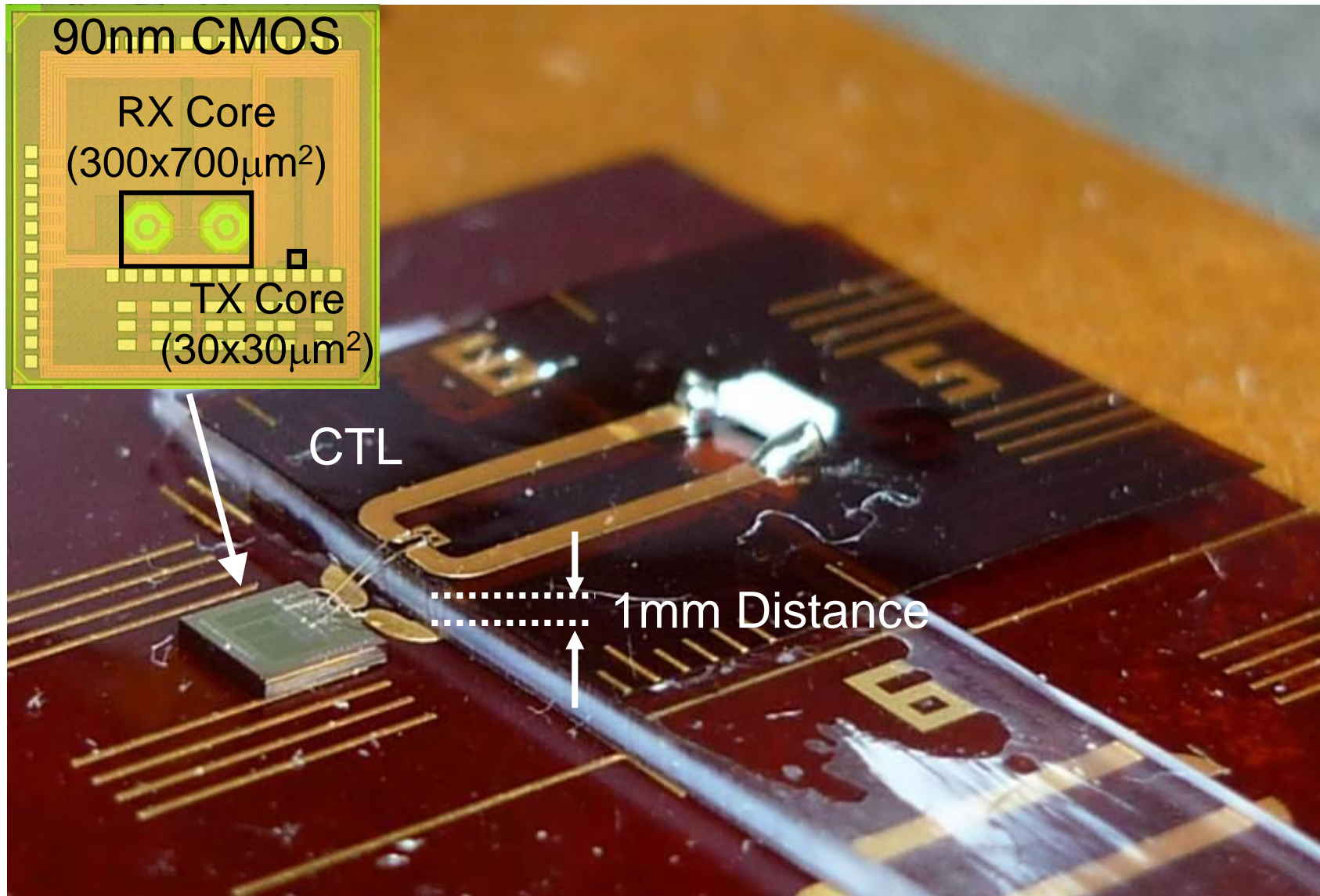
Proposed TLC



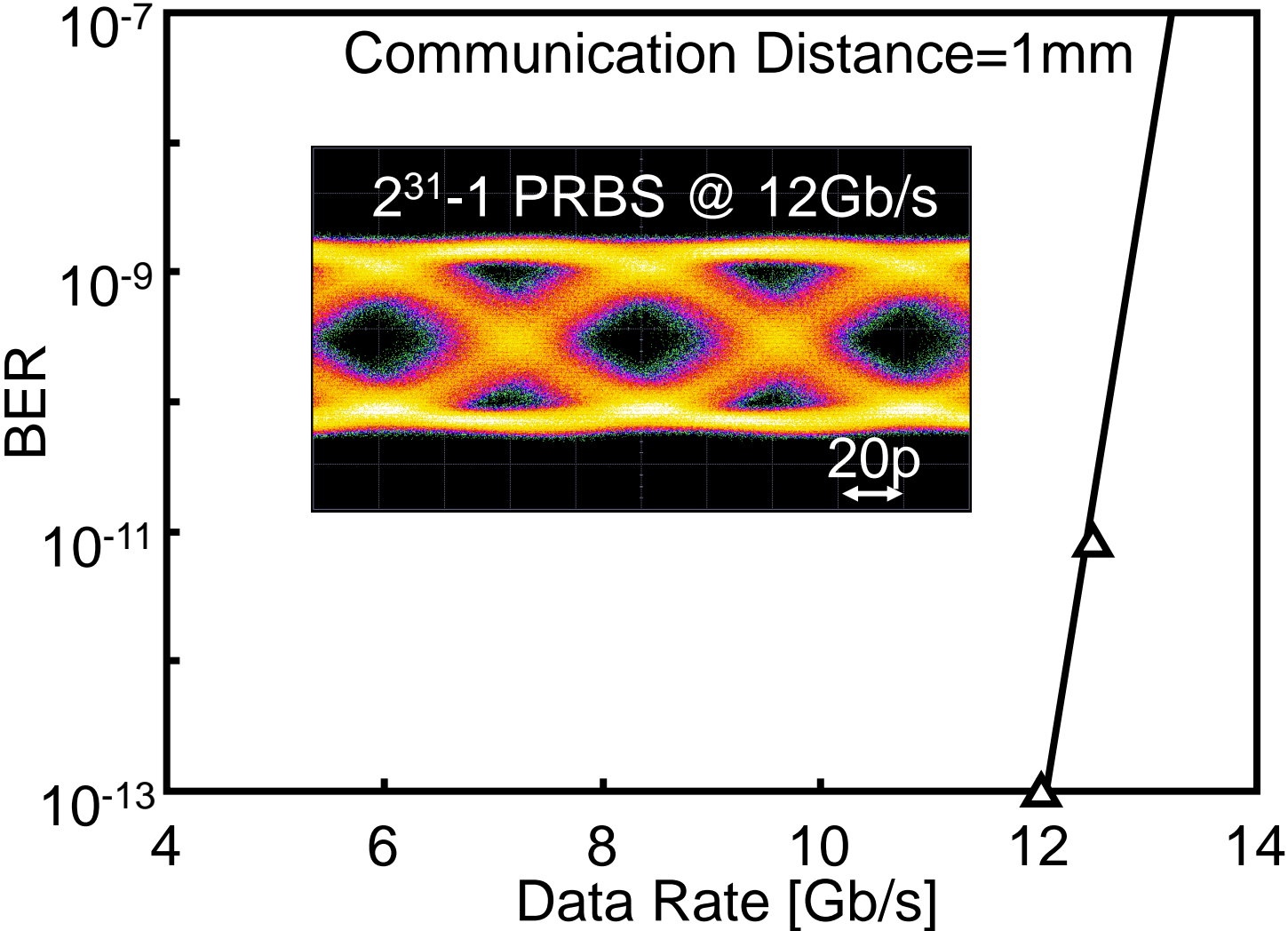
Immunity to EMI



Chip Photo and Evaluation System

