Application Report
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# Minimizing Shutdown Current of the bq76200

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BMS: Monitoring and Protection

**ABSTRACT**

The bq76200 high-side N-channel FET driver has a quiescent supply current even when disabled. While the current is low, in some applications it is desirable to minimize load current during times when the battery is idle. This document describes a circuit and test result that assists in the successful implementation of a battery switch circuit when shutting down the bq76200.

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## 1 Introduction

In many batteries, the battery is always on with the outputs enabled. The operating current of the components is the major concern in this situation. With other batteries, the internal circuitry may be shut down for long periods of time, in this case, the shutdown current of the components may be the more critical concern. The bq76200 has buffered inputs and draws current even with all inputs disabled. The bq76200 data sheet (SLUSC16) shows a typical shutdown current of 6 µA at 8 V. A first attempt at minimizing current is switching off the BAT pin, similar to the approach shown in Figure 1. In this schematic, Q3 and Q4 are used to switch off the voltage to the BAT pin and other circuitry powered by the battery voltage. This cuts off the supply to the bq76200 with the idea of reducing the supply current. However, if the gate of the charge power FET remains connected to the high voltage, the CHG pin is attempting to drive the pin to the BAT pin voltage and a leakage path exists inside the bq76200 back to the BAT pin and to other connected circuitry. See Figure 2 for an example of leakage current into the CHG pin. Also, since $R_{GS\_CHG}$ is larger than $R_{CHG}$, as the system voltage increases, the voltage across the gate-source resistor $R_{GS\_CHG}$ may stress the Q1 charge FET gate limit.

