Over-Voltage Protection IC and
Li+ Charger Front-End Protection IC with LDO Mode

GENERAL DESCRIPTION

The PW2601 is a charger front-end integrated circuit designed to provide protection to Li-ion batteries from failures of charging circuitry. The device monitors the input voltage, battery voltage and the charging current to make sure all three parameters are operated in normal range. The device will switch off internal MOSFET to disconnect IN to OUT to protect load when any of input voltage, output current exceeds the threshold. The Over temperature protection (OTP) function monitors chip temperature to protect the device. The PW2601 also can protect the system's battery from being over charged by monitors the battery voltage continuously. The device operates like a linear regulator, maintaining a 5.1V output with input voltages up to the input over-voltage threshold.

The PW2601 is available in DFN-2x2-8L package. Standard products are Pb-free and Halogen-free.

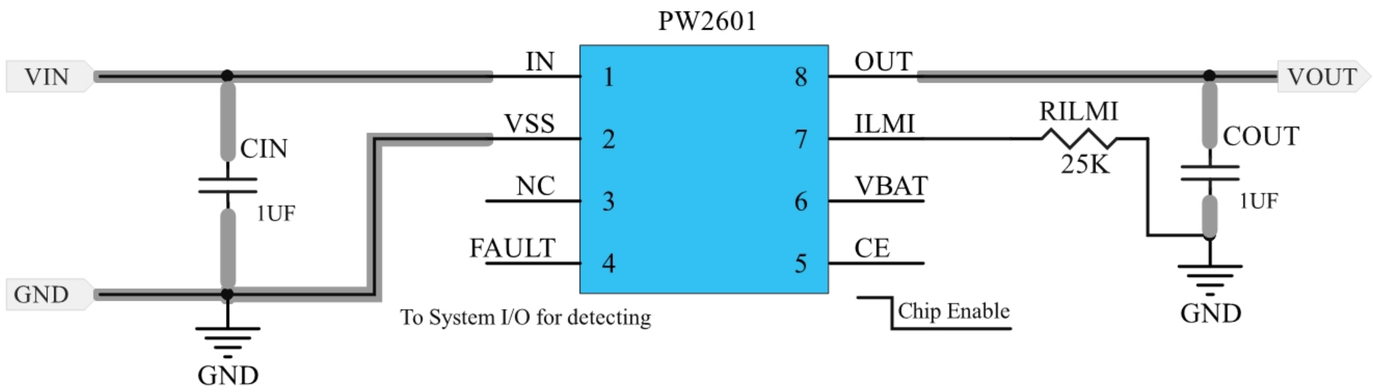
FEATURES

- Maximum Input Voltage: 24V
- Programmable OCP: Up to 1.5A
- Input OVP: 6.8V
- OVP Response Time: Less Than 1us
- Battery OVP threshold: 4.35V (Typ.)
- Over Temperature Protection
- Soft-Start to Prevent Inrush Currents
- LDO Mode Output: 5.1V
- Fault Indication Output
- Enable Input
- High Immunity of False Triggering Under Transient
- Thermal Enhanced DFN Package
- RoHS Compliant and Halogen Free

