Autonomous di/dt Noise Control Scheme for Margin Aware Operation

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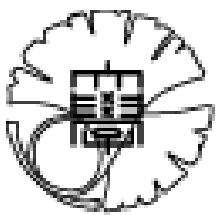

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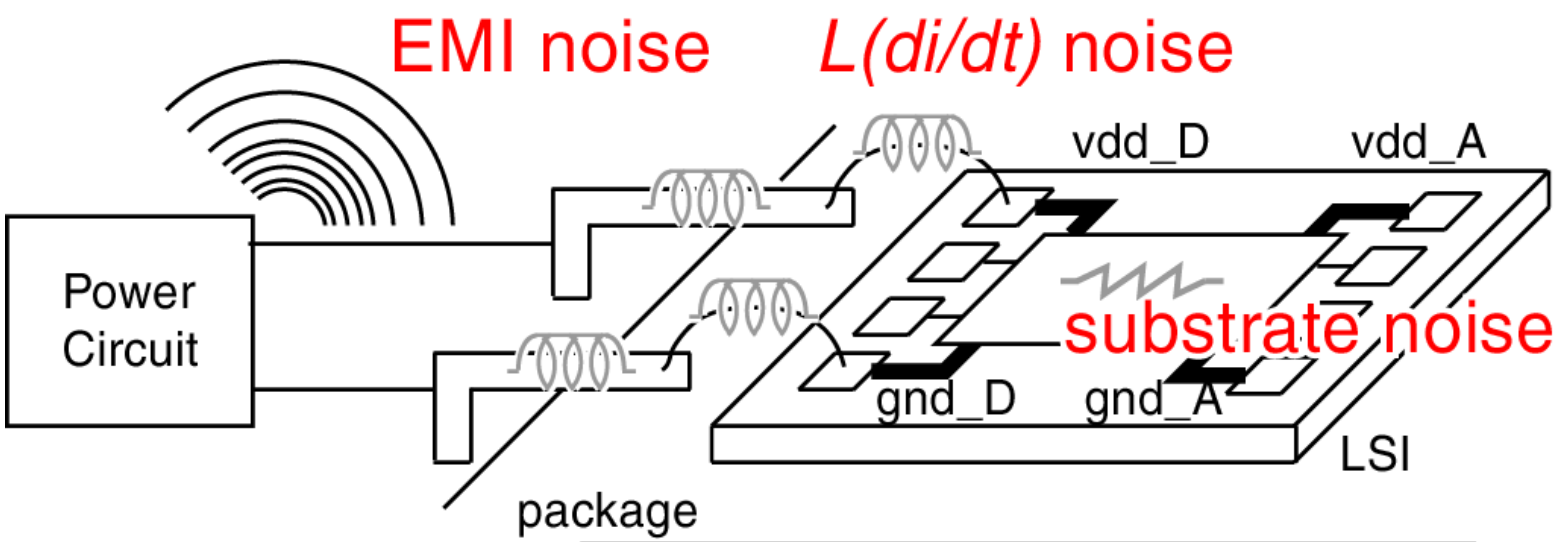
Background

- di/dt is becoming a critical issue
  - L(di/dt) noise of low voltage LSIs
  - Substrate noise on Mixed-signal LSIs
  - EMI noise of high-speed operation LSIs
- Control the operation mode based on di/dt



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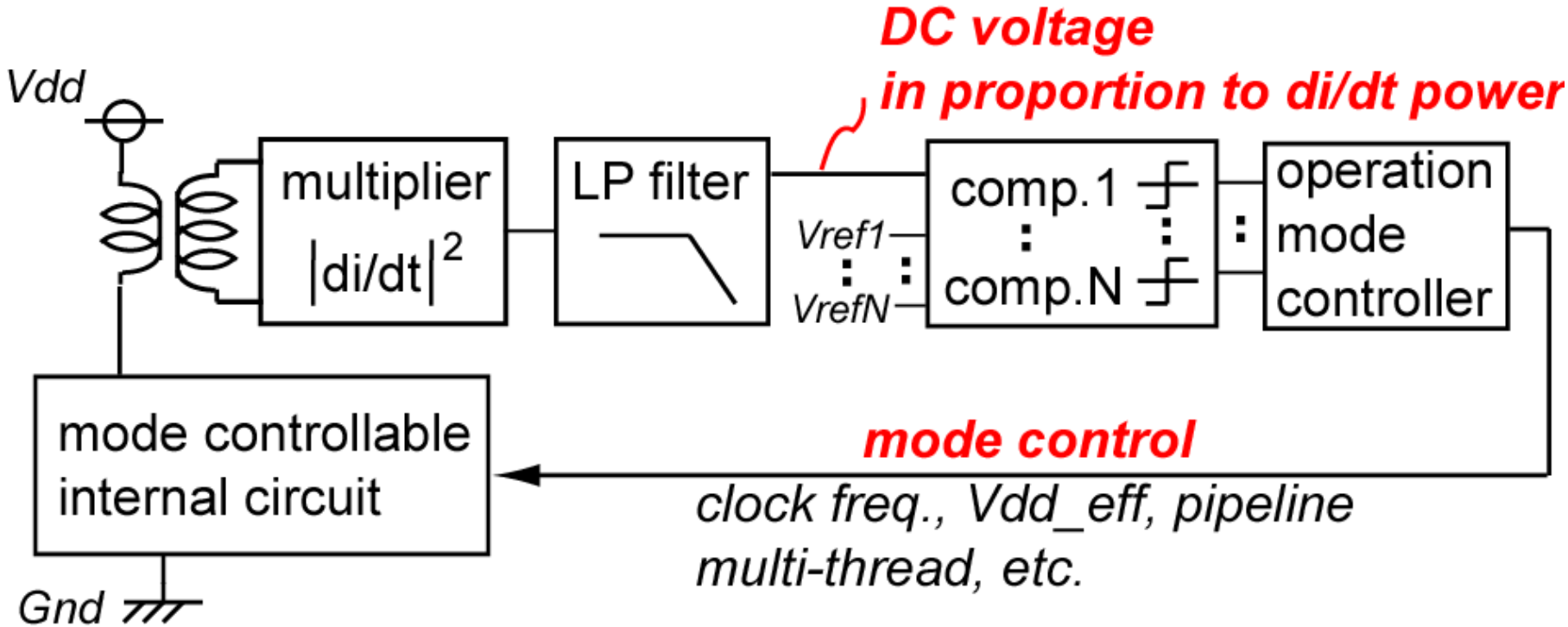
Autonomous di/dt Control

