

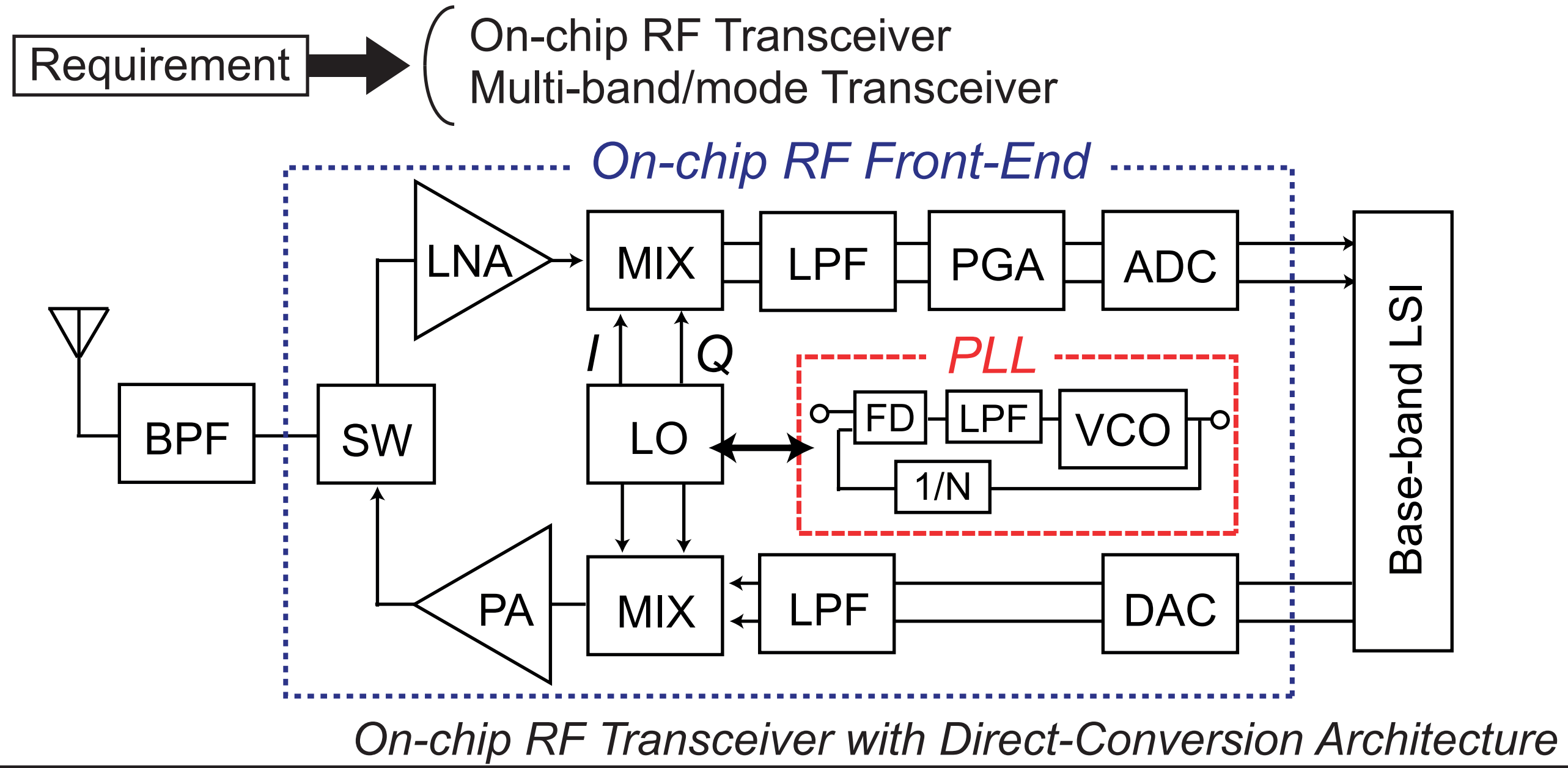
# Dynamic Reconfigurable RF Circuit Design

Yoshiaki Yoshihara, Hirotaka Sugawara, Hiroyuki Ito, Kenichi Okada, and Kazuya Masu

