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ABSTRACT

The BQ25120A is a highly integrated battery charge management IC that integrates the most common functions for wearable devices such as: linear charger, regulated output, load switch or linear dropout regulator, manual reset with timer, and battery voltage monitor. This document compiles the most frequently asked questions and answers about the BQ25120A functional operation. This document also applies to other devices that are part of the BQ2512x family of linear chargers.

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1 BQ25120A Charger Functionality FAQs

This section includes the frequently asked questions about the BQ25120A functionality.

1.1 What is Ship Mode and Why Do I Need It?

Ship mode is the state of the device where it is in the lowest power consumption. After manufacturing, the product will be on storage for a long time before reaching the consumer's hands. Nowadays, we want to use the device out of the box, without the need to wait for it to charge. To save battery capacity during the shelf/ship life, the device is placed on ship mode so it maintains its battery capacity. Additionally, since ship mode is where the device is consuming the lowest battery current it can also be set by the host microcontroller to save battery during device operation.

For additional information about ship mode you can refer to the following blog.

Blog Link: [How to implement ship mode in your lithium-ion battery design](#)

1.2 How Do I Enter and Exit Ship Mode?

The charger can enter ship mode by:

- To enter ship mode on the BQ25120A, the device needs to be operating on battery-only mode ($V_{IN} < V_{UVLO}$), and /CD and /MR must be high. Then you can:
 - Send the I2C command EN_SHIPMODE = 1 on the Status and Ship Mode Control Register (0x0).
 - Perform a button press of the MR button, if the MRREC = 1 on the Push-button Control Register (0x08).

The charger can exit ship mode by:

- Connecting an adapter to IN ($V_{IN} > V_{BAT} + V_{SLP}$)
- By pressing the /MR button when VIN is not present. In this case $V_{BAT} > V_{BAT_{UVLO}}$ for the device to exit ship mode.

1.3 What is the Purpose of the /CD Pin? Do I Need to Connect it to My MCU?

On the BQ25120A the chip disable (/CD) input pin is used to disable the device and has dual functionality based on if the adapter (VIN) is present.

- *Battery Only Mode:* When operating on battery only mode the /CD pin is used to place the device either in High Impedance mode (/CD = Low) or Active Battery mode (/CD = High).
 - >>*High Impedance Mode:* The lowest quiescent current while operating from the battery. SYS is powered by battery, the MR input and LSCTRL are active. Other circuits are in a low power or sleep stage.
 - >>*Active Battery Mode:* Normal operation from battery. SYS is powered by battery, and other circuits are active.
- *Adapter Present:* When the adapter (VIN) is present the /CD controls the charging operation, where driving /CD high will disable charge.

For connecting to the microcontroller (MCU): The /CD pin is internally pulled down on the device. If left unconnected, the device will be operating on High Impedance Mode without VIN and charge will be enable with the adapter present. The charge could be disable/enable via I2C by setting /CE = 0 on the Fast Charge Control Register (0x03). You should connect to the MCU if you would like to enter active battery mode or will like to control charge current with the /CD pin, instead of with the I2C command.

1.4 What Happens to the I2C Registers in Ship Mode (Entry/Exit)?

Once you enter ship-mode, the registers values are reset to their default values. You will need to reconfigure the registers again after exiting ship mode.

1.5 Can I Change the DC-DC Voltage (VSYS) Dynamically Through I2C?

Yes, you can change the system voltage (VSYS) on the SYS VOUT Control Register (0x06). The output can be programmable from 1.1 V up to 3.3 V.

1.6 Can I Change the LDO Voltage (LS/LDO) Dynamically Through I2C?

Yes, you can change the LDO/LS voltage and also disable the output on the Load Switch and LDO Control Register (0x07). The output can be programmable from 800mV to 3.3 V as a low dropout voltage regulator

(LDO) or configure as a Load Switch (LS). Note the LS/LDO output needs to be disabled first before setting a new LDO value or before switching between LDO and LS.

1.7 Can I Change the Wake Timers After a Button is Pressed?

You can configure their wake timers on the Push-button Control Register (0x08). The same registers will report the status on when the device met the WAKE1 and WAKE2 timer. After configuring the new wake timers, they will take effect on the next iteration when the button is pressed. If the button was held low during the reconfiguration, the previous values are going to be used. Note if the device goes into ship mode through push button, all registers will be reset to default after exiting ship mode.