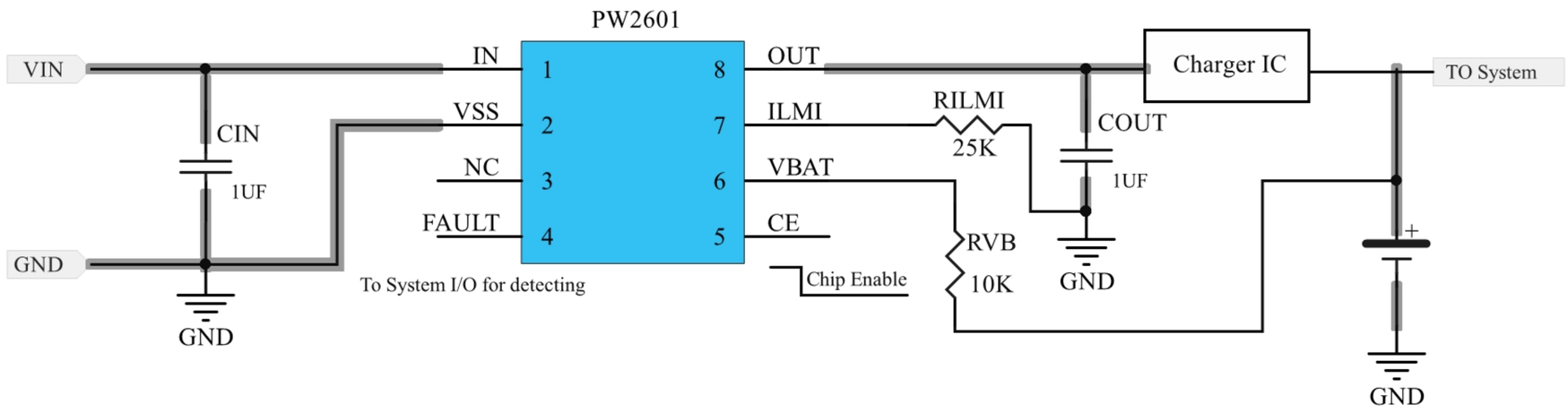
APPLICATIONS

- GPS
- MID
- Car DVR
- Digital Video

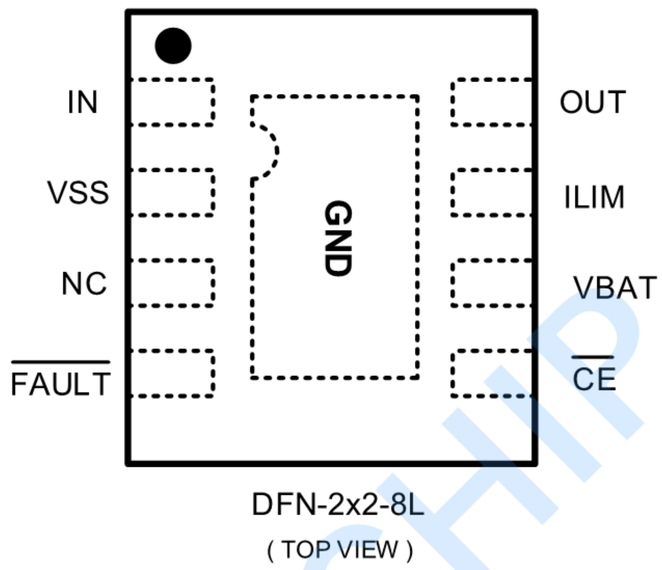
TYPICAL APPLICATION CIRCUIT



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PIN ASSIGNMENT/DESCRIPTION



Pin Number	Pin Name	Functions
1	IN	Input Power. Connected to external DC supply and bypass IN to VSS with a ceramic capacitor (1μF MIN).
2	VSS	Power ground. Connect to the thermal pad and to the ground rail of the circuit.
3	NC	Not connected.
4	$\overline{\text{FAULT}}$	This is an open-drain logic output that turns LOW when any protection event occurs.
5	$\overline{\text{CE}}$	Chip Enable (Active Low). Pull this pin to low or leave it floating to enable the IC and force it to high to disable the IC. This is internally pulled down and pull-down resistor is about 200kΩ
6	VBAT	Battery Voltage Sense Input. Connected to battery's positive terminal through a 10kΩ resistor.
7	ILIM	Over current protection threshold setting pin. Connect a resistor between this pin and GND to set the OCP threshold: (A) $I_{ocp} = 23000/R_{ILIM}$
8	OUT	Output terminal to the charging system. Bypass OUT to VSS with a ceramic capacitor (1uf MIN).
9	GND (Expose Pad)	Thermal pad electrically connected to GND pin internally. This pad must be soldered to a large PCB and connected to GND for maximum thermal dissipation.

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Absolute Maximum Ratings (note)

SYMBOL	ITEMS		VALUE	UNIT
IN	Input Voltage		-0.3~24	V
OUT	Output Voltage		-0.3~7	V
All other pins	$\overline{\text{FAULT}}$, $\overline{\text{CE}}$, ILIM, VBAT		-0.3~6	V
I_{OMAX}	Output Load Current		1.5	A
I_{SINK}	$\overline{\text{FAULT}}$ Pin Sink Current		15	mA
P_{DMAX}	Power Dissipation*1	DFN-2*2-8L	1	W
$R_{\theta JA}$	Thermal Resistance*2		75	℃/W
T_J	Junction Temperature		-40~150	℃
T_{STG}	Storage Temperature		-55 to 150	℃
T_{SOLDER}	Package Lead Soldering Temperature (10s)		260	℃
HBM	ESD Susceptibility, Human Body Model		8	KV
MM	ESD Susceptibility, Machine Model		400	V
CDM	ESD Susceptibility, Charged Device Model		2	KV

Note:

Exceed these limits might damage the device. Exposure to absolute maximum rating conditions may affect device reliability.

*1: Surface mounted on FR-4 Board using 1 square inch pad size, dual side, 1oz copper.

*2: Power dissipation is calculated by PD = (VIN-VOUT) x IOUT

RECOMMANDED OPERATING RANGE

SYMBOL	ITEMS	VALUE	UNIT
IN	Input Supply Voltage	3.5 to 24	V
OUT	Output Current	0.5~1	A
T_{OPR}	Operating Temperature	-40 to +85	℃

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ELECTRICAL CHARACTERISTICS

(VIN = 5V, RILIM = 23K, $\overline{CE}$ floating, TA = 25℃, CIN=COUT=1μF ,unless otherwise noted.)

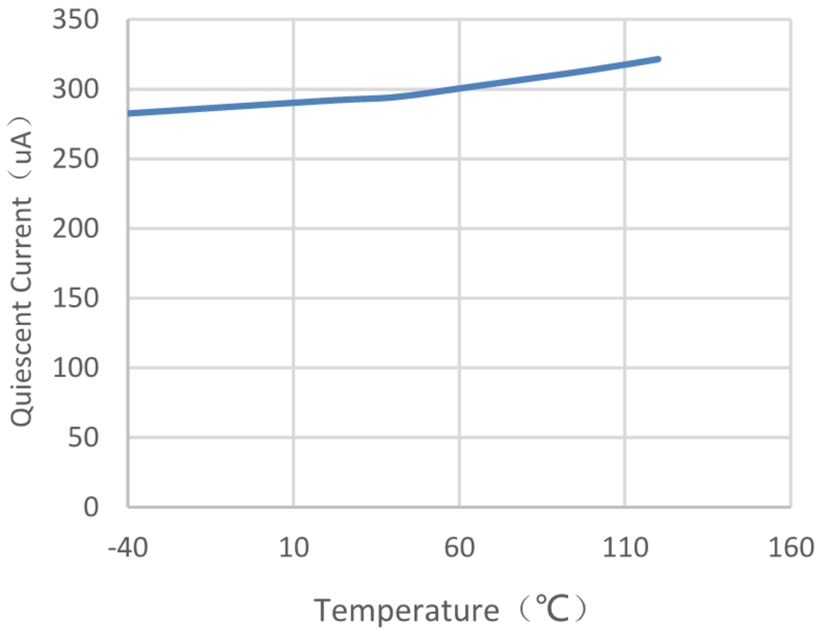
SYMBOL	ITEMS	CONDITIONS	MIN	TYP	MAX	UNIT
DC Characteristics and Power-On-Reset						
V_{IN}	Operation voltage		3.5		6.5	V
UVLO	Under voltage lockout threshold	V_{IN} increasing from 0~3V	2.5	2.7	2.9	V
$V_{HYS-UVLO}$	Under voltage lockout hysteresis	V_{IN} decreasing from 3~0V		80	150	mV
I_Q	Input quiescent current	V_{IN}=5.5V, $\overline{CE}$ =0,I_{OUT}=0A		280	400	μA
I_{SHDN}	Input shutdown current	$\overline{CE}$ =5V,I_{OUT}=0A		65	95	μA
t_{DGL}	Deglitch time, Input power detected status			8		ms
t_{ON}	Output power-on time	V_{IN} ready to output ON	6	8	10	ms
Input Over-Voltage-Protection (OVP)						
V_{OUT}	Output Voltage	V_{IN}=5.5V	4.9	5.1	5.3	V
V_{OVP}	OVP threshold		6.6	6.8	7	V
$V_{HYS-OVP}$	OVP hysteresis			100		mV
t_{OVP}	Input OVP propagation delay	V_{IN}: 5.5V to 10V			1	μs
$t_{ON(OVP)}$	Input OVP recovery delay	V_{IN}: 10V to 5.5V to output ON	6	8	10	ms
Over-Current-Protection (OCP)						
I_{OCP}	Over current protection	V_{IN} = 5V ,R_{ILIM}=23K	0.9	1	1.1	A
t_{OCP}	Over current protection blanking time			180		μs
$t_{ON(OCP)}$	Over current recover delay			64		ms
Battery Over-Voltage-Protection (BOVP)						
V_{BOVP}	Battery OVP threshold		4.3	4.35	4.4	V
$V_{HYS-BOVP}$	Battery OVP hysteresis			200		mV
t_{BOVP}	Battery OVP blanking time			180		μs
$t_{ON(BOVP)}$	Battery OVP recovery delay			8		ms
I_{VBAT}	VBAT pin leakage current	V_{VBAT} =4.4V			20	nA
Over-Temperature-Protection (OTP)						
T_{OTP}	OTP threshold			150		℃
$T_{OTP-HYS}$	OTP hysteresis			30		℃
$t_{ON(OTP)}$	OTP recovery delay			8		ms
Logic Levels ON $\overline{CE}$						
V_{IH}	Logic high input voltage	$\overline{CE}$ rising	1.5			V
V_{IL}	Logic low input voltage	$\overline{CE}$ falling			0.4	V
$R_{\overline{CE}}$	$\overline{CE}$ internal pull down resistor			200		KΩ
Logic Levels ON $\overline{FAULT}$						
V_{OL}	Output low voltage	I_{SINK}=5mA		0.15	0.3	V
I_{LKG}	Output logic high leakage current	$V_{\overline{FAULT}}$=5V			1	μA
Power MOSFIT						
R_{ON}	On resistance*3	I_{OUT}=0.5A		400		mΩ

