

Implementing a Simple Maximum Power Point Tracking (MPPT) Algorithm



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ABSTRACT

Solar charging is becoming a popular way to power electronics when grid power is not easy to access. For solar applications, a MPPT algorithm is needed to maximize the use of the solar panel. MPPT algorithms ensure that the charger extracts the maximum power from the solar panel and delivers it to the load or charges the battery, without collapsing the voltage at the solar panel output. The design tradeoffs of accuracy, cost, and implementation difficulty drive the type of MPPT selected.

This application note presents two different approaches to achieve MPPT with the BQ25798 battery charger. The first approach relies solely on the BQ25798's integrated Fractional Open Circuit Voltage (FOCV) method. Periodically the input voltage is measured and the MPP is set based on that measurement. The second approach uses the charger's ADC and host software to sweep the load on the solar panel in order to find a more precise MPP.

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1 Introduction

One defining parameter of a solar panel is its open circuit voltage (OCV). A solar panel's OCV has a strong negative correlation with the temperature of the solar cells [1] - [3]. **Figure 1-1** demonstrates the relationship between the temperature of a solar panel, its MPP voltage (V_{mp}), and OCV (V_{oc}). As shown, the MPP voltage and OCV change by the same percentage with temperature. As the temperature changes, whether by season or climate, the OCV will also change. Having a solar charger that considers these temperature variations makes a balanced and flexible solar charger. This means that using a MPPT method that combines the real-time OCV of the panel with a fixed percentage is a great approach because the MPP will track the changes of the OCV as shown by **Figure 1-1**.

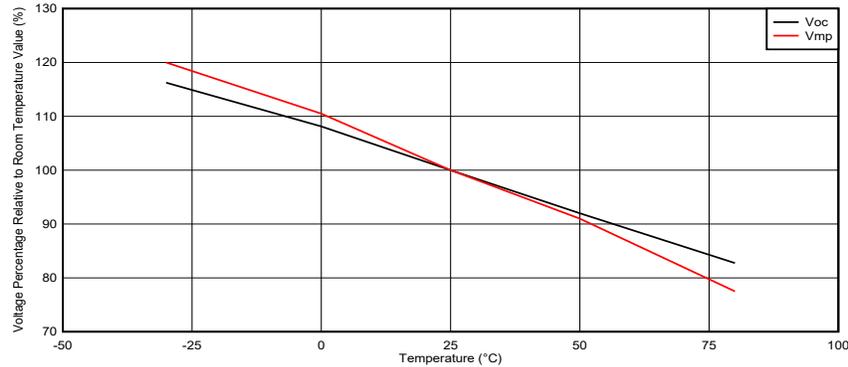


Figure 1-1. Example of a Solar Panel's Open Circuit Voltage and Maximum Power Point Voltage vs. Temperature

The actual voltage a solar panel experiences is also heavily related to the load on the solar panel. For example, a weakly irradiated solar panel will maintain its OCV based upon temperature, but the output voltage can lower significantly when a load is applied to the panel. **Figure 1-2** demonstrates the power-voltage characteristic under different irradiance conditions. The peak in the P-V curves is known as the MPP.

To maximize the power given to the battery, a MPPT algorithm is needed. The first and simplest method is FOCV. In this method, the OCV of the panel is measured and the input is regulated at a certain percentage of the OCV. The second method is Perturb & Observe (P&O). In this method, you systematically perturb the input voltage operating point until the maximum power is found. The third method is called Incremental Conductance and collects panel voltage and current information until the derivative of the panel power with respect to voltage is zero [4]. This would indicate the MPP has been found.

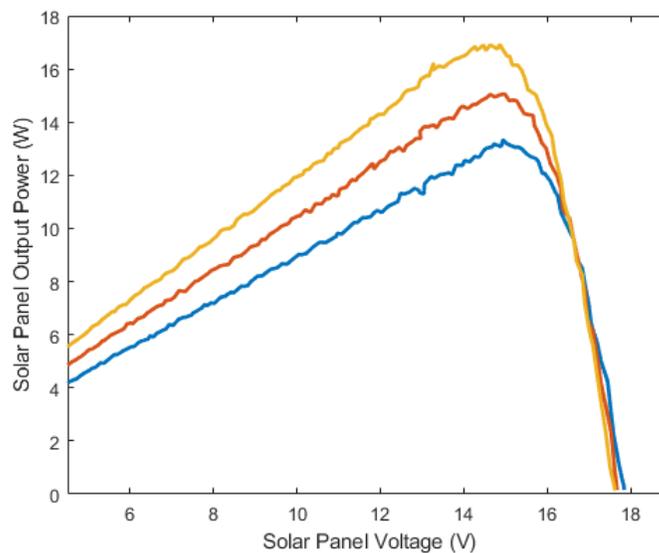


Figure 1-2. P-V Curve of Solar Panel Under Increasing Irradiances

2 Solar Battery Charging with the BQ25798

2.1 Making Use of FOCV

It is critical to find the OCV when using FOCV for MPPT in solar panels. To do this, the solar charger needs to be able to disable its input and then measure the OCV.

