Ultra Low Power MSP430 Backup Using the EnerChip™ CC

Introduction

Cymbet EnerChips are solid state rechargeable batteries having distinguishing characteristics compared to conventional rechargeable batteries. EnerChips have a high charge/discharge cycle life; low self-discharge; simple voltage controlled charging; flat discharge voltage profile; have no flammable solvents to leak or catch fire; are solder reflow tolerant; and are offered in low profile surface mount packages.

The EnerChip CC is a surface mount package containing a rechargeable solid state battery - the EnerChip - with integrated battery management that includes charge control, discharge cutoff circuitry, and a battery switchover (i.e., supply supervisory) function. EnerChips are used in applications requiring backup, bridging, or transition power to maintain real-time clock operation or SRAM data retention in the event of main power interruption; wireless sensing as the main power source when energy can be harvested from the ambient power and used to constantly trickle charge the EnerChip; and as a power source to perform housekeeping for microcontrollers (MCUs) and peripherals when main power is interrupted, to ensure an orderly shutdown or transition to low power modes.

In applications demanding ultra low power consumption, where the system uses a Texas Instruments MSP430 microcontroller, it is essential to reduce or eliminate the power drawn by components peripheral to the MSP430. This Application Note describes a method to completely eliminate the power drawn by the EnerChip CC integrated battery management circuitry when the system is in the normal operating mode. This approach enables a backup battery solution that does not draw power when in normal run mode, thus maximizing the main battery life in battery powered systems.

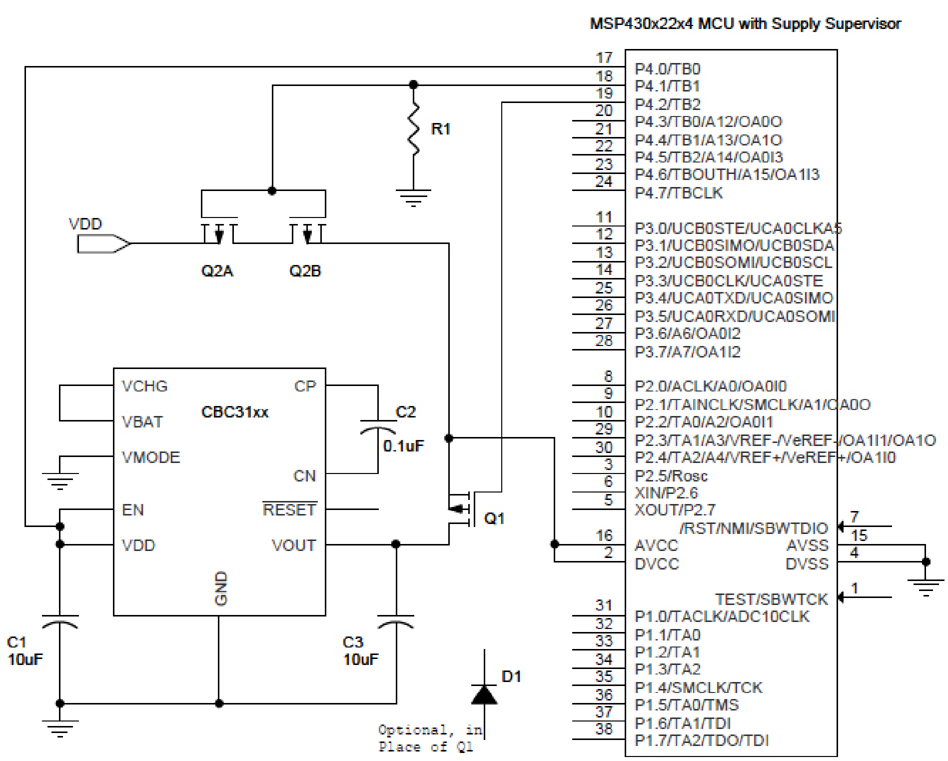

Figure 1. Ultra Low Power Application Circuit Using the EnerChip CC and MSP430 Microcontroller.

Circuit Description and Operation

Many systems utilizing microcontrollers require non-volatile date retention and/or real-time clock operation in the event of main power interruption. Normally, this is accomplished with the use of a supply supervisory circuit coupled with a backup power source such as a coin cell or supercapacitor. When main power is interrupted - as during line power outages or when the main battery is removed for recharging or replacement, the backup power source provides enough energy to maintain the data in the embedded SRAM or keep the internal real-time clock operational. Many MCUs have an internal supply supervisor circuit that can be used to control the switchover function from main power to auxiliary power. When the supply voltage threshold level is reached during power droop or complete power loss, the MCU can be programmed to generate an internal interrupt that places the MCU into a low power state for maximum run time from the backup power source. The EnerChip CC is a surface mount device that contains a rechargeable battery with integrated battery management that performs the charge control, discharge control, threshold voltage detection, and supply supervisory functions all in one low profile package. It operates over the range of 2.5V to 5.5V.