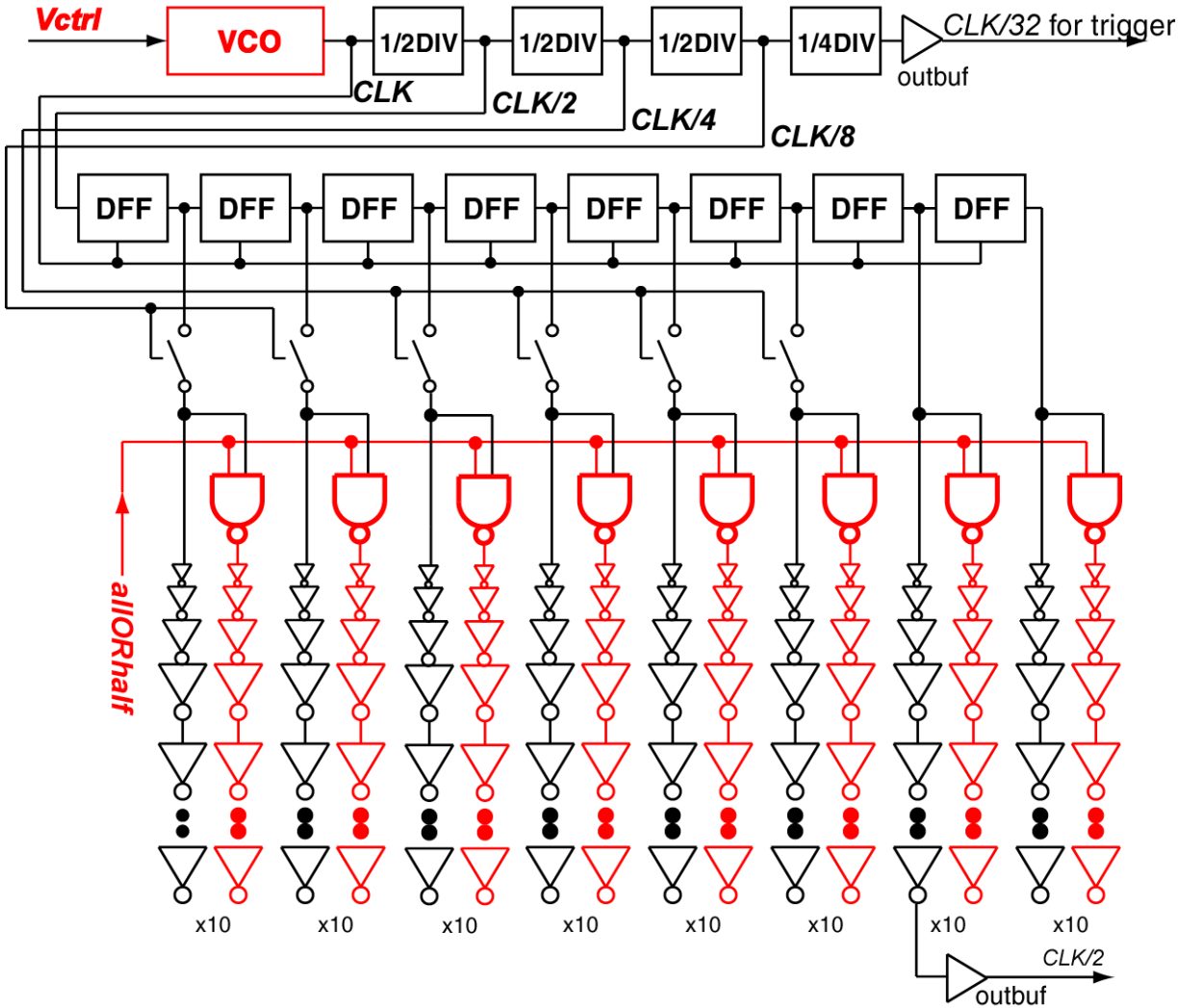
- **di/dt-based operation mode control**

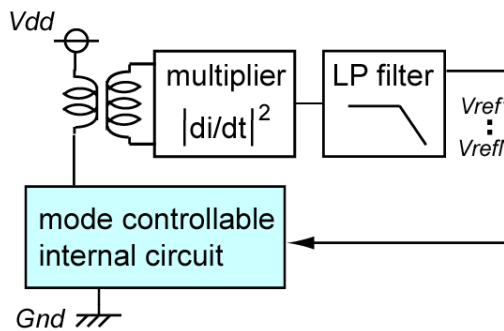


Advantages

- **Measurement base**
  - **PVT variation is taken into account**
  - **Difficult to predict the di/dt by a simulation**
- **Get “best effort” performance under the restricted di/dt**
- **The di/dt range is controllable by Vref**

