DESIGN NOTES

Supercapacitor-Based Power Backup System Protects Volatile Data in Handhelds when Power Is Lost

Design Note 498

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Introduction

Handheld electronic devices play a key role in our everyday lives. Because dependability is paramount, handhelds are carefully engineered with lightweight power sources for reliable use under normal conditions. But no amount of careful engineering can prevent the mistreatment they will undergo at the hands of humans. For example, what happens when a factory worker drops a bar code scanner, causing the battery to pop out? Such events are electronically unpredictable, and important data stored in volatile memory would be lost without some form of safety net—namely a short-term power holdup system that stores sufficient energy to supply standby power until the battery can be replaced or the data can be stored in permanent memory.

Supercapacitors are compact, robust, reliable and can support the power requirements of a backup system for short-term power-loss events. Like batteries, they require careful charging and power regulation at the output. The LTC®3226 is a 2-cell series supercapacitor charger with a PowerPath™ controller that simplifies the design of backup systems. Specifically, it includes a charge pump supercapacitor charger with programmable output voltage and automatic cell voltage balancing, a low dropout regulator and a power-fail comparator for switching between normal and backup modes. Low input noise, low quiescent current and a compact footprint make the LTC3226 ideal for compact, handheld, battery-powered applications. The device comes in a 3mm × 3mm 16-lead QFN package.

Backup Power Application

Figure 1 shows a power holdup system that incorporates a supercapacitor stack with the capacity to provide standby power of 165mW for about 45 seconds in the absence of battery power. An LDO converts the output of the supercapacitor stack to a constant voltage supply during backup mode.

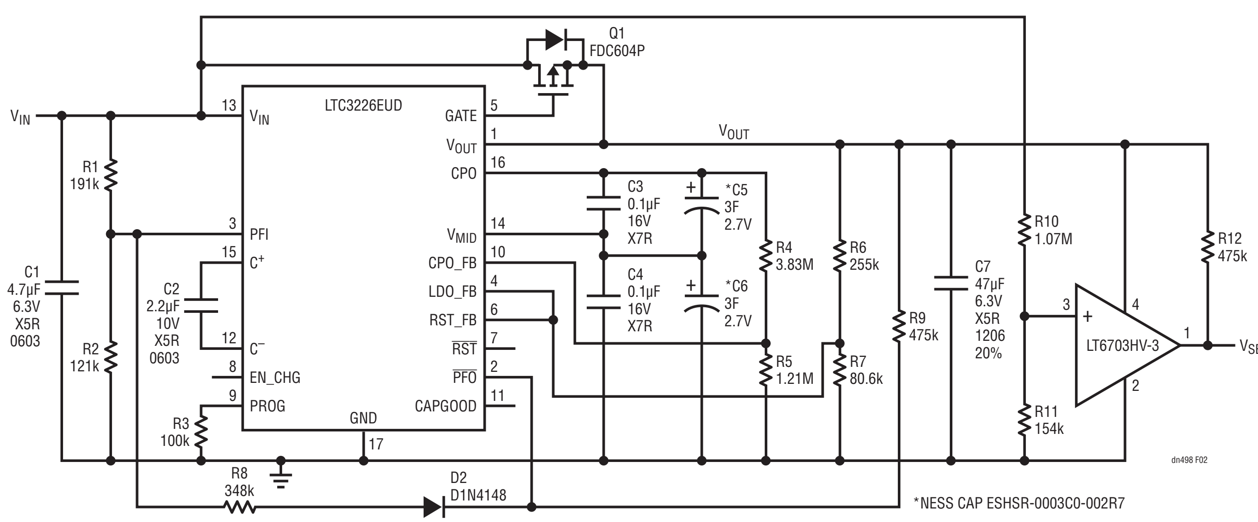

Figure 1. A Typical Power Backup System Using Supercapacitors

Designing a power backup system is easy with the LTC3226. For example, take a device that has an operating current of 150mA and a standby current (I_{SB}) of 50mA when powered from a single-cell Li-Ion battery. To ensure that a charged battery is present, the power-fail comparator (PFI) high trigger point is set to 3.6V. The device enters standby mode when the battery voltage reaches 3.15V and enters backup mode at 3.10V ($V_{BAT(MIN)}$), initializing holdup power for a time period (t_{HU}) of about 45 seconds.

