BQ25601 VBUS Behavior under VINDPM

BMS -- BCP

Issue Observed

Issue Reported:

Operating in VINDPM with SYS load, when VBAT is increasing to around 3V,

1) VBUS voltage could drop well below VINDPM setting and oscillates above & below VINDPM threshold.

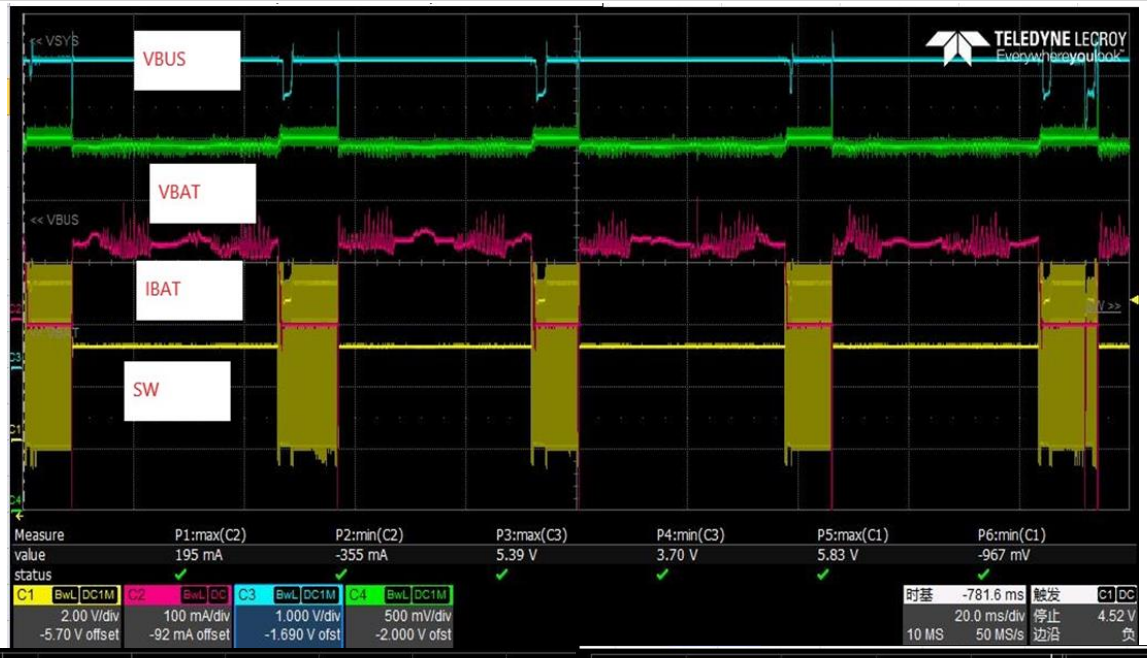
2) The device can't charge normally.

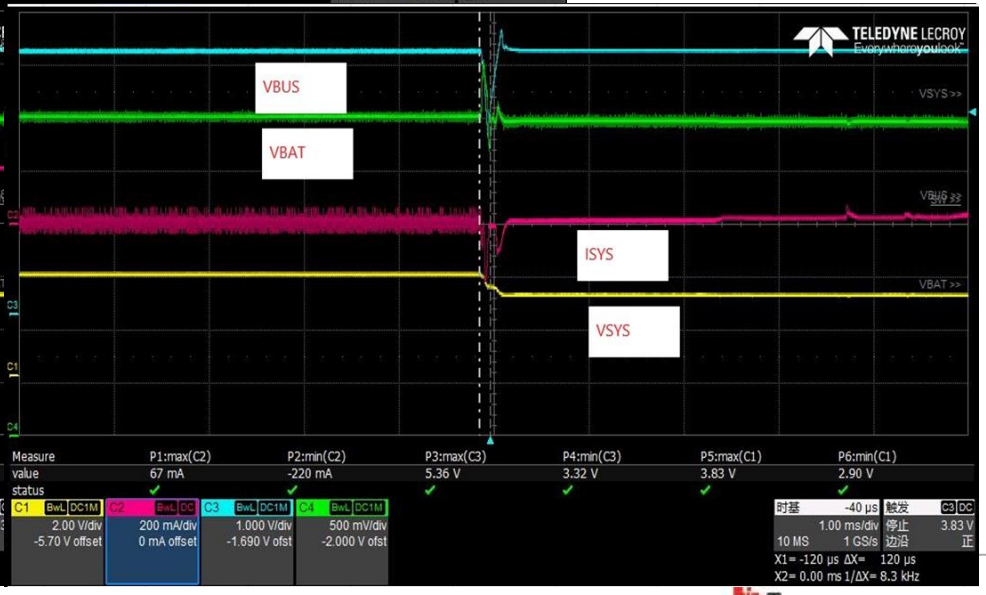
Test conditions:

BQ25601
VBUS=5V with 100mA current capability
VBAT sweep from 2.5V and up

VINDPM setting=4.4V
IPRECHG setting=60mA
ICHG setting=780mA
ISYS=~70mA

BMS-BCP| Customer Waveforms @ VBAT=3V





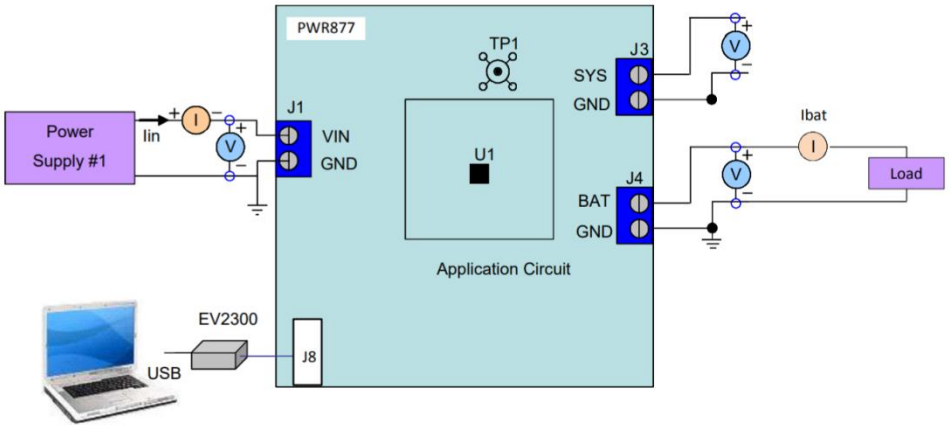
BQ25601 EVM Test Setup

Multi-bit I2C Pulldown Menu

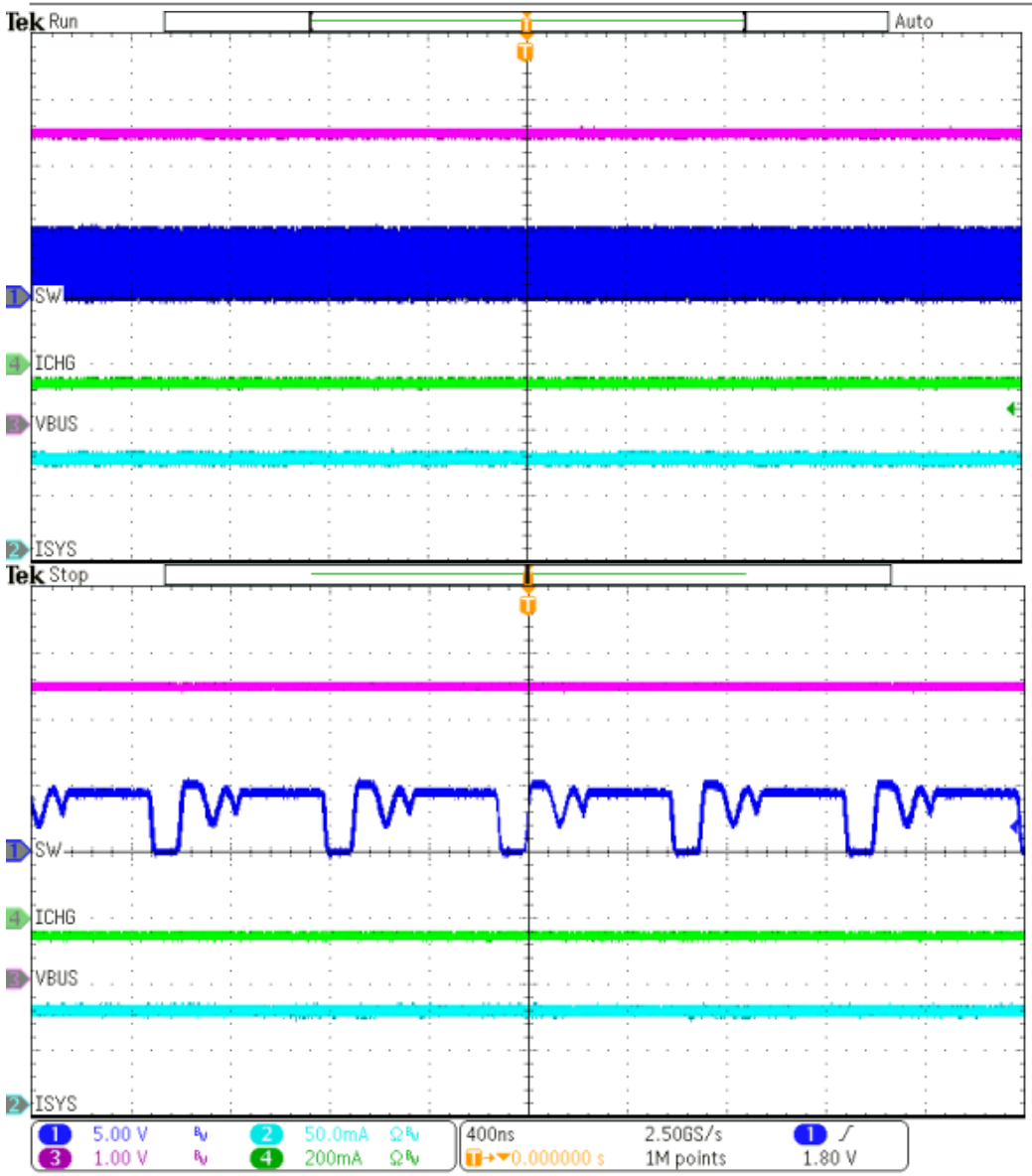
Enable IMON pin	Disable S	Input Current Limit	1.0A
Minimum System Voltage	3.5V	OTG Minimum Battery Voltage	2.8V
OTG Current Limit	1.2A	Q1 Option	Use full C
Fast Charge Current Limit	0.78A	Pre-charge Current Limit	0.06A
Termination Current Limit	0.18A	Charge Voltage Limit	4.400V
Top-Off Timer	30 minute	Recharge Threshold	100mV
Watchdog Timer	Disabled	Charge Safety Timer	10 hrs
Thermal Reg. Threshold	110C	JEITA Low Temp Fast Charge Current	20% of IC
VAC OVP Threshold	6.2V	BOOST Reg. Voltage	5.15V
Input Voltage Limit	4.4V	Sets VINDPM to track BAT voltage	Disable fi
VINDPM INT options	Allow VIN	INDPM INT options	Allow IIND

Single-bit I2C Selection

☐ Enable HIZ mode	☐ Disable PFM mode
☐ Watchdog Timer Reset	☐ OTG Enable
☐ Enable Charge	☑ Enable Termination
☐ Disable OVPFET	☑ Enable Charge Safety Timer
☐ Force IINDET_EN	☑ Enable 2X Extended Safety Timer
☐ Turn off Q4	☐ Set JEITA High Temp Charge Voltage to 4.1V
☐ Turn off Q4 Delay	☑ Enable Q4 System Reset via QON
☐ Register Reset	



