

# bq76200 高压电池组前端充电/放电高侧 NFET 驱动器

## 1 特性

- CHG 和 DSG 高侧 N 沟道金属氧化物半导体 (NMOS) 场效应晶体管 (FET) 驱动器，可控制电池保护快速 FET 导通和关断次数
- 预充电 P 沟道场效应晶体管 (PFET) 驱动器（用于为显著耗尽的电池组进行限流预充电）
- 独立的数字使能充/放电控制
- 所需外部组件最少
- 基于可扩展外部电容的电荷泵，适用于不同范围内的并行 FET
- 耐受高压（绝对最高电压为 100V）
- 使能电池组电压感测的内部开关
- 支持通用和独立的充/放电路径配置
- 设计为直接与 bq76940、bq76930 和 bq76920 电池监控器搭配使用
- 电流消耗：
  - 正常模式：40 $\mu$ A
  - 关断模式：< 10 $\mu$ A（最大值）

## 2 应用

- 电动自行车 (eBike)、电动踏板车 (eScooter) 和电动摩托车 (eMotorcycles)
- 储能系统和不间断电源 (UPS)
- 便携式医疗系统
- 无线基站电池系统
- 铅酸 (PbA) 备用电池
- 12V 至 48V 电池组

## 3 说明

bq76200 器件是一款低功耗、高侧 N 沟道系统。高侧保护可防止系统的接地引脚断开连接，同时允许电池组与主机系统之间进行持续通信。该器件的附加 P 沟道 FET 控制功能支持对深度耗尽型电池进行低电流预充电，其 PACK+ 电压监控控制功能支持主机感测 PACK+ 电压。

独立的使能输入允许单独导通和关断 CHG 与 DSG FET，从而提供灵活的电池系统实施方案。

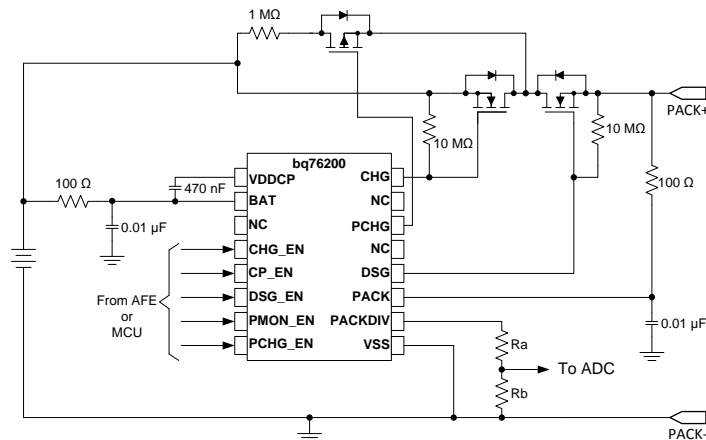
bq76200 器件可与配套的模拟前端器件搭配使用，例如 bq76920/30/40 系列、3 节至 15 节电池模拟前端监控以及主机微控制器或专用的充电状态 (SOC) 跟踪电量监测计器件。

器件信息<sup>(1)</sup>

| 部件号     | 封装         | 封装尺寸 (标称值)               |
|---------|------------|--------------------------|
| bq76200 | TSSOP (16) | 5.00mm × 4.40mm × 1.00mm |

(1) 要了解所有可用封装，请见数据表末尾的可订购产品附录。

简化电路原理图



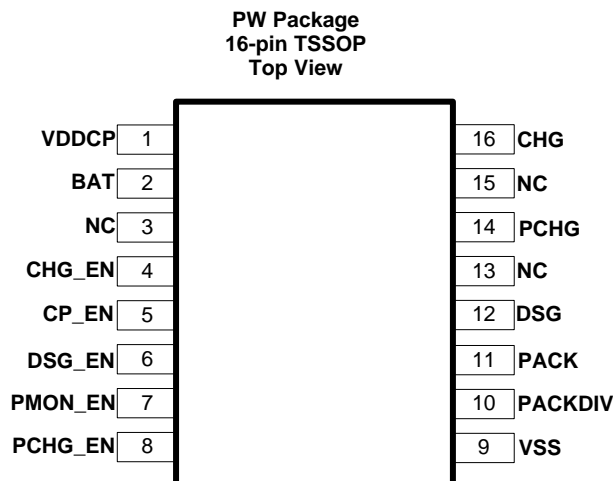
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## 4 修订历史记录

| 日期          | 修订版本 | 注释     |
|-------------|------|--------|
| 2015 年 11 月 | *    | 最初发布版本 |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN                    |           | TYPE <sup>(1)</sup> | DESCRIPTION   |
|------------------------|-----------|---------------------|---|
| NAME                   | NO.       | I/O                 |   |
| BAT                    | 2         | P                   | Top of battery stack  |
| CHG <sup>(2)</sup>     | 16        | O                   | Gate drive for charge FET   |
| CHG_EN <sup>(3)</sup>  | 4         | I                   | Charge FET enable   |
| CP_EN <sup>(3)</sup>   | 5         | I                   | Charge pump enable (internally logic ORed with CHG_EN and DSG_EN signals)           |
| DSG <sup>(2)</sup>     | 12        | O                   | Gate drive for discharge FET  |
| DSG_EN <sup>(3)</sup>  | 6         | I                   | Discharge FET enable  |
| NC                     | 3, 13, 15 | —                   | No connect. Leave the pin floating  |
| PACK                   | 11        | P                   | Analog input from PACK+ terminal  |
| PACKDIV <sup>(2)</sup> | 10        | O                   | PACK voltage after internal switch (connect to MCU ADC via resistor divider).       |
| PCHG <sup>(2)</sup>    | 14        | O                   | Gate drive for pre-charge FET   |
| PCHG_EN <sup>(3)</sup> | 8         | I                   | Pre-charge FET enable   |
| PMON_EN <sup>(3)</sup> | 7         | I                   | Pack monitor enable (allows connection of internal switch between PACK and PACKDIV) |
| VDDCP                  | 1         | O                   | Charge pump output. Connect a capacitor to BAT pin. Do not load this pin.           |
| VSS                    | 9         | P                   | Ground reference  |

(1) P = Power Connection, O = Digital Output, AI = Analog Input, I = Digital Input, I/OD = Digital Input/Output

(2) Leave the pin float if function is not used.

(3) Recommended to connect the pin to ground if function is not used.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                                |  | MIN  | MAX | UNIT |
|--------------------------------|--|------|-----|------|
| Input voltage range, $V_{IN}$  | BAT, PACK (both under charge pump disabled condition)  | -0.3 | 100 | V    |
|                                | CHG_EN, DSG_EN, PCHG_EN, PMON_EN, CP_EN <sup>(2)</sup> | -0.3 | 15  | V    |
| Output voltage range, $V_O$    | CHG, DSG, PCHG, PACKDIV, VDDCP                         | -0.3 | 100 | V    |
| $T_{FUNC}$                     | Functional Temperature                                 | -40  | 110 | °C   |
| Storage temperature, $T_{stg}$ |  | -65  | 150 | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The enable inputs need to be current limited with max current not exceeding 5 mA.

### 6.2 ESD Ratings

|                                     |  | VALUE | UNIT |
|-------------------------------------|--|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±2000 | V    |
|                                     | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±500  |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

Typical values stated where  $T_A = 25^\circ\text{C}$  and  $V_{BAT} = 48.8\text{ V}$ , Min/Max values stated where  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  and  $BAT = 8\text{ V}$  to  $75\text{ V}$  (unless otherwise noted)

|             |   | MIN | NOM | MAX | UNIT |
|-------------|---|-----|-----|-----|------|
| $V_{BAT}$   | Battery cell input supply voltage range                       | 8   |     | 75  | V    |
| $V_{PACK}$  | Charger/Load voltage range                                    | 0   |     | 75  | V    |
| $V_{IN}$    | Input voltage range   CHG_EN, DSG_EN, PCHG_EN, PMON_EN, CP_EN | 0   |     | 14  | V    |
| $C_{VDDCP}$ | Capacitor Between VDDCP and BAT                               |     | 470 |     | nF   |
| $T_{OPR}$   | Operating free-range temperature                              | -40 |     | 85  | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | TSSOP (PW) | UNIT |
|-------------------------------|--|------------|------|
|                               |  | 16 PINS    |      |
| $R_{\theta JA, High K}$       | Junction-to-ambient thermal resistance       | 106.8      | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case(top) thermal resistance     | 41.5       | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 51.8       | °C/W |
| $\psi_{JT}$                   | Junction-to-top characterization parameter   | 3.8        | °C/W |
| $\psi_{JB}$                   | Junction-to-board characterization parameter | 51.3       | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case(bottom) thermal resistance  | n/a        | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 6.5 Electrical Characteristics

Typical values stated at  $T_A = 25^\circ\text{C}$  and  $V_{(BAT)} = 48\text{ V}$ . MIN/MAX values stated with  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  and  $V_{(BAT)} = 8$  to  $75\text{ V}$  unless otherwise noted.

