NVIDIA Jetson AGX Xavier Series Battery and Charger Design Guidelines

Application Note

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Document History

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Version	Date	Description of Change
1.0	April 10, 2019	Initial Release
1.1	June 14, 2019	Updated to include all of Jetson AGX Xavier series modules

Table of Contents

List of Figures

List of Tables

Introduction

This application note contains design guidelines for a battery powered NVIDIA® Jetson AGX Xavier™ series 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.

References to Jetson AGX Xavier apply to any of the Jetson AGX Xavier series of modules.

The NVIDIA Jetson AGX Xavier module has a main high voltage power supply input, **SYS_VIN_HV**, which is typically supplied from a DC power supply. To power the module from a battery, at a minimum, the system should have the following:

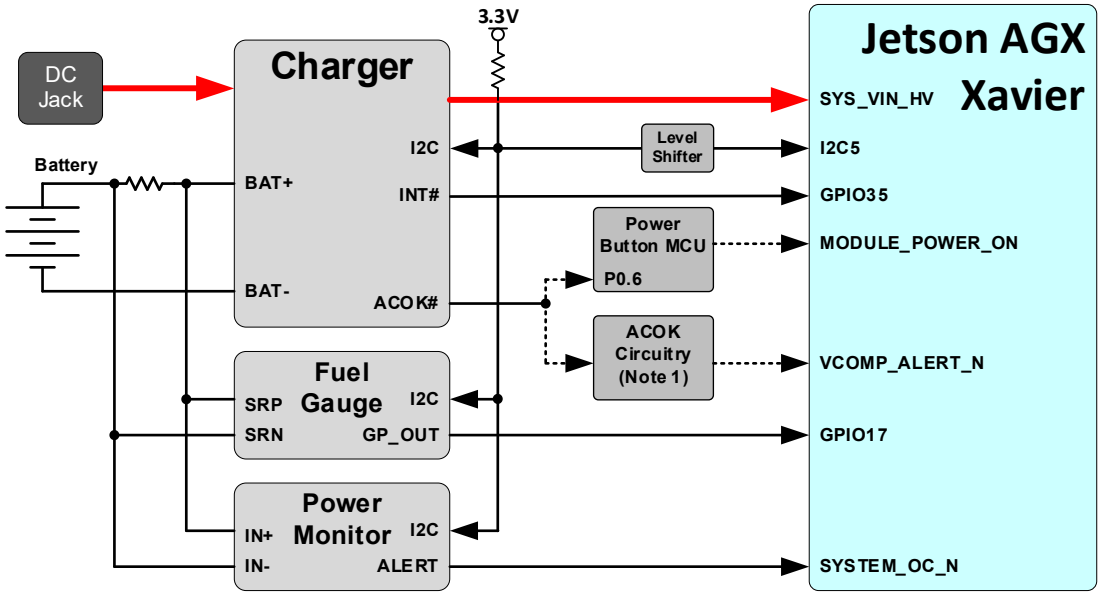
- Battery that meets the **SYS_VIN_HV** min/max voltage requirements
- Fuel gauge
- Power monitor

The charger can be separate or could be part of the solution. If the battery charger is not included, then the battery is connected to the platform and powers the **SYS_VIN_HV** supply on the Jetson AGX Xavier module. If the charger is included in the design, it charges the battery and supplies power to **SYS_VIN_HV** either from the DC power supply or the battery. The fuel gauge and power monitor (if charger included) are used to monitor the battery charge status and the system power draw, respectively.

The Jetson AGX Xavier module has several control signals to communicate with the battery charger, fuel gauge, and power monitor. See Table 2 for a list and description of the signals. The signals used were chosen from the list of signals available on the 40-pin header on the NVIDIA developer kit carrier board. Two exceptions are **SYSTEM_OC_N** and **ACOK#** on the charger which can connect to the 8-pin header (J508 pins 8 and 6 respectively) on the NVIDIA carrier board. This allows a solution to be developed that can easily be used with the NVIDIA carrier board. A user can decide to design their own carrier board and include the circuitry if that is desirable. If a customer carrier board is used that does not implement the MCU based power-on supervisor, then the **ACOK#** on the charger should be connected through the ACOK circuitry

shown in the *Jetson AGX OEM Product Design Guide* to the module connector **VCOMP_ALERT_N** pin instead.

