Demonstrations of Solar Charging and Energy Harvesting Applications

Power Ranges & Devices

100‘s µW to 100‘s mW
- *Keyboards, Mice, WSN*
- *Total power*
- *New storage tech.*

bq24210
- *Linear charger*
- *Input Voltage Regulation (VDPM)*
- *MPPT*

100‘s mW to ~5W
- *Portable consumer electronics*
- *Dyn Range – efficiency*

bq25504
- *Boost Charger: Iq 330nA*
- *High Efficiency*
- *Various Low Voltage Input Energy Sources*
- *Various Output Storage Elements*

bq24650
- *Multi chemistry charge controller*
- *Scalable Power Range*

SolarMagic™
- *Multi-Chemistry Charge Controller*
- *Scalable Power Range*

100’s mW to ~100W
- *LED Lanterns, Computing, Remote Monitoring*
- *Typical ½ panel*

Family Positioning

FEATURE	bq25504	bq24210	bq24650
Control Scheme	Standalone, Boost	Standalone, Linear	Standalone, Switch-Mode
Input Voltage Range	0.13 – 3V	3.75V - 7V	5 – 28V
Quiescent Current	330nA (typ)	800µA (typ)	0.7mA (typ)
Max Input Voltage	5.5V	20V	32V
Minimum Input to Start Charge	350mV (typ)	V_{IN} >= V_{BAT} + 100mV (typ)	V_{IN} >= V_{BAT} + 600mV (typ)
Maximum Current	100mA	800mA	10A
Output Voltage (0-85C)	2.5 – 5.25V +/-5%	1 cell, 4.2V +/-1%	2.1V to 26V
Battery Detection	-	Yes	Yes
Battery Voltage Tracking	-	Yes	Yes
Power Path Management	Yes	No	No
Input Current Regulation	Yes	Yes	Yes
Pre-Charge/Fast Charge Threshold	-	2.5V	Programmable
Operation Modes	Boost Charging Battery Management	Charging, Load, Suspend, Sleep, Ship (I_{VBAT} < 5µA)	Pre-Charge, Constant Current, Constant Voltage, Charge Termination Enable
Enable Pin	No	Yes	Yes
Programmable OVP	Yes	No, Fixed 7.5V	Yes
Thermal Regulation / Protect	Yes- Internal	Yes	Yes
Thermistor Input	No	Yes	Yes
Package	QFN-16, 3x3mm	SON-10, 2x3mm	QFN-16,3.5x3.5mm

bq24210

bq24210

3.75V to 20V Input, 800mA, Linear Charger for Solar Applications

Features

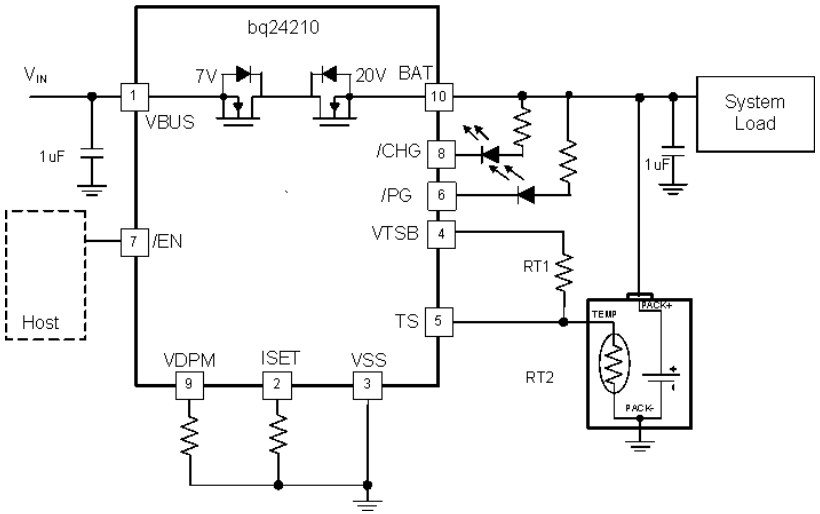
- **Solar Input Support** - Input Voltage Dynamic Power Management Feature (VIN_DPM)
- **Limited Power Charging Mode**
- Single Li-Ion cell charging with TS function for JEITA compatibility
- Load Mode
- 20V input rating, with 7.5V Over-Voltage Protection (OVP)
- Low Battery Leakage Current – 5uA Max Standby
- Status Indication – Charging and Power Good/Present
- Small 2 x 3mm SON-10 package