1.8 Can I Change the Reset Duration After a Button is Pressed?

You can configure your reset duration on the Push-button Control Register (0x08), by configuring the MRRESET fields. The same registers will allow you to configure if after reset the device will enter ship-mode or Hi-Z mode. After configuring the new reset durations values, they will take effect on the next iteration when the button is pressed. If the button was held low during the reconfiguration, the previous values are going to be used. Note if the device goes into ship mode through push button, all registers will be reset to default after exiting ship mode.

1.9 What is the Purpose of the Watchdog Timer?

In microcontroller applications, the watchdog timer is use to assure the host is still responsive and have not stopped operating. The BQ25120A has a 50-s watchdog timer that monitors the host through the I2C interface. The timer will reset every time an I2C communication is performed, in the case where the watchdog timer expired (host is unresponsive), the registers will reset to the default values.

1.10 Can I Disable the Watchdog Timer?

The watchdog timer of the BQ25120A cannot be disabled. However, when the device is placed on High Impedance (Hi-Z) mode the watchdog timer is disabled. The device is on Hi-Z mode when operating out of battery and the /CD pin = LOW. As an alternative, the BQ25121A or the BQ25120F3A are part of the same family and have the watchdog timer disabled by default.

1.11 The Device Stops Charging (or Charges Very Slowly) After a Minute or So? What is the Reason?

There are multiple reasons why the BQ25120A might stopped charging or charge very slowly. The first thing to look into is the watchdog timer, if the watchdog requirements was not met then all registers are return to default, which might re-configure your device to a low current setting. One more thing to look for if the device is on pre-charge current ($I_{PRETERM}$), due to the cell voltage of the battery being too low. In this case you will need to wait for the battery charge until it exceeds the battery short circuit threshold ($V_{BATSHORT}$), where it will start charging to the configure fast charge current (I_{CHARGE}).

Another option will be to confirm if the battery temperature is outside the normal charging range. You can enable the TS monitoring and read the status on TS Control and Faults Masks Register (0x02). The TS Fault field will report if the charger is outside the temperature range, which could reduce or stop the charge current. Other common source is when the input source (V_{IN}) is poor (less than U_{VLO} or on sleep mode) or the input is overloaded/overvoltage, in this case the internal loops of the BQ25120A power management will regulate the charge current to avoid collapsing the V_{BUS} (V_{IN}).

1.12 Can I Update the Default I2C Options?

You cannot modify the default options of the device. After powering up or waking out of ship mode all registers will be set to default values. Any changes made prior that will be lost and you will need to re-configure your registers. There are multiple devices which are part of the same family BQ2512x which has different default options. Refer to the BQ25120A, BQ25121A, BQ25122, BQ25123, BQ25120F3A, and BQ25125 data sheets for details or reach out to one of our marketing or field apps engineer for help selecting the device.

1.13 How is the Reset Pin Different from the MR Pin and CD Pin?

The RESET (reset output) pin of the BQ25120A is an open drain output pin, which will go low when the /MR (manual reset input) is held low for longer than T_{RESET} . The RESET pin can be use by the microcontroller (MCU) to detect or monitor when a reset event happens by the /MR input pin. The CD (chip disable) pin on the other

hand is an input of the BQ25120A which can be used to place the device on high-Z mode or enable/disable charging.

1.14 How Can I Tell if the BQ25120A is Charging?

You can read the STAT field on the Status and Ship Mode Control Register (0x0), to obtain the charging status. The STAT field will show when the device is ready to start charging, charging is in progress, charging is done or if there is a device fault affecting the charging status.

1.15 How Does DPPM Work (VINDPM and VDPPM)?

The dynamic power path management (DPPM) of the BQ25120A will separate the charging current from system current. When you have a valid IN source, current is shared at the PMID between charging the battery and providing system load. The device internal loops (VINDPM, DPPM) will monitor and control the input voltage and current constantly to detect faults and take any needed action to support both charging and the load at PMID, SYS, and LS/LDO. The following summarizes both modes, for a more detail explanation refer to the data sheet.

