Application Note

How To Implement External P&O Feature On BQ2575X

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ABSTRACT

This application note describes how to implement external Perturb and Observe (P&O) MPPT control on the BQ2575x by adjusting the VAC_DPM setting via I2C using an MCU host controller. This approach enables real-time optimization of solar energy harvesting and improve charging efficiency while using a solar panel input. This document also outlines the test procedures and results of this method.

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1 Introduction

The Maximum Power Point Tracking (MPPT) is essential in solar-powered systems to make sure that photovoltaic (PV) panels deliver the highest possible power output, which varies depending on sunlight intensity, temperature, and dynamic environmental conditions such as cloud cover or shading. The power generated by a solar panel is the product of voltage and current (P = V × I), and this relationship forms a curve where the peak corresponds to the maximum power point (MPP).Without MPPT, the system can operate at less than excellent voltage and current levels, leading to significant decrease in available energy.

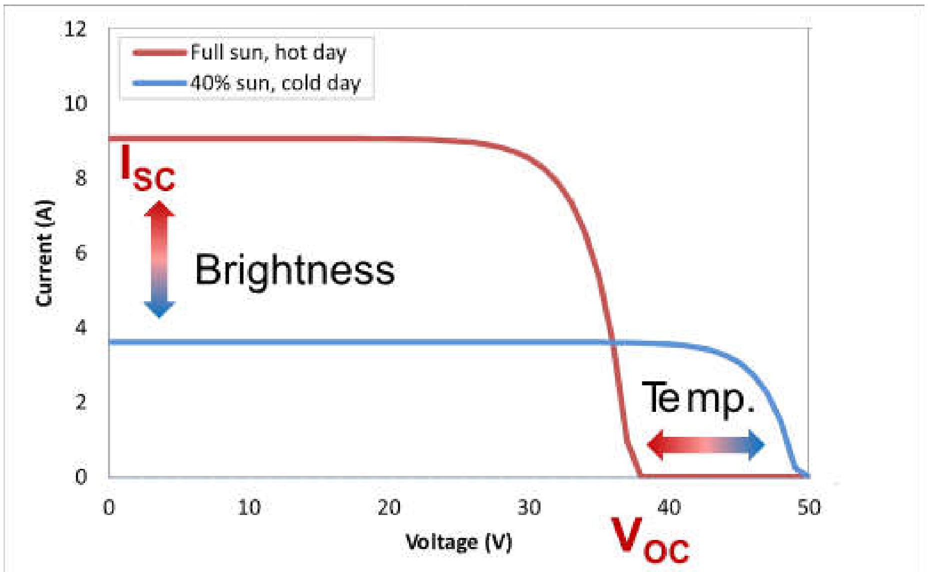

Figure 1-1. Excellent Solar PV Operating Curves

The BQ2575x family of buck-boost battery chargers includes an internal MPPT feature based on full panel sweeps, where the input voltage is stepped down across a wide range while monitoring charge current. This method identifies the voltage that yields the highest charge current (and by extension, power).