| PARAMETER                           | DESCRIPTION  | TEST CONDITION  | MIN | TYP | MAX | UNIT             |
|-------------------------------------|--|---|-----|-----|-----|------------------|
| <b>SUPPLY AND LEAKAGE CURRENT</b>   |  |   |     |     |     |                  |
| $I_{(BAT)}$                         | NORMAL mode current <sup>(1)</sup>                                   | $C_{(VDDCP)} = 470\text{ nF}$ , $V_{(BAT)} = V_{(PACK)}$ ,<br>$C_L = 10\text{ nF}$      |     | 40  | 50  | $\mu\text{A}$    |
| $I_{shut}$                          | Sum of current into BAT and PACK pin                                 | Shutdown Mode, PACK = 0 V, BAT = 8 V  |     | 6   | 9.5 | $\mu\text{A}$    |
| <b>CHARGE PUMP</b>                  |  |   |     |     |     |                  |
| $V_{(VDDCP)}$                       | Charge pump voltage  | No Load, CP_EN = hi, $V_{(VDDCP)} - V_{(BAT)}$  | 9   |     | 14  | V                |
| $t_{CPON}$                          | Charge pump start up time from zero volt                             | $C_{(VDDCP)} = 470\text{ nF}$ , 10% to 90% of $V_{(VDDCP)}$                             |     | 100 |     | ms               |
| <b>INPUT ENABLE CONTROL SIGNALS</b> |  |   |     |     |     |                  |
| $V_{IL}$                            | Digital low input level for CHG_EN, DSG_EN, PCHG_EN, CP_EN, PMON_EN  |   |     |     | 0.6 | V                |
| $V_{IH}$                            | Digital high input level for CHG_EN, DSG_EN, PCHG_EN, CP_EN, PMON_EN |   | 1.2 |     |     | V                |
| $R_{PD}$                            | Internal Pull down   | VIN = 5 V   | 0.6 | 1   | 4   | $\text{M}\Omega$ |
| <b>CHARGE FET DRIVER</b>            |  |   |     |     |     |                  |
| $V_{(CHGFETON)}$                    | CHG gate drive voltage (on)  | $C_L = 10\text{ nF}$ , CHG_EN = Hi, $V_{(BAT)} = V_{(PACK)}$ , $V_{(CHG)} - V_{(BAT)}$  | 9   | 12  | 14  | V                |
| $R_{(CHGFETON)}$                    | CHG FET driver on resistance   | $V_{(VDDCP)} - V_{(BAT)} = 12\text{ V}$ , CHG_EN = Hi, $V_{(BAT)} = V_{(PACK)}$         |     | 1.1 |     | $\text{k}\Omega$ |
| $R_{(CHGFETOFF)}$                   | CHG FET driver off resistance  | $V_{(VDDCP)} - V_{(BAT)} = 12\text{ V}$ , CHG_EN = Lo, $V_{(BAT)} = V_{(PACK)}$         |     | 0.3 |     | $\text{k}\Omega$ |
| <b>DISCHARGE FET DRIVER</b>         |  |   |     |     |     |                  |
| $V_{(DSGFETON)}$                    | DSG gate drive voltage (on)  | $C_L = 10\text{ nF}$ , DSG_EN = Hi, $V_{(BAT)} = V_{(PACK)}$ , $V_{(DSG)} - V_{(PACK)}$ | 9   | 12  | 14  | V                |
| $R_{(DSGFETON)}$                    | DSG FET driver on resistance   | $V_{(VDDCP)} - V_{(BAT)} = 12\text{ V}$ , DSG_EN = Hi, $V_{(BAT)} = V_{(PACK)}$         |     | 3.5 |     | $\text{k}\Omega$ |
| $R_{(DSGFETOFF)}$                   | DSG FET driver off resistance  | $V_{(VDDCP)} - V_{(BAT)} = 12\text{ V}$ , DSG_EN = Lo, $V_{(BAT)} = V_{(PACK)}$         |     | 1   |     | $\text{k}\Omega$ |
| <b>PRECHARGE FET DRIVER</b>         |  |   |     |     |     |                  |
| $V_{(PCHGFETON)}$                   | PCHG gate drive voltage (on)   | $V_{(PACK)} > 17\text{ V}$ , $V_{(BAT)} < V_{(PACK)}$ , $V_{(PACK)} - V_{(PCHG)}$       | 5   | 12  | 14  | V                |
| <b>PACK MONITOR (PACK_DIV)</b>      |  |   |     |     |     |                  |
| $R_{(PMONFET)}$                     | On resistance of internal FET (R between PACK and PACKDIV)           | PMON_EN = hi  | 1.5 | 2.5 | 3.5 | $\text{k}\Omega$ |

(1) NORMAL mode is defined as CHG\_EN = Hi, DSG\_EN = Hi, CP\_EN = Hi, PCHG\_EN = Lo, PMON\_EN = Lo. Current value is averaged out over time.

### 6.6 Timing Requirements

| Parameter        | Description                                  | TEST CONDITION   | MIN | TYP | MAX | UNIT          |
|------------------|--|--|-----|-----|-----|---------------|
| $t_{CHGFETON}$   | CHG on rise time + propagation delay         | $C_L = 10\text{ nF}$ , (20% of CHG_EN from Lo to Hi) to (80% of $V_{(CHGFETON)}$ ), CP_EN = Hi, (CP is already on) |     | 27  | 45  | $\mu\text{s}$ |
| $t_{CHGFETOFF}$  | CHG off fall time + propagation delay        | $C_L = 10\text{ nF}$ , (80% of CHG_EN from Hi to Lo) to (20% of $V_{(CHGFETON)}$ ), CHG_EN = Hi to Lo              |     | 7   | 20  | $\mu\text{s}$ |
| $t_{PROP\_CHG}$  | CHG EN to CHG output                         | $C_L = 10\text{ nF}$ , CP_EN = Hi, (CP is already on), see timing diagram  |     | 0.5 |     | $\mu\text{s}$ |
| $t_{DSGFETON}$   | DSG on rise time + propagation delay         | $C_L = 10\text{ nF}$ , (20% of DSG_EN from Lo to Hi) to (80% of $V_{(DSGFETON)}$ ), CP_EN = Hi, (CP is already on) |     | 24  | 50  | $\mu\text{s}$ |
| $t_{DSGFETOFF}$  | DSG off fall time + propagation delay        | $C_L = 10\text{ nF}$ , (80% of DSG_EN from Hi to Lo) to (20% of $V_{(DSGFETON)}$ )                                 |     | 7   | 20  | $\mu\text{s}$ |
| $t_{PROP\_DSG}$  | DSG EN to DSG output propagation delay       | $C_L = 10\text{ nF}$ , CP_EN = Hi, (CP already on), see timing Diagram   |     | 0.5 |     | $\mu\text{s}$ |
| $t_{PCHGOFF}$    | PCHG turn off time + propagation delay       | $C_L = 1\text{ nF}$ , (20% of PCHG_EN from Hi to Lo) to (80% of $V_{(PCHGFETON)}$ )                                |     | 30  | 55  | $\mu\text{s}$ |
| $t_{PCHGON}$     | PCHG turn on time + propagation delay        | $C_L = 1\text{ nF}$ , (80% of PCHG_EN from Lo to Hi) to (20% of $V_{(PCHGFETON)}$ )                                |     | 34  | 55  | $\mu\text{s}$ |
| $t_{PROP\_PCHG}$ | PCH_EN to PCHG propagation delay             | $C_L = 1\text{ nF}$  |     | 0.5 |     | $\mu\text{s}$ |
| $t_{PROP\_PMON}$ | PMON_EN and PACKDIV = PACK propagation delay |  |     | 0.5 |     | $\mu\text{s}$ |

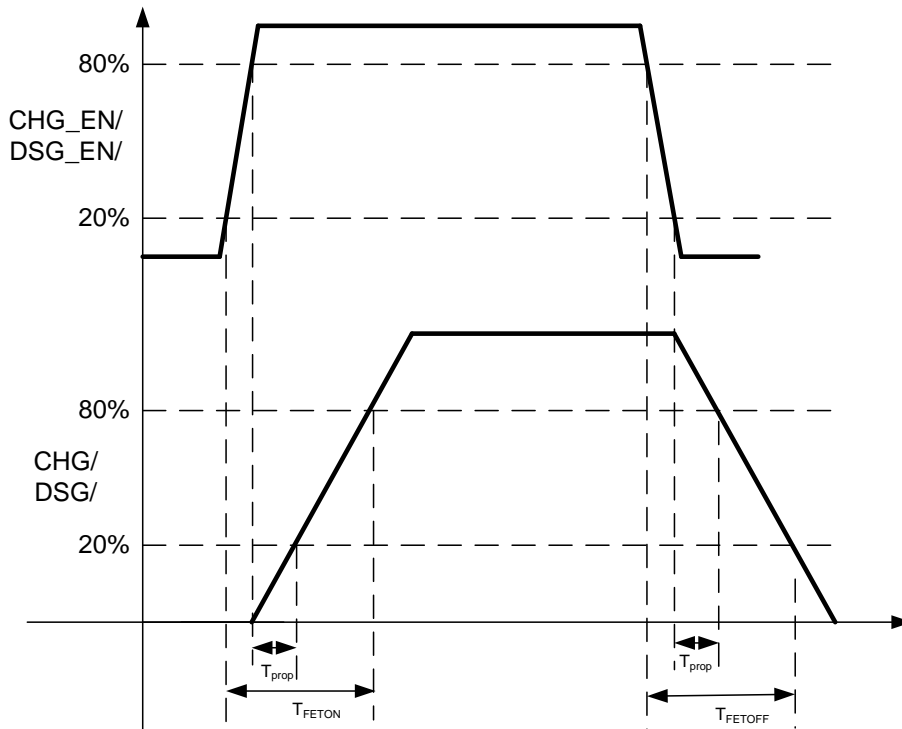


图 1. Timing Characteristics - ( CP assumed to be already On)