- *Input Voltage Based Dynamic Power Management (VINDPM)*: If the input source is not able to support the charging current and system load once the VIN approaches the set VINDPM threshold, the input current will be reduced to prevent further drop of the supply.
- *Dynamic Power Path Management Mode (DPPM)*: With a valid input source the input current is shared between charging the battery and powering the systems loads. If the sum of systems and charging current exceeds the VIN capabilities, the VINDPM loop will reduce the PMID current, which will drop the PMID voltage. if the PMID voltage drops below the DPPM threshold, the charging current will be reduced to stabilize PMID. If PMID continue to drop even without charge current, the device will enter supplement mode.

1.16 Can I Use DPPM to Improve the Battery Charging?

The dynamic power path management (DPPM) can improve the battery charging performance by avoiding system crashes and maximizing the power available from the adapter.

1.17 Why Does my BAT Voltage Measures ~2V or Seems to Oscillate When VIN is Present and Not Battery Connected?

On this scenario if VIN is present and charging is enabled, the BQ25120A will try to perform its function of charging a battery that is not present. Instead, it will charge the capacitor connected on the BAT pin, once the voltage regulation is met the charger will stop charging the capacitor which will then get discharged. Once the recharge threshold is met the charger will start the charging process again and repeat this loop. If you measure this average waveform with a multimeter, you will get the RMS value of the signal, which could be ~2V. If observing the waveform from a scope you will see the process of charge/discharge on the scope capture.

The battery charger is design to charge a real li-ion battery. If not battery is present, we recommend to:

1. Disable charging either by setting the /CD pin high or disabling charge via I2C
2. Connecting a real Li-Ion battery or a battery simulator to the BAT pin.

1.18 If I Masked my Interrupts, Will I Still Get the Status and Flags Bit Sets?

Yes, masking your interrupts will avoid the interrupts to be generated when the event triggers. You will still get a flag and status bits sets, as long as the condition is met. Refer to the 9.6 Registers Maps section for more details about interrupts masks, flags and status bits. Additionally, Table 11 of the data sheet shows how the device behaves under different fault conditions.

1.19 How do I Perform Battery Monitoring with the BQ25120A Registers?

The BQ25120A implements a simple voltage battery monitor which can be used to determine the depth of discharge of your battery. A high-level representation of the circuit can be seen on Figure 17 of the data sheet. Table 2 provides two different examples of typical VBATREG used on Li-Ion batteries to perform a simple 5-bar status indicator on your applications to allow user to see how much battery is left on the device. You can change your VBATREG on Battery Voltage Control Register (0x05) from 3.6 V to 4.65 V.

The specific battery used needs to be fully characterized to determine the threshold that will indicate the battery status. Then you can read the Voltage Based Battery Monitor Register (0x0A) to obtain the VMON read of your

battery. This register read value represents a percentage of your battery value with 2% increments between 60% and 100% of your selected VBATREG. On your actual application you can use this percentage to estimate the stage of discharge of your battery. For additional information refer to Section 9.3.4 Voltage Based Battery Monitor of the data sheet.

