DM3730/AM3703 SOM-LV Power Management
Application Note 488

Logic PD // Products
Published: July 2011
Last revised: January 2013

Abstract

This application note provides a high-level explanation of power-management schemes available on the DM3730/AM3703 SOM-LV.

Revision History

REV	EDITOR	DESCRIPTION	APPROVAL	DATE
A	NJK	-Initial release	JCA	07/20/11
B	RAH, SO	-Section 7.1.1: Removed references to scripts; provided new LogicLoader commands; -Added Section 7.1.2; -Deleted Appendix A: Sample Scripts, as LogicLoader 2.5.x supports I2C writes directly and script is no longer necessary	RAH, NJK	02/23/12
C	NJK	-Added Section 5.2	RAH, SO	01/17/13

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1   Introduction

This document summarizes how power management is handled on the DM3730/AM3703 SOM-LV and offers different approaches for implementing power-management schemes in custom applications.

2   DM3730/AM3703 SOM-LV Power

The DM3730/AM3703 SOM-LV can be powered by several different sources since the power rails on the SOM have been divided to allow for flexibility. Table 2.1 identifies the available power sources and provides a brief description of each.

Table 2.1: DM3730/AM3703 SOM-LV Power Sources

Power Source	Description
MAIN_BATTERY	External power source input. This signal should be driven directly by a single-cell lithium-ion battery or a fixed, regulated power source.
5V	5V power input. Used by power management controller to charge external MAIN_BATTERY supply.
3.3V	External 3.3V power input. This signal supplies power to 3.3V components on the SOM.
BACKUP_BATT	External input that supplies power to the onboard power management controller and real-time clock (RTC) interface. This signal should be powered by a coin-cell type battery or an always-on power source.
USB1_VBUS	May be used to charge the battery. **NOTE:** The current is limited by USB specification; a FET must be present at reference designator U24 for USB charging. Please see the *DM3730/AM3703 SOM-LV Schematic* for more information.

2.1   Powering On the SOM

The DM3730/AM3703 SOM-LV will power on when MAIN_BATTERY is supplied to the SOM; all other signals may remain in their default state. The SOM will also power on if 5V is supplied without MAIN_BATTERY; however, this is not a supported operating mode. Supplying USB1_VBUS to the SOM will not power on the SOM.

The PWRON signal may be used to power on/off the SOM only after MAIN_BATTERY has been supplied to the SOM; software must set up the signal before it becomes a valid power switch. MAIN_BATTERY must be supplied to the SOM at all times when using the PWRON signal to power on/off the SOM. For more information, please see the Texas Instruments (TI) *TPS65950 OMAP Power Management and System Companion Device ES 1.2 Technical Reference Manual (TRM)*.[1]

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[1] http://focus.ti.com/docs/prod/folders/print/tps65950.html#technicaldocuments

3 Recommended Power Management Paths

3.1 Lithium-ion Battery Power

If a lithium-ion battery is used, the input power supplies should be connected as described in Table 3.1.

Table 3.1: Power Supplies using Lithium-ion Battery

Power Source	Connections for Power through Lithium-ion Battery
MAIN_BATTERY	Connect to the lithium-ion battery. Connecting a minimum 80 uF capacitor to this rail on the baseboard is recommended.
5V	Can be connected to a DC voltage source to charge the MAIN_BATTERY. If connected, this signal will be used as a charging source in this context. If the TPS65950 is not going to be used as the charging source of the battery, this input should be connected to GND.
3.3V	Connect to a 3.3V supply.
BACKUP_BATT	Connect to a coin-cell type battery or an always-on power source if desired. If not used, connect to GND.
USB1_VBUS	Can be connected to a USB host to charge the MAIN_BATTERY. Software is required to enable charging. **NOTE:** USB charging current is limited by the USB specification; a FET must be present at reference designator U24 for USB charging. Please see the *DM3730/AM3703 SOM-LV Schematic* for more information.

Please contact Logic PD[2] for reference designs that use a lithium-ion battery.

3.2 No Battery Power

To power the SOM without using a battery, the input power supplies should be connected as described in Table 3.2.

Table 3.2: Power Supplies using No Battery

Power Source	Connections for Power through MAIN_BATTERY
MAIN_BATTERY	Connect to a fixed regulated power source. Connecting a minimum 80 uF capacitor to this rail on the baseboard is recommended.
5V	Connect to GND.
3.3V	Connect to a 3.3V supply.
BACKUP_BATT	Connect to a coin-cell type battery or an always-on power source if desired. If not used, connect to GND.
USB1_VBUS	Should only be used as an output power source. USB1_VBUS will try to charge MAIN_BATTERY if a FET at U24 is present and software enables charging, which may damage the PMIC or MAIN_BATTERY circuitry.