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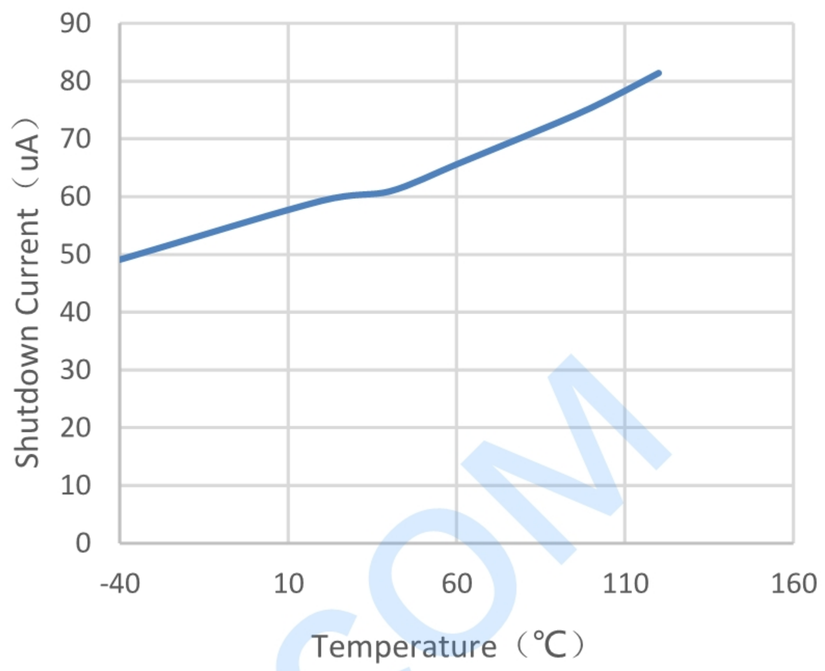
TYPICAL PERFORMANCE CHARACTERISTICS

VIN = 5V, RILIM = 23K, $\overline{CE}$ floating, TA = 25℃, CIN=COUT=1μF, unless otherwise noted.

