Application Note

How to Prevent Solar-Powered Chargers From Shutting Down in Low Light Conditions

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ABSTRACT

This application note provides a simple external circuit method that prevents a solar-powered BQ25672 or BQ25798 from shutting down in low sunlight if the battery completely discharges.

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1 Introduction

All NVDC power path battery chargers have output (that is, SYS pin) short circuit protection. In a properly designed application where the input power of the NVDC charger is sufficient, the charger provides the minimum system voltage (MINSYS) for the maximum system load even with a completely discharged battery pack. With no battery or completely discharged battery pack with open protector, the BQ25798 (or BQ25672) SYS voltage (VSYS) can fall below $V_{SYS\text{-}SHORT}$ = 2.0V if the system load is higher than the input power at VBUS supply or if the input voltage falls below the minimum input voltage threshold (VINDPM) of the charger. After seven attempts to restore VSYS, the BQ25798 forces high impedance (HiZ) mode (battery-only mode) by setting the EN_HIZ I2C register bit = 1 as shown in Figure 1-1. Oscilloscope CH1 (royal blue) is the VAC1 pin of the charger, CH2 (light blue) is the REGN pin, CH3 (pink) is SYS output and CH4 (green) is the simulated panel output voltage connected to VAC1 pin.

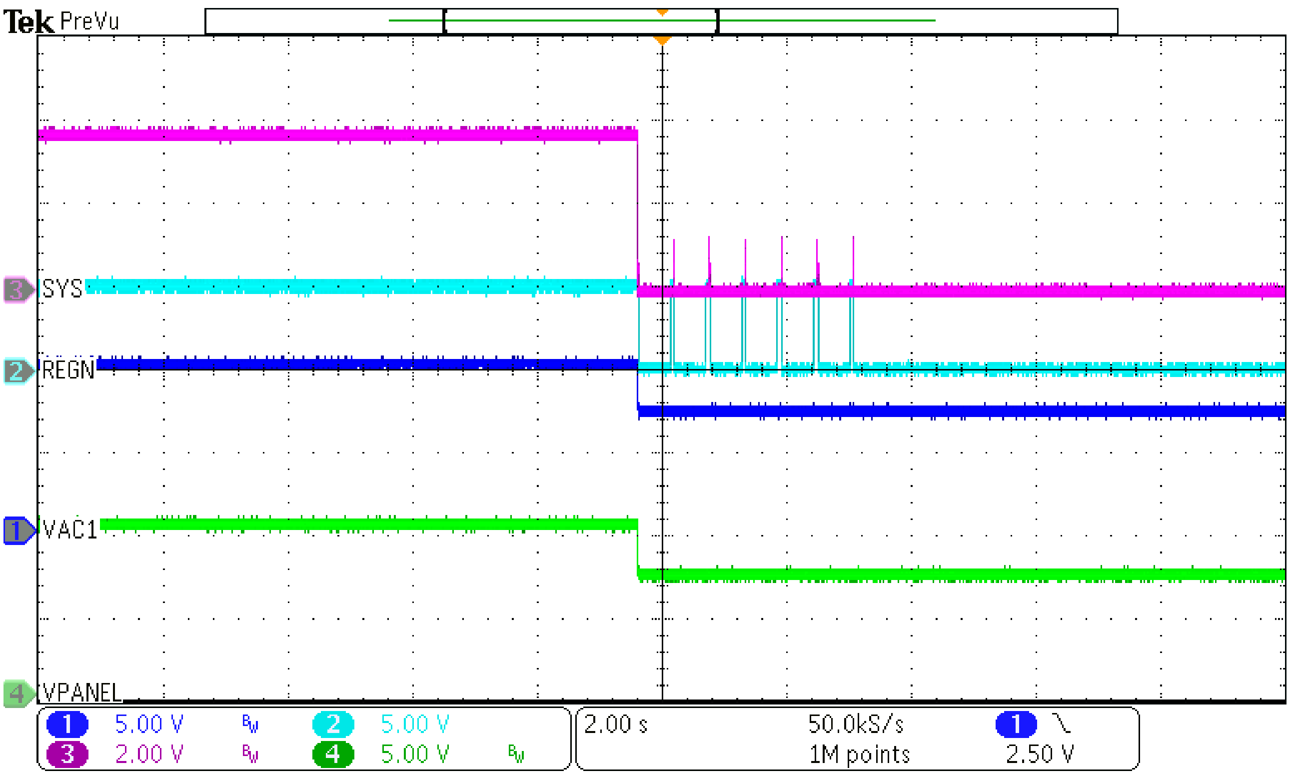

Figure 1-1. Charger with No Battery Entering VSYS Short when Input Voltage Falls Below VINDPM Threshold

