HIGH EFFICIENCY DESIGNS FOR ENERGY CONVERSION, ENERGY STORAGE AND POWER MANAGEMENT

Applied Power Electronics Conference and Exposition 2013

Henrik Zessin, Fraunhofer IIS
Long Beach, March 19, 2013

HIGH EFFICIENCY DESIGNS FOR ENERGY CONVERSION, ENERGY STORAGE AND POWER MANAGEMENT

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3. Software and regulation loop
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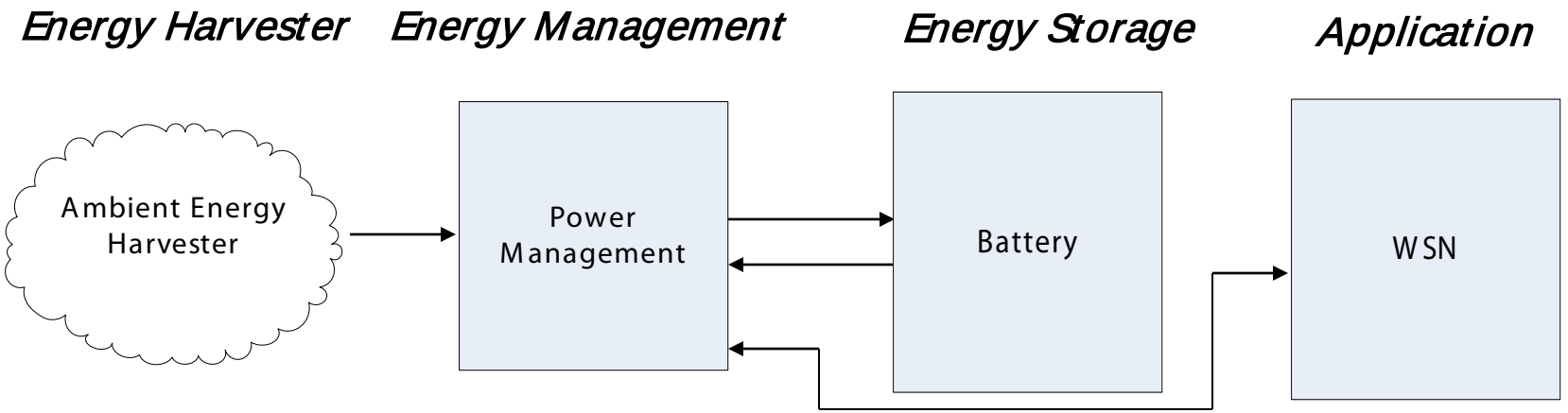
High efficiency designs for energy conversion, energy storage and power management