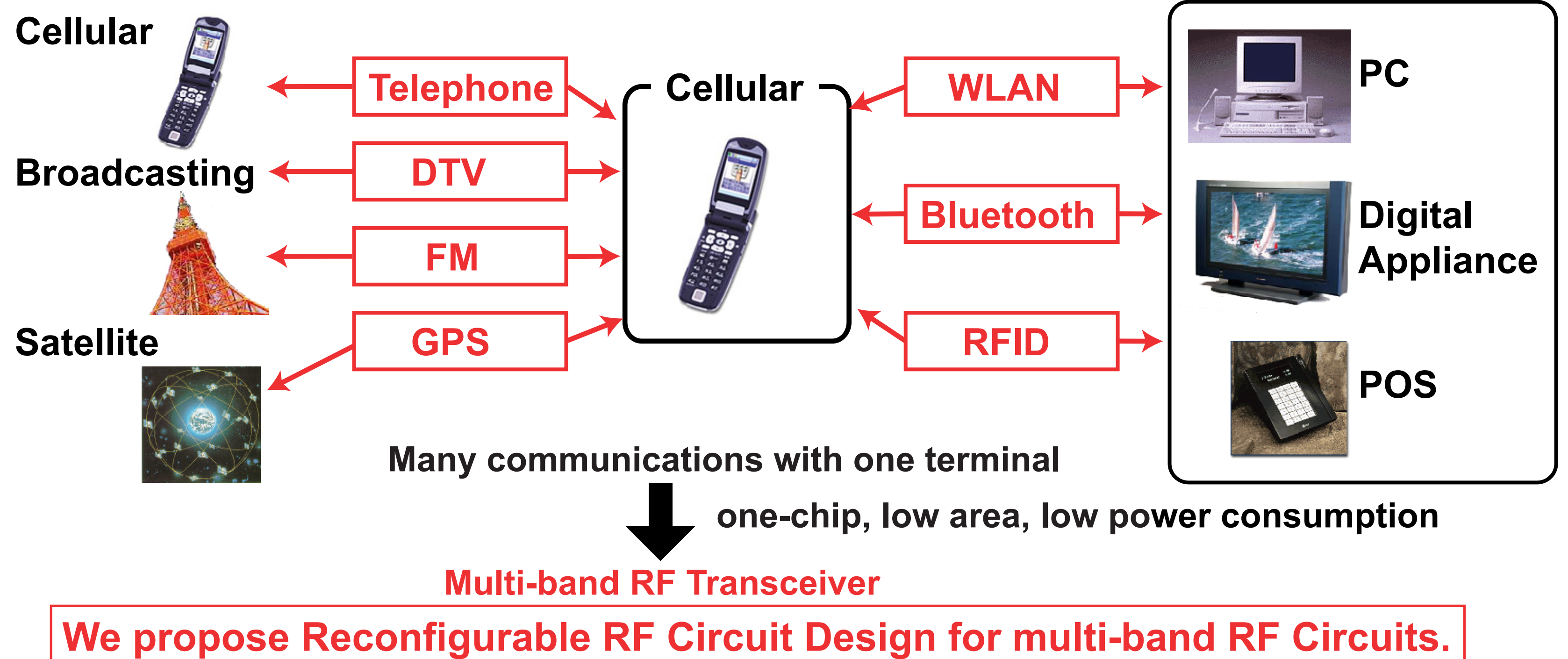
Precision and Intelligence Laboratory, Tokyo Institute of Technology, Japan