## 6.7 Typical Characteristics

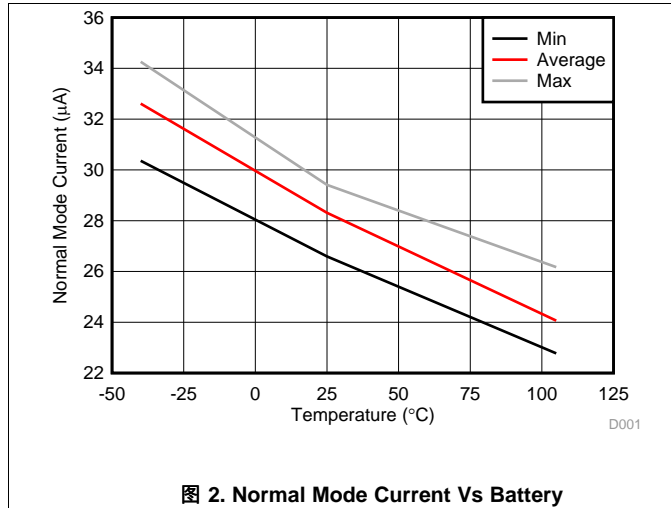


图 2. Normal Mode Current Vs Battery

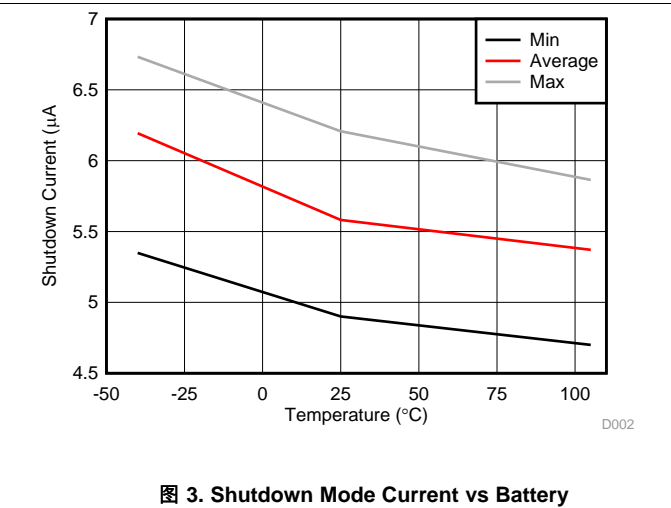


图 3. Shutdown Mode Current vs Battery

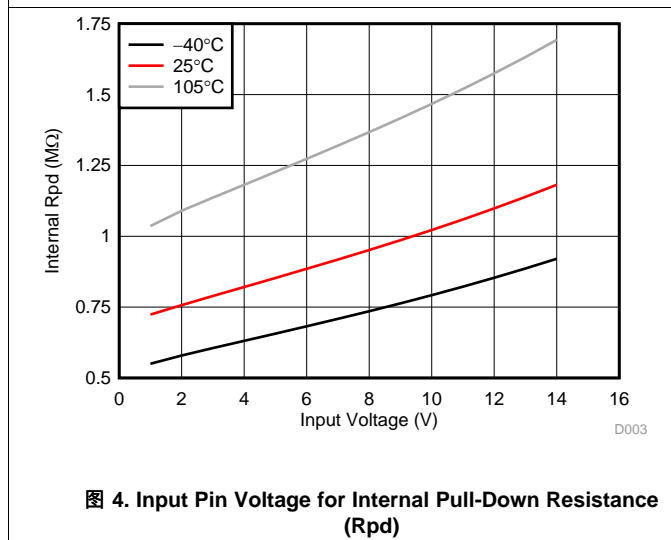


图 4. Input Pin Voltage for Internal Pull-Down Resistance (Rpd)

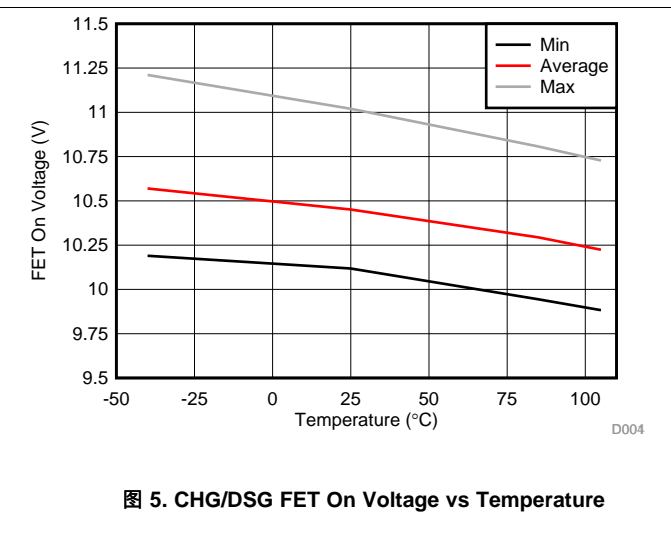


图 5. CHG/DSG FET On Voltage vs Temperature

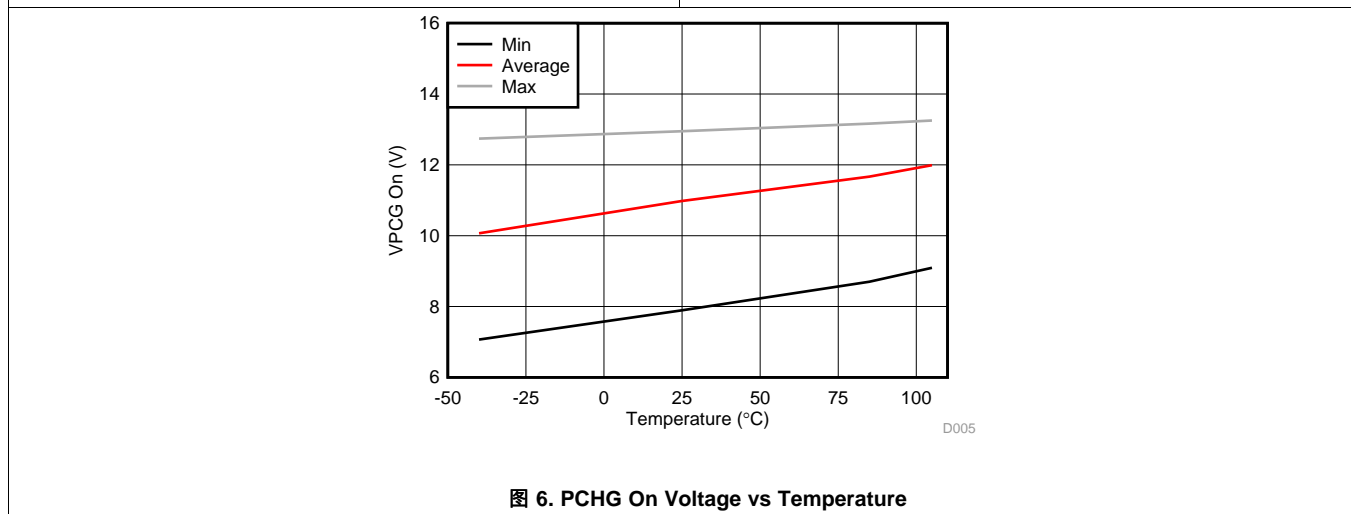


图 6. PCHG On Voltage vs Temperature

## 7 Detailed Description

### 7.1 Overview

The bq76200 device is a low-power, high-side, N-Channel MOSFET driver for battery-pack protection systems, allowing a low-side battery-protection system to be implemented into a high-side protection system.

High-side charge/discharge FETs offer a huge advantage versus their low-side counterparts; with high-side implementation, a system-side processor can always communicate with the monitor or micro-controller (MCU) within the battery pack, regardless of whether the FETs are on or off — this is not easily supported in a low-side switching architecture due to the lack of a shared ground reference. One key benefit of an ever-present communication link is the ability to read out critical pack parameters despite safety faults, thereby enabling the system to assess pack conditions before determining if normal operation may resume.

The device allows independent control on charging and discharge via the digital enable pins. The device has integrated charge pump which is enabled by the CP\_EN pin. The enable inputs, CHG\_EN, DSG\_EN, and PCHG\_EN control the CHG, DSG, and PCHG FET gate drivers, respectively. The enable inputs can be connected to low-side FET driver outputs of an Analog Front End (AFE) such as Texas Instruments bq769x0 series, a general purpose microcontroller, or dedicated battery pack controller such as the bq783xx series.

In normal mode, the AFE or MCU enables the CHG\_EN and DSG\_EN, turning on the CHG and DSG FET drivers to connect the battery power to the PACK+ terminal. When a fault is detected by the AFE or the microcontroller, it can disable the CHG\_EN and/or DSG\_EN to open the charge or discharge path for protection. Note that when either the CHG\_EN or DSG\_EN is enabled, the charge pump will be automatically enabled even if the CP\_EN is in the disable state. It is recommended to enable the charge pump via CP\_EN pin during system start-up to avoid adding the  $t_{CPON}$  time into the FET switching time during normal operation.

A lower charging current is usually applied to a deeply depleted battery pack. The bq76200 PCHG\_EN input provides an option to implement a P-Channel MOSFET pre-charge path (current-limited path) in the battery pack.

An AFE usually provides individual cell voltages and/or battery stack voltage measurements, but it is not necessary to have PACK+ voltage measurement. The bq76200 PMON\_EN pin, when enabled, will connect the PACK+ voltage onto the PACKDIV pin, which is connected to an external resistor divider to scale down the PACK+ voltage. This scaled down PACK+ voltage can be connected to a microcontroller's ADC input for voltage measurement. The system can use this information for charger detection or to implement advanced charging control.

For safety purposes, all the enable inputs are internally pulled down. If the AFE or microcontroller is turned off, or if the PCB trace is damaged, the internal pull down of the enable inputs will keep CHG, DSG, PCHG in an off state and the PACK+ voltage does not switch onto the PACKDIV pin.