Introduction



- Photovoltaic
- Electro-Mechanical
- Thermo-Electric
- Radio Frequency

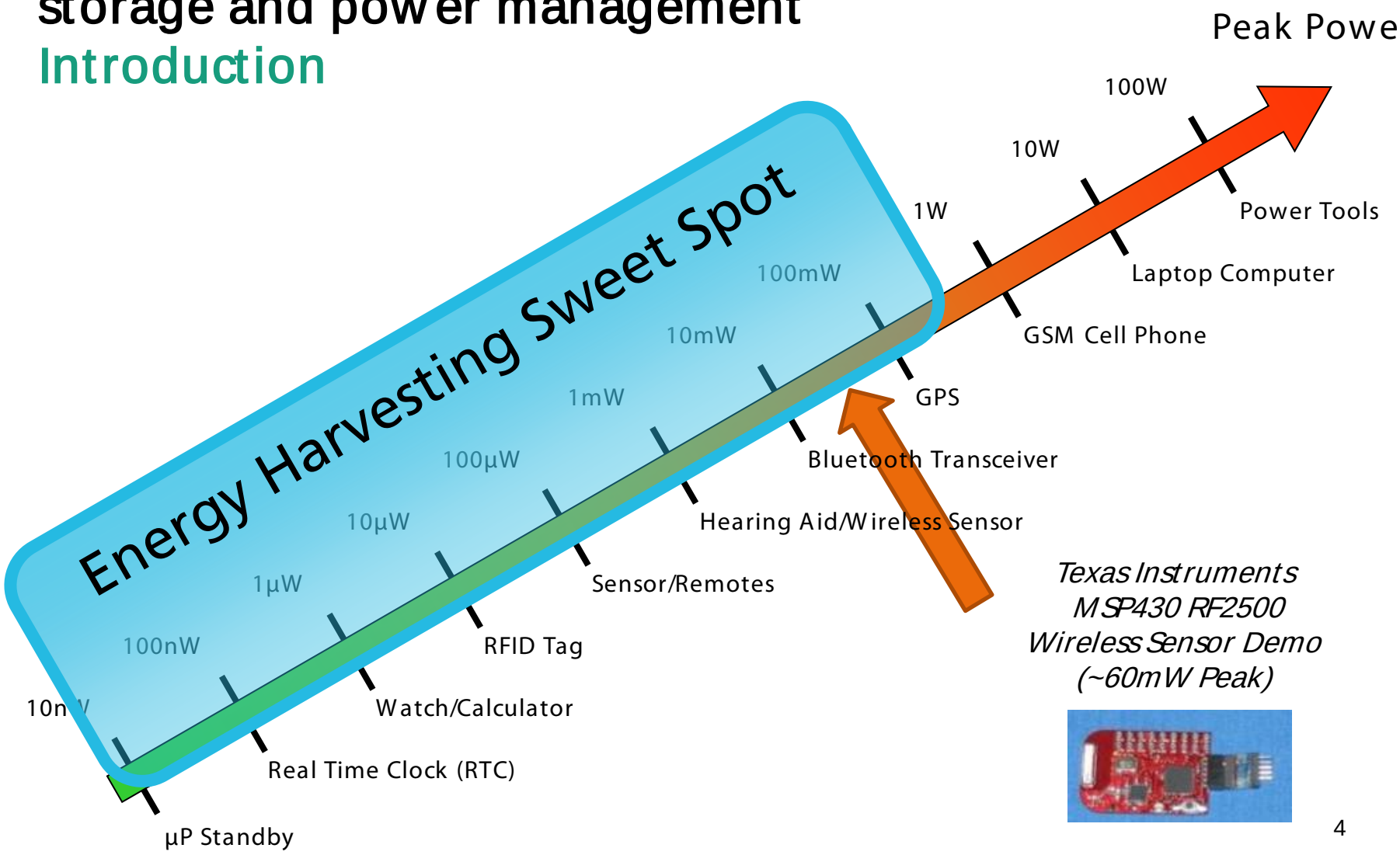
- Energy Conversion
- Manage Energy Storage
- Powers Application

- Thin Film Battery
- Capacitor
- Traditional Battery
- Etc.

- Wireless Sensor
- Powered Card
- Implantable Medical
- Many, many more…

High efficiency designs for energy conversion, energy storage and power management