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[2] http://support.logicpd.com/support/askaquestion.php

4 Charging a Battery using the TPS65950

The DM3730/AM3703 SOM-LV was designed to optimize space and cost constraints; that level of optimization required necessary tradeoffs that may impact battery charging. Please adhere to the following guidelines when designing an application that utilizes battery charging. Also, please note that some applications may require an external charger.

The DM3730/AM3703 SOM-LV is designed to support DC current-nonlimited chargers on the 5V rail and USB charging on USB1_VBUS. The 5V input to the SOM can support input voltages from 4.6V-7.0V. Because the input voltage directly relates to the power loss in the Power MOSFET (P=IV), the lower the input voltage, the higher the amount of current that can go through the FET. The minimum voltage that the charger can handle is defined as:

VBATMAX + 2 PMOS drop + 0.22 Ohm resistor drop (where VBATMAX is the maximum voltage value of the battery; that is, 4.2V for a Li-ion battery)

For a Li-ion battery, the input can go down to approximately 4.6V, given the circuitry of the SOM. Using a 4.6V input to the 5V charging power rail of the SOM will help improve the amount of charge current that can be delivered to the battery.

The current that flows through the charging circuitry is shared between the system and the battery, so the more current that is used by the system, the less current that remains for battery charging. Because of this, it is recommended to charge the battery with the processor in a low-power or sleep state. Additional charging current will also go to the battery if the baseboard components are powered directly by the DC charger when it is inserted.

The following examples provide scenarios for using battery charging on the SOM. There may be more options than those listed below. If your application does not fit any of these guidelines, please contact Logic PD for help evaluating your charging needs.

4.1 Usage Scenarios

NOTE: All of the temperatures listed below are ambient temperatures. Enclosing the DM3730/AM3703 SOM-LV in a case will require special attention to airflow and heat dissipation.

4.1.1 Max Current at Room Temperature

Setup: 4.6V input to 5V power rail of the SOM; Li-ion battery operating from 3.2V (start of main charge) to 4.2V (end of charge)

When using the SOM at typical room temperatures (below 30°C), limiting the total current through the SOM to 0.6A is recommended. This will provide safe operating conditions for all ICs in the power path.

4.1.2 Max Current at Room Temperature with Heat Save

Setup: 4.6V input to 5V power rail of the SOM; Li-ion battery operating from 3.2V (start of main charge) to 4.2V (end of charge)

When using the heat-save feature of the TPS65950 at typical room temperatures (below 30°C), the starting current threshold should be set to 0.541A. The heat-save voltage threshold can be set to 3.95V and the charging current can be set to 1.2A when above that voltage.

4.1.3 Max Current at Temperatures below 40°C with Heat Save and 5V Input

Setup: 5.0V input to 5V power rail of the SOM; Li-ion battery operating from 3.2V (start of main charge) to 4.2V (end of charge)

When using the heat-save feature of the TPS65950 at temperatures below 40°C, the starting current threshold should be set to 0.42A. The heat-save voltage threshold can be set to 4.0V and the charging current can be set to 0.75A when above that voltage.

4.1.4 Max Current at Room Temperature and USB Charging

Setup: 5.0V input to USB1_VBUS power rail of the SOM; Li-ion battery operating from 3.2V (start of main charge) to 4.2V (end of charge)

When using the SOM at typical room temperatures (below 30°C), it is recommended to limit the total current through the SOM to 0.45A. This will provide safe operating conditions for all ICs in the power path.

4.1.5 Max Temperature with Safe Current

Setup: 4.6V input to 5V power rail of the SOM; Li-ion battery operating from 3.2V (start of main charge) to 4.2V (end of charge)

To operate the SOM at temperatures up to 60°C, the charge current should be set to 0.44A.

4.1.6 Max Temperature with Safe Current and Heat Save

Setup: 4.6V input to 5V power rail of the SOM; Li-ion battery operating from 3.2V (start of main charge) to 4.2V (end of charge)

When using the heat-save feature of the TPS65950 at temperatures up to 60°C, the starting current threshold should be set to 0.42A. The heat-save voltage threshold can be set to 4.0V and the charging current can be set to 1.0A when above that voltage.

