Using the Cymbet™ EnerChip™ as a Backup Power Source for the Texas Instruments MSP430 Microcontroller

Introduction

Cymbet™ EnerChip™ thin film, solid state batteries feature all solid state construction, are packaged in standard integrated circuit packages, and can be reflow soldered for high volume PCB assembly. They are ideal as rechargeable backup power sources for clocks, memories, microcontrollers (MCUs) and other low-power circuits where data or timing information must be retained in the absence of primary power. This application note describes the use of EnerChip batteries as a backup power source in systems using the Texas Instruments (TI) MSP430 microcontroller and TPS3619-33-33 backup-battery supervisor.

Low profile, surface mount EnerChip batteries can provide up to several weeks of backup energy in systems using low power microcontrollers such as the MSP430 from Texas Instruments, which requires as little as 0.1 µA of current in data retention mode. For example, the rechargeable CBC050 EnerChip from Cymbet Corporation, with 50 µAh of charge capacity, can deliver data retention power to the MSP430 for three weeks between recharge cycles. Because the EnerChip is rechargeable thousands of times, it serves as a component class backup energy source for MCU-based systems.

Circuit Example

Because many systems operate on 3V supplies and the MSP430 has a maximum operating voltage of 3.6V, the 4.1V charge voltage of the EnerChip requires the use of a charge pump or other means of elevating the supply voltage in order to charge the battery. In the circuit of *Figure 1*, this is achieved through the use of a charge pump connected to the PWM output of the MCU, with feedback to one of the MSP430 A/D channels. The circuit also depicts the various connections between the TI MSP430 microcontroller, TPS3619-33-33 battery-backed supervisor, and discrete components required to create the charge pump and charge control circuit for the EnerChip. The software code for controlling the battery charging voltage is available through Cymbet. Please contact the applications department at http://www.cymbet.com/content/support.asp for details.

The circuit also includes a cutoff circuit that disconnects the EnerChip from the load when the battery terminal voltage drops to 3V. This feature extends the cycling efficiency of the EnerChip to provide years of service as a backup storage device.

In a typical system, the circuit would be similar to that in *Figure 1*, except that only one EnerChip battery would be placed on the circuit board instead of the two that are present in the EnerChip evaluation circuit of *Figure 1*. In systems with a 5V supply, the charge pump circuitry is not required; a simple linear or shunt regulator could be used instead. See AN-1002 for examples of charging circuits for the EnerChip.

Theory of Operation

The circuit operates in conjunction with the MSP430 as a classic voltage doubler charge pump. To charge the EnerChip, the MSP430 outputs high level signals to the CHARGEROFF/ and BATTERYOFF/ inputs. This enables charge current to flow into the EnerChip and enables the load to be powered by the EnerChip. The MSP430 then enables its PWM output for a 50% duty cycle, ~8 kHz square wave. Meanwhile, the MSP430 monitors the feedback voltage divider amplitude at its A/D input. If the feedback voltage is not at approximately mid span of the A/D range, then the frequency of the PWM (PFM) output is adjusted up or down until the feedback voltage is approximately equal to mid span.

At high input voltages - around 3.6 volts - the PFM output will be around 8-10 kHz. At low input voltages - about 2.6V - the PFM output will be around 20-30 kHz. When the PFM output goes low, current is sourced from the CHARGEROFF/ output pin on the MSP430 through the first diode and into the 1000 pF flying capacitor, C1. When the PFM output goes high, the charge in the flying capacitor is transferred through the second diode and into the holding capacitor, C2. When main power is absent, the power management device TPS3619-33 will automatically switch from the main power source to using the EnerChip for the power source. The MSP430 will also be notified that it is running from backup power. If this occurs the MSP430 will stop the PWM output and output a low level signal to the CHARGEROFF/ signal line and disable the A/D input. The MSP430 should be programmed to place itself in its lowest power data retention mode at this time.

After the EnerChip has reached full charge voltage, the MSP430 could also disable the charging circuit in order to reduce power consumption if the main power source is also a battery. The charger can also be disabled periodically if more microcontroller resources are needed for the main application program.

Li-ion batteries having a 4.1V-4.2V charging voltage, including the EnerChip, will be damaged if they are discharged much below 3V. To prevent this from happening while backing up the MSP430 for an abnormally long period of time, the MSP430 should be programmed to take itself out of data retention mode and monitor the EnerChip voltage at a periodic rate (every 2 hours or so) to prevent the EnerChip from being discharged below 3V. The EnerChip voltage is monitored by sending a high output to the CHARGEROFF/ signal and using the feedback A/D to measure the EnerChip voltage. The MSP430 will then output a low level to the CHARGEROFF/ output line and disable the A/D and go back into data retention mode if the EnerChip voltage is above 3V. If the EnerChip voltage is below 3V, the MSP430 will output a low level to the BATTERYOFF/ signal, disconnecting the backup power source from the MSP430. At this point, all data will be lost but the EnerChip will not be damaged. Note that at low current drain, 90% of the energy stored in the EnerChip will have been depleted by the time the voltage reaches 3.6V. Using 3.6V as the decision point will allow more margin at the system level for circuit and manufacturing variables.