The next critical element is finding the K-factor. This is a ratio between 0 and 1 that is multiplied by the OCV to determine the input voltage operating point. Typically, this is found experimentally, and can vary depending on the solar panel and environmental conditions.

After the OCV and K-factor have been found, they are multiplied together and this is the MPP voltage. The solar charger needs to hold the input voltage no lower than this voltage to maximize the solar input.

The last key piece is a way to maintain the input voltage of the charger at the MPP voltage. In a solar charger, if this feature is absent you could crash the input voltage to the converter due to the solar panel current-voltage characteristic. It is necessary to hold the input voltage at the MPP voltage if the charger tries to draw more current than the solar panel can source.

2.2 BQ25798 Key Features for MPPT

To implement these key requirements for a solar charger, we need a charger that:

1. Can disable its input
2. Can measure the OCV
3. Can set the K-factor
4. Can hold the input voltage at the MPP

The BQ25798 is the perfect candidate and meets all of these requirements. First, it has a Hi-Z mode that allows disabling of the input. Second, it has an ADC that can measure the OCV. Third, it has an I2C register to set the K-factor. Last, it has flexible Input Voltage Dynamic Power Management (VINDPM) to hold the solar panel voltage at the MPP voltage. See [Figure 2-1](#) for BQ25798 features that enable MPPT.

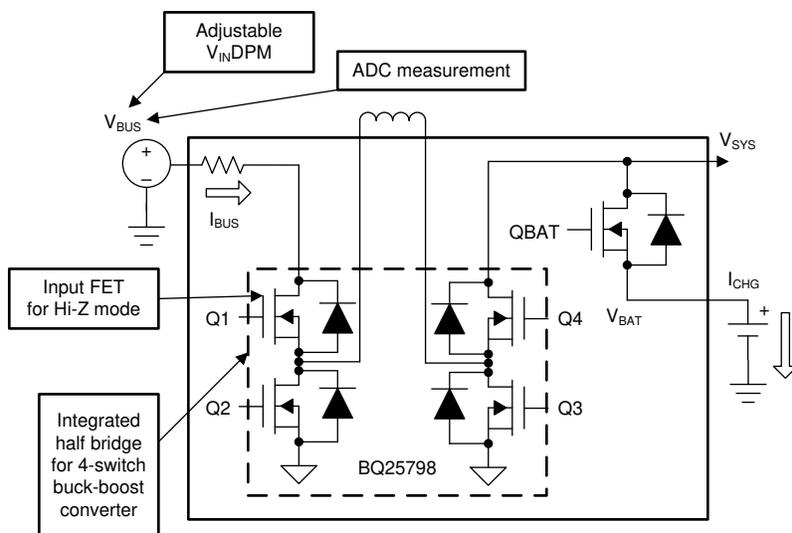


Figure 2-1. BQ25798 Integration and Features

2.3 BQ25798 Key Registers

The BQ25798 has one key register, REG15, to allow solar panel MPPT. The most important bits relate to the K-factor control and the MPPT enable control. [Table 2-1](#) demonstrates the key bits for MPPT control.

The K-factor control is implemented by the VOC_PCT bits and determines what percentage of the OCV of the solar panel the BQ25798 will set the VINDPM register to. This is crucial to the operation of the panel.

To enable the MPPT, the EN_MPPT bit needs to be checked. The battery has to also be above VSYSTEMIN to enable MPPT.

In addition, the VOC_RATE bits adjust how often the OCV of the solar panel is measured. The VOC_DLY bits adjust how long the converter turns off when the solar panel OCV is measured.

Table 2-1. REG15 Key Bits for MPPT Control

Name	Bits	Function
VOC_PCT	7-5	To set the VINDPM as a percentage of the VBUS open circuit voltage when the VOC measurement is done.
EN_MPPT	0	Enable the MPPT to measure the VBUS open circuit voltage.
VOC_RATE	2-1	The time interval between two VBUS open circuit voltage measurements.
VOC_DLY	4-3	After the converter stops switching, the time delay before the VOC is measured.