Introduction

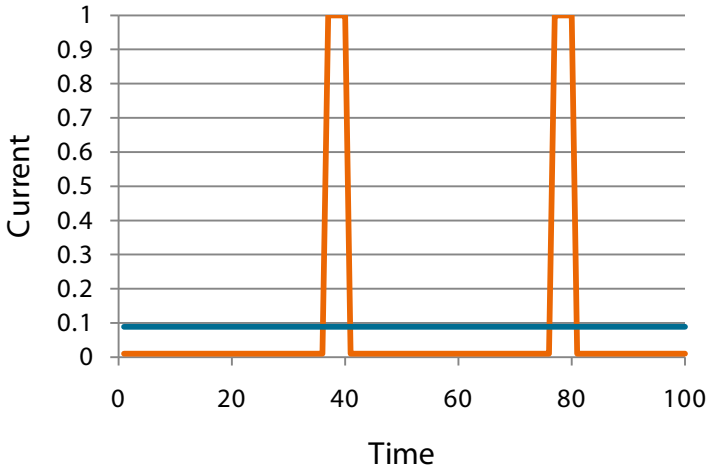


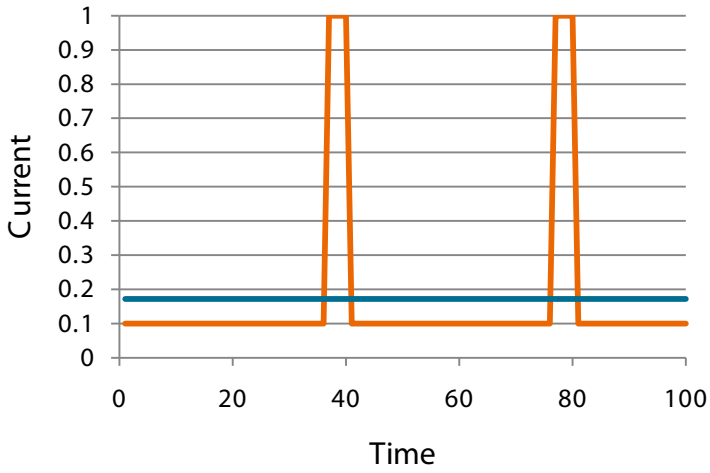
Texas Instruments MSP430 RF2500 Wireless Sensor Demo (~60mW Peak)

High efficiency designs for energy conversion, energy storage and power management

Introduction

- High efficiency designs
  - Minimize **losses** (on-resistance, coil resistance, ESR, leakage, …)
  - Minimize **standby power**
  - Maximize **harvested power**





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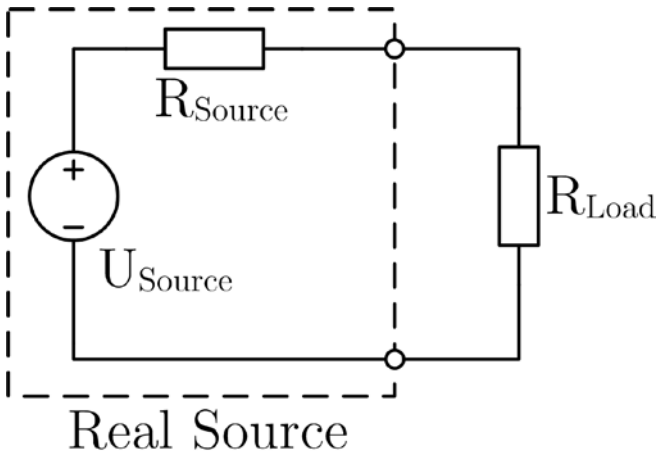
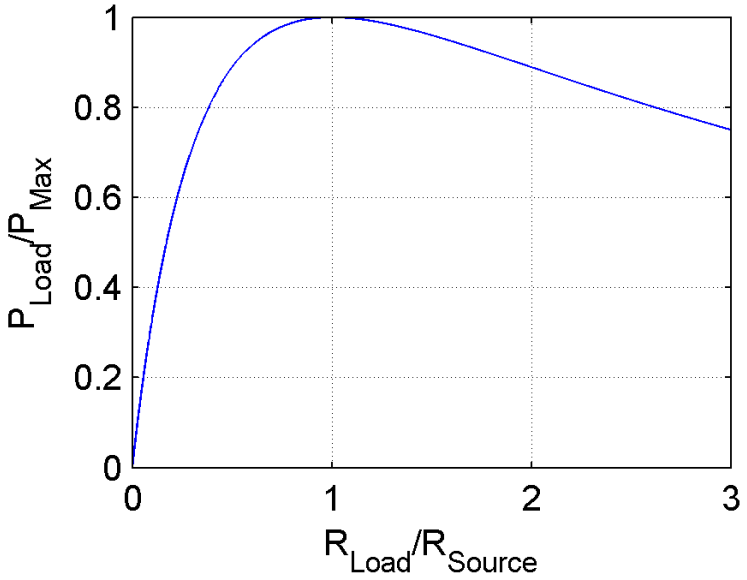
Introduction

- What is the **Maximum Mower Point**?





