

## 针对锂电池供电系统的单片电源和电池管理集成电路 (IC)

查询样品: [TPS65471](#)

### 特性

- 40 引脚四方扁平无引线 (QFN) 封装 (6mm x 6mm) 并带有 PowerPAD™
- 带有电源正常信号输出和反向电流保护的集成动态电源路径电路 (VBUS, VAC, VBAT)
- 带有 2 个状态引脚和安全定时器的 550mA 锂离子 电池充电器
- 集成的 4.25V 同步升压转换器 (PWM) 和低压降稳压器 (LDO) 为 LED 提供电压源
- 用于系统中每个功能的 4 个 LDO
- USB 挂起模式
- 复位输出
- 带有脉宽调制 (PWM) 控制的 3 个 LED 驱动器
- 集成的 3.0V LDO 稳压器
- 集成的 3.2V LDO 稳压器
- 一个电机驱动器控制
- LDO 稳压器和升压转换器打开/关闭控制
- 指示线性充电器状态的状态输出
- 反向电流保护和热关断电路

### 应用范围

- 手持式设备

### 说明/订购信息

TPS65471 集成一个锂离子线性充电器、电源路径管理、四个 LDO 稳压器、4.25V 同步升压转换器和 4.25V LDO 稳压器、三个 LED 驱动器和一个电机驱动器。

借助于电源路径电路，USB 端口、AC-DC 适配器和锂离子电池电源可以被无缝切换为 3.2V LDO 输出稳压器电源。这样就防止了系统中的不稳定性。

TPS65471 充电器自动选择 USB 端口或者 AC-DC 适配器。

EN\_VLDO 数字输入被用于打开或者关闭 VLED4P25, VLD02 和 VLD04 的输出。

EN\_VLDO3 数字输入被用于打开或者关闭 VLD03 的输出。

TPS65471 采用 40 引脚 QFN 封装并具有 PowerPAD™。

### ORDERING INFORMATION

T <sub>J</sub>	PACKAGE	ORDERABLE PART NUMBER	TOP-SIDE MARKING
-10°C to 125°C	RHA (QFN)	TPS65471RHA	TPS65471



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

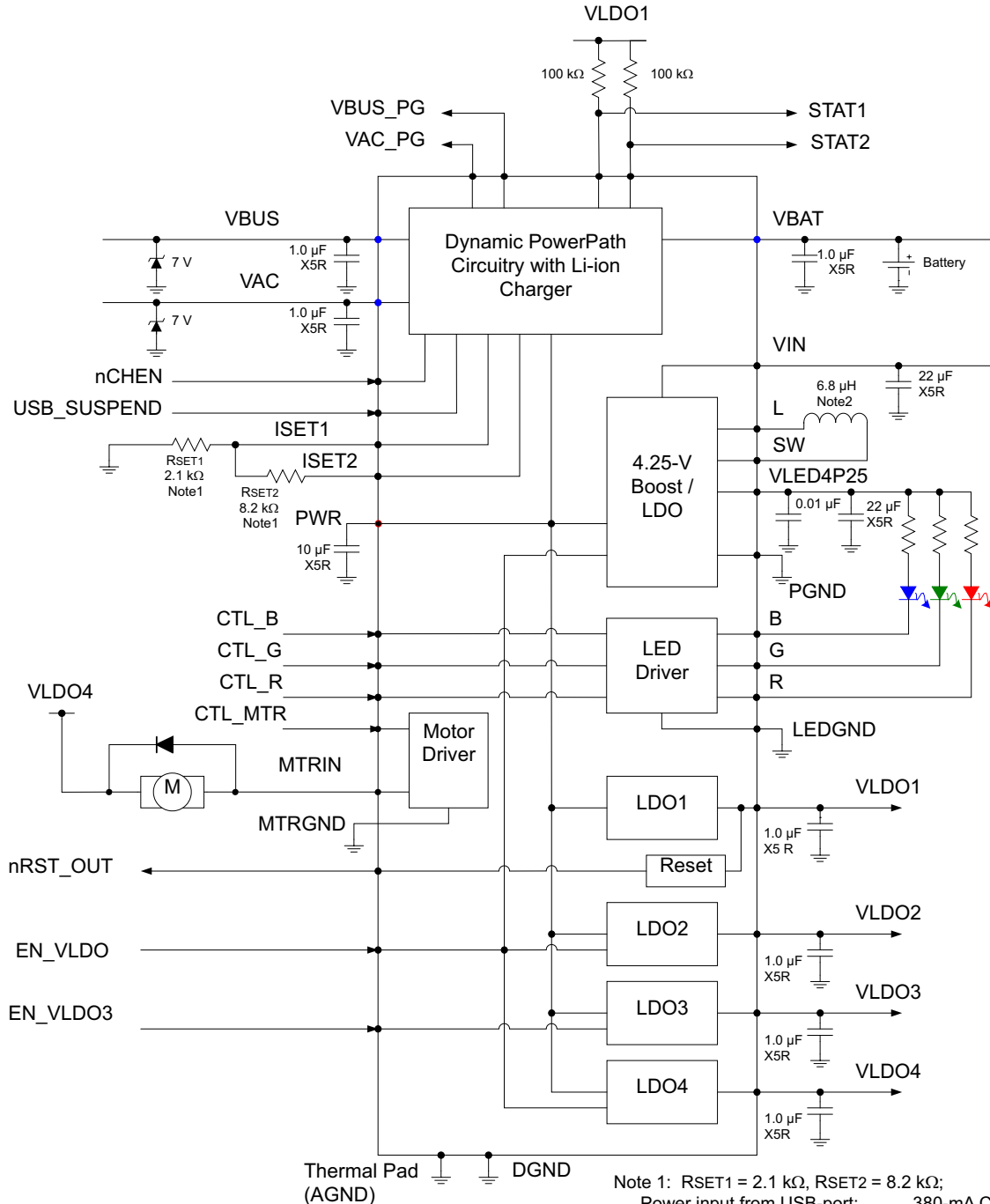
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English Data Sheet: [SLVSBE8](#)



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

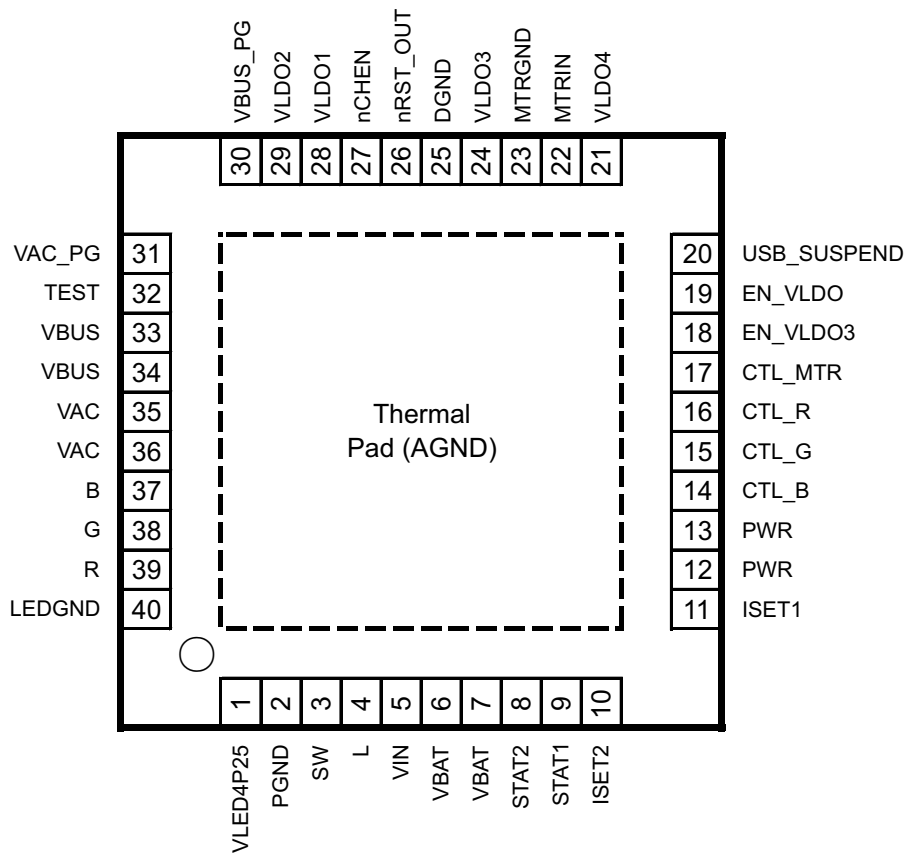
**TYPICAL APPLICATION**



Note 1: RSET1 = 2.1 kΩ, RSET2 = 8.2 kΩ;  
 Power input from USB-port: 380-mA CHARGE CURRENT  
 38-mA PRE-CHARGE CURRENT  
 Power input from AC-DC adaptor: 480-mA CHARGE CURRENT  
 48-mA PRE-CHARGE CURRENT  
 Note 2: TAIYO YUDEN NR4018T6R8M or equivalent  
 These logic inputs and outputs interface are based on 3.2-V system.

PIN OUT

RHA PACKAGE  
(TOP VIEW)



### TERMINAL FUNCTIONS

NAME	NO.	DESCRIPTION	EXTERNAL REQUIRED COMPONENTS (SEE TYPICAL APPLICATION)
VAC	35, 36	Power input from AC-DC adapter	1- $\mu$ F capacitor to AGND to minimize overvoltage transients during AC power hot-plug events. Also Zener diode for surge protection is connected.
VBUS	33, 34	Power input from USB-port	1- $\mu$ F capacitor to AGND to minimize overvoltage transients during BUS power hot-plug events. Also Zener diode for surge protection is connected.
VBUS_PG	30	VBUS power-good status output. (CMOS output)	Can be used to indicate Power Good signal to system.
VAC_PG	31	VAC power-good status output (CMOS output)	Can be used to indicate Power Good signal to system.
STAT1	9	Charge status output 1 (open-drain output)	Connect 100-k $\Omega$ external pullup resistor between STAT1 and VLDO1.
STAT2	8	Charge status output 2 (open-drain output)	Connect 100-k $\Omega$ external pullup resistor between STAT2 and VLDO1.
ISET1	11	Charge current set point for VBUS input	External resistor from ISET1 pin and AGND pin sets charge current value when the power input from USB-port.
ISET2	10	Charge current set point for VAC input	External resistor from ISET1 pin and ISET2 pin sets charge current value when the power input from AC-DC adapter.
nCHEN	27	Charge enable input (active low)	Charge enable signal from system.
VIN	5	Power input for boost regulator. It is connected to the Li-ion battery.	Connect to Li-ion battery positive terminal. Connect 22- $\mu$ F capacitor from VIN pin to PGND.
L	4	The inductor is connected between this pin and the SW pin	6.8- $\mu$ H inductor to SW pin.
SW	3	Switching node of the IC. Connect the inductor between this pin and the L pin.	6.8- $\mu$ H inductor to L pin.
VLED4P25	1	LDO and synchronous boost converter output	22- $\mu$ F capacitor to PGND. Connect series resistor for current limitation to each LED (R,G,B).
PGND	2	Synchronous boost converter power ground	Connect to ground plane.
VBAT	6, 7	Power input and output for Li-ion battery	Connect to Li-ion battery positive terminal. Connect 1- $\mu$ F capacitor from VBAT pin to AGND.
R	39	Output for Red LED driver. The open-drain output pulls low when the CTL_R pin goes to H level. $R_{ON} = 1 \Omega$ (typical)	Connect to RED input of Red LED.
G	38	Output for Green LED driver. The open-drain output pulls low when the CTL_G pin goes to H level. $R_{ON} = 1 \Omega$ (typical)	Connect to GREEN input of Green LED.
B	37	Output for Blue LED driver. The open-drain output pulls low when the CTL_B pin goes to H level. $R_{ON} = 1 \Omega$ (typical)	Connect to BLUE input of Blue LED.
LEDGND	40	LED drivers power ground	Connect to ground plane.
VLDO1	28	LDO output, fixed 3.2 V. The output current of VLDO1 is limited to 20 mA (maximum), when both EN_VLDO and EN_VLDO3 input pins are low level.	1- $\mu$ F capacitor to AGND
VLDO2	29	LDO output, fixed 3.2 V	1- $\mu$ F capacitor to AGND
VLOD3	24	LDO output, fixed 3.2 V	1- $\mu$ F capacitor to AGND
VLDO4	21	LDO output, fixed 3.0 V	1- $\mu$ F capacitor to AGND
nRST_OUT	26	System reset output, generated according to the VLDO1 output voltage (open-drain output). Connect 100-k $\Omega$ internal pullup resistor between nRST_OUT and VLDO1.	Can be used to indicate the reset output signal to system.
MTRIN	22	Motor driver output. The open-drain output pulls low when the CTL_MTR pin goes to H level. $R_{ON} = 1 \Omega$ (typical)	Can be used to drive motor.
CTL_MTR	17	Control input for motor driver (active H)	Motor driver control input signal from system
MTRGND	23	Motor driver power ground	Connect ground plane

