Trickle Charging Lithium Batteries with the ISL1208 and ISL1209 RTC Devices

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Introduction

The ISL1208 and ISL1209 Real Time Clock (RTC) devices include an active battery backup switchover function. This function allows a backup source tied to the V_{BAT} pin to assume powering the device once the main V_{DD} supply has dropped below the minimum operating voltage (see the RTC data sheet). A backup supply is crucial to the function of an RTC since it will enable the device to continue clocking and updating time while the RTC is powered off or during an AC blackout period.

The main options available for backup supplies include a super capacitor, a lithium coin cell, or a rechargeable lithium battery (usually Manganese Lithium or similar chemistry). These sources can provide the microamps of supply current needed by the RTC for extended backup operation yet are available in small, economical packaging.

Super capacitor backup is relatively straightforward. The super capacitor is charged by the main supply through a low leakage, low loss series diode, and the positive terminal is tied to V_{BAT}. In some cases a series resistor is included in the charging circuit to limit inrush current when power is applied. The ISL1208 and ISL1209 have redundant series elements in the path from V_{BAT} to V_{DD} so there is no need for a separate diode connecting the positive terminal of the supercap to the V_{BAT} pin (see the ISL1208 and ISL1209 datasheets for complete super capacitor backup information).

The lithium coin cell (usually 3.0V, but other types can be up to 3.6V) is connected directly to the V_{BAT} pin. Lithium batteries are to be protected from any type of charging currents in order to prevent failure (which can be spectacular). The battery switchover circuit containing redundant series protection elements in the RTC devices meets for UL recognition requirements for battery backup. Depending on the size, Lithium coin cells can provide continuous RTC backup for up to 10 years.

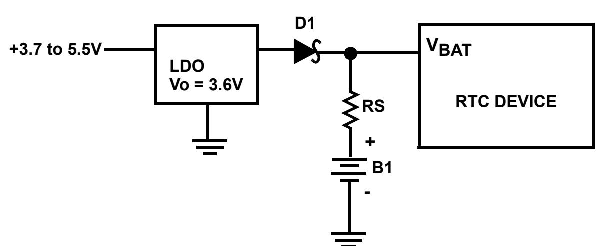
Using Rechargeable Lithium Batteries

Rechargeable Lithium batteries require a trickle charge circuit to keep them near a fully charged state and ready for backup operation. This trickle charge circuit is not unlike the charging circuit for a supercap, except that there are severe restrictions on the voltage applied to the rechargeable Lithium battery. We will concentrate on Manganese Lithium devices here, but other chemistries such as Vanadium Pentoxide Lithiums have similar restrictions.

Rechargeable Lithium batteries do not like simple constant current charging circuits as with Nickel Cadmium batteries. The constant current circuits allow the voltage to drift upward during trickle charge, and that causes problems with rechargeable Lithiums. Ideally, the voltage should be kept constant at a value from 3.0V to 3.3V in the normal operating temperature range (-20 to +60°C). Charging with a voltage higher than 3.3V not only reduces battery performance but can permanently damage the battery, and reduce the capacity. Charging below 3.0V will undercharge the battery, reducing available capacity and backup time for the RTC. These are the main guidelines for using rechargeable Lithiums, and some simple trickle charging circuits can be used safely with an RTC device to provide reliable long term backup power.

Trickle Charging Circuits

Since rechargeable Lithiums prefer constant voltage, the simplest method of charging them involves using a low cost linear regulator to apply a regulated constant voltage to the device. Figure 1 shows the preferred circuit, which requires a low dropout regulator and a low-leakage Schottky diode to provide a regulated 3.6V output from a 3.7V to 5.5V input. The Schottky diode prevents excessive discharge currents when the main supply goes away and the series resistor limits maximum charge current when the battery is greatly discharged. Note that no Schottky diode is required between the battery and the V_{BAT} input, since the RTC device has redundant series elements in the path from V_{BAT} to V_{DD}.

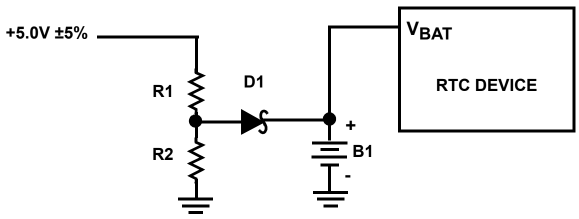


RS = 150Ω to 6.2kΩ, depending on capacity
D1 = MA2J728 or MA700
B1 = 3.0V Manganese Lithium Rechargeable Battery

FIGURE 1.

With a regulated 3.6V output from the LDO, the battery should charge up to about 3.3V maximum, keeping it inside the safe operating range. Note that this circuit can be used with a 3.3V ±5% supply, which would replace the LDO output and connect directly to the anode of D1. Care should be taken, if the tolerance of the 3.3V supply is ±10%, then the battery could be subject to excessive charge voltage or significant undercharging.

Another more economical circuit uses a simple resistor divider to provide a charging voltage to the battery, yet keep it within the maximum guidelines allowable. Figure 2 shows this circuit and components used.



R1 = 5.1kΩ
R2 = 9.1kΩ
B1 = 3.0V Manganese Lithium Rechargeable Battery
D1 = MA3X716
Note: R1 and R2 can be reduced in value to increase charge current, but the ratio must stay the same.

FIGURE 2.

In this circuit the battery will draw current up to where the resistor divider limits the voltage, thus providing a low trickle charge near that voltage. In this circuit, the resistor divider is set to slightly higher than 3.20V, and with the Schottky diode drop this essentially limits the charge voltage to about 3.0V max. Again, note that no Schottky diode is required between the battery and the V_{BAT} input, since the RTC device has redundant series elements in the path from V_{BAT} to V_{DD}. This circuit will allow the battery to charge very near 100% capacity, but will take much longer time than the circuit in Figure 1.

References

Panasonic; Charging circuits for ML Lithium Coin Cells; http://www.panasonic.com/industrial/battery/oem/images/pdf/Panasonic_Lithium_ML.pdf

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

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