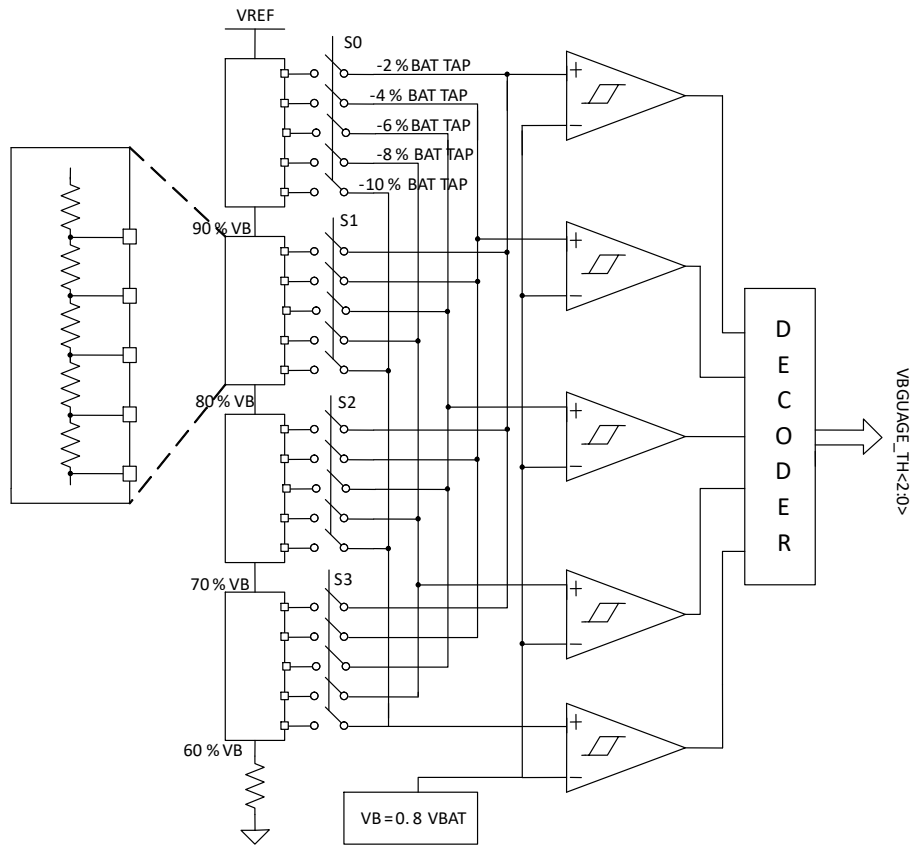


Figure 1-1. Voltage Battery Monitor

2 BQ25120A Charger Design FAQs

This section includes the frequently asked questions about the BQ25120A design, including schematic and layout questions.

2.1 Can I Use the BQ25120A as a Standalone Device Without an I2C Controller?

Yes, you can configure the BQ25120A as a standalone device by configuring the current limit, fast charge current, and termination current. To do so you will need to select the appropriate resistors for the ILIM, ISET and IPRETERM inputs based on your applications need. Additionally, you can also use the BQ25120A as a I2C controlled device by modifying the different control registers via the I2C bus.

2.2 Is There a Schematic Checklist?

Yes, the BQ25120A setup guide tool includes a schematic checklist that will help getting starting on designing your application with the charger.

BQ25120A Setup Guide Link: [BQ25120A Setup Guide Tool](#)

2.3 What are the Device Choices? The BQ25120A, BQ25121A, BQ25122, BQ25123, BQ25125, and so on Look Very Similar?

The devices BQ25120A, BQ25121A, BQ25122, BQ25123, BQ25125, BQ25120F3A, and so on, are all part of the same family of battery chargers: BQ25120x. They function similarly, but the default registers vary by device selection. Below table shows the key differences between the devices. Please refer to the data sheet for more information and to select the correct device for your application.

Table 2-1. Key Differences Between The Devices

Device	VSYS	LS/LDO (Default)	VIN_DPM	Watchdog Timer	DPPM
BQ25120A	1.8 V	Load Switch	Enabled	Enabled	Enabled
BQ25121A	2.5 V	Load Switch	Enabled	Disabled	Enabled
BQ25122	1.2 V	Load Switch	Enabled	Enabled	Enabled
BQ25123	1.25 V	LDO (3.0V) – Disable	Enabled	Enabled	Enabled
BQ25125	1.8 V	LDO (1.8V) – Disable	Disabled	Enabled	Disabled
BQ25120F3A	1.8 V	LDO (1.8V) – Disable	Enabled	Disabled	Enabled

2.4 Do You Have any Design Tools to Help Me with the Registers?

Yes, you can refer to the BQ25120A setup guide to get started with the charger. You can configure all registers and generate the initialization on C code.

BQ25120A Setup Guide Link: [BQ25120A Setup Guide Tool](#)

2.5 What Capacitor Ratings Should I Pick?

For choosing the capacitor voltage we recommend looking into Pins Functions section of the BQ25120A data sheet, where the recommended capacitor value will be mentioned. For selecting the right voltage ratings, refer to the Recommended Operating Conditions and Absolute Maximum Rating of the data sheet. As a rule, you want your voltage rating to be ~2X of your operating voltage, or refer to the derating percentage of your capacitor. While placing your components on your board, you want your bypass capacitor be as close to the pin as possible, you can refer to Section 12.2 Layout Example of the data sheet for a guideline on how to place and route your capacitors.