4.2 Key Battery Charging Registers

This section provides some key registers that must be configured for battery charging to work correctly; it is not meant to provide all necessary information to properly charge a battery. For additional information, please refer to "Chapter 7: Battery Charger Interface and Backup Battery" in TI's *TPS65950 OMAP Power Management and System Companion Device ES 1.2 TRM* (literature number SWCU050G).

Table 4.1: Battery Charging Registers

Register	Description
GPBR1(MADC_HFCLK_EN & DEFAULT_MADC_CLK_EN)	Both MADC_HFCLK_EN and DEFAULT_MADC_CLK_EN should be set to "1" after power on. Turning these bits on will enable the ADC to work properly, which is necessary for the TPS65950 to monitor the battery voltage. If these bits are not set, battery charging will not start. This should be one of the first tasks the boot code performs.
BCIMFTH1(VBATOV1TH)	VBATOV1TH sets the voltage threshold when the battery charger changes modes from pre-charge to main charge. On a fully-depleted battery (voltage less than 3.2V), the charger will enter pre-charge mode until the battery voltage reaches 3.2V. Once at 3.2V, the charger turns off while the system boots. If the battery drops below VBATOV1TH from the time the boot starts until the GPBR1 register (above) is set, the charger will return to pre-charge mode and limit the charging current to only 100 mA. Changing VBATOV1TH to a lower value can help with this situation. This should also be one of the first tasks the boot code performs. The VBATOV1TH setting is dependent upon the battery used in the system and should be verified on individual designs.
BCIIREF1 & BCIIREF2	BCIIREF1 and BCIIREF2 set the main charging current. This is just one of many locations the charging current can be set. Please reference TI's *TPS65950 TRM* for alternate methods.

Register	Description
BCIMFTH9(HSVOLTTH)	HSVOLTTH defines the heat-save voltage threshold. Please refer to "Section 7.5.6: Heat-Save Detection" in TI's *TPS65950 TRM* for information on enabling the heat-save feature.
BCIMFTH9(HSCURTH)	HSCURTH defines the heat save current threshold. Please refer to "Section 7.5.6: Heat-Save Detection" in TI's *TPS65950 TRM* for information on enabling the heat-save feature.

5   External Battery Charging

5.1   Main Battery

If using a single-cell Li-ion or Li-polymer-based battery to power the DM3730/AM3703 SOM-LV, Logic PD has provided a reference battery charging design on the *SDK2 Baseboard Schematics*. The reference design is based on a TI BQ24032A power management chip.

Please contact Logic PD if you need any assistance in battery charging design considerations.

5.2   Backup Battery

The backup battery may be connected in different configurations depending on the system power setup. The TPS65950 supports backup battery charging through the BB_CFG register. For more information, please see the TI's *TPS65950 OMAP Power Management and System Companion Device ES 1.2 TRM*.

5.2.1   Rechargeable or Non-rechargeable Backup Battery; MAIN_BATTERY Not Switched

If MAIN_BATTERY is not controlled by a switch before the SOM and is instead left on at all times, the backup battery should be connected as shown in Figure 5.1 below. Software must be configured to control the backup battery charging enable bit of the TPS65950 depending on whether the backup battery is rechargeable or non-rechargeable.
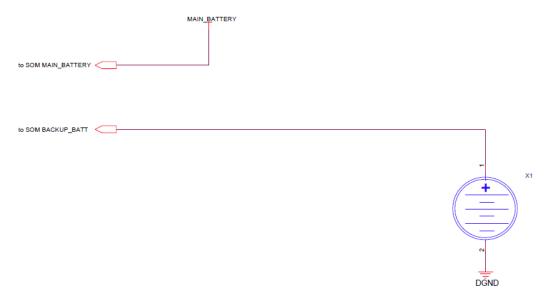

Figure 5.1: Backup Battery Configuration for MAIN_BATTERY without Switch

5.2.2 Non-rechargeable Backup Battery; MAIN_BATTERY Switched

If using a non-rechargeable backup battery when MAIN_BATTERY is controlled by a switch before the SOM, the backup battery should be connected as shown in Figure 5.2 below. Software must not enable backup battery charging in the TPS65950.
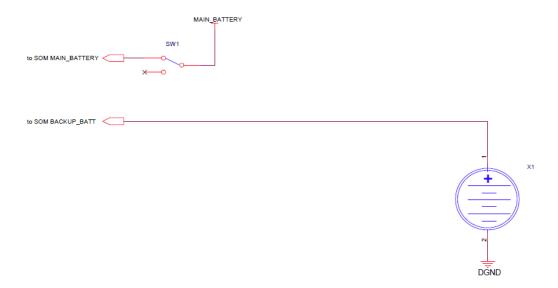