## 1. Background

### Recent RF Transceiver



### Multi-band RF Transceiver



## 2. Reconfigurable RF Circuit Design

### Reconfigurable RF Circuit

#### Multi function

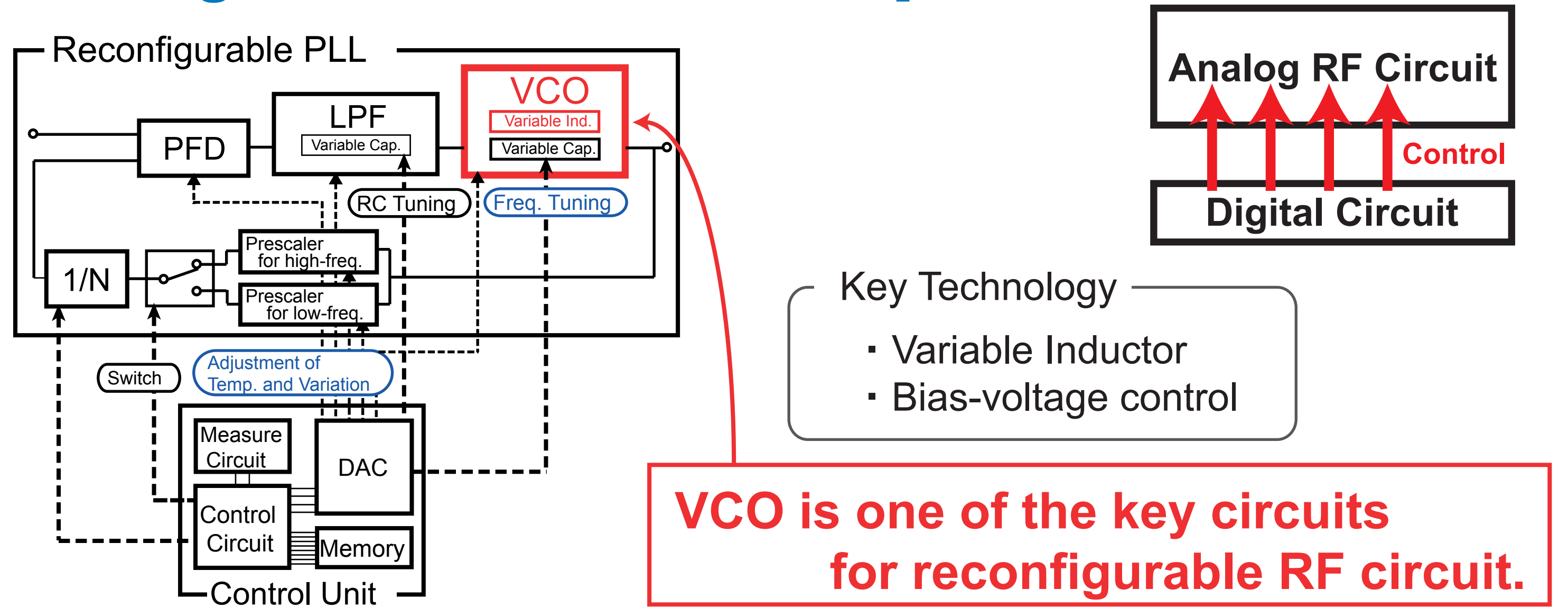
- Discrete (switching) Dual-band, Quad-band, Dual-mode, ...
- Continuous Multi-band, Multi-mode

Multi-band/mode Transceiver  
Convenience, Downsizing, ...