Figure 1. Jetson AGX Xavier System Power Block Diagram



Note: See the *Jetson AGX Xavier OEM Product Design Guide* for details related to the ACOK circuitry. This circuitry is not implemented on the NVIDIA Developer Kit carrier board.

Table 1. Battery Based System Power Signals

Pin Name	Module Pins	Description	Voltage Tolerance
SYS_VIN_HV	C65, D65, E65, F65, G65, H65, J65, C64, D64, E64, F64, G64, H64, J64, B63, C63, E63, F63, G63, J63, B3, D3, F3, H3, K3, C2, D2, E2, F2, G2, H2, J2, C1, D1, E1, F1, G1, H1, J1	Jetson module main power	9-20V

Table 2. Battery Based System Control Signals

Pin Name (Function)	Module Pin	Exp. Hdr Pin	Description	Pin Type	Voltage Tolerance
I2C5_CLK	K5	5	I2C #5 Clock and Data used to communicate with the charger, fuel gauge and power monitor.	Bidir	OD, 1.8V
I2C5_DAT	L8	3		Bidir	
(ACOK#)	Note 1	Note 1	Active low indication that the AC power is present on the charger IC	Input	OD, 1.8V.
GPIO35	L50	18	Interrupt from the charger IC to the Jetson module, if charger has output interrupt pin.	Input	CMOS, 1.8V
GPIO17	A54	22	Active Low Interrupt from the fuel gauge to indicate that the battery voltage is low.	Input	CMOS, 1.8V
SYSTEM_OC_N	A61	15	Interrupt form power monitor to the Jetson module, if battery has output over-current event.	Input	CMOS, 1.8V

Notes:

1. If the NVIDIA Developer Kit carrier board is used, or if a custom carrier board implements the button power-on supervisor MCU, this signal from the charger should connect to the MCU P0.6 Pin. If a custom board is used that does not implement the power-on supervisor MCU, the ACOK# signal on the charger should connect to the ACOK circuitry described in the Jetson AGX Xavier OEM Product Design Guide. An output of the circuitry connects to the module pin VCOMP_ALERT_N to signal (interrupt or wake) to the module that a power source has been connected.
2. SYS_VIN_HV total power consumption depends on the use cases required.
3. Figure 1 shows a level shifter on the I2C interface (I2C5 on Jetson AGX Xavier) between the module and the charger. I2C5 is pulled to 1.8V on the Jetson AGX Xavier module but may be required to operate at 3.3V depending on the requirements of the charger. The NVIDIA carrier board has level shifters that can be enabled with Jumper J514. When this jumper is in the 1-2 position, the I2C interface and GPIOs are at 3.3V levels. If this mechanism cannot be used, then an additional level shifter will be required.

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. The number of cells in series depends on the battery type. A standard single LiPo battery cell has a nominal operating voltage of 3.7V, a minimum voltage of ~3.0V and a fully charged voltage of ~4.2V. Because the operating voltage of **SYS_VIN_HV** on the Jetson AGX Xavier module is 9.0V-20.0V, the battery pack needs the number of cells in series that satisfies the **SYS_VIN_HV** min/max voltage range. For LiPo batteries that would be 3S or 4S. More cells can be placed in parallel if the application requires more battery capacity.

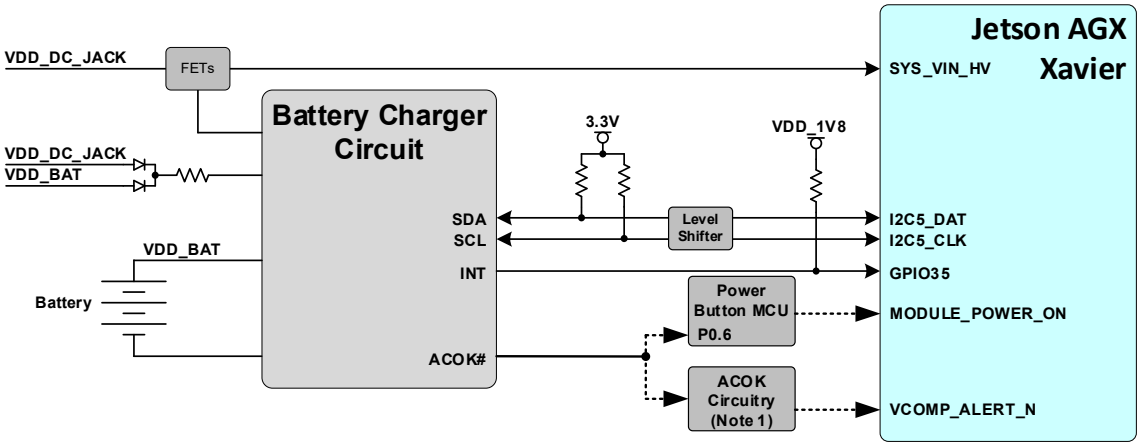
Note: Care should be taken not to allow operation below the battery minimum voltage to avoid damage to the battery. Check the battery manufacturer specifications for the safe minimum operating voltage.

