Application Brief

Using Battery Tracking VINDPM to Make the Most of Solar and High-Impedance Power Sources

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Battery Charging Products

Introduction

Input Voltage Dynamic Power Management (VINDPM) is a feature present in many chargers as a safety feature to protect input weak input sources. This feature prevents the input source voltage from collapsing below a pre-determined voltage threshold (V_{INDPM}) by limiting current draw. This prevents a system load that is too large or charge current from collapsing the input source to a level at which it can no longer be used for charging. For example, if the charger is connected to a 100mA USB power source but the system load current exceeds the 100mA capabilities of the power source, then the input voltage to the charger quickly starts to drop. By preventing the input system load voltage from dropping below V_{INDPM}, 100mA of charge current can still be used to power the system load.

This feature is present in many chargers with selectable, fixed-voltage V_{INDPM} thresholds. Common voltage options are 4.7V, 4.5V, and 4.2V, which are all above typical battery voltage regulations for Li+ based batteries. Battery-tracking VINDPM introduces a V_{INDPM} that is based on the dynamic battery voltage rather than a fixed voltage threshold.

Wider Input Operating Range

Applications where the source is unknown and have a wider input voltage range typically benefit from VINDPM protection. This protection makes sure that the input voltage sleep threshold of a device is not crossed and that charging can proceed as normal. A fixed VINDPM of 4.2V cannot provide sufficient overhead to allow the battery to charge up to full battery capacity, while a VINDPM of 4.7V can limit the range of input sources with which the system can charge. By following the battery voltage low and increasing as the battery charges, the battery tracking VINDPM threshold maximizes the operating range with which the charge can function.

Improved Efficiency and Thermals

Linear charger efficiency (P_{OUT} / P_{IN}) is primarily determined by the ratio between input voltage and output voltage (V_{OUT} / V_{IN}). The energy lost between input and output is dissipated as heat, so inefficiency results in higher temperatures in the system. Since output voltage range is predetermined by battery chemistry and can change as the battery charges and discharges. Output voltage is largely outside of the control of the designer. For this reason, designers choose to minimize the energy loss and thermal dissipation by minimizing the voltage difference between the input and the output voltages.

Some designers choose to place the V_{INDPM} at the lowest voltage at which the device can charge the battery fully. This results in worse efficiency and more thermal dissipation at lower battery voltages when the voltage drop from V_{IN} to V_{BAT} is greater. Some designers address this by disabling the VINDPM feature, and manually adjusting the input source using a programmable supply. This can be very complex and taxing in terms of engineering design time and host controller processing. Battery Tracking VINDPM can be beneficial in combining the simplicity of using the VINDPM feature with the efficiency of a more dynamic input voltage.

Selecting a charge current higher than the rated current of the input allows the input voltage can be regulated purely by the VINDPM loop. The charger attempts to pull more current than the power source can provide, but only enough to collapse the input voltage to the VINDPM threshold. With a fixed input voltage threshold, the rising battery voltage can increase to the point where there is not sufficient difference in voltage to enable the regulator. By using Battery Tracking VINDPM, as the battery voltage rises the VINDPM voltage rises, and therefore the input voltage rises. Ultimately, this creates a system where the input voltage is always a fixed voltage above battery with minimal controls required from a host controller or power supply. For the BQ25188, for instance, this system results in a V_{IN} that is at most 330mV above V_{BAT}.

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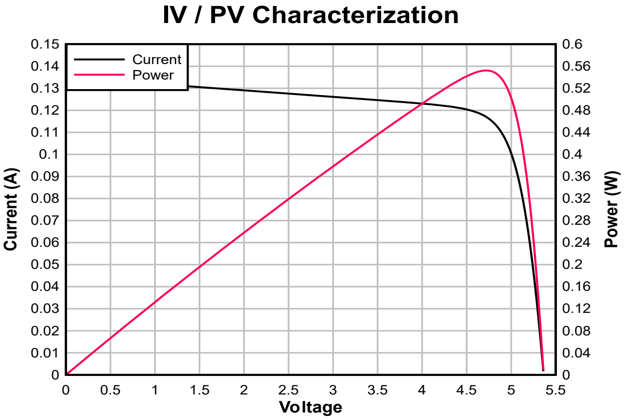
Solar and High-Impedance Sources

High-impedance sources, such as photovoltaic cells, are characterized by having a higher open-circuit voltage which quickly drops under load. These types of sources require complex designs for input voltage regulation. VINDPM serves exactly this purpose. To maximize power, these sources are often regulated to a Maximum Power Point (MPP) using Maximum Power Point Tracking (MPPT). This feature balances input voltage and current to maintain the point where maximum power is available. For battery charging, maximum power is not always the objective, particularly when using a linear charger.