The EnerChip CC quiescent current of ~ 2 µA will in some cases be greater than the current drawn from the MSP430 microcontroller while in low power standby mode. Therefore, it is desirable in those cases to eliminate the EnerChip CC parasitic current consumption whenever possible. In other words, when the EnerChip internal to the EnerChip CC is not being charged, the EnerChip CC ought to be disabled without compromising its utility or performance.

This can be done by disabling the EnerChip CC most of the time by taking advantage of the internal supply supervisory feature of the MSP430 and, as a result, dramatically reduce overall system power consumption. This is especially important when the main system power is a battery that will need to be recharged or replaced during the operational life of the system.

The circuit of Figure 1 relies on the internal supply supervisor feature of the MCU to signal the system when main power has fallen below the threshold voltage necessary for normal circuit operation. While the EnerChip CC also has this threshold detection feature, its operation contributes to the quiescent current draw. In MCUs where that function is already embedded, it is logical to remove the redundant feature if doing so results in lower operating current and does not compromise other essential attributes of the system. The remaining features of the EnerChip CC that may continue to be utilized with the threshold voltage detection and switchover features disabled are:

- Internal battery charge control circuit that tightly regulates the charging voltage on the internal EnerChip;
- Battery cutoff circuit that disconnects the load from the EnerChip when the discharge voltage reaches a preset limit.

Both of these features are essential elements to maximizing the service life of the EnerChip and should be utilized to ensure proper operation of the embedded EnerChip as the backup power source.

Under normal operation, the MCU derives its power from the main system supply, which might be a large coin cell, prismatic cell, cylindrical batteries, or indirectly from wall power through a voltage regulator. In that mode, the EnerChip CC is isolated from the MCU by means of transistor Q1 being turned off when its gate is forced high using an I/O from the MCU. Transistors Q2A and Q2B allow the main supply voltage to pass to the MCU, their respective gates being forced low by another MCU I/O. Because the EnerChip has very low self-discharge, it needs to be charged only after it has been used in the performance of its duty as a backup power source or on a very infrequent basis to keep it fully charged when not being used. To maintain a charge of 90% or greater on the EnerChip when it has not been used as a backup power source for prolonged periods, the EnerChip would need no more than one hour of charging time per month. This would present a negligible parasitic load to the main power source, as the EnerChip charges quickly and its charging current decays to a small fraction of a microAmpere when fully charged. Therefore, the EnerChip CC supply (VDD) and ENABLE pins may be forced to the low state the vast majority of the time using an MCU I/O. In this mode, the EnerChip CC will draw essentially zero current. The I/O line can be forced high periodically as needed to replenish the charge in the internal EnerChip. The MCU can be programmed to automatically do this periodically or for an hour or two automatically upon returning to the normal operating condition after a power loss condition has occurred. Output drive current of the MCU I/O must be on the order of 0.5 mA minimum to ensure the EnerChip CC internal charge pump operates properly.

During a main power supply interruption, the MCU is programmed to isolate (by turning off Q2A and Q2B) the main supply from the MCU and EnerChip CC to prevent the EnerChip from inadvertently powering whatever output stage is connected to the main supply line. Simultaneously, Q1 is turned on, allowing current to flow from the EnerChip CC output to the power supply pin of the MCU, which is programmed to go automatically into a low power mode when the threshold voltage limit is reached. The purpose of the dual transistors in the VDD line is to prevent leakage current from passing through the transistor body diodes in any of the operating modes.

Q1 can be replaced by diode D1, eliminating the need for using the MCU I/O that is otherwise controlling the gate of Q1. Ensure that during power-up, the gates of Q2A and Q2B are low so that power to the MCU is applied through the two transistors. If that condition does not occur naturally, it can be forced low using a filter capacitor on the gates of Q2A and Q2B, or with a pull-down resistor (R1) as shown.

The implementation described herein has been demonstrated with the MSP430 low power microcontroller. Embedded source code written for this application is available from Cymbet upon request.

Conclusion

Traditional backup power sources have long charge times, high self-discharge, high steady state parasitic charging current, and often require external components for charge control and discharge cutoff. The EnerChip - with its low self-discharge, low parasitic current draw when charged, and fast recharge time - is a superior solution to supercapacitors and coin cell batteries in backup power applications. When implemented in MCU-based systems, the EnerChip CC delivers a robust backup power source with high cycle life and integrated battery management while drawing no current under normal operating conditions. This approach can lead to a significant extension in the operating life of the main battery.