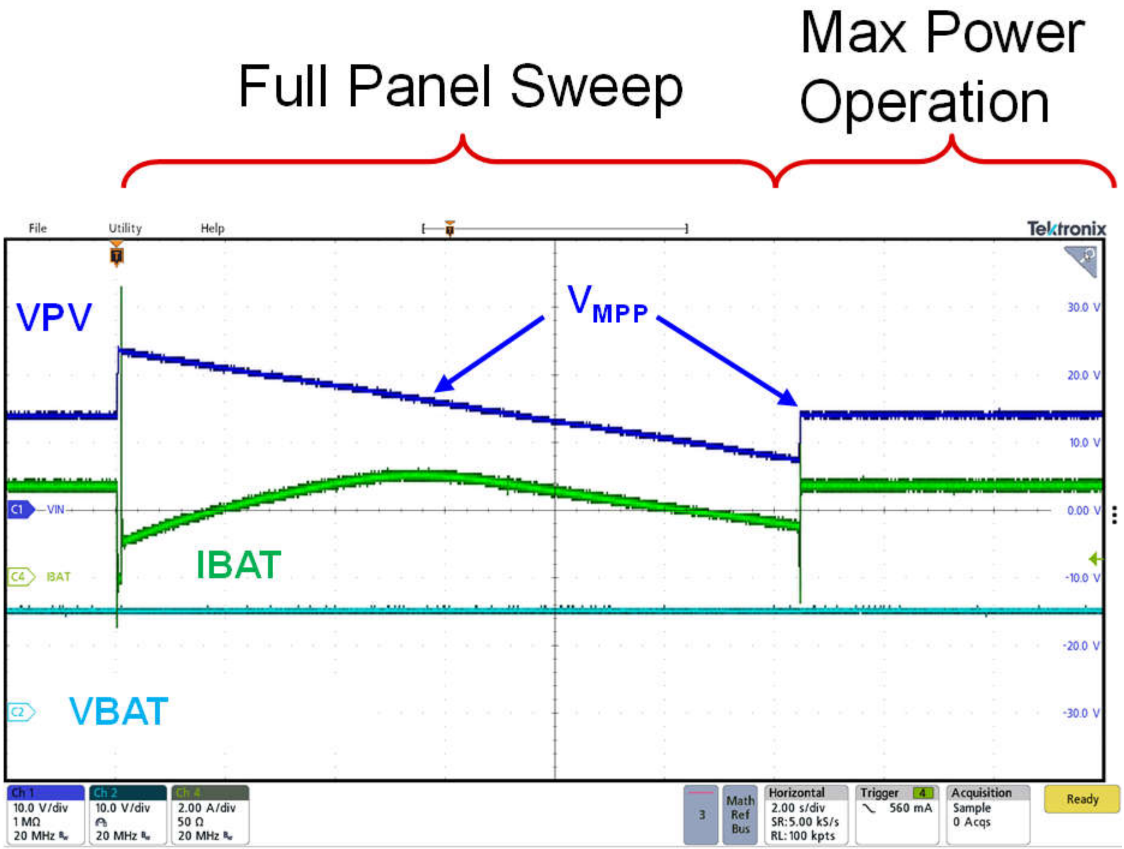

Figure 1-2. BQ2575x MPPT Full Panel Sweep

While the full panel sweep can accurately locate the maximum power point and is an excellent choice for most solar charging applications, the full panel sweep requires sweeping the panel every time the MPP needs updating. As shown in Figure 1-2, the operating voltage often moves away from MPP during the sweep, causing the charge current to temporarily decrease. This lowers the average power harvested and reduces efficiency. Additionally, with a minimum timer of three minutes, environmental changes within that window can cause the system to deviate from the true MPP until the next sweep occurs, further impacting efficiency and is not an excellent choice for rapidly changing conditions.

For applications that require faster or more continuous tracking, such as mobile or shaded solar environment, MPPT performance can be improved by implementing the Perturb and Observe (P&O) algorithm externally using a host microcontroller.

2 Perturb And Observe

Perturb and observe works by periodically adjusting the operating voltage of the solar panel (perturb) and measuring the resulting change in input power (observe). This allows the system to dynamically track the MPP of the panel in real-time.

The P&O algorithm incrementally converges towards the maximum power point by using a simple comparison logic to step up or down the PV operating point. If power increases, then the system continues to increase the PV operating point in the same direction. If power decreases, then the direction is reversed. Once near the MPP, the system naturally ends up oscillating slightly around the peak power point, because the system must keep perturbing to stay close to the maximum power point.

The size of the perturbation step (Δ) can be adjusted to fit the needs of the system. A smaller step causes finer fluctuations with less deviation from the MPP, but the controller can take longer to reach the MPP under rapidly changing conditions, while a larger step causes faster changes but larger swings in power.