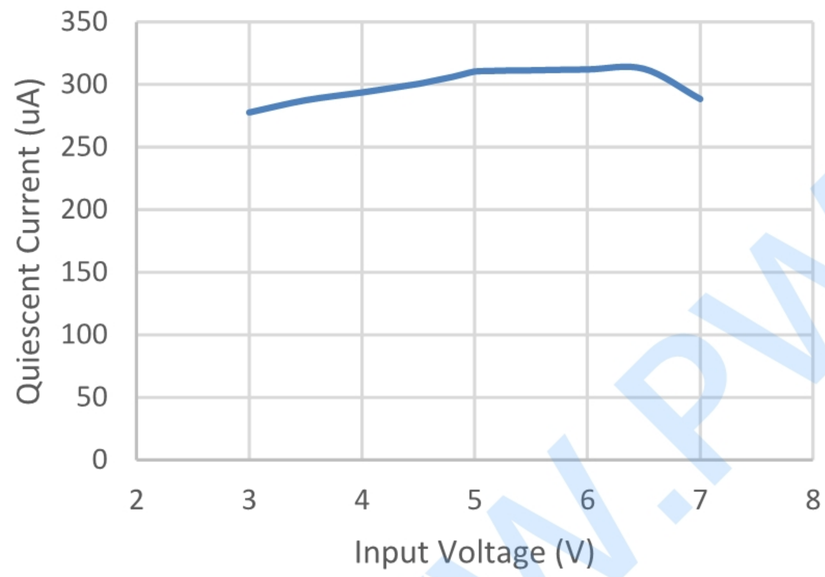
Quiescent Current vs. Temperature



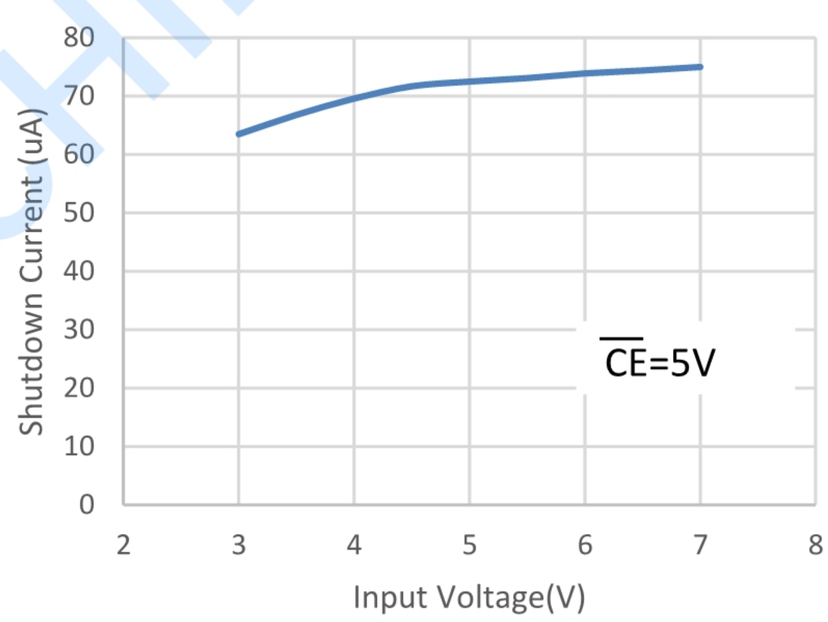
Shutdown Current vs. Temperature



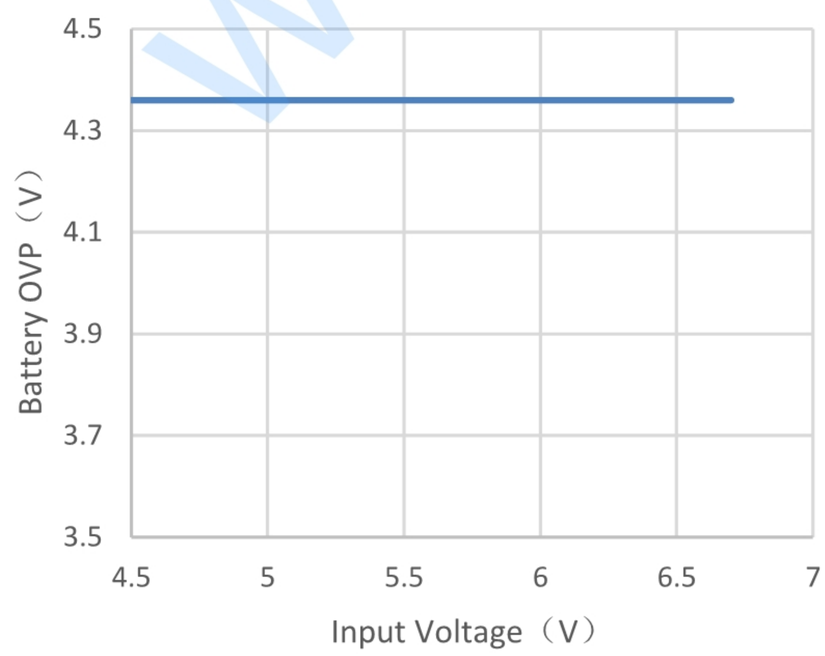
Quiescent Current vs. Input Voltage



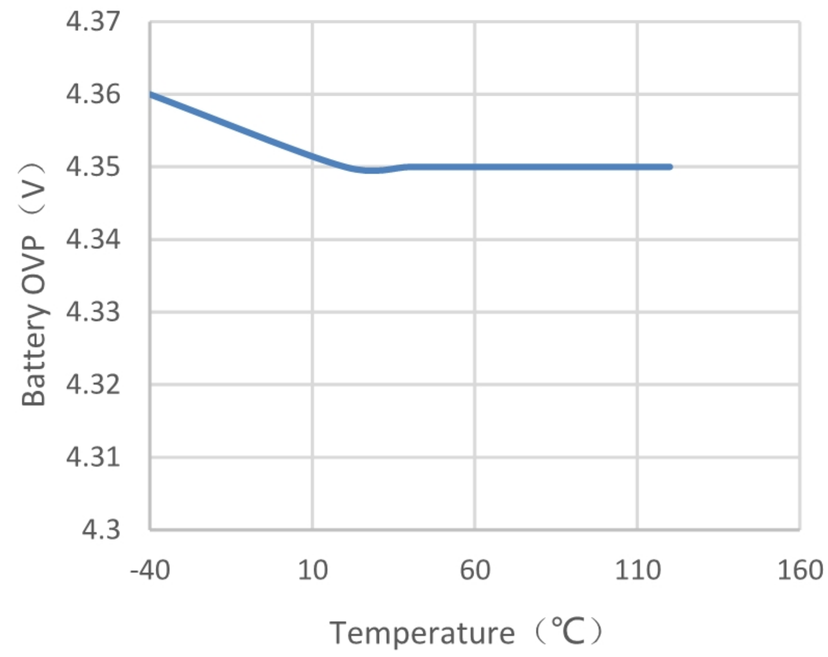