In the example shown in *Figure 1*, the EnerChip serves as the backup power source for the MSP430 microcontroller, while the backup-battery supervisor controls the transition from main power to battery power in the event the main power supply falls below a preset threshold.

See TPS3619-33 and MSP430 data sheets for specifications and functional descriptions of those devices, selection of R_X, R_Y, and other external components. The MSP430 has a typical RAM retention current of 0.1 µA and the supervisory IC has a battery-backed operating current of 0.5 µA typical. Therefore, the combined load on the battery will be 0.6 µA under normal circumstances. With charge capacity ratings of 12 µAh (CBC012) and 50 µAh (CBC050), the EnerChips shown in *Figure 1* will provide a RAM retention time of 20 hours and 83 hours, respectively. Backup durations of this order exceed the vast majority of power interruptions.

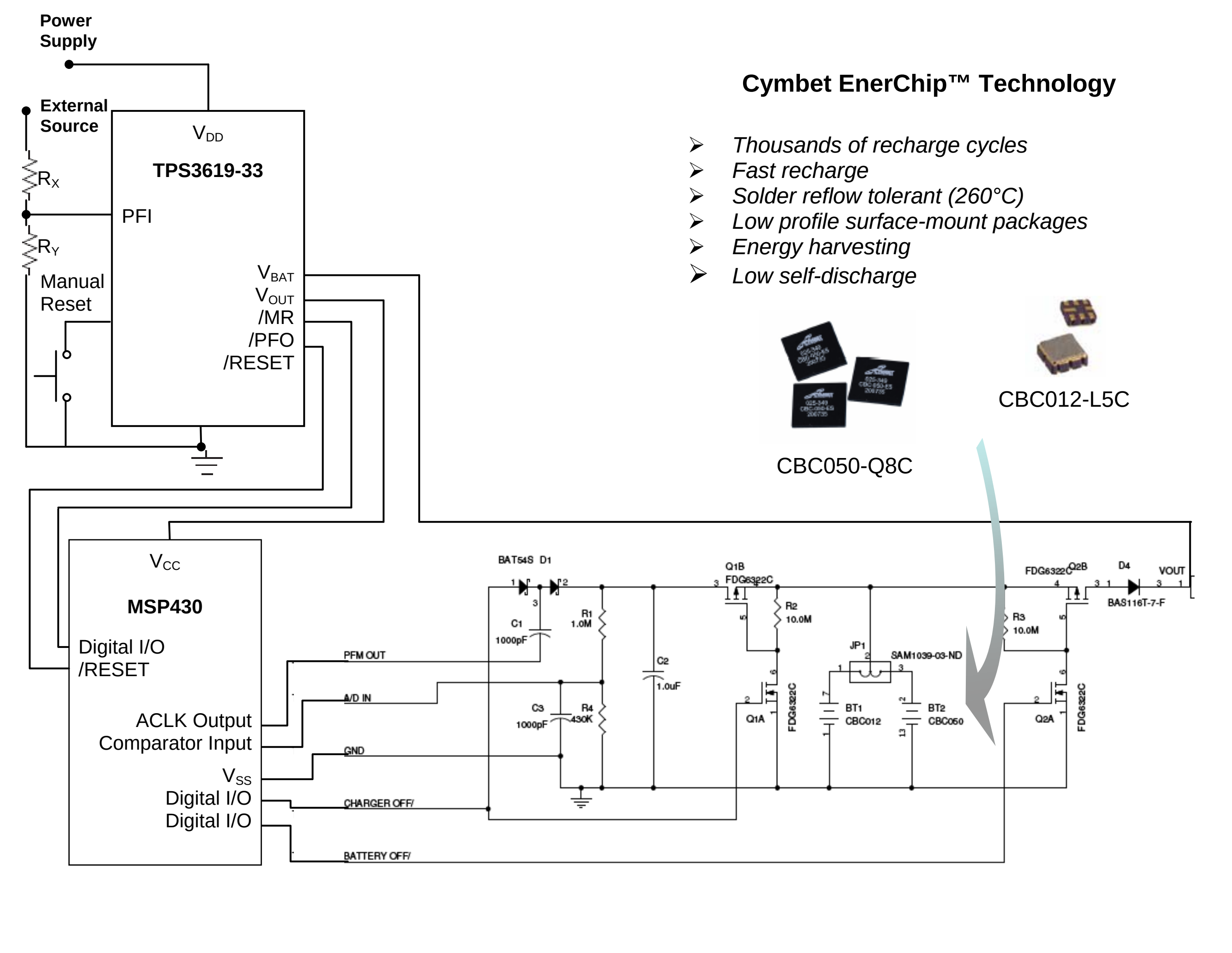

Figure 1. Example Circuit Showing the Cymbet EnerChip™ in a TI MSP430-Based System.