## 7.2 Functional Block Diagram

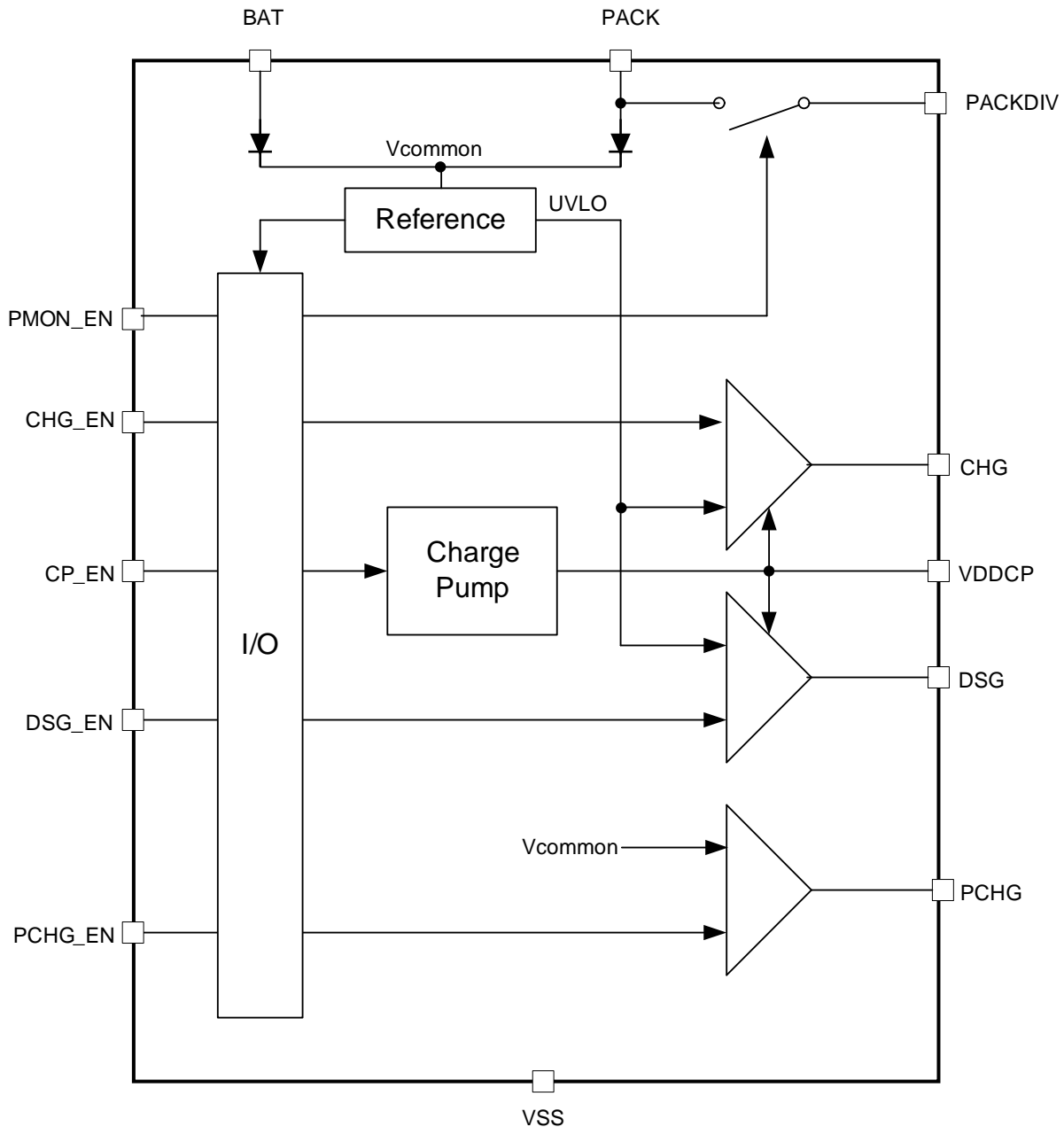


图 7. Functional Block Diagram

## 7.3 Feature Description

### 7.3.1 Charge Pump Control

The bq76200 device has an integrated charge pump. A minimum of 470-nF capacitor is required on the  $V_{(VDDCP)}$  pin to the BAT pin to ensure proper function of the charge pump. If the  $V_{(VDDCP)}$  capacitor is disconnected, a residual voltage could reside at the CHG and/or DSG output if CHG\_EN and/or DSG\_EN are enabled. Such a fault condition can put the external FETs in high  $R_{ds(on)}$  state and result in FET damage.

## Feature Description (接下页)

The  $V_{(VDDCP)}$  capacitor can be scaled up to support more FETs in parallel (such as high-total FET-gate capacitance) than the value specified in the electrical characteristics table. A higher VDDCP capacitance results in longer  $t_{CPON}$  time. See the [Application Information](#) section for more information. Note that probing the VDDCP pin may increase the loading on the charge pump and result in lower measurement value than the  $V_{(VDDCP)}$  specification. Using higher impedance probe can reduce such effect on the measurement.

The charge pump is controlled by CP\_EN and also OR'ed with the CHG\_EN and DSG\_EN inputs. This means by enabling CHG\_EN or DSG\_EN alone, the charge pump will automatically turn on even if the CP\_EN pin is disabled. The PCHG\_EN controls the PCHG pin, which is a P-channel FET driver and does not require the function of the charge pump. The charge pump is turned off by default. When CP\_EN is high, the charge pump turns on regardless of the status of the CHG\_EN and DSG\_EN inputs.

When CP\_EN is enabled, the charge pump voltage starts to ramp up. Once the voltage is above an internal UVLO level, about 9-V typical above  $V_{BAT}$ , the charge pump is considered on. The charge pump voltage should continuously ramp to the  $V_{(VDDCP)}$  level. If the CHG\_EN and/or DSG\_EN is enabled, the CHG and/or DSG voltage will start to turn on after the charge pump voltage is above the UVLO level, and ramp up along the charge pump voltage to the  $V_{(VDDCP)}$  level. Otherwise, the CHG and DSG do not turn on if the charge pump voltage fails to ramp up above UVLO. For example, if the  $C_{(VDDCP)}$  is not scaled properly to support the number of FETs in parallel, the heavy loading would prevent the charge pump to ramp up above UVLO. CHG and DSG would not be turned on in this case.

When CHG\_EN and/or DSG\_EN is enabled after the charge pump is fully turned on, the CHG\_EN-enable to CHG-on delay (or DSG\_EN-enable to DSG-on delay) is simply the sum of ( $t_{prop}$  + FET rise time). A system configuration example for this scenario will be connecting the CP\_EN to the host MCU, enable CP\_EN at system start-up and keep the CP\_EN enabled during normal operation. This is the recommended configuration, because the charge pump ramp-up time,  $t_{CPON}$ , becomes part of the system start-up time and does not add onto the FET switch delay during normal operation.

If CP\_EN is not used (it is highly recommended to connect the CP\_EN to ground), the charge pump on- and off-state is controlled by CHG\_EN or DSG\_EN. The CHG or DSG output will only be on after the charge-pump voltage is ramped up above UVLO. This means the CHG\_EN-enable to CHG-on delay (or DSG\_EN-enable to DSG-on delay) will be ( $t_{CPON}$  +  $t_{prop}$  + FET rise time).

The charge pump is turned off when CP\_EN AND CHG\_EN AND DSG\_EN signals are all low. The charge pump is not actively driven low and the voltage on the  $V_{(VDDCP)}$  capacitor bleeds off passively. If any of the CP\_EN, CHG\_EN, or DSG\_EN signals is switched high again while the  $V_{(VDDCP)}$  capacitor is still bleeding off its charge, the charge pump start up time,  $t_{CPON}$ , will be shorter.

### 7.3.2 Pin Enable Controls

The bq76200 has four digital enable inputs that control the state of associated output signals as defined in the following table. The  $V_{IH}$  and  $V_{IL}$  levels of these enable pins are low enough to work with most MCUs. At the same times, the pins have high enough tolerant to allow direct control from an AFE FET driver. This gives system maker a flexible option to architect the battery pack configuration.

| INPUT PIN | ASSOCIATED OUTPUT PIN | DESCRIPTION            |
|-----------|-----------------------|------------------------|
| CHG_EN    | CHG                   | Charge FET control     |
| DSG_EN    | DSG                   | Discharge FET control  |
| PCHG_EN   | PCHG                  | Pre-charge FET control |
| PMON_EN   | PACKDIV               | Pack monitor control   |

### 7.3.2.1 External Control of CHG and DSG Output Drivers

The CHG\_EN and DSG\_EN pins provide direct control of the CHG and DSG FET driver. 表 1 summarizes the CHG and DSG statute with respect to the CP\_EN, CHG\_EN and DSG\_EN inputs.

**表 1. CHG and DSG with Respect to CP\_EN, CHG\_EN, and DSG\_EN**

| CP_EN        | CHG_EN       | DSG_EN       | CHARGE PUMP   | CHG           | DSG           |
|--------------|--------------|--------------|---------------|---------------|---------------|
| Lo (default) | Lo (default) | Lo (default) | OFF (default) | OFF (default) | OFF (default) |
| Lo           | Lo           | Hi           | ON            | OFF           | ON            |
| Lo           | Hi           | Lo           | ON            | ON            | OFF           |
| Lo           | Hi           | Hi           | ON            | ON            | ON            |
| Hi           | Lo           | Lo           | ON            | OFF           | OFF           |
| Hi           | Lo           | Hi           | ON            | OFF           | ON            |
| Hi           | Hi           | Lo           | ON            | ON            | OFF           |
| Hi           | Hi           | Hi           | ON            | ON            | ON            |

### 7.3.2.2 External Control of PCHG Output Driver

The PCHG output driver is designed to drive a P-channel FET and is controlled by the PCHG\_EN pin. The PCHG driver provides an option to implement a separate charging path with a P-channel FET to charge the battery when the cells are deeply depleted. A resistor should be added in series to the P-channel pre-charge FET to limit the charging current. A pre-charge current is usually at or less than 1/20 of the normal charge current if the charger does not support lower current pre-charge. Refer to the battery cell specification from the cell manufacturer charging for the appropriate current limit.

| PCHG_EN      | PCHG          |
|--------------|---------------|
| Lo (default) | OFF (default) |
| Hi           | ON            |

### 7.3.2.3 Pack Monitor Enable

The bq76200 device provides an internal-switch control to post the PACK+ voltage on to the PACKDIV pin. A resistor divider can be connected to the PACKDIV pin externally to divide down the PACK+ voltage into a measurable range of an MCU. The PMON\_EN controls the internal switch between PACK pin and PACKDIV pin. The internal switch has an on resistance of  $R_{(PMONFET)}$ . The external resistor divider for PACKDIV pin should be selected to avoid exceeding the absolute maximum of the PACKDIV pin and should also keep the loading current < 500  $\mu$ A. If this function is not used, the PACKDIV pin should leave floating. To reduce power consumption, the PMON\_EN should be enabled only when PACK+ voltage measurement is needed.

| PMON_EN      | PACKDIV            |
|--------------|--------------------|
| Lo (default) | DISABLED (default) |
| Hi           | ENABLED            |

## 7.4 Device Functional Modes

- In NORMAL mode, the bq76200 charge pump is turned on by enabling either CP\_EN, CHG\_EN, or DSG\_EN. In this mode, typically the CHG and DSG outputs are driven to  $V_{(BAT)} + V_{(VD DCP)}$ .
- In SHUTDOWN mode, the bq76200 is completely powered down. When CHG\_EN, DSG\_EN, and CP\_EN are driven low, the device enters SHUTDOWN mode, and the outputs are driven low.

| DEVICE MODES | CONDITION  |
|--------------|--|
| NORMAL       | CHG_EN = Hi, DSG_EN = Hi, CP_EN = Hi, PCHG_EN = don't care, PMON_EN = don't care |
| SHUTDOWN     | CHG_EN = Lo, DSG_EN = Lo, CP_EN = Lo, PCHG_EN = Lo, PMON_EN = Lo                 |

## 8 Application and Implementation

### 注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The bq76200 device is a high-side NMOS FET driver with integrated charge pump. The device can convert a low-side battery protection system into a high-side protection system, allowing the battery monitor device or battery MCU to always maintain communication to the host system regardless if the protection FETs are on or off. The device provides independent enables to control charge and discharge of a battery pack.