Battery Charger

The battery charger may be part of the design including the fuel gauge and power monitor or could be separate. The 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 **SYS_VIN_HV**. Some battery chargers can even supplement power from the battery pack to **SYS_VIN_HV** when the power from the DC power supply is insufficient for the system.

For a battery charger on the system carrier board, shows a simplified charger with connections to the Jetson AGX Xavier module. 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



For non-autonomous battery chargers that require a host processor to manage the charging, the Jetson AGX Xavier module has an I2C Bus, I2C5. The Jetson AGX Xavier module is the master of the I2C Bus and the battery charger is the slave. See Note under the "Battery Based System Control Signals" table (Table 2) about possible level shifter requirements for I2C5. The charger interrupt is an alert to the Jetson module and can connect to the **GPIO35** Jetson AGX Xavier pin. The active-low interrupt signal from the charger is an alert to the Jetson module. The **ACOK#** signal on the charger is an active-low signal used to indicate to the Jetson module when a DC power supply is plugged into the system. Charger **ACOK#** pin should be connected in one of the two ways described in the following two sections, depending on the design of the carrier board and is described in the following two sections.

NVIDIA Developer Kit (or Equivalent) with Power Button Supervisor MCU

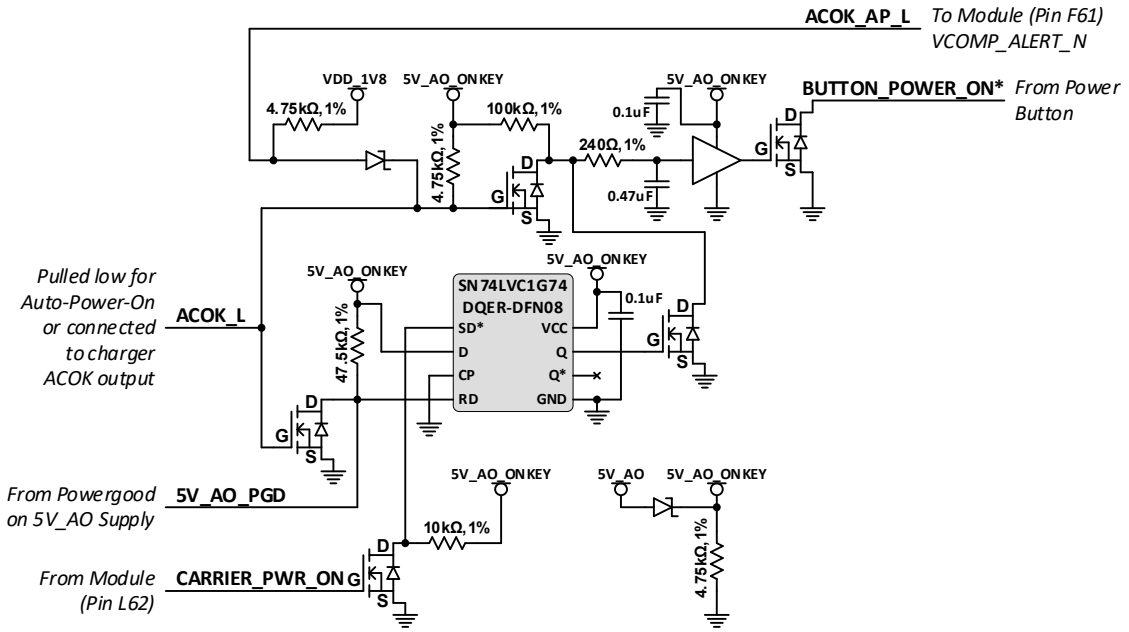
The **ACOK#** signal on the charger is an active-low signal used to indicate to the Jetson module when a power supply is connected to the system. **ACOK#** from the charger (level shifted may be necessary) is connected to the Power Button Supervisor MCU Pin P0.6. The MCU drives the **MODULE_POWER_ON** signal to power up the module when an AC charger is plugged in. One use of this function is when plugging in an AC Charger to charge a dead battery, where the module needs to wake up to program the charger to take full advance of the charger's capabilities.

