Ultra Low-Power PMIC Platform for Energy-Harvesting Smart Sensor for IoT

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ABSTRACT: By 2025, the world will have 1 trillion IoT devices. Many of these will be wireless sensors, operating at very low average power levels but with the ability to offer high levels of functionality with well regulated voltages derived from scant, variable and intermittent ambient energy sources. Our objective is to make the IoT more sustainable by eliminating battery chemistries to the greatest extent possible.

SOLUTION: "Mischief" (multi source energy harvesting) PMIC platform is a modular flexible mixed-signal approach. It is appropriate for DC sources such as Photovoltaic (PV) or Thermoelectric (TEG) as well as for Vibrational (AC) energy transducers such as piezo-electric, electro-magnetic and triboelectric. The objective is to enable commercial products offering higher efficiency at lower powers and the flexibility to interface with complex source, storage and load requirements

Mischief PMIC architecture and key features

- *MCCI associated project*
- *4 Switch QR Non-Inverting Buck-Boost Power Path*
- *Mixed signal innovative architecture for 93+% from 10 uW*
- *Asynchronous PFM Modes Generation*
- *400 pJ/sample hysteretic voltage sense*
- *<500nA Cold Start Oscillator/Charge Pump/Fractional reference system*
- *SPI Master Configurable Mixed Signal (ext. Serial EEPROM)*
- *High Speed Analog Event detect latches*
- *Variety of Digital-to-time converters (DTC) (6 nW @ 33 mHz)*
- *Advanced and flexible ultra low-power digital control schemes*

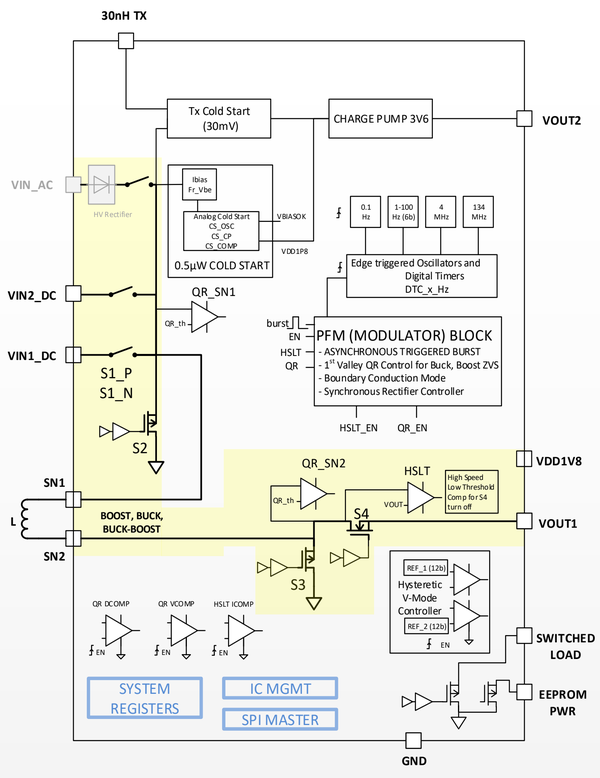

Figure 1. 'MISCHIEF' IC Platform – Representative Blocks

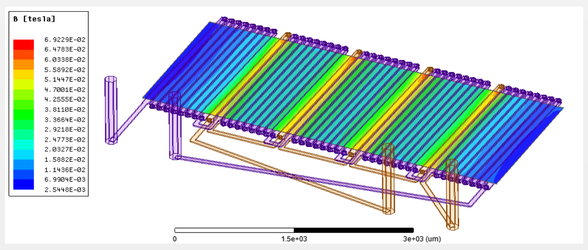

Figure 2. Magnetics-on-Silicon Planar Cold Start Transformer

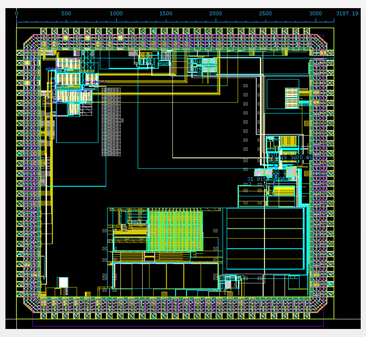

Figure 3. 'MISCHIEF' 180 nm CMOS Block Array

EnABLES *EU Project 730957*

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Characteristics

- *Optimized for average power levels from <1 µW to 100 mW*
- *Wide input and output voltage operating range, 30mV to 5V (200 VAC)*
- *Modular, digitally configurable analog through SPI*
- *Cold-start circuits compatible with micro-scale transformers*
- *Suitable for various energy transducers, DC and AC*
- *Adoptable to different application systems and demands*
- *Designed in XFAB 180 nm CMOS process*

Parameter	*Mischief*	Best Commercial	Comment
Efficiency @ 10µW	95%	85%	High efficiency from 1µW
Minimum Power	½ µW	3µW	
Quiescent Current	100nA	300nA	
Digital Control	yes	no	Advanced functionality at 1uW