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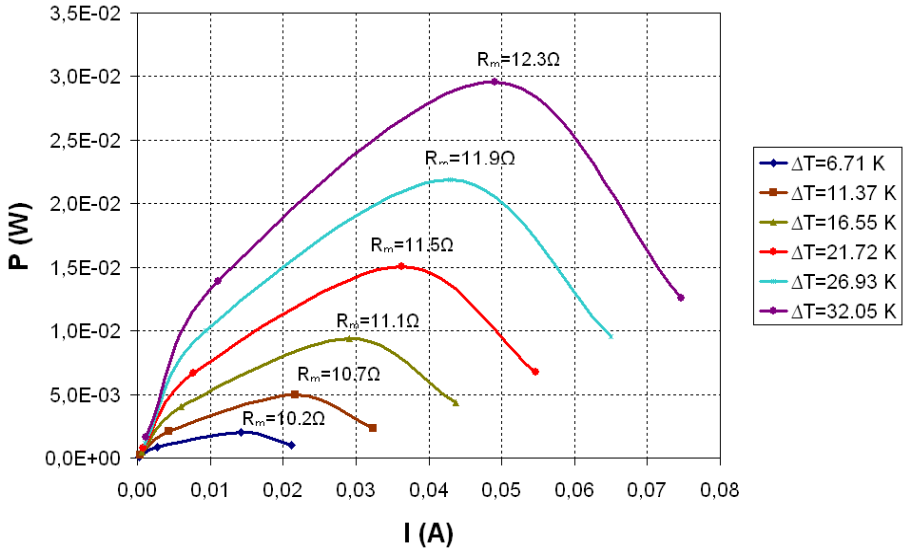
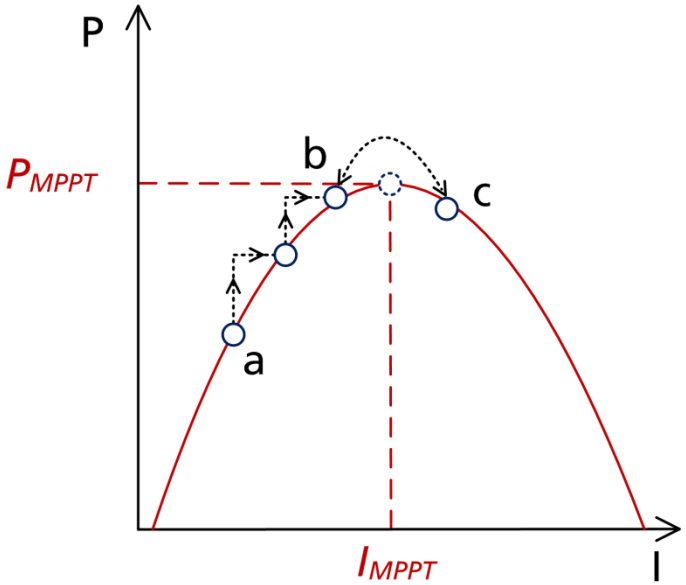
Introduction

- What is Maximum Power Point **Tracking**?





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Introduction

- MPPT algorithms
  - Incremental conductance (ΔP/ΔV)
  - P&O
  - Fractional OCV

  } **Hill climbing** algorithms

- Fractional OCV
  - MPP voltage has a **fixed ratio** to open circuit voltage (0.7 – 0.8)
  - But: Ratio **not constant** and **different** for every generator
- P&O
  - **Generic** algorithm
  - **Oscillates** around MPP

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Circuit design

- MPPT works for **all** converter types
- This case study: Boost converter for **low voltage** sources
- Input
  - Thermogenerator
  - Solar cell
  - Fuel cell