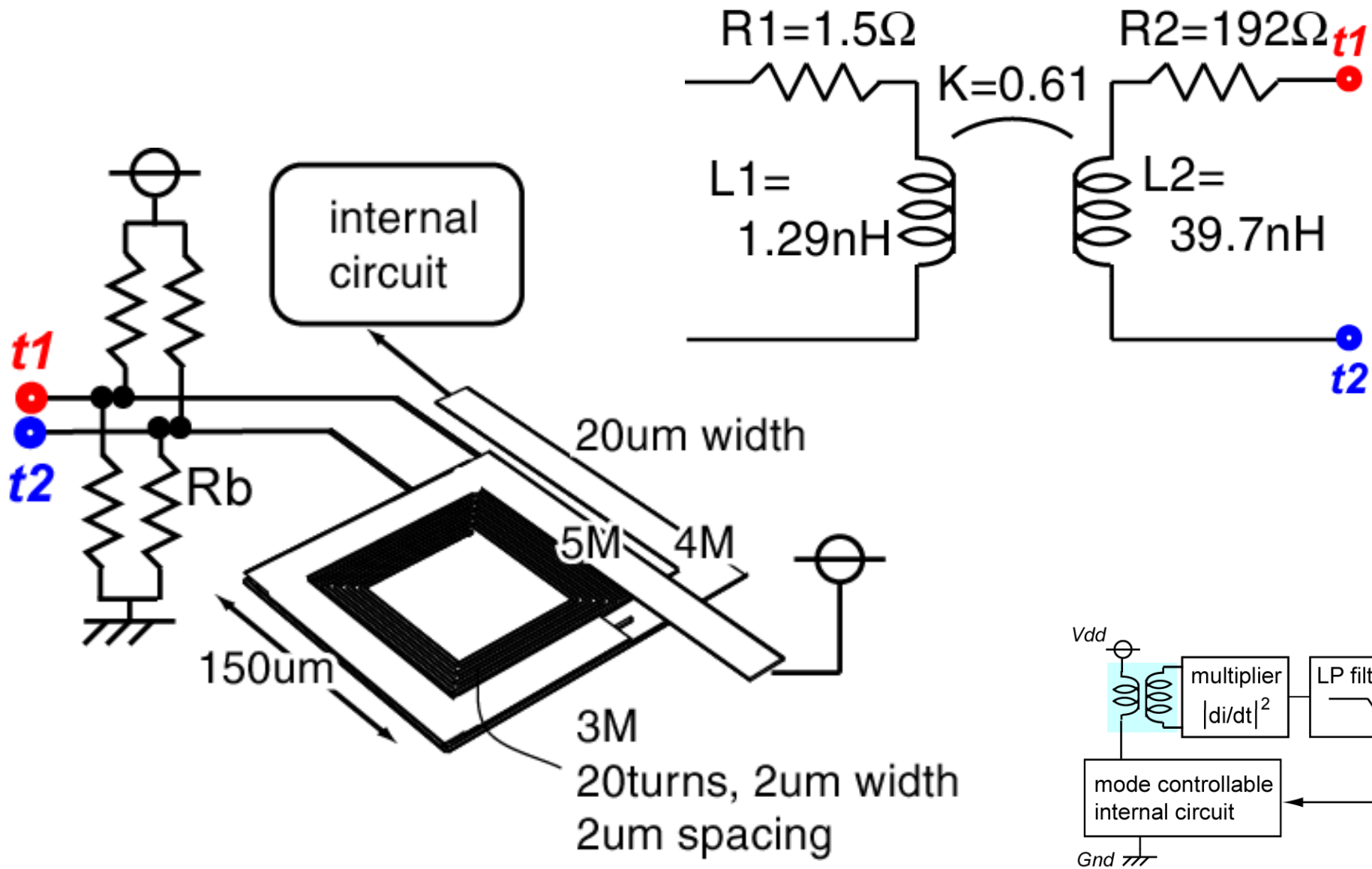
Mode Controllable Int. Circuit



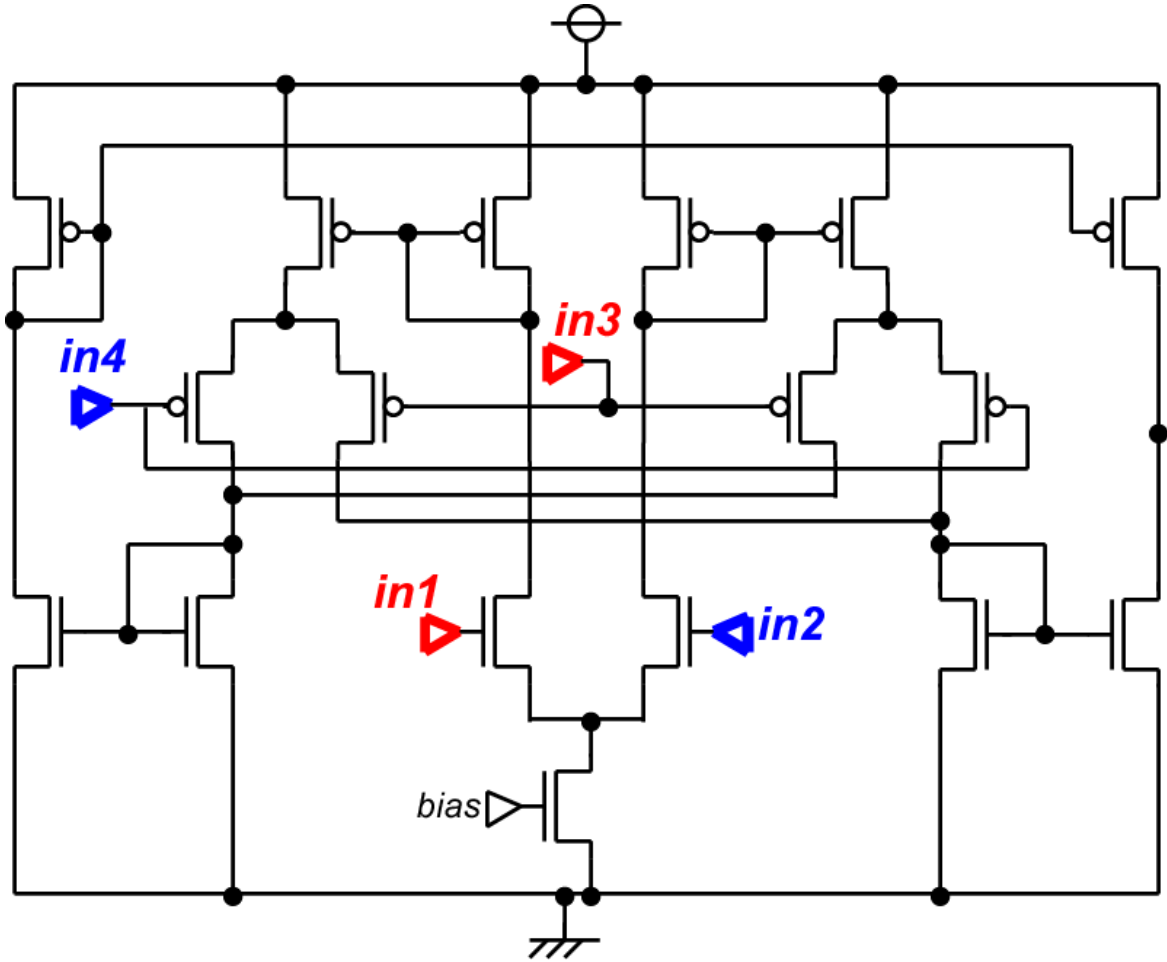


- "all" (high-performance), "half" (low-noise) mode

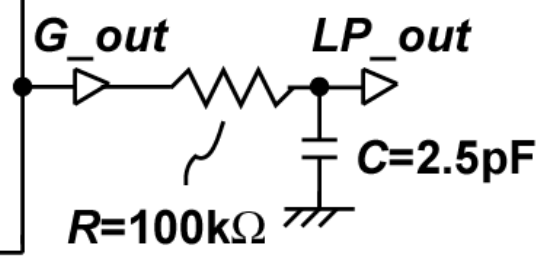