Benefits

- Maximum Current Extraction from Solar panel using **Battery Tracking Mode** while minimizing power loss into the IC and prevents collapse of Solar panel input voltage via VIN_DPM
- Charge at uA levels and still charge without tripping termination too early *(with 100mV typ differential input to output)*
- Capable of supporting normal USB/Adapter charger applications safely with the JEITA specification
- Provide power to VBUS from the battery
- Protect system and battery from unregulated USB power supplies
- Maximize the energy received from the solar input

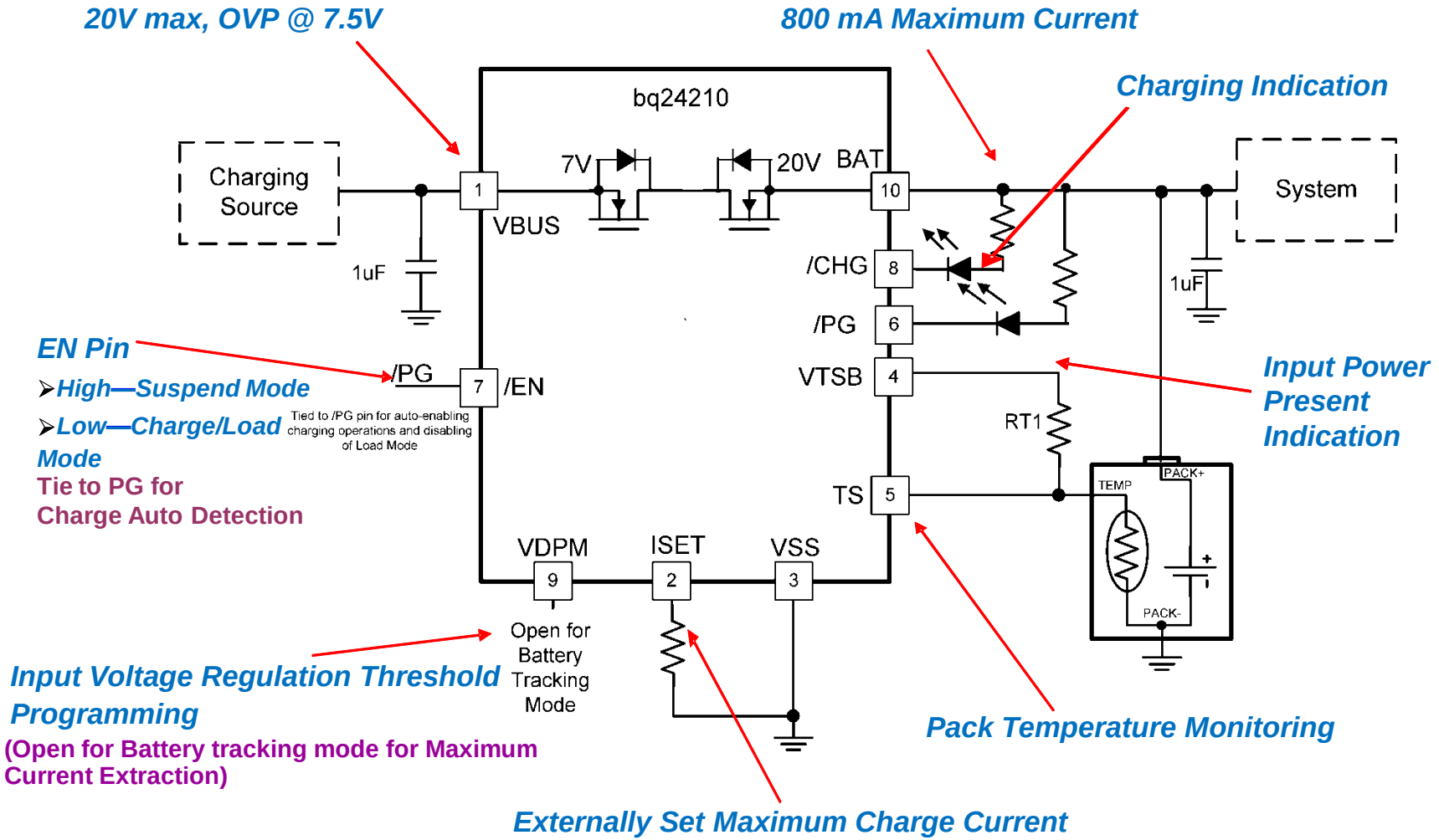
Applications

- Smart Phones
- PDAs
- eTablets
- MP3 Players
- Low-Power Handheld Devices
- Auxiliary Solar Chargers
- Multiple solar cells