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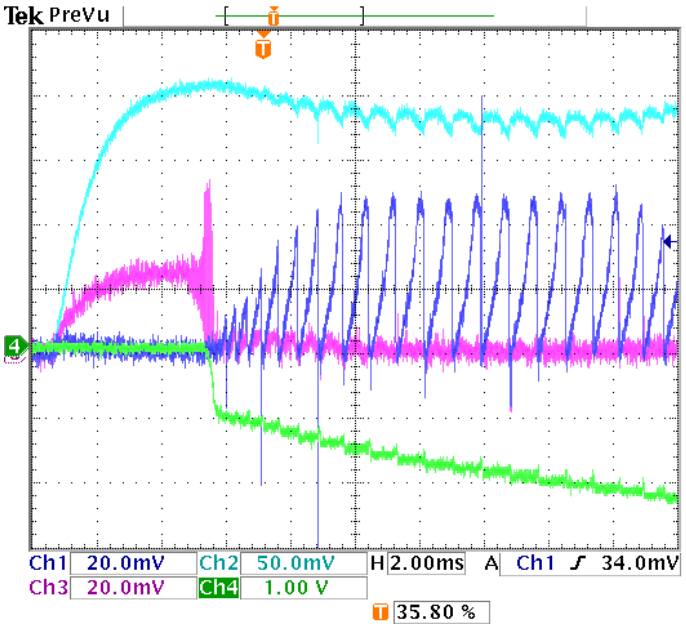
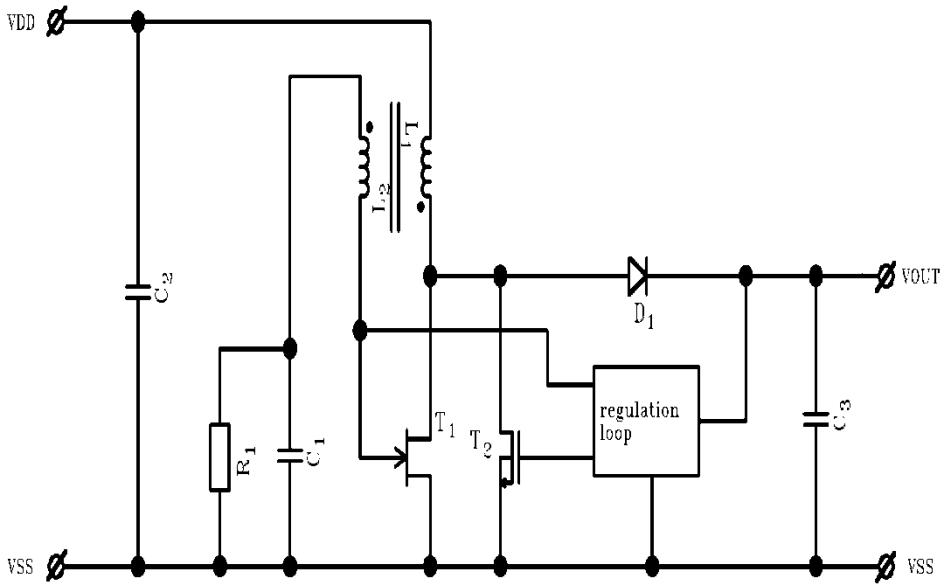
Circuit design

- **Coupled inductor** DC/DC converter
- **20mV** startup voltage
- **Minimal** thermal gradient or illumination





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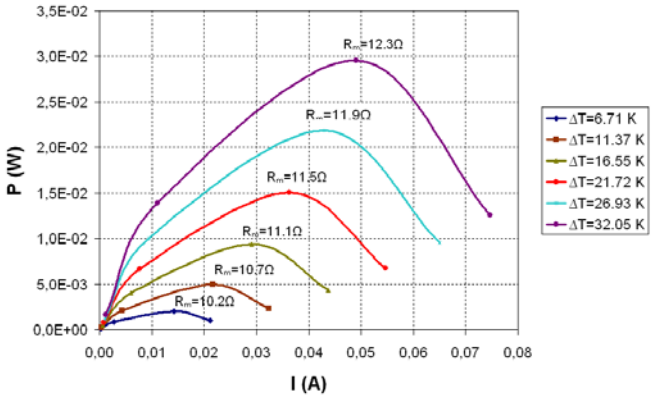
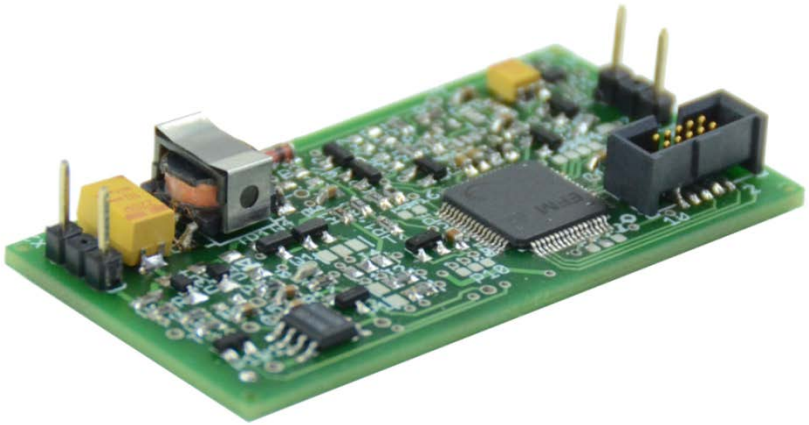
Circuit design