With battery voltage (VBAT) higher than MINSYS voltage, the BQ25798 maximum power point tracking (MPPT) feature periodically resets the input voltage dynamic power path (VINDPM) threshold to a fixed percent of the panel open circuit voltage (VOC). This makes sure of the continued operation of the charger without collapsing the voltage of the panel due to too much current draw at a voltage that is not at the (MPP) voltage. Figure 1-2 shows an example of the MMPT feature in operation. CH2 (light blue) is battery charge current. When the panel output voltage drops below the V_{INDPM} threshold, the charger stops. Once the MPPT timer expires, the charger recomputes the V_{INDPM} threshold based on V_{OC} measurement and the MPP percentage register. Then, the converter restarts and continues charging the battery, eventually with less current and the newly limited input power.

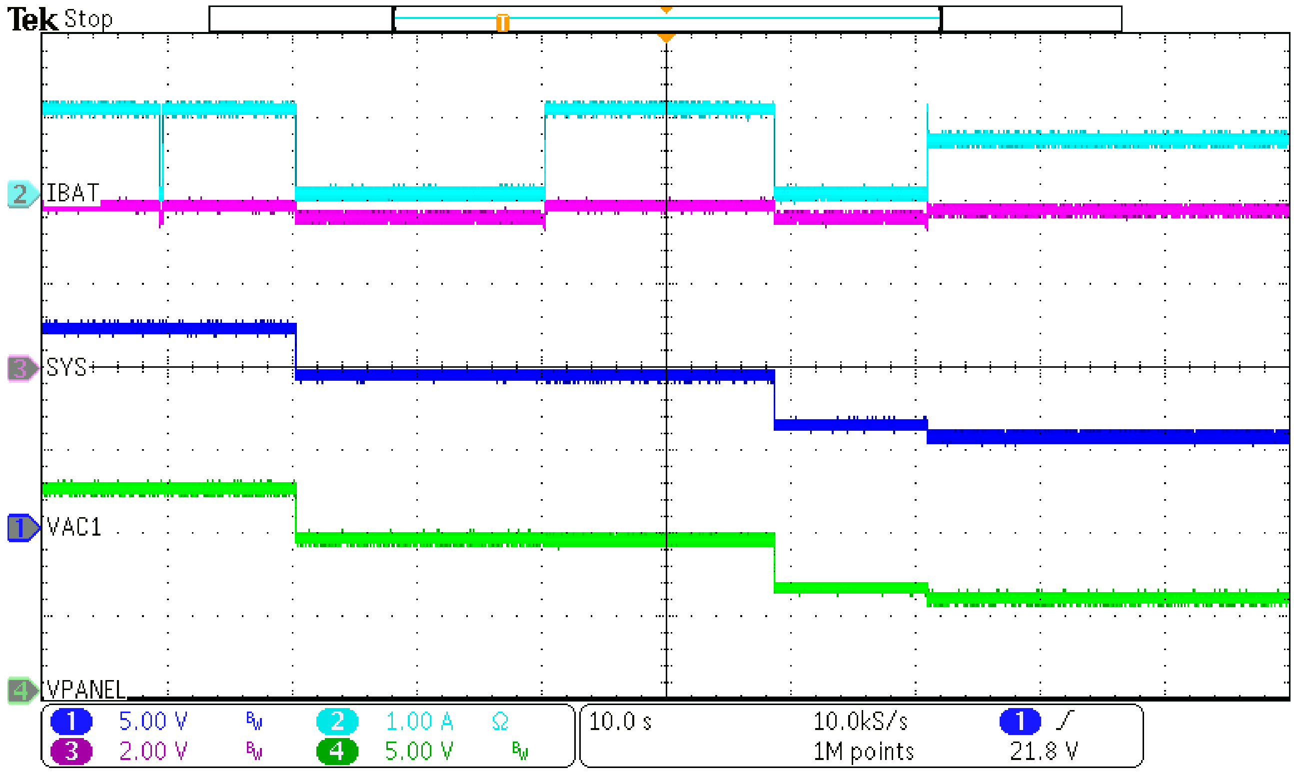

Figure 1-2. MPPT Sampling with MINSYS=3.5V, VBAT=3.7V, ICHG=1A, MPPT Period=30s

Unfortunately, the periodic V_{INDPM} reset of the MPPT feature is only enabled if VBAT is higher than MINSYS. With a discharged battery, the charger VINDPM threshold defaults to VOC minus 0.7V for low voltages or 1.4V for high voltages. At sunrise, if a cloud passes over the panel, then the output voltage can start high and drops below in between the VINDPM threshold and charger UVLO. This causes VSYS to collapse and the charger to enter HiZ mode, as shown in Figure 1-1. Charger HiZ mode can only be exited by an I2C write from a system processor that has no input voltage or waiting for the panel voltage to drop below UVLO (3.4V).

