AN_653x_019

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Return to Mission Mode under Battery Power

Introduction

The 71M653x Family of metering ICs operates the MPU at reduced clock speed when in brownout mode, i.e. with the mains power missing and with operation supported by a battery or super-capacitor. The reduced clock speed supports basic operations like tamper detection, display and other household functions, but not communication at UART speeds higher than 300 baud and computation-intensive activities. Also, the ADC and CE of the 71M653x are disabled in brownout mode, which prevents analog metering functions, such as temperature measurement in battery operation.

This Application Note describes methods that enable the 71M653x to return to mission mode when the grid power is not present in order to perform computation-intensive tasks or analog functions under battery power.

Brownout Mode

Brownout mode is characterized by the following conditions:

- Absence of the IC supply voltage V3P3SYS and V3P3A
- A battery or other DC supply is connected to the VBAT pin
- V1 voltage below VBIAS
- The IE_PLLFALL interrupt flag is set
- The UARTs and DIO pins are operational

In brownout mode, the MPU clock speed is reduced to 7/8 of the CK32 clock, i.e. 28.672 kHz, regardless of the setting of the *MPU_DIV* register. The analog function blocks of the 71M653x are disabled, which means that analog samples including those from the temperature sensor cannot be processed.

The supply current for the 71M653x is provided by the battery connected to the VBAT pin. Typical supply currents are between 82 µA and 112 µA. It should be mentioned that the V3P3SYS and V3P3A pins will still draw current in brownout mode, if a voltage other than 0 VDC is applied.

Transitions to sleep mode or LCD mode can be commanded by the MPU under code control. These operation modes can save supply current. For example, in sleep mode, the VBAT current can be as low as 0.7 µA.

In the absence of a nominal supply voltage at V3P3SYS and V3P3A, the 71M653x is forced to stay in brownout mode.

Return to Mission Mode

External circuitry can be used to force the 71M653x back to mission mode from brownout mode. In the context of this Application Note, this special operation mode will be referred to as Battery-Supported Mission Mode or *BSMM*. In the absence of a nominal supply voltage at the V3P3SYS and V3P3A pins, the supply power has to be provided by a charge source such as a battery or a super-capacitor. It is obvious that this operation mode should not be used frequently and for extended periods of time, since it will drain the battery fast. Supply currents for V3P3SYS are typically 4.2 mA and 3.2 mA for V3P3A.

External Circuitry for Battery-Supported Mission Mode (BSMM)

Ideally, a battery or super-cap separate from the battery supplying the RTC is used to enable the BSMM (see Figure 1). Any type of switch can be used to connect the battery to the V3P3SYS and V3P3A pins, such as photo-MOS switches, FETs, analog switches, or relays.

If the same battery or super-cap is used for both the RTC (VBAT pin) and for supporting the BSMM, the designer has to be careful not to discharge the battery or super-cap too much. Otherwise, the return from sleep mode to brownout mode (VBAT > 3./0 VDC) or the supply of the oscillator and RTC (VBAT > 2.0 VDC) cannot be guaranteed.

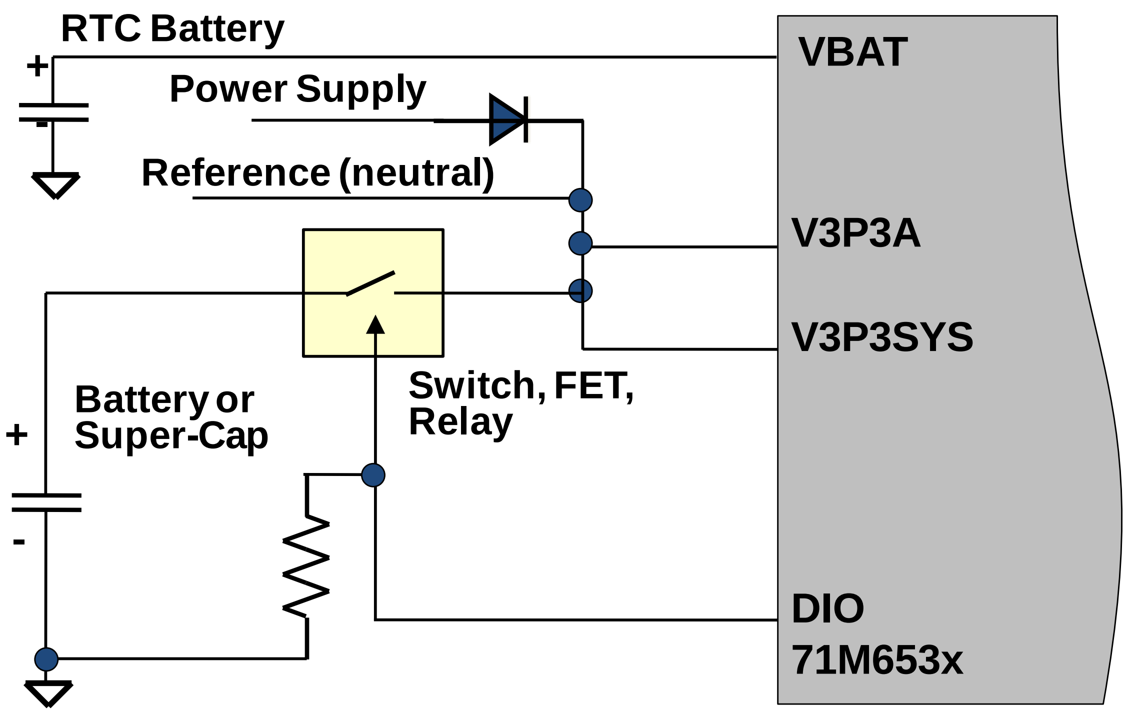

Figure 1: Sample Circuitry for Return to BSMM

Sample Switch Components

When selecting a switch, the following switch properties should be considered:

- Actuator current: Since the switch is activated in brownout mode and maintained in BSMM, the actuator current should be well below 1 mA in order to preserve battery charge as much as possible.
- Isolation and leakage: Leakage must be low in order to prevent battery drain through the opened switch. Ideally, the leakage is much lower than 1 µA.
- On-resistance: The on-resistance of the switch must be low enough to restrict the voltage drop at the expected current consumption of 7.4 mA to less than 100 mV. This makes an on-resistance of 10 Ω or less desirable.

Table 1 compares a few selected components that can be used for switching.

Table 1: Switch Comparison

Part No.	Part Type	Manufacturer	Activation Current	Leakage, Isolation	On-Resistance [Ω]
MAX4707	Analog CMOS switch	Maxim	0.05 µA	0.1 nA	2.0
SSM6J08FU	FET	Toshiba	--	1 µA	0.2
AZ853PS-3	Latching Relay	Zettler	33 mA pulse	10^9 Ω	0.075
TLP222A	Photo-relay	Toshiba	5 mA		

Methods for Increasing the Usable Battery Voltage Range

The operating voltage range of the 71M653x in mission mode is between 3.0 VDC and 3.6 VDC. A battery that is connected directly to the V3P3SYS and V3P3A pins of the 71M653x fails to meet the supply voltage requirements of the 71M653x, once the voltage drops below 3.0 VDC[1], even though there is charge left in the battery. Buck boost converters can help to generate the constant 3.3 VDC supply needed for the 71M653x from a battery or super-capacitor with highly variable voltage. Figure 2 shows the MAX8625A as an example for a buck boost circuit. The MAX8625A offers up to 92% efficiency.

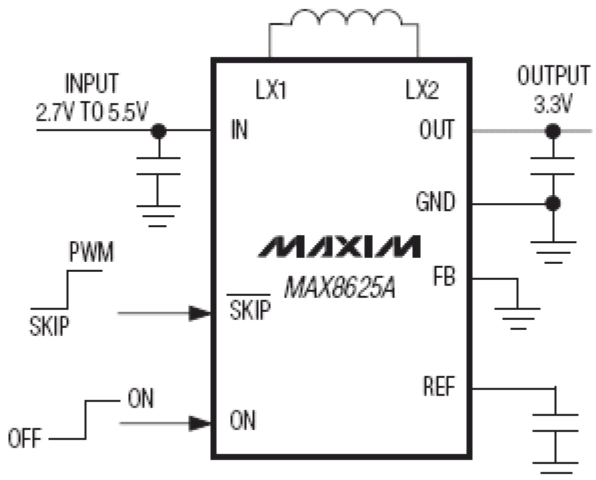

Figure 2: Buck Boost Circuit with 3.3 VDC Output

This circuit has an additional advantage: The battery or super-capacitor can be charged up to its voltage limits (e.g. 5.5 VDC for many types of super-capacitors) without exceeding the voltage limit at the VBAT pin of 3.6 VDC, which increases the stored charge by a large margin.

Table 2 lists achievable survival times in BSMM for two charge sources. The time of 340 seconds, achieved with the MAX8625A and a 1.0 F super-capacitor (boost circuit efficiency was assumed to be 90%) is more than 4 times the time achievable without the boost circuit. If longer survival times are required, a Lithium battery should be used in conjunction with a boost circuit.

Table 2: Survival Times for a Various Charge Sources

Charge Source	Connection Type	Maximum Voltage	Minimum Voltage	Charge at Maximum Voltage	Charge at Minimum Voltage	Time Circuit is able to Sustain Mission Mode (7.4 mA)
Super-Capacitor (1.0 F)	Direct	3.6 V	3.0 V	3.6 As	3.0 As	81 s
	Using MAX8625A	5.5 V	2.7 V	5.5 As	2.7 As	340 s
Lithium Battery (1500 mAh)	Using MAX8625A	3.6 V		1500 mAh		180 hours

[1] 71M653x ICs have been observed to operate the MPU at V3P3SYS voltages as low as 2.5 VDC (with the voltage at V1 > VBIAS). However, this operation mode is not guaranteed and is not supported by characterization data. This observation should not be interpreted as a design recommendation.

Firmware Precautions

Once the 71M653x returns to BSMM, the MPU should immediately take precautions to save supply current. These precautions include:

- Disable the CE
- Disable the ADC
- Disable any DIO pins not necessary for the operation under BSMM
- Scale back the MPU clock speed to the minimum required frequency, e.g. by setting *MPU_DIV* to 7.

Hardware Precautions

The hardware of the meter should be designed to present a minimal load to the power supply system. Measures to minimize supply current include:

- Chose large values for pull-up and pull-down resistors
- Chose peripheral components with the lowest supply power specifications
- Add switches that disable parts of the meter that are not required to function under BSMM
- Avoid back-feed from the battery or super-capacitor to the power supply components via V3P3SYS and V3P3A when in BSMM

Revision History

Revision	Date	Description
Rev. 1.0	4/22/2011	First publication.

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