Shutdown Current vs. Input Voltage



Battery OVP vs. Input Voltage

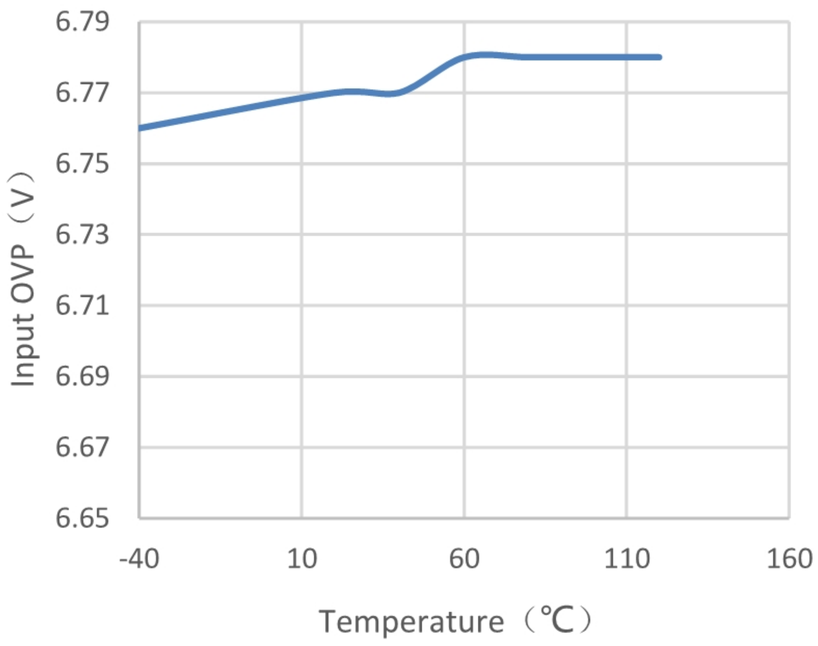


Battery OVP vs. Temperature

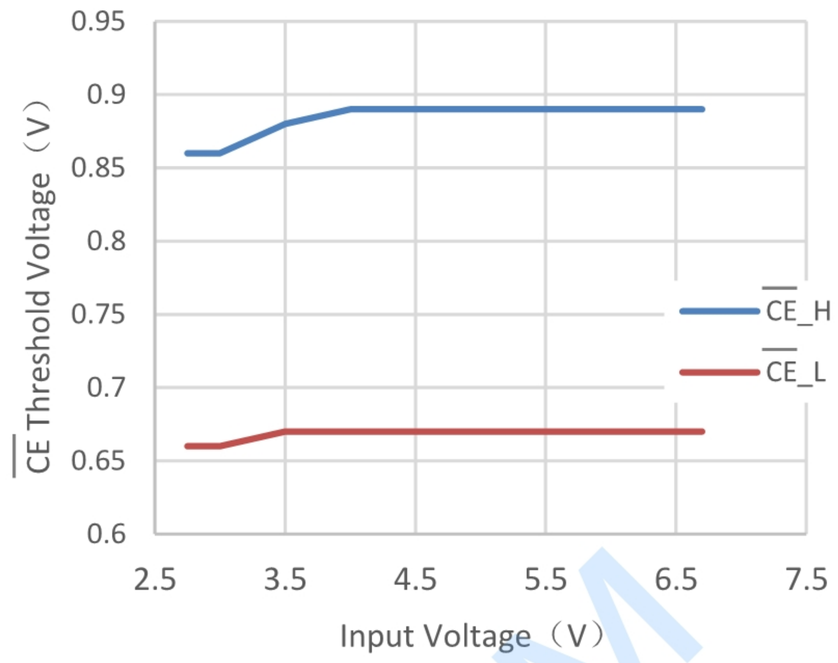


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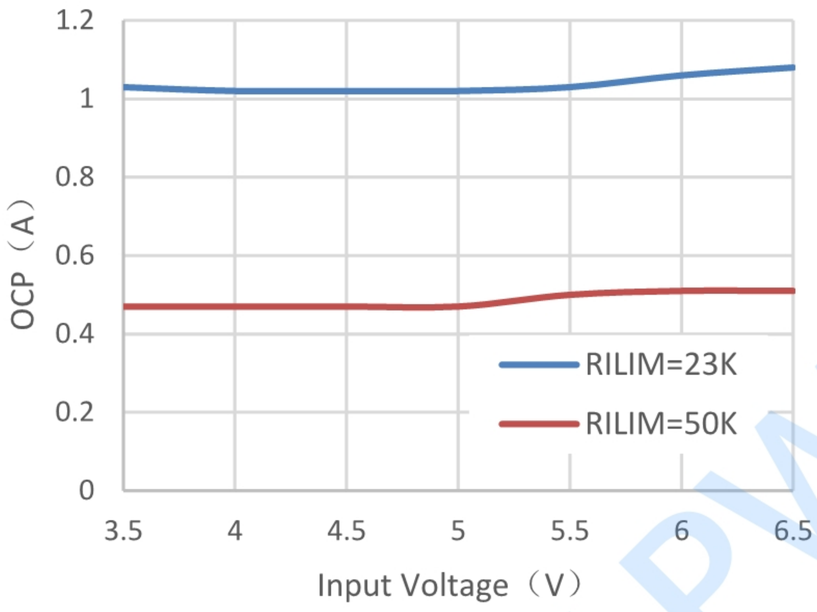
Input OVP vs. Temperature



