1S-16

Sub-1-μs Start-up, 32-MHz Relaxation Oscillator for Low-Power Intermittent VLSI Systems

Hiroki Asano, Tetsuya Hirose, Taro Miyoshi,

Keishi Tsubaki, Toshihiro Ozaki,

Nobutaka Kuroki, Masahiro Numa

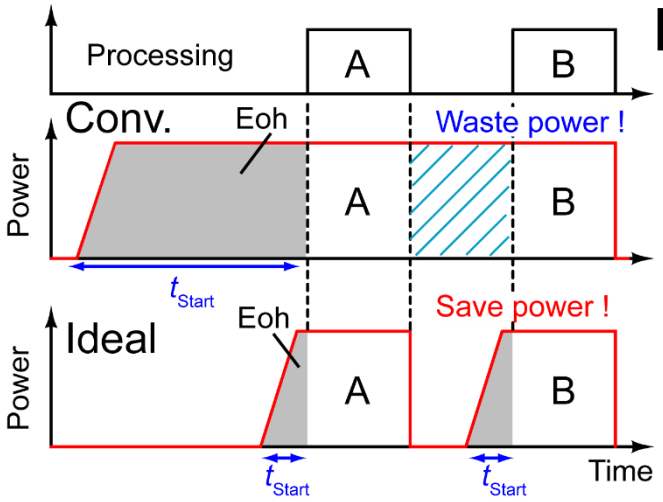
Kobe University, Japan

Background

Internet of Things* (IoT)

- **Big data utilization**
  - Medical, Agriculture etc…
- **Specification of IoT device**
  - Small size
  - Low cost
  - Low-power operation

Intermittent operation

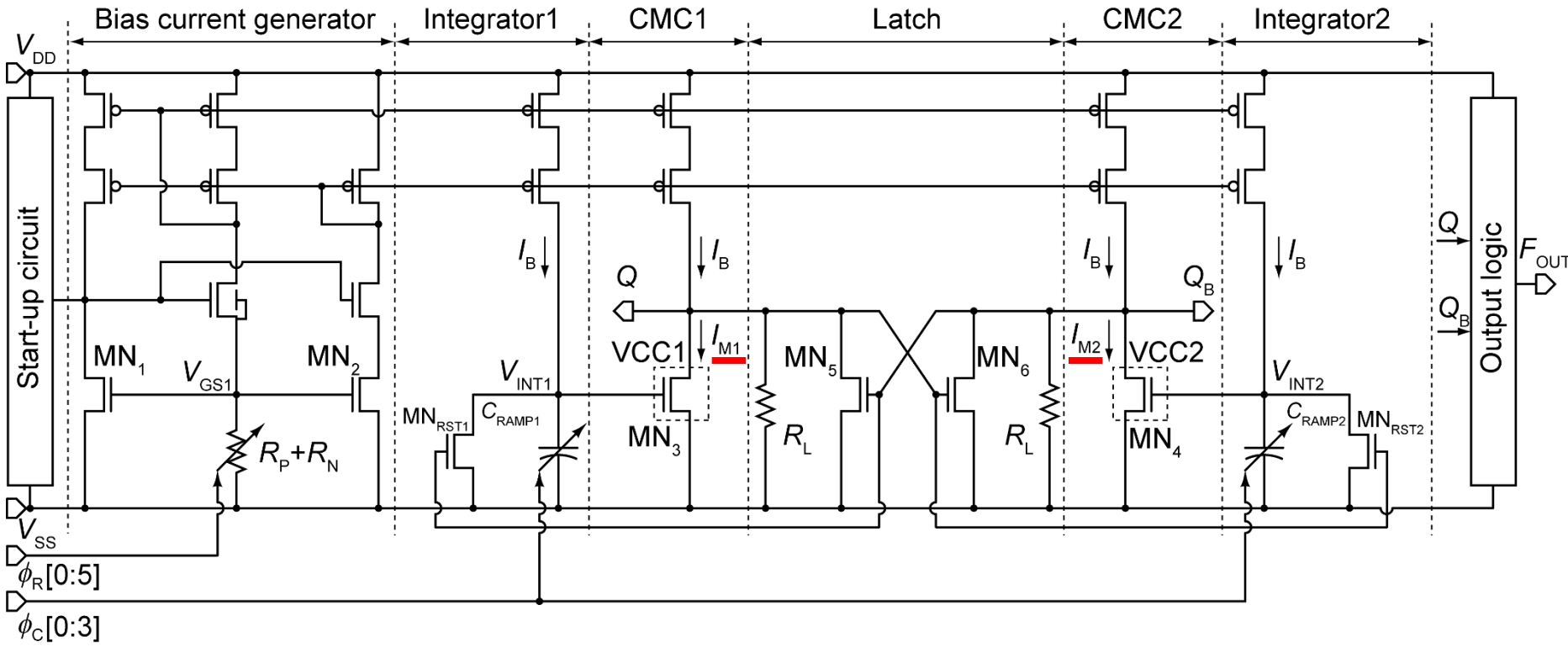


- **Requirements for intermittent operation**
  - **Minimize start-up time**
  - **Aggressively cut off the power supply**