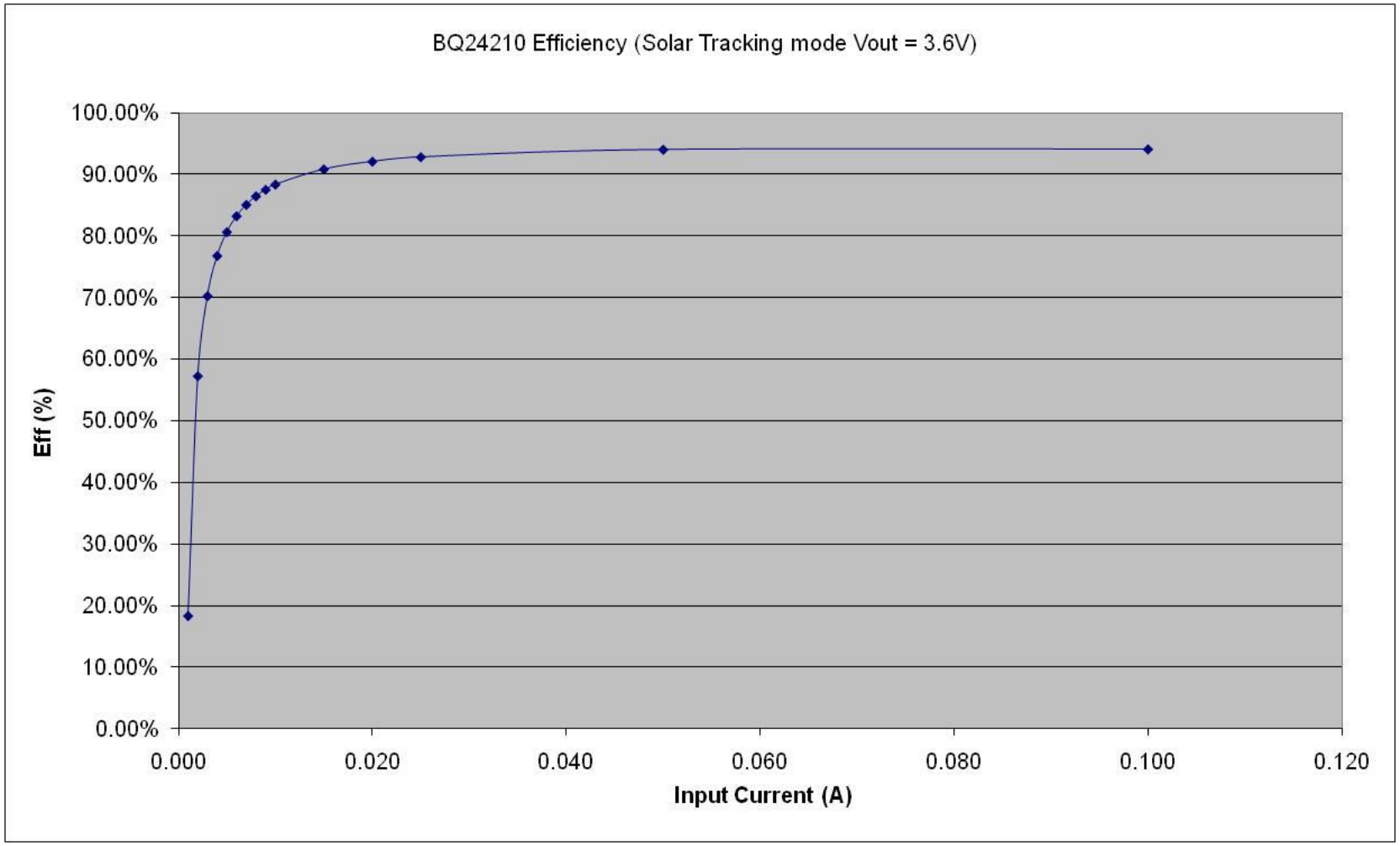


bq24210

3.75V to 20V Input, 800mA, Linear Charger for Solar Applications

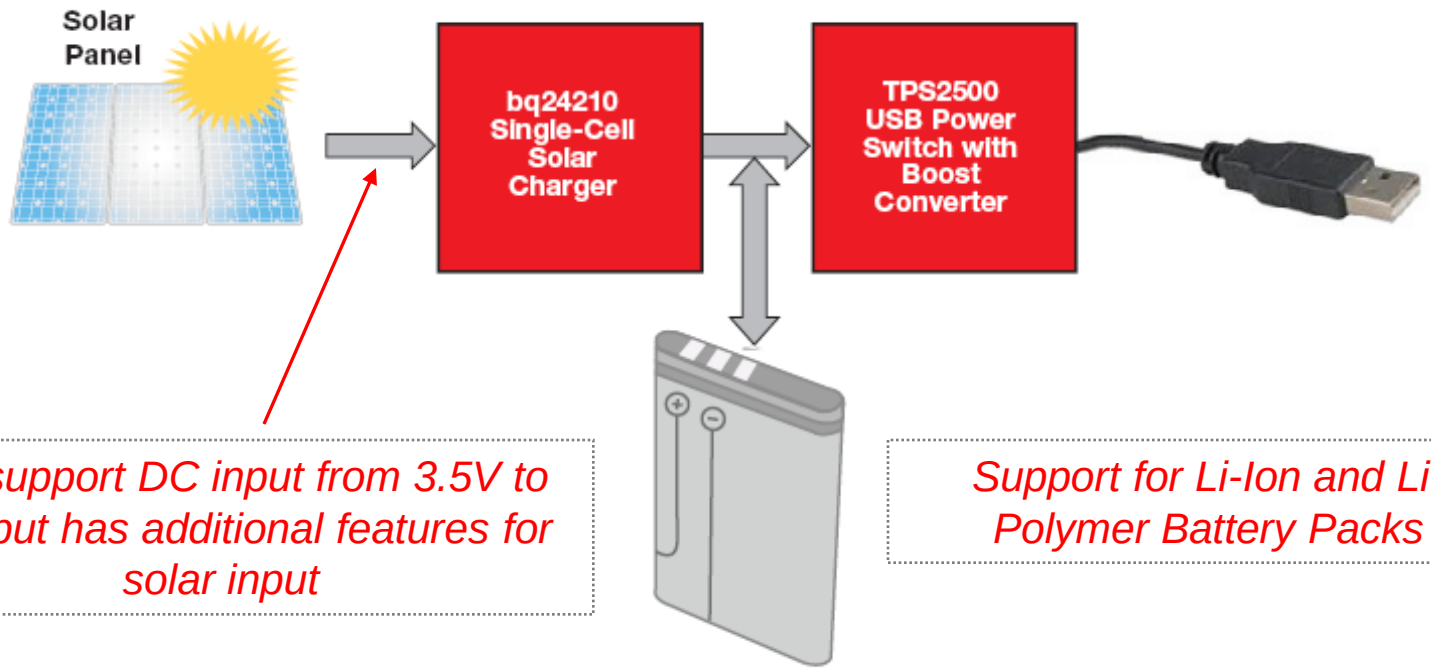


bq24210 Efficiency vs. Input Current



Solar-Powered Battery Charging

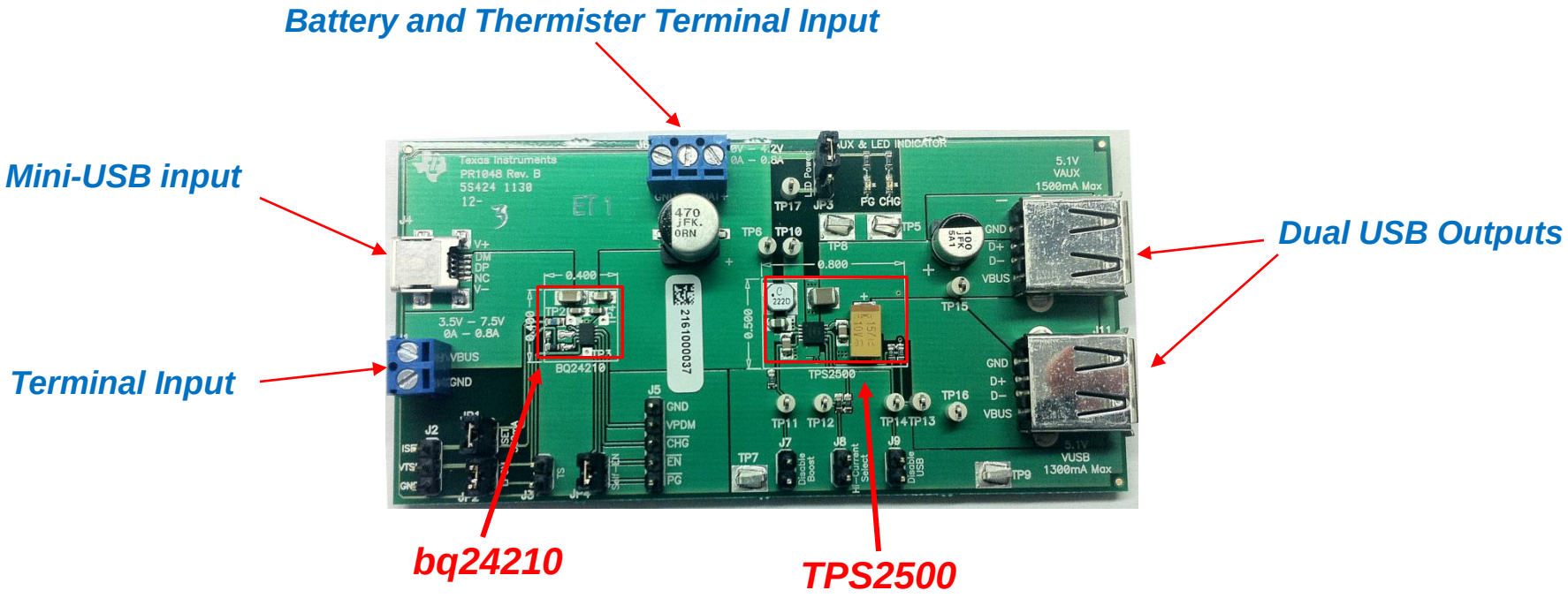
Solar USB System Demonstration PCB



Solar Battery Charger and USB Output Driver

TI's Solar USB system reference design is great for experimenting and gaining knowledge on how bq24210 operates. This board will demonstrate bq24210's ability to minimize battery charging time while maximizing solar power extraction using a simple linear charger.

Solar USB System Demonstration PCB



