Ultra Low Power PMIC

Multi-Source Energy Harvesting IC for IoT-Edge and Wearable devices

Tyndall National Institute
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Challenges

The world will have 1 trillion IoT devices within the next few years all needing a power source. Most of these will be wireless sensors at the 'edge' using a 'battery'.

Our objectives are to make the battery outlive the system, harvest all available ambient energies, cater for increasing complex system power demands and make the best possible use of safe, biologically compatible, environmentally friendly battery chemistries.

Solution:

"Mischief" (multi-source energy harvesting) PMIC IC platform is a modular mixed signal circuit block based approach to enable fast track ultra-low power application tuned power management ASIC (ASSP) development.

It is appropriate for DC sources such as photovoltaic (PV) or Thermoelectric (TEG). Extensions are planned to interface with a variety of Vibrational (AC) energy transducers such as electro-magnetic (EMT), piezo-electric, electret or triboelectric.

It is optimised for average power levels from <1 µW to 100mW and has wide input and output voltage operating range, 30mV to 5V.

Operating efficiencies and solution densities are better than other competitor solutions.

Functional blocks are designed for advanced ultra-low power digital control schemes to bring a very high degree of solution flexibility – allowing advanced features such as conditional monitoring of the storage device's battery chemistry.

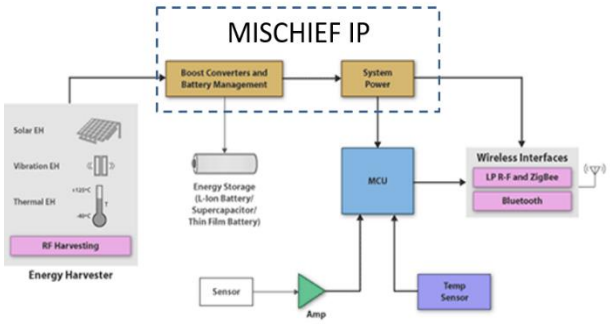
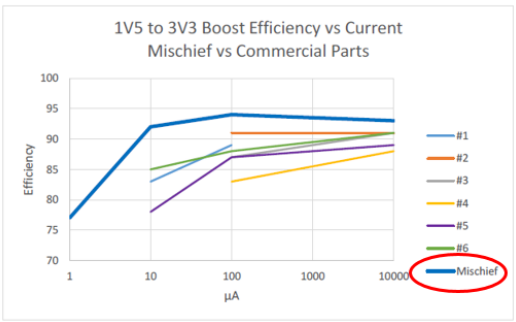


Figure 1. MISCHIEF usage in a wireless IoT edge device. Capable of harvesting multiple ambient energies



Mischief based on Top Level Schematic Sims (not LVS)