di/dt Detector



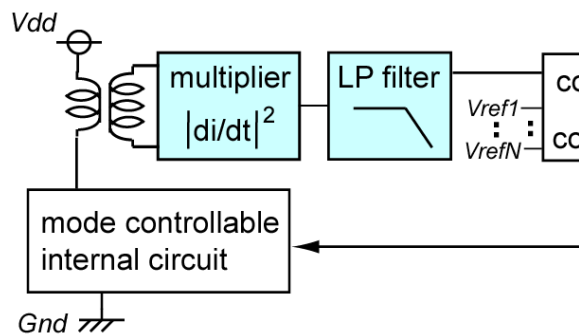
di/dt Multiplier, Low Pass Filter



VGout
=(Vin1-Vin2) x (Vin3-Vin4)
=(Vin1-Vin2)^2

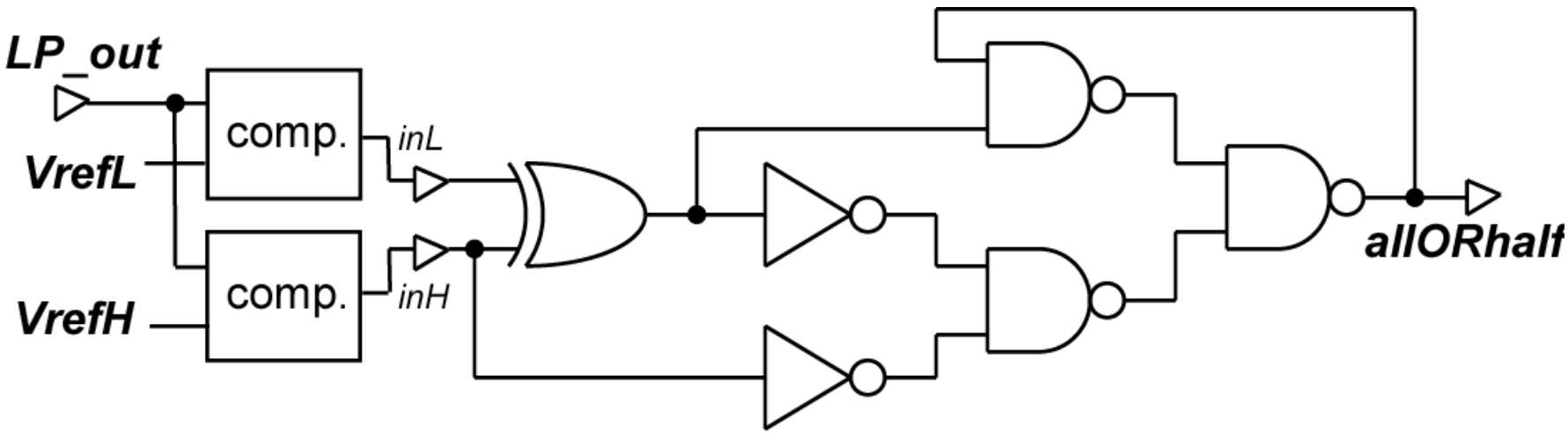


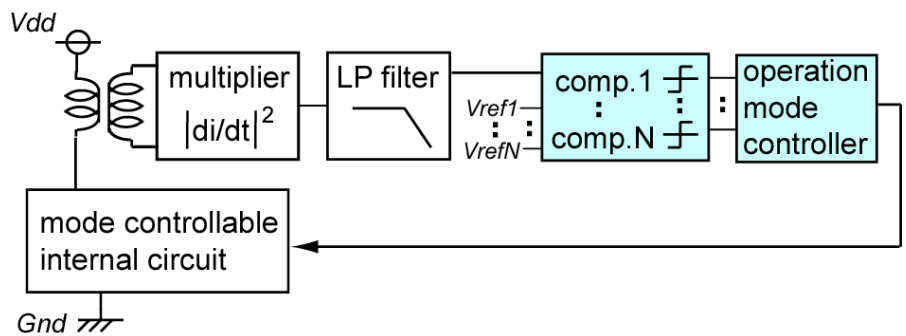