**TERMINAL FUNCTIONS (continued)**

NAME	NO.	DESCRIPTION	EXTERNAL REQUIRED COMPONENTS (SEE TYPICAL APPLICATION)
CTL_B	14	Control input for (B pin) Blue LED driver (active H)	Blue LED driver control input signal from system
CTL_G	15	Control input for (G pin) Green LED driver (active H)	Green LED driver control input signal from system
CTL_R	16	Control input for (R pin) Red LED driver (active H)	Red LED driver control input signal from system
DGND	25	Digital ground	Connect to ground plane.
PWR	12,13	Power path output. The power supply for each LDO.	10- $\mu$ F capacitor to AGND. Regarding an effect of DC bias on capacitor, select a capacitor that can secure at least 4.7- $\mu$ F in worse case.
EN_VLDO	19	Enable input for VLDO2, VLDO4 and VLED4P25 (active H)	LDO2, LDO4 and 4.25 VLDO control input signal from system
EN_VLDO3	18	Enable input for VLDO3	LDO3 control input signal from system
TEST	32	Test pin. Normally open.	
USB_SUSPEND	20	Control input for USB suspended mode. To reduce supply current from VBUS (active H).	USB suspended input signal from system
Thermal Pad (AGND)		Analog ground (AGND) input. Thermal ground should be soldered to the analog ground, use thermal via to connect to ground plane for ideal power dissipation.	Connect the PowerPAD to ground plane.

**ABSOLUTE MAXIMUM RATINGS**

over operating free-air temperature range (unless otherwise noted)

Input voltage	VBUS, VAC, PWR, SW, ISET1, ISET2	-0.3 to 7	V
	VBAT, VLDO1, VLDO2, VDLO3, VDLO4, VLED4P25, VIN, L, R, G, B, MTRIN	-0.3 to 5.5	
	nCHEN, USB_SUSPEND, CTL_R, CTL_G, CTL_B, CTL_MTR, EN_VLDO, EN_VLDO3, nRST_OUT, VBUS_PG, VAC_PG, STAT1, STAT2	-0.3 to 3.6	
Output sink/source current	VBUS_PG, VAC_PG, nRST_OUT, STAT1, STAT2	15	mA
T <sub>J</sub>	Junction temperature range	-40 to 150	°C
T <sub>STG</sub>	Storage temperature range	-65 to 150	°C

**RECOMMENDED OPERATING CONDITIONS**

		MIN	NOM	MAX	UNIT
V <sub>VBUS</sub>	Supply voltage (VBUS)	4.75		5.25	V
V <sub>VAC</sub>	Supply voltage (VAC)	4.75		5.75	V
V <sub>VBAT1</sub>	Supply voltage (VBAT) for linear charger	2.7		4.3	V
V <sub>VBAT2</sub>	Supply voltage (VBAT) for 4.25-V boost output	3.2		4.3	V
T <sub>A</sub>	Operating ambient temperature	-10		85	°C
T <sub>J</sub>	Operating junction temperature	-10		125	°C

**PACKAGE DISSIPATION RATINGS**

PACKAGE	$\theta_{JA}$ (°C/W)	T <sub>A</sub> < 40°C POWER RATING (W)	DERATING FACTOR ABOVE T <sub>A</sub> = 40°C (mW/°C)
RHA	30.1	2.82	33.2

## ELECTRICAL CHARACTERISTICS

over  $-10^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$  and recommended supply voltage (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT		
<b>INPUT CURRENT</b>							
$I_{VAC}$	Active supply current from VAC	No load, EN_VLDO = H, EN_VLDO3 = H, nCHEN = H, USB_SUSPEND = L, VBAT = 3.8 V, VAC = 5.25 V		237	$\mu\text{A}$		
$I_{VBUS}$	Active supply current from VBUS	No load, EN_VLDO = H, EN_VLDO3 = H, nCHEN = H, USB_SUSPEND = L, VBAT = 3.8 V, VAC = 5 V		237	$\mu\text{A}$		
$I_{VBUS(USPND)}$	VBUS current at USB suspend mode	No load, EN_VLDO = H, EN_VLDO3 = H, nCHEN = H, USB_SUSPEND = H, VBAT = 2.8 V, VAC = 5.25 V		207	290 $\mu\text{A}$		
$I_{VBAT}$	Active supply current from VBAT	No load, EN_VLDO = H, EN_VLDO3 = H, nCHEN = H, USB_SUSPEND = L, VBAT = 4.2 V		1.4	$\text{mA}$		
$I_{VBAT(STBY)}$	VBAT standby current	No load, EN_VLDO = L, EN_VLDO3 = L, nCHEN = H, USB_SUSPEND = L, VBAT = 4.2 V, $T_J = 60^{\circ}\text{C}$		56	88 $\mu\text{A}$		
$I_{VBAT(SUP)}$	Sleep current at VBAT	Sum of current into VBAT pin. VBAT = 2.5 V < $V_{(BATUVLO)}$ At nCHEN=H and state #01, 02, 03, 04, 09, 10, $T_J = 60^{\circ}\text{C}$		3	$\mu\text{A}$		
<b>UVLO/PG COMPARATOR/OVER DISCHARGE PROTECTION FOR LI-ION</b>							
$V_{(VBUSPG)}$	Power good threshold voltage for VBUS	At VBUS pin, L to H		4.08	4.25	4.42	V
$V_{(VBUSPGHYS)}$	Hysteresis voltage on $V_{(VBUSPG)}$	At VBUS pin, $V_{(VBUSPG)} - V_{(VBUSPGHYS)}$ is threshold voltage for H to L			100		mV
$V_{(VACPG)}$	Power good threshold voltage for VAC	At VAC pin, L to H		4.08	4.25	4.42	V
$V_{(VACPGHYS)}$	Hysteresis voltage on $V_{(VACPG)}$	At VAC pin, $V_{(VAC)} - V_{(VACPGHYS)}$ is threshold voltage for H to L			100		mV
$V_{(BATUVLO)}$	Under voltage lock out voltage for Li-ion	At VBAT pin		2.6	2.7	2.8	V
$V_{BATmin(BATUVLO)}$	Minimum $V_{BAT}$ for over discharge protection	At VBAT pin			1.5		V
$t_{dly(BATUVLO)}$	Li-ion UVLO deglitch time	Only for falling edge (H to L)			420		$\mu\text{s}$
<b>POWER PATH</b>							
$R_{ON(BUS)}$	Resistance of a FET between VBUS and PWR	VBUS = 4.75 V			130		$\text{m}\Omega$
$R_{ON(AC)}$	Resistance of a FET between VAC and PWR	VAC = 4.75 V			130		$\text{m}\Omega$
$R_{ON(BAT)}$	Resistance of a FET between VBAT and PWR	VABT = 3.3 V			50		$\text{m}\Omega$
		VBAT = 3.3 V, EN_VLDO = L, EN_VLDO3 = L			5		$\Omega$

## ELECTRICAL CHARACTERISTICS

 over  $-10^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$  and recommended supply voltage (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
<b>LDO REGULATORS</b>						
<b>LDO4 (<math>C_{OUT} = 1 \mu\text{F}</math>, <math>3.4 \text{ V} &lt; \text{PWR} &lt; 5.75 \text{ V}</math>)</b>						
$V_{(VLDO4)}$	VLDO4 output voltage	$3.4 \text{ V} < \text{PWR} < 5.75 \text{ V}$	2.9	3	3.1	V
$I_{(VLDO4)}$	VLDO4 output current		1		150	mA
$V_{DO(VLDO4)}$	VLDO4 dropout voltage	$I_O = 150 \text{ mA}$		0.14		V
$I_{(VLDO4\_ILMT)}$	VLDO4 output current limit		350			mA
$\text{PSRR}_{(VLDO4)}$	Power supply rejection ratio		-60			dB
<b>LDO1 (<math>C_{OUT} = 1 \mu\text{F}</math>, <math>3.4 \text{ V} &lt; \text{PWR} &lt; 5.75 \text{ V}</math>)</b>						
$V_{(VLDO1)}$	VLDO1 output voltage	$3.4 \text{ V} < \text{PWR} < 5.75 \text{ V}$	3.136	3.2	3.264	V
$I_{(VLDO1)}$	VLDO1 output current		1		100	mA
$V_{DO(VLDO1)}$	VLDO1 dropout voltage	$I_O = 100 \text{ mA}$		0.12		V
$I_{(VLDO1\_ILMT)}$	VLDO1 output current limit			250		mA
$\text{PSRR}_{(VLDO1)}$	Power supply rejection ratio		-60			dB
$R_{ON(VLDO1\_dichg)}$	Discharge resistance on VLDO1		630			$\Omega$
<b>RESET CIRCUIT</b>						
$V_{(RST)}$	Reset threshold voltage	At VLDO1, H to L	2.7	2.8	2.9	V
$V_{(RSTHYS)}$	Hysteresis voltage for reset	At VLDO1, $V_{(RST)} + V_{(RSTHYS)}$ is threshold voltage for L to H		140		mV
<b>LDO2 (<math>C_{OUT} = 1 \mu\text{F}</math>, <math>3.4 \text{ V} &lt; \text{PWR} &lt; 5.75 \text{ V}</math>)</b>						
$V_{(VLDO2)}$	VLDO2 output voltage	$3.4 \text{ V} < \text{PWR} < 5.75 \text{ V}$	3.136	3.2	3.232	V
$I_{(VLDO2)}$	VLDO2 output current		1		30	mA
$V_{DO(VLDO2)}$	VLDO2 dropout voltage	$I_O = 30 \text{ mA}$		0.03		V
$I_{(VLDO2\_ILMT)}$	VLDO2 output current limit			250		mA
$\text{PSRR}_{(VLDO2)}$	Power supply rejection ratio		-60			dB
<b>LDO3 (<math>C_{OUT} = 1 \mu\text{F}</math>, <math>3.4 \text{ V} &lt; \text{PWR} &lt; 5.75 \text{ V}</math>)</b>						
$V_{(VLDO3)}$	VLDO3 output voltage	$3.4 \text{ V} < \text{PWR} < 5.75 \text{ V}$	3.136	3.2	3.264	V
$I_{(VLDO3)}$	VLDO3 output current		1		150	mA
$V_{DO(VLDO3)}$	VLDO3 dropout voltage	$I_O = 150 \text{ mA}$		0.13		V
$I_{(VLDO3\_ILMT)}$	VLDO3 output current limit			250		mA
$\text{PSRR}_{(VLDO3)}$	Power supply rejection ratio		-60			dB

