



TI Innovation Day France 2010

TI solutions for energy harvesting

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Agenda

- Introduction
- When does energy harvesting makes sense?
- Energy harvesting trade-offs
- Energy harvesting sources
- Application examples
- Architecture
- Why energy harvesting at TI?
 - MSP430 portfolio
 - Low power step-down regulator
 - Low power step-up regulator
 - Low power wireless RF
- Demonstrations
- Conclusion

Introduction

- Energy harvesting is the process by which energy is captured and stored
- “conversion of ambient energy into usable electrical energy”, also known as energy scavenging and power harvesting



When does harvesting makes sense?

- Harvestable energy available
- Difficult to install or power devices
- Cords/wiring too costly
- Difficult to reach devices for maintenance
- Numerous devices – high maintenance in the case of battery driven
- Environmentally friendliness required
- High uptime demanded – battery failure problematic or expensive

Energy Harvesting Tradeoffs

- **Advantages**

- Mobile: no power wires
- Easier installation
- Lower maintenance
- Environmentally friendly
- Higher uptime

- **Disadvantages**

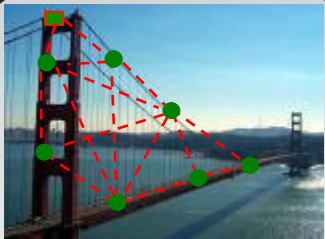
- Dependent on availability of harvestable energy source
- Strict power budget
- Upfront cost may be higher
- Less mature technology

Energy Harvesting Sources

| Energy Source | Characteristics | Efficiency | Harvested Power |
|---------------|-----------------|------------|-------------------------------|
| Light | Outdoor | 10~24% | 100 mW/cm ² |
| | Indoor | | 100 μ W/cm ² |
| Thermal | Human | ~0.1% | 60 μ W/cm ² |
| | Industrial | ~3% | ~1-10 mW/cm ² |
| Vibration | ~Hz–human | 25~50% | ~4 μ W/cm ³ |
| | ~kHz–machines | | ~800 μ W/cm ³ |
| RF | GSM 900 MHz | ~50% | 0.1 μ W/cm ² |
| | WiFi | | 0.001 μ W/cm ² |

