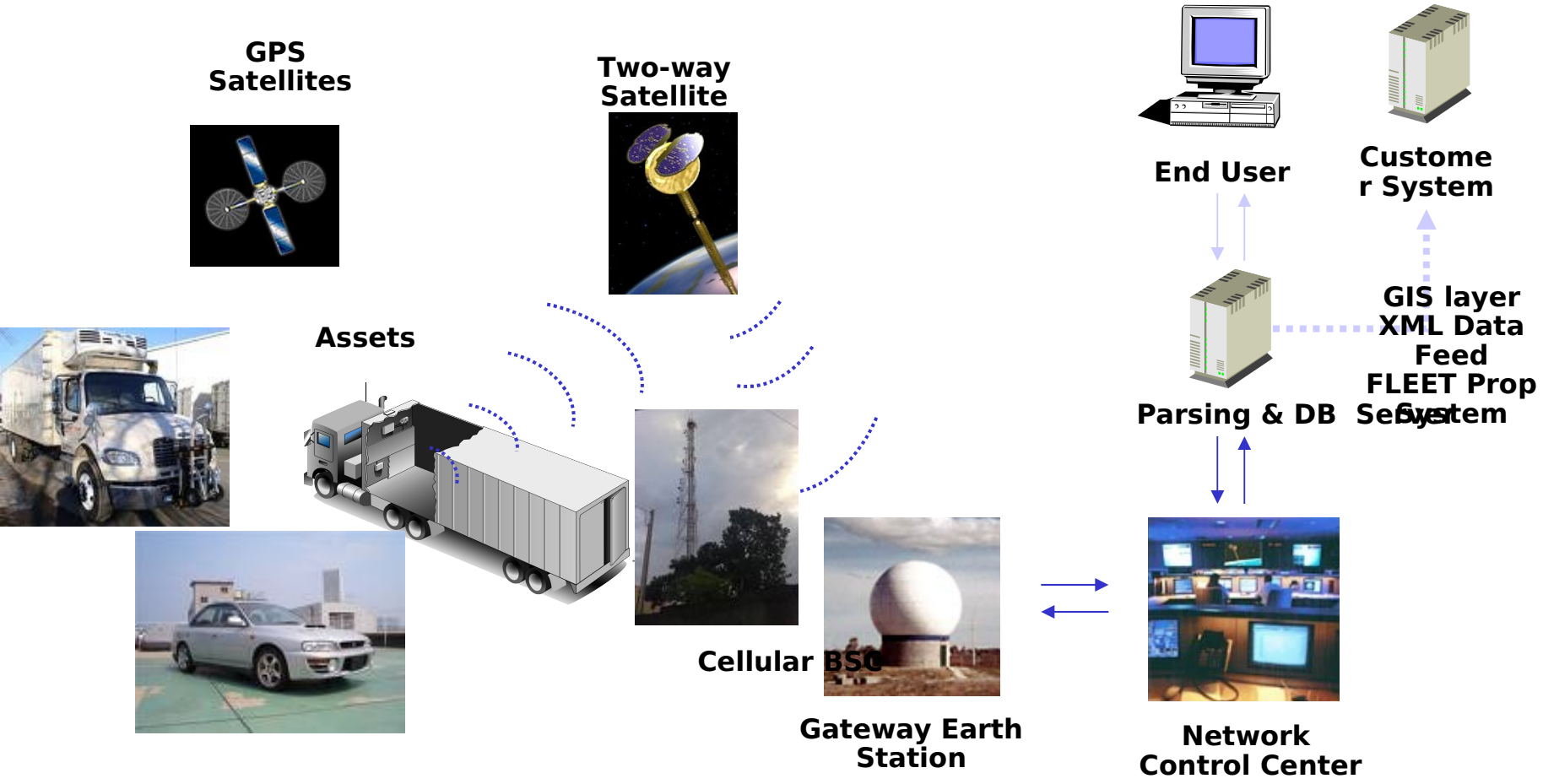
Energy Harvesting
Free Energy

- Discuss the advantages of installing solar-assisted telemetry into the power supply of assets, for ex. reduced fuel usage, enhanced systems reliability

- Explore the future of alternative power sources and generators, such as piezoelectric, for in-car telematics and asset-management industries

J. Jesson
0642010

Typical Telematics-M2M Architecture



Standard Telematics Architecture installed on Powered and Unpowered Assets

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Commercialized Solar-Powered Tracking

•**TRAILERS, >60,000 in Production**

1 x PVs, Solar Augmented

2 x PVs, 100% Solar w/o Sensors

• **RAIL**

4 x PVs, 100% Solar

Solar PV Specifications

Weight (typical)	9 oz.
Size	8.2” x 3.4” x 47”
Rated Current	120 ma (9V OC)
Service Life	>10 years
Panel Impact	1” hailstones @ b50 mph
Rated Power	1.25 Watts
Rated Temperature	-40C to +85C

* SLA Battery Pack Life Extended with Solar Trickle Charging

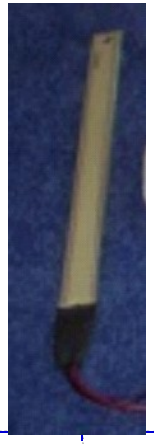
Why Solar or Energy Harvesting?