## ELECTRICAL CHARACTERISTICS

over  $-10^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$  and recommended supply voltage (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
<b>LINEAR CHARGER</b>						
<b>VOLTAGE REGULATION (<math>V_{O(\text{REG})} + V_{(\text{DO\_MAX})} &lt; V_{\text{PWR}}</math>, <math>I_{(\text{TERM})} &lt; I_{O(\text{OUT})} &lt; 550 \text{ mA}</math>)</b>						
$V_{O(\text{REG})}$	Output voltage		4.2		V	
$A_{\text{CC}(\text{REG})}$	Voltage regulation accuracy	$T_A = 25^{\circ}\text{C}$ , $I_{O(\text{OUT})} = 50 \text{ mA}$	-0.35	0.35	%	
		See	-1	1		
$V_{(\text{DO})}$	Dropout voltage ( $V_{(\text{PWR})} - V_{(\text{OUT})}$ )		350	500	mV	
<b>CURRENT REGULATION</b>						
$I_{O(\text{OUT})}$	Output current range	$V_{\text{PWR}} > V_{(\text{LOWV})}$ $V_{\text{PWR}} - V_{\text{BAT}} > V_{(\text{DO})}$ $V_{\text{PWR}} > 4.6 \text{ V}$	50	550	mA	
$V_{(\text{SET})}$	Output current set voltage	Voltage on ISET1 pin, $V_{\text{PWR}} = 4.85 \text{ V}$ , $I_{O(\text{OUT})} = 550 \text{ mA}$ $V_{\text{BAT}} = 4 \text{ V}$	2.463	2.5	2.538	V
$K_{(\text{SET})}$	Output current set factor	$V_{\text{PWR}} = 4.85 \text{ V}$ , $I_{O(\text{OUT})} = 60 \text{ mA}$ $V_{\text{BAT}} = 2.8 \text{ V}$ , Pre-charge mode	299	319	339	
		$V_{\text{PWR}} = 4.85 \text{ V}$ , $I_{O(\text{OUT})} = 60 \text{ mA}$ $V_{\text{BAT}} = 4 \text{ V}$ , CC mode	285	321	357	
		$V_{\text{PWR}} = 4.85 \text{ V}$ , $I_{O(\text{OUT})} = 550 \text{ mA}$ $V_{\text{BAT}} = 4 \text{ V}$ , CC mode	307	322	337	
<b>PRECHARGE AND SHORT-CIRCUIT CURRENT REGULATION</b>						
$V_{(\text{LOWV})}$	Precharge to fast-charge transition threshold	Voltage on VBAT pin	2.8	3	3.2	V
$t_{(\text{DEG-FtoP})}$	Deglintch time for fast-charge to precharge transition	$V_{\text{PWR}(\text{min})} > 4.6 \text{ V}$ , $t_{\text{FALL}} = 100 \text{ ns}$ , 10-mV overdrive, VBAT decreasing below threshold.	250	375	500	ms
$I_{O(\text{PRECHARGE})}$	Precharge range	$0 \text{ V} < V_{\text{PWR}} < V_{(\text{LOWV})}$ , $t < t_{(\text{PRECHG})}$	5		55	mA
$V_{(\text{PRECHG})}$	Precharge set voltage	Voltage on ISET1 pin, $V_{O(\text{REG})} = 4.2 \text{ V}$ , $0 \text{ V} < V_{\text{PWR}} > V_{(\text{LOWV})}$ , $t < t_{(\text{PRECHG})}$	235	250	265	mV
<b>TERMINATION DETECTION</b>						
$I_{(\text{TERM})}$	Charge termination detection range	$V_{\text{BAT}} > V_{(\text{RCH})}$ , $t < t_{(\text{TRMDET})}$	5		55	mA
$V_{(\text{TERM})}$	Charge termination detection set voltage	Voltage on ISET1 pin, $V_{O(\text{REG})} = 4.2 \text{ V}$ $V_{\text{BAT}} > V_{(\text{RCH})}$ , $t < t_{(\text{TRMDET})}$	235	250	265	mV
$t_{(\text{TRMDET})}$	Deglintch time for termination detection	$V_{\text{PWR}(\text{min})} > 4.6 \text{ V}$ , $t_{\text{FALL}} = 100 \text{ ns}$ , Charging current decreasing below 10-mV overdrive	250	375	500	ms
<b>BATTERY RECHARGE THRESHOLD</b>						
$V_{(\text{RCH})}$	Recharge threshold	$T_A = 25^{\circ}\text{C}$	$V_{O(\text{REG})} - 0.115$	$V_{O(\text{REG})} - 0.10$	$V_{O(\text{REG})} - 0.085$	V
$t_{(\text{DEGL})}$	Deglintch time for recharge detect	$V_{\text{PWR}(\text{min})} > 4.6 \text{ V}$ , $t_{\text{FALL}} = 100 \text{ ns}$ , Decreasing below or increasing above threshold, 10-mV overdrive	250	375	500	ms
<b>TIMERS</b>						
$t_{(\text{PRECHG})}$	Precharge time		1620	1800	1989	s
$t_{(\text{CHG})}$	Charge time		22680	25200	27720	s
$I_{(\text{FAULT})}$	Timer fault recovery current			200		$\mu\text{A}$
$t_{(\text{TMRRST})}$	Deglintch time to reset timers when disabling charger		250	375	500	ms
<b>BATTERY CHARGER ON/OFF COMPARATOR</b>						
$V_{(\text{CHGOFF})}$	Charger off threshold voltage	$2.7 \text{ V} < V_{\text{BAT}} < V_{O(\text{REG})}$		$V_{\text{PWR}} < V_{\text{BAT}} + 80 \text{ mV}$		V
$V_{(\text{CHGON})}$	Charger on threshold voltage	$2.7 \text{ V} < V_{\text{BAT}} < V_{O(\text{REG})}$		$V_{\text{PWR}} > V_{\text{BAT}} + 110 \text{ mV}$		V
<b>ISET2</b>						
$R_{\text{ON}(\text{ISET2})}$	N-channel MOSFET on-resistance between ISET2 and GND	$V_{\text{AC}} = 4.75 \text{ V}$		4		$\Omega$



## ELECTRICAL CHARACTERISTICS

 over  $-10^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$  and recommended supply voltage (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT		
<b>4.25-V BOOST AND LDO (<math>C_{OUT} = 22 \mu\text{F}</math>, <math>L = 6.8 \mu\text{H}</math>, <math>C_{IN} = 22 \mu\text{F}</math>)</b>							
$V_{(VLED4P25)}$	VLED4P25 output voltage	$3.2 \text{ V} < V_{BAT} < 4.3 \text{ V}$ for boost or $4.6 \text{ V} < PWR < 5.75 \text{ V}$ for LDO		4.165	4.25	4.335	V
$I_{(VLED4P25)}$	VLED4P25 output current			1	140		mA
<b>4.25-V LDO</b>							
$I_{(VLED4P25\_ILMT)}$	4.25-V LDO output current limit	$4.6 \text{ V} < PWR < 5.75 \text{ V}$		250			mA
$V_{DO(VLED4P25)}$	4.25-V LDO dropout voltage	$I_O = 140 \text{ mA}$				0.35	V
$PSRR_{(VLED4P25)}$	Power supply rejection ratio			-60			dB
<b>4.25-V BOOST</b>							
$f_{OSC\_VLED4P25}$	4.25-V boost switching frequency			555			kHz
$I_{(VLED4P25\_Boost\_ILMT)}$	4.25-V boost output current limit	$3.2 \text{ V} < V_{BAT} < 4.3 \text{ V}$		800			mA
$R_{ON(ISO)}$	Isolation MOSFET on-resistance between VIN and L	$V_{BAT} = 3.2 \text{ V}$		300			m $\Omega$
<b>R, G, B OUTPUTS</b>							
$R_{ON(R)}$	N-channel MOSFET on-resistance between R and LEDGND			1			$\Omega$
$R_{ON(G)}$	N-channel MOSFET on-resistance between G and LEDGND			1			$\Omega$
$R_{ON(B)}$	N-channel MOSFET on-resistance between B and LEDGND			1			$\Omega$
<b>MTRIN OUTPUT</b>							
$R_{ON(MTR)}$	N-channel MOSFET on-resistance between MTRIN and MTRGND			1			$\Omega$
<b>CTR_R, CTL_G, CTL_B, CTL_MTR, EN_VLDO, EN_VLDO3, USB_SUSPEND AND nCHEN INPUTS</b>							
$V_{IL}$	Low level input voltage	VLDO1 = 3.2 V		0.3 x VLDO1			V
$V_{IH}$	High level input voltage	VLDO1 = 3.2 V				0.7 x VLDO1	V
$R_{PD(CTL\_R)}$	Pull-down resistor (CTL_R)			1000			k $\Omega$
$R_{PD(CTL\_G)}$	Pull-down resistor (CTL_G)			1000			k $\Omega$
$R_{PD(CTL\_B)}$	Pull-down resistor (CTL_B)			1000			k $\Omega$
$R_{PD(CTL\_MTR)}$	Pull-down resistor (CTL_MTR)			100			k $\Omega$
$R_{PD(EN\_VLDO)}$	Pull-down resistor (EN_VLDO)			100			k $\Omega$
$R_{PD(EN\_VLDO3)}$	Pull-down resistor (EN_VLDO3)			100			k $\Omega$
$R_{PD(USB\_SUSPEND)}$	Pull-down resistor (USB_SUSPEND)			100			k $\Omega$
$R_{PU(nCHEN)}$	Pull-up resistor (nCHEN) to VLDO1			100			k $\Omega$
<b>VBUS_PG, VAC_PG OUTPUTS</b>							
$V_{OH(PG)}$	High-level output saturation voltage	$3.4 \text{ V} < PWR < 5.75 \text{ V}$ , $I_O = -500 \mu\text{A}$ , $V_{DD} = VLDO1$		VDD - 0.25			V
$V_{OL(PG)}$	Low-level output saturation voltage	$3.4 \text{ V} < PWR < 5.75 \text{ V}$ , $I_O = 500 \mu\text{A}$ , $V_{DD} = VLDO1$				0.25	V
<b>STAT1, STAT2 OUTPUTS</b>							
$V_{OL(STAT)}$	Low-level output saturation voltage	$I_O = 2.5 \text{ mA}$				0.25	V
<b>nRST_OUT OUTPUT</b>							
$V_{OL(nRST)}$	Low-level output saturation voltage	$I_O = 2.5 \text{ mA}$				0.25	V
$R_{PU(nRST)}$	Pull-up resistor (nRST_OUT) to VLDO1			100			k $\Omega$
$t_{dly(nRST)}$	Deglintch time on nRST_OUT			95	125	160	ms
<b>THERMAL SHUTDOWN THRESHOLD</b>							
$T_{(SHTDWN)}$	Thermal trip threshold	$T_J$ increasing		150			$^{\circ}\text{C}$
$hys_{(SHTDWN)}$	Thermal hysteresis	$T_J$ increasing		15			$^{\circ}\text{C}$

## FUNCTION DESCRIPTION

### Power Path Function

TPS65471 has a power-path circuitry to choose automatically any one of USB-port (VBUS), AC-DC adapter (VAC) and Li-ion battery (VBAT) as power source for LDOs.

The priority of power selection is VBUS, VAC, then VBAT. When both VBUS and VAC are available, VBUS is used as the power source of the charger and LDOs.

The exception is USB suspend mode, in this cases, power source of charger and LDOs are provided to PWR from VAC.

The VBAT (Li-ion battery) is chosen as a power source when both VBUS (USB-port) and VAC (AC-DC adapter) are not available. In this case, the linear charger function does not operate.

shows an equivalent circuit of the power path. Power FETs SW1, SW2 and SW3 are turned on/off per and provide appropriate power sources to each power output.

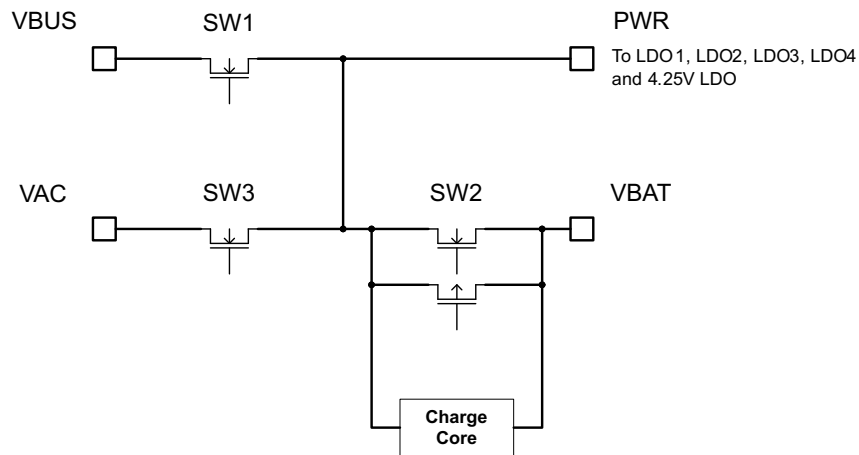


Figure 1. Power Path Circuitry

As shows, the state of the linear charger circuitry depends on the state of the power path circuitry. If the power path circuitry is not ready for charging, regardless of nCHEN = L, the charger function is not turned on.