Applications examples

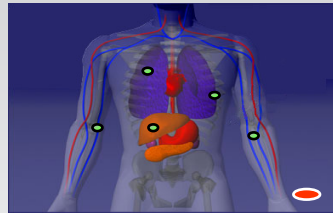
INDUSTRIAL



- Structural health monitoring
- Wireless sensing

Vibration energy

MEDICAL



- Patient monitoring
- Patient ID and tracking
- Smart patches

Thermal energy

BUILDING AUTOMATION



- Lighting controls
- HVAC controls and monitoring
- Security

Solar energy

Thermal energy

Vibration energy

RF

AGRICULTURE



- Soil conditions
- Plant pH

Solar energy

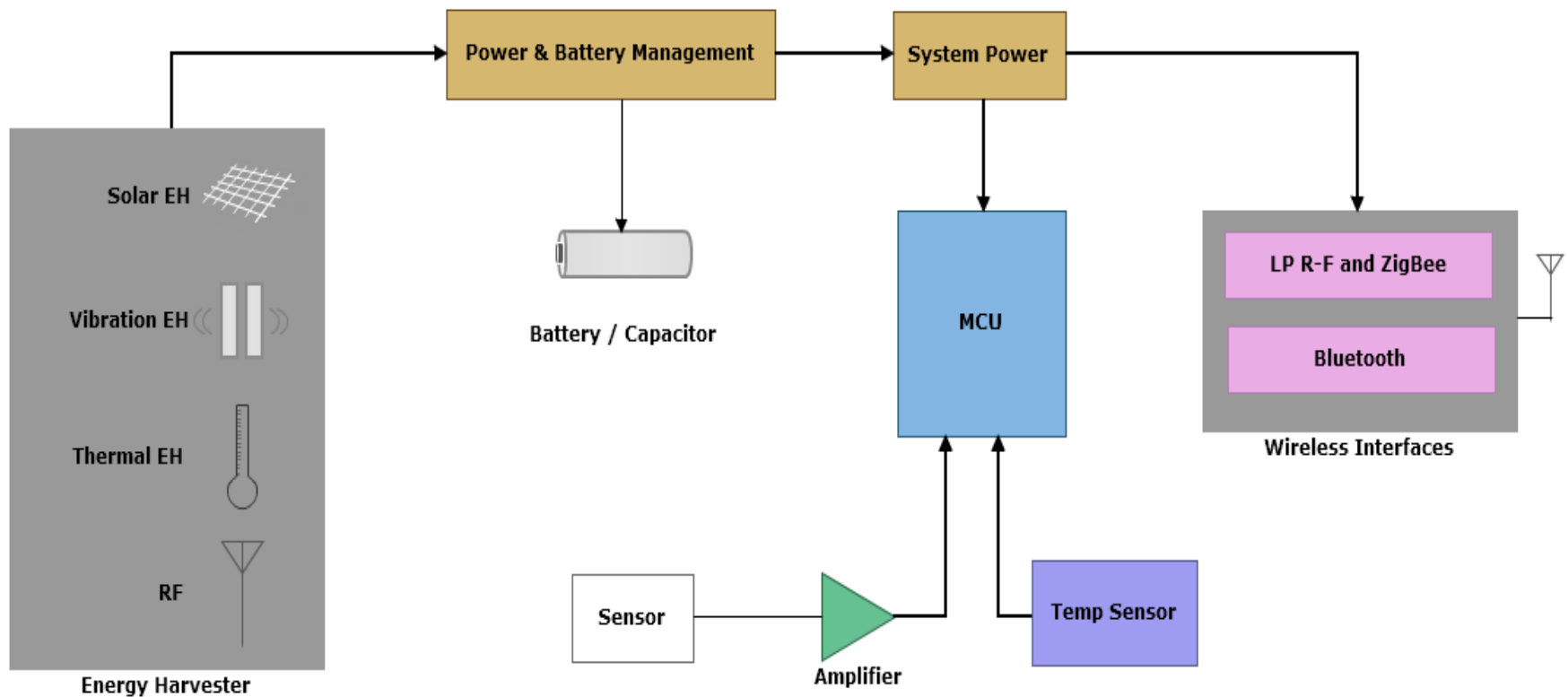
AUTOMOTIVE



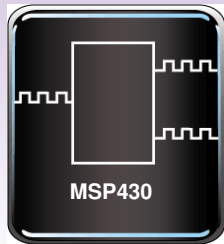
- Tire pressure gauges

Vibration energy

Architecture

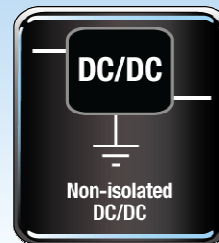


Why energy harvesting at TI?



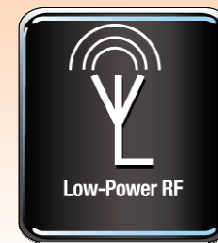
MSP430

- ♦ 16 bit ultra low power MCUs
 - ♦ Up to 25MHz
- ♦ Flash 1KB to 256KB
- ♦ Analog I/Os, ADC. LCD, USB, RF



