EnerHarv 2024

PSMA International Workshop | 26-28 June, 2024 | Perugia, Italy

MCCI SOLVE THE IMPOSSIBLE

Ultra-low power, wide range 35-bit Digital to Time converter

Daniel Woodward, Hugo Cruz
Tyndall National Research Institute

ABSTRACT: **There are currently 15 billion IoT devices with the number expected to double by 2030 many of which will be powered by unreliable energy sources. Hence, power management circuits for such systems will be salient. This 35-bit digital to time converter aims to provide timing signals in the tens of nanoseconds to hours range for the power management circuits. It features 7 dynamically selectable oscillators for reduced power and a dead time oscillator.**

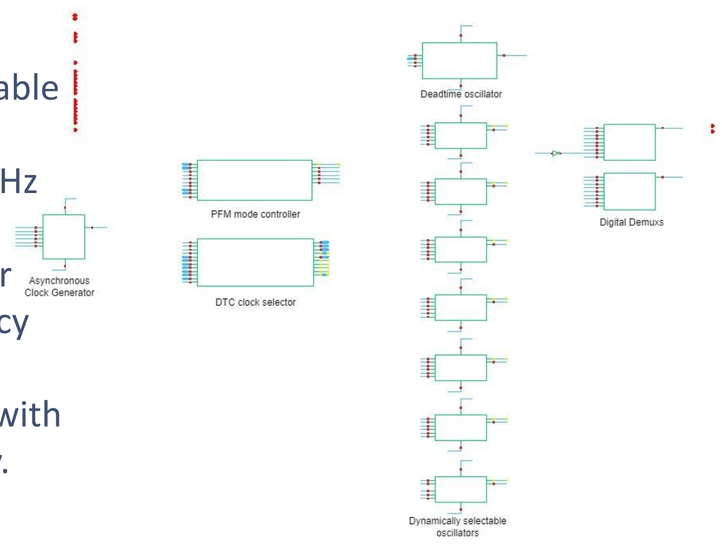
Background

- Mischief (multi source energy harvesting) is a PMIC platform MCCI project in association with Energy ECS. [1]
- Ultra low power digital to time converter (DTC) in control circuits.
- New oscillator designs and topologies reduce the power and area consumed by the DTC.

35 bit Digital-To-Time Architecture

Features

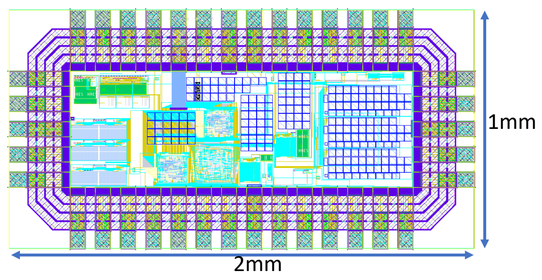
- 7 dynamically selectable and trimmable oscillators from 32mHz to 32MHz.
- Digital PLL control for background frequency trimming.
- Deadtime oscillator with a 134MHz frequency.
- 32KHz RTC master reference.



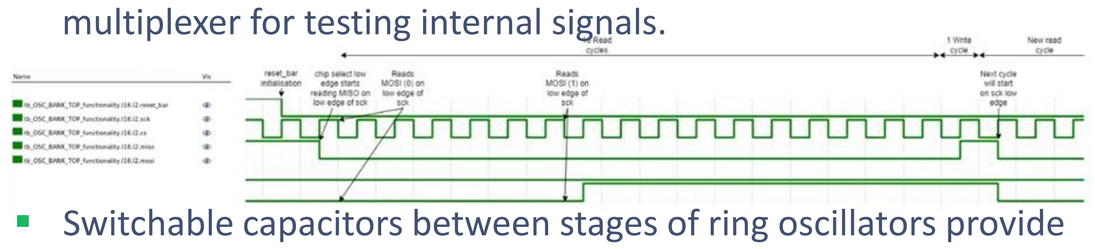
DTC Schematic

Oscillator Bank

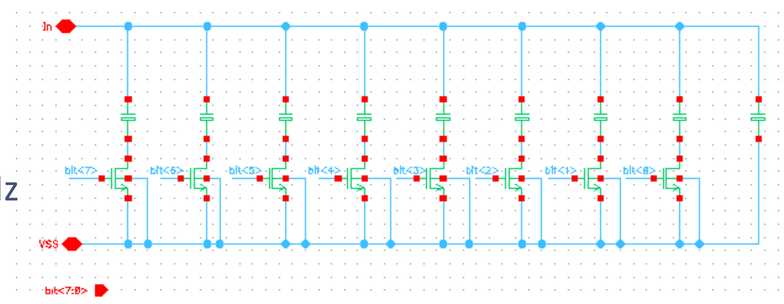
- 134MHz, 32MHz, 32kHz, 32Hz, 1Hz oscillator have been submitted for tapeout on XFAB 180nm CMOS process.



- Package features digital control through an SPI controller and memory block for oscillator trim as well as digital and analog multiplexer for testing internal signals.



- Switchable capacitors between stages of ring oscillators provide variable propagation times for trimming.
- Capacitor value increases in powers of 2 for linear trimming. E.g values for 1Hz bit0 = 26fF, bit1 = 52fF, bit2 = 106fF etc.



Oscillator Bank PEX Results

Oscillator	Length (um)	Height (um)	Area (umm^2)	Area (mm^2)	Power consumption (uW)	Current consumption (uA)	Oscillator Topology
134MHz	67.420	30.460	2053.613	0.002	75.930	42.183	Ring
32MHz	306.110	154.250	47217.468	0.047	28.940	16.078	Current starved inverter ring
32KHz	299.940	129.265	38771.744	0.039	0.481	0.267	Current starved inverter ring
32Hz	380.000	375.000	142500.000	0.143	0.120	0.067	Current starved inverter ring
1Hz	250.000	264.000	66000.000	0.066	7.731	4.295	Current starved thyristor ring

Summary

Improvements to the oscillators with the DTC for the Mischief PMIC platform offer saves in power and area. The redesigned 32kHz oscillator is expected to consume 481nW of power compared to the previous 32kHz reference oscillator which consumed 680nW. The next steps are to characterise the oscillators and prepare for tapeout of the full DTC this year.

References

[1] *Ultra Low-Power PMIC Platform for Energy-Harvesting Smart Sensor for IoT" ,Séamus O Driscoll, Enerharv 2022 Posters*
[2] *XT018 Technology*, X-FAB, www.xfab.com/xt018. Accessed 7 June 2024.