Application Report
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bq24707/25/26 Input Voltage DPM

Tahar Allag/Wang Li
Battery Power Applications

ABSTRACT

The bq24707/25/26 are high-efficiency synchronous battery chargers. They offer low component count for space-constrained, multichemistry, battery-charging applications. They feature real-time system control on the I_{LIM} pin to limit the charge current. In this application report, the I_{LIM} pin is used to implement real-time, input-voltage, dynamic power management. It is used to reduce the charging current as the input voltage drops below a fixed threshold.

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1 Charge Current Setting Description

The charge current for the bq24707/25/26 can be set either by using the internal charge current register or by the external I_{LIM} pin. For the internal register, it is set by simply writing charge current commands on the charge current register using the data format listed in the data sheet of each part. The other option is by using the I_{LIM} pin. This allows the user to program the maximum allowed charging current in real time.

This secondary option can limit the charging current into the battery by programming the I_{LIM} voltage. Usually, this is done by connecting a resistor divider from the system reference 3.3-V rail to the I_{LIM} pin to ground as shown in Figure 1.

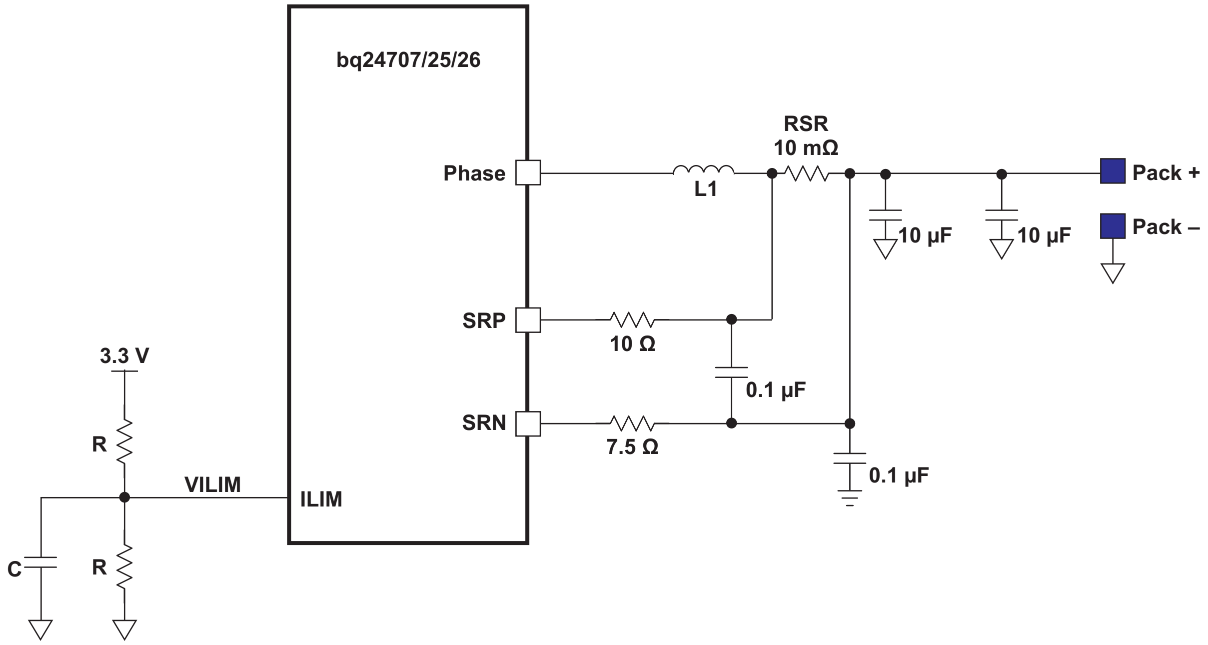

Figure 1. Typical Connection of I_{LIM} for bq24725/26/707

As the voltage on the I_{LIM} pin gets lower, the charging current limit decreases as shown in Equation 1, where R_{SR} is the current-sensing resistor. Once the voltage on I_{LIM} falls below 75 mV, the charging current is disabled. A 30-mV hysteresis occurs, meaning that the part enables the charging again as the voltage rises above 105 mV. For disabling the control on I_{LIM}, set V_{ILIM} above 1.6 V. The current-limit register must be set higher than the external DPM set point in order to avoid internal current-limit interruption to the external settings.

$$V_{ILIM} = 20 \times I_{CHG} \times R_{SR} \quad (1)$$

In this application, the I_{LIM} pin controls the charging current as the input voltage of the charger decreases. This is useful for dynamic power regulation that uses the input voltage.