#### Self compensation

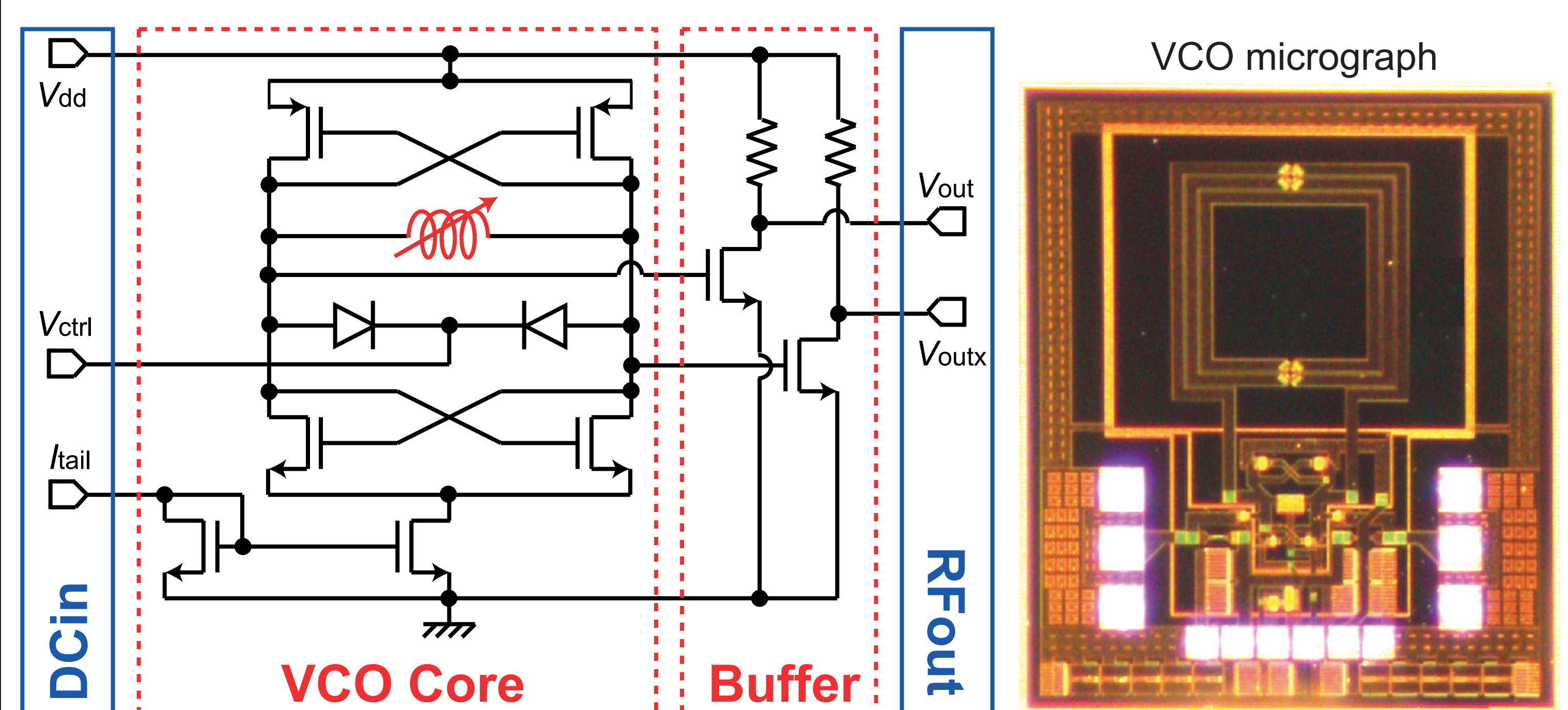
- Static Process fluctuation, Design error, Simulation error, ... → Yield enhancement
- Dynamic Temperature, Noise, Power supply, ... → Dynamic power reduction