- **DC/DC converter** controlled by microcontroller
- Start up circuit starts at **70mV**
- **Digitally controlled** maximum power point tracker
- Integrate your own **application**
- Algorithm is **portable**
- Regulation of **input** or **output** power





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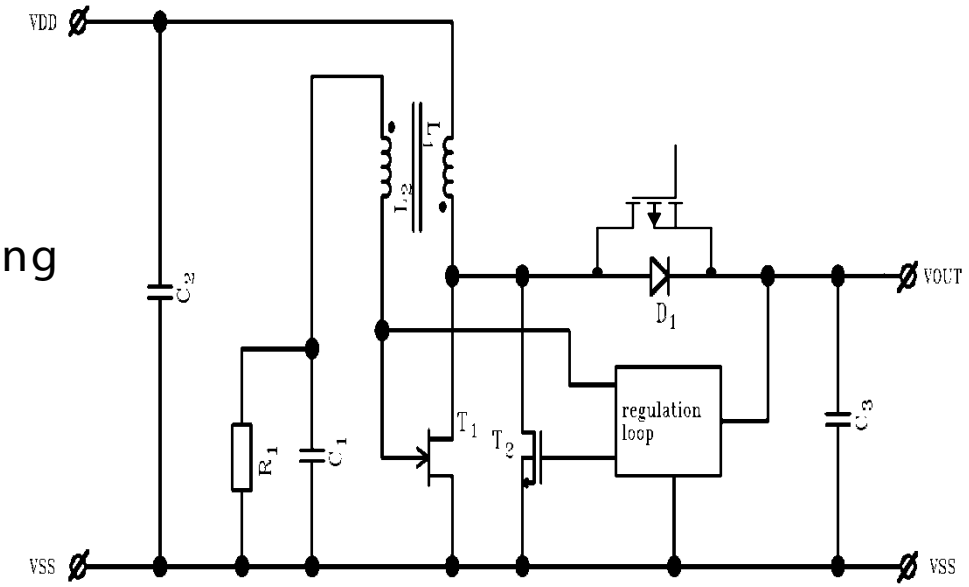
Circuit design

- **Startup** circuitry
- **Synchronous** rectification
- µC **shuts down** self-oscillating circuit when in regulation