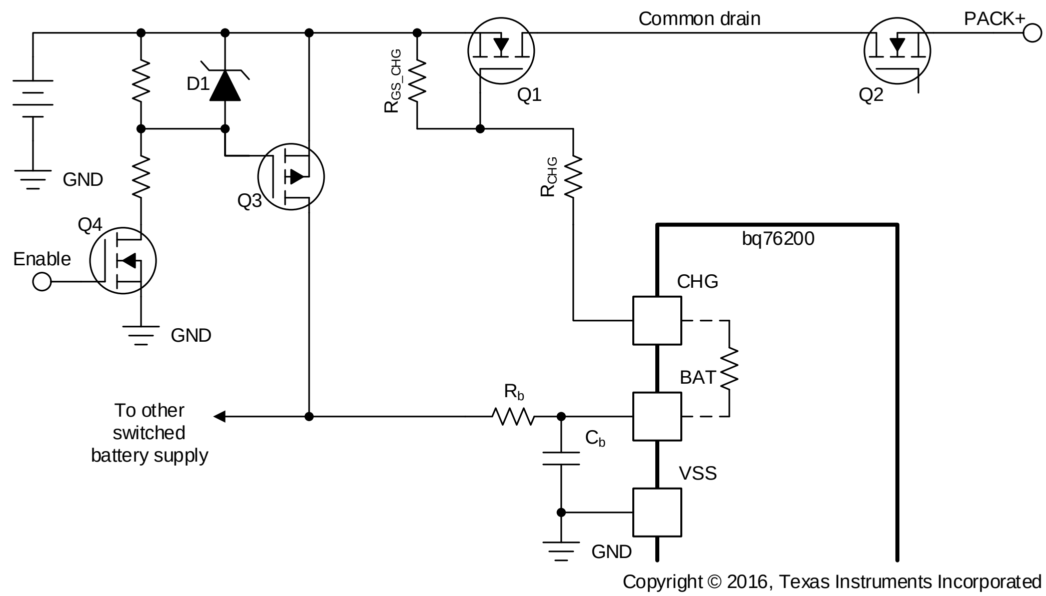


**Figure 1. Simple Attempt at Switching BAT**

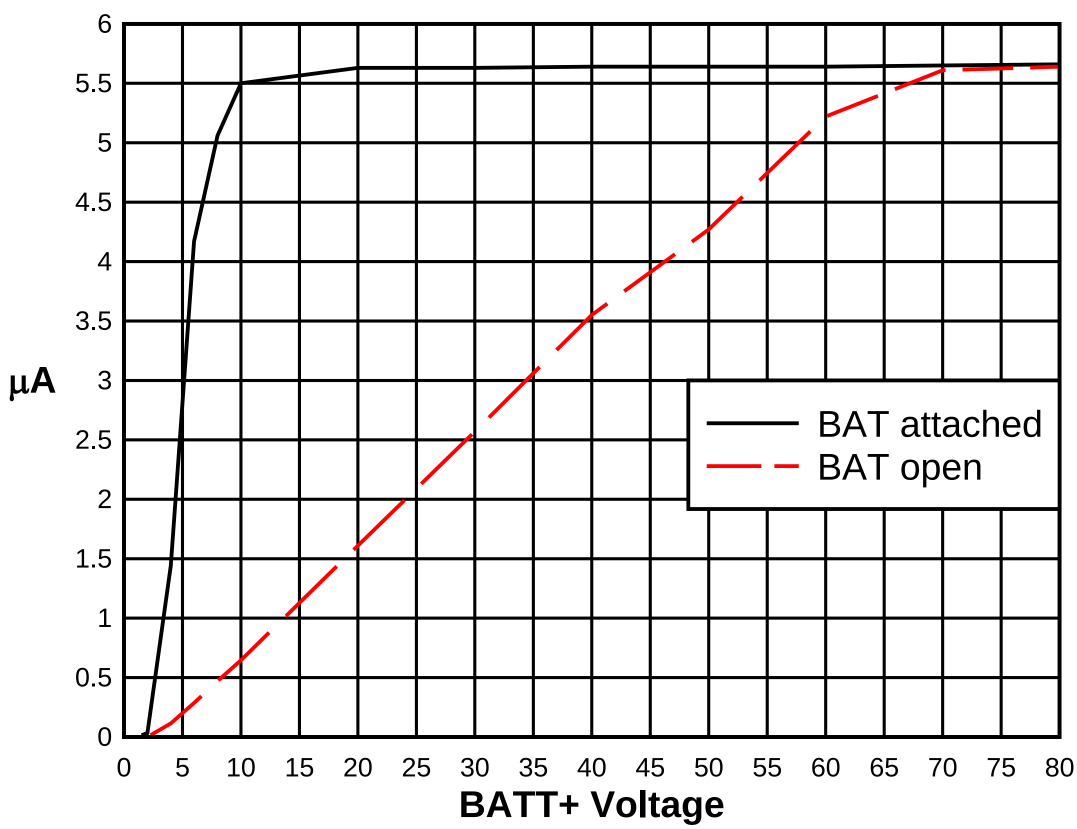


**Figure 2. Leakage Into CHG**

## 2 Blocking Current Into CHG

Overstress of the charge FET gate can be prevented using a zener diode in parallel with the gate-source resistor, $R_{GS\_CHG}$. A solution to the leakage current into the bq76200 is blocking the current into the CHG pin with a diode. The CHG output could turn on the MOSFET, but turn off needs to be accomplished with the $R_{GS\_CHG}$ resistor. The bq76200 drives the FETs with a charge pump, so current must be limited and the resistor cannot be made arbitrarily small. The data sheet does not specify a charge pump current, but it can be estimated as 40 µA from the startup specifications. The typical 10 MΩ $R_{GS\_CHG}$ provides a load of approximately 1.2 µA.

Figure 3 shows a circuit implementation where a small P-channel MOSFET is added to turn off the power FET. A second gate resistor, $R_{GS\_CHG2}$, is added to turn on the P-channel FET. The combined load is increased to 3.3 MΩ and the charge pump current for the charge FET is increased to approximately 3.6 µA.