2 Discrete VINDPM Auto-reset Circuit

The REGN pin voltage, VREGN, of the charger drops when VSYS falls below V_{SYS_SHORT}. The two 1MΩ resistors, pull-down resistor R_{PD}, p-channel MOSFET (PFET), n-channel MOSFET (NFET) and 0.33 to 1µF capacitor configured form the auto-reset circuit as shown in Figure 2-1. The VREGN drop triggers a V_{INDPM} threshold reset by momentarily disconnecting VACx from the panel, which collapses the charger's VACx pin voltage.

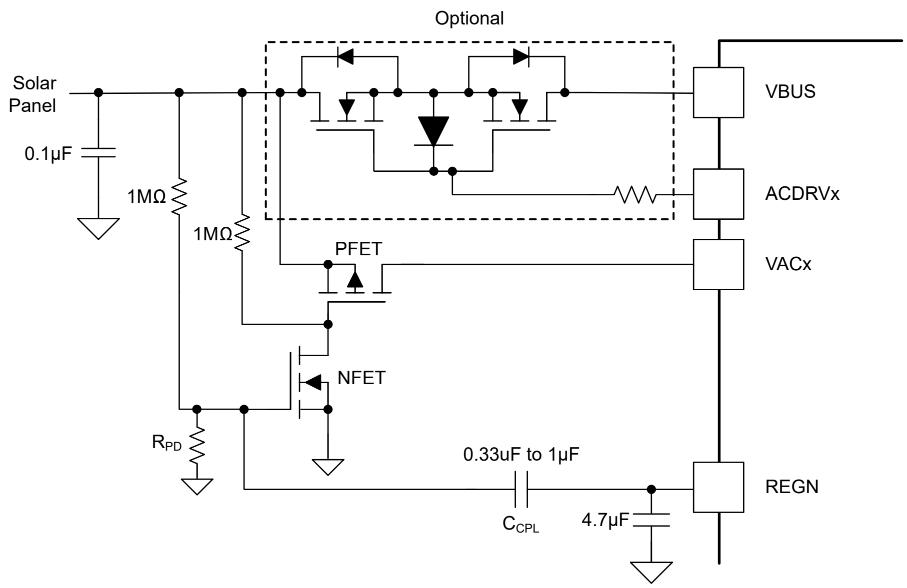

Figure 2-1. Discrete VINDPM Auto-reset Circuit

Figure 2-2 shows BQ25798 with the circuit above operating with no battery attached and a 4Ω resistor from SYS to GND. After each drop in simulated panel output voltage below the V_{INDPM} threshold but still above UVLO, the converter of the charger stops switching which causes VSYS and VREGN (CH2 in light blue) to collapse. The normally on NFET momentarily turns off then back on due to the capacitor that is coupled to REGN. This toggles the PFET that is pulled up to the solar panel voltage off then on, causing the VAC1 pin voltage to fail below UVLO then up to the new VOC voltage. The fast VAC1 toggle resets the V_{INDPM} threshold before the charger enters HiZ mode due to VSYS drop to ground.