BMS-BCP| VBAT=2.9V



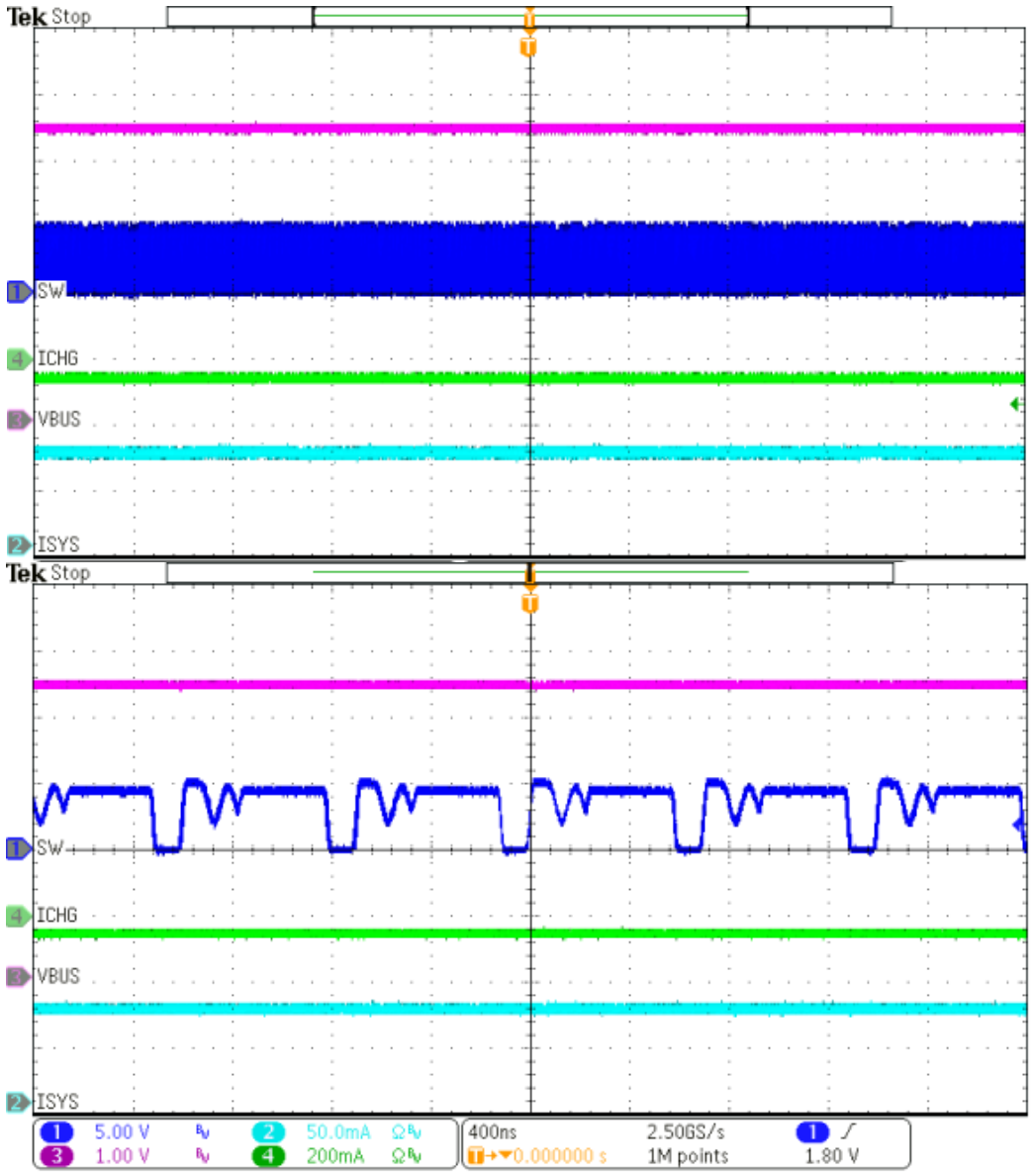
Status			
VBUS	USB DCP (2.4A) (OTP: 1.5A/2.4A)	Charge State	Pre-charge
Power Good	Power Good	Thermal Reg. Status	Not in thermal regulation
VSYS	In VSYSMIN regulation	VBUS_GD	VBUS attached
VINDPM Status	In VINDPM	IINDPM Status	Not in IINDPM
Top-Off Timer Status	Top off timer not counting	ACOV status	Not in ACOV

Fault			
Watchdog Fault	Normal	Boost Fault	Normal
Charge Fault	Normal	Battery Fault	Normal
Battery Temperature Fault	Normal		

Part			
Device ID	bq25601	Rev ID	1.1

The device pre-charges normally in VINDPM

BMS-BCP| VBAT=3.2V



Status			
VBUS	USB DCP (2.4A) (OTP: 1.5A/2.4A)	Charge State	Fast Charging
Power Good	Power Good	Thermal Reg. Status	Not in thermal regulation
VSYS	In VSYSMIN regulation	VBUS_GD	VBUS attached
VINDPM Status	In VINDPM	IINDPM Status	Not in IINDPM
Top-Off Timer Status	Top off timer not counting	ACOV status	Not in ACOV