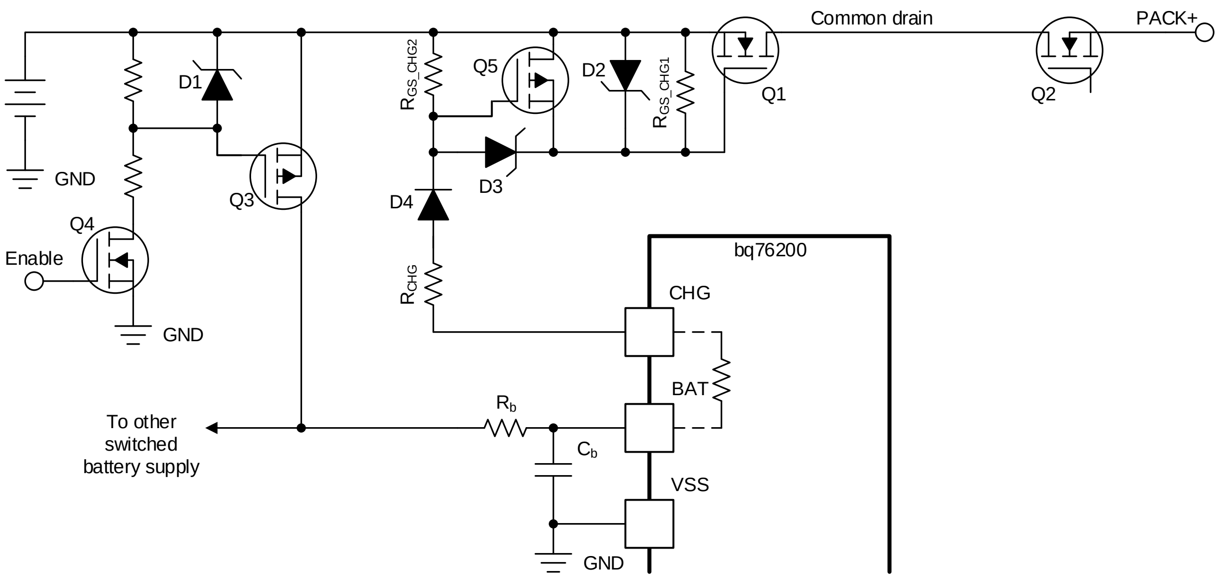



**Figure 3. Switching BAT With CHG Pin Current Blocking**

## 3 Test Result

The circuit in Figure 3 is constructed using the components shown in Table 1

**Table 1. Test Circuit Values**

| Reference | Part or Value |
|---|---|
| Q1 | CSD19532Q5B |
| Q5 | BSS84 |
| $R_{CHG}$ | 510 Ω |
| $R_{GS\_CHG1}$ | 10 MΩ |
| $R_{GS\_CHG2}$ | 5.1 MΩ |
| D2 | MMSZ5246B 16V |
| D3 | MMSZ5231B 5.1V |
| D4 | BAT46 |

The switch and diode in the CHG path has some leakage current, so current will not be as low as opening the signals, however it provides a substantial reduction in the current to the bq76200 circuit. Figure 4 shows a comparison measurement of current into the circuit with the standard circuit, with BAT only open, BAT and CHG open, and with a switch and CHG blocking circuit in place.

