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APPLICATION NOTE 3644

Power Considerations for Accurate Real-Time Clocks

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Abstract: By utilizing the new programmable temperature update time feature in the DS3231/DS3232, an application can reduce the total current requirements of an accurate real-time clock while maintaining superior timekeeping accuracy.

Overview

With the introduction of the DS3231 extremely accurate, I²C-compatible, integrated RTC/TCXO/crystal, Dallas Semiconductor has redefined the accuracy expectations of a stand-alone, real-time clock. The DS3231 provides ±3.5ppm of accuracy over the industrial temperature range (-40°C to +85°C). The device achieves this level of accuracy by measuring the device temperature every 64 seconds (64s) and adjusting the load capacitance of the crystal to approach 0ppm accuracy at that specific temperature.

Current Requirements

The periodic temperature update process increases the current requirements of the device for a short period of time (worst case, 200ms). The time chart in **Figure 1** demonstrates the worst-case current requirements of the DS3231 over time. All calculations assume a battery voltage of 3.63V with the I²C-compatible interface inactive.
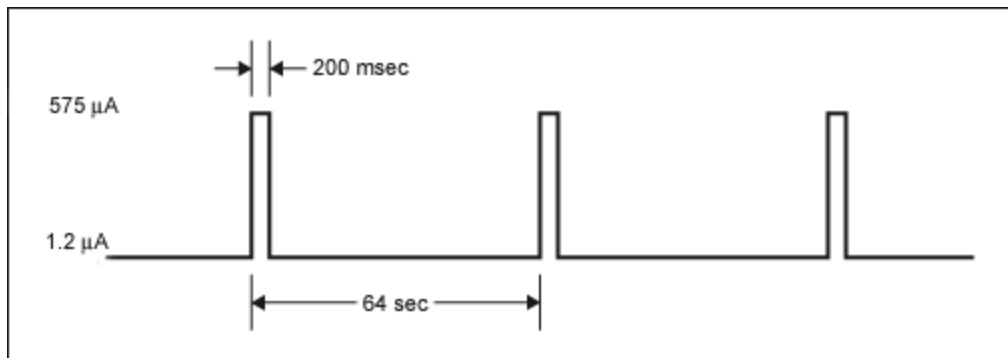

Figure 1. DS3231 Worst-case current requirements.

The maximum average current draw is determined by the following calculation:

$$Iavg = \frac{(1.2)(64 - 0.2) + (575)(0.2)}{64} = 3.0 \mu A$$

The maximum average current value of 3.0µA is provided in the DS3231 data sheet. As this value reveals, the temperature conversion process increases the total current requirement by 250%! This current increase is especially significant for applications that require extended operation from a backup power source (e.g. Lithium battery, super capacitor).

Reducing Current Requirements

The DS3232/DS3234 provide a bit field in a user-programmable register that allows the time between temperature updates to be increased, thus reducing the average current requirement. Both devices provide the C_Rate bit field in the Control/Status Register, which provides four different periods between temperature updates. This register is detailed in **Table 1**.

Table 1. Control/Status Register Bit Assignments

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
OSF	BB32KHZ	**C_Rate1**	**C_Rate0**	EN32kHz	BSY	A2F	A1F

Table 2 shows the time between temperature updates and the resulting worst-case currents for the DS3232/DS3234. All calculations assume a battery voltage of 3.3V with the I²C-compatible interface inactive. This C_Rate bit field will default to zero at power-up, which corresponds to 64s between temperature updates.

Table 2. Time Between Temperature Updates and Resulting Worst-Case Currents

C_Rate [1:0]	Temperature Update Time (s)	DS3232/DS3234 Average Current (µA)
00	64	2.50
01	128	1.56
10	256	1.10
11	512	0.86

By adjusting this bit field, the current requirements can be reduced by more than 65%, extending the lifetime of a backup power source.

Accuracy

With the increase in time between temperature updates, there could be a reduction in accuracy during rapid temperature fluctuations. There is no affect on accuracy when the temperature remains stable or changes slowly.

Temperature Control

The DS3234 has added a Temperature Control Register that allows an application to disable temperature updates when the device is powered by the back-up power source. The BB_TD bit in this register controls the disable function. This bit defaults to zero at power-up, which corresponds to temperature updates being active. The register is detailed in **Table 3**.

Table 3. Temperature Control Register Bit Assignments

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	0	0	BB_TD

Enabling this bit reduces the total current requirement of a back up power source, but there will be degradation in timekeeping accuracy without temperature updates.

Summary

With the addition of programmable temperature update times, Dallas Semiconductor has provided accurate timekeeping with lower current requirements by introducing the DS3231/DS3232/DS3234 integrated RTC/TCXO/crystals.

Related Parts		
DS3231	Extremely Accurate I²C-Integrated RTC/TCXO/Crystal	Free Samples
DS3231M	±5ppm, I²C Real-Time Clock	Free Samples
DS3232	Extremely Accurate I²C RTC with Integrated Crystal and SRAM	Free Samples
DS3234	Extremely Accurate SPI Bus RTC with Integrated Crystal and SRAM	Free Samples
DS32B35	Accurate I²C RTC with Integrated TCXO/Crystal/FRAM	
DS32C35	Accurate I²C RTC with Integrated TCXO/Crystal/FRAM	

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