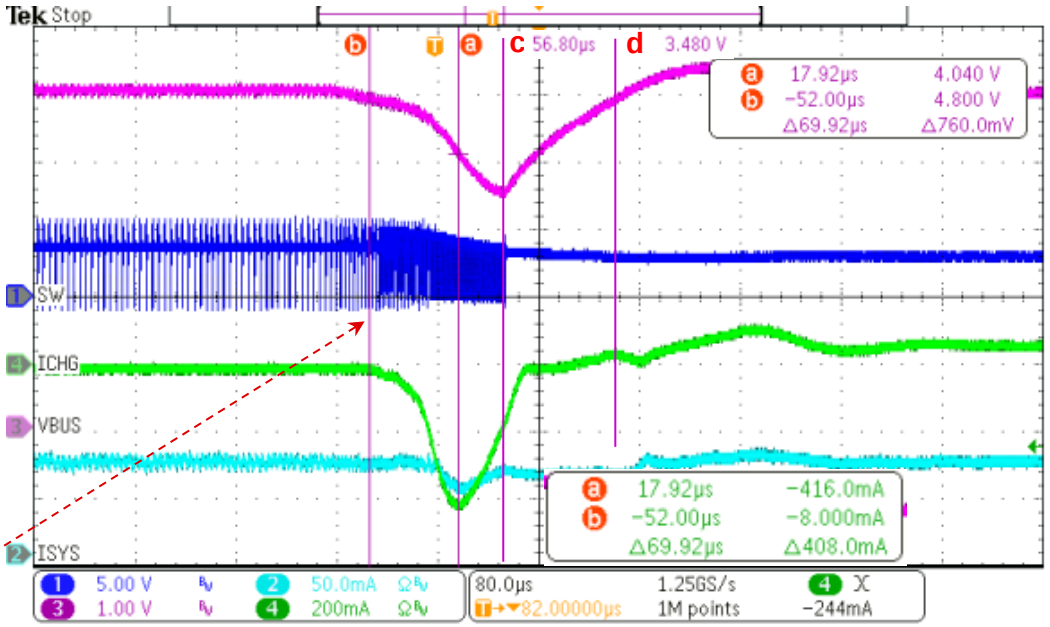
Fault			
Watchdog Fault	Normal	Boost Fault	Normal
Charge Fault	Normal	Battery Fault	Normal
Battery Temperature Fault	Normal		

Part			
Device ID	bq25601	Rev ID	1.1

The device fast-charges normally in VINDPM

VBAT=3V – Pre-Charge to Fast Charge Transient

$V_{BATLOWV\_RISE}$	Battery LOWV rising threshold	Pre-charge to fast charge	3.0	3.12	3.24	V



Referring to the time points b, a, c, d above:

b. When VBAT rises above ~3V, the device transients from pre-charge current (e.g. 60mA setting) to fast charge current (e.g. 780mA setting) instantly. In this case, the charge current changes 408mA in ~70us.
a. VINDPM loop starts to reduce the charge current.
c. VINDPM loop is unable to control the charge current effectively and VBUS falls to low to switch. After the device stops switching, VBUS begins rising and recovers to normal voltage.
d. The charger virtually operates in battery only mode and enters supplement mode.

Root Cause

- The charge current loop has faster response time than the VINDPM loop.
- The VINDPM loop can not respond to quick charge current change in time to prevent VBUS voltage drop.
- For VINDPM testing, adding a resistor in between the power supply and VBUS pin is closer to the real-world VINDPM behavior than using the power supply current limiting. The power supply feedback loop may interact with the device VINDPM loop and make it difficult for the device to find a DC operating point. *Suggest to use the setup of a power supply with a series resistor to test.*

- Avoid big step change for charge current settings. Adjust IPRECHG and ICHG settings based on Charge Status bit (REG08[4:3]).

4	CHRG_STAT[1]	x	R	NA	Charging status: 00 – Not Charging 01 – Pre-charge (< $V_{BATLOWV}$) 10 – Fast Charging 11 – Charge Termination
3	CHRG_STAT[0]	x	R	NA	

e.g.

If the Charge Status bit = Pre-charge, set IPRECHG = ICHG = 60mA
If the Charge Status bit = Fast charging, step up ICHG setting to the targeted value by 60mA step (240mA max) every 1ms until the target ICHG setting is reached.