The input current is equal to the sum of the load current, the device supply current I_{BIAS}, and the charger input current as shown in Equation 2

$$I_{INPUT} = I_{LOAD} + [(I_{BATTERY} \times V_{BATTERY}) / (V_{IN} \times \eta)] + I_{BIAS} \quad (2)$$

Where η is the efficiency. As the current demand from the output exceeds the input maximum limit, the input voltage decreases. The ideal solar charging application operates the solar cell at its maximum power point (MPP). Without a current-limiting mechanism, the solar charger cannot operate a solar cell at its MPP. Thus, I_{LIM} becomes a useful feature to reduce the charging current limit to operate a solar cell at its MPP.

2 Input Voltage Dynamic Power Management Design

In order to control the charging current with respect to the input voltage, the circuit shown in Figure 2 is proposed. The LMV321DBV operational amplifier is used in an inverting integrator configuration to sense Vin and to integrate the change.

R1 and R2 are designed to set the threshold input voltage. R3 and R4 are designed to set the reference voltage of the integrator. As the input voltage drops below the threshold level, the voltage on R5 increases and turns on the MMST3904 transistor accordingly. That forces the voltage on I_{LIM} down and consequently reduces the charging current.

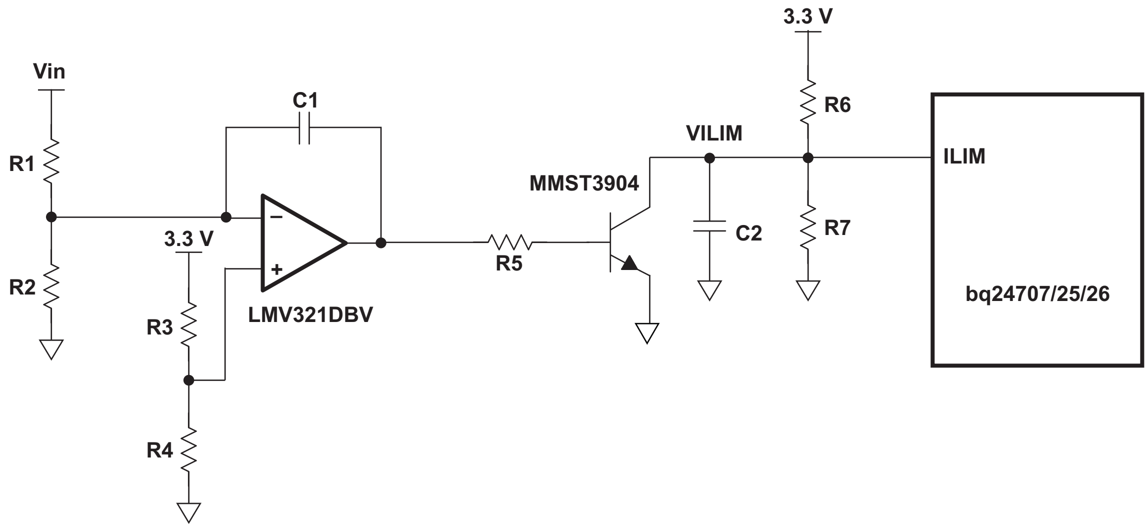

Figure 2. Input Voltage DPM for bq24725/26/707

3 Design Example

In this section, a design example is provided. The input voltage is fixed to 20 V. So, any voltage below 20 V at the input of the charger reduces the charging current to allow the input voltage to go back to its desired level. The reference voltage at the positive input of the operational amplifier is chosen to be 2 V as shown in Figure 3. The resistor values of R2 and R4 are fixed to 100 kΩ and R1 and R3 are designed according to the following equations:

R1 = R2 (Vin – 2 V) / 2 = 100K (20 – 2) / 2 = 900 kΩ
R3 = R4 (3.3 V – 2 V) / 2 = 100K (3.3 – 2) / 2 = 64.9 kΩ

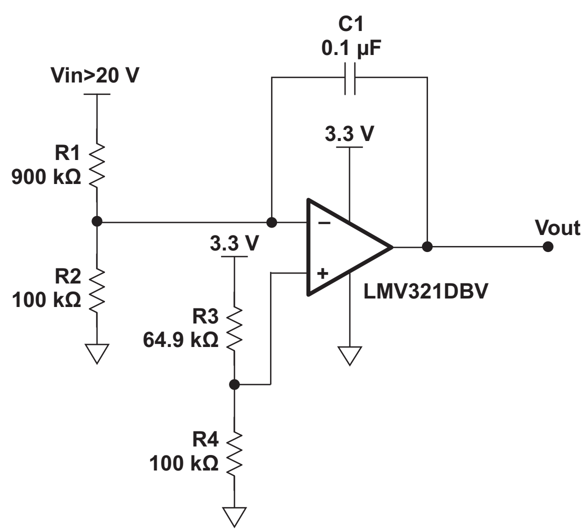

Figure 3. Inverting Integrator Operational Amplifier Design

Both C1 and C2 determine the transient response speed of the system. A small value of C1 can cause the system to be unstable. For good stability of the system, a 0.1-µF capacitor is chosen for C1 and a 0.01-µF capacitor for C2.