The following section highlights several recommended implementations when using this device. A detail bq76200 Application Note, [SLVA729](#), is available at [www.ti.com](http://www.ti.com).

#### 8.1.1 Recommended System Implementation

##### 8.1.1.1 *The bq76200 is a Slave Device*

The bq76200 is a FET driver. It controls the output pins (CHG, DSG, PCHG, and PACKDIV) according to the input pin (CHG\_EN, DSG\_EN, PCHG\_EN, CP\_EN, and PMON\_EN) status. The device does not validate if the inputs should or should not be turned on or off. For example, if both CHG\_EN and PCHG\_EN are enabled, bq76200 will turn on both CHG and PCHG simultaneously, enabling two charging paths to the system. The system designer should avoid undesirable enable combination via schematic, AFE, or host MCU implementation.

##### 8.1.1.2 *Flexible Control via AFE or via MCU*

The bq76200 device has simple-logic input pins (CHG\_EN, DSG\_EN, PCHG\_EN, CP\_EN, and PMON\_EN) that can accept a control signal from any MCU I/O. At the same time, the input pins are designed to tolerate high voltage signal such as the FET driver output from an AFE. This flexibility allows a mix of control input driving from AFE and/or MCU to optimize the system design.

For example, it is recommended to control the CP\_EN pin via MCU which the system can turn on the charge pump at system start-up, excluding the extra FET delay due to charge pump voltage ramping. On the other hand, the CHG\_EN and DSG\_EN can be driven by the AFE FET driver output, especially if the AFE has hardware protection features (such as the bq76920/30/40 family), to optimize the FET reaction time.

All the input pins have internal pull-down resistor. The outputs are default to be off if any of the input pins are at high-Z state.

##### 8.1.1.3 *Scalable VDDCP Capacitor to Support Multiple FETs in Parallel*

The bq76200 requires a minimum 470-nF capacitor to be connected between the VDDCP pin and BAT pin in order to turn on the integrated charge pump. The Electrical Characteristics Specification of this document specified the device performance based on 10 nF loading with 470-nF VDDCP capacitor. The loading capacitance varies with FET choices, number of FETs in use, and in parallel and simultaneous switching versus sequential switching of CHG and DSG FET.

The more FETs that are in parallel, the higher the loading capacitance. Similarly, simultaneously switching of the CHG and DSG FET loads down the charge pump more than sequentially switching both FETs. Eventually, the loading capacitance can exceed the supported range of a 470-nF VDDCP capacitor. A > 470-nF VDDCP capacitor can be used to support higher-loading capacitance.

Application Information (接下页)

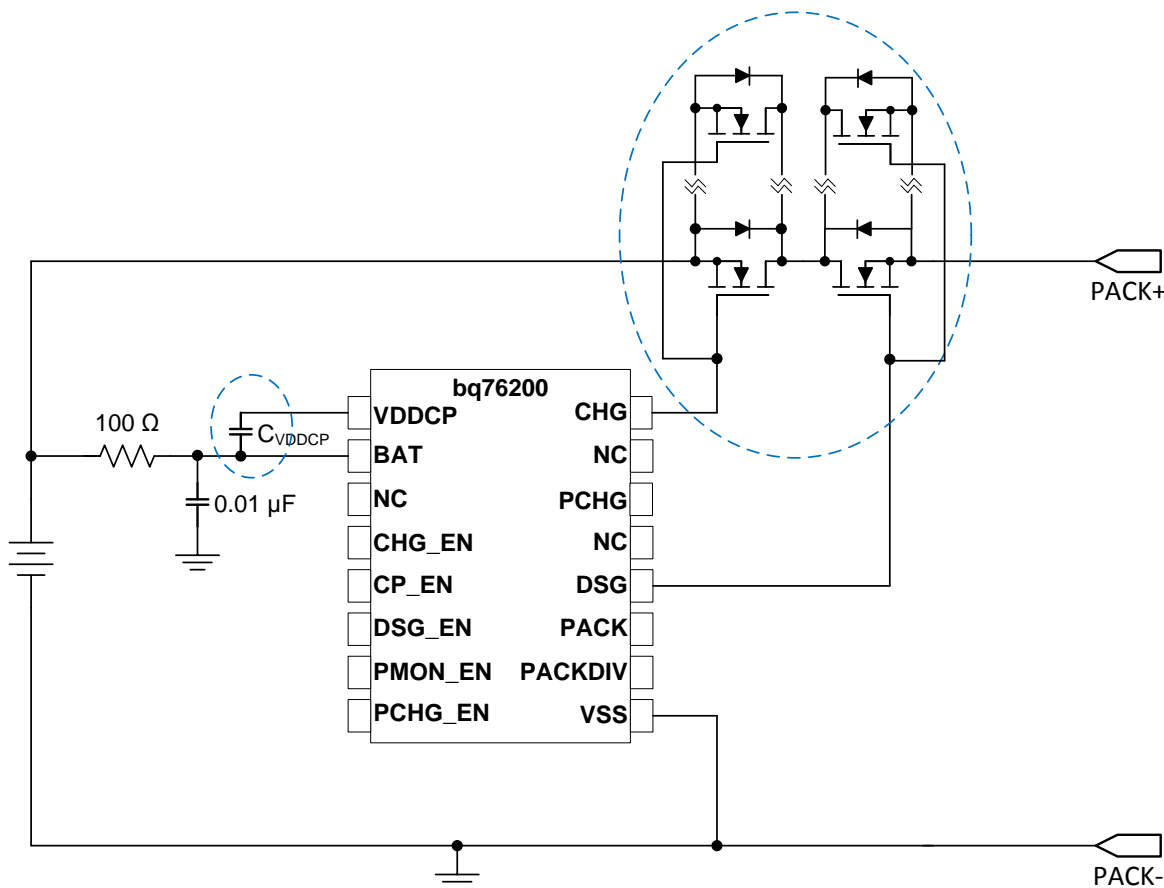


图 8. Scale  $C_{VDDCP}$  to Support Multiple FETs in Parallel (Partial Schematic Shown)

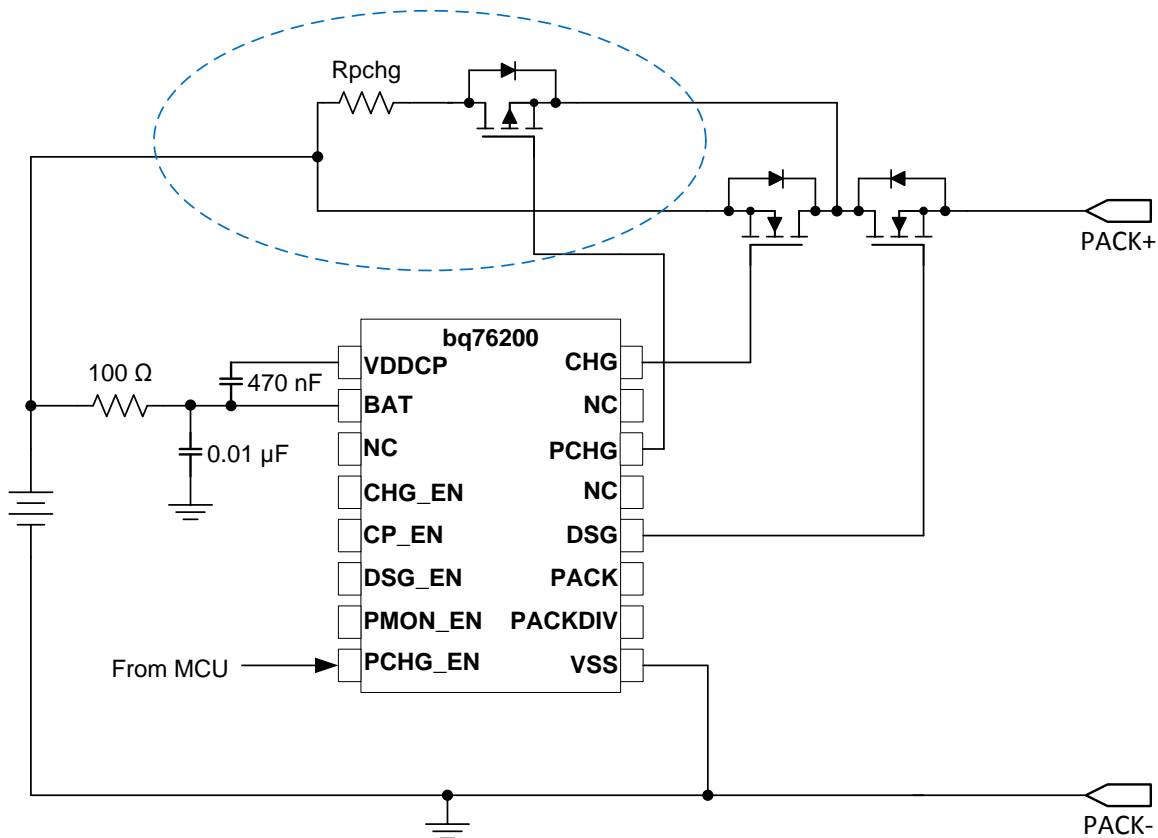
Based on test results, 470-nF VDDCP capacitor can support up to approximately 30-nF loading capacitance. Using a 470-nF/20-nF ratio (to include some design margin), a 2.1- $\mu$ F VCCDP capacitor can support up to ~90 nF loading capacitance. Note that a larger VDDCP capacitor increases the charge pump start up time; a higher loading capacitance increases the FET on and off time. System designers should test across the operation range to ensure the design margin and system performance. Refer to the bq76200 Application note for more test results.

