

# Using bq2425x’s DPM Feature for Solar Panel Applications

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## ABSTRACT

After installation and maintenance expenses, harvesting the sun’s energy through the use of solar cells panel is 100% free and clean energy. Despite the superb performance of this technology, its characteristic limitation tenders them difficult to use in some applications, especially in portable power applications. This application note explores how to overcome its characteristic limitation by using the VIN\_DPM feature of the bq2425x single battery charger.

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## 1 Introduction

The bq2425x is a highly-integrated single-cell Li-ion battery charger device targeted for space-limited, portable applications with high-capacity batteries. The charger has a single input that operates from either a USB port or AC wall adapter. A solar panel can also be used as an input power supply as long as it provides the charger with the adequate power and input voltage needed to operate.

## 2 Solar Cell Panel

### 2.1 Solar Cell Panel Overview

A solar cell converts solar energy (light) into electrical energy through crystalline or amorphous silicon photovoltaic panels. There are many advantages for this renewal energy source; however its application is not straight forward.

## 2.2 Understanding Maximum Power Point of a Solar Cell Panel

As in any other energy converter system, the efficiency and maximum power transfer of a solar cell is important. Figure 1 shows the V-I characteristic of a typical solar cell panel and its power curve under a constant light with constant temperature conditions.

The solid-colored blue line represents the output current of the solar panel as its voltage varies. The solid green line represents the output power. The figure shows that the panel's current drops slightly as the voltage increases from 0 V to about 4.0 V, and then drops dramatically after 4.5 V until it reaches 0 A at around 5.5 V. The power delivered also drops due to this dramatic decrease in current.

At lower solar cell voltages, the current is nearly constant, thus, the power delivery corresponds primarily to the solar cell's voltage. Due to this V-I characteristic, a maximum power delivered occurs only at single specific voltage and current points as shown in Figure 1. This point called Maximum Power Point (MPP) and the corresponding current and voltage are called  $I_{MPP}$  and  $V_{MPP}$ , respectively.

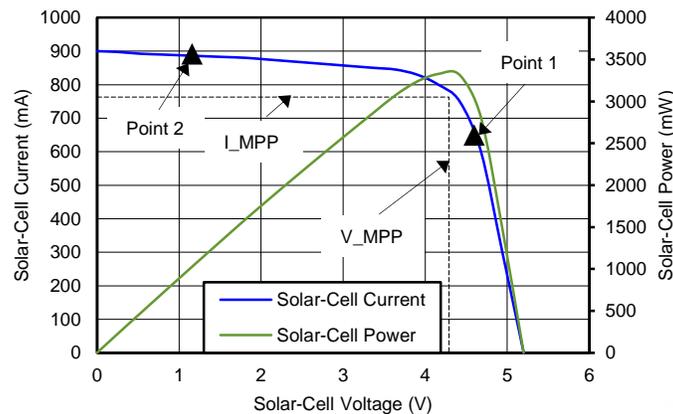


Figure 1. Solar Panel's V-I Curve and Output Power Curve

Keep in mind that in real applications, a solar cell's Maximum Power Point varies with different light conditions and temperatures. Figure 1 shows the V-I curve of the cell at only a constant light condition and temperature.

In conditions where small charging current and system load are required, the solar cell may operate at point 1 as shown in Figure 1, which is below its MPP. In this case, the solar cell is not operating at its maximum power capability, and both the system and the battery are getting the power they need without any issues.

In conditions where the battery charge current or system power requirements increase, the charger must draw more current from the solar panel. This may cause the panel to operate at point 2. At this point, the solar cell's output voltage decreases, causing the actual delivered power to decrease. In addition, the input voltage may decrease to a point where the charger shuts down, causing the whole system to fail. External circuitry is needed to prevent this scenario from happening.

## 3 Input Voltage Dynamic Power Management

### 3.1 bq2425x Input Voltage-Based DPM

The bq2425x device family contains the VIN\_DPM feature. This feature allows the device to monitor the input voltage during the normal charging process and dynamically manage the power delivered to both the system and the battery accordingly.

