

## APPLICATION NOTE 3816

## Selecting a Backup Source for Real-Time Clocks

*Abstract: Most Dallas Semiconductor real-time clocks (RTCs) include a supply input for a backup power source. This alternate supply source allows the RTC to maintain the current time and date while the main power source is absent. This application note discusses the various types of alternate supplies that can be used, as well as some of the criteria a designer should consider when selecting a backup source.*

### Introduction

The first Dallas Semiconductor RTCs were designed so that a backup source, such as a primary (nonrechargeable) lithium coin cell, could be used as the backup supply. Since then, Dallas has introduced additional RTCs with built-in trickle chargers. Changes that affect system requirements since the first RTCs were introduced include the shift to IR reflow in manufacturing and restrictions on transportation and disposal of lithium cells. The following paragraphs discuss backup techniques and the advantages and limitations of commonly used backup supply sources.

### Backup Supply Operation

Early Dallas Semiconductor RTCs had a relatively simple voltage-comparator circuit to monitor  $V_{CC}$  and switch between the  $V_{CC}$  and  $V_{BAT}$  supplies. The DS1307, for example, uses a comparator and a voltage divider to switch to  $V_{BAT}$  when  $V_{CC}$  drops below approximately 1.25 times the voltage on  $V_{BAT}$ . Other RTCs, such as the DS1305/DS1306, switch when  $V_{CC}$  drops below the  $V_{BAT}$  input voltage. When using these devices, care must be taken to ensure that the voltage on  $V_{BAT}$  never rises high enough to cause the device to inadvertently switch over to  $V_{BAT}$  while  $V_{CC}$  is at the normal operating voltage. An external charging circuit must limit the maximum charging voltage to prevent such an occurrence. Newer Dallas RTCs, which are designed to allow operation whether  $V_{CC}$  is above or below the voltage on  $V_{BAT}$ , use an internal bandgap voltage reference to determine when  $V_{CC}$  is too low for normal operation.

The following table lists the common supply technologies used for backup power. The table lists key parameters that affect selection. The paragraphs following the table discuss each technology and their advantages and drawbacks.

**Table 1. Common Backup Supply Sources and Key Selection Criteria**

Technology	Operating Temperature (°C)	PC Board Attachment	Self-Discharge Rate	Disposal/Transportation Restrictions	Charging Circuit/Cycles	Backup Time
Primary Lithium	-30 to +80	Wave solder <sup>1</sup>	Low	High	N/A	Long
Capacitor	-40 to +85	SMT	High	Low	Simple/unlimited	Short
Rechargeable (NiCd/NiMh)	0 to +40 <sup>2</sup>	Hand solder <sup>3</sup>	Medium	Medium	Simple/≈500	Short
Reflowable ML	-20 to +60	SMT	Low	High	Voltage 12 - > 1000	Medium <sup>4</sup>

1. Primary lithium cells may be wave soldered as long as the cell temperature does not exceed +85°C. Cells may be placed in a holder or hand soldered after reflow (tabbed cells).
2. Ambient temperature during charging. The allowed ambient temperature during discharge may be higher.
3. Batteries may be placed in a holder or hand soldered after reflow (tabbed batteries).
4. Total backup time is dependent upon the depth of discharge between each charging cycle.

## Lithium Primary (BR and CR) Cells

Primary lithium coin cells are commonly used for RTC and memory backup. Lithium cells have a high energy density, thus taking up a small amount of room on a PC board. Lithium cells cannot withstand IR reflow, so the cell must either be soldered on after reflow or inserted in a holder, thus increasing cost. Self-discharge near room temperature and below is typically less than 1% per year. At temperatures above about +60°C, self-discharge quickly increases. Recent regulations limit the transportation of lithium primary cells aboard passenger aircraft. Other regulations govern disposal of the cells at end of life, in some cases placing the burden on the manufacturer.

Lithium primary cells are usually sized to power the RTC for the expected life of the product. To calculate cell life based upon the current draw of the RTC, divide the cell capacity in ampere-hours by the timekeeping current draw of the RTC. For example, the timekeeping current of the DS1307 RTC (with the square-wave output off) is specified as 500nA maximum. A BR1225 lithium primary cell is rated at 48mAh. Therefore,  $(0.048 / 500e) - 9 = 96,000$  hours, or 4,000 days (almost 11 years). For additional information regarding calculating cell life, please refer to application note 505, [Lithium Coin-Cell Batteries: Predicting an Application Lifetime](#).