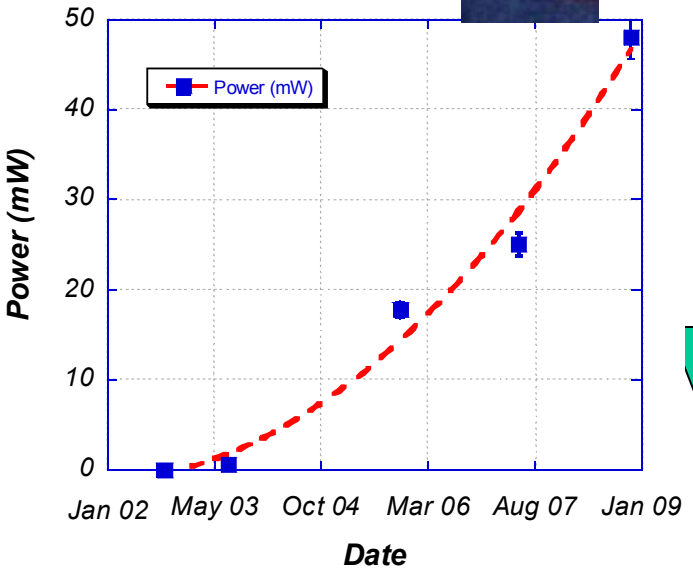
Clear Telematics Business Benefits:

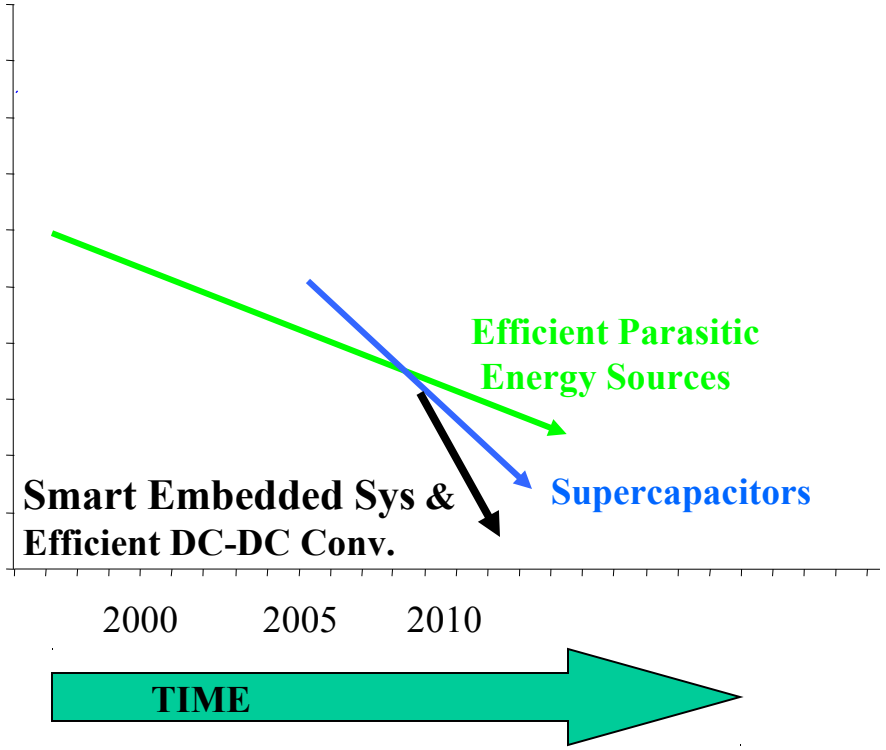
- ✓ **Pricing Inflection Point**
- ✓ **Improved Reliability**
- ✓ **Reduction in Fuel**
- ✓ **Quicker Installation**
- ✓ **Improved Covert Mtg (Motion)**
- ✓ **Longer Battery Life**

Why Solar or Energy Harvesting?

Three Intersecting Technologies in Time:







Why Solar or Energy Harvesting?

Proven Reliability Improvements:

- **Minimizing the Battery Discharge Level Not to Exceed 20% to 30% will Extend the Battery Life ~9x or to Reach a 7-12 YEAR Usable Life.**

- **No Manual Wiring Required with Energy Harvesting, Eliminating Potential Wiring Defects and Boosts Reliability 1% to 5%**

Minimizing Battery Deep Discharges is key to a Long Life.

****The new GM VOLT spec calls for a <30% discharge Use Cycle to Insure a 10-year Life**

Why Solar or Energy Harvesting?

Reduction in FUEL Savings:

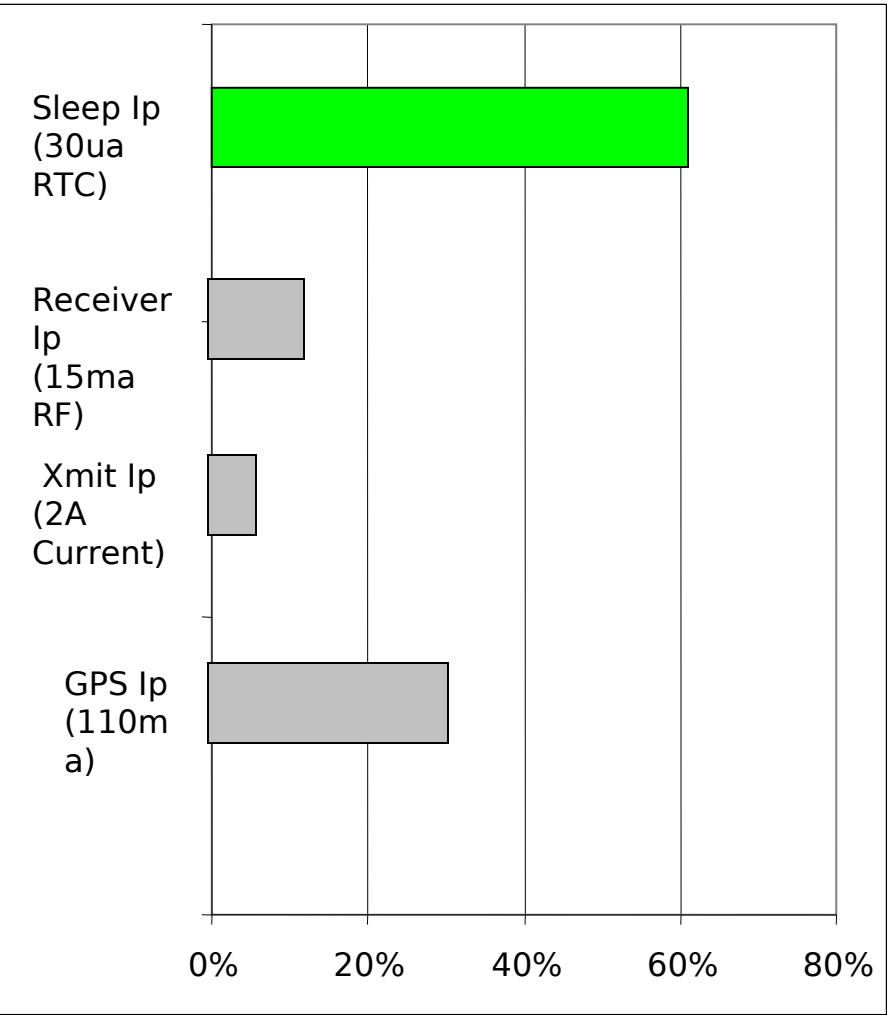
The fuel savings is based on the power generated by the solar panel offsetting the alternator load and hence the albeit small decrease in load on the engine.

**** Approximatly 0.07 liters/day/trailer savings, x 60,0000 =**

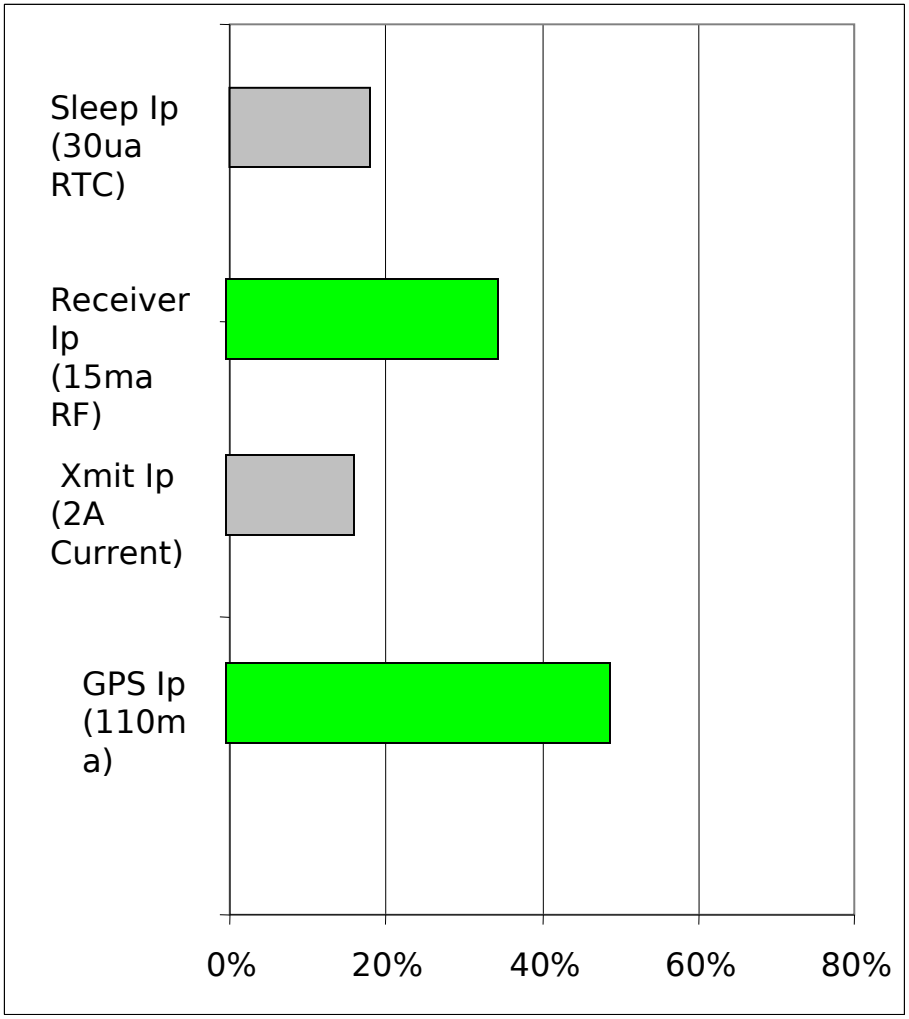
4200 LITERS/DAY SAVINGS ON A LARGE RETAIL FLEET

Percent Power by Architecture Element

Infrequent Location Reports (2x Day):



Frequent Location Reports (12x Day):



Relative Power Availability by Parasitic Source:

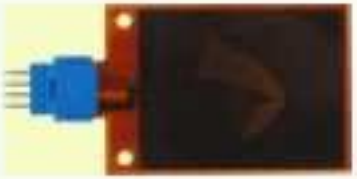
Energy Source	Challenge	Estimated Power (in 1 cm^3 or 1 cm^2)
Light	Conform to small surface area Wide input voltage range	10μW-15mW (Outdoors: 0.15mW-15mW) (Indoors: <10μW)
Vibrations	Variability of vibration	1μW-200μW (Electrostatic: 50μW-100μW) (Electromagnetic: <1μW)
Thermal	Small thermal gradients	15μW (10°C gradient)
Piezoelectric	Capturing pressure or motion	~ 200μW
RF & Inductive	Coupling & rectification	Various

Source: EE Times

AdaptivEnergy – JouleThief™

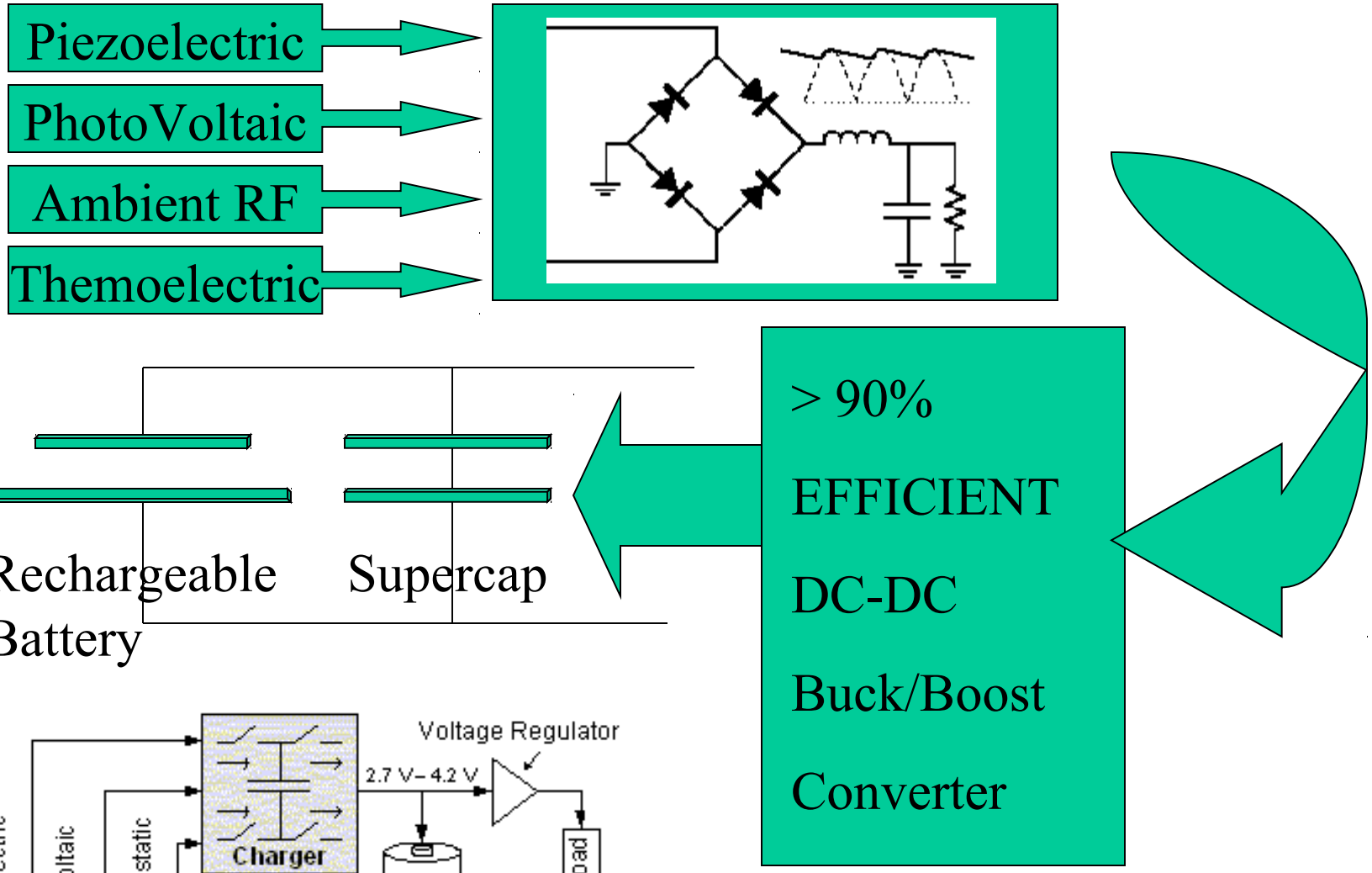
Solar - Various

Peltier - Thermo Life



MIDE – Volture™ Piezo

Architecture of Parasitic Power Supply



New Low-Voltage, Efficient DC-DC Boost Converter

The TPS61200 boasts extremely low 0.5V start-up capability in any load condition and operates with more than 90 percent efficiency. In contrast, today's best step-up converters can only support an input voltage beginning at 0.7V with start-up at 0.9V—good for primary rechargeable battery cells or main supplies, but not low enough to support new applications using energy-harvesting power sources such as solar cells or fuel cells.

The TPS61200's ability to operate from a single solar cell eliminates the need for multiple solar cells in series, and eliminates the required protection circuitry associated with the series connection. This opens the door to new potential innovative designs, such as built-in solar-powered cell phone chargers that use indoor ambient lighting to help provide an infinite amount of stand-by time.