In conditions where the input power supply is unable to support either the programmed (default) charging current of the battery or the demanded power from the system, the input supply voltage will decrease automatically. Once the supply drops to the VIN\_DPM threshold, the input current limit is reduced to prevent further drop of the supply. When the IC enters this mode, the charge current is lower than the set target. This feature ensures IC compatibility with adapters and input power supplies of different current capabilities without a need for hardware changes.

### 3.2 Adjusting the VIN\_DPM of the bq2425x

The VIN\_DPM threshold is programmable, either externally or using I2C commands. Let's first understand how to program the bq2425x externally. Based on the application diagram's reference designators in Figure 2, the resistor (R1 and R2) can be calculated in order to set the desired VIN\_DPM threshold. The equation for this calculation is as follows:

$$VIN\_DPM = VREF\_DPM \times (R1 + R2) / R2 \quad (1)$$

VREF\_DPM is the reference DPM voltage, equal to 1.2 V. The VIN\_DPM threshold should be chosen first along with R1. Choosing R1 first ensures that R2 will be greater than the resistance chosen. This is the case since VIN\_DPM should be chosen to be greater than 2x VREF\_DPM.

For example, if the needed input DPM threshold is 4.4 V, R1 is chosen to be 267 kΩ. By solving Equation 1, R2 is found to be equal to 100 kΩ. To enable the default input DPM threshold of 4.36 V, short the VDPM pin to GND.