3 Implementing P&O with BQ2575x

The external P&O MPPT operation begins with an initialization sequence that prepares the charger for maximum power point tracking. Upon startup, the microcontroller enables the battery current ADC to allow real-time monitoring of charging current. The microcontroller configures the force sweep timer to trigger a full sweep, for example, every 20 minutes, and sets the VAC_DPM register to a custom-selected minimum panel voltage. This voltage value is also stored separately as the variable PAN_MIN_V acts as a safety floor during run-time adjustments. A custom timer is also configured to enforce periodic resets of the operating point.

Following initialization, the system performs a full panel sweep. The microcontroller monitors the interrupt pin and the MPPT status register to detect when the sweep completes. Once the sweep completes, the host reads the VAC_MPP register and updates the VAC_DPM setting to match the detected maximum power point. At this point, the internal MPPT is disabled to allow full external control.

The microcontroller then enters a continuous P&O control loop. The microcontroller first measures and stores the baseline charging current. Then, slightly perturbs the VAC_DPM value by increasing the value, and measures the resulting charging current. If the new current is greater than the previous value, then the system continues perturbing in the same direction by further increasing VAC_DPM. If the new current decreases, then the perturbation direction is reversed, and VAC_DPM decreases instead. After each adjustment, the current is remeasured to determine the next step.

Throughout this process, the system checks that VAC_DPM remains above the saved PAN_MIN_V threshold. If VAC_DPM falls below this minimum, then VAC_DPM is forcibly reset back to PAN_MIN_V. Additionally, once the custom timer expires, the device performs another full panel sweep to reset the VAC_DPM setting. This makes sure the system remains properly anchored to the maximum power point and minimizes drift caused by prolonged perturbation cycles.

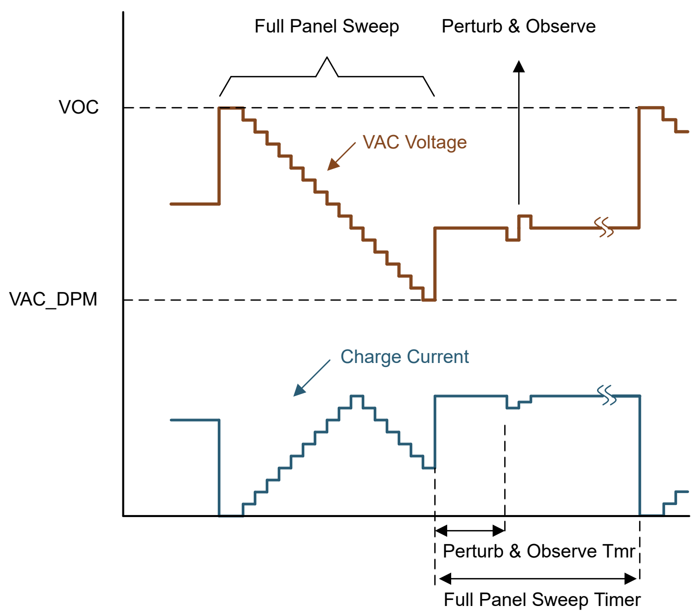

Figure 3-1. External P&O MPPT Algorithm Operation

Table 3-1. BQ2575x P&O Algorithm Register Guide

Register Address	Bit	Bit Name	Function	Options
0x08	[13:2]	VAC _DPM	Sets the lower voltage for MPP search	4.2–65V
0x1A	[2:1]	FORCE_SWEEP	Force a new panel sweep to search for MPP	0 or 1
0x1A	[2:1]	FULL_SWEEP_TMR	Controls the time between full panel sweep (minutes)	3min, 10min, 15min, 20min
0x1A	[0]	EN_MPPT	Enables max power point tracking function	0 or 1
0x1F	[13:2]	VAC_MPP	Read-only value holds the VAC max power point from recent search	4.2–65V
0x2F	[15:0]	IBAT_ADC	IBAT ADC reading with 5mΩ RBAT_SNS	-20A-20A
0x22	[1:0]	MPPT_STATUS	Max power point tracking algorithm status	MPPT disabled; MPPT enabled, but not running; full panel sweep in progress; max power voltage detected