Table 1. Power Path Circuitry Truth Table

AC-DC ADAPTER (VAC)	USB-PORT (VBUS)	LI-ION BATTERY (VBAT)	USB_SUSPEND	POWER SOURCE	STATE	CHARGE STATUS
Absent	Absent	Absent	X	Non	#01#	
Absent	Present	Absent	H	Non	#02#	
Absent	Present	Absent	L	VBUS	#03#	nCHEN = L: Recovery - Charge
Present	Absent	Absent	X	VAC	#04#	nCHEN = L: Recovery - Charge
Absent	Absent	Present	X	VBAT	#05#	
Absent	Present	Present	H	VBAT	#06#	
Absent	Present	Present	L	VBUS	#07#	nCHEN = L: Charge
Present	Absent	Present	X	VAC	#08#	nCHEN = L: Charge
Present	Present	Absent	H	VAC	#09#	nCHEN = L: Recovery - Charge
Present	Present	Absent	L	VBUS	#10#	nCHEN = L: Recovery - Charge
Present	Present	Present	H	VAC	#11#	nCHEN = L: Charge
Present	Present	Present	L	VBUS	#12#	nCHEN = L: Charge

## USB Suspend Function

TPS65471 has USB suspend function. USB\_SUSPEND = H sends TPS65471 into USB suspend mode. While in USB suspend mode, current from the USB host to the VBUS pin is reduced under the USB suspended current.

USB suspend mode does not depend on Li-ion battery status. Even if the Li-ion battery on the VBAT pin is removed or NG. VBUS, which is in USB suspend mode, does not provide electrical power for 3.2-V, 3-V and 4.25-V outputs and these outputs should be disabled.

Even in USB suspend mode, when VAC exists, source power is provided to the 3.2-V, 3-V and 4.25-V outputs from VAC.

This function complies with .

## Standby Function

TPS65471 enters standby mode when the power source Li-ion battery (states #05# and #06#) and both logic inputs of EN\_VLDO and EN\_VLDO3 are at L level. While in standby mode, current from the Li-ion battery to the VBAT pin is reduced under  $V_{VBAT(STBY)}$ . The low resistance PMOS FET and NMOS FET are connected to SW2 between the PWR pin and VBAT pin in parallel. In order for the TPS65471 to decrease the power supply current, the PMOS FET operates in standby mode. In standby mode, the PMOS FET turns on corresponding to the output current of the VLDO1 voltage drop of PWR.

To recover from standby mode, the logic input of EN\_VLDO or EN\_VLDO3 is set to H level, then the low resistance NMOS FET connected between PWR and VBAT turns on. The startup time of the LDOs controlled by these logic input signals is approximately 1 ms.

Timing Diagrams of Power Path Operation

USB-Port Hot-Plug During Battery Operation (Absent VAC and Charge Off, #5# → #7# → #5#)

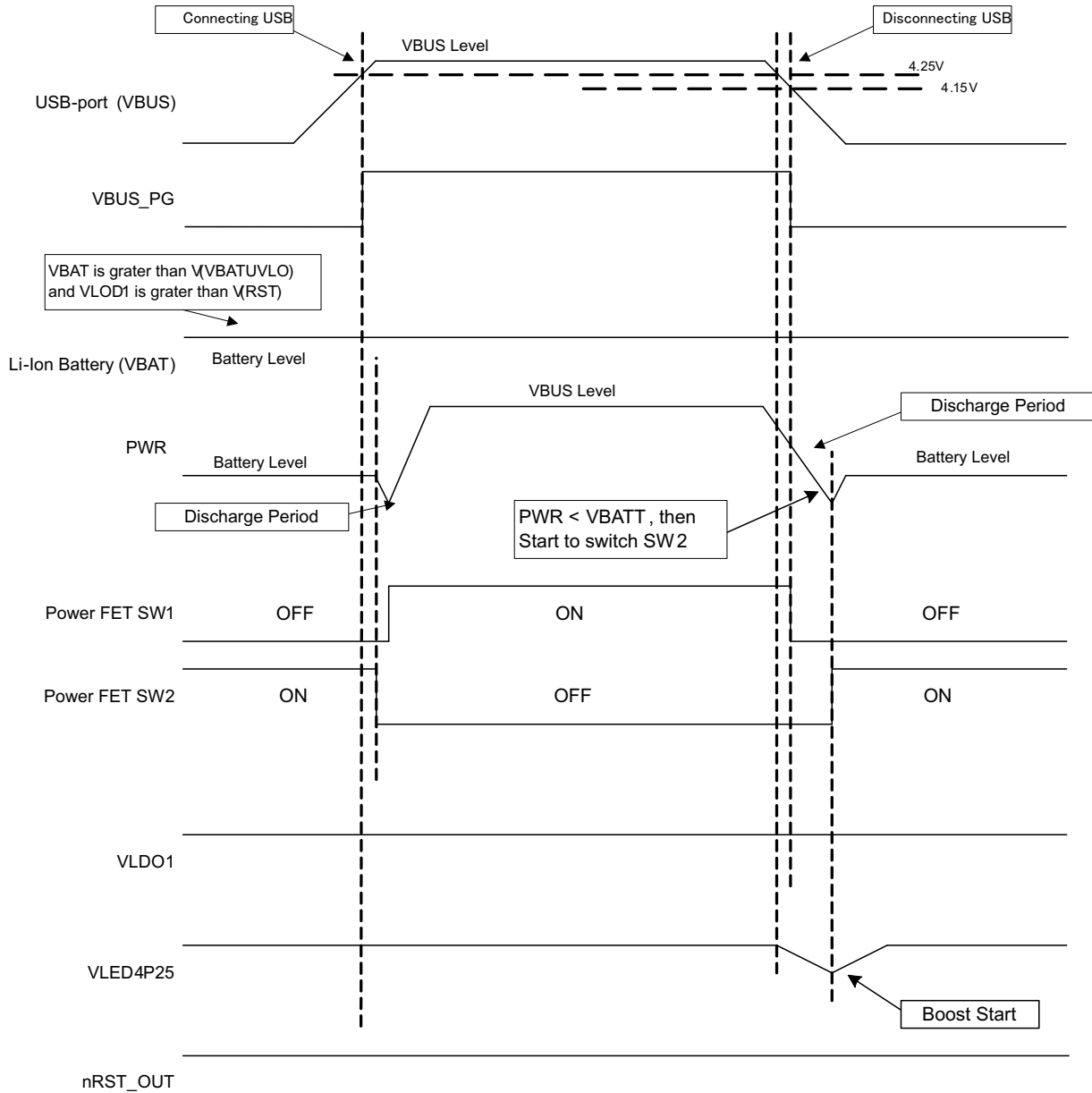


Figure 2. USB-Port Hot-Plug During Battery Operation (#5# → #7# → #5#, Charge Off, EN\_VLDO = H)

USB-Port Hot-Plug During Battery Operation (Absent VAC and Charge On, #5# → #7# → #5#)

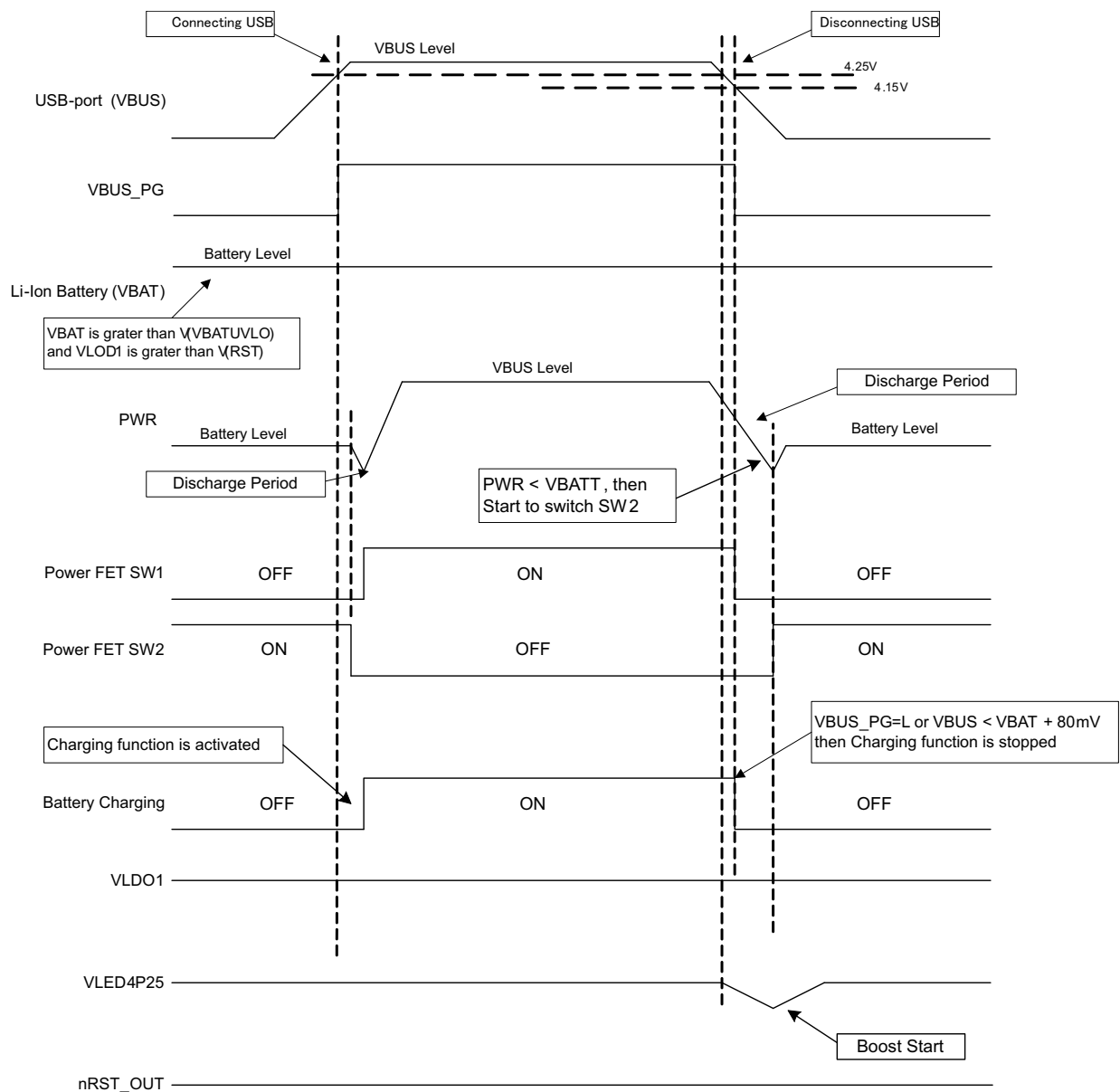


Figure 3. USB-Port Hot-Plug During Battery Operation (#5# → #7# → #5#, Charge On, EN\_VLDO = H)

USB-Port Hot-Plug (Absent Battery and VAC, #1# → #3# → #1#)