Also notice that any damage or disconnection of the VDDCP capacitor during operation can leave a residual voltage on the FET driver output if the inputs are enabled. This can result in putting the external FETs in a high-R<sub>ds(on)</sub> state and cause FET damage.

**8.1.1.4 Pre-Charge and Pre-Discharge Support**

For a deeply depleted battery pack, a much lower charging current, for example, a C/10 rate, is usually used to pre-charge the battery cells. This allows the passivating layer of the cell to be recovered slowly (the passivating layer might be dissolved in the deep discharge state).

The bq76200 has a PCHG output to drive an external P-channel FET to support battery pre-charge. In this scenario, the external P-channel FET is placed in parallel with the CHG FET and a power resistor can be connected in series of the P-channel FET to limit the charging current during the pre-charge state. The MCU can be used to control the PCHG\_EN pin to determine the entry and exit of the pre-charge mode.

**Application Information (接下页)**

**图 9. P-channel FET in Parallel With CHG FET for Pre-Charging (Partial Schematic Shown)**

Alternatively, the CHG pin can also be used to pre-charge a battery pack given if the charging current is controlled by the system (i.e. does not require external component to limit the charging current such as a smart charger) and the battery stack voltage is higher than minimum operation voltage of the bq76200 (i.e. the charge pump can start to turn on the CHG FET). PCHG should leave floating if it is not used in the application.

The PCHG output can be used to pre-discharge a high-capacitive system. For example, a load removal can be one of the recovery requirements after a discharge related fault has been detected. In a high-capacitive system, the residual voltage at the system side can take a significant time to bleed off. This results in an additional delay in fault recovery. The PCHG output can be used to control an external P-channel FET placed in parallel with the DSG FET to pre-discharge the residual voltage in order to speed up the fault recovery process.

Application Information (接下页)

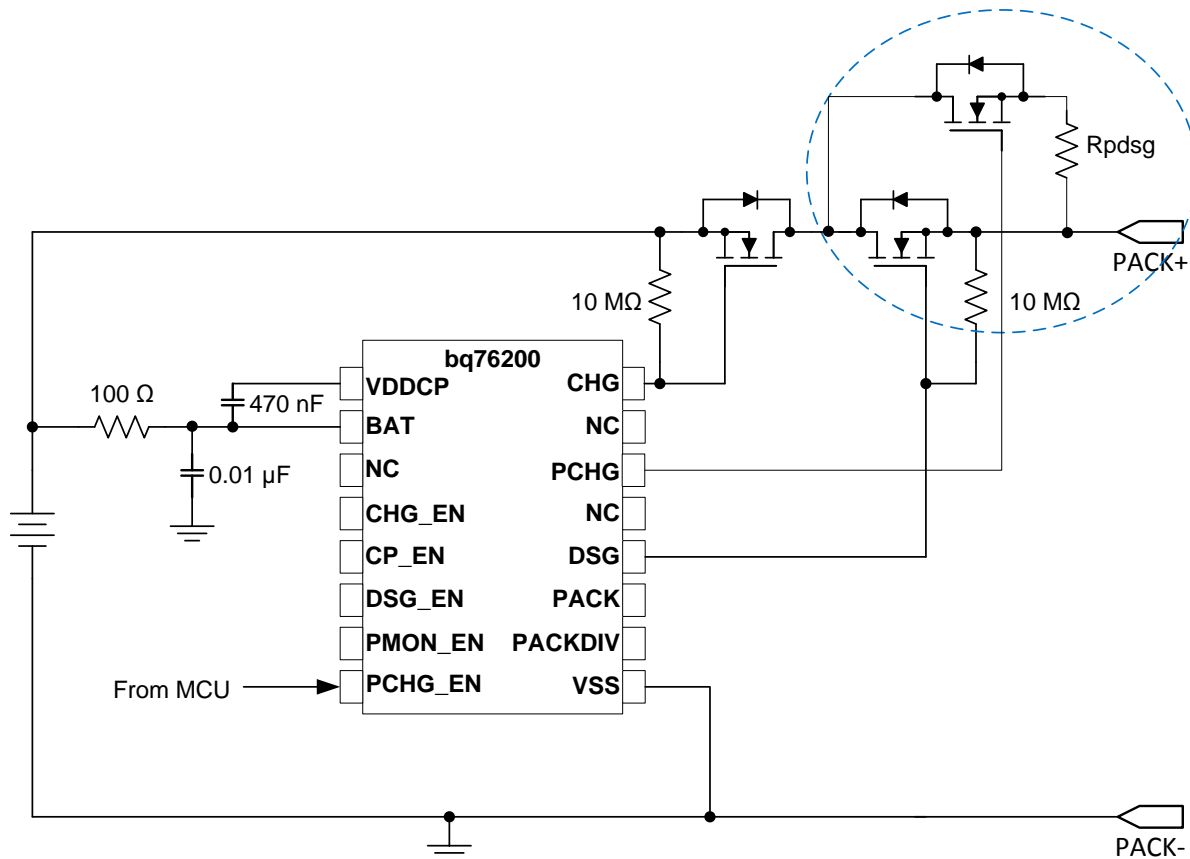


图 10. P-channel FET in Parallel with DSG FET for Pre-Discharging (Partial Schematic Shown)

8.1.1.5 Optional External Gate Resistor

The CHG and DSG have certain internal on and off resistance. However, an optional external gate resistor can be added to CHG and/or DSG FET to slow down the FET on and off timing.

8.1.1.6 Separate Charge and Discharge paths

In some systems, the charging current might be significantly lower than the discharge current. In such systems, the system designer may prefer to implement a separate charge and discharge paths in which the number of FET in parallel for charge and discharge can be different to reduce to BOM cost.

Application Information (接下页)

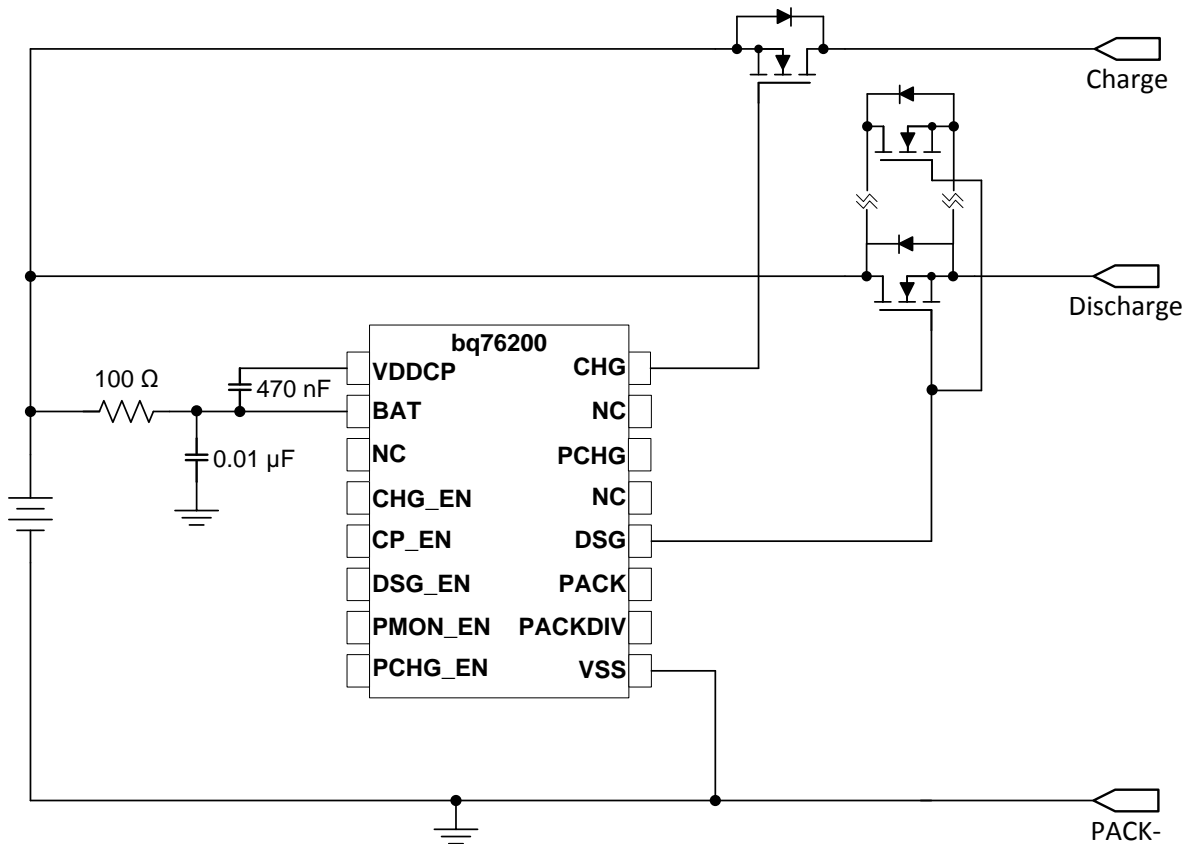
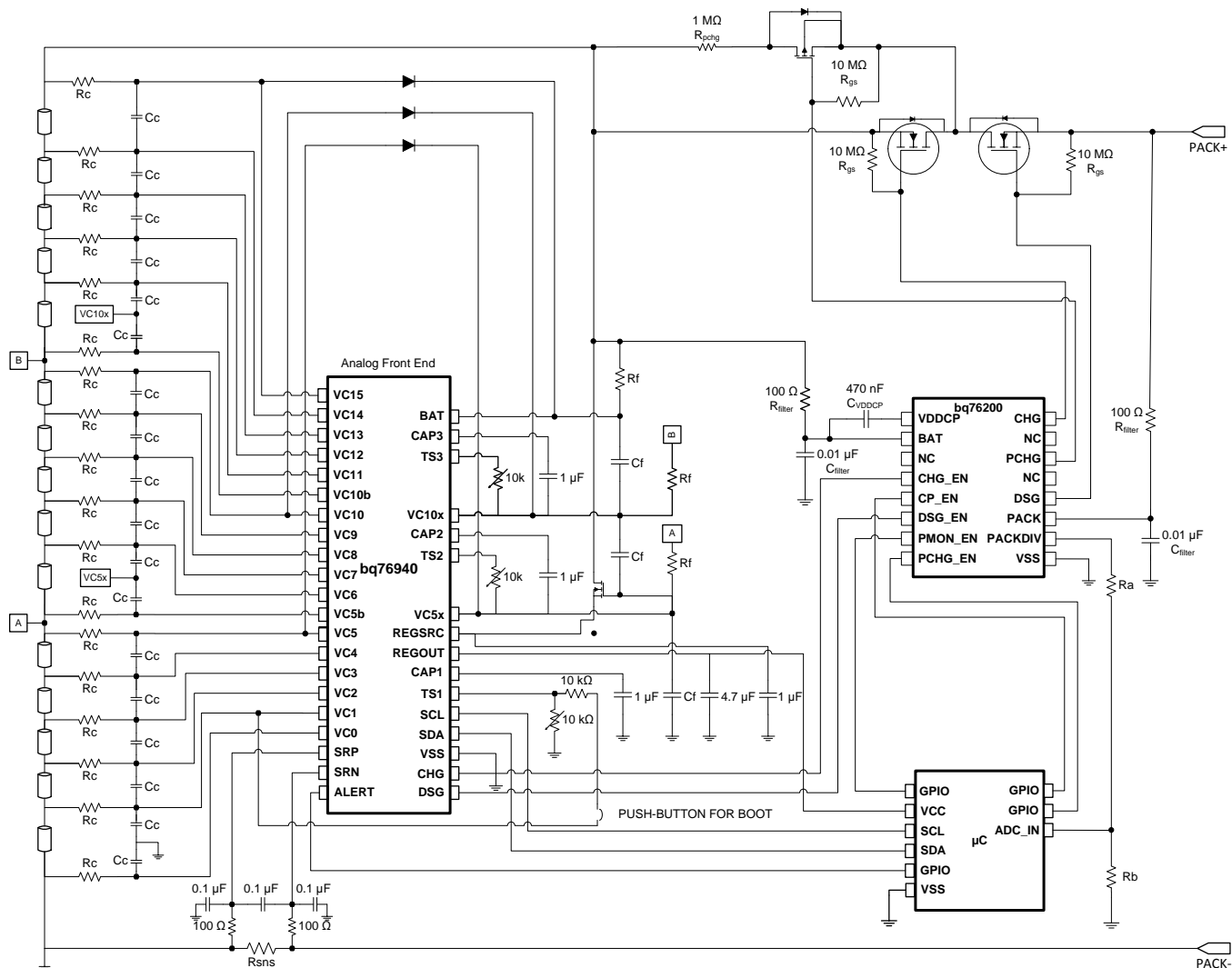