2.6 Do I Need to Tie the PGND and GND Together?

Yes, both PGND and GND needs to be tight together on your printed circuit board (PCB). Based on your design needs and grounding methodology, you can keep them isolated on separate nets and connect all your grounds (AGND, PGDN, DGND, and so on) later on a star ground connection, or you can tie them both together to the same ground plane of your PCB.

2.7 Where Do I Need to Pull Up the I2C Pins To?

On the I2C BUS (SDA/SCL) you need to connect your I2C pull up resistors to the V_{SYS} rail. Keep in mind that the I2C Bus of your system is shared between slaves and needs to match the logic level of your microcontroller (MCU).

2.8 Can I Pull Up the /INT and /PG to Any Voltage?

Both the /INT (Status Output) pin and /PG (Power Good) pins are open-drain outputs, you can connect these pins through a pull up resistor or LED to the desired logic voltage. If monitoring the /INT or /PG pins via a microcontroller (MCU) application, you want your digital level to match by tying it to your MCU digital power rail.

2.9 Do I Need to Connect the ILIM/ IPRETERM and ISET Resistors?

If using the BQ25120A as a standalone device, you should connect the ILIM/IPRETERM and ISET resistors to configure your current limit and fast charge parameter following the data sheet recommendation. If configuring the BQ25120A via I2C, you can connect those inputs directly to GND. Communicating via I2C will override the resistors configuration.

2.10 What is the Switching Frequency of the DC-DC Converter?

The BQ25120A integrates a switching regulator with DCS control and during the pulse width modulation (PWM) mode it operates in continuous conduction mode with a frequency up to 2Mhz. The frequency will vary based on current load, LC output filter, SYS desired output voltage, and battery voltages. Under the typical application SYS Output Curves section, Figure 61 shows data of V_{SYS} Frequency vs Load Current for SYS = 1.8 V. Additionally the SYS will operate on pulse frequency modulation (PFM) on light loads to maintain high efficiency, on this power save mode stage the device will perform a single switching pulse, follow by a sleep period.

2.11 How Do I Estimate the Ripple Current of the Inductor of the Buck Output?

The inductor ripple current will depend on the inductor value, the voltages, and the switching frequency. To estimate the inductor ripple current you can use [Equation 1](#) of the BQ25120A data sheet:

$$\Delta I_L = V_{SYS} \times \frac{\left(1 - \frac{V_{SYS}}{V_{PMID}}\right)}{(L \times f)} \quad (1)$$

Where

- F = Switching Frequency
- L = Inductor Value
- ΔI_L = Peak to Peak inductor ripple current
- $I_L(\max)$ = Maximum inductor current

Additionally, you can use the BQ25120A Setup Guide Tool which includes the Passive Component Calculator tab which helps calculating the ripple currents by inputting your application specs.

BQ25120A Setup Guide Link: [BQ25120A Setup Guide Tool](#)

2.12 How Do I Pick the Correct Inductor for the DC-DC Converter?

For picking the correct inductor for the DC-DC converter of the BQ25120A, you want to look into the maximum inductor current of your applications. You can use [Equation 2](#) of the data sheet to calculate your current. Additionally, Table 7 of the data sheet shows recommended inductors from different suppliers you can use.

$$I_L(\max) = I_{SYS}(\max) + \frac{\Delta I_L}{2} \quad (2)$$

Where

- ΔI_L = Peak to Peak inductor ripple current

2.13 I Am Controlling the BQ25120A Through I2C, Do I Still Need to Include the IPRETERM, ISET and ILIM Resistors?

If you are configuring the BQ25120A via I2C, you do not need to include the resistors, instead you can connect IPRETERM, ILIM and ISET to ground on your schematic. This will power up your device to the default configuration.

2.14 Can I Drive the /MR Pin Externally Through a GPIO?

The Manual Reset Input (/MR) is pulled up internally to BAT. To drive the signal with a microcontroller (MCU) you can use a N-Channel mosfet (nMOS) to mimic a *press* action from the MCU. [Figure 2-1](#) shows the connection. Refer to the section 3 of the BQ21061 app note that includes an example of this application and is applicable to the BQ25120A as well.