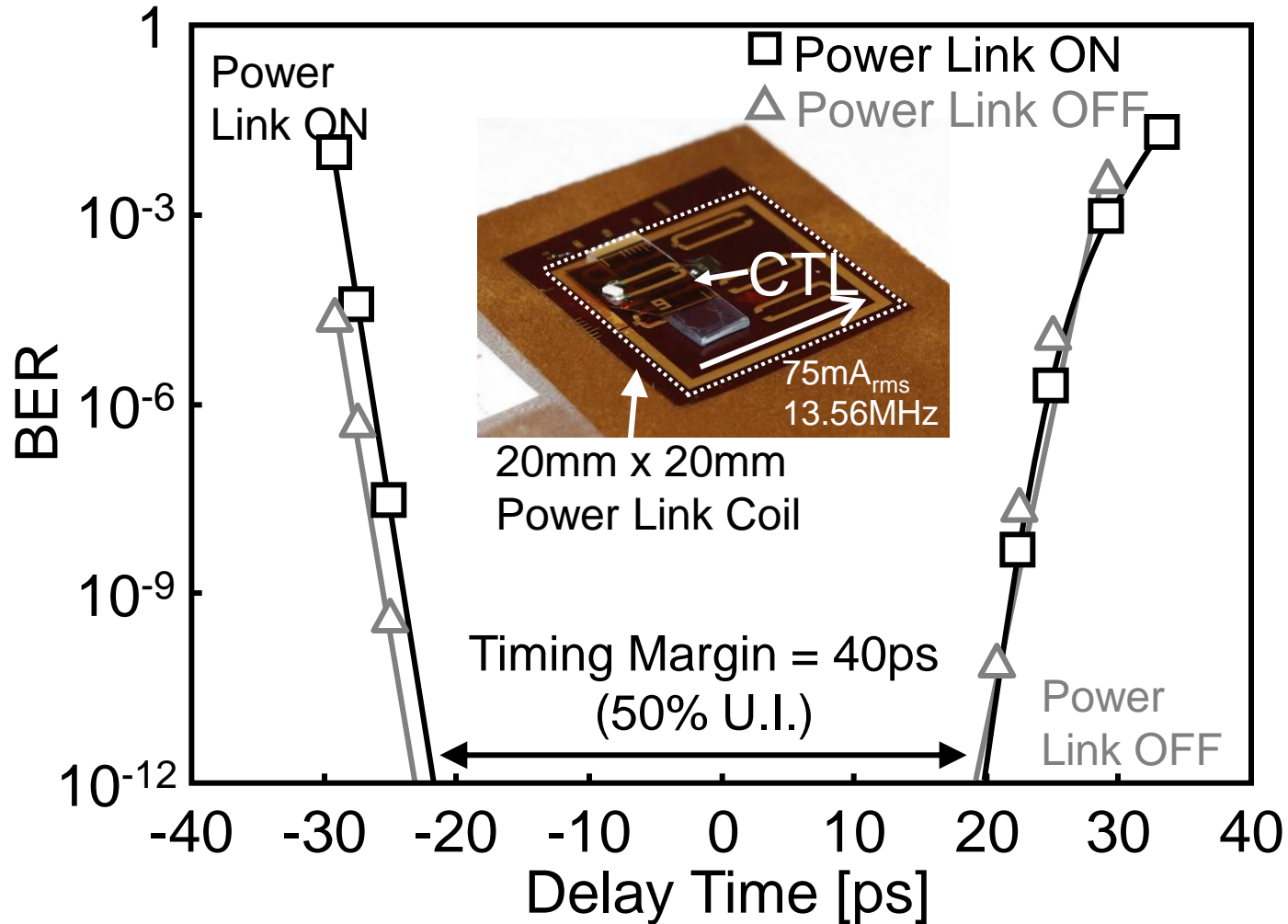


12Gbps Communication



Reliable Communication in Wireless Power Delivery

$2^{31}-1$ PRBS @ 12Gb/s, Communication distance=1mm



Future Applications

Wireless Power transfer to battery-less EV etc.



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