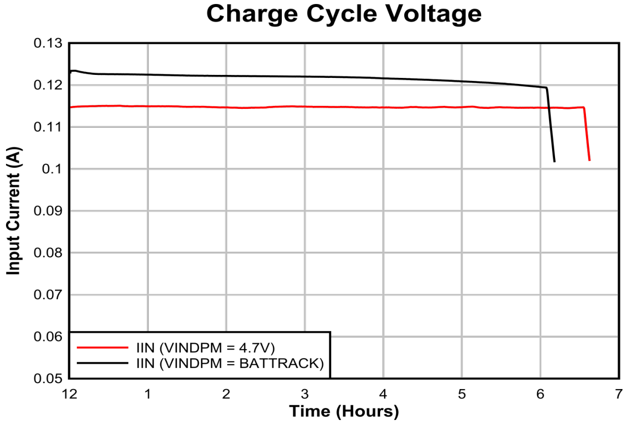
Battery charging rate a function of current that flows into the battery; maximizing current will minimize battery charging times. For this reason, MPPT and maximizing power is not optimal. By prioritizing solely current while maintaining an adequate input voltage, BATTRACK VINDPM maximizes charging rate with a high-impedance source. For linear chargers, this is the optimal way to charge from a high-impedance source, simultaneously increasing efficiency, decreasing thermal dissipation, and decreasing charge time.

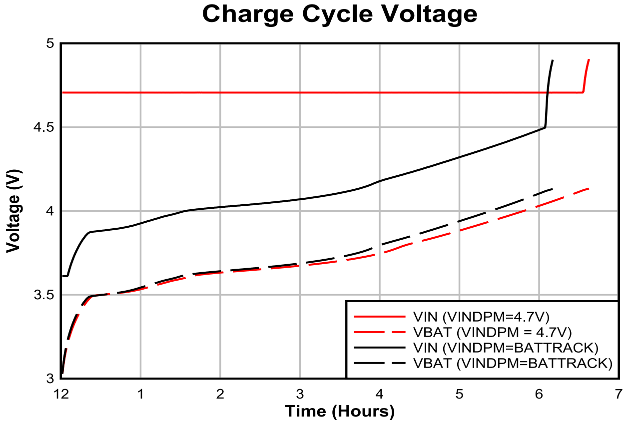
Example Implementation

For the following comparison of fixed-voltage input voltage regulation and battery-tracking input voltage regulation, a battery of approximately 700mAh was charged using a BQ25185 charger with a high-impedance input source. The high impedance input source is a solar cell simulator mimicking available PV cells. In this scenario, a cell with an open-circuit voltage of 5.4V and short-circuit current of 135mA is used.

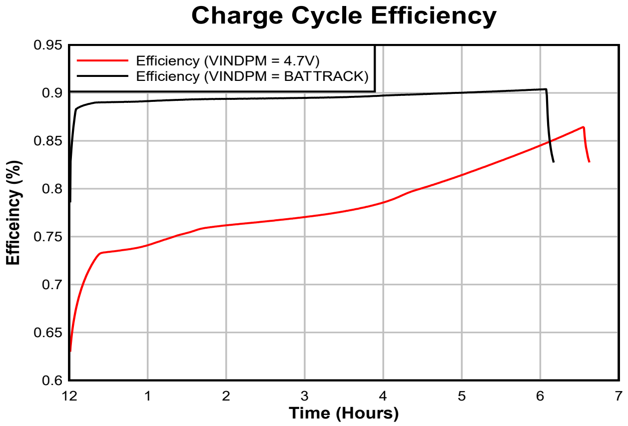


From the described characteristics, one can observe that the maximum power-point voltage can be found at approximately 4.75V. With this, the previously described battery was charged using this input source with a configured charge current of 200mA (larger than the short circuit current of the input source) and with a VINDPM of 4.7V and BATTRACK for comparison. The charge results are the following:





A higher charge current is achievable, resulting in a faster charge cycle and shorter charge duration. One additional benefit that can be calculated from the charge cycle characteristics is the improvement in efficiency. With less energy dissipated as heat, the charging process provides a charging with less heat concerns.



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