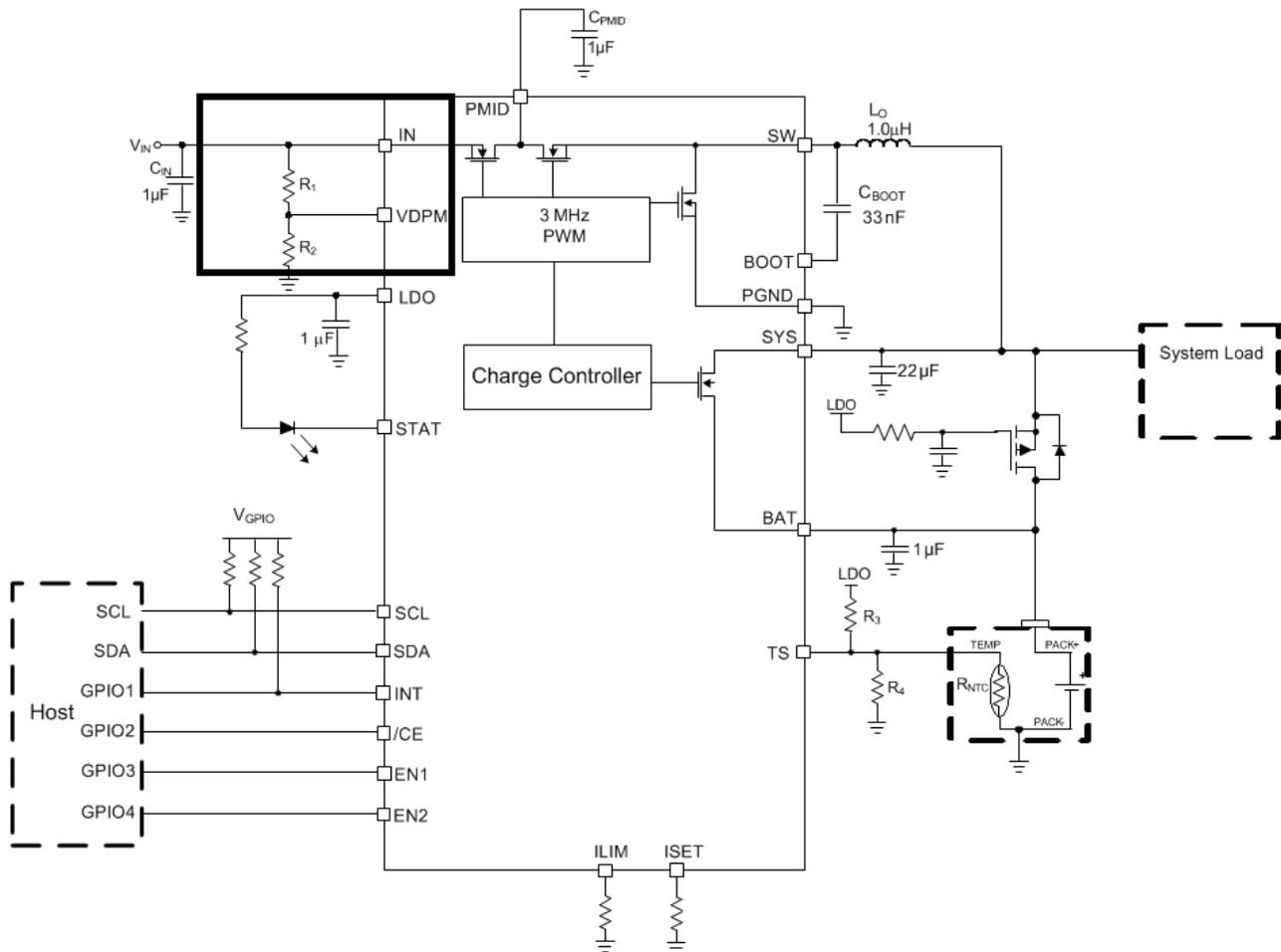


Figure 2. bq2425x Typical Application Circuit

Selecting the VIN\_DPM threshold can also be done through the use of I2C commands. This can be done by programming register #5 bits 0, 1, and 2. The offset DPM voltage is 4.2 V, and can be adjusted in steps of 80 mV. The DPM default voltage is 4.36 V. The only drawback of the I2C is that the minimum voltage is 4.2 V, whereas when selected externally, it can be set much lower.

#### 4 Input Voltage DPM for Solar Panel Applications

As described previously, the solar cell voltage depends on the current delivered by the panel. Operating at the maximum power point is desired. The input DPM feature of the bq2425x device can monitor the voltage and dynamically manage the current drawn from the solar panel. Figure 3 provides a graph of the input voltage of the bq2425x charger and shows how the solar cell current is controlled.

Initially, the system is not drawing a load current from the input. All the power delivered by the solar panel charges the battery. In this condition, the panel sustains its voltage high enough to deliver the needed power to the battery. However, as the system starts drawing more current from the input, the voltage of the panel drops. The input DPM feature of the bq2425x prevents it from dropping below the VIN\_DPM threshold. That is done by reducing the input current and prioritizing the system over the battery. The battery charge current can be reduced or even adjusted to supplement the system load.