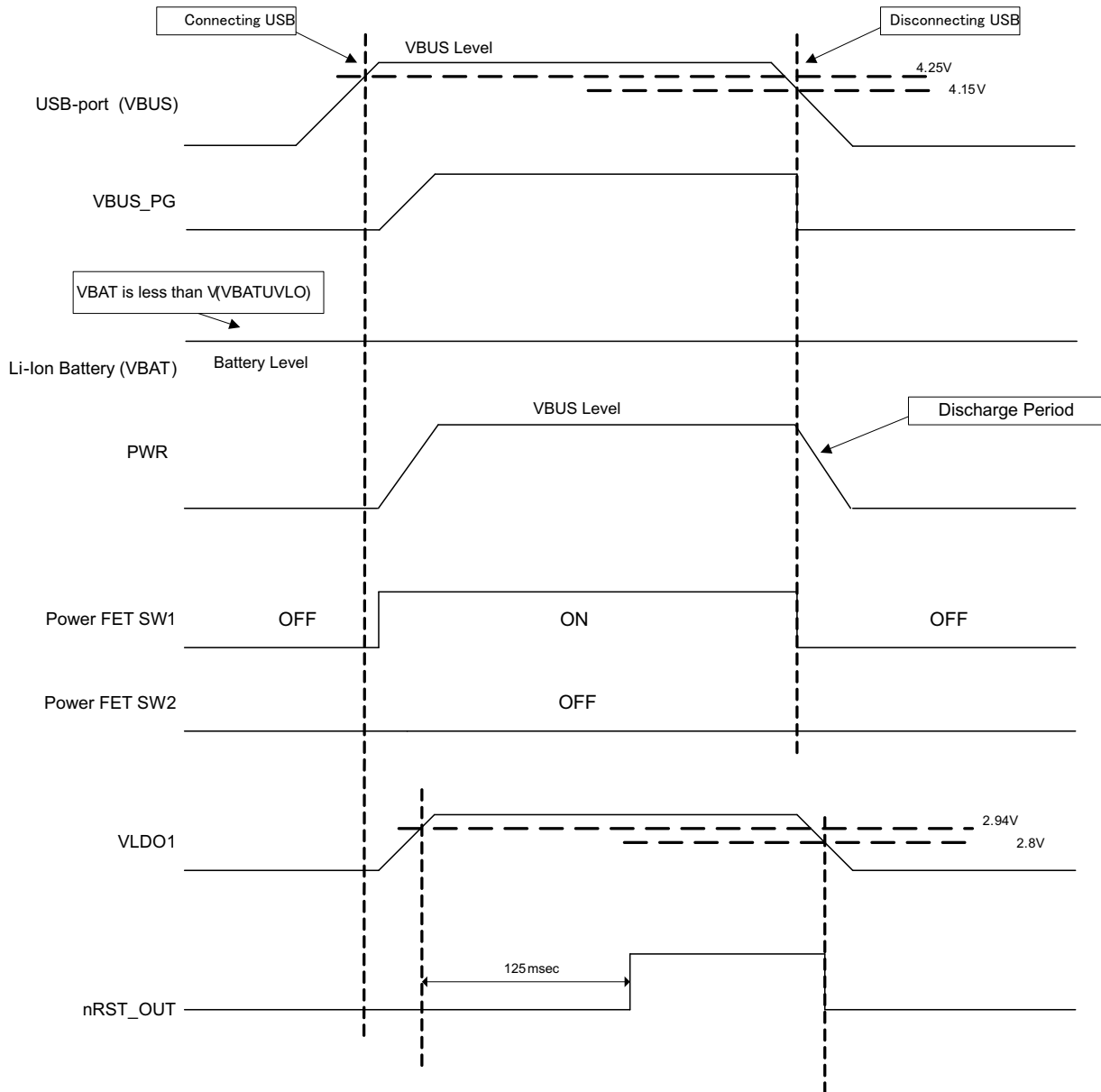
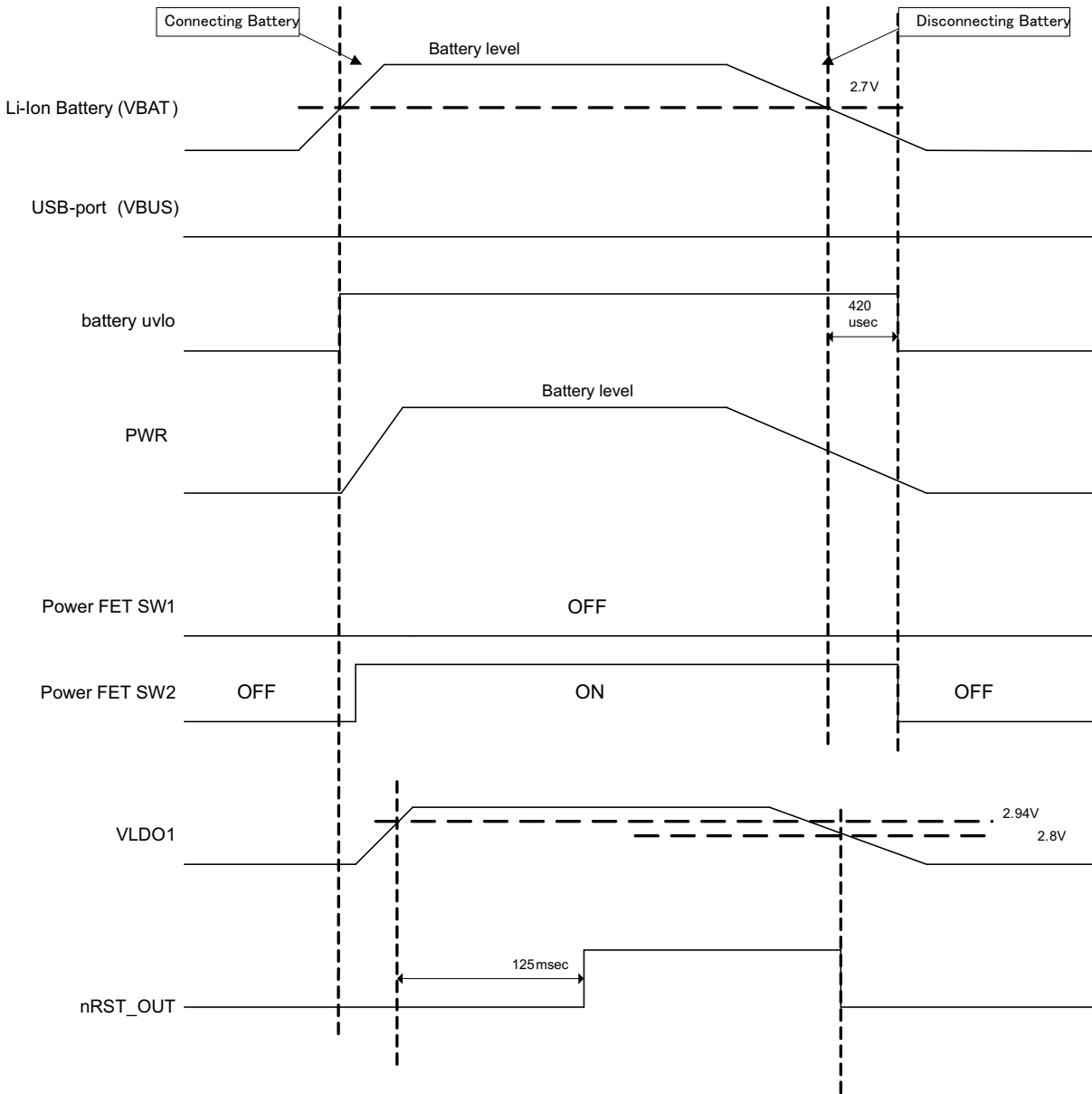


Figure 4. USB-Port Hot-Plug (Absent Battery and VAC, #1# → #3# → #1#)

**Battery Hot-Plug (Absent VBUS and VAC, #1# → #5# → #1#)**



**Figure 5. Battery Hot-Plug (Absent VBUS and VAC, #1# → #5# → #1#)**

USB Suspend Enabling/Disabling (Present VBUS and Battery, Absent VAC, #7# → #6# → #7#)

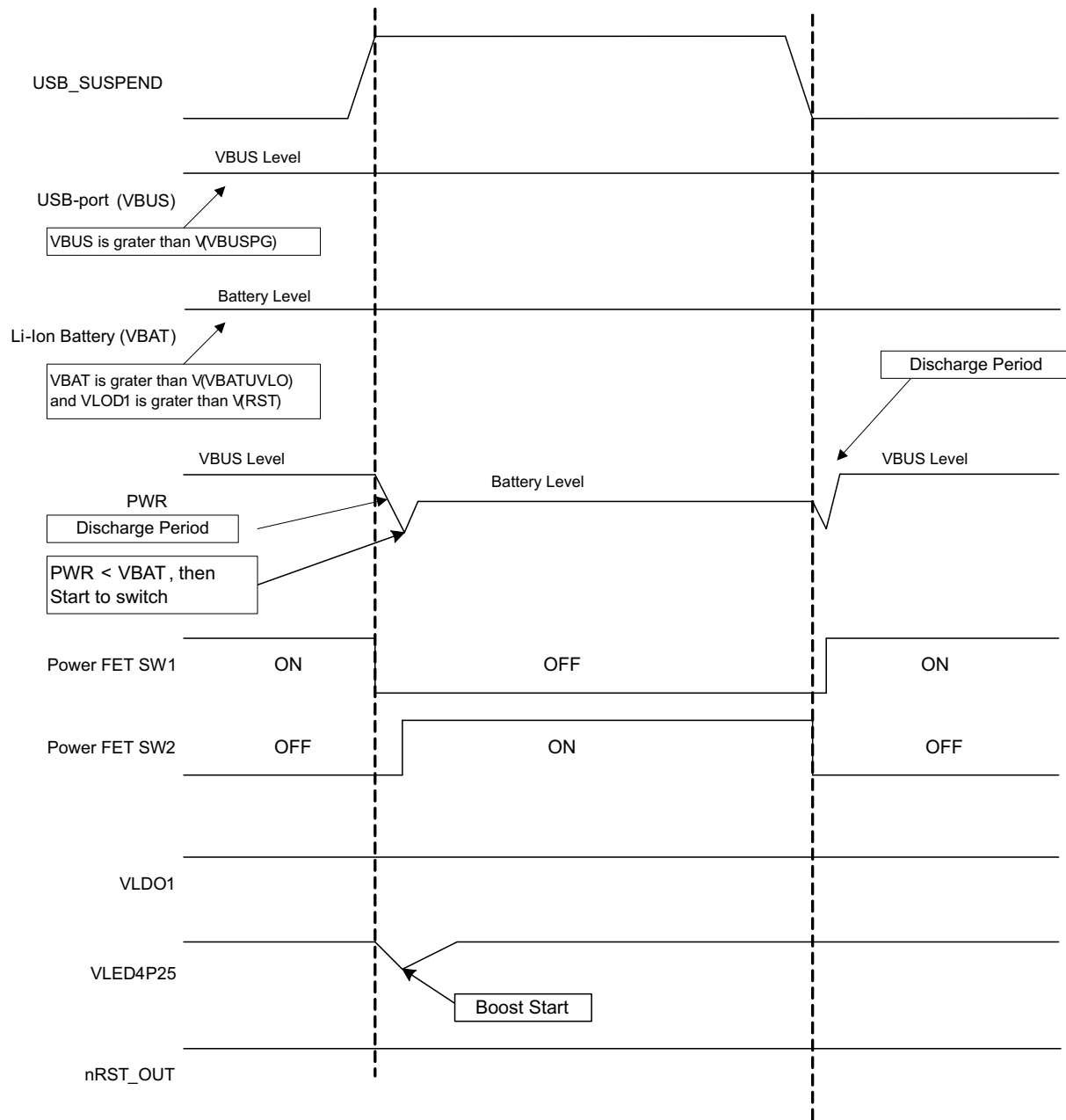


Figure 6. USB Suspend Mode (#7# → #6# → #7#, EN\_VLDO = H)



## LDO1

The TPS65471 has a 3.2-V regulator as the LDO1 power and it provides a stable and accurate voltage of 3.2 V ( $\pm 64$  mV). Complying with , LDO1 keeps its operation during PWR on. This LDO provides the power supply to the circuit of logic I/O. If PWR power decreases, discharge resistors at VL0D1 will be turned on and discharge power to the remaining electrode.