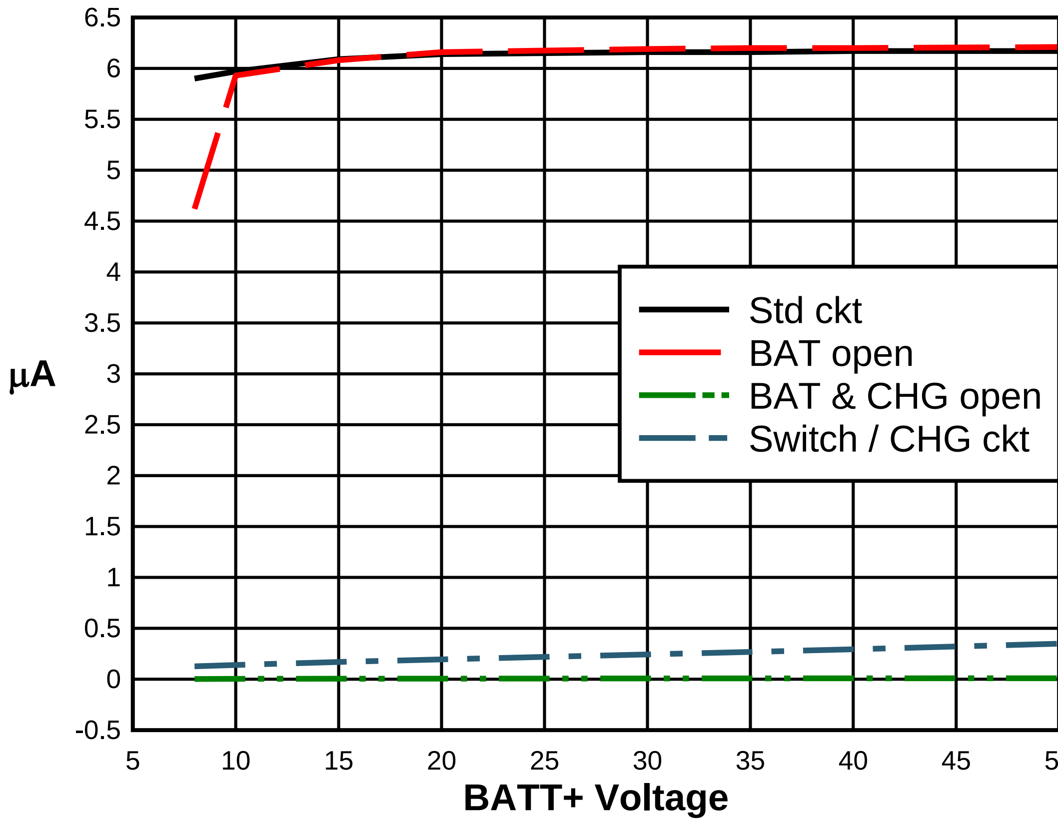


**Figure 4. Shutdown Current Comparison**

Figure 5 shows the turn off of the charge FET without the blocking diode and P-channel FET. Figure 6 shows the result with the blocking diode and P-channel FET. The current blocking circuit does provide a delay to the switching as well as the slower switching.