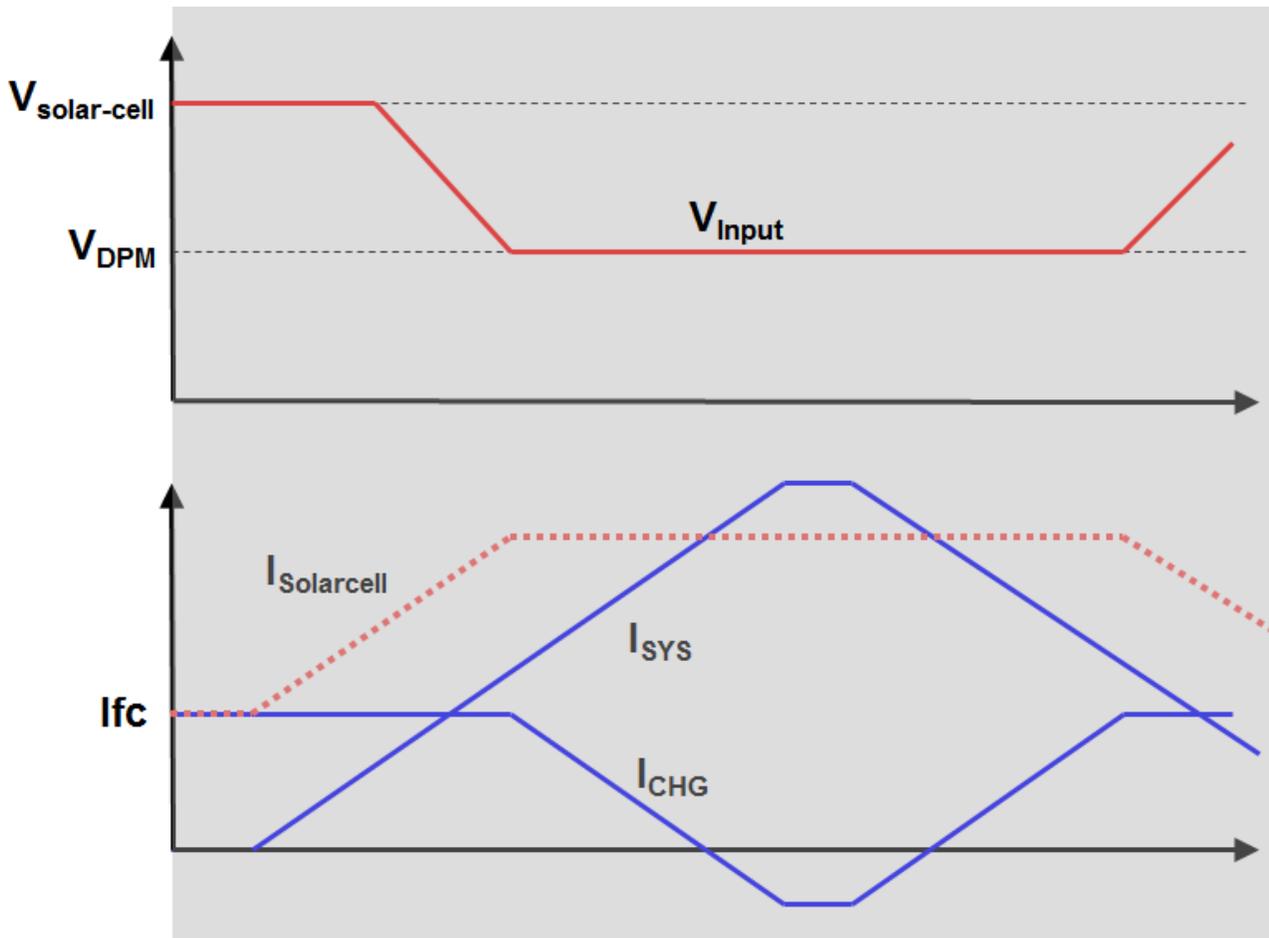


Figure 3. Controlling Solar Cell Current Using VIN\_DPM Feature of bq2425x Charger

## 5 Solar Cell VIN\_DPM Design Example and Test Result

In this design example, a solar cell is used as an input to the bq24250 charger. It is charging a 4.2-V single cell Li-ion battery and powering a system concurrently. The fast charge current is set to 1000 mA; the IC is operating only in Stand Alone mode. The system load varies with time from 0 mA to 2000 mA, due to variations on the operating condition of the system.

As described previously, the voltage of the solar panel drops significantly as demand for current from the charger increases. To prevent this from happening, the charger needs to reduce the current drawn from the input as the supply drops to the VIN\_DPM threshold.

Through the characterization of the solar panel, it is found that the maximum power point is 4.6 V and 1.1 A. Thus, the target VIN\_DPM threshold is approximately 4.6 V. Using Equation 1, R1 is chosen to a standard value of 250 kΩ and R2's value is solved to be 90 kΩ.