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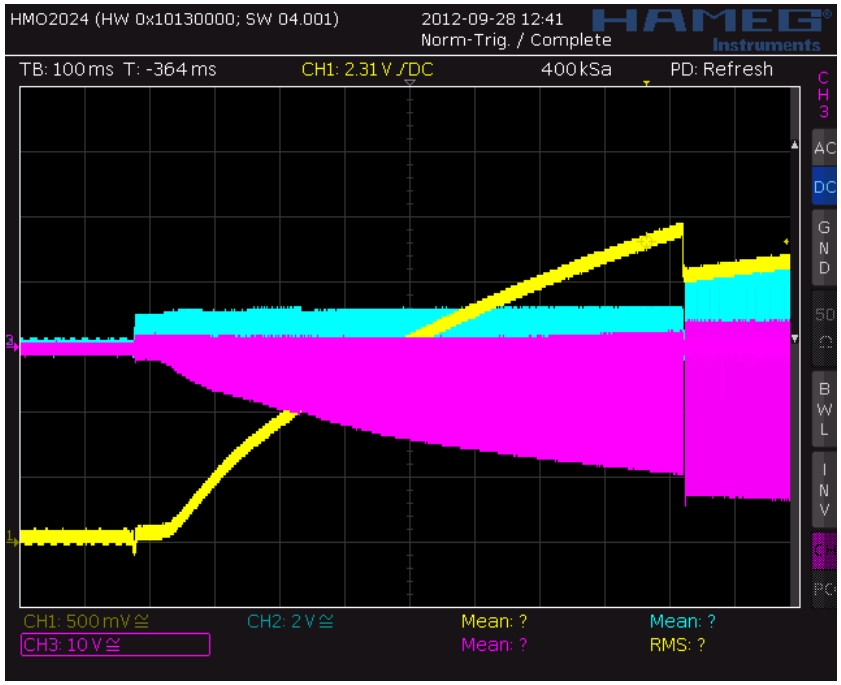
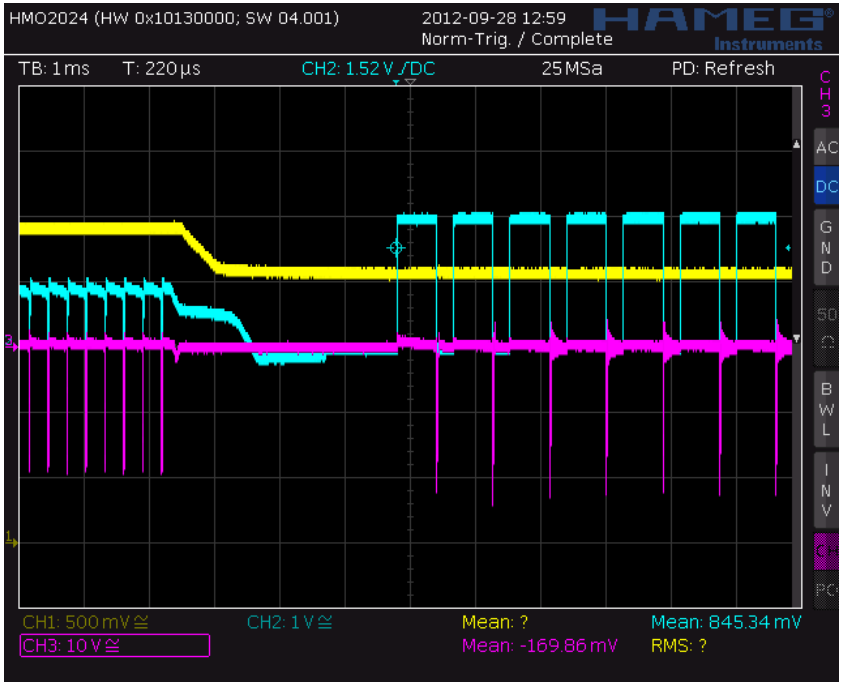
Circuit design

Oscillator startup



Startup of µC and MPPT



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Software and regulation loop

- MPPT
  - Simple and **sufficiently precise** tracking
  - Relatively **slow**
  - Requires **more energy** than FOCV
- FOCV
  - **Simplifies** measurement
  - **Energy loss** due to sampling of open circuit voltage
  - Choosing the **sampling period**
  - Voltage constant **varies** around 0.7 and 0.8
- µC enables **dynamically** choosing best algorithm

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Software and regulation loop

- **Clock source** dependent on **duty cycle**
- Use **hardware** modules
- **PWM** vs. **PFM**
- Complete **shutdown**