### Reconfigurable Phase Locked Loop

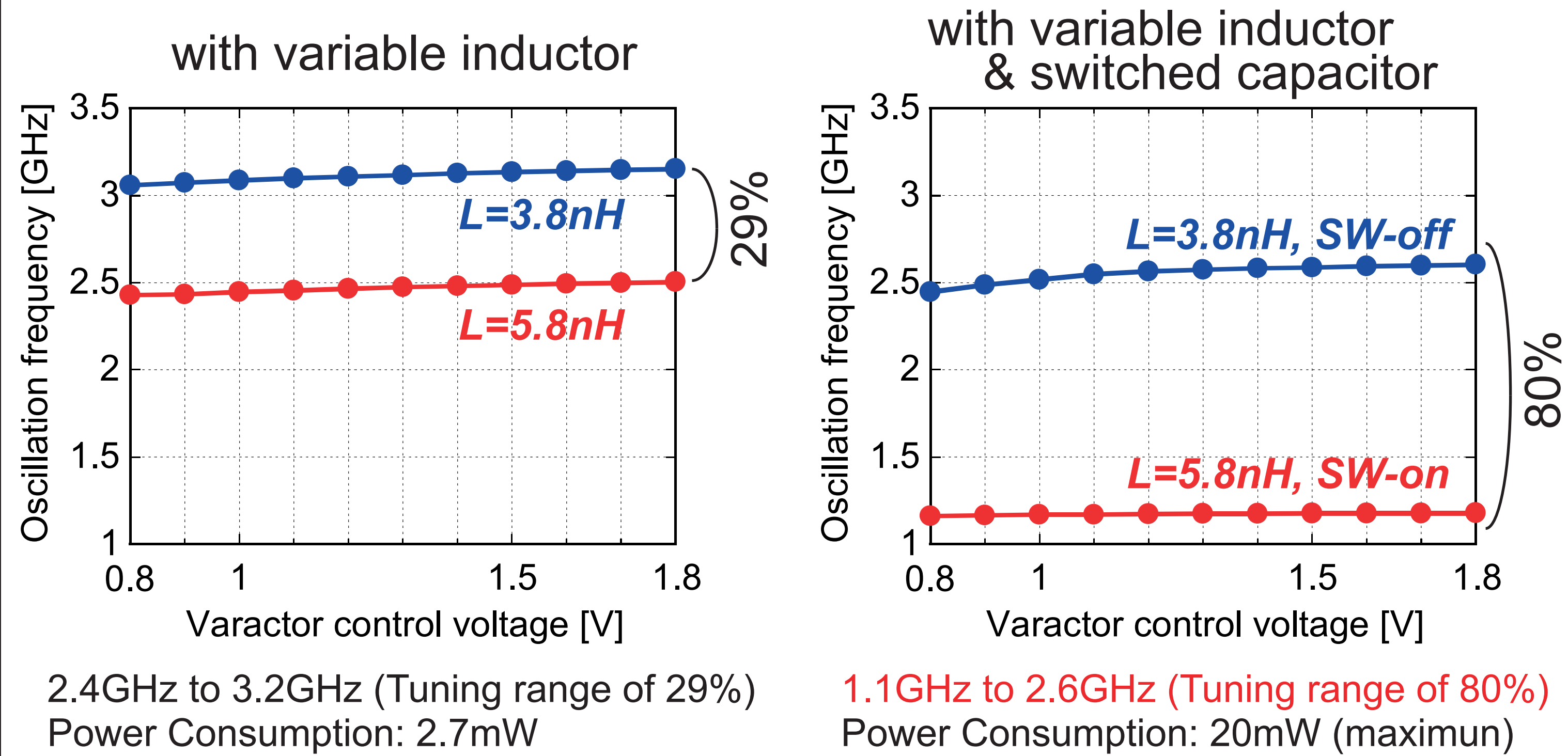


## 4. Wide Tuning Range LC-VCO

### LC-VCO Using Variable Inductor



### Simulation Results



## 3. Dynamic Self Reconfiguration

### Power Reduction

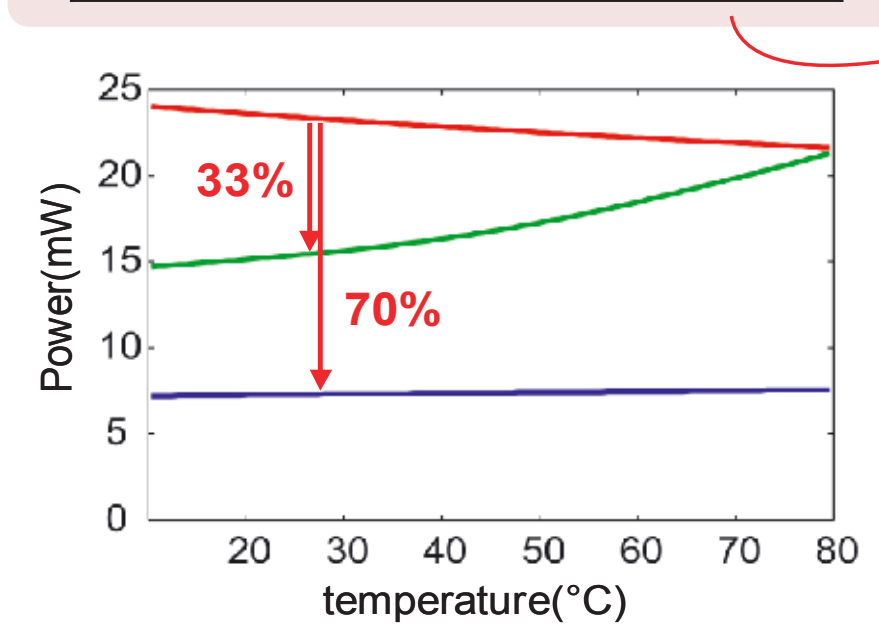
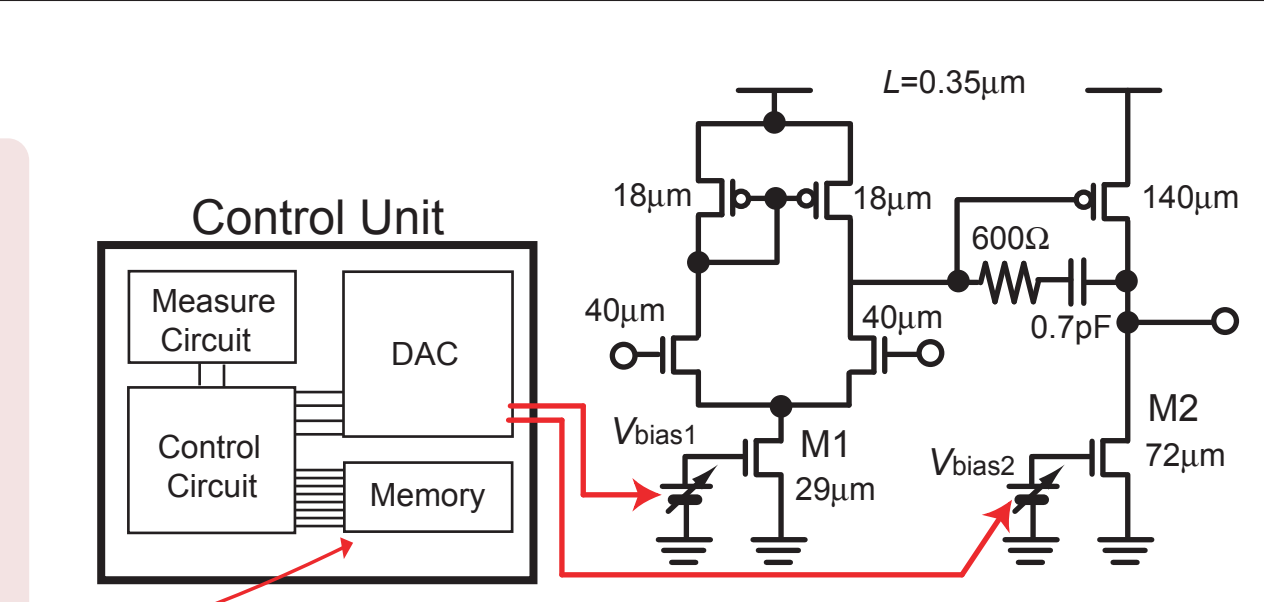
### Reconfigurable table

Multi-function  
500MHz or 900MHz  
Temperature compensation  
10-80°C

Vbias1	10°C	27°C	50°C	80°C
500MHz	0.79v	0.80v	0.81v	0.83v
900MHz	0.92v	0.95v	1.00v	1.10v

Vbias2	10°C	27°C	50°C	80°C
500MHz	0.89v	0.90v	0.92v	0.94v
900MHz	1.08v	1.10v	1.15v	1.25v