Low power DC-DC

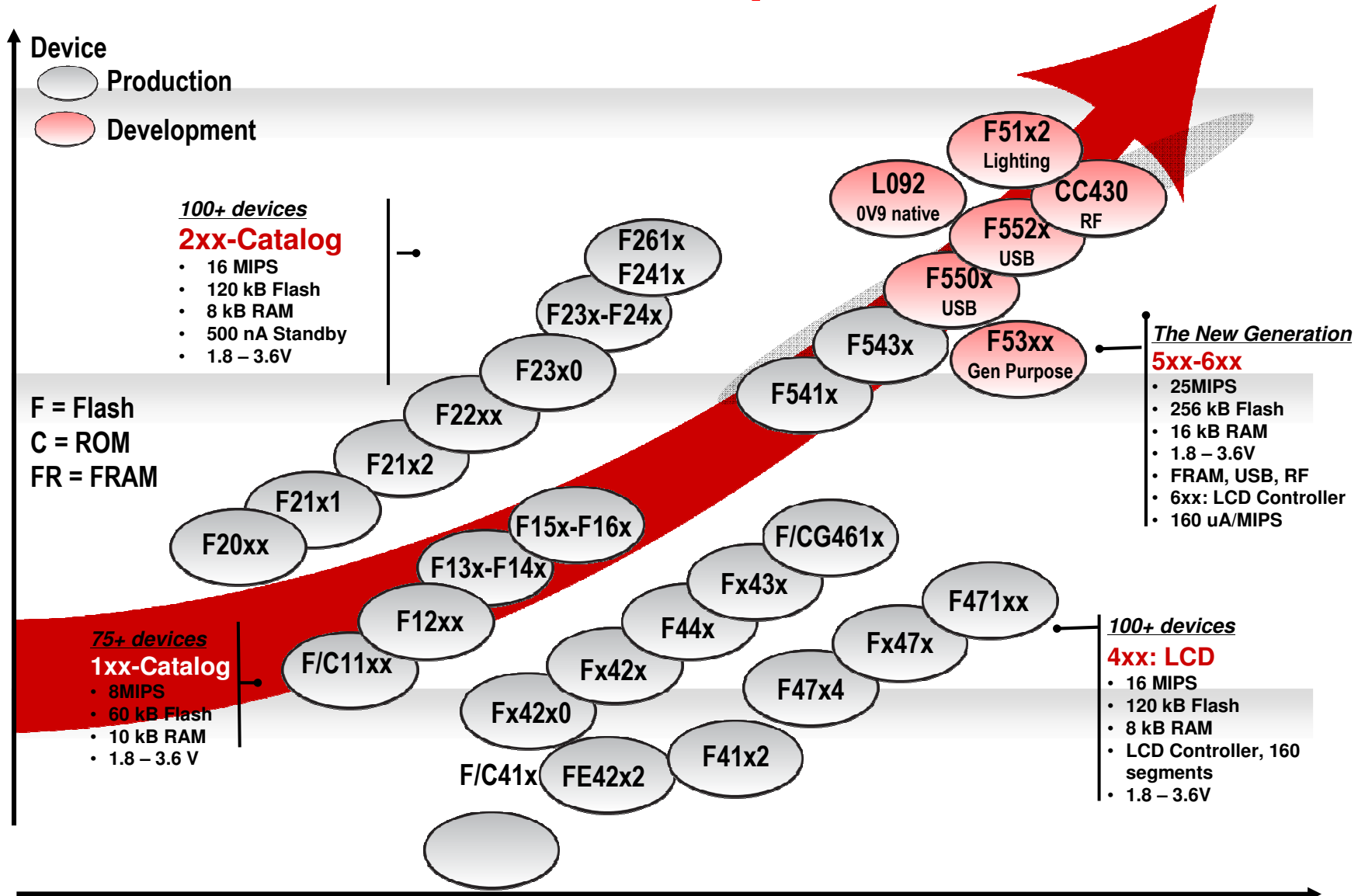
- ♦ step-down regulators
- ♦ step-up regulators