The following is a list of links to some lithium coin-cell manufacturer web sites:

[Panasonic: OEM Batteries](#)

[Sanyo: Industrial Batteries](#)

[Rayvac: Specifications and Product Guides](#)

[Rayvac: Technical/OEM News](#)

## Capacitors

Large low-leakage capacitors, sometimes called supercaps, are sometimes used for backup. The advantages of a capacitor over primary lithium cells include the ability to IR reflow the capacitor and fewer regulations concerning shipment and disposal. However, capacitors require a charging circuit, and provide backup operation for a relatively short time. Capacity may decrease with use, especially at higher operating temperatures.

For additional information about capacitors for backup and how to calculate the backup time for a given capacitor size, please refer to application note 3517, [Estimating Super Capacitor Backup Time on Trickle-Charger Real-Time Clocks](#). To determine backup time, please refer to the online [Super Capacitor Calculator \(For Trickle Charger RTCs\)](#).

The following is a list of links to some capacitor manufacturer web sites:

[Panasonic: Gold Capacitors](#)

[NEC TOKIN: Super Capacitors](#)

[Kanthal Global: Capacitors](#)

[Cooper Electronic Technologies: Supercapacitors](#)

## NiMH and NiCd Batteries

Rechargeable NiMH and NiCd batteries have a relatively high self-discharge rate of about 10% per month for NiCd and 20% per month for NiMH at room temperature. The typical operating temperature range (charging) is approximately 0°C to +40°C. NiMH and NiCd batteries must be hand-soldered or placed in a battery holder after

the PC board has gone through reflow. The batteries may be charged using a relatively simple current-limited charging circuit. Overcharging may reduce the life of the battery. Disposal at end of life may be regulated in some regions. NiMH and NiCd battery life is limited by the number of charge/discharge cycles.

The following is a list of links to some rechargeable battery manufacturer web sites:

[Panasonic: OEM Batteries](#)

[Sanyo: Industrial Batteries](#)

## Lithium Secondary (ML) Cells

ML cells require a regulated-voltage-charging source. The maximum voltage must be closely regulated or permanent damage will occur, while too low a voltage results in incomplete charging. ML cells are subject to the same transportation and disposal regulations as lithium primary cells. The DS12R885/DS12R887 RTCs include a charger with the required voltage and current limits on-chip. The DS12R887 RTC integrates the ML cell in a BGA package.

One issue with secondary cells is the number of charge/discharge cycles that they can withstand during the normal service life. For ML cells, the number of charging cycles is directly related to the depth of discharge as detailed in application note 3779, [Calculating ML Cell Life for an RTC Backup Operation](#). An on-line [Manganese Lithium Rechargeable Cell Lifetime Calculator \(For Constant-Voltage Trickle Charger RTCs\)](#) is available for determining ML cell lifetime.

The following is a list of links to some rechargeable lithium ML coin cell manufacturer web sites:

[Panasonic: OEM Batteries](#)

[Sanyo: Industrial Batteries](#)

## Conclusion

No single RTC backup power source is perfect for every application. The designer must use such criteria as expected system lifetime, governmental regulations, and manufacturing requirements to select a backup supply that is best suited for the application. Using such criteria, the system designer can select a suitable RTC backup supply technology.

---

Application Note 3816: [www.maxim-ic.com/an3816](http://www.maxim-ic.com/an3816)

### More Information

For technical support: [www.maxim-ic.com/support](http://www.maxim-ic.com/support)

For samples: [www.maxim-ic.com/samples](http://www.maxim-ic.com/samples)

Other questions and comments: [www.maxim-ic.com/contact](http://www.maxim-ic.com/contact)

---

### Automatic Updates

Would you like to be automatically notified when new application notes are published in your areas of interest?

[Sign up for EE-Mail™.](#)

---

### Related Parts

DS12885: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

DS12R885: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

DS12R885: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

DS1302: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

DS1305: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1306: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1307: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1315: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1318: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1337: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1337: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1338: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1338: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1338: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1339: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1339: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1340: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1340: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1374: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1390: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1391: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1392: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1393: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS14285: [QuickView](#) -- [Full \(PDF\) Data Sheet](#)  
DS1500: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1501: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1558: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1670: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1672: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1673: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1677: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1678: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS1685: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS17285: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS17485: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS17885: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS3231: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS3232: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS3234: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)  
DS32KHZ: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

Additional legal notices: [www.maxim-ic.com/legal](http://www.maxim-ic.com/legal)