RC=250ns



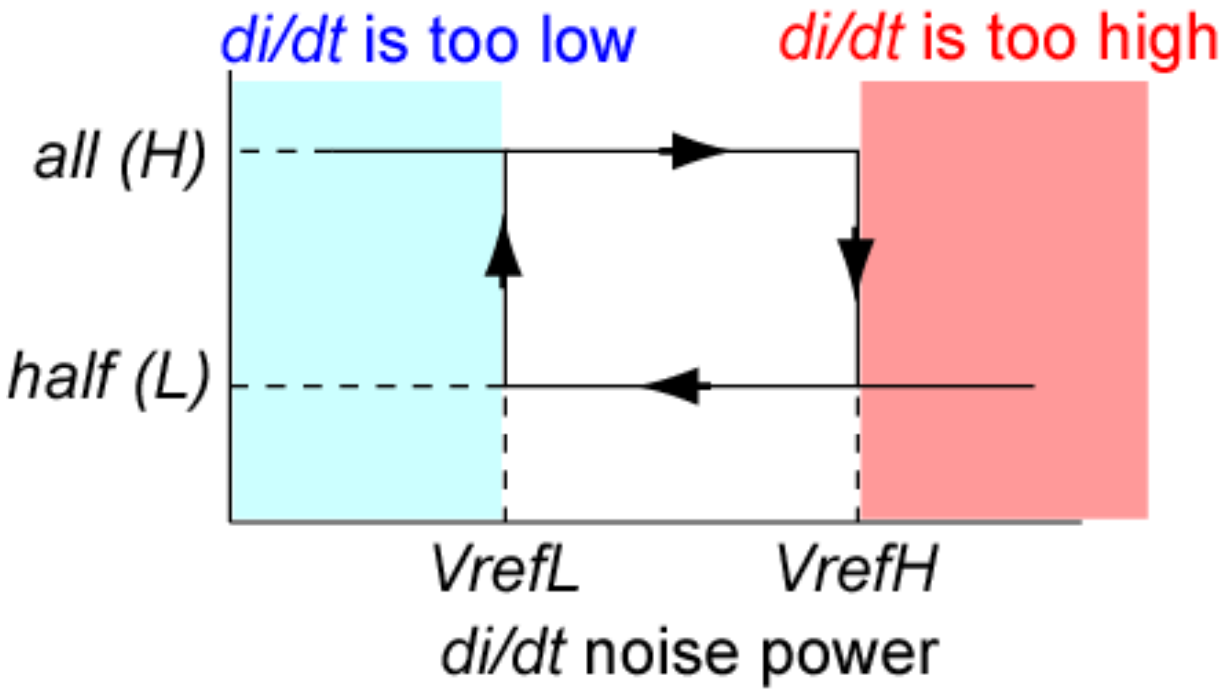
Operation Mode Controller

- **Mode control is realized by two comparators and combination of gates**





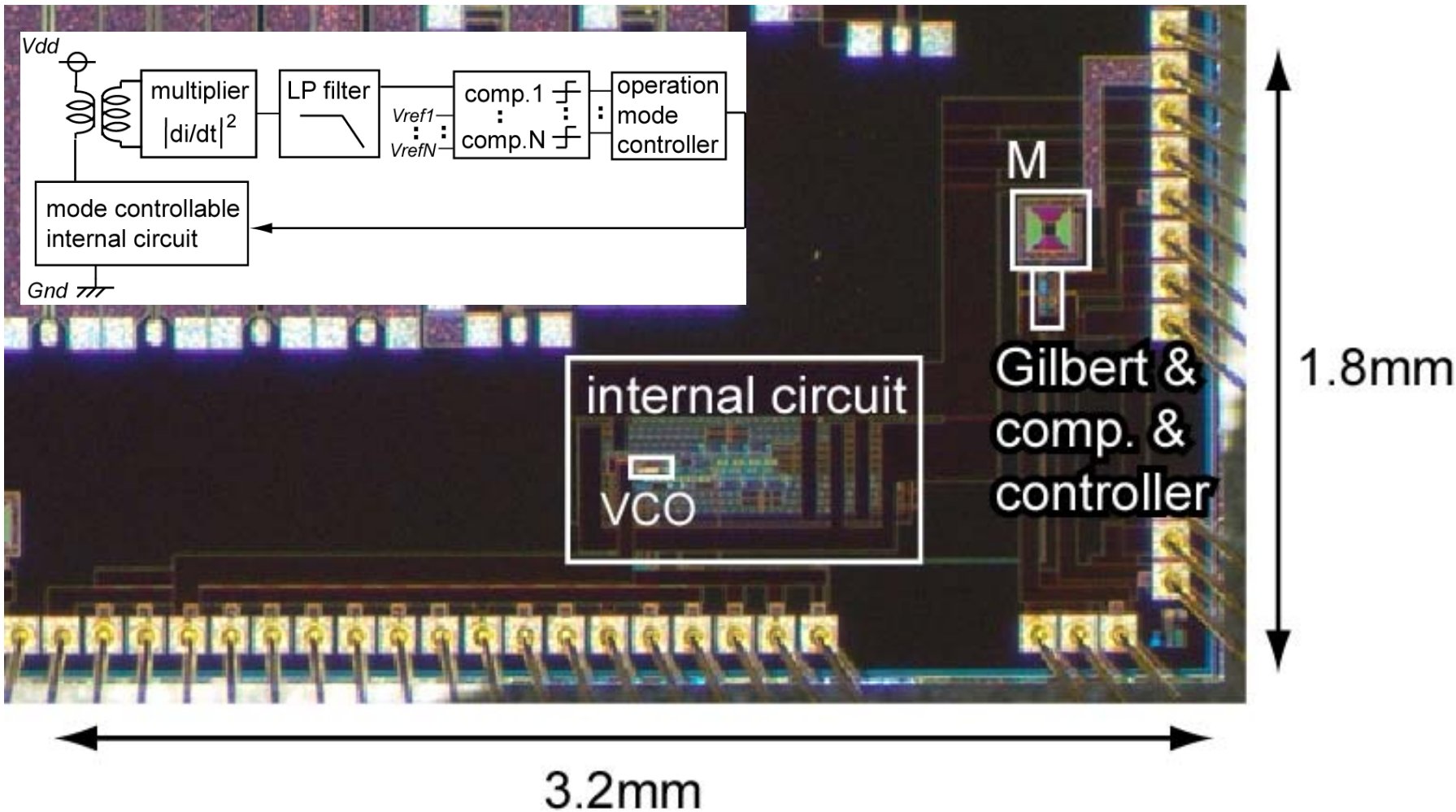