Part nos ADP5090, MB39C831, AEM10940, SPV1050, BQ25504, MAX17220

Figure 2. MISCHIEF efficiency versus commercial PMICS

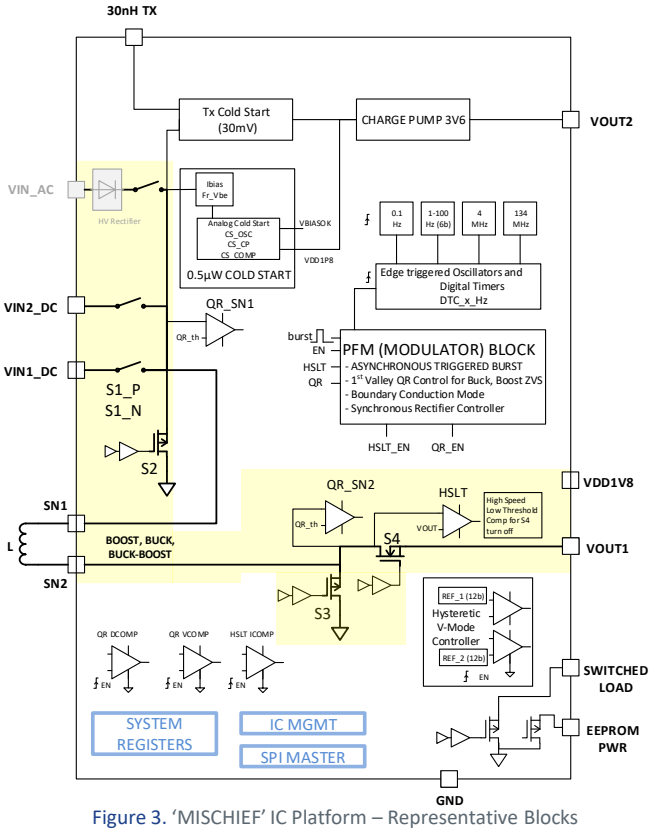


Figure 3. 'MISCHIEF' IC Platform – Representative Blocks

Parameter	Mischief	Best Commercial	Comment
Efficiency @ 10µW	95%	85%	High efficiency from 1µW
Minimum Power	0.5µW	3µW	
Quiescent Current	100nA	300nA	
Digital Control	yes	no	Advanced functionality at 1uW

Figure 4. Superior performance in key attributes

MCCI SOLVE THE IMPOSSIBLE

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

Benefits Summary

Leveraging Tyndall's own 'Power IoT' atoms-to-systems ecosystem and links with external partners, MISCHIEF has been developed with powering the 'trillion sensor' economy challenge in mind. Tyndall has deep expertise in piezo-MEMs, EMT, UV PV and TEG energy transducers, battery chemistries, ALD Supercapacitors and advanced silicon circuits supports. This technology is a key platform that enables developers of energy harvesting transducers, storage components and smart sensing nodes to offer optimised system level performance and create energy harvesting compatible power sources. We are the perfect development partner to bring this technology to market.

- Industry leading efficiency, voltage ranges, quiescent current.
- Unique flexible mixed signal control and analog interfacing blocks creates a platform suitable for advanced DC (Photovoltaic, Thermal) or AC (Vibrational : Piezo, Electromagnetic) energy harvesting or interfacing with next generation battery chemistries or supercapacitors.
- Cold-start circuits compatible with micro-scale transformers
- High frequency operation for very high density miniature solution.
- Rapid development time for application. Features can be implemented in digital.

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

Technical specifications

- I/P voltage range 0.05-4.5V
- O/P voltage range 1.2-4.5V
- Efficiency typ. 95
- Quiescent current <100nA
- Power range 1uW to 100mW
- Vin min cold start 400mV w/o Tx (30mV with Tx)
- Vin min operating 50mV
- Digital Control and SPI interface
- Dynamic impedance matching for multiple energy harvesting transducer types DC and AC (in development)
- Operating frequency (1-10MHz)
- Footprint <3mm^2

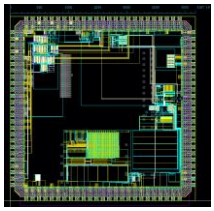


Figure 5. MISCHIEF 180 nm CMOS Block Array

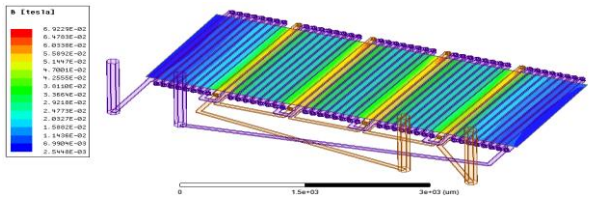


Figure 6. Planar Cold Start Transformer

Development Stage

1st tape-out of most core circuit block complete via projects MISCHIEF (EI funded) & EU EnABLES & Energy ECS. Additional asset tracking application circuit blocks being developed under EU project LoLiPoP IoT.

Commercial Status

Tyndall are looking for co-developers and licensees across the full supply-chain.

Intellectual Property

More than €30M invested in 'Power IoT' research resulting in extensive IP & know-how in design and integration of PMICs particularly for ultra low power edge devices.

Sample IP Blocks

- 4 Switch QR Non-Inverting Buck-Boost Power Path for 95% efficiency from 1uW to 100mW
- Mixed signal innovative architecture for 98% efficient control to energy transfer ratio
- Asynchronous PFM Modes Generation
- 20nA Voltage Comparator
- 10ns Current Input Comparator
- 250 pJ/sample hysteretic voltage sense
- 10ns High Side Voltage low voltage threshold Comparator
- Starved Inverter Ring Oscillators
- <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) (4nW @ 1Hz)
- Ultra Low Energy ADC Systems (in development)