BQ21061 SFF App Note Link: [BQ21061 Two-Layer Small Form Factor Design for Cost-Optimized PCBs](#)

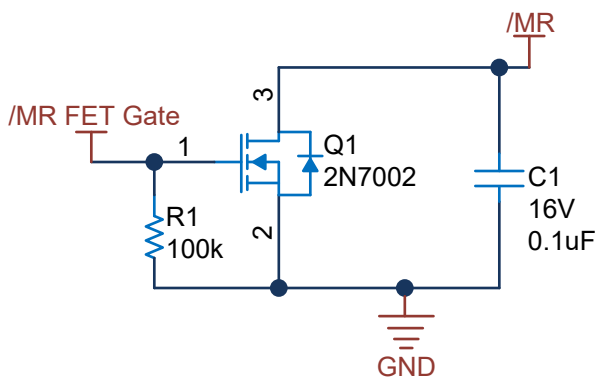


Figure 2-1. nMOS Schematic For Toggling The MR Pin

2.15 Reverse Current From BAT to IN? Does the Device Protect Against any Reverse Currents?

Yes, the BQ25120A input FET (Q1/Q2), It is a blocking FET with back to back diodes to protect from reverse current from BAT to IN.

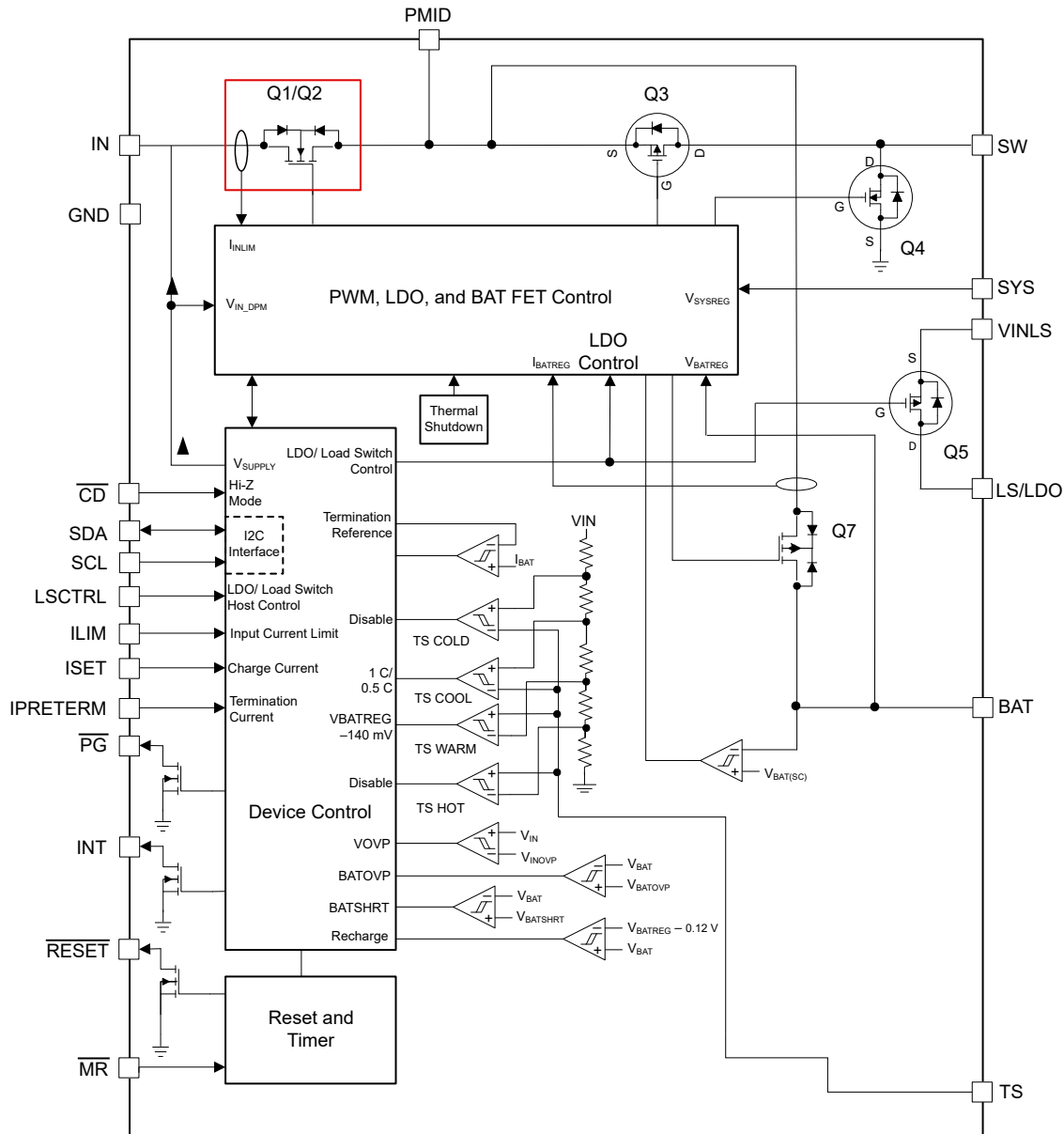


Figure 2-2. Functional Block Diagram

2.16 What is the LDO Dropout Voltage?

You can calculate the dropout of the LDO by multiplying the LDO_{RDSON} by the load current.

2.17 How Do I Select the Correct Resistor Values for the NTC?

On the BQ25120A, you need to connect the Battery Pack NTC Monitor *TS* pin to the center tap of a resistor divider from *VIN* to GND and the NTC from *TS* to GND. For selecting the correct resistors values for the