$\overline{CE}$ Threshold Voltage vs. Input Voltage



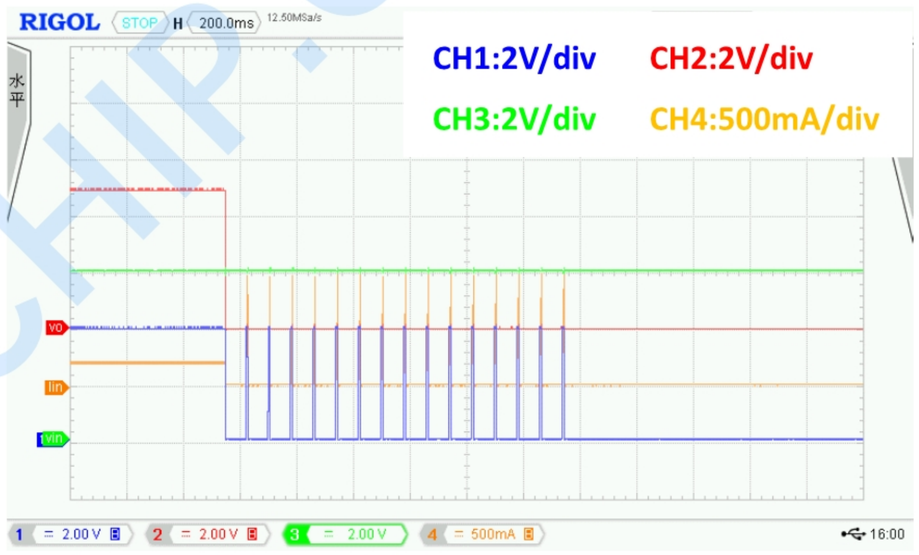
OCP vs. Input Voltage



OCP

CH1:$\overline{FAULT}$ CH2:V_{OUT}

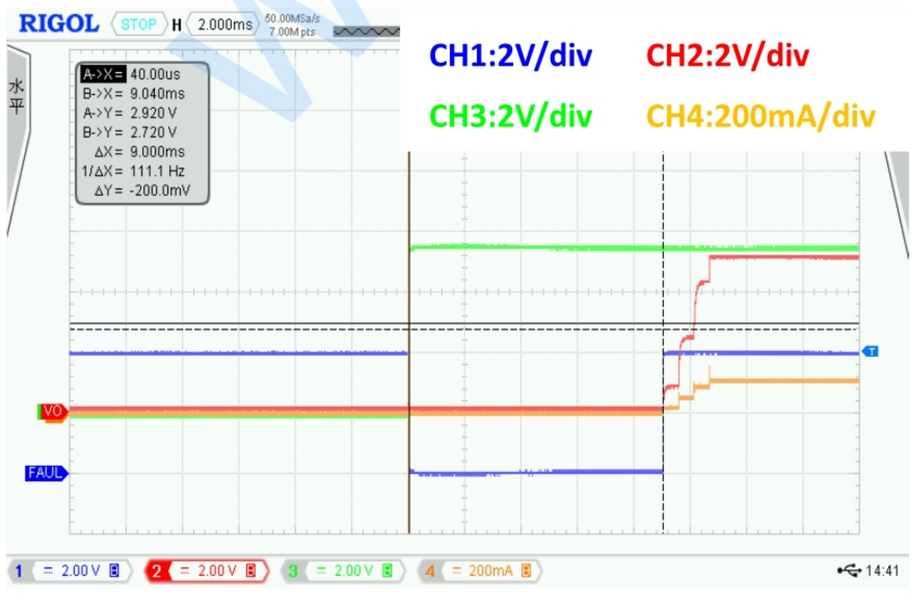
OCP



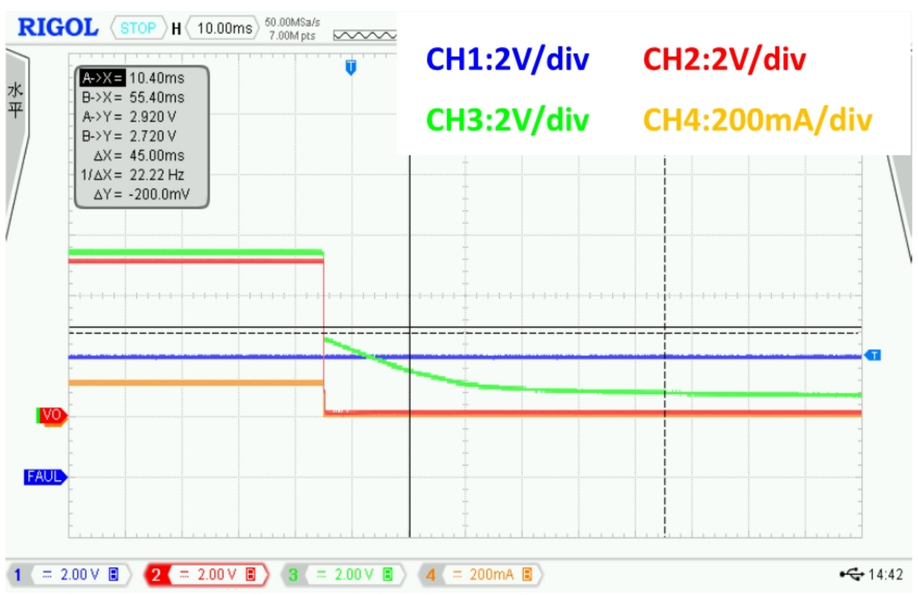
Power ON/OFF

CH1:$\overline{FAULT}$ CH2:V_{OUT} CH3:V_{IN} CH4:I_{OUT}

Power ON



Power OFF

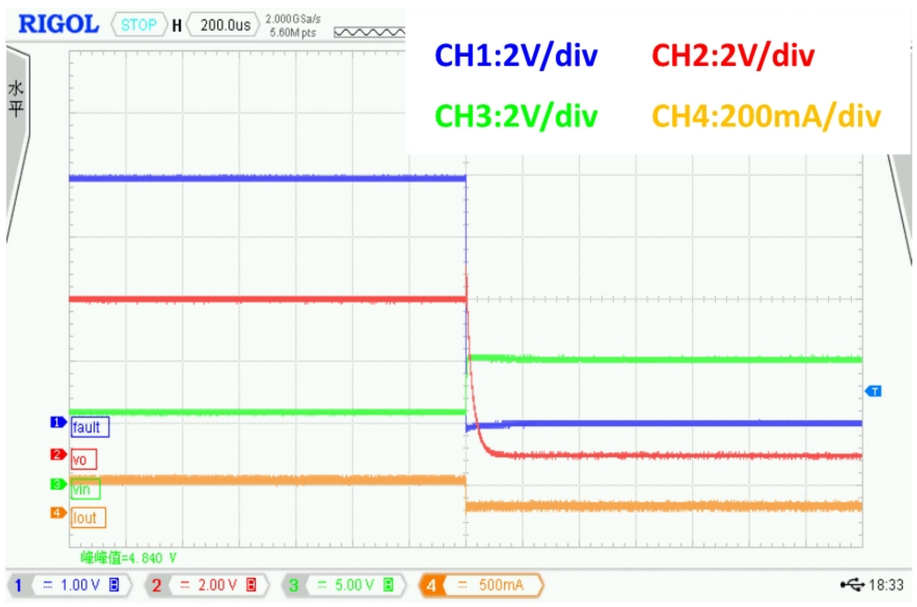


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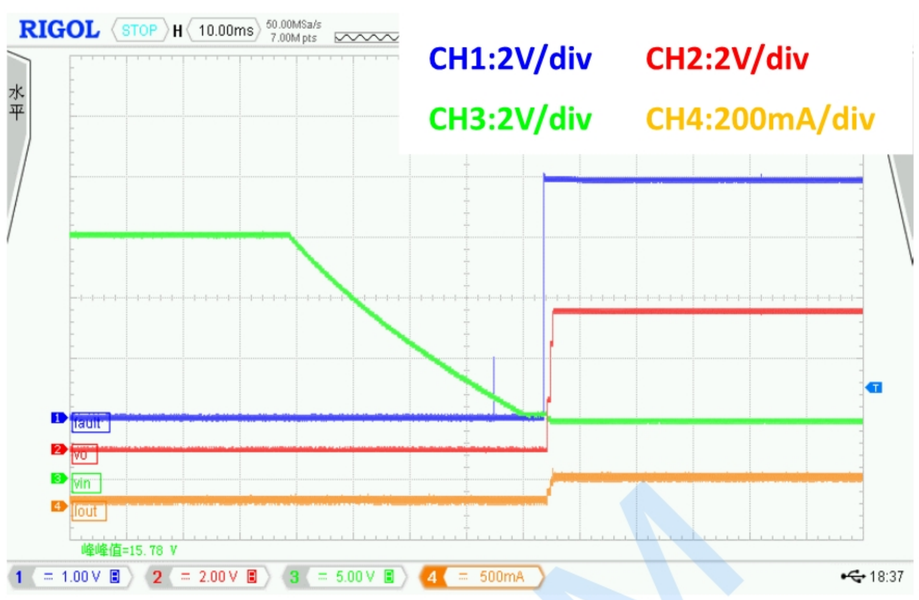
Input OVP