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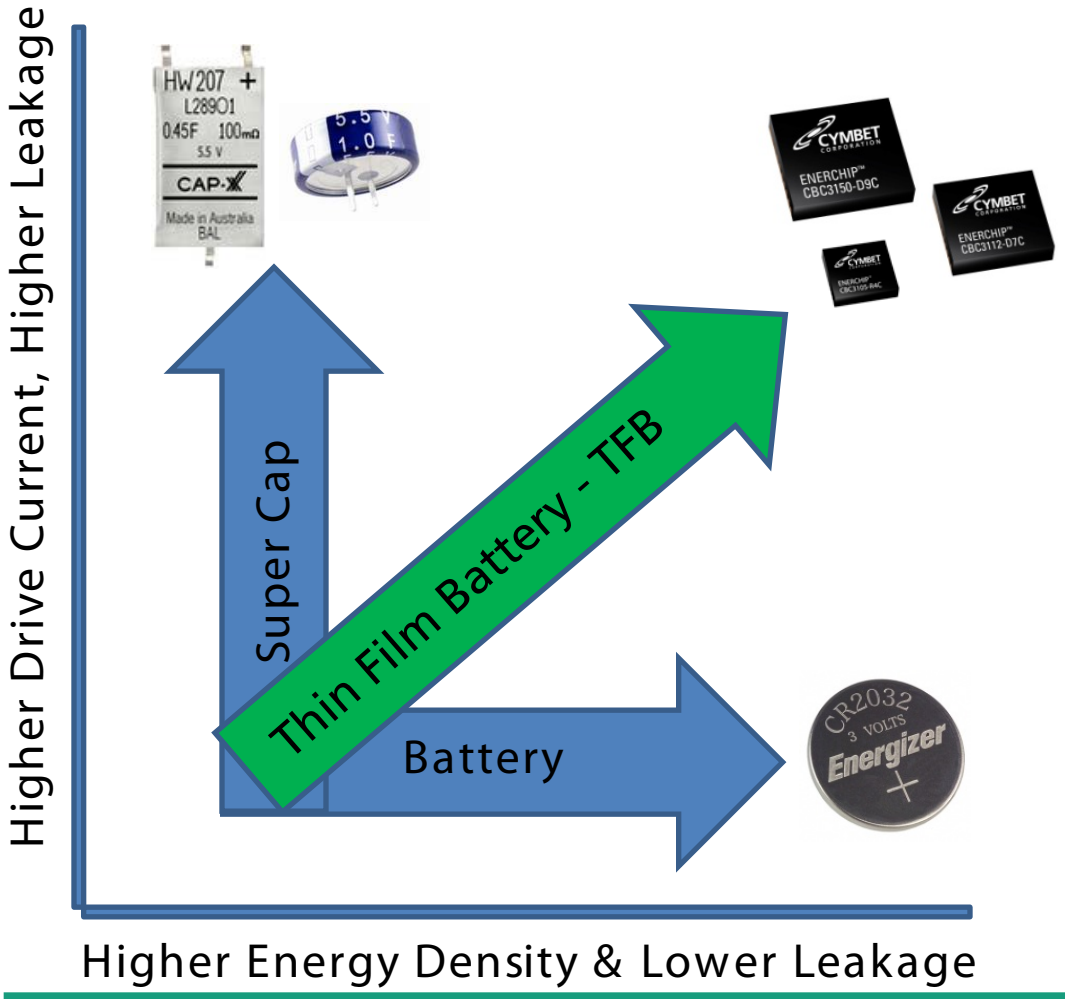
Energy storage



SSB = Best of Both

- High Drive Current
- High Energy Density
  - *50 X SuperCap*
- Lowest Leakage
  - *4,000 X < SuperCap*
- Rechargeable / Long Life
- Superior Lifetime Energy – never replace a battery

High efficiency designs for energy conversion, energy storage and power management

Summary

- Most power available if load **matches source**
- **Power management** ensures maximum power output
- **Energy storage** always required
- **Transducers can be shrunken** due to more efficient power management
- System costs **significantly lower** when transducers are smaller

Thank you for listening!

Any questions.....?

- Contact: Henrik Zessin
  Fraunhofer-Institute for Integrated Circuits
  Nordostpark 93
  90411 Nuremberg
  Tel. 0911 / 58061 6425
  henrik.zessin@iis.fraunhofer.de

- www.iis.fraunhofer.de/ec/power
- www.smart-power.fraunhofer.de