Figure 4 shows the test results. The solar panel voltage is fixed at the designed VIN\_DPM threshold by limiting the input current to the charger. The system load is supplemented by reducing the charge current.

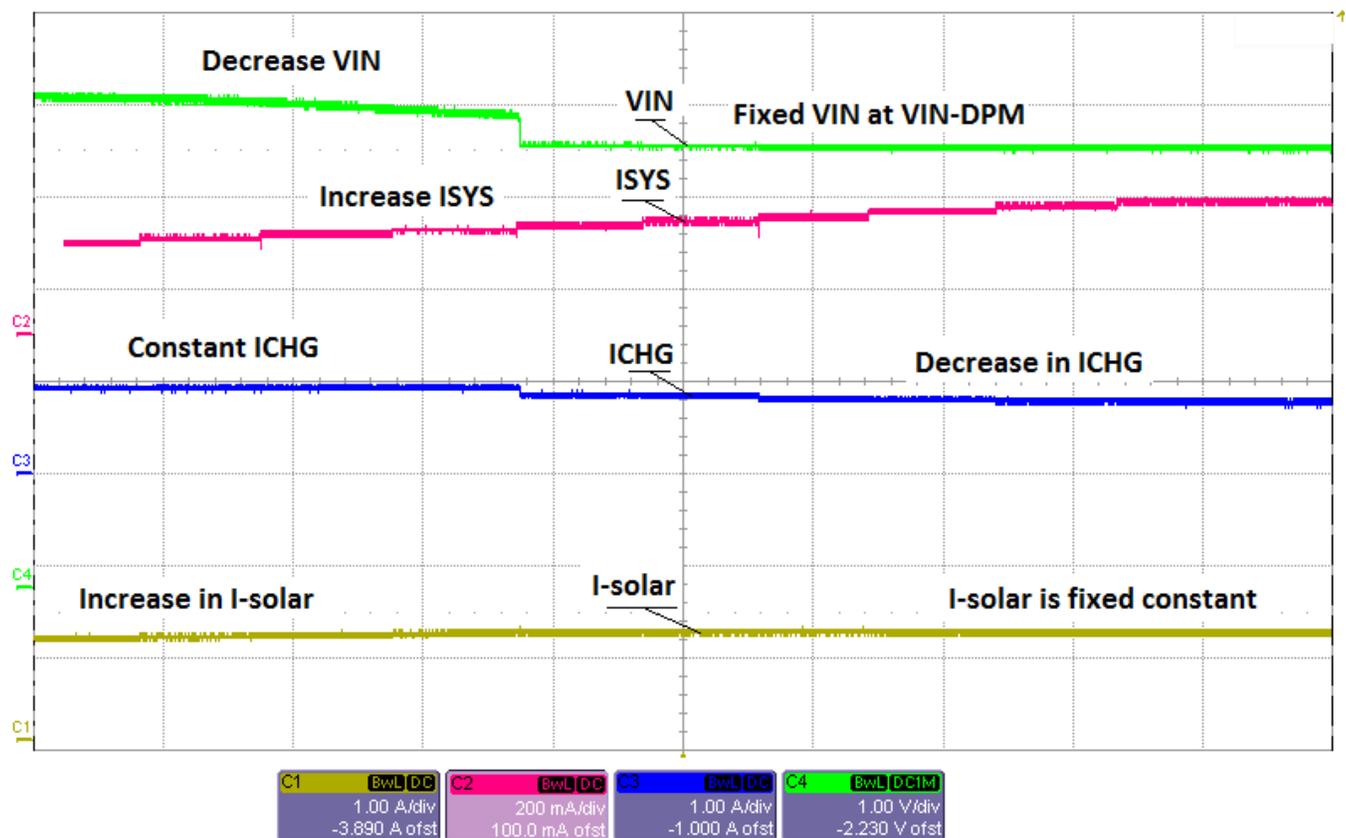


Figure 4. VIN\_DPM on Solar Panel Test Result

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