NVIDIA JETSON TX1 AND JETSON TX2 MODULE BATTERY AND CHARGER DESIGN GUIDELINES

DA-08405-001_v1.5 | July 2017

Application Note

DOCUMENT CHANGE HISTORY

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Version	Date	Description of Change
1.0	May 1, 2017	Initial Release
1.5	July 20, 2017	•Updated all figures •General updates throughout application note

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

This application note contains design guidelines and an example for a battery powered NVIDIA® Jetson™ TX1 and Jetson TX2 system with a charger.

Notes: This application note provides information to enable our customers to develop a battery operated embedded device. However, NVIDIA does not have a reference platform nor software implementation in L4T BSP. Developers should feel free to select proper components and implement their software based on NVIDIA's design information.

In addition, battery thermal management should be considered in the system and is the responsibility of the system designer to implement.

Jetson TX2 utilizes NVIDIA® Tegra® X2 which is a Parker series SoC.

The NVIDIA Jetson TX1 and Jetson TX2 modules have a main power supply input, **VDD_IN**, which is typically supplied from a DC power supply. To power the module from a battery, the system needs the following:

- 2S-4S battery
- Battery charger
- Fuel gauge
- Power monitor

The battery charger charges the battery and supplies power to **VDD_IN** either from the DC power supply or the battery. The fuel gauge and power monitor are used by the NVIDIA Jetson TX1 and Jetson TX2 modules to monitor the battery charge status and the system power draw, respectively.

The NVIDIA Jetson TX1 and Jetson TX2 modules have several dedicated control signals used to communicate with the battery charger, fuel gauge, and power monitor. See Table 1 for a list and description of the signals.

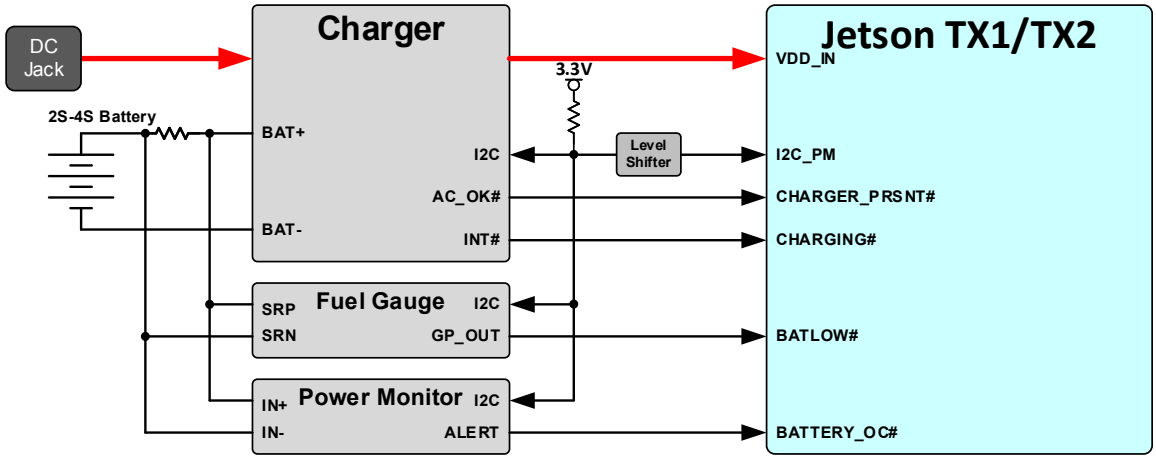

Figure 1. Jetson TX1 and Jetson TX2 System Power Block Diagram

Table 1. Battery Based System Control Signals

Pin Name	Pin	Description	Pin Type	Voltage
VDD_IN	A1, A2, B1, B2, C1, C2	Jetson TX1 and Jetson TX2 power	Power Input	6-19V
I2C_PM_CLK	A6	Power Management I2C Clock dedicated for communication with the charger, fuel gauge and power monitor.	Bidirectional	Open Drain, 1.8V
I2C_PM_DAT	B6	Power Management I2C Data dedicated for communication with the charger, fuel gauge and power monitor.	Bidirectional	Open Drain, 1.8V
CHARGER_PRSNT#	A49	Active low indication that the AC power is present on the charger IC	Input	Open Drain, 1.8V.
CHARGING#	A7	Interrupt from the charger IC to the module, if charger has output interrupt pin.	Input	CMOS, 1.8V
BATLOW#	C7	Active Low Interrupt from the fuel gauge to indicate that the battery voltage is low.	Input	CMOS, 1.8V
BATTERY_OC#	C8	Interrupt form power monitor to the module, If battery has output over-current event.	Input	CMOS, 1.8V

Notes:

1. **VDD_IN** maximum supported current on the expansion connectors is ~4000 mA.
2. **VDD_IN** total power consumption depends on your use case.
3. A level shifter is required on **I2C_PM** interface which is pulled to 1.8V on the Jetson TX1 and Jetson TX2 modules but must be pulled to 3.3V to support the SMBus interface supported by the charger.