Extends the Operating Range of Single-Cell Alkaline, NiCd, and NiMH Batteries

The extremely low operating voltage of the integrated circuits also eliminates many of the design challenges that occur when operating single-cell alkaline, nickel-cadmium (NiCd), and nickel-metal hydride (NiMH) batteries to power anything from toys to portable medical devices. The TPS61200 extends the operating time of many pulsed-load applications.

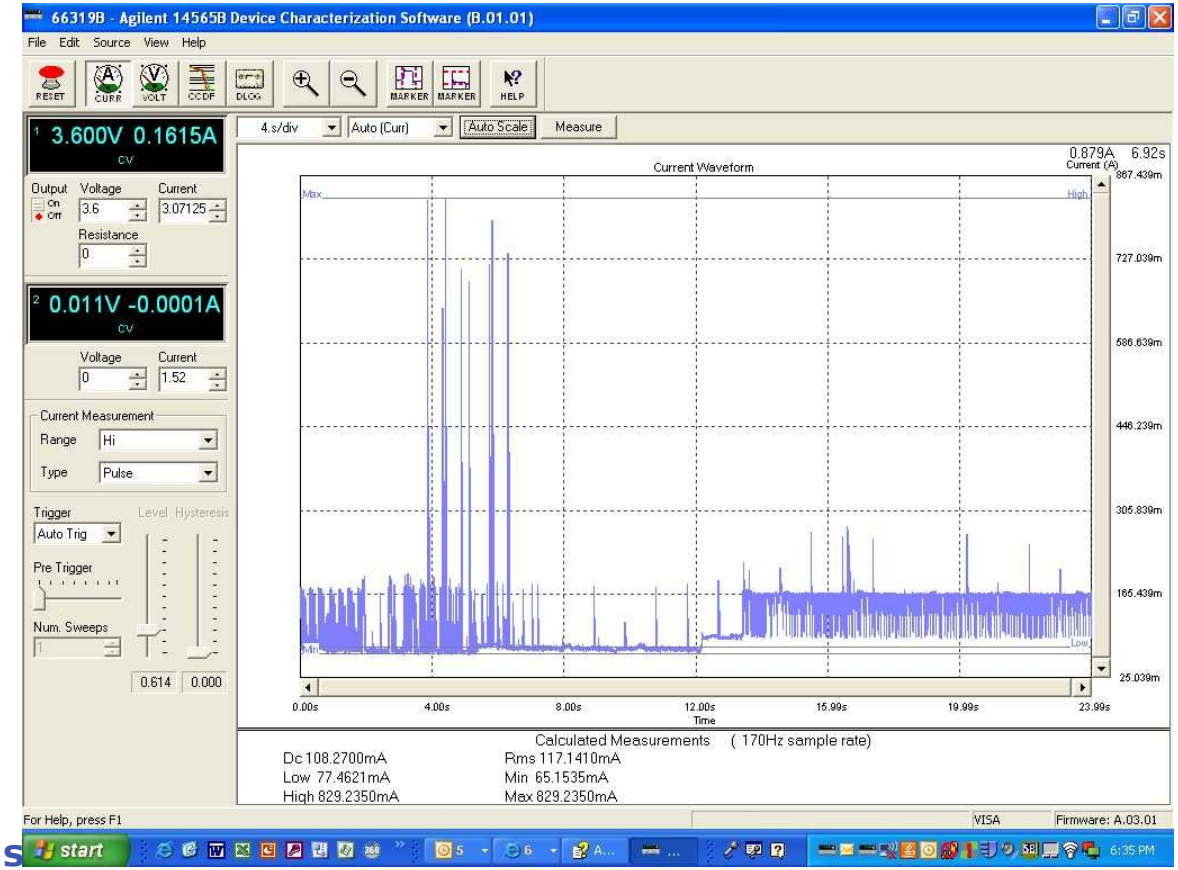
APPLICATIONS:

- All single-cell, 2-cell, and 3-cell alkaline, NiCd or NiMH, and single-cell Li-Ion battery-powered products
- Fuel- and solar-cell powered products
- Portable audio players
- PDAs
- Cellular phones
- Personal medical devices
- White LED drivers

FEATURES:

- 0.3V-5.5V input operation
- Start-up into full load at 0.5V input voltage
- Up to 90% efficiency
- Automatic transition between boost and down conversion modes

Supercapacitor Requirement:

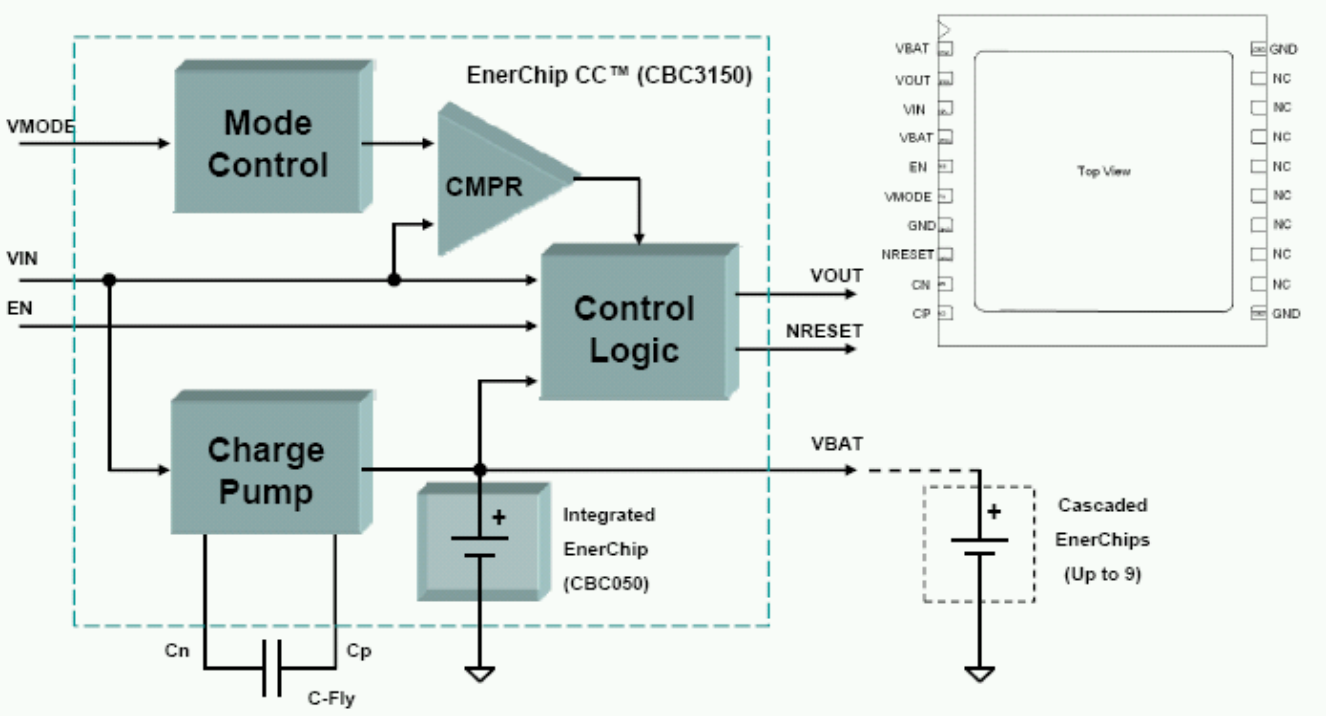


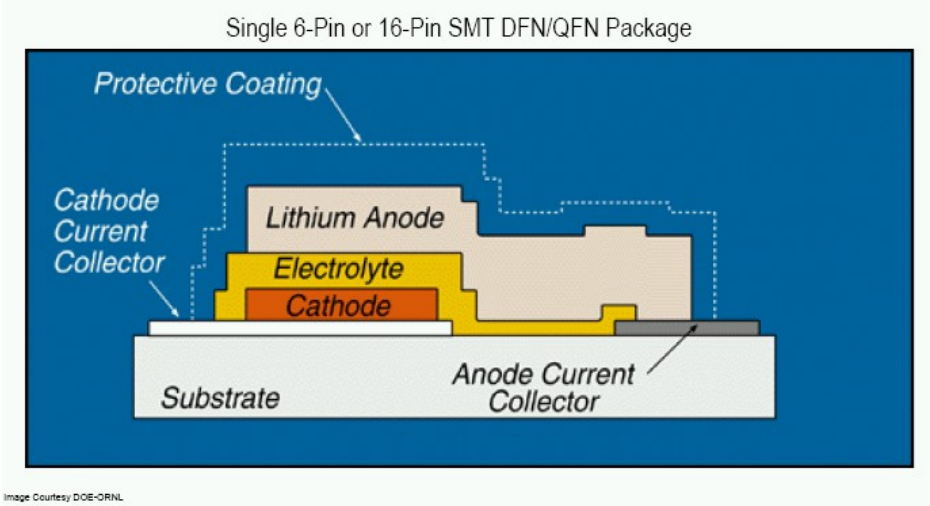
SUMMARY of Power Anaysis

- ✓**20-70 MicroAmp Sleep Current**
- ✓**Normal 1A@155us X 8 GSM NETWORK Registration**

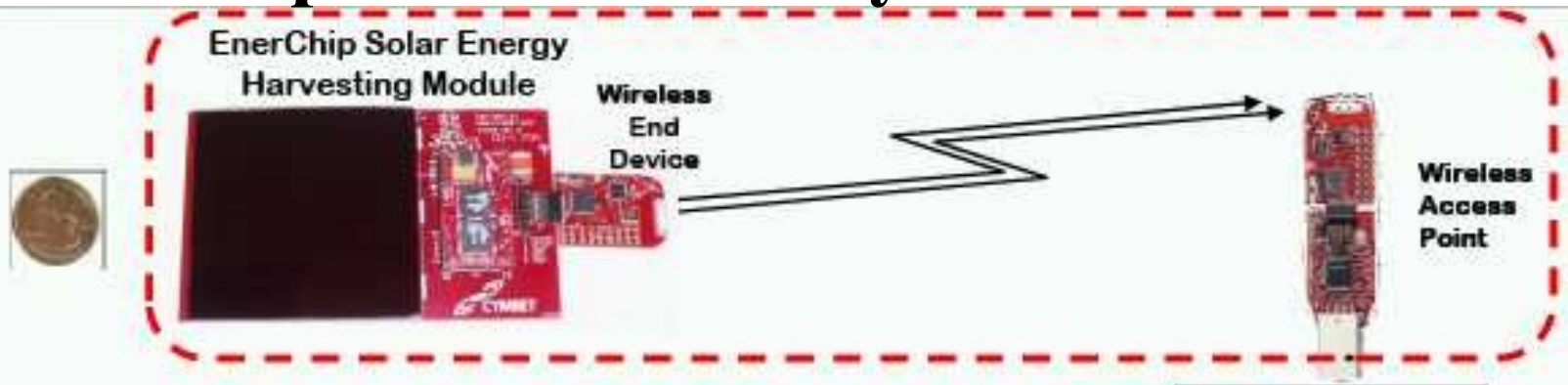
A Supercap not only supplies a high current Xmit pulse, typically <=2 A, But also extends the battery life