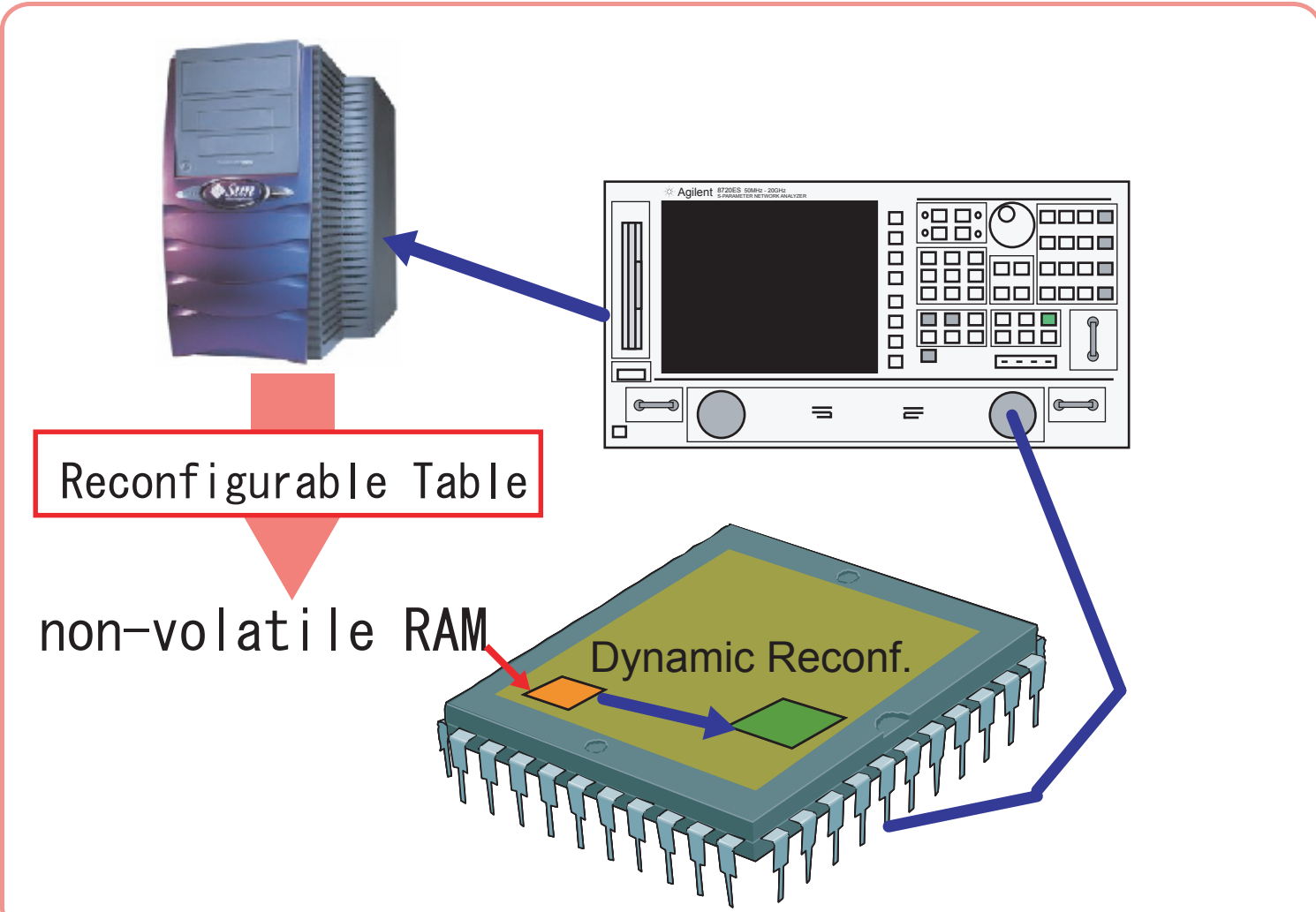


Power consumption

	10°C	27°C	50°C	80°C
Conventional	24.0mW	23.3mW	22.5mW	21.6mW
Proposed	500MHz 14.7mW	15.5mW	17.3mW	21.4mW
	900MHz 7.23mW	7.33mW	7.43mW	7.59mW