CH1:$\overline{FAULT}$ CH2:V_{OUT} CH3:V_{IN} CH4:I_{OUT}

Input OVP



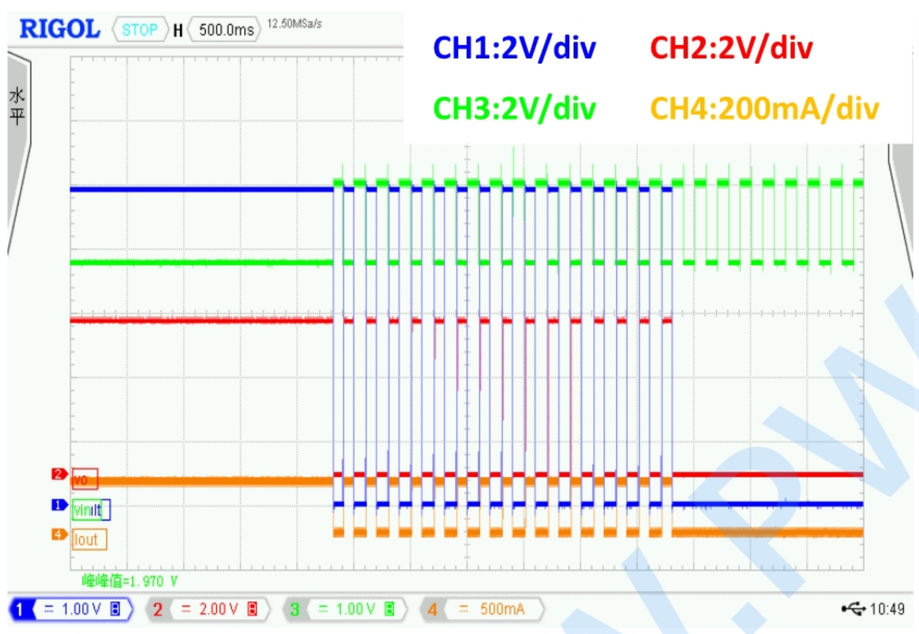
Input OVP recovery



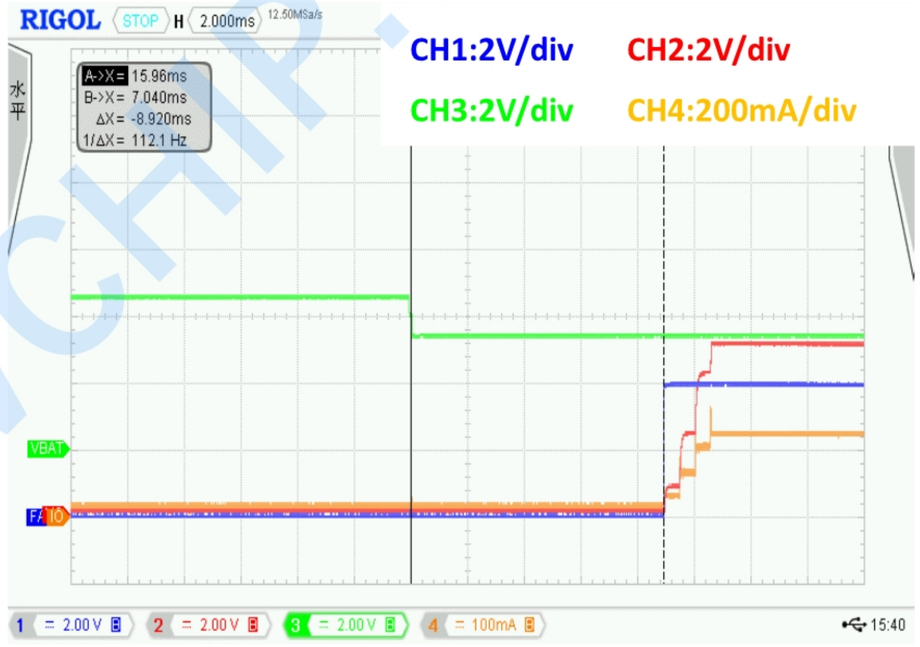
Battery OVP

CH1:$\overline{FAULT}$ CH2:V_{OUT} CH3:V_{BAT} CH4:I_{OUT}

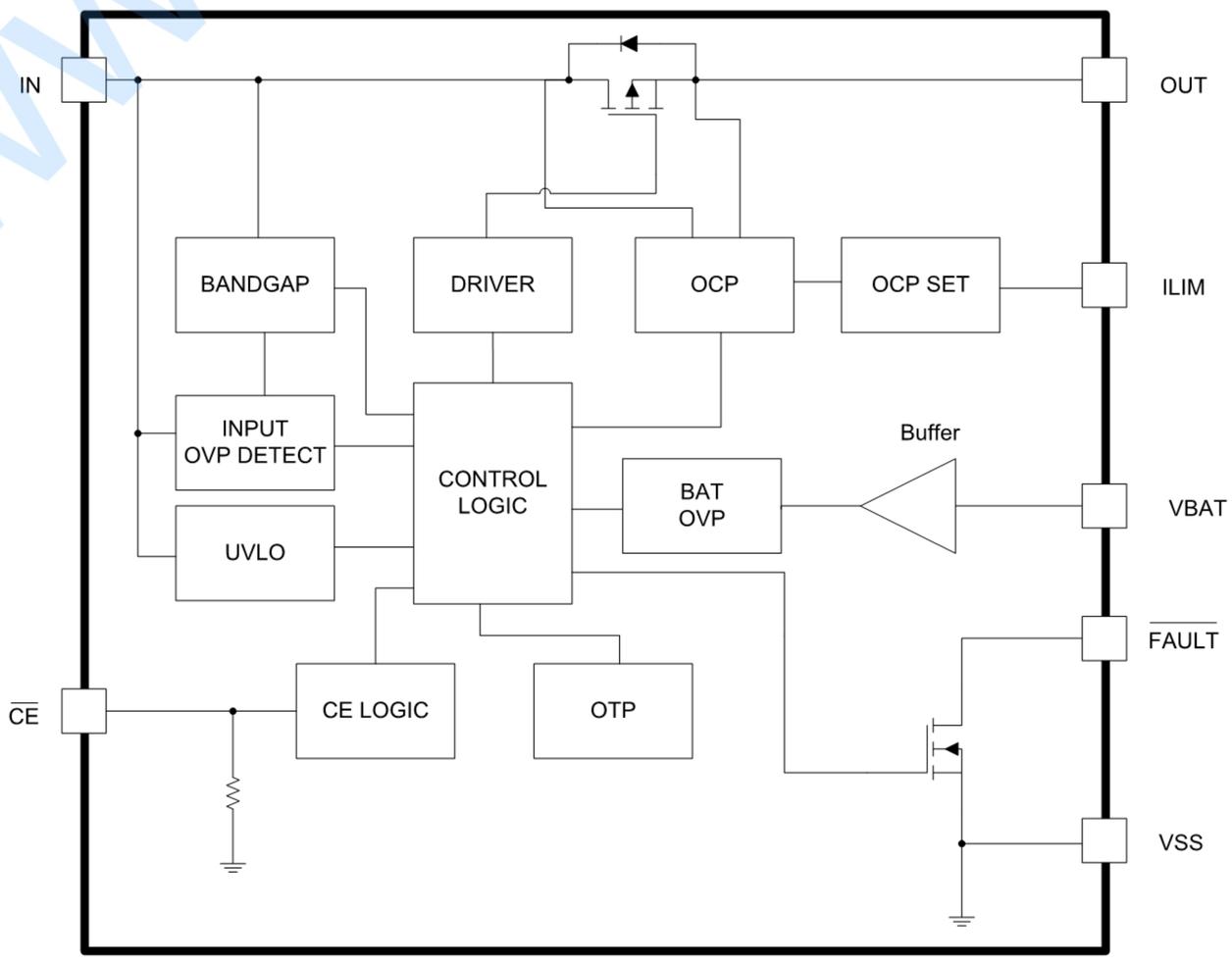
Battery OVP



Battery OVP recovery



SIMPLIFIED BLOCK DIAGRAM



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APPLICATION INFORMATION

The PW2601 is a highly integrated circuit designed to provide protection to Li-ion batteries from failures of the charging circuit and the input source. The IC continuously monitors the input voltage and the battery voltage. The device operates like a linear regulator, maintaining a 5.1V output with input voltages up to the input over-voltage threshold (VOVP = 6.8V). If the input voltage exceeds VOVP, the IC turn off the MOSFET and disconnects the system from input power. Additionally, if the battery voltage rises above 4.35V, the IC switches off the MOSFET, removing the power from the system until the battery voltage falls to safe levels. The IC also monitors its die temperature and switches the MOSFET off if it exceeds 150°C.

The IC can be controlled by a processor, and also provides status information about fault conditions to the host.

Power Up

The PW2601 has a threshold of 2.7V power on reset (UVLO) with a built-in hysteresis of 80mV. Before the input voltage reaches the UVLO threshold, the PW2601 is off. When the input voltage is over the UVLO threshold; the PW2601 will delay for 8ms and the soft-start will be activated after the 8ms delay. The 8ms delay allows any transient at the input during a hot insertion of the power supply to settle down before the IC starts to operate.

During the soft-start transition, the PW2601 slowly turns on the internal MOSFET to reduce the inrush current.

Enable Control

The PW2601 offers an enable ($\overline{CE}$) input. When the $\overline{CE}$ pin is pulled to logic high (>1.5V), the PW2601 will shut down. When the $\overline{CE}$ pin is pulled to logic low (<0.4V), the PW2601 will power on. The $\overline{CE}$ pin has an internal pull-down resistor, and leaving the $\overline{CE}$ pin floating can enable the IC.

$\overline{FAULT}$ Indication Output

The $\overline{FAULT}$ pin is an open-drain output that indicates a LOW signal when any protection event occurs (Input OVP, Output OCP, Battery OVP and OTP). When the protection events are released and then the $\overline{FAULT}$ pin indicates a HIGH signal.