图 11. Separate Charge and Discharge Paths (Partial Schematic Shown)



## 8.2 Typical Applications



### 8.2.1 Design Requirements

For this design example, use the parameters listed in [表 2](#).

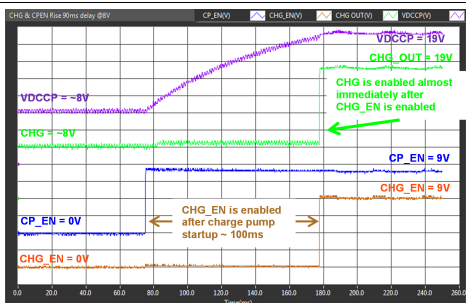
表 2. Design Parameters

| PARAMETER                           | EXTERNAL COMPONENT  | NOTE  |
|-------------------------------------|---------------------|---|
| BAT and PACK Filters                | Rfilter and Cfilter | Recommended to use 100 Ω and 0.01 μF.   |
| VDDCP capacitor                     | CVDDCP              | A minimum of 470 μF is required. A higher value can be used to support higher-loading capacitance. See Recommended Implementation and bq76200 Application Note () for details.      |
| PACKDIV resistor divider            | Ra and Rb           | Based on the max PACK voltage of the application, calculate the total value of (Ra + Rb) that can keep the PACKDIV current below 500 μA.  |
| CHG, DSG, PCHG gate-source resistor | Rgs                 | Recommended to use 10 MΩ. A different Rgs value may change the loading level of the charge pump. System designer should perform thorough system testing if a different Rgs is used. |

### 8.2.2 Detailed Design Procedure

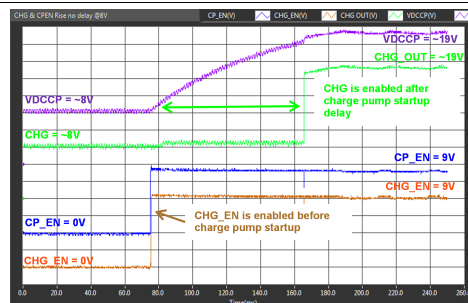
1. Determine if CP\_EN pin will be driven by MCU. It is highly recommended to use CP\_EN to turn on the charge pump at system start-up. However, it is not a must to operate the bq76200 to switch on CHG and DSG pins. System designer should ensure the FET's turn on time is acceptable during normal operation if CP\_EN is not enabled at system startup.
2. Select the correct VDDCP capacitance. Scaling up the VDDCP capacitance allows support for a higher number of FETs in parallel. This test result of various parallel FETs versus VDDCP capacitance in the bq76200 application is for general reference only. System designer should always validate their design tolerant across operation temperature range.
3. If the PMON\_EN is used, the PACKDIV resistor divider, Ra and Rb, must be selected to satisfy  $(Ra+Rb) < 500\mu A$ , AND  $[Rb/(Ra + Rb)] < (\text{max ADC input range})/(\text{max PACK+ voltage})$ . For example, In a 48V system, if the max charger voltage is 50.4V and a MCU's max ADC input is 3V. To meet both  $(Ra + Rb) < 500\mu A$ , AND  $[Rb/(Ra + Rb)] < (3V/50.4V)$  requirements, the Ra value might be 100 kΩ or less and Rb value might be 6 kΩ or less.
4. Follow the application schematic (see *Typical Applications*) to connect the device.

### 8.2.3 Application Curves



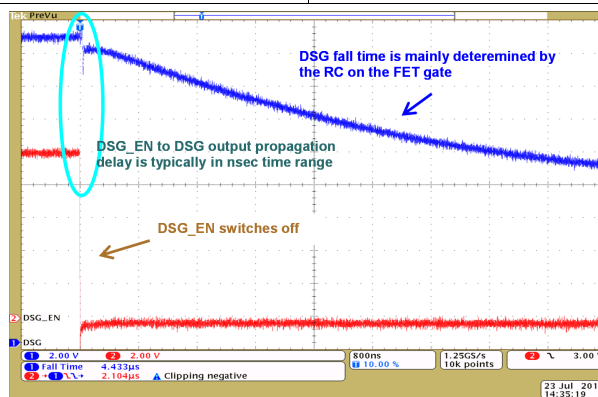
CHG output reacts to the CHG\_EN signal immediately. Similar behavior applies to DSG pin.

图 12. CHG\_EN Switched On After Charger Pump Turns On and is Stable



CHG output reacts to the CHG\_EN signal after charge pump startup delay. Similar behavior applies to DSG pin.

图 13. CHG\_EN Enabled Before Charge Pump is Turned On



With 10 nF loading and no Rgs on DSG output. Note the time scale was 800ns/div. Hence, the DSG waveform above was basically the DSG FET fall time

图 14. DSG\_EN to DSG Output Propagation Delay

## 9 Power Supply Recommendations

The maximum recommended operation voltage on the BAT and PACK pins is 75 V. The charge pump, when it turns on, will add 14 V maximum voltage on top of the BAT or PACK voltage to the device, pushing the total device voltage to approximately 89 V.

The bq76200 has high voltage (100 V) tolerant pins, but system designer should take into account the worst-case transient voltage and the maximum charge pump on voltage to determine the maximum voltage applying to BAT and PACK pins.

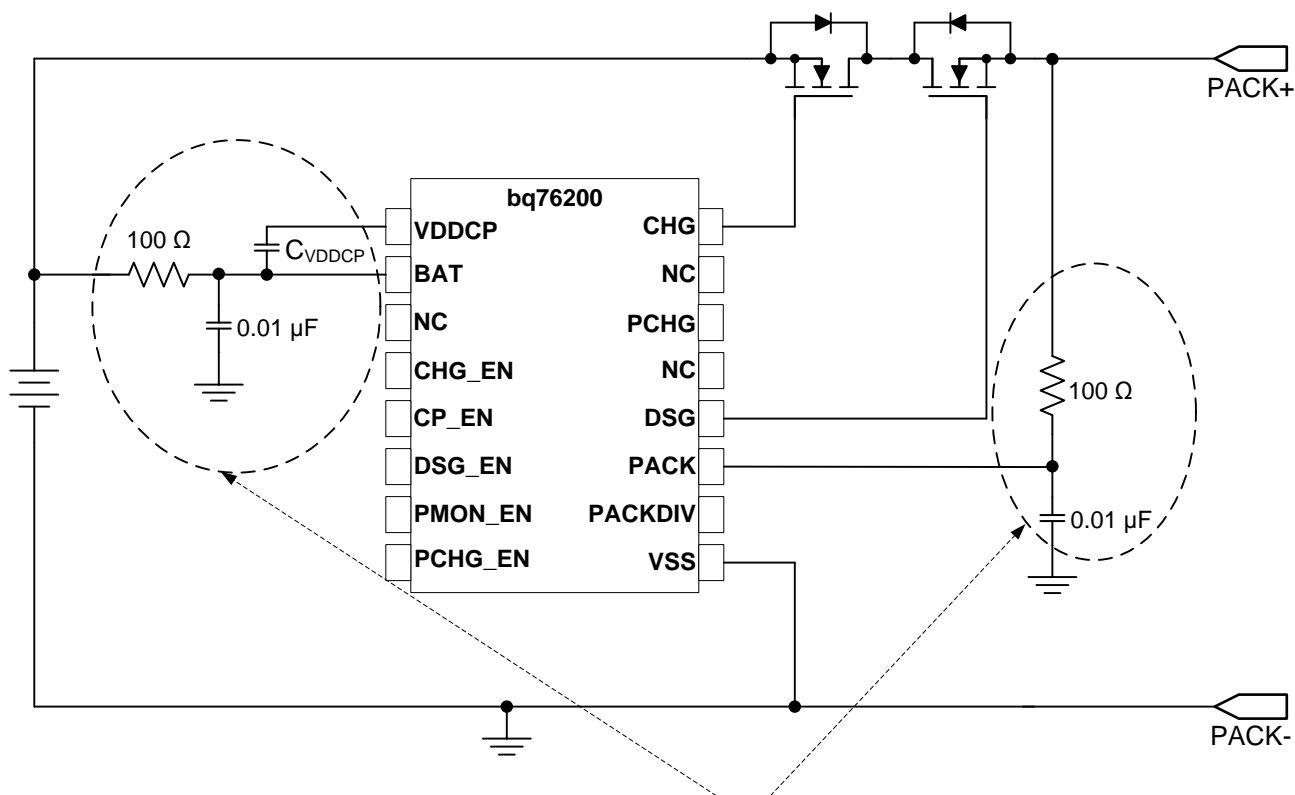
## 10 Layout

### 10.1 Layout Guidelines

For the following procedure, see [图 15](#) and [图 16](#).

