DESIGN NOTES

Battery Backup Regulator is Glitch-Free and Low Dropout

Design Note 170

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A new class of linear regulator has been developed for battery backup applications. It eliminates both the losses associated with steering diodes, the glitches and battery-to-battery cross conduction inherent in MOSFET switching schemes and the poor regulation inherent in dual regulator schemes previously used for this purpose. See the comparison detailed in Table 1.

Figure 1 shows a simplified block diagram of the LT®1579 dual input regulator. The regulator features 300mA output capability and low dropout. Two batteries, or a battery and an AC-derived power source, are connected to V_{IN1} and V_{IN2}. The relative voltage of these two sources plays no role in determining which input supplies power to the load: the primary input (V_{IN1}) is normally used to power the output, and the secondary input (V_{IN2}) takes over as a backup when the primary source fails. Unlike diode steering circuits, this allows batteries of any voltage to serve as primary or backup. Either battery can be removed and replaced without disturbing the output voltage.

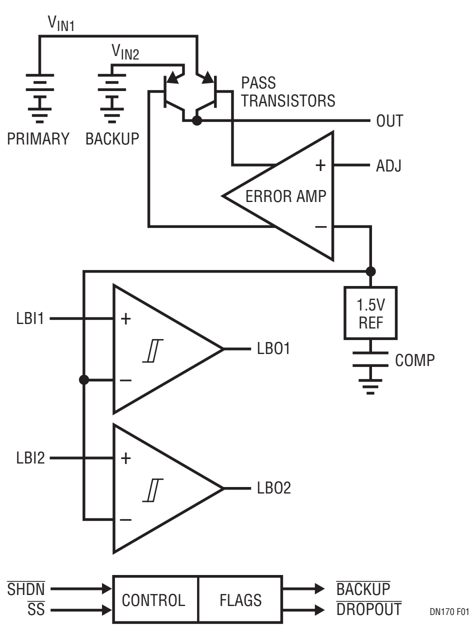

Figure 1. LT1579 Block Diagram

Several other important features are included to simplify integration of the LT1579 into a battery-backed system. Again referring to Figure 1, two logic flags, $\overline{\text{BACKUP}}$ and $\overline{\text{DROPOUT}}$, are useful for monitoring the status of the regulator. $\overline{\text{BACKUP}}$ goes low when V_{IN1} fails and V_{IN2} takes over, whereas $\overline{\text{DROPOUT}}$ indicates that both V_{IN1} and V_{IN2} have failed.

Two comparators independently monitor the condition of the batteries. In contrast to $\overline{\text{BACKUP}}$ and $\overline{\text{DROPOUT}}$, the low-battery detectors give advance warning of impending battery failure. Secondary Select ($\overline{\text{SS}}$) overrides V_{IN1}'s priority over V_{IN2}, forcing the regulator to abandon the primary battery in favor of the backup.

The primary battery normally supplies the load until its terminal voltage is nearly equal to the output voltage; however, some battery types may be damaged if discharged this far. $\overline{\text{SS}}$, used in conjunction with a low-battery detector, allows the regulator to abandon the primary battery at a higher, nondamaging end-of-discharge voltage.

Table 1. Backup Method Comparison

	LT1579	STEERING DIODES	MOSFET SWITCHING	TWO REGULATORS
Guaranteed Battery-to-Battery Isolation	✓	✓		
Prioritized Inputs	✓		✓ (Needs Circuitry)	
Seamless Switching	✓	✓		✓
Seamless Regulation	✓			
Logic Override	✓		✓	
Battery Disconnect	✓		✓	✓

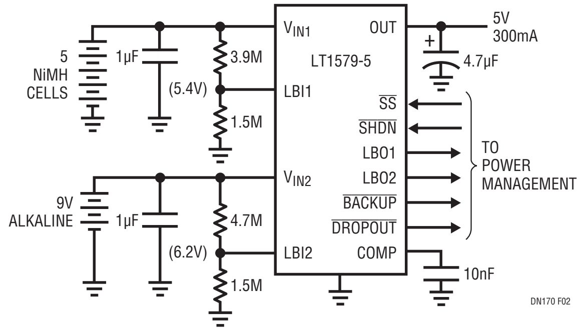

Figure 2. A 9V Battery Backs Up Five NiMH Cells

One last feature is $\overline{\text{SHUTDOWN}}$; this turns the regulator off and reduces total drain from both inputs to less than 7µA.