Solar Battery Charger and USB Output Driver

TI's Solar USB system reference design is great for optimizing the solar panel and battery which simplifies your design and accelerates the time to market for your applications

Low-Power Energy Harvesting

bq25504

bq25504 Ultra Low Power Boost Converter/Charger

Features

Ultra low power with high efficiency DC/DC boost converter/charger

- **Continuous energy harvesting from low input sources:** Vin ≥ 80mV *(typ)*
- **Ultra low quiescent current:** Iq ≥ 330nA *(typ)*
- **Low Cold-start voltage:** Vin ≥ 330mV *(typ.)*

Dynamic Maximum Power Point Tracking (MPPT)

- Input voltage regulation prevents collapsing input source
- Programmable Integrated dynamic maximum power point tracking for optimal energy extraction from a **variety** of energy generation sources

Energy storage

- Energy can be stored to re-chargeable Li-ion batteries, thin-film batteries, super-capacitors, or conventional capacitors
- Battery charging and protection
- User programmable Under-Voltage (UV) / Over-Voltage (OV) thresholds
- On-chip temperature sensor with programmable over-temperature (OT) shutoff threshold

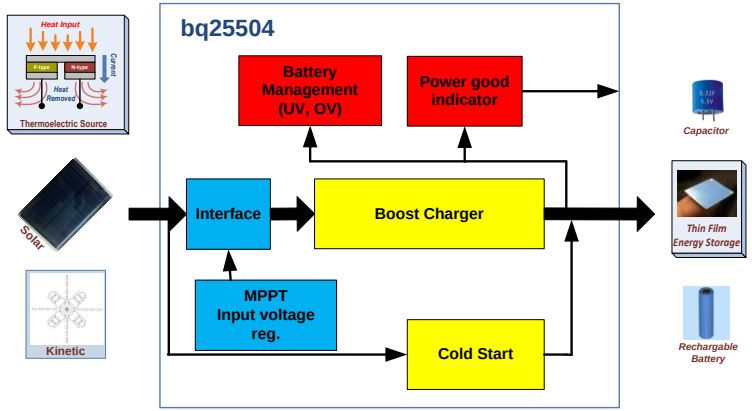
Battery Status Output

- Battery Good output pin
- Programmable threshold and hysteresis
- Warn attached microcontrollers of pending loss of power
- Can be used to enable/disable system loads