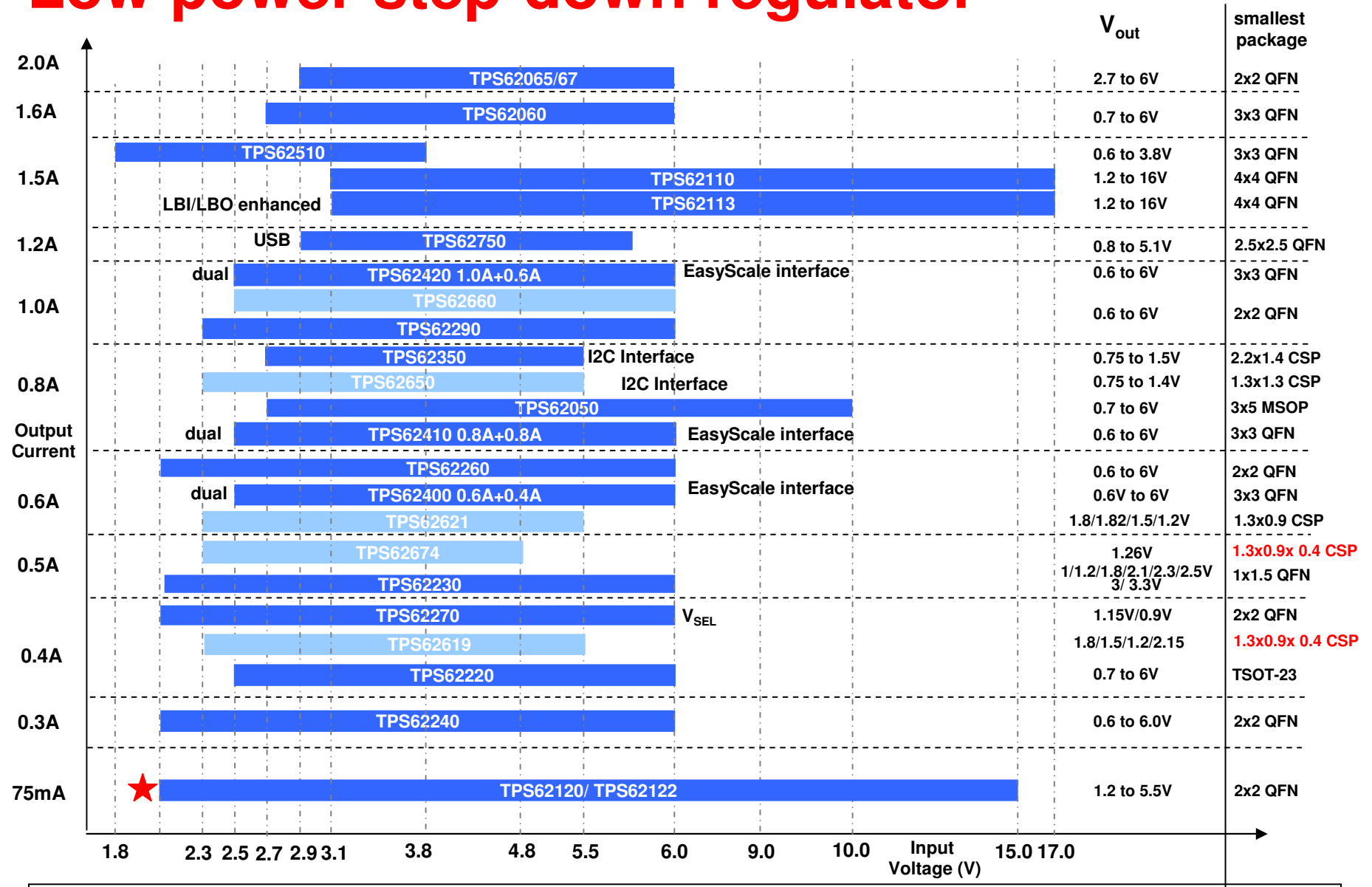
Low power radio

- ♦ <1GHz band transceivers and SOCs
- ♦ 2,4GHz band radios and SOCs

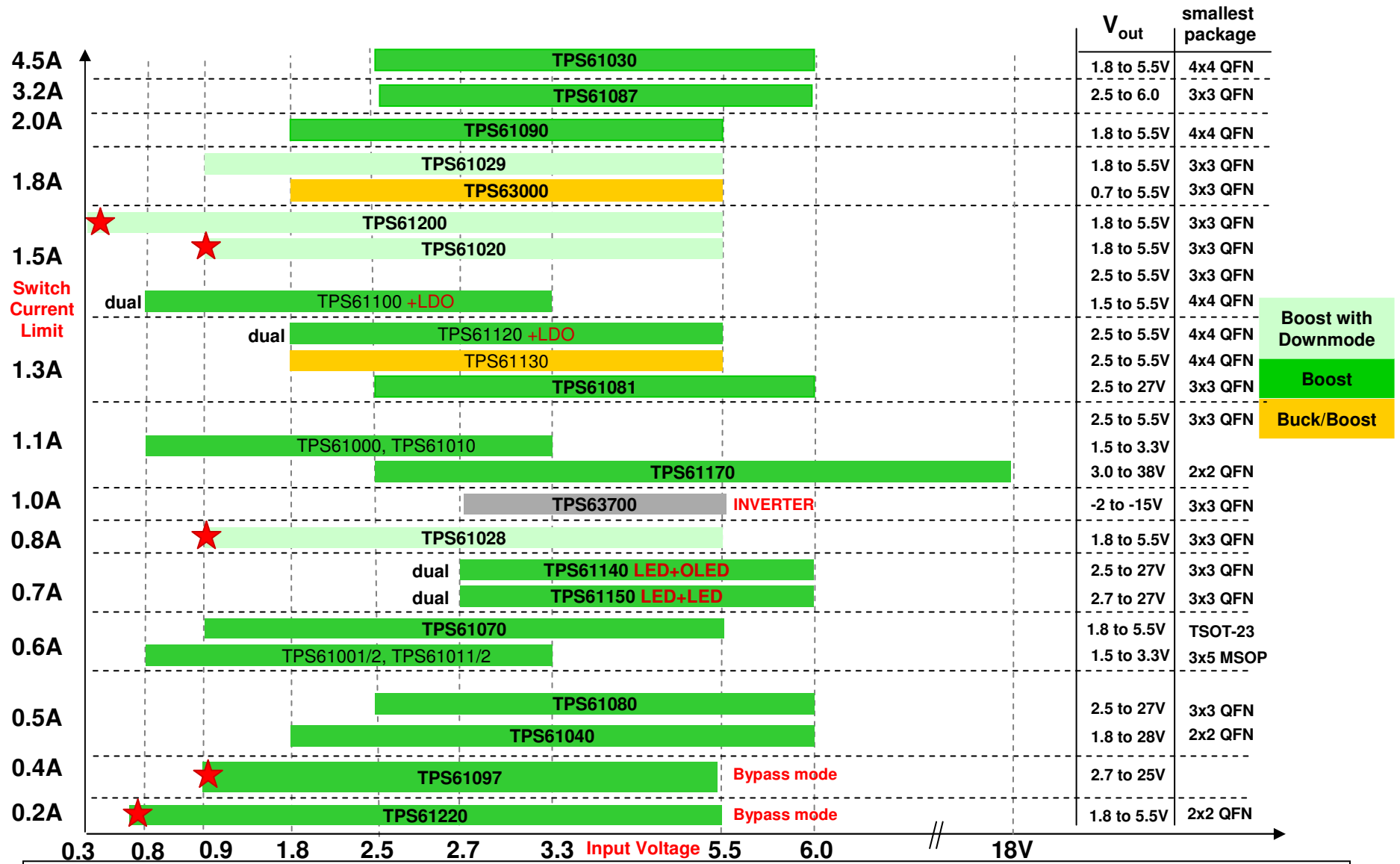
MSP430 Portfolio + Roadmap



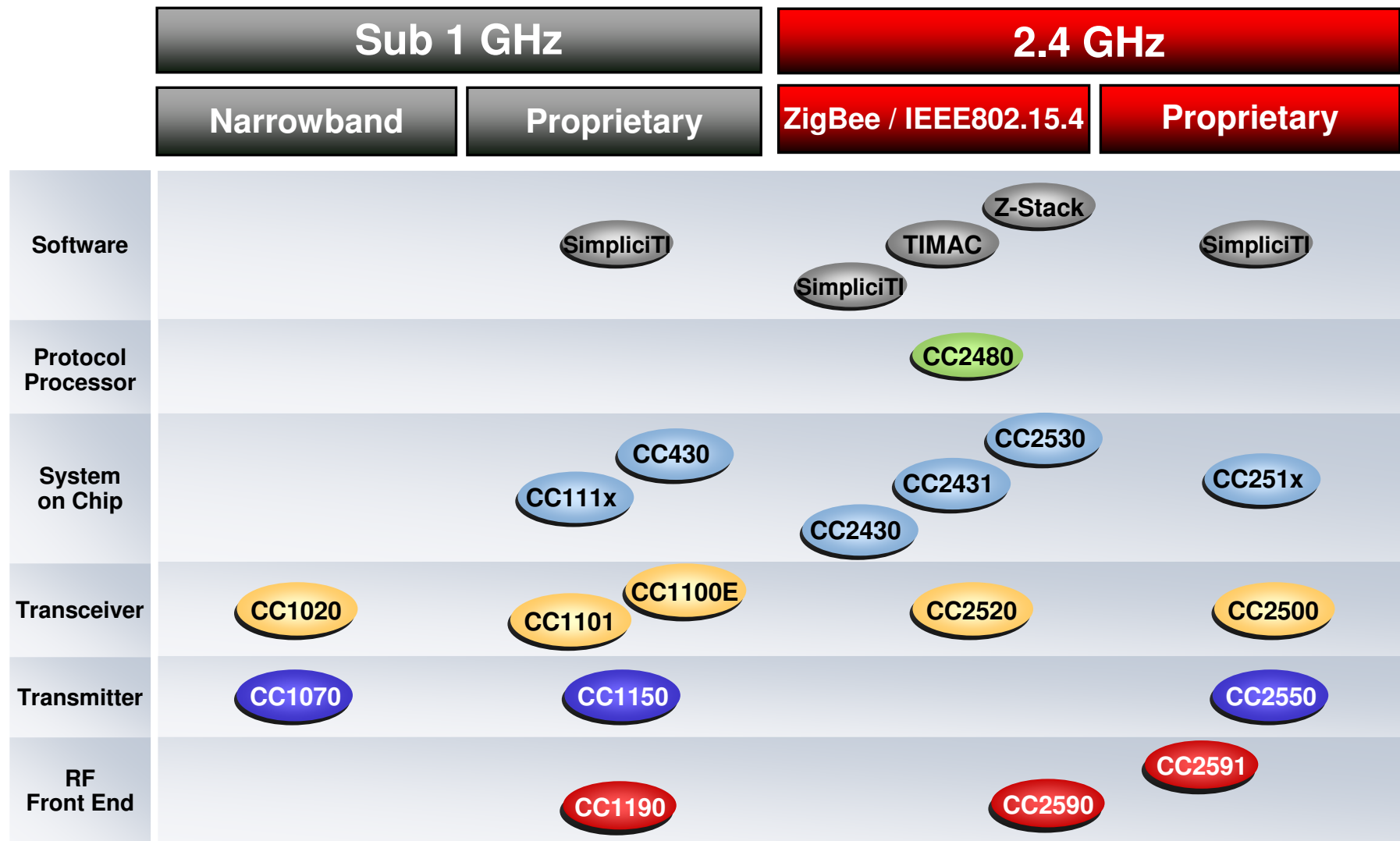
Low power step-down regulator



Low power step-up regulator

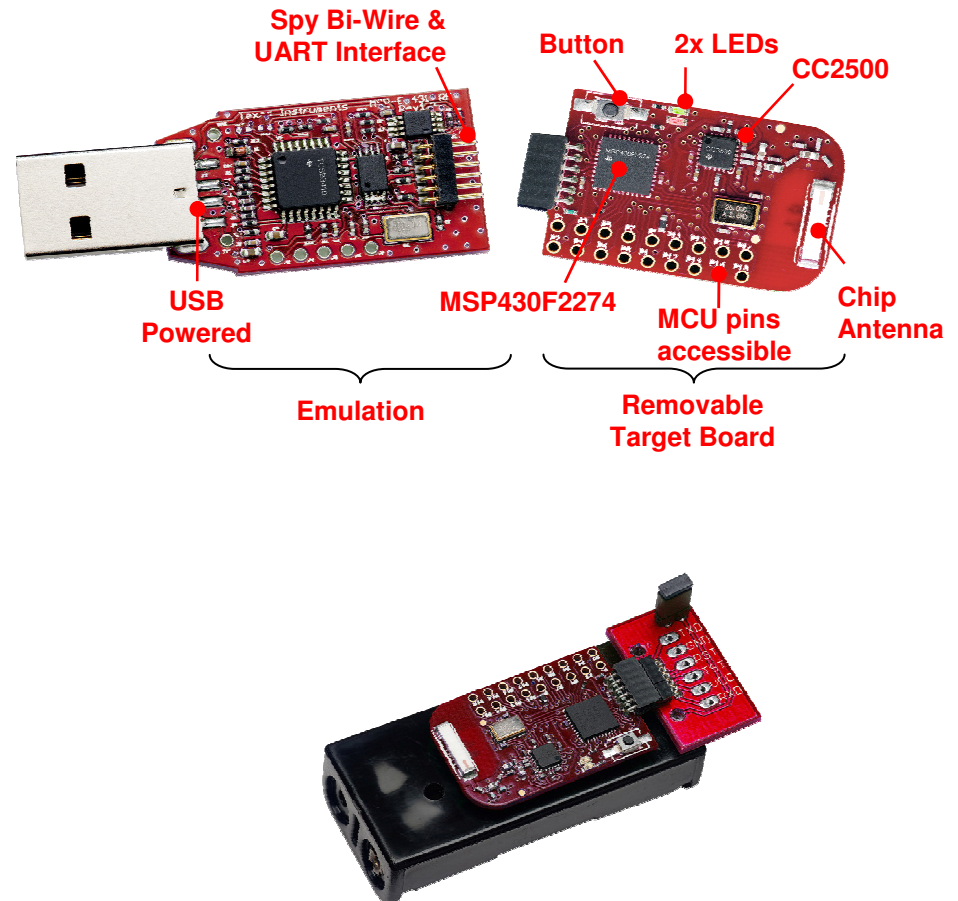


Low power RF



Ez430-RF2500

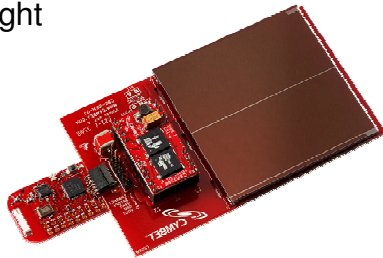
- Easy to use, Wireless development tool
- Ultra Low Power: MSP430F2274 + CC2500
- 2.4 GHz ISM wireless
- Includes SimpliciTI Network Stack
- Includes Wireless Sensor Network Demo Project
- Compatible with all MSP430 Spy Bi-Wire devices
- Standalone target boards & eZ430-RF2480 also available



Demonstrations