Figure 4. 'MISCHIEF's' Superior performances in key attributes

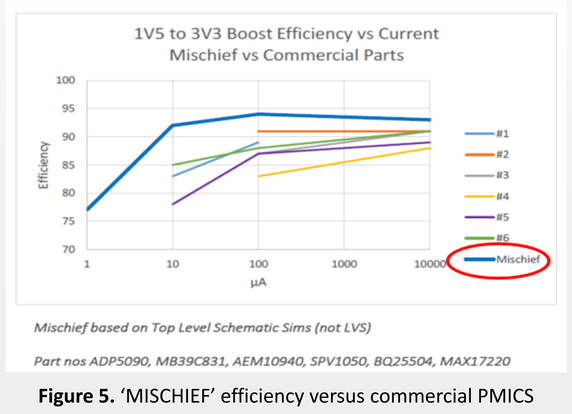


Figure 5. 'MISCHIEF' efficiency versus commercial PMICS

Novel Digital-To-Time (DTC) PLL architecture for system state-machine timing, control and PFM modulators

- *Uniform, ultra-low power time base from 10 ns to hours*
- *10 nW long duration timing*
- *Timing for high flexibility asynchronous digital control scheme*
- *32 KHz RTC: on chip master reference 680 nW*
- *System of seven leaking-latch and current-starved ring oscillators*
- *PLL system to background trim*

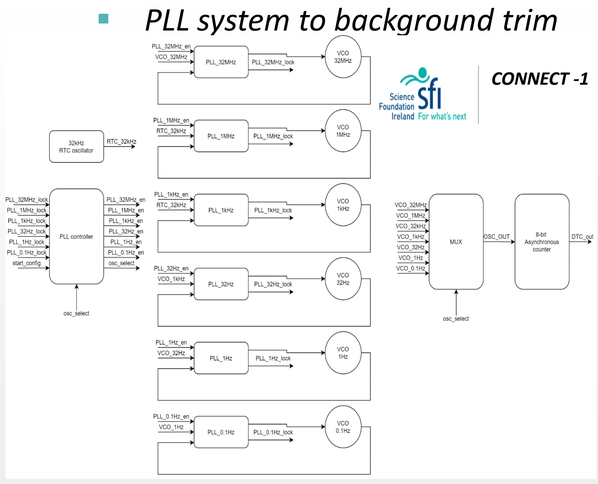


Figure 6. DTC architecture

Development stage

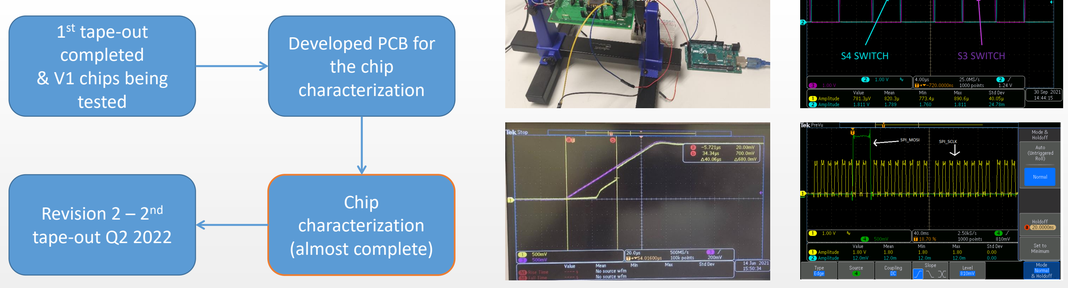
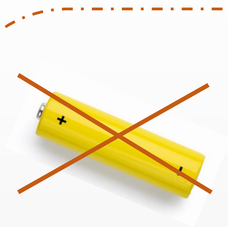


Figure 7. 'MISCHIEF' test setup (top-left), boost modulator waveforms (top-right), VHIGH power-up (bottom-left) and SPI (bottom-right)

Applications

- *Power Management for ultra low power IoT edge devices*
- *MEMS scale smart energy sources.*
- *Energy Source on-chip, in-package - eSiP.*
- *Fully integrated smart sensing node, incorporating analog sensing systems*



Energy Source-in-Package (eSiP)

CONNECT

Battery replacement solution

TEG + PMIC + STORAGE = eSiP*

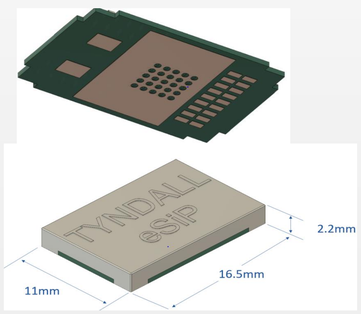


Figure 8. eSiP casing

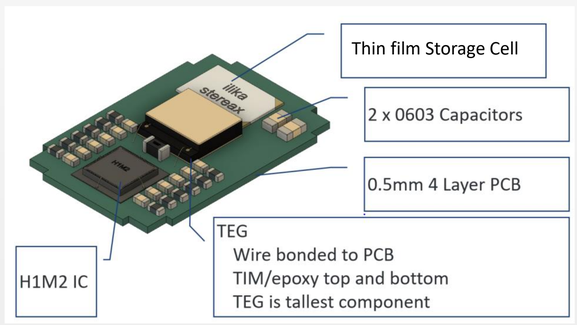


Figure 9. eSiP architecture

*future versions will be able to work with PV, piezo etc.

References

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