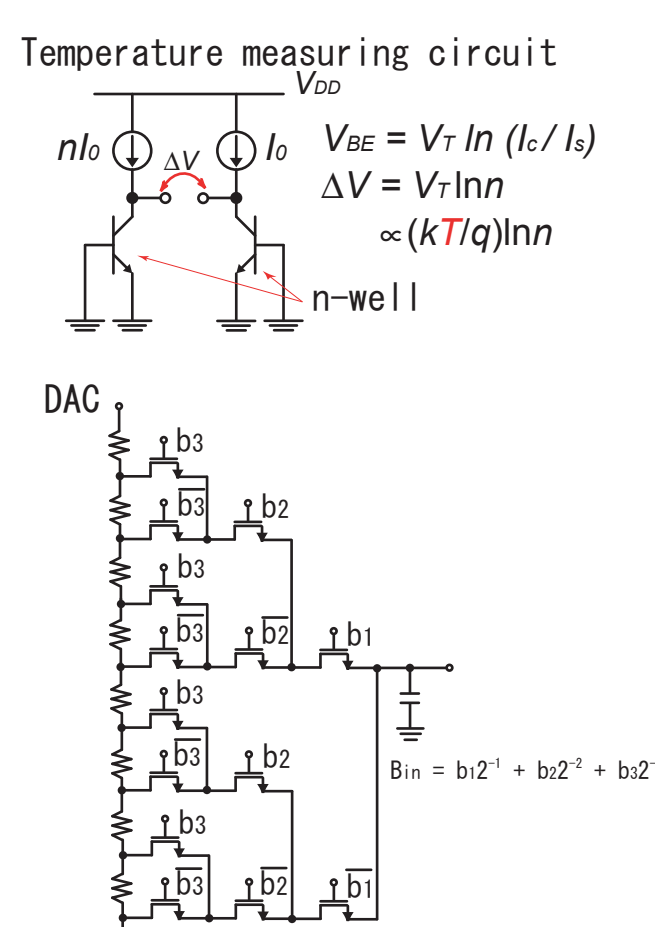
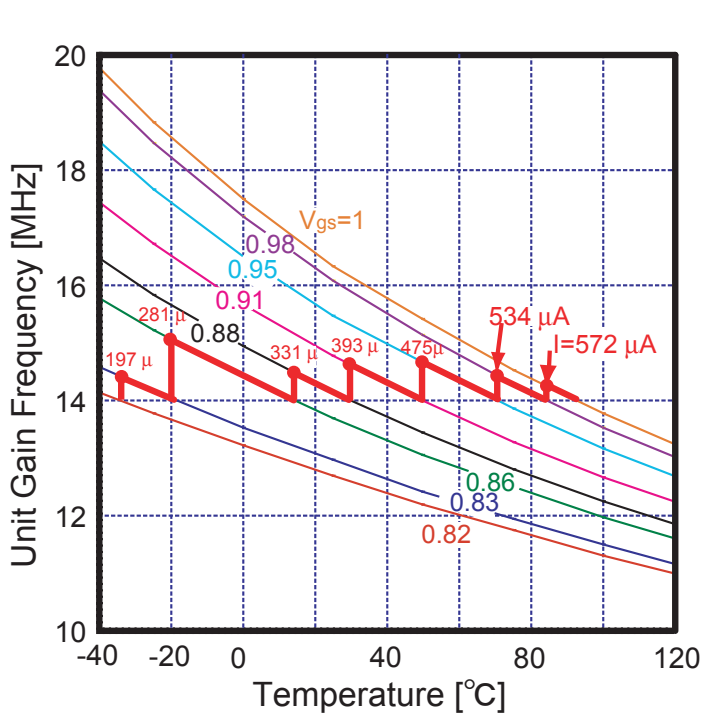
70%

### Post-fab. compensation



### Reconfiguration after fabrication

- Short TAT
- Yield enhancement
- First silicon success



### Comparison of Wide Tuning Range VCO Architecture

VCO Architecture	Tuning Range	Power Consumption	Phase Noise
① Ring Oscillator	very wide	small	bad
② Varactor	narrow	not large	very good
③ Switched Capacitor	wide	large	good
④ Variable Inductor	wide	not large	very good
⑤ Variable Inductor + Switched Capacitor	very wide	large	good

LC-VCO with variable inductor and switched capacitor provides 80% of tuning range and good phase noise characteristic.

## 5. Summary

Reconfigurable RF circuit architecture was proposed.

- Multi-function and Self compensation

Multi-band/mode Transceiver, Convenience, Downsizing, ...  
Dynamic power reduction, Yield enhancement, ...