2.4 BQ25798 MPPT Algorithm

To ensure the MPPT algorithm fully works, the charger needs to be in VINDPM. The easiest way to ensure this is to set the charging current to maximum. The user can configure the battery charger to start the MPPT mode. The charger will turn off the input for the VOC_DLY time and measure the OCV. Then the charger will multiply the chosen VOC_PCT by the measured OCV and set the VINDPM to this value. The charger will resume charging until VOC_RATE has been met and the OCV will be measured again. The VOC_PCT chosen value will be determined by the user's application. See [Figure 2-2](#) for more details of the OCV measurement.

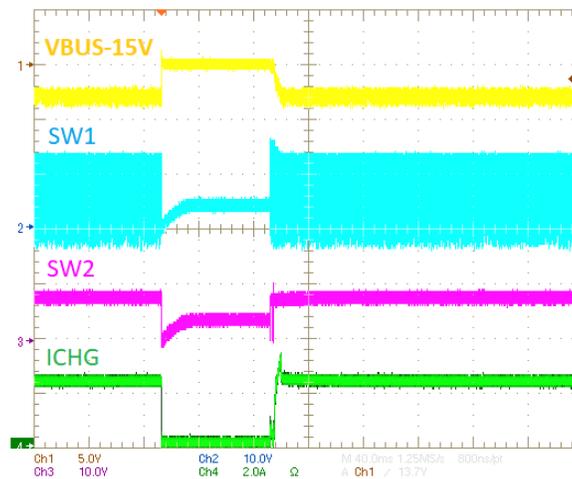


Figure 2-2. Open Circuit Voltage Measurement

Based upon the tested solar panel's measurement results, a VOC_PCT of 81.25% optimized the input power for a specific day. Assuming no significant change in sunlight conditions, the tested solar panel could remain at this setting all day across different seasons in order to maximize the use of the tested solar panel.

This algorithm helps the BQ25798 to perform in different temperature and sunlight environments. As the temperature gets colder the OCV of the panel will rise. However, the VINDPM setting will also rise because the VOC_PCT register value remains the same. This makes the BQ25798 an ideal candidate for a solar charger because it can handle the variations of the seasons and can be used in different climates around the world.

2.5 Using Charge Current for Algorithm Improvement

The second MPPT algorithm builds upon the first using charge current measurement. First, one K-factor is selected and tested. After charging resumes, the charging current is recorded. Next, another K-factor is chosen and the charge current following the change is evaluated. This process is performed iteratively across all K-factors. Whichever K-factor gives the highest charge current optimizes the input power the most. With a nearly constant battery voltage in the short term, the charge current is a benchmark for the output power.

Due to the presence of the VOC_PCT register bits and the ADC in the BQ25798, both the K-factor selection and the charge current observation are realizable. A sample algorithm for finding the MPPT with one power maximum for the BQ25798 is demonstrated in Figure 2-3. In the sample algorithm, a VOC_PCT setting above and below the original VOC_PCT setting is tested each time and whichever of the three settings yields the most charge current decides the next steps.

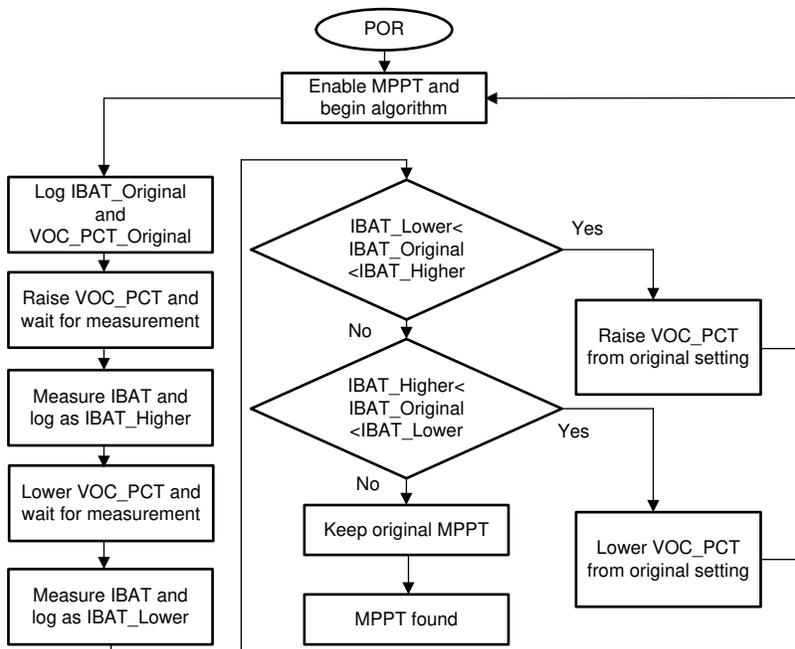


Figure 2-3. Sample BQ25798 MPPT Algorithm with ADC

2.6 Second Algorithm in Action

The second proposed MPPT solution is a combination of the FOCV and P&O methods and leverages several key features of the BQ25798. First, the charger implements a simple yet robust MPPT feature using the VINPDM feature of the part with a configurable K-factor. Second, the charger allows access to the charge current via the ADC to monitor if the MPP has been reached.