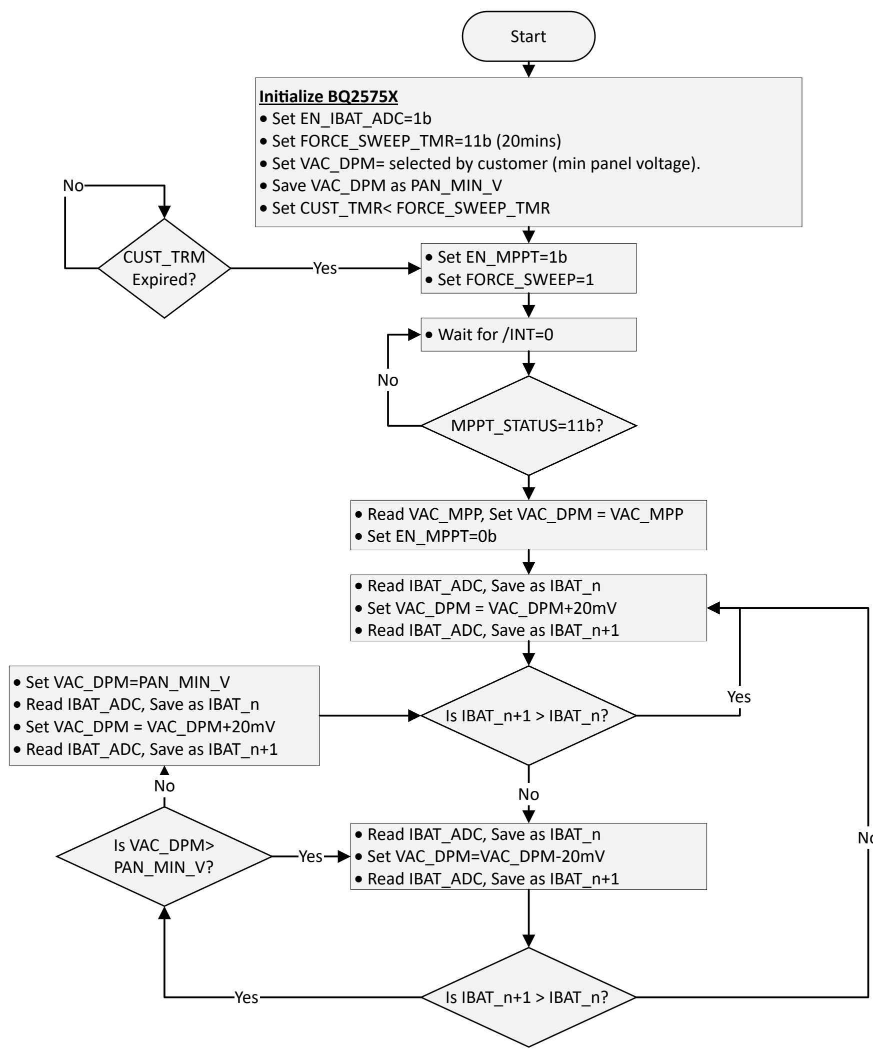

Figure 3-2. External P&O MPPT Control Algorithm for BQ2575x

4 Testing the External P&O MPPT Algorithm

The developed P&O MPPT algorithm was validated using the BQ2575x Evaluation Module (EVM) in conjunction with the LP-MSPM0L1306 LaunchPad microcontroller. The LP-MSPM0L1306 was programmed with firmware implementing the flowchart shown in Figure 3-1. The objective of the testing was to verify correct operation of the external MPPT control loop, including proper VAC_DPM adjustment, IBAT measurement, and convergence to the maximum power point (MPP) under dynamic conditions.

While the fundamental P&O MPPT algorithm remained unchanged, parameters such as the VAC_DPM step size, delay time, and ADC sampling rate were adjusted to produce cleaner and more stable waveforms. These changes were made to improve waveform appearance without affecting the operation of the algorithm. Additional improvements can be made by tuning the VAC_DPM ramp rate, ADC update intervals, and perturbation step size to better match the solar panel and load behavior. A timer can also be implemented to run the P&O function periodically, rather than continuously, to further stabilize system performance during steady-state conditions.