Figure 5.2: Non-rechargeable Backup Battery Configuration for MAIN_BATTERY with Switch

5.2.3 Rechargeable Backup Battery; MAIN_BATTERY Switched

If using a rechargeable backup battery when MAIN_BATTERY is controlled by a switch before the SOM, the backup battery should be connected as shown in Figure 5.3 below. Software should enable backup battery charging in the TPS65950 to ensure the backup battery is fully charged while the system is on. D1 must be chosen so that the voltage to the backup battery is within its charging specifications; this may require adding more diodes in series to increase the voltage drop. Rx must also be chosen to limit the charging current to the backup battery.
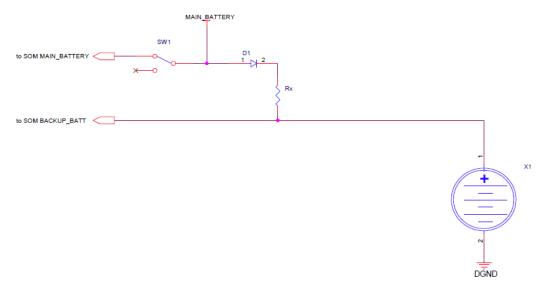

Figure 5.3: Rechargeable Backup Battery Configuration for MAIN_BATTERY with Switch

6   Reference Voltages

Several voltages come off the high-density connectors for use as reference voltages. While the intent of these voltages is strictly as a reference level, some of the supplies may be connected on custom baseboards to supply low-current devices. Table 6.1 provides the recommended maximum current for each reference voltage.

IMPORTANT NOTE: These values are only suggestions. Please verify supply voltage current limits of the TPS65950 in custom designs.

Table 6.1: Reference Voltages

Reference Voltage	Usage
VSIM	Connected to VIO_1V8 through a 0 ohm resistor; follow VIO_1V8 recommendations.
VIO_1V8	Used to power most peripherals on the SOM. Not recommended to power devices off-board. Only use to determine the voltage for a particular interface.
VAUX3	Can supply up to 200 mA off-board. Requires capacitance on the baseboard for stabilization; 1 uF or larger recommended.
VMMC1	Can supply up to 200 mA off-board.
VMMC2	Can supply up to 100 mA off-board.
VPLL2	Can supply up to 35 mA off-board.

7   Power Supplies

7.1   VAUX4

VAUX4 is disabled by default on the TPS65950. If using one of the camera GPI signals, this supply must be turned on by software. There are two key registers for setting and enabling the VAUX4 voltage. Details can be found in TI's *TPS65950 OMAP Power Management and System Companion Device ES 1.2 TRM*.

Table 7.1: VAUX4 Register Descriptions

Register	Description
VAUX4_DEDICATED	This register controls the voltage for VAUX4 and must be configured first.
VAUX4_DEV_GRP	This register controls when VAUX4 is enabled and must be configured second.

NOTE: The voltage range for this power supply is 1.71V to 1.89V. Operation outside this range is not recommended.

7.1.1   Sample LogicLoader Instructions to Enable VAUX4

Sample LogicLoader instructions to enable VAUX4 are provided below. LogicLoader v2.5 can use the *w* command to write to the I2C port and the *x* command to read from the I2C port on the PMIC.

```
losh> w /b
losh> w /b 0x004b0081 0x05 /dev/pm0
#0x4b is the address inside the TPS65950 for the PM_RECEIVER module
#0x81 is the VAUX4_DEDICATED register
#0x05 sets the voltage on VAUX4 to 1.8V
```

```
losh> w /b 0x004b007e 0xe0 /dev/pm0
#0x4b is the address inside the TPS65950 for the PM_RECEIVER module
#0x7e is the VAUX_DEV_GRP register
#0xe0 enables VAUX4 to all device groups. Causes VAUX4 to turn on
```

7.1.2   Sample Linux Instructions to Enable VAUX4

Sample Linux instructions to use the *i2cset* and *i2cget* commands to enable VAUX4 are provided below.

```
DM-37x# i2cset -f -y 1 0x4b 0x81 0x05
DM-37x# i2cset -f -y 1 0x4b 0x7e 0xe0
```

8   Summary

There are several different powering options for the DM3730/AM3703 SOM-LV using either a DC supply or battery. This document has provided a high-level perspective of the different power supplies available for custom applications.