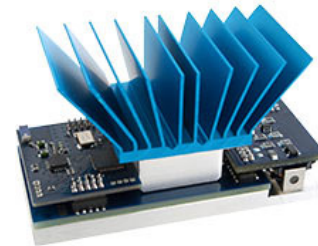
Cymbet – Solar Energy Harvesting Kit (TI e-store)

- Leveraging Cymbet thin film battery technology
- Works in low ambient light
- Negligible self-discharge
- 400+ transmission with no light



MicroPelt – Thermal energy harvesting unit

- Heat sink interface for thermal path optimization
- Plug-on DC-DC converter and sensor/wireless unit
- USB to PC wireless receiver
- 1 transmit/sec from 17°C temperature difference



AdaptivEnergy – Joule Thief

- Uses Ruggedized Laminated Piezo (RLP) technology
- Highly efficient harvesting with periodic vibration sources
- Higher energy output density with small form factor
- Ability to customize to range of vibration frequencies
- Complete power management solution with switching and storage
- Joule-Thief (Li-ion version) example
 - Output Voltage: 3.6V
 - Capacity: 40 mAh
 - Size: 56.5 mm x



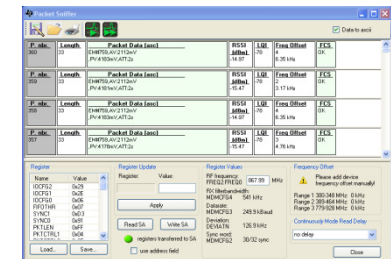
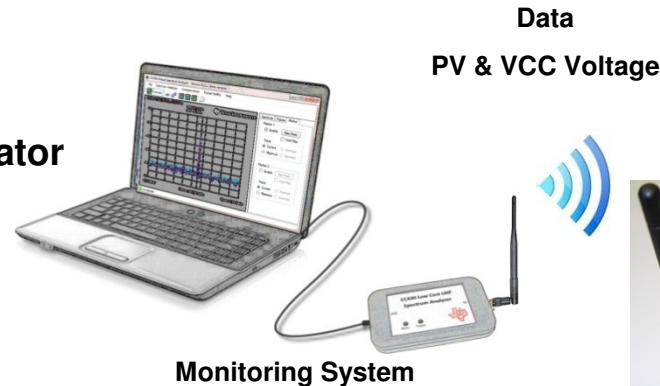
Powercast – Power harvester Receiver

- Designed for charging capacitors in battery-free devices, or energy cells with high input impedance.
- Provides intermittent / pulsed power output.
- Harvesting range from 850-950 MHz.
- Works with standard 50-ohm antennas.
- Configurable, regulated output voltage up to 5.25V.
- Power management and control I/O for system optimization.



Demonstrations

- **FEATURES**
- **CC430F6137 = MSP430 + CC1101**
- **TPS62120 75mA 2V-15V VIN buck regulator**
(11uA Quiescent Current)
- Thin film Solar Panel Type Sanyo AM-5710CAR-SCE 4.6V
- Regulated 2.1V supply voltage for CC430
- RF frequency 868MHz
- RF filter BW 541kHz
- Data rate 250 kBaud
- Deviation 127 kHz
- RF protocol length 50Byte total
- 36byte data
- 16bit CRC
- RF Power level 0dBm
- Software optimized protocol to reduce current consumption



Packet Sniffer

Conclusion

- Ultra low power MCU/RF enable perpetually powered operation through energy harvesting
- Range of efficient DCDC products to support, battery/capacitor and system power
- Various energy harvesters are available for many applications
- New energy storage technology enables new class of applications
- TI technology enables low power processing, sensing, wireless transmission, and power management

Thank you!