EnerChip Architecture:





TI & Chipcon Radio & Cymbet Evaluation Board:

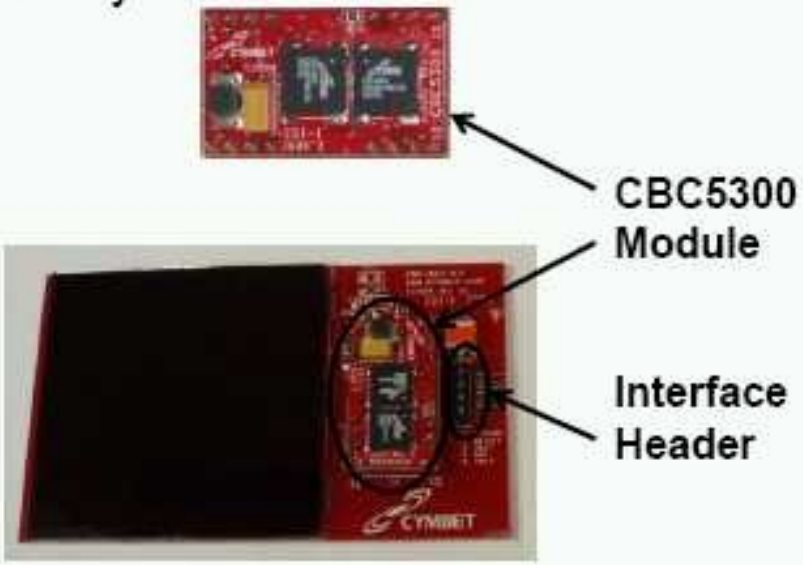


- Available as the TI eZ430-RF2500-SEH Evaluation Kit in January 2009
- Compact module with integrated solar cell
- Works in low light – down to 150Lux
- Low self-discharge enables high-efficiency
- No battery replacement or disposal; 10-year life
- Uses the EnerChip EH CBC5300 – Energy Harvesting Module
- CBC-EVAL-08 is Cymbet's version of Solar EH Board for generic Energy Harvesting designs

TI's eZ430-RF2500-SEH Evaluation Kit Contents

TI & Chipcon Radio & Cymbet Evaluation Board:

- EnerChip EH Module – CBC5300:
  - Capacity = 100uAh, uses 2 CBC050s
  - Compatible with solar, inductive, piezo & thermoelectric transducers
  - No battery replacement or disposal; 10-year life
  - Provides control signals to enable "Energy Aware" sensor nodes
  - Low self-discharge enables high-efficiency
  - Order P/N: CBC5300-24C
- Solar Evaluation Board – EVAL-08:
  - Solar Energy Harvesting Demo Kit
  - Compact module with integrated solar cell array
  - Works in low ambient light:
    - Down to 100Lux
  - Uses the EnerChip CBC5300
  - Adaptable to many sensors and wireless networks via Interface Header
  - Order P/N: CBC-EVAL-08