divider, you can refer to section 9.3.16 of the data sheet where Figure 18 shows the connection diagram and Formula 1 and Formula 2 shows the calculations for both resistors.

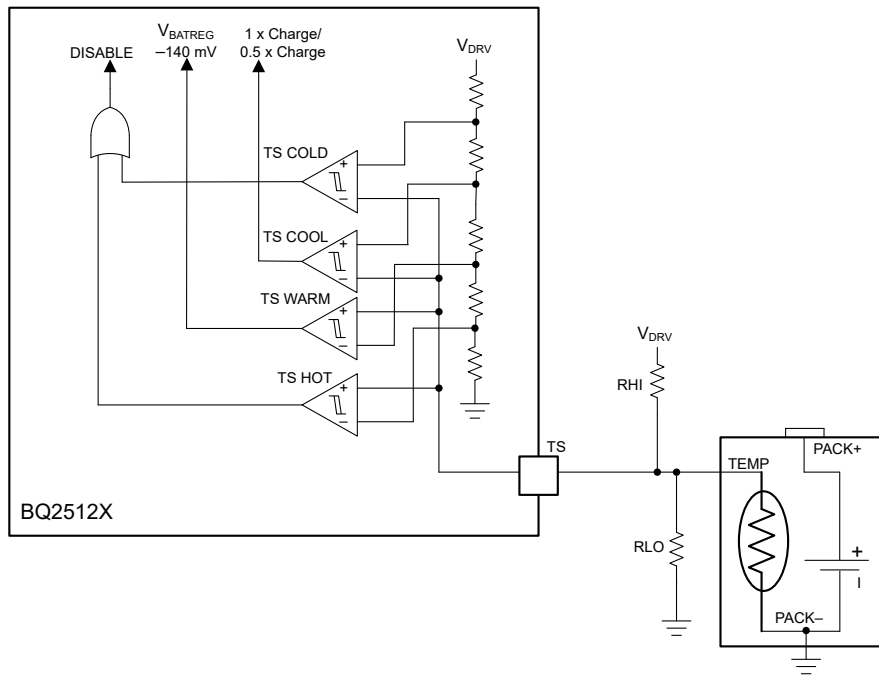


Figure 2-3. TS Circuit

$$R_{(LO)} = \frac{V_{IN} \times R_{(COLD)} \times R_{(HOT)} \left(\frac{1}{V_{(COLD)}} - \frac{1}{V_{(HOT)}} \right)}{R_{(HOT)} \times \left(\frac{V_{IN}}{V_{(COLD)}} - 1 \right) - R_{(COLD)} \times \left(\frac{V_{IN}}{V_{(COLD)}} - 1 \right)} \quad (3)$$

$$R_{(HI)} = \frac{\left(\frac{1}{V_{(COLD)}} - 1 \right)}{\left(\frac{1}{R_{(LO)}} - \frac{1}{R_{(COLD)}} \right)} \quad (4)$$

Where

* $R_{(HOT)}$ = The NTC resistance at the hot temperature.

* $R_{(COLD)}$ = The NTC resistance at the cold temperature.

Additionally, you can use the BQ25120A Setup Guide Tool which includes the TS Calculator tab that helps calculating the resistors by input your JEITA parameters.