## LDO2

The TPS65471 has a 3.2-V regulator as the LDO2 power and it provides a stable and accurate voltage of 3.2 V ( $\pm 32$  mV). LDO2 is controlled by logic input EN\_VLDO and source of supply is PWR. This output is turned off when the EN\_VLDO is L.

**Table 2. Output Control Truth Tables**

EN_VLDO	LDO2	LDO4	4.25-V BOOST/LD
H	3.2 V (On)	3 V (On)	4.25 V (On)
L	0 V (Off)	0 V (Off)	0 V (Off)

EN_VLDO3	LDO3
H	3.2 V (On)
L	0 V (Off)

## LDO3

The TPS65471 has a 3.2-V regulator as the LDO3 power and it provides a stable and accurate voltage of 3.2 V ( $\pm 64$  mV). LDO3 is controlled by logic input EN\_VLDO3 and source of supply is PWR. This output is turned off when the EN\_VLDO3 is L.

## LDO4

The TPS65471 has a 3-V regulator as the LDO4 power and it provides a stable and accurate voltage of 3 V ( $\pm 0.1$  V). LDO4 is controlled by logic input EN\_VLDO. This output is turned off when the EN\_VLDO is L.

## 4.25-V Boost/LDO

The TPS65471 has a 4.25-V regulator and synchronous boost converter as the LED power. It provides a stable and accurate voltage of 4.25 V ( $\pm 85$  mV) connected to the VLED4P25. The boost converter is based on a fixed frequency pulse-width-modulation (PWM) controller. This output is controlled by logic input EN\_VLDO. If USB-port (VBUS pin) or AC-DC adapter (VAC pin) powers are detected, the 4.25-V LDO operates (PWR supply source), and the 4.25V synchronous boost converter stops operation. If the voltage on both VBUS pin and VAC pin are less than the Power Good voltage, the power is provided to VBAT pin from the Li-ion battery, then the 4.25-V synchronous boost converter operates and the 4.25-V LDO stops operation. Complying with , in USB suspend mode (even if the voltage of VBUS pin is greater than  $V_{(VBUSPG)}$ ) the source of supply is the battery.

## R, G and B

The TPS65471 has three open-drain outputs for LED drivers. The R output is controlled by logic input CTL\_R, the G output is controlled by CTL\_G and the B output is controlled by CTL\_B. For example, the open-drain output of R pulls low (On) when the CTL\_R pin goes to H level. The open-drain output turns off when the CTL\_R is L. These functions can operate when the EN\_VLDO is H.

## MTRIN

The TPS65471 has one open-drain output for the motor driver. The MTRIN output is controlled by logic input CTL\_MTR. The open-drain output of MTRIN pulls low (On) when the CTL\_MTR pin goes to H level. The open-drain output is turned off when the CTL\_MTR is L.

### Reset Generator

The TPS65471 monitors the status of VLDO1 (LDO1) and has reset generator circuitry to indicate a reset signal to the system.

The reset signal output is L level when the voltage of VLDO1 is less than  $V_{(RST)}$ , and H level when the voltage of VLDO1 is greater than  $V_{(RST)} + 0.14\text{ V}$ . The Reset pin goes to H level  $t_{dly(RESET)}$  after internal signal goes to H. The Reset terminal has a 100-k $\Omega$  pull-up resistor to VLDO1. Also the outputs of VLDO2, VLDO3, VDDO4 and VLED4P25 turn Off when the voltage of VLDO1 is less than  $V_{(RST)}$ . If VLDO1 becomes greater than  $V_{(RST)} + 0.14\text{ V}$ , these outputs are turned On at the input level of each control signal.

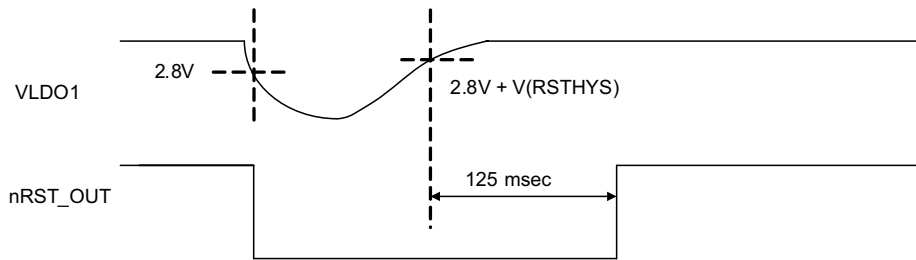


Figure 7. Timing of nRST\_OUT Signal When a Voltage Drop Occurs on VLDO1

### Charge Control

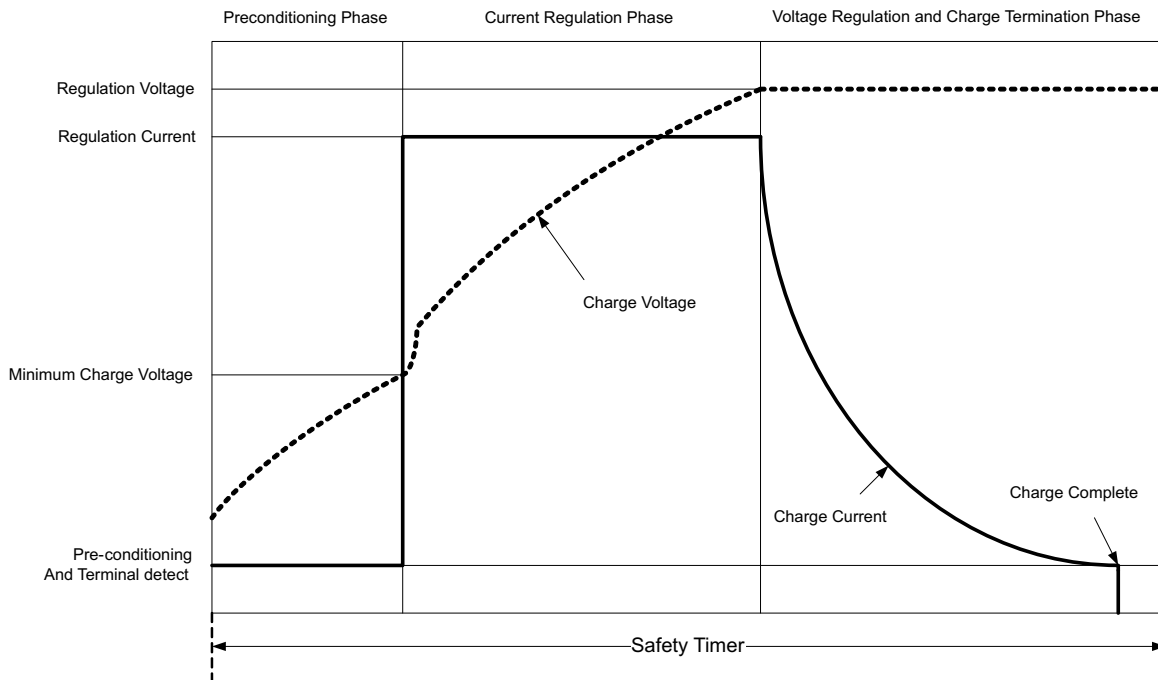


Figure 8. Charging Profile

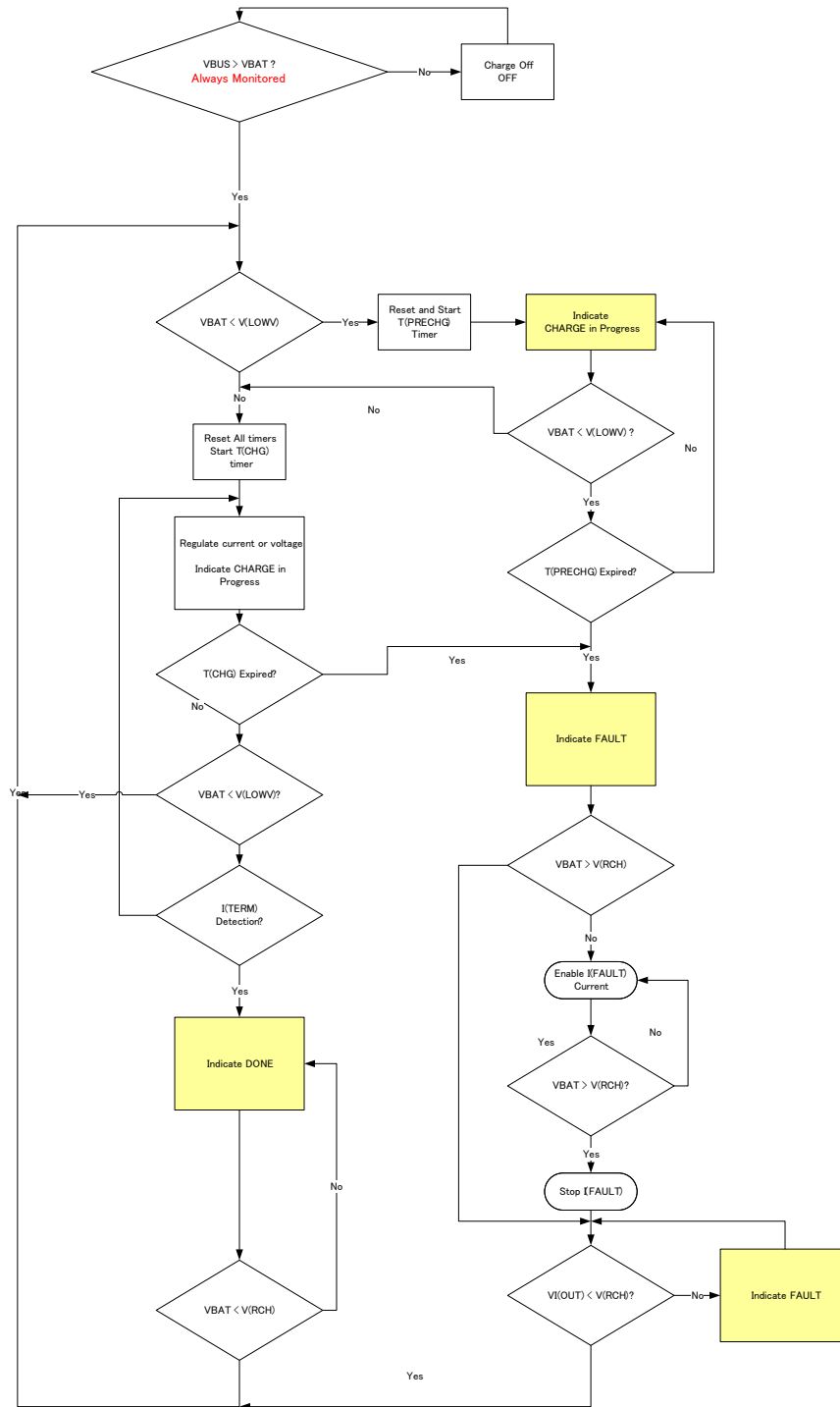


Figure 9. Charging Flow Chart

## Battery Pre-Conditioning

During a charge cycle, if the battery voltage is below the  $V_{(LOWV)}$  threshold, the device applies a pre-charge current,  $I_{O(PRECHG)}$ , to the battery. This feature revives deeply discharged cells. Resistor RSETn, connected between ISET1 and AGND and also connected between ISET1 and ISET2, determines the pre-charge rate. The  $V_{(PRECHG)}$  and  $K_{(SET)}$  parameters are specified in the Electrical Characteristics table.

$$I_{O(PRECHG)} = \frac{V_{(PRECHG)} \times K_{(SET)}}{R_{SET}} \quad (1)$$

TPS65471 activates a safety timer,  $t_{(PRECHG)}$ , during the conditioning phase. If the  $V_{(LOWV)}$  threshold is not reached within the timer period, the device turns off the charger and enunciates FAULT on the STATx pins. See the Timer Fault Recovery section for additional details.