Figure 2 shows a typical application of the LT1579 with primary power supplied by five NiMH cells and backup provided by a 9V alkaline. Both low-battery comparators are used; they report the condition of the primary and backup batteries to a microprocessor. The $\overline{\text{BACKUP}}$ and $\overline{\text{DROPOUT}}$ flags keep the microprocessor apprised of the regulator's status. In addition to the fixed 5V version shown, 3V, 3.3V and adjustable versions are also available.

9V snap terminals are easily reversed by the end user during installation of the battery. No harm is done to the LT1579 because both inputs are reverse-battery protected. No current is drawn from the reversed battery and no excess current is drawn from the adjacent battery. Best of all, the load never knows the difference. The regulator continues to deliver the correct output voltage throughout the entire event.

Figure 3 shows a typical sequence of events for the circuit of Figure 2. Initially, both batteries are fully charged and all status flags (LBO1, LBO2, $\overline{\text{BACKUP}}$ and $\overline{\text{DROPOUT}}$) are high. Load current, assumed to be 100mA, is drawn from the primary battery at V_{IN1}. After a period of time, V_{IN1} begins to falter. At point A, V_{IN1} = 5.4V and LBO1 goes low, predicting the eventual depletion of the primary battery. When V_{IN1} enters dropout (B), $\overline{\text{BACKUP}}$ goes low and the regulator begins to gradually transfer the load to the backup battery at V_{IN2}. By time C, the primary battery has dropped below the point where it can deliver useful current to the output and all load current is supplied by the backup battery.

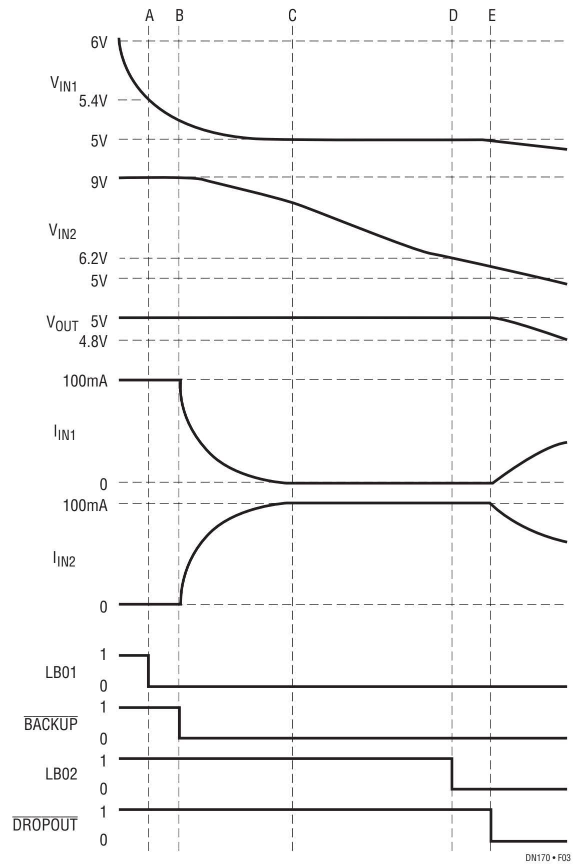

Figure 3. Typical Event Sequence for the Circuit of Figure 2. The Time Scale is Distorted for Purposes of Illstration

The backup battery reaches its low voltage threshold at point D, signaling impending doom. This is the last chance for the system to alert the user, store critical data, shed load and find ways to survive until the batteries are replaced or recharged. In Figure 3 the relentless load continues unabated and discharges the backup battery. The regulator can no longer maintain its 5V output at point E and a logic low appears on the $\overline{\text{DROPOUT}}$ pin. Now the output falls below 5V and some current is once again drawn from the primary battery.

The LT1579 integrates a complex current steering function into one chip and can significantly reduce board space and design time while adding a number of useful power management features. It is ideally suited for battery- or line-operated equipment that relies on a backup battery for reliability and uninterrupted service. The output is unaffected by battery changes or power cycling, and status flags allow implementation of a very complete power management system with minimal external components.

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