1. Place  $C_{VDDCP}$  capacitor close to the device.
2. Place BAT and PACK RC filters close to the device.
3. Generally, a typical system using an AFE, MCU, and bq76200 usually have a high-current ground trace/plane and low-current ground plane in the PCB layout. If so, the bq76200 ground should be connected to the low-current ground plane of the PCB layout to remove noise affecting the ENABLE signals.

### 10.2 Layout Example



Place these components close to the device pins

图 15. Place  $C_{VDDCP}$  and Filter Components Close to Device

Layout Example (接下页)

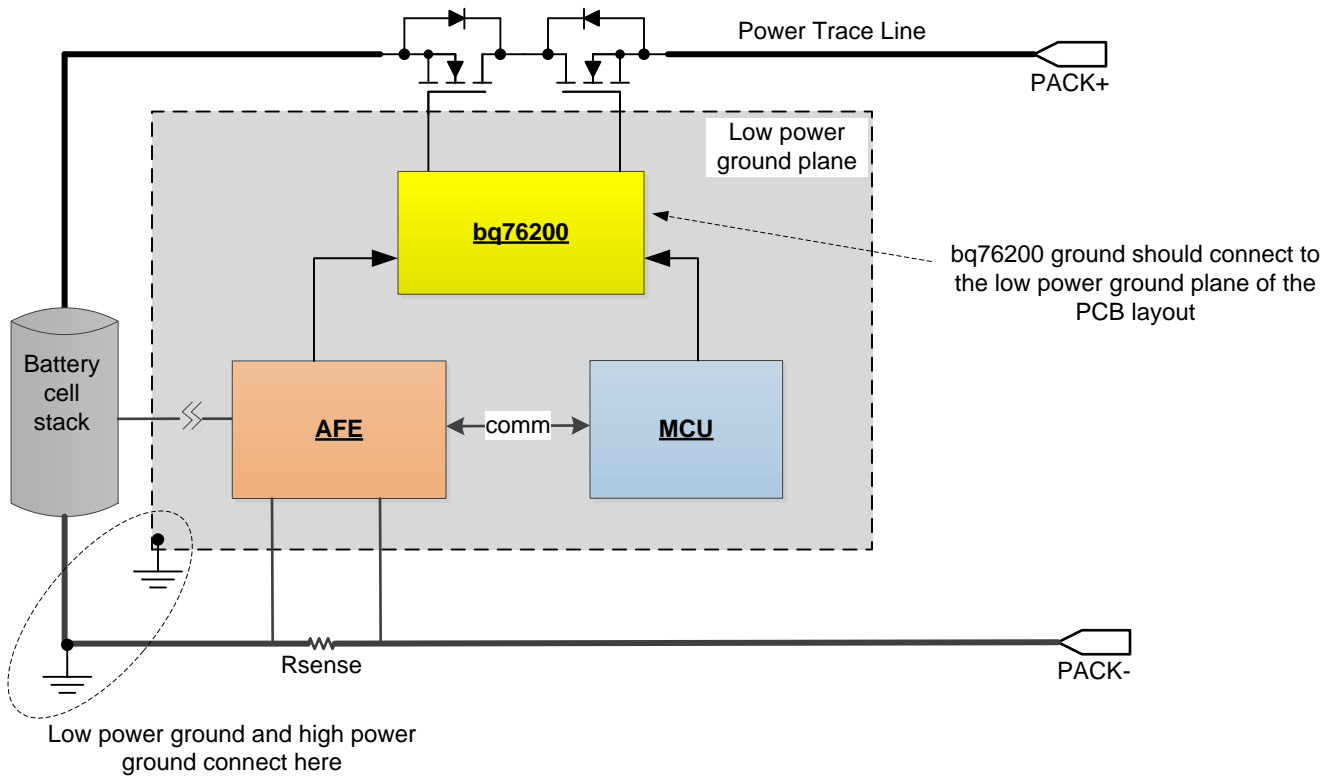


图 16. Connect bq76200 to Low Power Ground Plane on PCB Layout

## 11 器件和文档支持

### 11.1 文档支持

#### 11.1.1 相关文档

如需相关文档，请参见《*bq76200 FET 配置测试结果*》（文献编号：[SLVA729](#)）。

### 11.2 社区资源

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

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### 11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。 这些信息是针对指定器件可提供的最新数据。 这些数据会在无通知且不  
对本文档进行修订的情况下发生改变。 欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

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| 放大器和线性器件      | <a href="http://www.ti.com.cn/amplifiers">www.ti.com.cn/amplifiers</a>                     | 计算机及周边       | <a href="http://www.ti.com.cn/computer">www.ti.com.cn/computer</a>           |
| 数据转换器         | <a href="http://www.ti.com.cn/dataconverters">www.ti.com.cn/dataconverters</a>             | 消费电子         | <a href="http://www.ti.com.cn/consumer-apps">www.ti.com.cn/consumer-apps</a> |
| DLP® 产品       | <a href="http://www.dlp.com">www.dlp.com</a>   | 能源           | <a href="http://www.ti.com.cn/energy">www.ti.com.cn/energy</a>               |
| DSP - 数字信号处理器 | <a href="http://www.ti.com.cn/dsp">www.ti.com.cn/dsp</a>                                   | 工业应用         | <a href="http://www.ti.com.cn/industrial">www.ti.com.cn/industrial</a>       |
| 时钟和计时器        | <a href="http://www.ti.com.cn/clockandtimers">www.ti.com.cn/clockandtimers</a>             | 医疗电子         | <a href="http://www.ti.com.cn/medical">www.ti.com.cn/medical</a>             |
| 接口            | <a href="http://www.ti.com.cn/interface">www.ti.com.cn/interface</a>                       | 安防应用         | <a href="http://www.ti.com.cn/security">www.ti.com.cn/security</a>           |
| 逻辑            | <a href="http://www.ti.com.cn/logic">www.ti.com.cn/logic</a>                               | 汽车电子         | <a href="http://www.ti.com.cn/automotive">www.ti.com.cn/automotive</a>       |
| 电源管理          | <a href="http://www.ti.com.cn/power">www.ti.com.cn/power</a>                               | 视频和影像        | <a href="http://www.ti.com.cn/video">www.ti.com.cn/video</a>                 |
| 微控制器 (MCU)    | <a href="http://www.ti.com.cn/microcontrollers">www.ti.com.cn/microcontrollers</a>         |              |  |
| RFID 系统       | <a href="http://www.ti.com.cn/rfidsys">www.ti.com.cn/rfidsys</a>                           |              |  |
| OMAP应用处理器     | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                       |              |  |
| 无线连通性         | <a href="http://www.ti.com.cn/wirelessconnectivity">www.ti.com.cn/wirelessconnectivity</a> | 德州仪器在线技术支持社区 | <a href="http://www.deyisupport.com">www.deyisupport.com</a>                 |

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**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| BQ76200PW        | ACTIVE        | TSSOP        | PW              | 16   | 90          | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | BQ7620B                 | <a href="#">Samples</a> |
| BQ76200PWR       | ACTIVE        | TSSOP        | PW              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | BQ7620B                 | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

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NOTES: (continued)

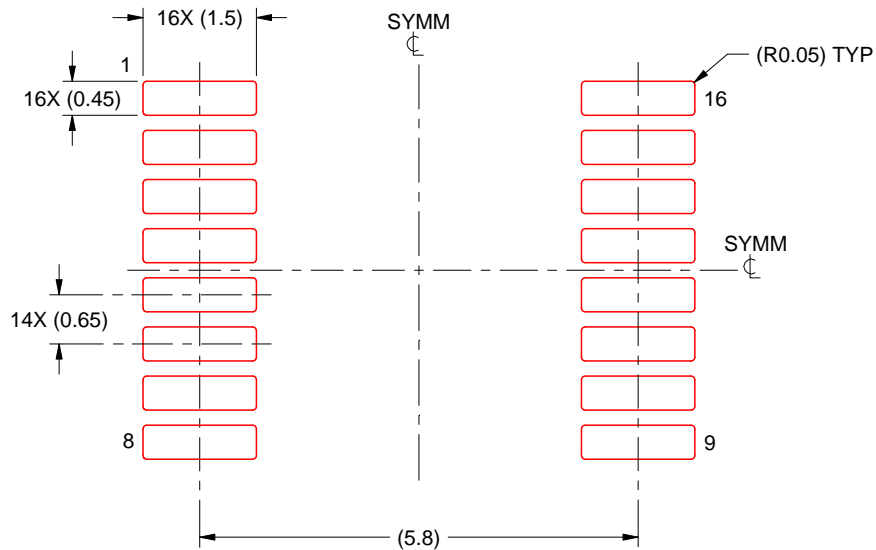
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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