The standby mode trigger level is controlled by an external comparator circuit while the backup mode trigger level is controlled by the PFI comparator. While in backup mode, the device must be inhibited from entering full operational mode to prevent overly fast discharge of the supercapacitors.

The design begins by setting the PFI trigger level. R2 is set at 121k and R1 is calculated to set the PFI trigger level at the PFI pin (V_{PFI}) to 1.2V.

$$R1 = \frac{V_{BAT(MIN)} - V_{PFI}}{V_{PFI}} \bullet R2 = 191.6k\Omega$$

Set R1 to 191k.

The hysteresis on the V_{IN} pin needs to be extended to meet the 3.6V trigger level. This can be accomplished by adding a series combination of a resistor and diode from the PFI pin to the PFO pin. $V_{IN(HYS)}$ is 0.5V, $V_{PFI(HYS)}$ is 20mV and V_f is 0.4V.

$$R8 = \frac{V_{PFI} + V_{PFI(HYS)} - V_f}{V_{IN(HYS)} - \frac{V_{PFI(HYS)}}{R2} \bullet (R1 + R2)} \bullet R1 = 349.3k\Omega$$

Set R8 to 348k.

Set the LDO backup mode output voltage to 3.3V by setting R7 to 80.6k and calculating R6. $V_{LDO(FB)}$ is 0.8V.

$$R6 = \frac{V_{OUT} - V_{LDO(FB)}}{V_{LDO(FB)}} \bullet R7 = 251.9k\Omega$$

Set R6 to 255k.

The fully charged voltage on the series-connected supercapacitors is set to 5V. This is accomplished with a voltage divider network between the CPO pin and the CPO_FB pin. R5 is set to 1.21M and R4 is calculated. $V_{CPO(FB)}$ is 1.21V.

$$R4 = \frac{V_{CPO} - V_{CPO(FB)}}{V_{CPO(FB)}} \bullet R5 = 3.78M\Omega$$

Let R4 equal 3.83M.

As the voltage on the supercapacitor stack starts to approach V_{OUT} in backup mode, the ESR of the two supercapacitors and the output resistance of the LDO must be accounted for in the calculation of the minimum voltage on the supercapacitors at the end of t_{HU}. Assume that the ESR of each supercapacitor is 100mΩ and the LDO output resistance is 200mΩ, which results in an additional 20mV to $V_{OUT(MIN)}$ due to the 50mA standby current. $V_{OUT(MIN)}$ is set to 3.1V, resulting in a discharge voltage (ΔV_{SCAP}) of 1.88V on the supercapacitor stack. The size of each supercapacitor can now be determined.

$$C_{SCAP} = 2 \bullet \frac{I_{SB} \bullet t_{HU}}{\Delta V_{SCAP}} = 2.39F$$

Each supercapacitor is chosen to be a 3F/2.7V capacitor from Nesscap (ESHSR-0003C0-002R7).

Figure 2 shows the actual backup time of the system with a 50mA load. The backup time is 55.4 seconds due to the larger 3F capacitors used in the actual circuit.

Conclusion

High performance handheld devices require power backup systems that can power the device long enough to safely store volatile data when the battery is suddenly removed. Supercapacitors are compact and reliable energy sources in these systems, but they require specialized control systems for charging and output voltage regulation. The LTC3226 makes it easy to build a complete backup solution by integrating a 2-cell supercapacitor charger, PowerPath controller, an LDO regulator and a power-fail comparator, all in a 3mm × 3mm 16-lead QFN package.

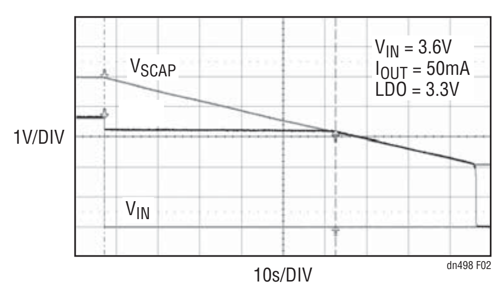

Figure 2. Backup Time Supporting 50mA Load

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dn498f LT/TP 0112 196K • PRINTED IN THE USA