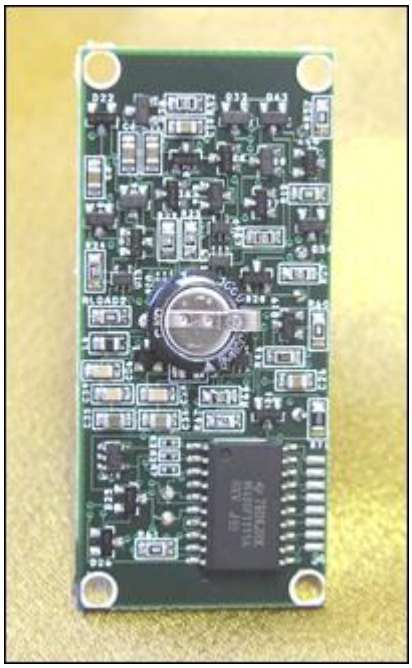
ENERPAK™

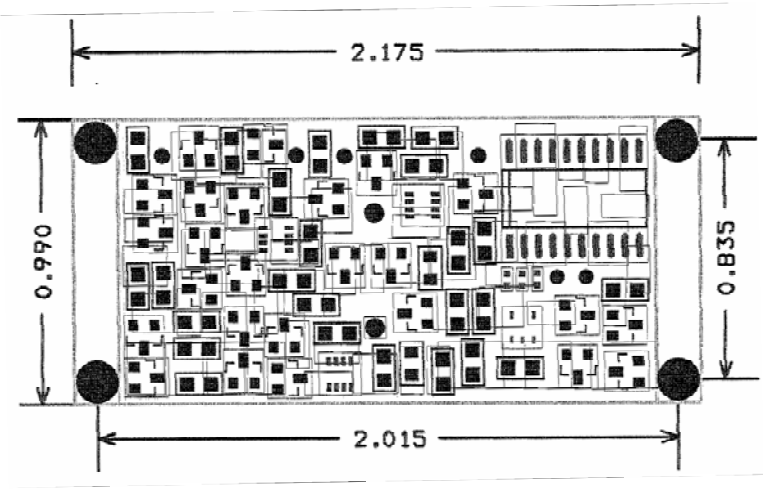
POWERING THE WIRELESS SENSOR REVOLUTION

Overview

The EnerPak™ power management and energy storage system provides more high power output and high stored energy density for wireless sensors and other commercial applications. Whether incorporating lithium-polymer, or thin film, or other battery technology, the unique EnerPak supercapacitor and battery charging and discharging circuitry delivers dynamic peak power tracking, a broad operating temperature range and a broad range of efficiently delivered power—microwatts to hundreds of milliWatts. It accommodates the low, variable and intermittent voltage and current of a variety of energy harvesting power sources while providing reliable, regulated power necessary for critical applications. Built around the ultra-low power Texas Instruments MSP 430 MCU, the EnerPak can consume as little as 5-8uA, delivering the most net harvested energy for the application load. The system uses low impedance supercapacitors at the output to efficiently deliver high power burst loads while lithium-polymer, thin-film or other battery storage provides energy needed for longer duty cycles and periods of insufficient energy harvesting.



The heart of the EnerPak PM-1 is a supercapacitor-lithium-polymer battery combination for applications such as industrial wireless sensor networks (ZigBee, Wireless HART, ISA 100). The PM-1 is compatible with different types of energy harvester devices, including thermoelectric, photovoltaic, vibration, and others. The EnerPak PM-1 is available for evaluation or integration into a customer's sensor module as an encapsulated circuit board. The EnerPak SC-1 provides the same functionality as the PM-1 with a photovoltaic energy harvester included. Other supercapacitor-battery combinations can be tailored to customer power requirements.



EnerPak PM-1 PRODUCT SPECIFICATIONS

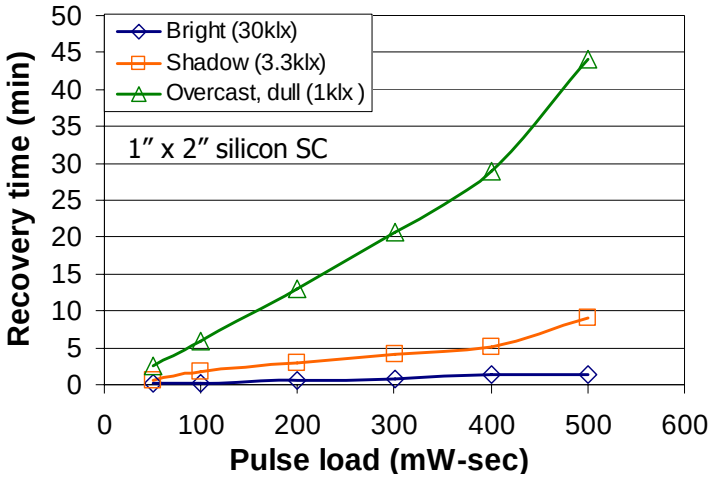
General	Parameter	Value
	Operating voltage	2.75 - 3.3V
	Voltage stability	±10% over full temperature range
	Peak current	up to 80 mA (3 second burst)*
	Minimum input energy	>1.5V rms, 100µA >500Lux (solar)§ >0.1G (vibrations)§
	Operational temperature	-20° C to 60° C, lithium-polymer battery* *(-20° C to 70° C thin-film battery)
	Minimum temperature	-40° C to 60° C, lithium-polymer battery** **(battery ≤50% capacity)
	Dimensions (L x W x H) Board alone	1.0" x 2.2" x 0.56" (25.4mm x 55.9mm x 14.2mm)
	Board Weight	0.81 oz (22.9g)
Back-up capability	**Average sensor power draw**	**Run time with no harvested energy‡**
	1mW	7 days
	3mW	2.5 days
	10mW	18 hours