Operation Mode Control



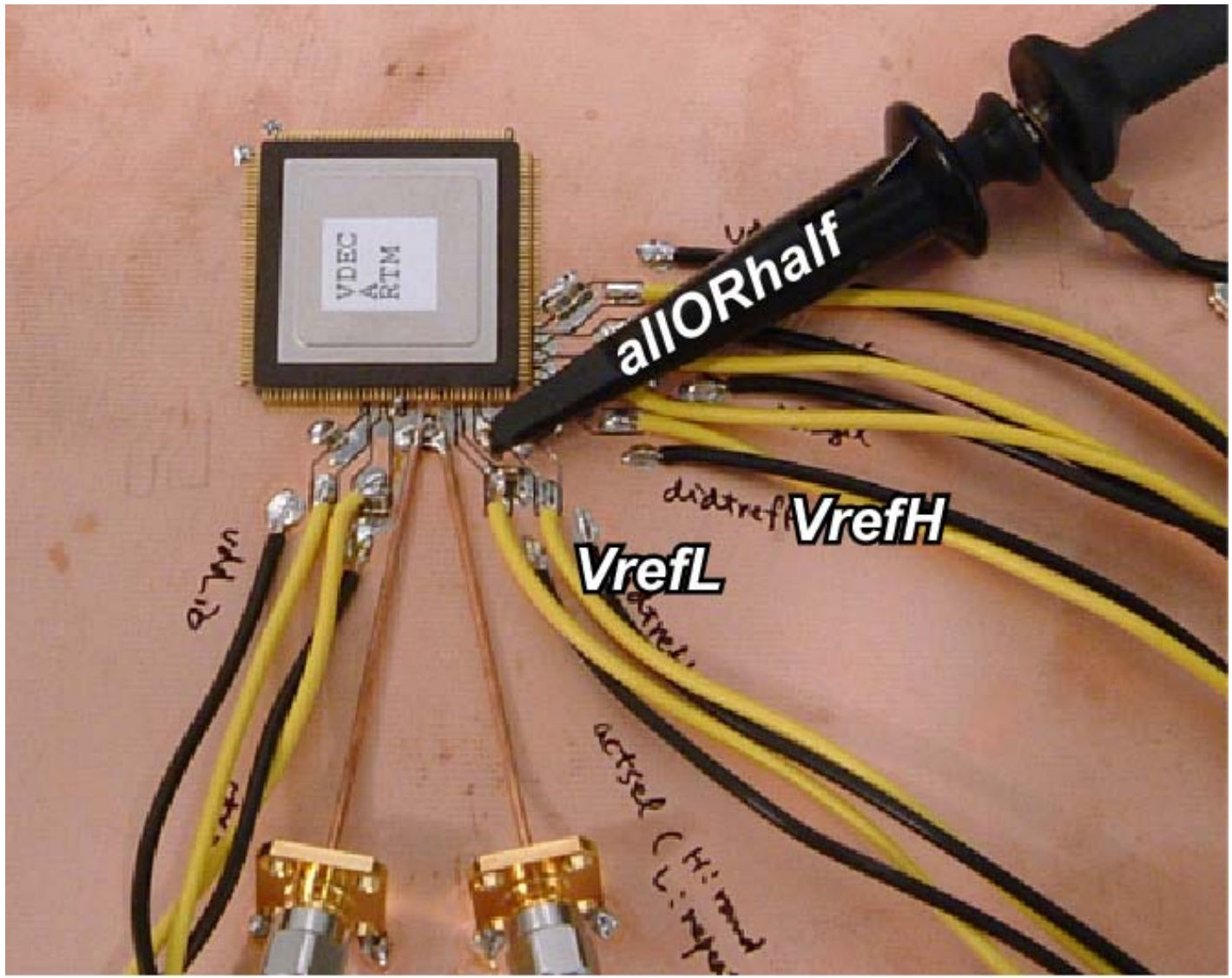
- **When di/dt is too high**
  --> change to “half” (low-noise) mode
- **When di/dt is too low**
  --> change to “all” (high-performance) mode