As discussed in the previous section, the proper voltage at I_{LIM} is between V_{ILIM_FALL} (0.75 mV) or V_{ILIM_RISE} (105 mV) and 1.6 V. The relationship between V_{ILIM} and the charging current is given in Equation 1. In this design example, a 0.96-A charging current is chosen with which to charge the battery. The sensing resistor is fixed to 10 mΩ. Thus, the feedback resistors for the I_{LIM} pin are calculated to be 1.5 MΩ for R6 and 93.1 kΩ for R7 as shown in Figure 4.

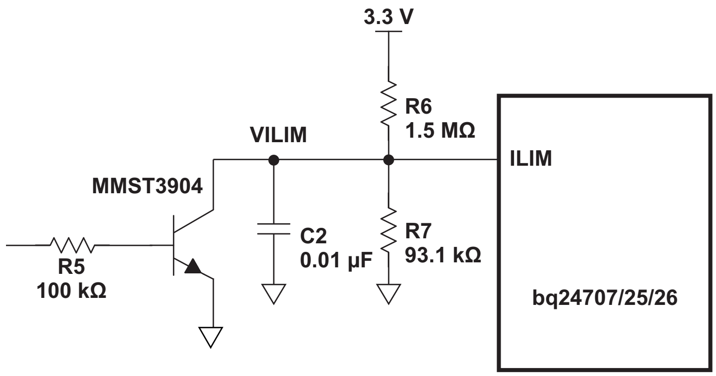

Figure 4. I_{LIM} and Transistor Feedback Design

4 Test Result

Figure 5 shows the charging current and the input voltage. The charging current is set to 960 mA as long as the input voltage does not drop below 20 V. As soon as the input voltage starts dropping below the threshold, the voltage at the output of the operational amplifier increases allowing the transistor to force V_{ILM} to drop. As a consequence, the charging current decreases until it reaches 375 mA and terminates to 0 A. The charging current of 375 mA corresponds to a V_{ILIM_FALL} (0.75-mV) voltage at V_{ILIM}, which is the minimum voltage on I_{LIM} before the charging becomes disabled. Note that the plot is not taken with a real solar panel.

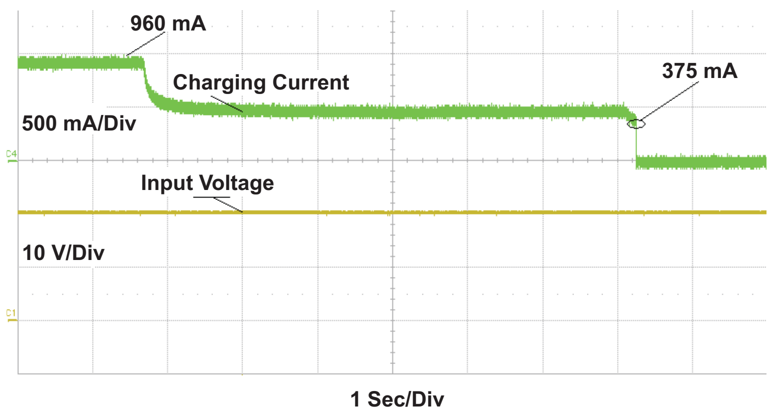

Figure 5. Charging Current in Input Voltage DPM

5 Conclusion

External dynamic power management is explored in this application report. Instead of using the internal DPM loop, this topology uses an external input current regulation loop and has the input voltage feedback signal on the I_{LIM} pin. This application is useful for solar cells; it externally controls, in real time, the charging current to allow the solar cell to operate at its MPPT.

6 References

1. *bq24726, 1-4 Cell Li+ Battery SMBus Charge Controller with N-Channel Reverse Blocking MOSFET Gate Driver and Advanced Circuit Protection* data sheet (SLUSA79)
2. *bq24725, 2-4 Cell Li+ Battery SMBus Charge Controller with N-Channel Power MOSFET Selector and*

Advanced Circuit Protection data sheet (SLUS702)

3. *bq24707, 1-4 Cell Li+ Battery SMBus Charge Controller With Independent Comparator and Advanced Circuit Protection* data sheet (SLUSA78)

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