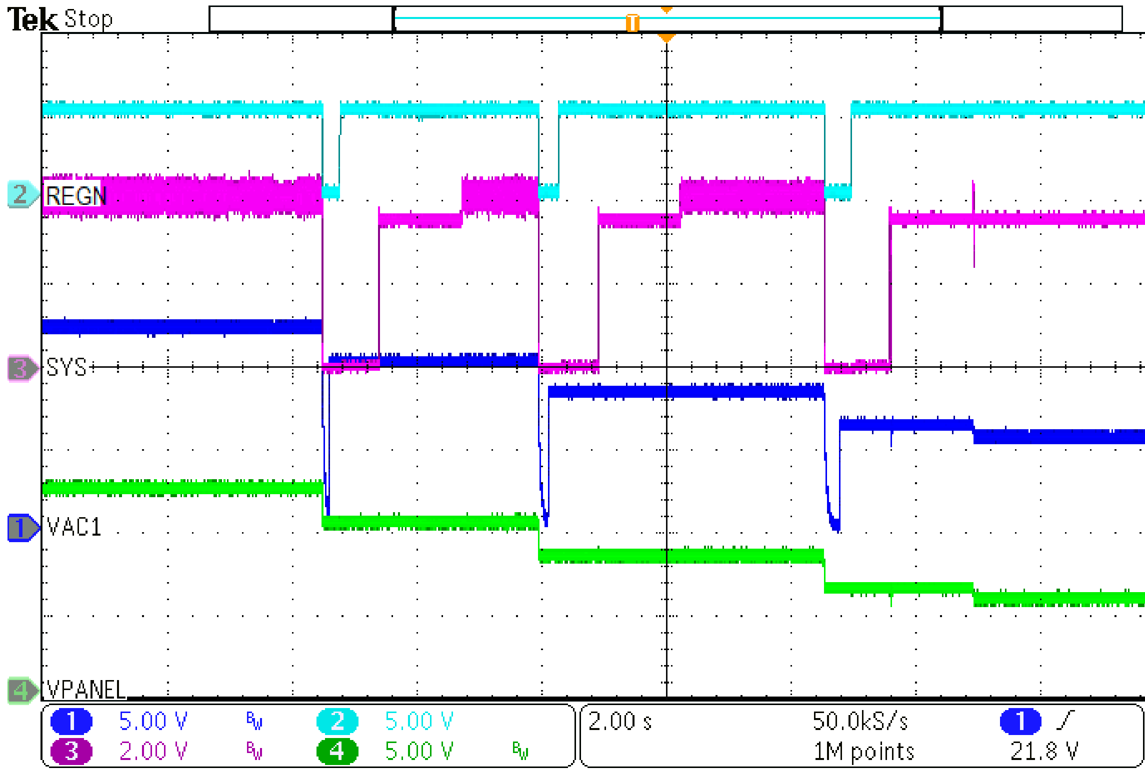

Figure 2-2. Discrete V_{INDPM} Auto-reset Circuit Operation

Table 2-1 shows the specs for the FETs, coupling capacitor and pull-down resistor. The charger's $V_{INDPM(MIN)}$ = 3.6V sets the minimum panel MPP voltage for operation.

Table 2-1. Circuit Component Specifications

Component	Specification	Example Part Number
NFET	VDS and VGS > V_{OCmax}, R_{DSon} < 100Ω	IRF7105PbF - NFET
PFET	VDS and VGS < -$V_{OCmax,}$ R_{DSon} < 100Ω	IRF7105PbF - PFET
C_{CPL}	0.33 uF - 1uF non polarized, Voltage rating >V_{OCmax}*R_{PD}/(1MΩ + Rpd)	Any
R_{PD}	10% > 1.0MΩ / [(3.6V/$V_{GSTH-NFET}$) -1)] assuming the pull up resistors are 1.0MΩ	Any

3 Summary

This application note demonstrates a discrete circuit that resets the default V_{INDPM} threshold of the charger after VSYS collapse. The circuit works for either VAC1 or VAC2 sensed inputs and with or without ACDRVx driven MUX FETs. By being below either 0.7V or 1.4V of the VOC of a solar panel, the default VINDPM threshold of the charger is likely not exactly the MPP of the panel, but is generally close enough for the charger to provide VSYS=MINSYS to allow the processor to power up or recharge the battery.

4 References

- Texas Instruments, BQ25798 I2C Controlled, 1- to 4-Cell, 5A Buck-Boost Battery Charger with Dual-Input Selector, MPPT for Solar Panels and Fast Backup Mode, data sheet.
- Texas Instruments, BQ25672 I2C Controlled, 1- to 4-Cell, 3A Buck-Boost Battery Charger with Dual-Input Selector, MPPT for Solar Panels , data sheet.

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