Chip Photograph

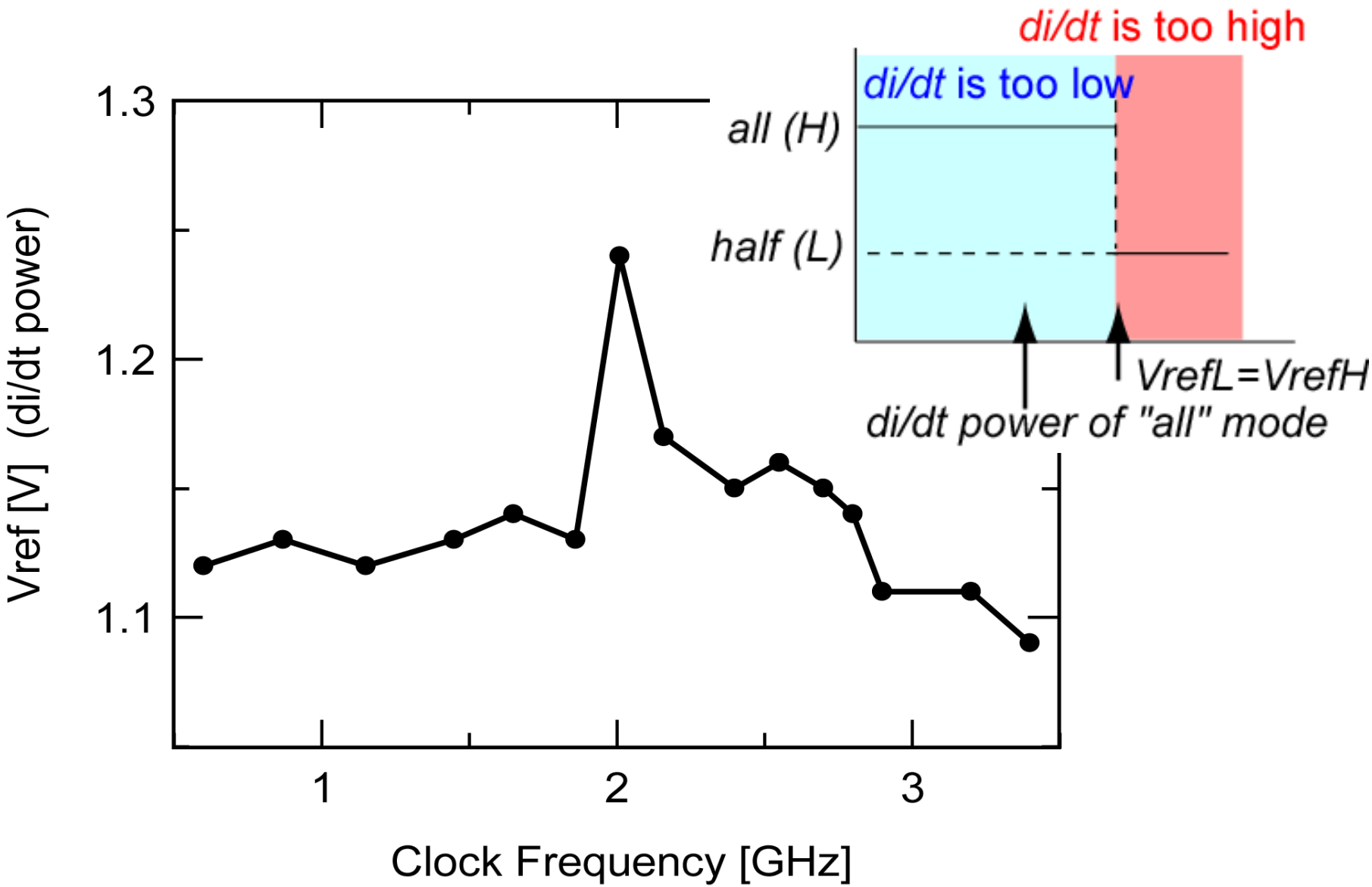
- **0.15um 5ML SOI-CMOS**



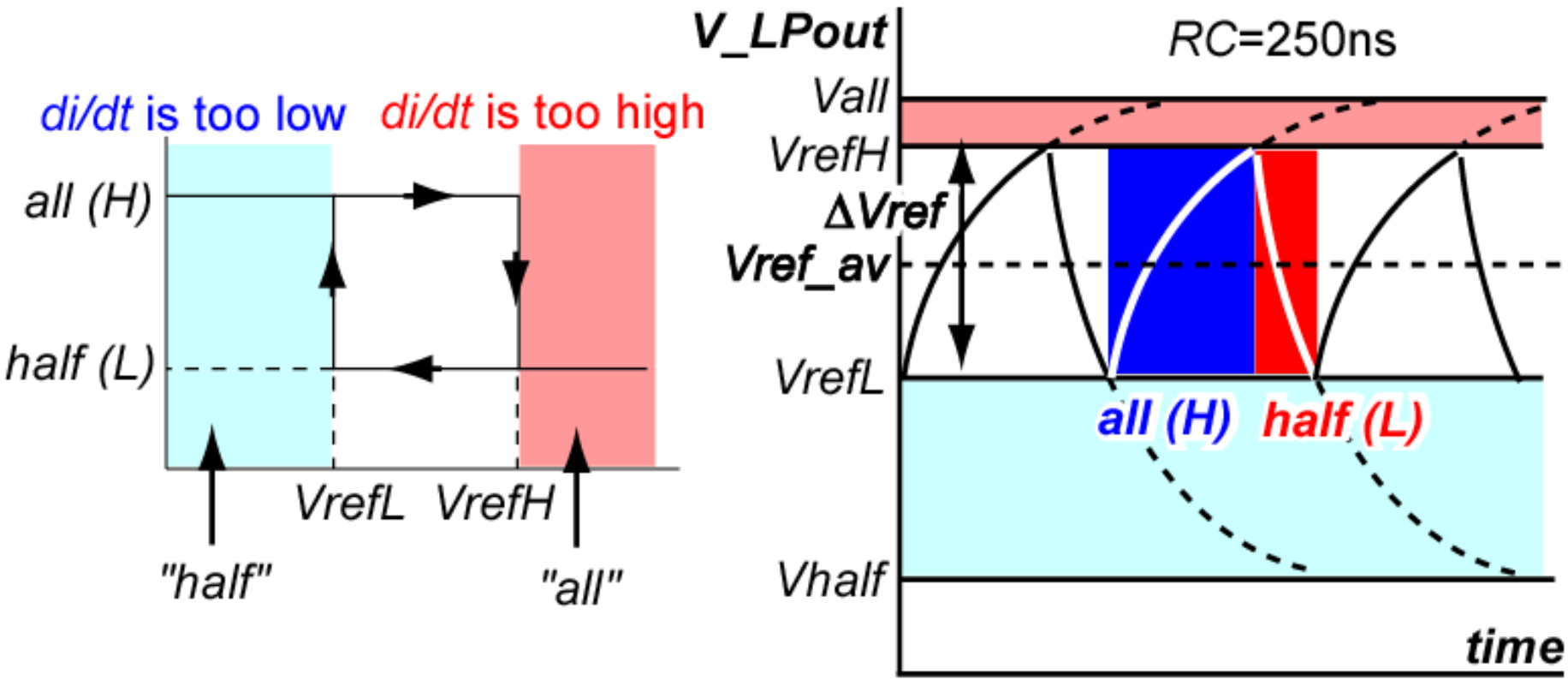
Measurement Setup



Frequency vs di/dt Noise Power

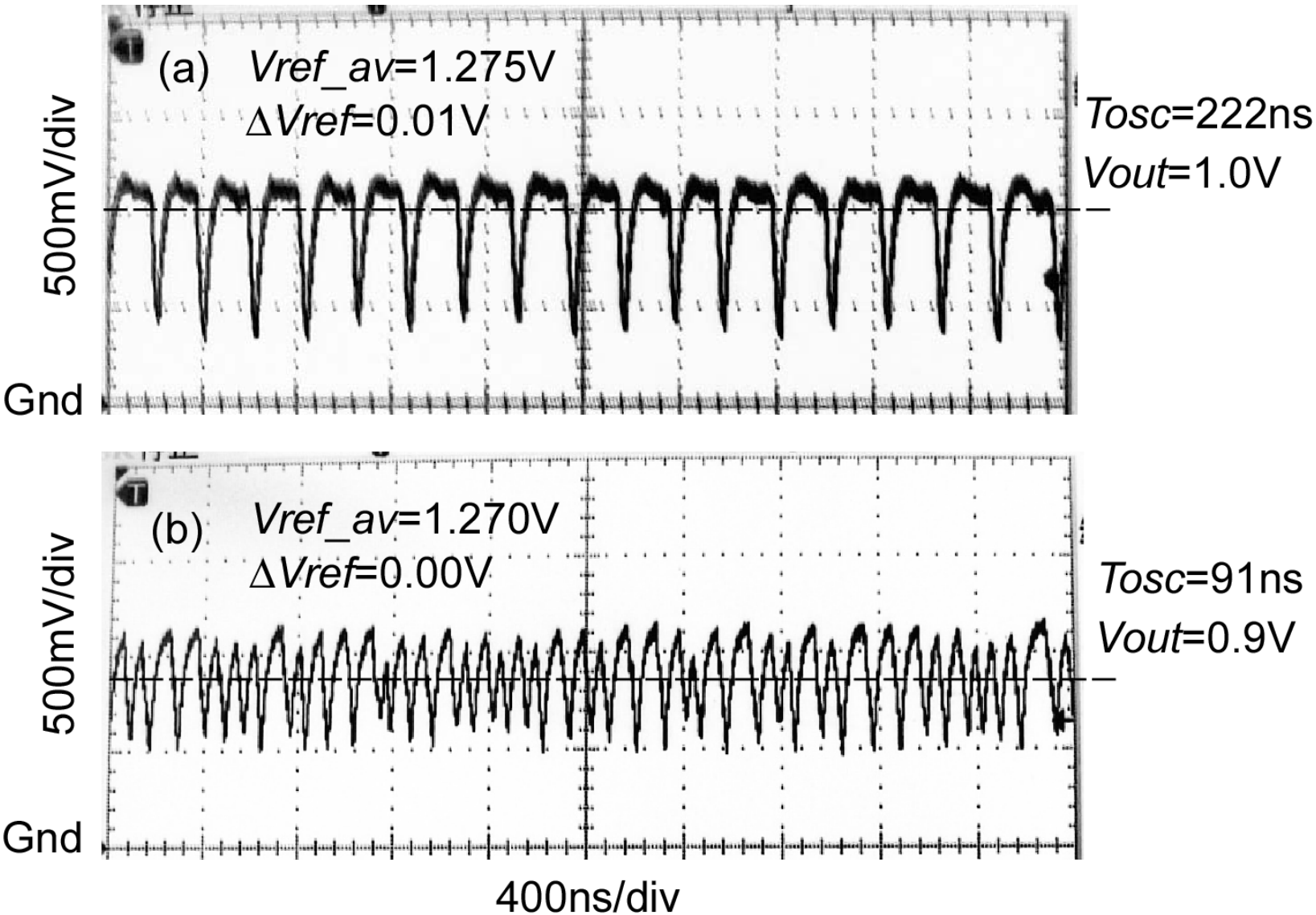


Proof of Operation -- Oscillation

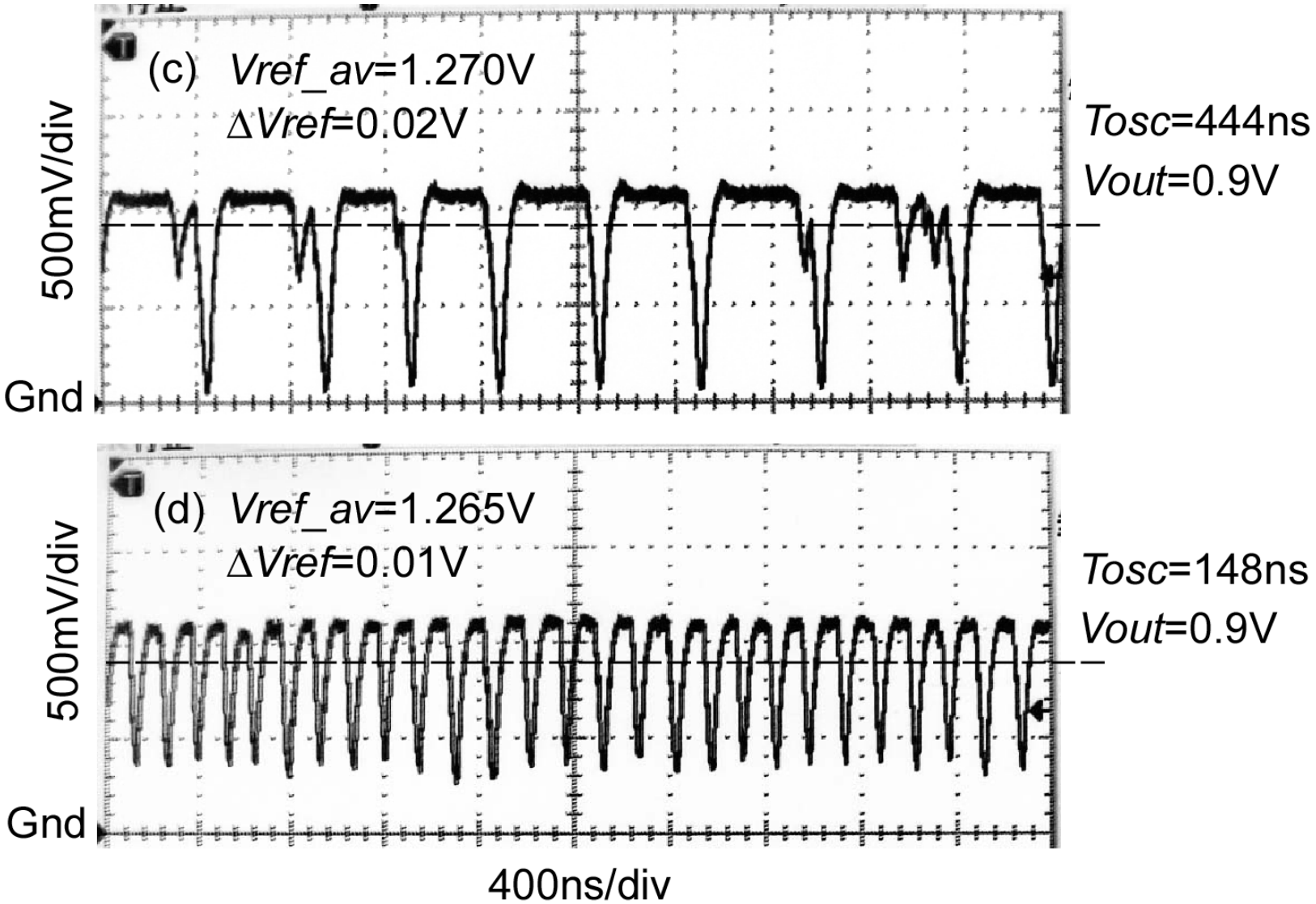


- **Oscillation occurs between two modes**
  - **Frequency depends on *ΔVref***
  - **H/L ratio depends on *Vref_av***

Oscillation Waveforms (1)



Oscillation Waveforms (2)



Oscillation Frequency, H/L ratio

(I)

	Vref_av [V]	ΔVref [V]	Out [V]	period [ns]
(b)	1.270	0.00	0.9	91
(d)	1.265	0.01	0.9	148
(a)	1.275	0.01	1.0	222
(c)	1.270	0.02	0.9	444

Frequency depends on *ΔVref*

(II)

	Vref_av [V]	ΔVref [V]	Out [V]	period [ns]
(a)	1.275	0.01	1.0	222
(b)	1.270	0.00	0.9	91
(c)	1.270	0.02	0.9	444
(d)	1.265	0.01	0.9	148

H/L ratio depends on *Vref_av*

- **L when VrefL<1.25, H when VrefH>1.29**

Summary

- Autonomous and margin aware di/dt noise control scheme was demonstrated
- DC voltage in proportion to di/dt power is compared with reference voltages, and the operation mode is controlled based on the comparator output
- The measured oscillation waveforms prove that the autonomous di/dt control scheme works as being designed