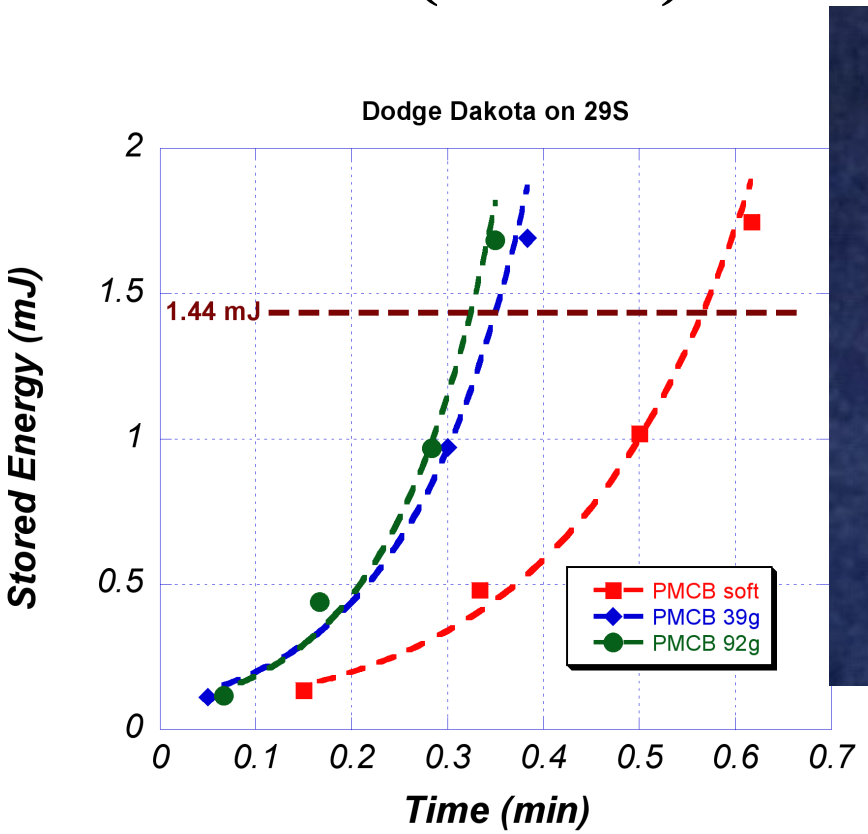


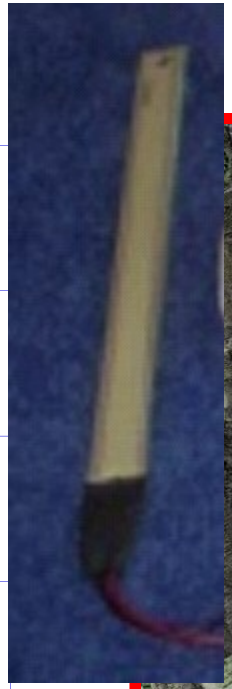
Evaluation Board Power for 802.15.4 Protocol:

Parameter	Min	Typical	Units
Min input Lux	200		Lux
Full charge Lux	700		Lux
Load current (charging		20	uA
Load Current (not charging)		800	nA
Battery Charge Voltage		4.06	Volts
Battery Cutoff Voltage	3.0	3.3	Volts
UVLO Trip Select Voltage		0.7	Volts

Key Take-away is the 802.15.4 short-range wireless protocol can be powered through most of the Energy Harvesting Technologies which Enable self-powered sensors TODAY!

ACI Piezo (PFCB) Transducer:

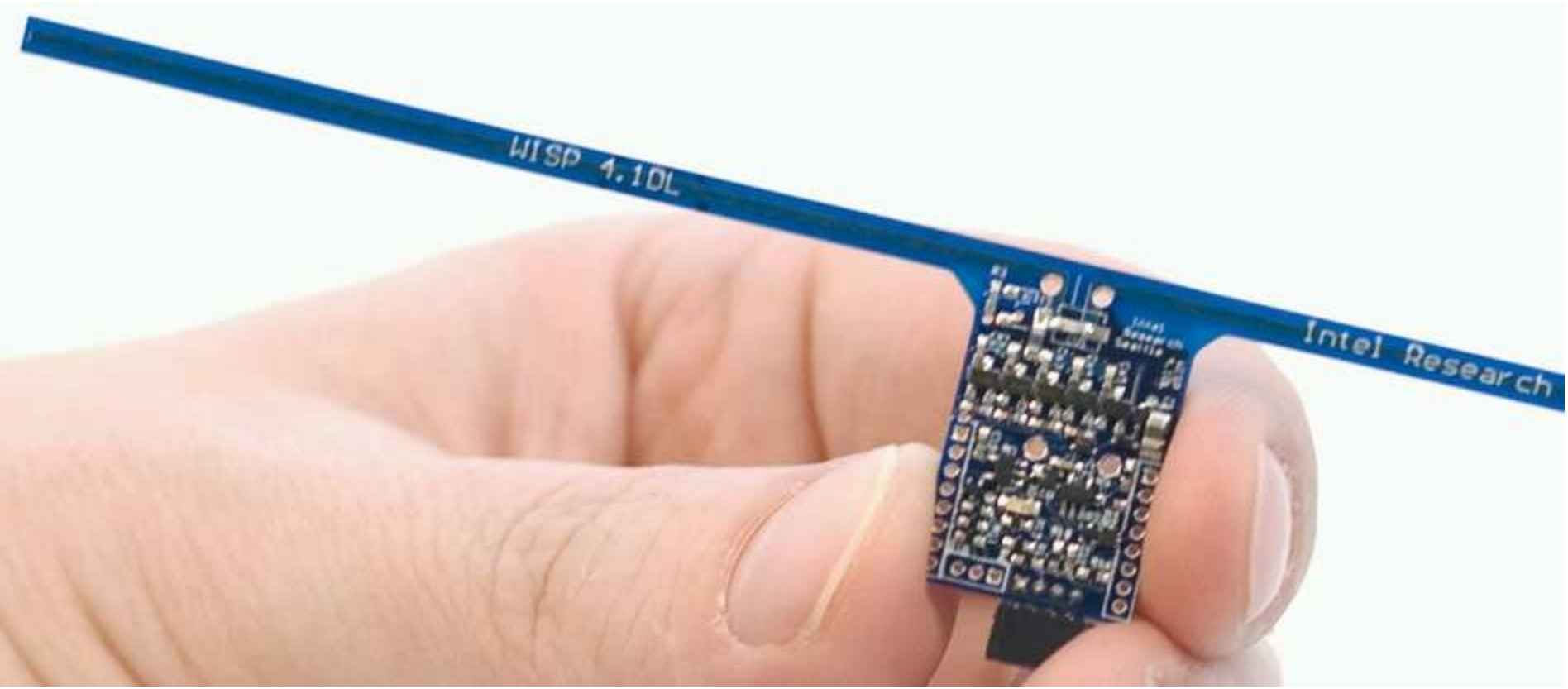




- ACI Tested cars: Honda Civic, Dodge Dakota
- All vehicles produced sufficient energy in less than minute for wireless transmission.

This Piezo-based Innovative Technology Will Power a 802.15.4 Sensor Today (2+ mJ) from a Typical Sedan Drive. Under Extreme Deflection,

Intel WISP, Wireless identification and Sensing Platform:



Imagine Powering your Smart Wireless Sensors by Stealing Power from your Local TV Station? Shades of Nicolai Tesla!!