* Depends on on size of supercapacitors. § Depends on size and other characteristics of harvester and available energy. ‡ 50mAhr lithium-polymer cell, can be increased or decreased as needed for the application.

Output Recovery

Performance of EnerPak SC-1 system under pulsed loads (time – mm:ss – to recover to preset voltage following application of load pulse).

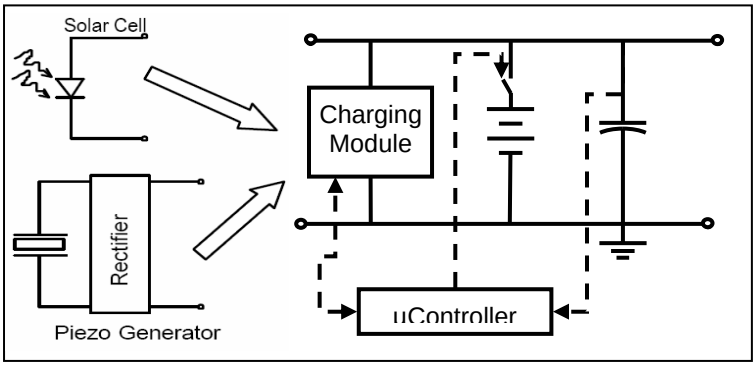
Pulse load (mW-sec)	Bright day 30klx	Shadow 3.3klx	Dull overcast 1klx
500	01:20	09:02	46:00
400	01:15	05:07	31:00
300	00:45	04:11	22:45
200	00:36	03:01	15:00
100	00:17	01:50	08:00
50	00:08	00:40	04:30



EnerPak SC-1/PM-1
Application Notes

1. Principle of Operation

The EnerPak uses energy harvesting to provide electrical energy to the charge module which transfers it for storage by a battery and supercapacitors (see Block Diagram). For the SC-1 module, the energy harvester is a box-mounted solar panel (~1" x 2.25"); for the PM-1 module, a harvester of the user's choice can be connected through a 2.5mm audio jack, or Infinica can specify and source a harvester based on an evaluation of the customer's operating environment. The supercapacitors are the primary source of output energy from the Enerpak while the battery provides long-term energy storage. These two energy storage devices provide complementary features: supercapacitors deliver energy efficiently (high specific power), while batteries store energy efficiently and so provide back-up power when the harvester is not providing enough power. The use of supercapacitors as the primary energy delivery devices provides the system with low output impedance (<<1 Ohm), allowing efficient delivery of high power bursts. The Texas Instruments MSP430 low-power microcontroller provides state-of-charge monitoring to prevent over-charging or over-discharging the battery and supercapacitor. It simultaneously monitors the level of harvested energy and dynamically adjusts the operation of the charging module to accommodate any fluctuations in the level of energy delivered by the solar panel to maintain the most efficient use of the harvested energy. Should the incoming energy not be sufficient to recharge the supercapacitors (e.g., at night for SC-1), the microcontroller switches in the battery (so-called "Dark Mode"). Once sufficient incoming energy is available again, the battery is switched out and refreshed with any available energy.



EnerPak functional block diagram

2. Connections to the Enerpak

The only connection to the Enerpak SC-1 available to the user is to the output equipped with a 3.5mm mono audio jack. To connect to the output use any standard mono 3.5mm audio plug. The tip of the plug should be poled positive. For the EnerPak PM-1 power management module, a 2.5mm audio jack is provided to connect the user's own energy harvesting module.

3. Start-Up

If the EnerPak SC-1 has been sitting in the dark or in very low light levels for a period of time the energy storage components may need to be replenished before using it for testing; similarly for the PM-1 module, if no active harvester has been connected to V_{in}. Place the SC-1 in direct sunlight for a few hours or up to a day with no load applied to the output; for the PM-1 connect an appropriate harvester and monitor V_{out} until the target voltage has been reached. The back-up lithium polymer battery may take sometime to become fully charged depending on the initial state of charge and cannot be monitored directly by the user. Back-up battery selection can be defined based on the user's anticipated worst-case scenario.

4. Output Capabilities

See Data Sheet