Package - Small 3 x 3mm QFN-16

Benefits

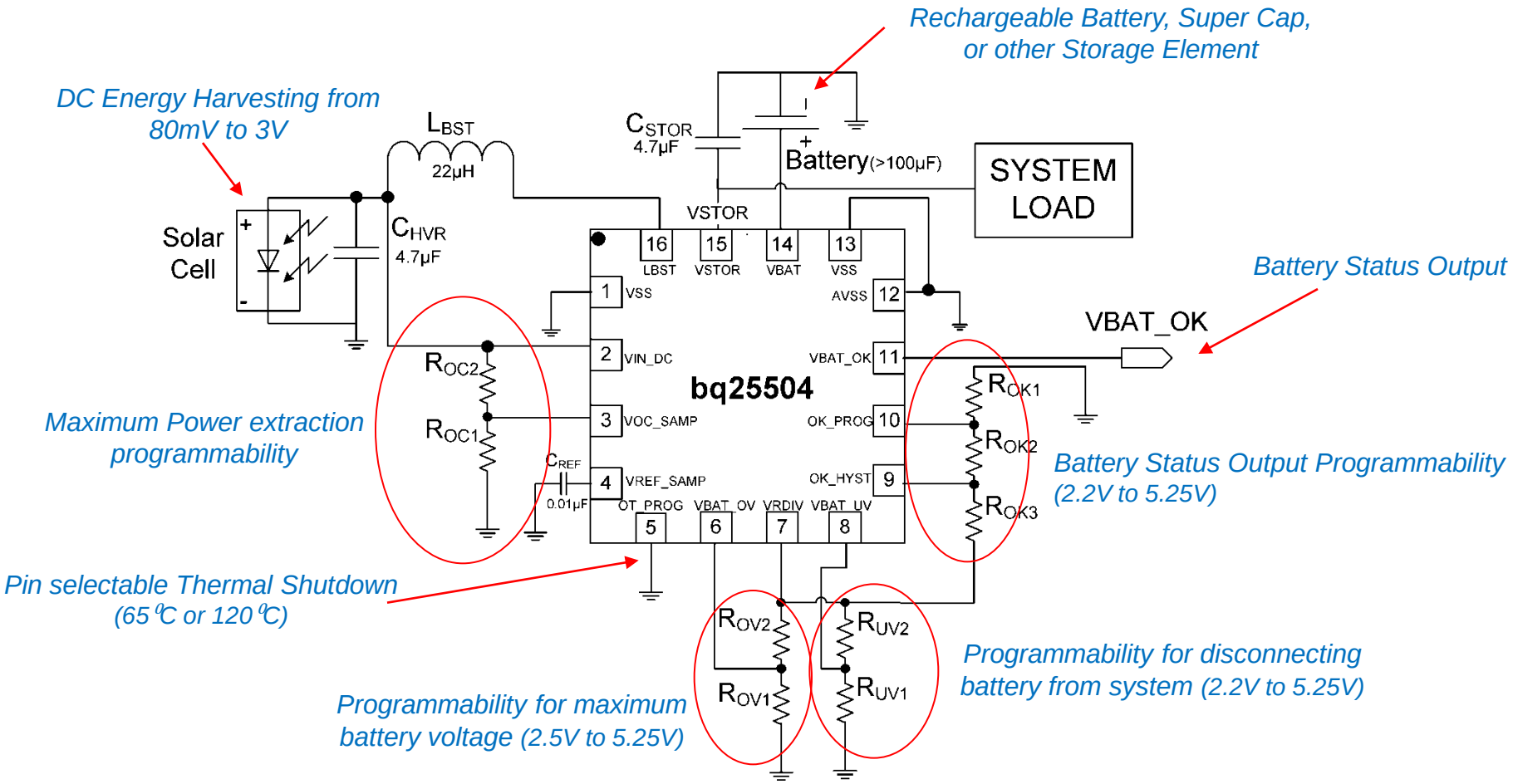
- Provides efficient acquisition and management of microwatts (µW) to miliwatts (mW) of power generated
- Supports low input voltages from a variety of energy sources
- MPPT dynamically optimizes input energy source operating point for maximum power extraction
- High efficiency and low quiescent current provides the maximum power extraction with minimal loss
- User programmability allows optimization of operating point for maximum lifetime of storage element and application usefulness
- Capability to handle a variety of storage elements from simple and inexpensive to exotic and expensive
- Provides safety and operational status to user system/MCU to warn of power drop out