Custom Carrier Board without MCU (Discrete ACOK# Circuitry Implemented)

If a custom carrier board design does not implement the MCU, then additional circuitry is required between the charger and the Jetson AGX Xavier module for **ACOK#**. See Figure 3 which includes the necessary circuitry. The charger **ACOK#** pin connects to the **ACOK_L** signal. The output of the circuit is the **ACOK_AP_L** signal which connects to the module **VCOMP_ALERT_N**

pin which is used to notify Tegra software through an interrupt of the changes in the state of the AC Charger presence. **VCOMP_ALERT_N** is a wake-capable pin.

Figure 3. Non-MCU Based Design ACOK# Circuitry

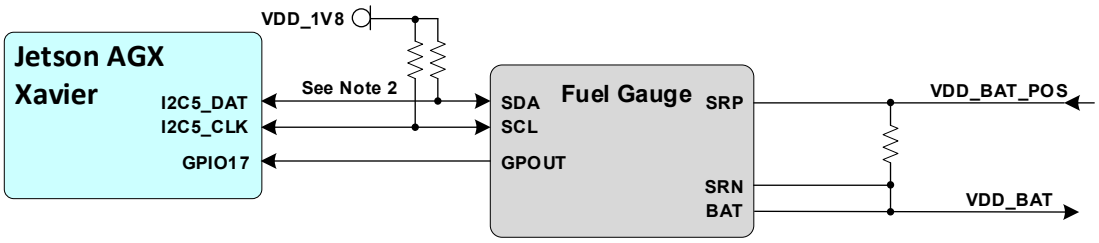


Fuel Gauge

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 the power scheme dynamically to extend the battery life. Many battery packs have the fuel gauge in the pack because it performs other functions, such as cell balancing and protection.

I2C5 is the I2C bus used by the Jetson module to communicate to the fuel gauge. An optional active-low signal from the fuel gauge (**GPOUT** in Figure 4) is routed to the Jetson module **GPIO17** pin to indicate if the battery pack voltage is low.

Figure 4. Fuel Gauge Connections



Notes:

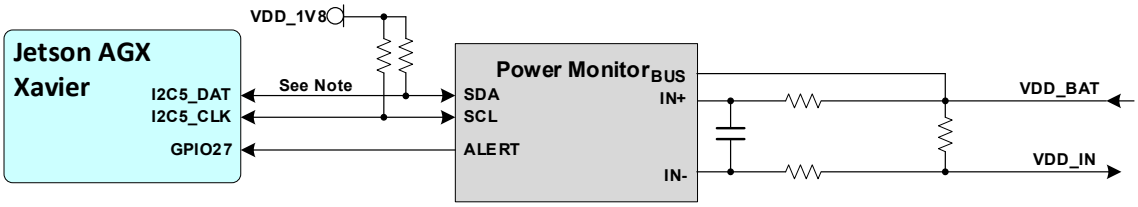
1. Check with your fuel gauge vendor to for the correct way to connect the battery to the fuel gauge.
2. See Note under "Battery Based System Control Signals" table (Table 2) about possible level shifter requirements for I2C5.

Power Monitor

A battery power monitor circuit is recommended, 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 module communicates to the power monitor over the I2C5 Bus. The **ALERT** pin of the power monitor is an active-low signal from the power monitor to the module **GPIO27** pin to indicate when the measured current has exceeded a programmable threshold.

Figure 5. Power Monitor Connections



Note: See Note under "Battery Based System Control Signals" table (Table 2) about possible level shifter requirements for I2C5

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