

# 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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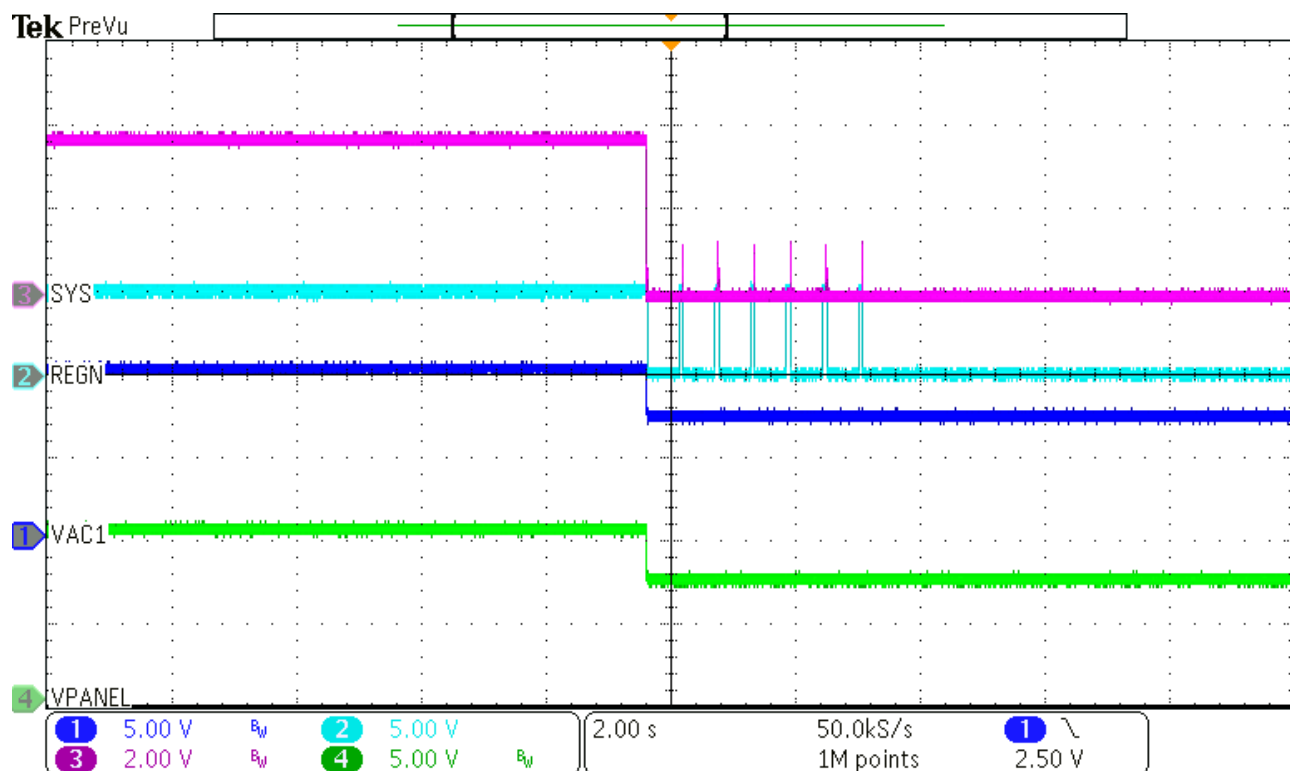
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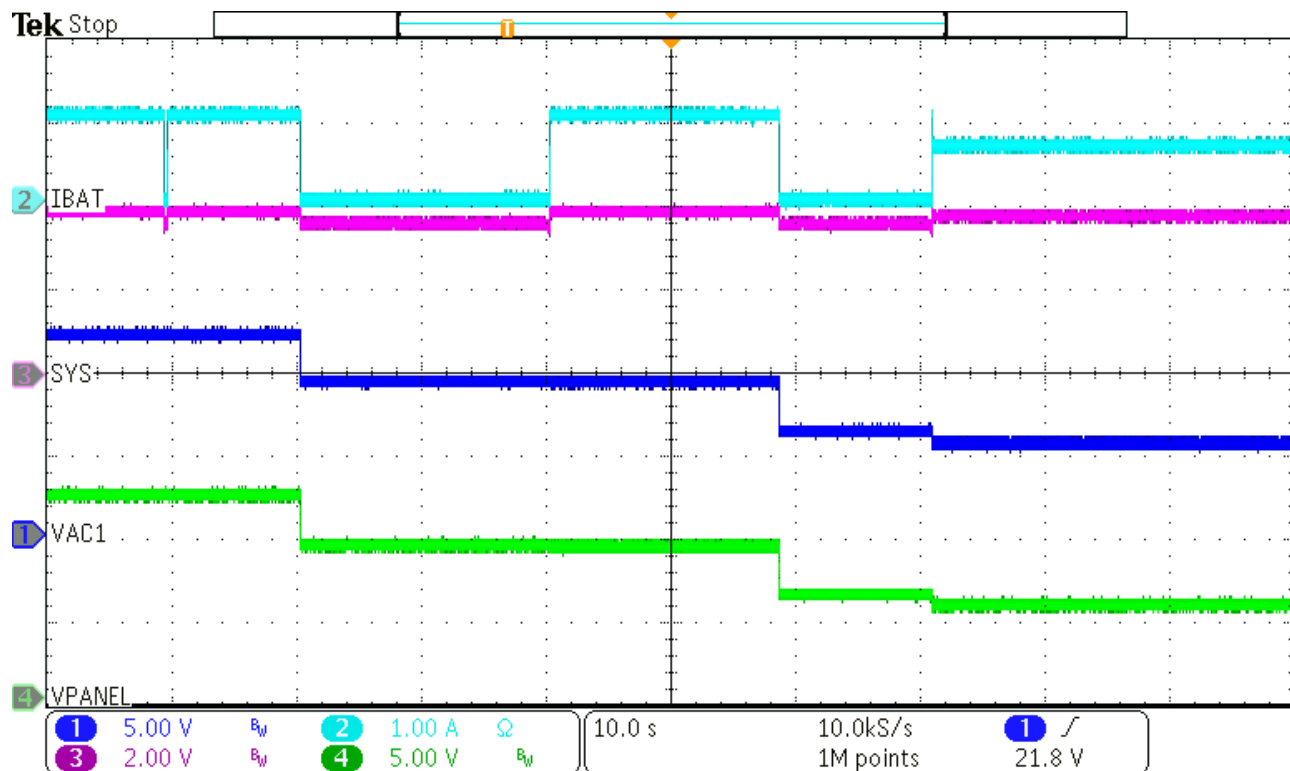
## 1 Introduction