Applications

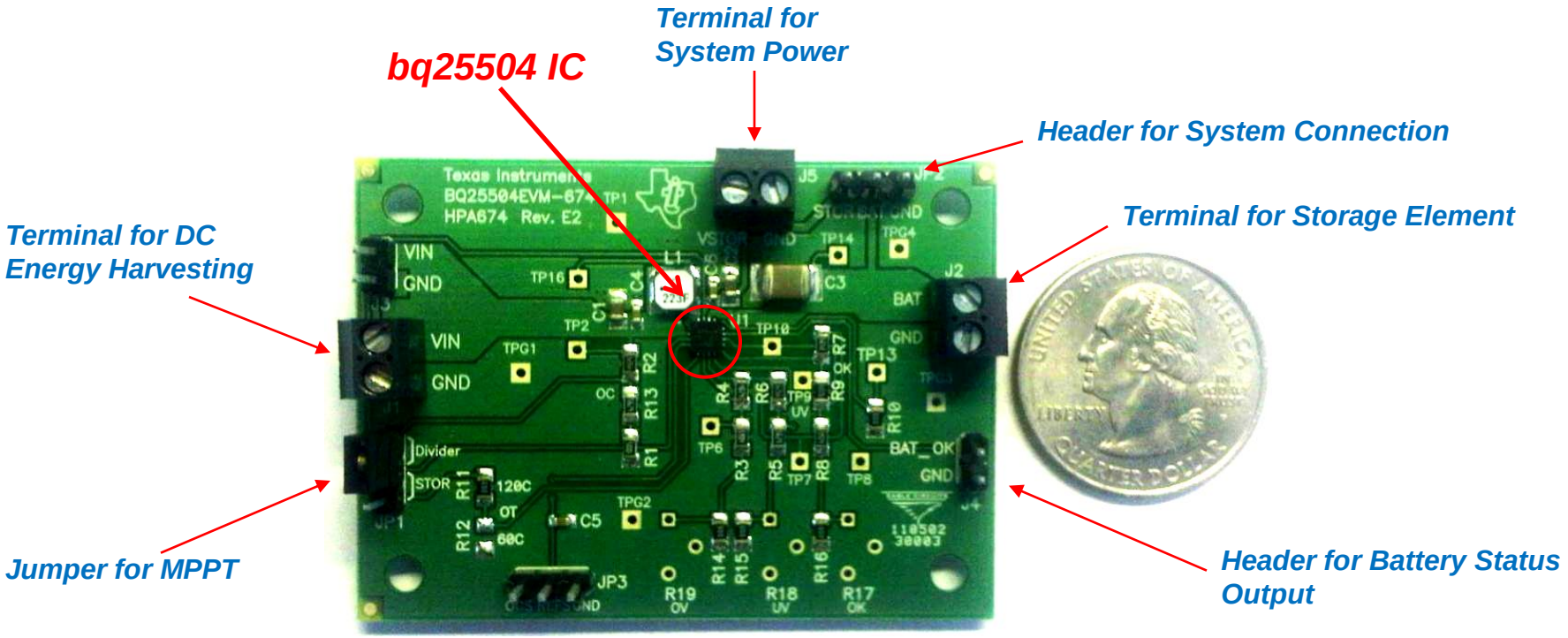
- Energy Harvesting
- Solar Charger
- Thermal Electric Generator (TEG) Harvesting
- Wireless sensor networks
- Environmental monitoring
- Bridge / structural health monitoring
- Smart Building Controls
- Portable and wearable health devices
- Entertainment remote controls

bq25504 – Solar Application Schematic



TI's bq25504 IC's flexibility allows optimization for any energy harvesting transducers and storage element combination while maintaining high efficiency and long operation lifetime making your applications out perform the competition

bq25504 – EVM PCB



bq25504 Engineering Evaluation PCB

TI's bq25504 EVM is great for experimenting with different energy transducers and optimizing the system for a battery and system loading and will accelerate development of a energy harvesting power management solution making a faster time to market for your applications