BATTERY POWER SUPPLY DESIGN

There are four critical system components that are essential for a battery powered system.

- Battery pack
- Battery charger
- Fuel gauge
- Power monitor

BATTERY PACK

A battery pack consists of a single cell or multiple battery cells in parallel or in series. A standard single Li+ battery cell has a nominal operating voltage of 3.7V and a maximum operating voltage of 4.2V. Because the operating voltage of **VDD_IN** on the Jetson TX1 and Jetson TX2 modules is 5.5V-19.6V the battery pack needs a minimum of 2 Li+ cells in series (2S battery). The maximum number of cells in series is 4 (4S battery). More cells can be placed in parallel if more battery capacity is required by the application.

BATTERY CHARGER

The battery charger charges the battery pack when the DC power supply is plugged in and manages the power path between the DC power supply and the battery pack to the **VDD_IN**. Some battery chargers can even supplement power from the battery pack to **VDD_IN** when the power from the DC power supply is insufficient for the system.

For non-autonomous battery chargers that require a host processor to manage the charging, the Jetson TX1 and Jetson TX2 modules has an I2C Bus, **I2C_PM**, and two

GPIOs, **CHARGING#** and **CHARGER_PRSNT#**, to communicate with the charger. On **I2C_PM**, the module is the master of the bus and the battery charger is the slave. Since the charger supports SMBus, a level shifter is required on **I2C_PM** interface which is pulled to 1.8V on the Jetson TX1 and Jetson TX2 modules. On the charger side of the level shifter, the interface needs to be pulled to 3.3V to be compatible with SMBus. **CHARGING#** is an active-low interrupt signal used by the charger to alert the module. The **CHARGER_PRNT#** is an active-low signal used to indicate to the Jetson TX1 and Jetson TX2 modules when a DC power supply is plugged into the system.

For battery charger on the system carrier board, Figure 2 shows a simplified charger with connections to the Jetson TX1 and Jetson TX2 modules. For detailed implementation find a suitable multi-cell battery charger from your vendor's web site and refer to its data sheet.

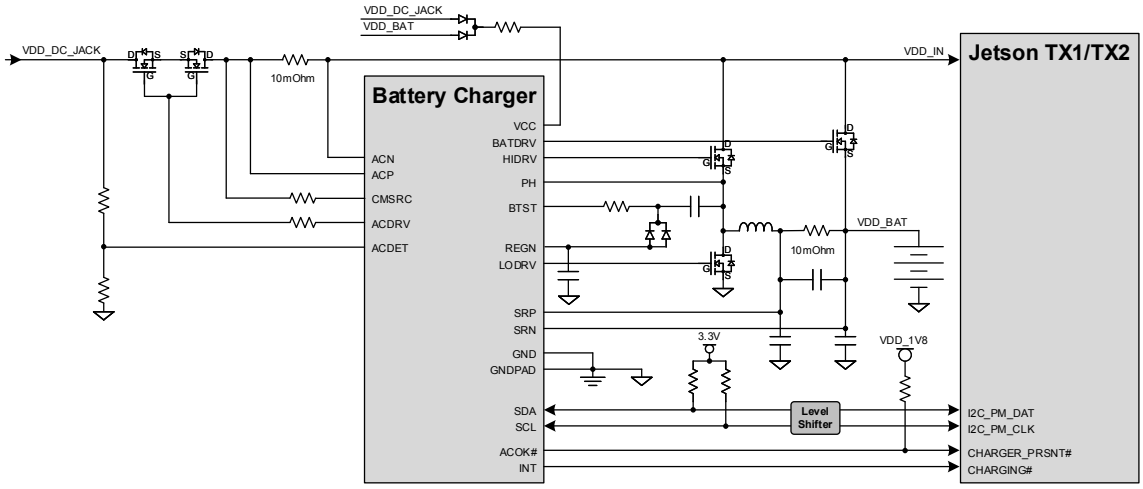

Figure 2. Battery and Charger Connections Example

Notes:

1. Find a typical charger schematic from the TI BQ24735 datasheet, Chapter 10.3 "System Examples."
2. A level shifter is required on **I2C_PM** interface which is pulled to 1.8V on the Jetson TX1 and Jetson TX2 modules but must be pulled to 3.3V to support the SMBus interface supported by the charger.