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 (V<sub>SY</sub>) can fall below  $V_{\text{SYS-SHORT}} = 2.0\text{V}$  if the system load is higher than the input power at V<sub>BUS</sub> supply or if the input voltage falls below the minimum input voltage threshold (V<sub>INDPM</sub>) of the charger. After seven attempts to restore V<sub>SY</sub>, 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 V<sub>SY</sub> Short when Input Voltage Falls Below V<sub>INDPM</sub> Threshold**

With battery voltage (V<sub>BAT</sub>) higher than MINSYS voltage, the BQ25798 maximum power point tracking (MPPT) feature periodically resets the input voltage dynamic power path (V<sub>INDPM</sub>) threshold to a fixed percent of the panel open circuit voltage (V<sub>OC</sub>). 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<sub>INDPM</sub> threshold, the charger stops. Once the MPPT timer expires, the charger recomputes the V<sub>INDPM</sub> threshold based on V<sub>OC</sub> 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.

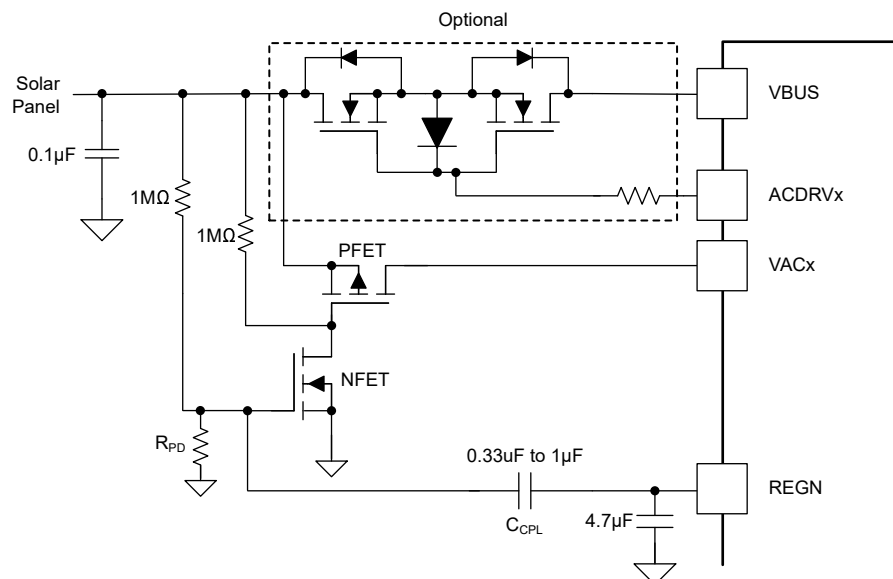


**Figure 1-2. MPPT Sampling with MINSYS=3.5V, VBAT=3.7V, ICHG=1A, MPPT Period=30s**

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).