Figure 2-4 shows a demonstration of this MPPT algorithm. First, the user starts with MPPT enabled at the lowest setting of 56.25% of the open circuit voltage. Every 30 seconds, the MPPT register setting is increased and the change in the charge current is observed. After increasing the MPPT register setting to 87.5% it was noticed the charge current decreased, indicating the 81.25% maximizes the charge current. The host could rerun the algorithm as the sun condition changes to find the new MPPT.

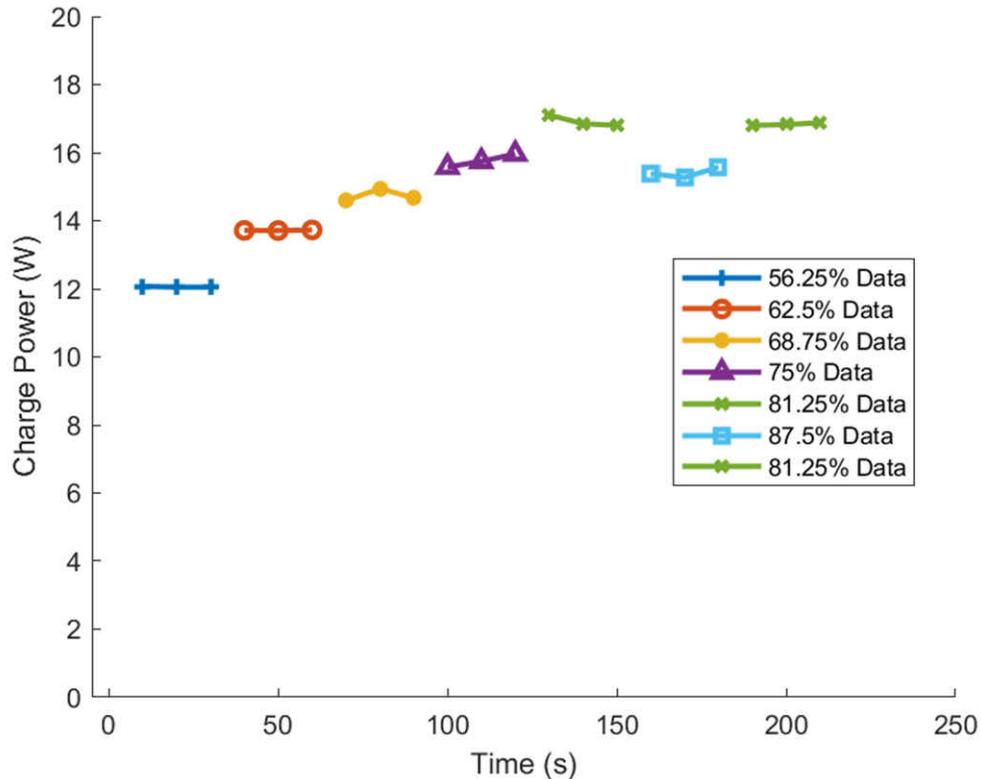


Figure 2-4. MPPT Second Approach Algorithm Example

3 Summary

Two different algorithms to implement solar MPPT with the BQ25798 were discussed. They both make use of the key VINDPM feature that allows the input voltage to be maintained at the MPP. The first method requires just setting the VOC_PCT and keeps the VINDPM at the value of the multiplication of the OCV and the VOC_PCT. Adding in the tracking of the charge current allows greater flexibility to find the MPP.

4 References

1. N. H. Zaini, M. Z. Ab Kadir, M. Izadi, N. I. Ahmad, M. A. M. Radzi and N. Azis, *The effect of temperature on a mono-crystalline solar PV panel*, 2015 IEEE Conference on Energy Conversion (CENCON), 2015, pp. 249-253.
2. Texas Instruments, [Maximum Power Point Tracking With the bq24650 Charger](#) (pp 3-4) application report.
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4. T. Esram and P. L. Chapman, *Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques*, in *IEEE Transactions on Energy Conversion*, vol. 22, no. 2, pp. 439-449, June 2007.

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