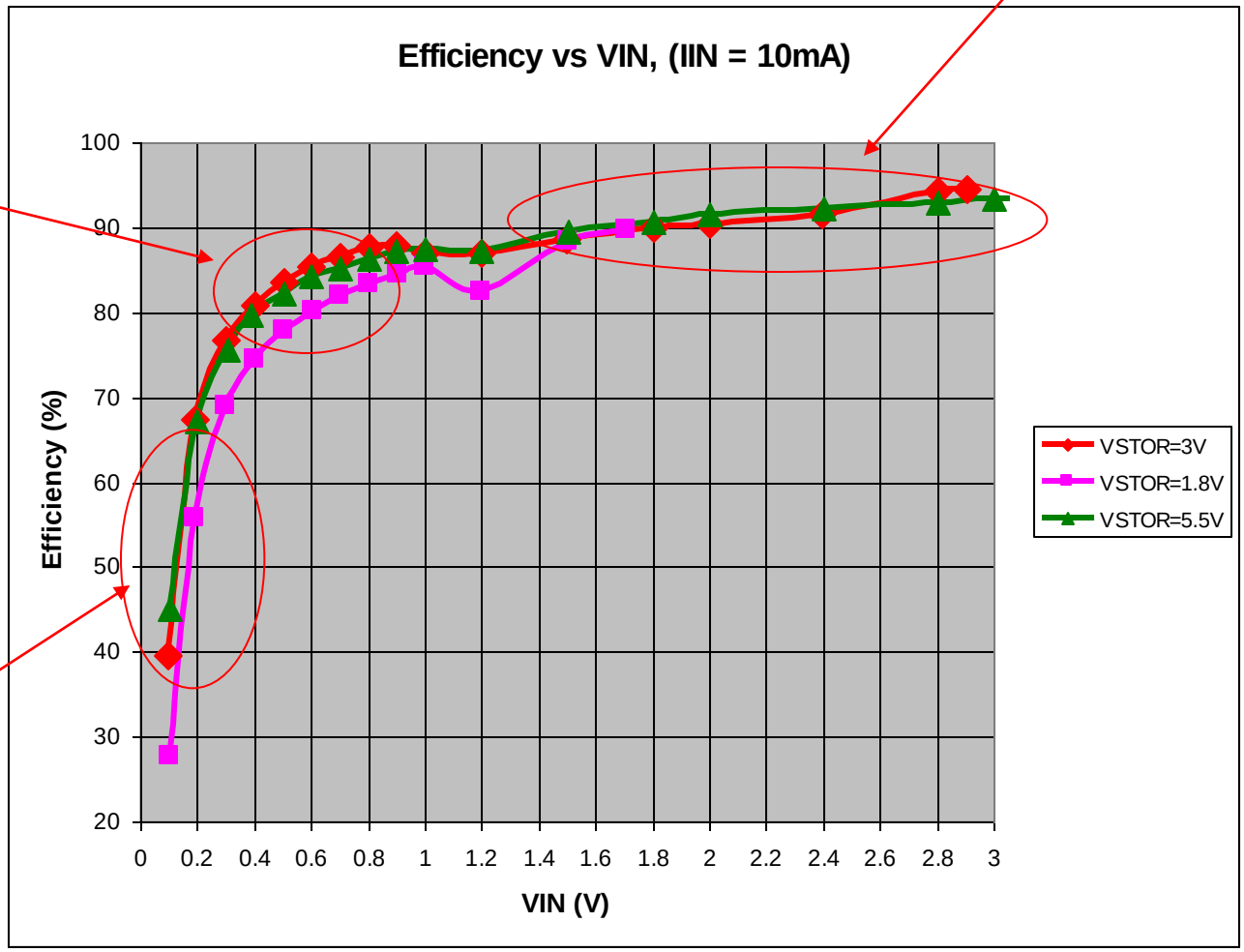
bq25504 Measured Efficiency

Multiple Cell Solar Range

Single Cell Solar Operation Range

Best in Class performance for two types of DC energy harvesting transducers
(Solar and Thermal)

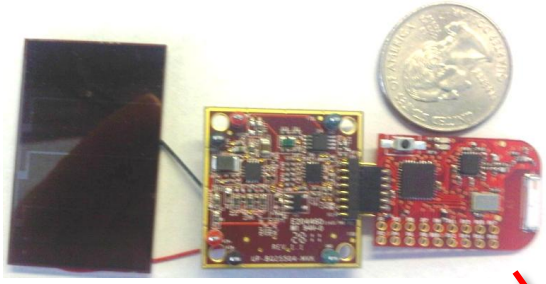
TEG Operation Range for small Delta T

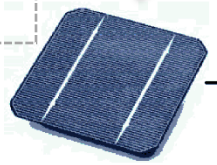


bq25504 Wireless Sensor Network Demonstration

Application Demo – Wireless Sensor Network

Support DC inputs from 80mV to 3V and supports MPPT for solar inputs





Solar Panel

BQ25504 Boost Charge Energy Harvester micro-MAVRK Board

CC430 MCU/Radio Daughter Board

EZ430 RF Dongle

Support for Rechargeable Battery Packs and Super Capacitors

2.5V to 5.25V

Rechargable Battery

EZ430 RF User Interface

bq25504 Engineering Evaluation PCB

TI's bq25504 micro-MAVRK power module is perfect for experimenting with different energy transducers and optimizing the firmware for Wireless Sensor Network (WSN) systems and will accelerate development of a energy harvesting WSN solution making a faster time to market for your applications

bq25504 Solar Keyboard Demonstration

Application Demo – Solar Powered Keyboard

TI's bq25504 IC powers keyboard using indoor optimized solar cell array

- Uses off-the-shelf keyboard and added our energy harvesting device along with indoor optimized solar panel energy source
- Operates from typical office indoor lighting
- Lifetime of battery now becomes lifetime of product *(3 to 5 years typical)*
- Provides design flexibility
  - Thinner solution with no need of large batteries
  - Allows creative solutions
- Uses small rechargeable Lithium battery
- OEM proprietary wireless link

bq24650

bq24650 - TI's First Solar (MPPT) Charger Supporting High-Charging Current Multi-Cell Standalone Applications

- **Maximum Power Point Tracking (MPPT) Capability with Programmable Input Voltage Regulation**
- 600kHz NMOS-NMOS Controller Supports up to 10A Programmable Charging Current
- Charge up to 26V for Lead Acid, 7 LiFePO4 cells or 6 Li-Ion/Polymer cells
- +/-0.5% Charge Voltage Regulation Accuracy over 0-85 C°

- Simple resistor programmable MPPT vs. Software/MCU-based solution – "Set it and forget it"
- 5X the charging current vs. competing solution for the max battery capacity
- Supports 2 additional cells in series vs. competing solar charging solution
- Maximize capacity after 100's of charge cycles with 10+% more capacity than competing solution

- Solar Powered Applications
- Remote Monitoring Stations
- LiFePO4 Applications
- Portable Handheld Instruments
- 12V to 24V Automotive Systems
- Current Limited Power Source