## Battery Fast-Charge Constant Current

The TPS65471 offers on-chip current regulation with programmable set point. Resistor, RSETn, connected between the ISET1 and AGND and also connected between ISET1 and ISET2, determines the charge rate. The  $V_{(SET)}$  and  $K_{(SET)}$  parameters are specified in the Electrical Characteristics table.

$$I_{O(OUT)} = \frac{V_{(SET)} \times K_{(SET)}}{R_{SET}} \quad (2)$$

If USB-port (VBUS pin) is detected, MOS-FET of N channels connected to ISET2 turns off. The charge current is determined by the resistance of RSET1 connected between ISET1 and GND. If AC-DC adapter (VAC pin) is detected, MOS-FET of N channel connected to ISET2 turns on. The charge current is determined by the resistance of RSET1 and RSET2. When both VBUS and VAC are present, the charge current is determined by the resistance of RSET1 connected between ISET1 and AGND.

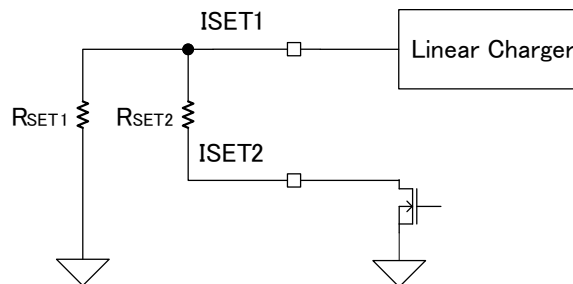


Figure 10. Equivalent Circuit ISET1 and ISET2 Terminals

## Battery Fast-Charge Voltage Regulation

The voltage regulation feedback is through the VBAT pin. This input is tied directly to the positive side of the battery pack. The device monitors the battery-pack voltage between the VBAT and AGND pins. When the battery voltage rises to the  $V_{O(REG)}$  threshold, the voltage regulation phase begins and the charging current begins to decrease.

As a safety backup, the device also monitors the charge time in charge mode. If charge is not terminated within this time period,  $t_{(CHG)}$ , the charger is turned off and FAULT is set on the STATx pins. See the Timer Fault and Recovery section for additional details.

## Charge Termination Detection and Recharge

The TPS65471 monitors the charging current during the voltage regulation phase. Once the termination threshold,  $I_{(TERM)}$ , is detected, charge is terminated. The  $V_{(TERM)}$  and  $K_{(SET)}$  parameters are specified in the specifications.

$$I_{O(TERM)} = \frac{V_{(TERM)} \times K_{(SET)}}{R_{SET}} \quad (3)$$

After charge termination, the device restarts the charge once the voltage on the VBAT pin falls below the  $V_{(RCH)}$  threshold. This feature keeps the battery at full capacity at all times.

The device monitors the charging current during the voltage regulation phase. Once the termination threshold,  $I_{(TERM)}$ , is detected, the charger is terminated immediately.

Resistors RSETn, connected between the ISET1 and AGND and also connected between ISET1 and ISET2, determine the current level at the termination threshold.

## Charge Status Outputs

The open-drain STAT1 and STAT2 outputs indicate various charger operations as shown in .

These status pins can be used to communicate to the host processor. Note that this open-drain output is powered by VLDO1 and an external pull-up resistor should be applied. Iso, note that OFF indicates the open-drain transistor is turns off.

**Table 3. State of STAT1/STAT2 Pins**

CHARGE STATE	STAT1	STAT2
Pre-charge in progress	ON	ON
Fast charge in progress	ON	OFF
Charge done	OFF	ON
Charge suspend, Timer Fault Any device state except #07#, #08#, #11#, #12# of charging	OFF	OFF

## Charge Enable Signal

The nCHEN digital input can control a state of the charger function. If nCHEN is H level, TPS65471 stops all charge functions and turns the charger off.

## Timer Fault Recovery

As shown in , the device provides a recovery method to deal with timer fault conditions. The following summarizes this method:

**Condition Number 1:** Charge voltage above recharge threshold ( $V_{(RCH)}$ ) and timeout fault occurs.

**Recovery Method:** The device waits for the battery voltage to fall below the recharge threshold. This could happen as a result of a load on the battery, self-discharge, or battery removal. Once the battery voltage falls below the recharge threshold, the device clears the fault and starts a new charge cycle. A POR or nCHEN toggle also clears the fault.

**Condition Number 2:** Charge voltage below recharge threshold ( $V_{(RCH)}$ ) and timeout fault occurs.

**Recovery Method:** Under this scenario, the device applies the  $I_{(FAULT)}$  current. This small current is used to detect a battery removal condition and remains on as long as the battery voltage stays below the recharge threshold. If the battery voltage goes above the recharge threshold, then the device disables the  $I_{(FAULT)}$  current and executes the recovery method described for Condition Number 1. Once the battery falls below the recharge threshold, the device clears the fault and starts a new charge cycle. A POR or nCHEN toggle also clears the fault.

## Over Discharge Protection

TPS65471 monitors the voltage of Li-ion battery and protects it from over discharge.

If the voltage on VBAT pin is under  $V_{(BATUVLO)}$ , the current path from VBAT to the device is cut off and the current from the Li-ion battery will be minimized ( $< I_{BAT(ODP)}$ ) as much as possible. This can prevent early battery degradation.

In this case, if the USB-port power source condition or AC-DC adaptor power source is good (state #03#, #04#, #09#, #10#), charge function can be enabled by  $nCHEN = L$ . Charge operation must be started from the pre-conditioning phase. When the pre-conditioning phase exceeds  $V_{(BATUVLO)}$ , the state of TPS65471 changes to (#07#, #08#, #11#, #12#).

## Thermal Shut Down Function

When the junction temperature of TPS65471 increases higher than  $T_{(SHTDWN)}$ , the thermal shut down function is activated.

During a state of thermal shut down, all functions (for the charge, power paths LDO1, LDO2, LDO3, LDO4 and 4.25-V Boost/LDO) are turned off and any current is shut off. If the junction temperature decreases less than  $T_{(SHTDWN)}$ , (Note:  $-15^{\circ}\text{C}$  (typical) hysteresis) TPS65471 goes back to normal operation. In this case, timers in the charger are not cleared. The charger timer maintains operation.

## APPLICATION INFORMATION

### Behavior of the Charger Without Li-Ion Battery on VBAT Pin

If charger function is activated without the Li-ion battery on the VBAT pin, the charger shows the below phenomenon.

1. Voltage level of VBAT pin goes to 4.2 V.
2. After  $t_{(TRMDET)}$  has passed, the charger function is turned off. Then the voltage level on the VBAT pin goes to GND.
3. Since the voltage level on the VBAT pin become less than  $V_{O(RCH)}$ , after  $t_{(DEGL)}$  turns off, the charger function is activated again.
4. Return to 1.

Condition :

$VBUS > V_{(VBUSPG)}$

or  $VAC > V_{(VACPG)}$

$nCHEN = L$

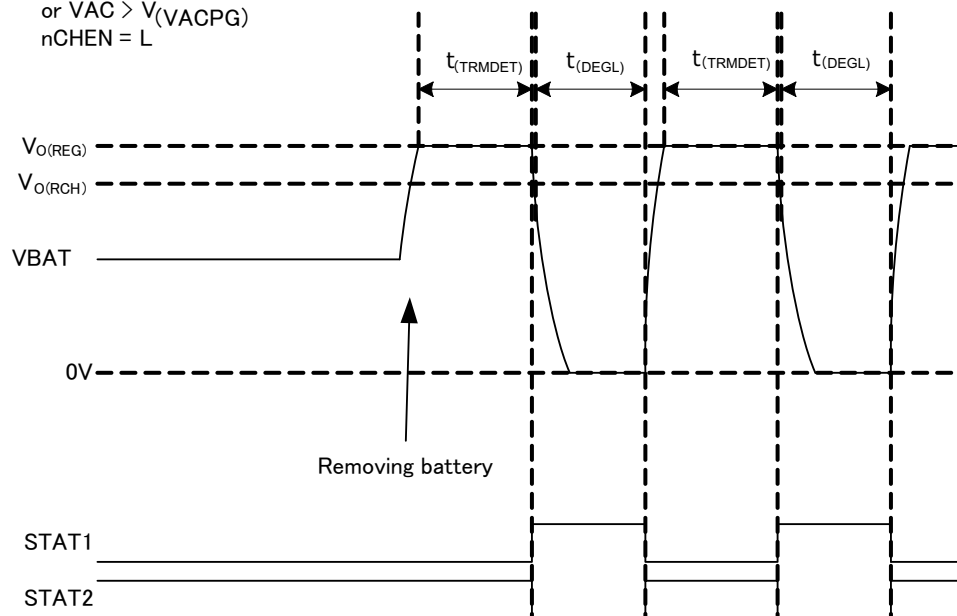


Figure 11. VBAT Waveform When Charging Without Battery Connection

### Behaviors If a Short Occurs

#### VLDO1 Output Shorted to GND

If a short-circuit occurs between the 3.2-V LDO output (VLDO1) and GND, the current is limited by the LDO's current limit. If LDO is heated by the current and voltage, thermal shut down is activated (depending on ambient temperature and PCB structure).

#### VLDO2, VLDO4 or VLED4P25 Output Shorted to GND

If a short-circuit occurs between the output and GND, the current is limited by the LDO's current limit. If these output terminals decrease below LVP (low voltage protection), these power outputs will be turned off and this state will be held. In addition, if any output of VLDO2 or VLDO4 or VLED4P25 is connected to GND, all the outputs controlled by the signal of EN\_VLDO are turned off. Recovery method, EN\_VLDO pin goes to L level at once, then goes to H level.

**VLDO3 Output Shorted to GND**

If a short-circuit occurs between the 3.2-V LDO output (VLDO3) and GND, the current is limited by the LDO current limit. If this output terminal decreases below LVP, the power output will be turned off and this state will be held. Recovery method, EN\_VLDO3 pin goes to L level at once, then goes to H level.

**PWR Shorted to GND**

(VBAT pin) Li-ion battery provides power to PWR. If a short-circuit is detected on the PWR pin, power-path SW2 goes to high-resistance mode immediately and limits this current. If the SW2 is heated by the current and voltage, thermal shut down is activated (depending on ambient temperature and PCB structure).

(VBUS pin or VAC pin) USB-port or AC-DC adaptor power provide power to PWR. If a short-circuit is detected on the PWR pin, current flows through power-path SW1 from VBUS to PWR. This current is limited by internal current limit on SW1. Short current flow through power-path SW3 from VAC to PWR is limited by internal current limit on SW3. If SW2 or SW3 is heated by the current and voltage, thermal shut down is activated (depending on ambient temperature and PCB structure).

**VBAT Shorted to GND**

If VBAT is shorted to GND, a protection IC in the battery pack will protect the battery.



## BILL OF MATERIALS

**Table 4. Recommended Inductors and Capacitors**

PIN	PARTS	VALUE	CHARACTERISTIC	NOTE
VBUS	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
VAC	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
VBAT	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
PWR	Ceramic capacitor	10 $\mu$ F	X5R/X7R	Regarding an effect of DC bias on the capacitor, select a capacitor that can secure at least 4.7 $\mu$ F in worst case.
VLDO1	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
VLDO2	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
VLDO3	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
VLDO4	Ceramic capacitor	1.0 $\mu$ F	X5R/X7R	
VLED4P25	Ceramic capacitor	22 $\mu$ F	X5R/X7R	
VIN	Ceramic capacitor	22 $\mu$ F	X5R/X7R	
Between SW and L	Inductor	6.8 $\mu$ H	$\pm$ 20%	NR4018T6R8M : TAIYO YUDEN or equivalent

## LAYOUT CONSIDERATION

As for all switching power supplies, the layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems.


1. Use wide and short traces for the main current path and for the power ground tracks without using vias if possible. If vias are unavoidable, use many vias in parallel to reduce resistance and inductance.
2. The input capacitor, output capacitor and the inductor should be placed as close as possible to the IC. These components should be placed on the same side of the printed circuit board. The order of placement for these components is output capacitor (VLED4P25 pin and PGND pin), inductor (L pin and SW pin), then input capacitor (VIN pin and ground plane).
3. Use of a ground plane is recommended.

Since TPS65471 provides charging current and system power with internal linear regulators, users need to consider thermal condition.