BQ25120A Setup Guide Link: [BQ25120A Setup Guide Tool](#)

2.18 What is the Maximum Current I Can Pull from PMID?

The maximum discharge current you can pull from the PMID output depends on if adapter (VIN) is present or not. Operating on BAT only mode, the max current from PMID will be your Current Limit on Discharge Mode (I_{BAT_OCP}). When the adapter is present the max current from PMID will be your Input Current Limit (I_{LIM}) + I_{BAT_OCP} . You can find the currents specs of the BQ25120A on the Electrical Characteristics table of the data sheet.

2.19 Can I Bypass the VIN Pin and Directly Connect My Adapter to PMID?

No, the VIN cannot be directly connected to the PMID. The BQ25120A includes protection and regulation to charge the battery and provide system load simultaneously from the VIN input. If the VIN gets bypass and connected directly to PMID this internal protection is also bypass and you risk shorting VIN to BAT, generating

high currents and violating abs max and charger specs. The adapter must be connected to the VIN input for the charger to operate correctly.

2.20 What are the Differences Between the BQ25120 and the BQ25120A?

The BQ25120A is the new revision of the BQ25120 (not recommend for new designs). They are pin-to-pin and software compatible, but the BQ25120A has added improvements such as:

- Added quick output discharge feature on PMID when going to ship mode
- Improvement on state machine when connected to wireless charging on VIN side
- Improvement on ship mode entry when VIN and MR are glitching
- VIN Startup with any VBAT voltage
- Charging progress indication status feedback addressing VBATREG < VBAT values

The BQ25120 is not recommended for new designs. Please refer to the BQ25120A data sheet when you are designing your system.

2.21 What is the Difference Between PMID, SW, LDO? Are They all Connected to the Load? When do I Need to Use Them?

The BQ25120A is a highly integrated power management unit which includes integrated power rails: a buck converter (SW/SYS) and a linear regulator (LDO/LS). The charger is also part of our power path family which includes the PMID output on the high side FET (Q1/Q2) of the charger to allow for dynamically charging the battery and charging the system.

You can connect different types of loads to each output based on your application's electrical needs. Section 8.5 of the data sheet shows a typical application circuit to be used as reference to start designing with the BQ25120A. Refer to the Section 8.5 of the data sheet for the specifications of all the integrated rails.

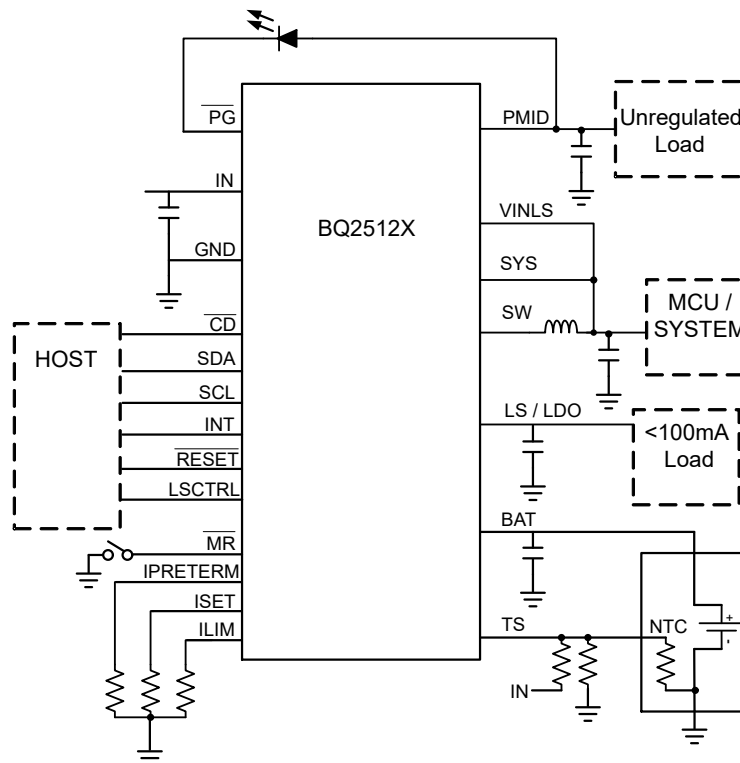


Figure 2-4. Simplified Schematic

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