**NOTE:** Waveform captures in this document show charge current as positive.

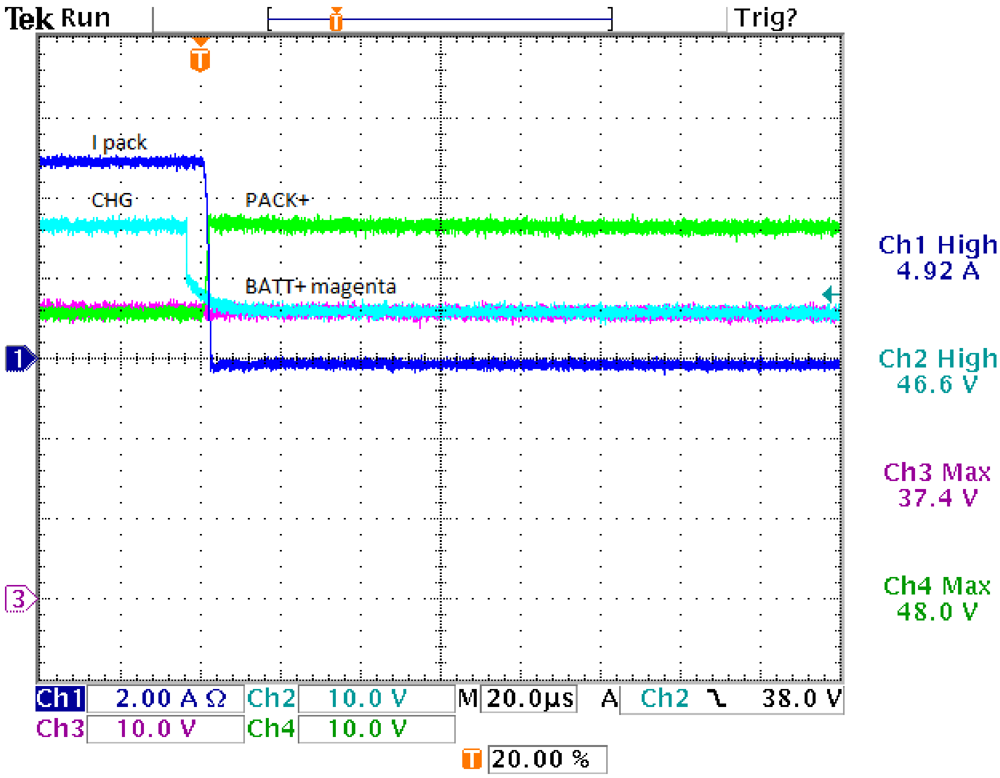


**Figure 5. Charge FET Switching With Normal Circuit**

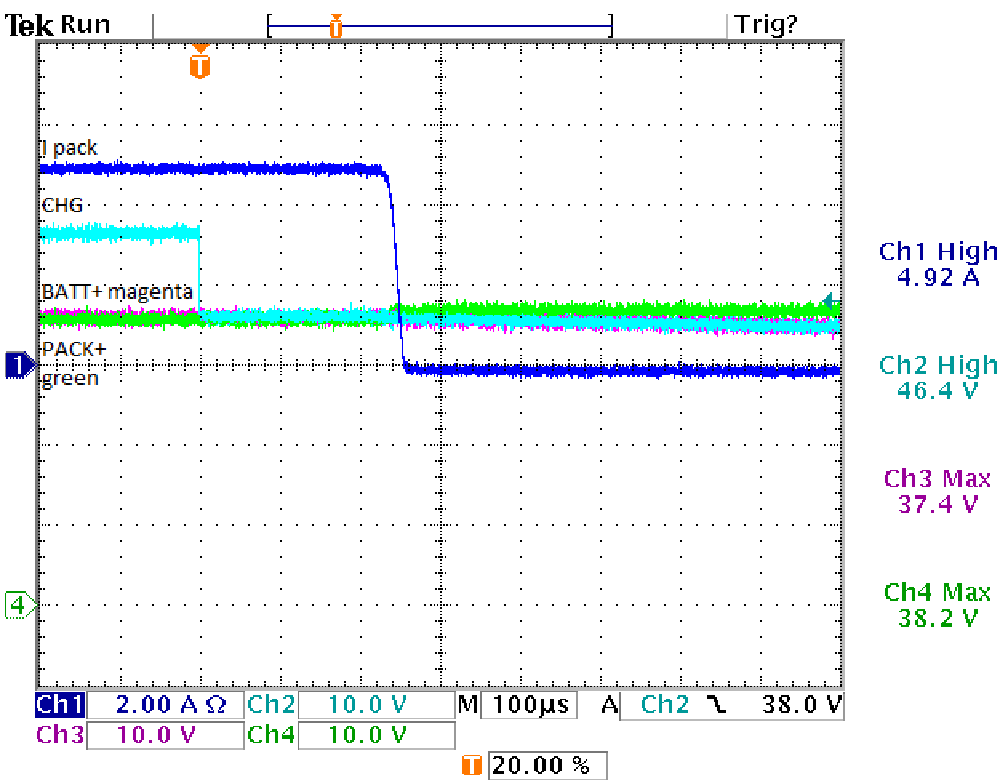


**Figure 6. Charge FET Switching With Current Blocking Circuit**

## 4 Precharge Consideration

A side effect of switching BAT is that the bq76200 no longer knows the common drain voltage of the power FETs, so the PCHG function of the bq76200 cannot be used. With the BAT and PACK pins both at 0 V, the PCHG pin goes to 0 V, which could stress the gate of the precharge FET, turn on the precharge FET, or provide leakage current into the bq76200. If a precharge circuit is needed it needs to be implemented externally, similar to Figure 7.