1. PowerPAD should be soldered to a thermal land on the PCB.
2. Vias on the thermal land of the PCB are necessary. This is a thermal path through the other side of the PCB.
3. A thermal pad of the same size is required on the other side of the PCB. All thermal pads should be connected by vias.
4. A metal layer should cover all of the PCB if possible.
5. Place vias to connect other sides to create thermal paths.

With these steps, the thermal resistance of TPS65471 can be lowered.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS65471RHAR	ACTIVE	VQFN	RHA	40	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-10 to 85	TPS 65471	

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=100ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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## GENERIC PACKAGE VIEW

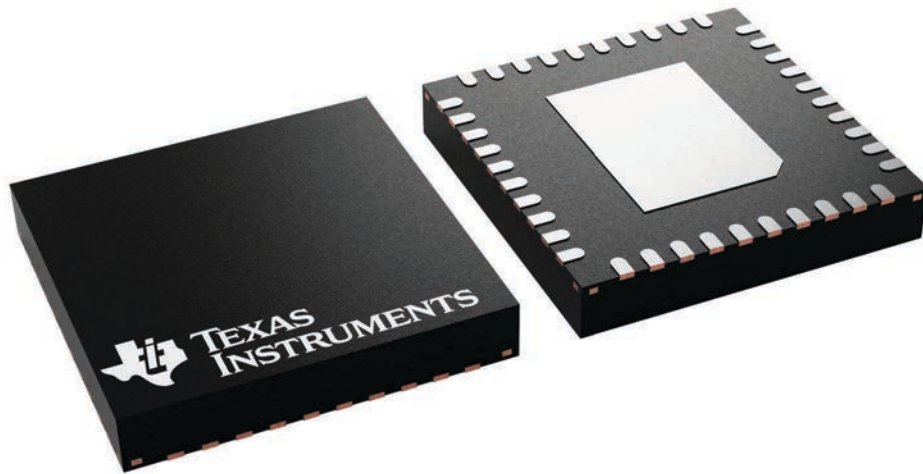
**RHA 40**

**VQFN - 1 mm max height**

6 x 6, 0.5 mm pitch

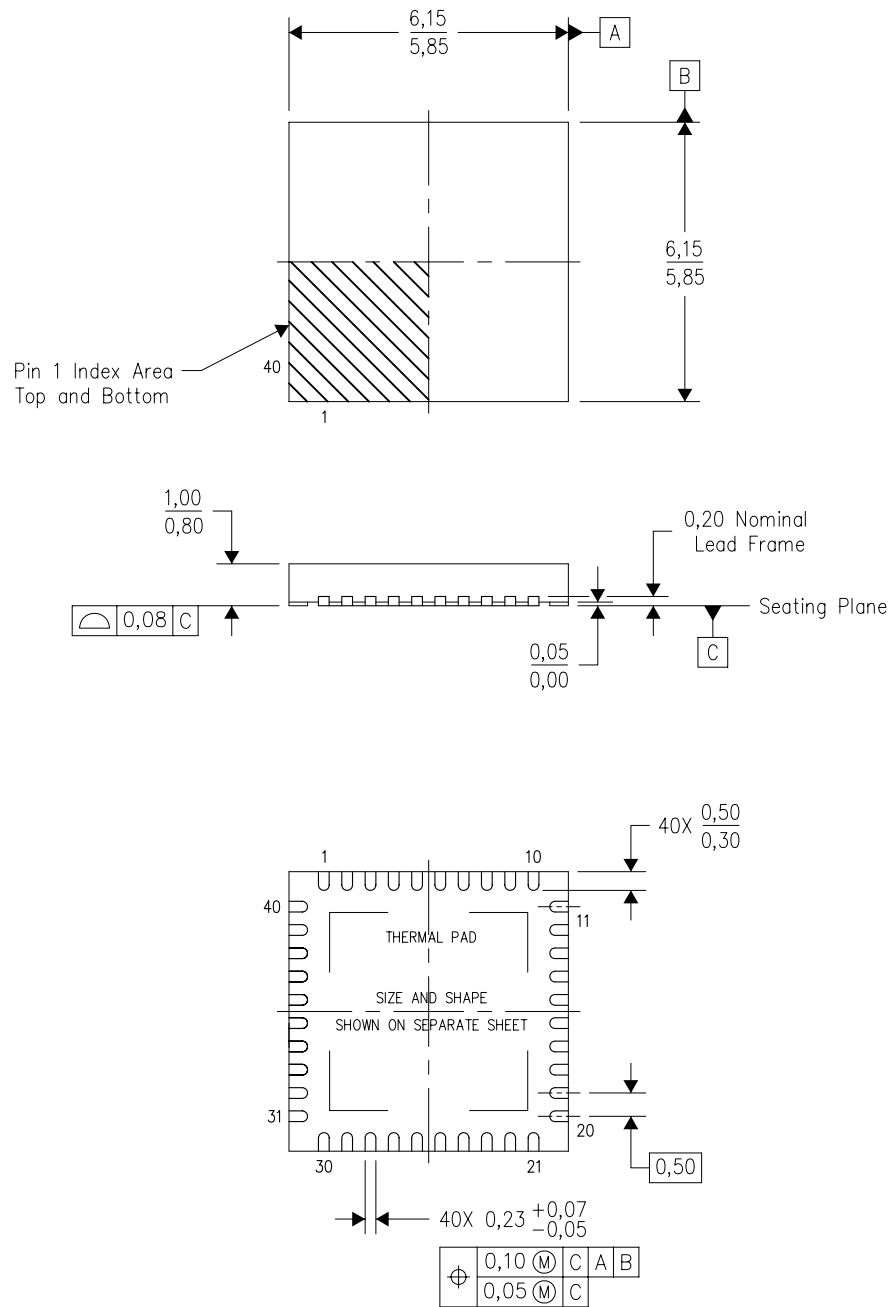
PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



RHA (S-PVQFN-N40)

PLASTIC QUAD FLATPACK NO-LEAD



Bottom View

4204276/E 06/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - QFN (Quad Flatpack No-Lead) Package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - Package complies to JEDEC MO-220 variation VJJD-2.

## THERMAL PAD MECHANICAL DATA

RHA (S-PVQFN-N40)

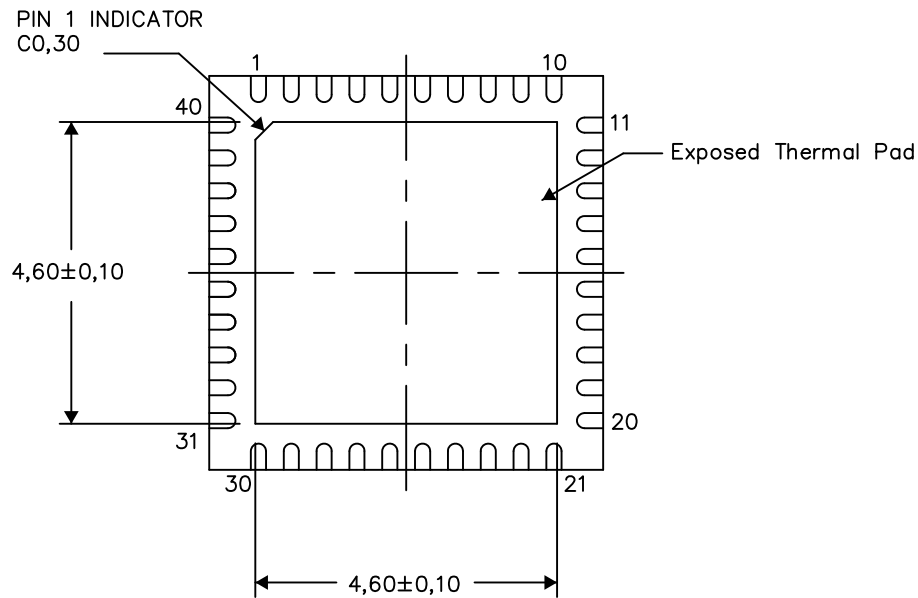
PLASTIC QUAD FLATPACK NO-LEAD

### THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

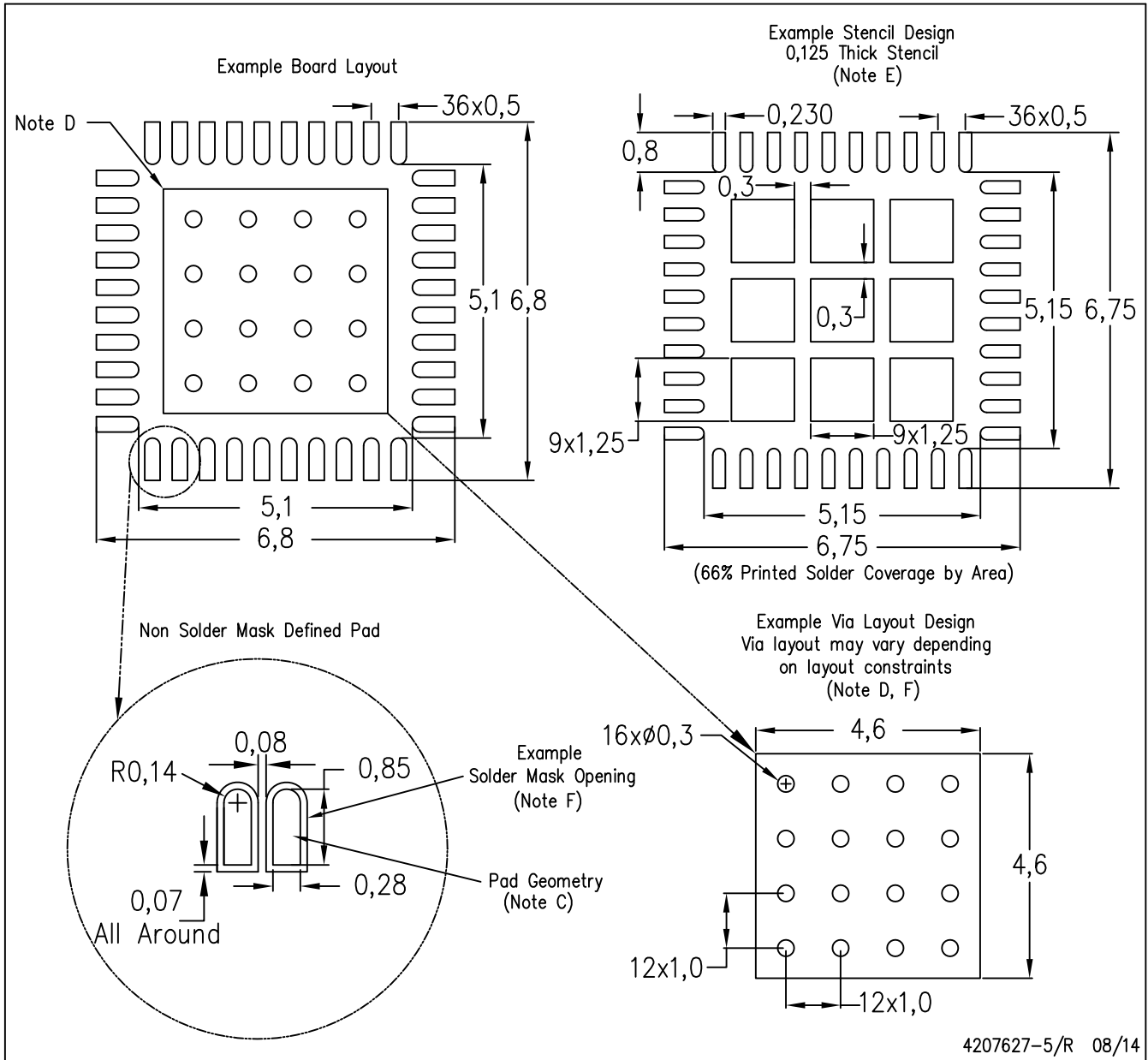
Exposed Thermal Pad Dimensions

4206355-5/X 08/14

NOTES: A. All linear dimensions are in millimeters

RHA (S-PVQFN-N40)

PLASTIC QUAD FLATPACK NO-LEAD



4207627-5/R 08/14

- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

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