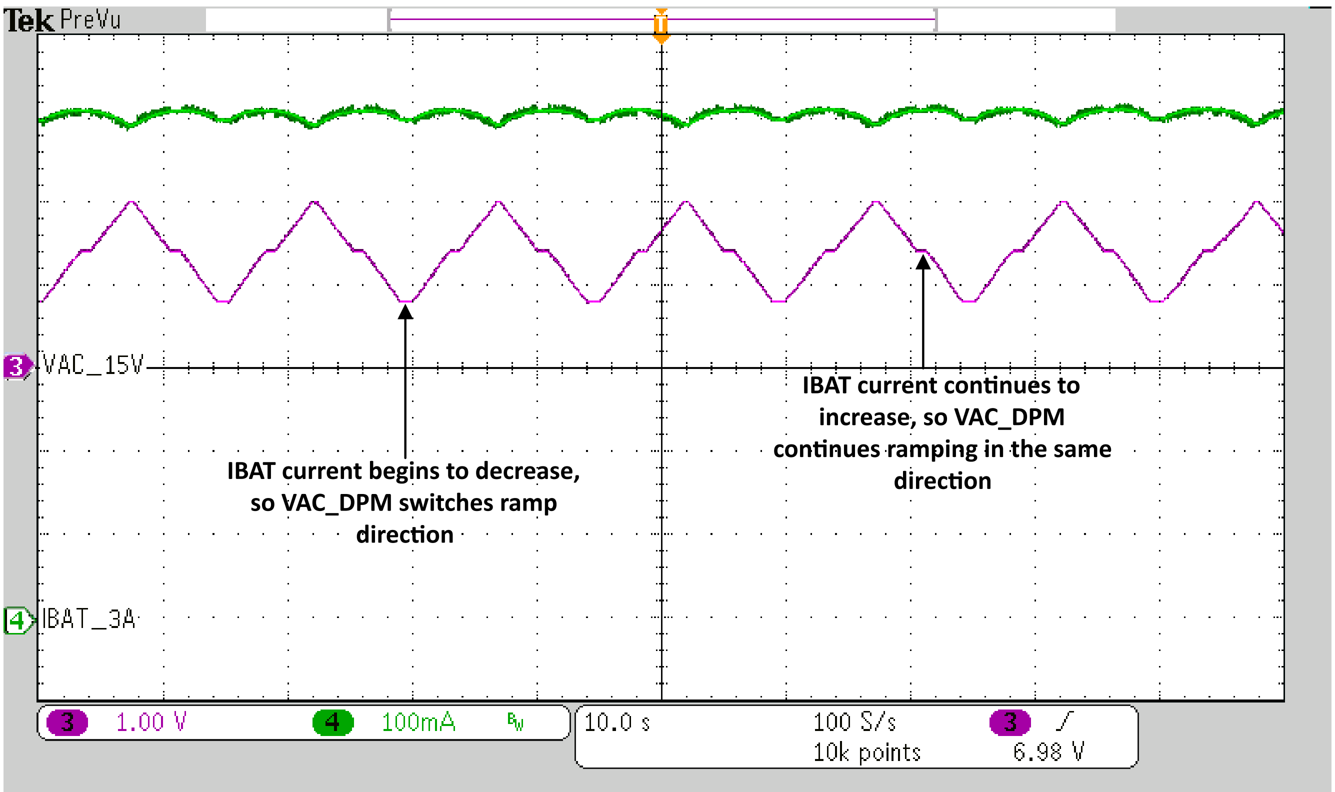

Figure 4-1. P&O MPPT Operation

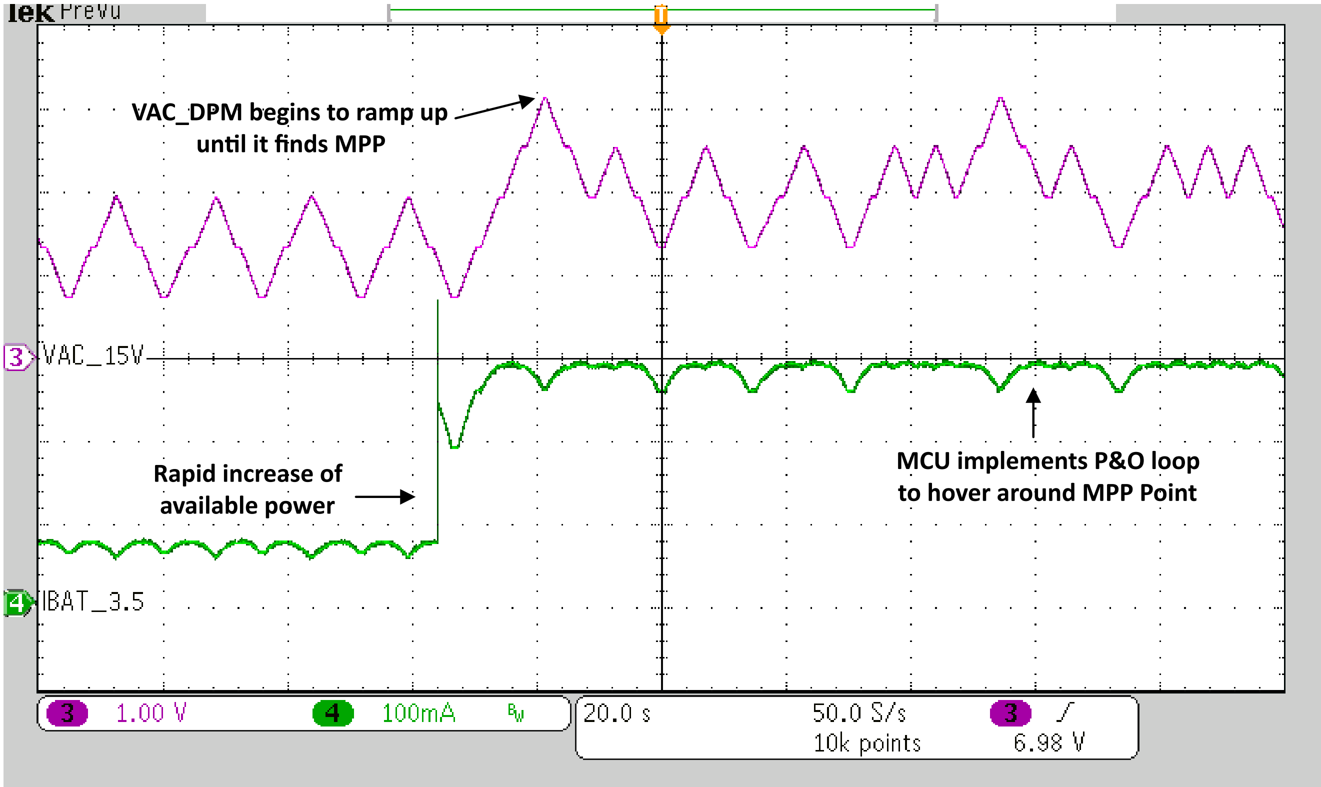

Figure 4-2. P&O MPPT Response to Sudden Increase in Available Solar Power

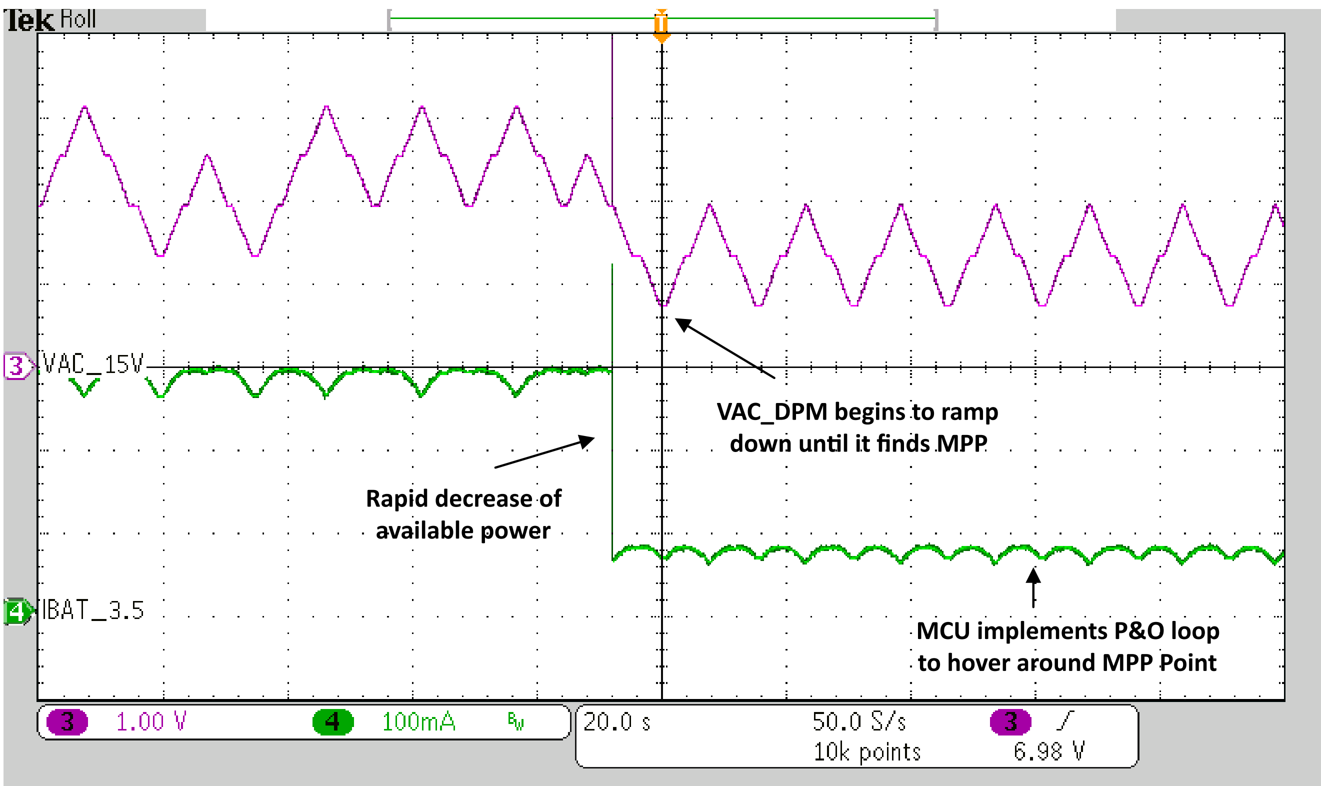

Figure 4-3. P&O MPPT Response to Sudden Decrease in Available Solar Power

5 Summary

This application note demonstrated the external implementation of the Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm for the BQ2575x family of battery chargers. By adjusting the VAC_DPM register externally using an MCU host controller, real-time optimization of solar panel output was achieved, improving overall system charging efficiency. The proposed method was validated using the BQ2575x Evaluation Module (EVM) and the LP-MSPM0L1306 LaunchPad, showing effective convergence toward the maximum power point under dynamic operating conditions. Testing confirmed that the external P&O control method successfully maintained system operation near the maximum power point, and adapted to changing solar input conditions

6 References

- Texas Instruments, BQ25756: Standalone/I2C Controlled, 1- to 14-Cell Bidirectional Buck-Boost Battery Charge Controller, data sheet
- Texas Instruments, BQ25756 Evaluation Module, user's guide
- Texas Instruments, BQ25750: Standalone/I2C Controlled, 1- to 14-Cell Bidirectional Buck-Boost Battery Charge Controller with Direct Power Path Control, data sheet
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- Texas Instruments, MSPM0L1306 LaunchPad Development Kit (LP-MSPM0L1306), user's guide