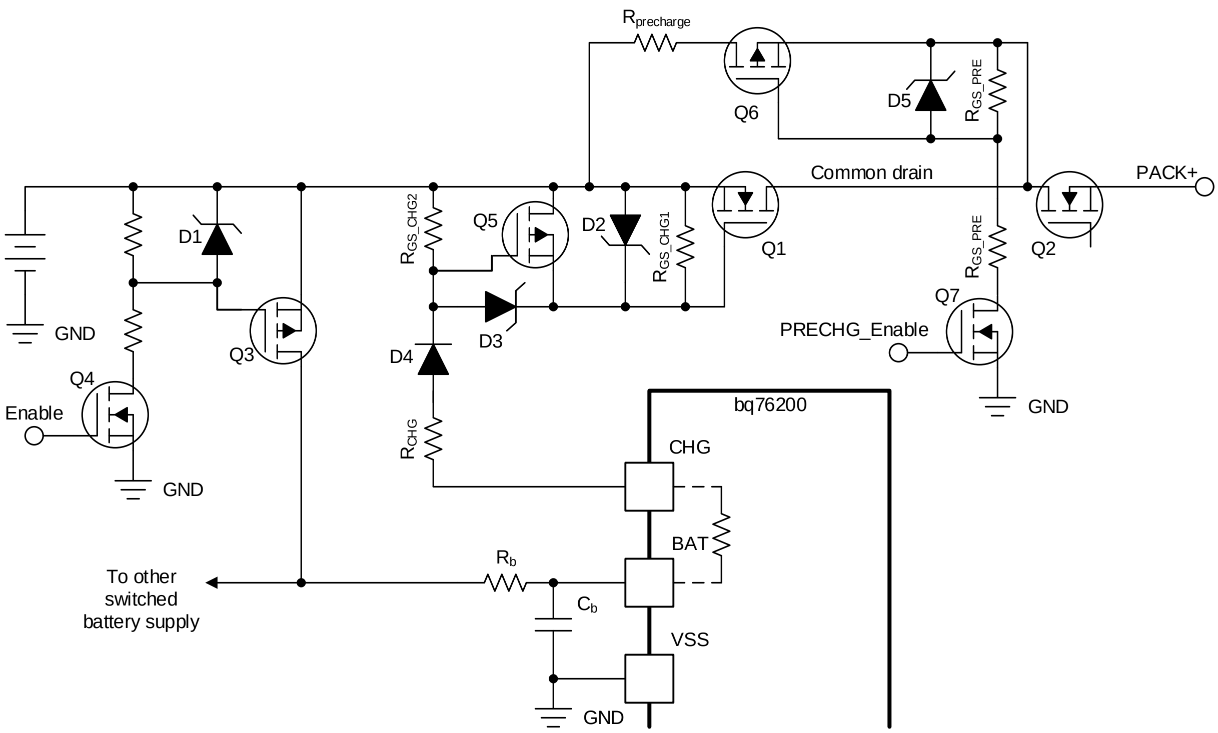




**Figure 7. External Precharge Driver**

## 5 Conclusion

When lower standby current is required, switching BAT to the bq76200 also requires blocking current into CHG. The blocking diode and the high gate-source resistance required for the low drive current of the bq76200 charge pump results in a slow turn off of the CHG output. The system may need a circuit to speed up the turn off of the charge FET. When switching the BAT pin, the internal precharge driver is not useable. Provide precharge control outside the bq76200, if needed.

## 6 References

For additional information, refer to the documents below available at www.ti.com.

- *bq76200 High Voltage Battery Pack Front-End Charge/Discharge High-Side NFET Driver* data sheet (SLUSC16)
- bq76200 EVM user's guide (SLVU926)

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