FUEL GAUGE

The fuel gauge is used to measure the amount of charge in the battery pack and indicates the health of the battery pack. A good fuel gauge helps the system change power scheme dynamically to extend the battery life. Typically a 2S-4S battery pack has the fuel gauge in the pack because it performs other functions, such as cell balancing and protection.

The **I2C_PM** is the I2C Bus used by the Jetson TX1 and Jetson TX2 modules to communicate to the fuel gauge. **BATLOW#** is an optional active-low signal from the fuel gauge to the module to indicate if the battery pack voltage is low.

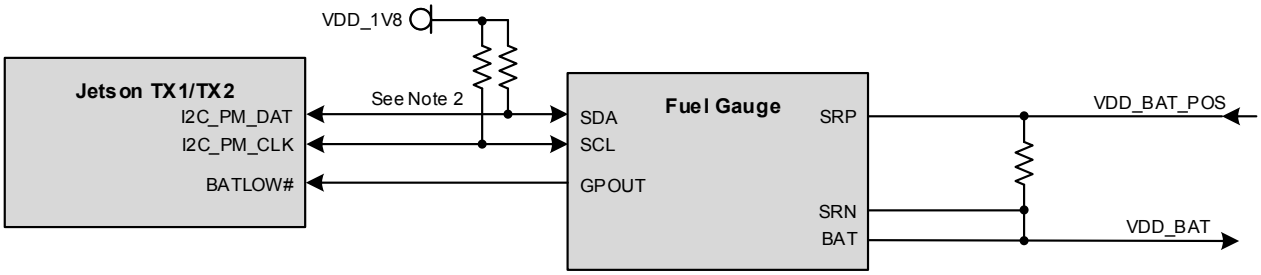

Figure 3. Fuel Gauge Connections

Notes:

1. Check with your vendor to ensure the connections for 2-4 cell battery packs are correct.
2. Pull-up resistors (to 1.8V) for the **I2C_PM** Bus are present on the Jetson TX1 and Jetson TX2 modules. Ensure the fuel gauge is compatible with a 1.8V I2C interface. If it requires 3.3V, the level shifted interface shown in the "Battery and Connections Example" can be used.

POWER MONITOR

A battery power monitor circuit is recommended, in order to check for over-current conditions that could indicate a problem or lead to overheating. The actual circuitry will depend on the supply voltage level to be monitored. Some battery chargers have this function integrated and an external discrete power monitor is not required.

The Jetson TX1 and Jetson TX2 modules communicate to the power monitor over the **I2C_PM** bus. The **BATTERY_OC#** is an active-low signal from the power monitor to the module to indicate when the measured current has exceeded a programmable threshold.

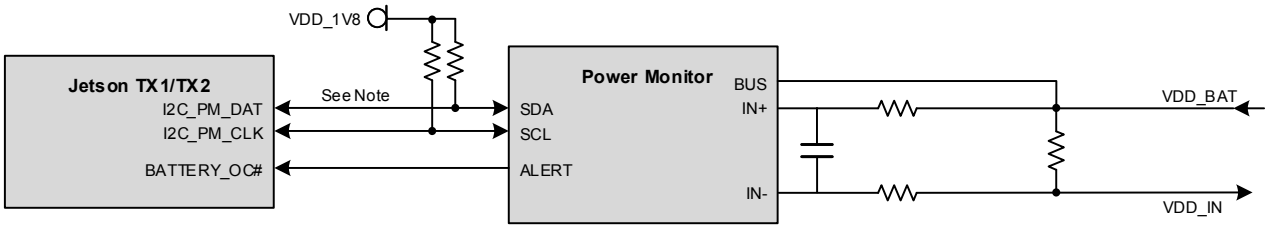

Figure 4. Power Monitor Connections

Note: Pull-up resistors (to 1.8V) for the **I2C_PM** Bus are present on the Jetson TX1 and Jetson TX2 modules. Ensure the fuel gauge is compatible with a 1.8V I2C interface. If it requires 3.3V, the level shifted interface shown in the "Battery and Connections Example" can be used.

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