A fast start-up relaxation oscillator (ROSC) with fully on-chip configuration

* D. Blaauw et al., " IoT design space challenges: circuit and systems," in *Symp. VLSI Technology Dig. Tech. Papers*, 2014, pp. 1-2.

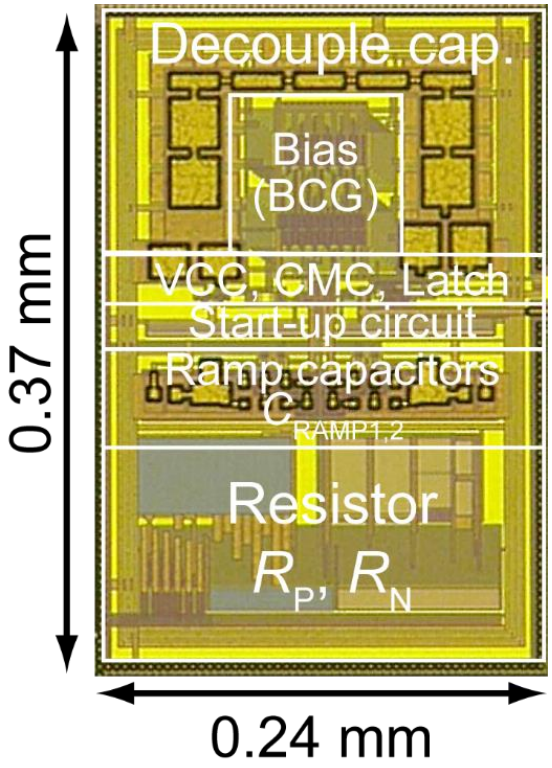
Schematic of our proposed ROSC



- **Fully on-chip configuration**
- **Employing current mode architecture**
- **Start-up-time is determined by that of BCG**

Chip Micrograph & Results

0.18-μm CMOS



Area: 0.09 mm²

Start-up waveform

Fast start-up, sub-1-μs,
with 32.6 MHz, 300.6 μW

Performance summary and comparison

Ref.	[2]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	This work
Type	XO	ROSC	ROSC	ROSC	ROSC	ROSC	ROSC	ROSC	ROSC
Tech. [nm]	65	180	180	180	180	180	180	350	180
Area [mm^2]	0.08	0.14	0.14	0.015	0.032	0.012	0.013	0.08	0.09
V_{DD}[V]	1.68	1.9-3.0	1.4-1.9	1.4-2.0	1.7-1.9	0.6 – 1.1	1.5 - 3.6	1.8 - 3.0	1.6-2.0
T [°C]	-40 - 90	NA	-40 - 125	-40 - 125	-40 - 125	-30 - 120	-40 - 85	-20 - 100	-20 - 125
f [MHz]	24	2.02	25*	10.5	14.0	12.77	32.8	30	32.6
T_{start} [µs]	64	NA	15*	NA	NA	NA	<5*	2.5*	<1
P [µW]	393	12	39.6	219.8	43.2	56.2	16.6	180	300.6
FoM [µW/MHz]	16.4	5.94	1.58*	20.9	3.09	4.4	0.51	6	9.22
$\Delta f_V/(f)$ [%]	NA	±0.06	±0.2*	±0.13	±0.16	±0.01	±0.27**	±2.4	±0.69**
$\Delta f_T/f$ [%]	NA	NA	±0.18*	±1.13	±0.19**	±0.4	±0.84**	±0.6	±0.38**
σ_f/μ_f [%]	NA	5.62	NA	NA	NA	>0.8	NA	2.7	0.62**
Ext. signal	X-tal	No	No	No	I_{BIAS}	No	I_{BIAS}	No	No

* simulation result ,** with trimming

Fastest start-up-time ROSC, sub-1-µs, with PVT stability

[2] D. Griffith et al., ISSCC'16, [5] H. Bhamra et al., ISCAS'13,
[6] H. Abbasizadeh et al., VLSI-SoC'15,[7] J. Lee et al., ISSCC'16, [8] Y. Tokunaga et al., ISSCC'09,
[9] J. Wang et al., A-SSCC'15, [10] Y. Lam et al., A-SSCC'14, [11] K. Ueno et al., ESSCIRC'09