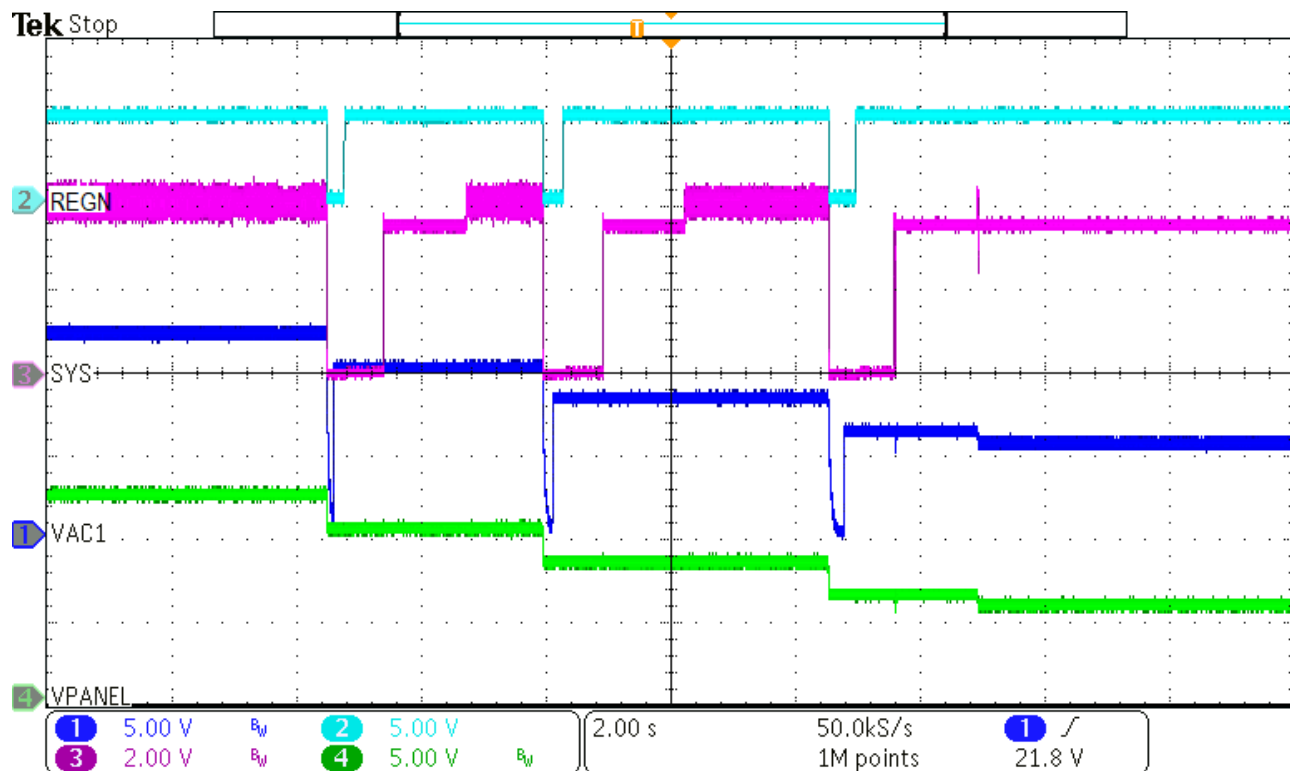
## 2 Discrete VINDPM Auto-reset Circuit

The REGN pin voltage, VREGN, of the charger drops when  $V_{SYS}$  falls below  $V_{SYS\_SHORT}$ . The two  $1\text{M}\Omega$  resistors, pull-down resistor  $R_{PD}$ , p-channel MOSFET (PFET), n-channel MOSFET (NFET) and  $0.33$  to  $1\mu\text{F}$  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  $4\Omega$  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  $V_{SYS}$  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  $V_{SYS}$  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	$V_{DS}$ and $V_{GS} > V_{OCmax}$ , $R_{DSon} < 100\Omega$	IRF7105PbF - NFET
PFET	$V_{DS}$ and $V_{GS} < -V_{OCmax}$ , $R_{DSon} < 100\Omega$	IRF7105PbF - PFET
$C_{CPL}$	0.33 $\mu F$ - 1 $\mu F$ non polarized, Voltage rating $> V_{OCmax} * R_{PD} / (1M\Omega + R_{pd})$	Any
$R_{PD}$	$10\% > 1.0M\Omega / [(3.6V/V_{GTH-NFET}) - 1]$ assuming the pull up resistors are 1.0M $\Omega$	Any

### 3 Summary

This application note demonstrates a discrete circuit that resets the default  $V_{INDPM}$  threshold of the charger after  $V_{SYS}$  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  $V_{INDPM}$  threshold of the charger is likely not exactly the MPP of the panel, but is generally close enough for the charger to provide  $V_{SYS}=V_{MINSYS}$  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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