Over Temperature Protection (OTP)

The PW2601 monitors its own internal temperature to prevent thermal failures. The chip turns off the MOSFET when the internal temperature reaches 150°C. The IC will resume after the internal temperature is cooled down below 30°C.

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Input Over Voltage Protection

The PW2601 monitors input voltage to prevent the input voltage lead to output system failures. The PW2601 input OVP threshold is set by the internal resistor. When the input voltage exceeds the threshold, the PW2601 outputs a logic signal to turn off the internal MOSFET within 1us to prevent the high input voltage from damaging the electronics in the handheld system. The hysteresis of the input OVP threshold is 100mV. When the input voltage returns to normal operation voltage rage, the PW2601 re-enables the MOSFET.

Battery Over Voltage Protection

The battery OVP threshold voltage is set at 4.35V typically and the PW2601 has a built-in 180us blanking time to prevent any transient voltage from triggering the battery OVP. If the OVP situation still exists after 180us, the internal MOSFET will be turned off and the $\overline{\text{FAULT}}$ pin indicate a LOW signal. The battery OVP threshold has a 200Mv built in hysteresis. The control logic contains a 4-bit binary counter. If the battery over voltage event occurs for consecutive 16 times, the MOSFET will be turned off permanently unless the input power or the enable pin is reset.

Over Current Protection (OCP)

The PW2601 monitors the output current to prevent the output short or the charging of the battery with an excessive current. The OCP (Over Current protection) threshold can be set by the ILIM pin. The PW2601 has a built-in 180us delay time to prevent any transient noise from triggering the OCP. If the OCP situation exists for 180us, the internal MOSFET will be turned off and the $\overline{\text{FAULT}}$ pin indicate a LOW signal. When the OCP happens for consecutive 16 times, the internal MOSFET will be turned off permanently unless the input power is recycled or the enable pin is toggled.

The OCP threshold can be set by the resistor connected between the ILIM pin and GND. The OCP threshold can be calculated by the following equation:

$$(A)\ \frac{23000}{\text{RILIM}} = \text{IOCP}$$

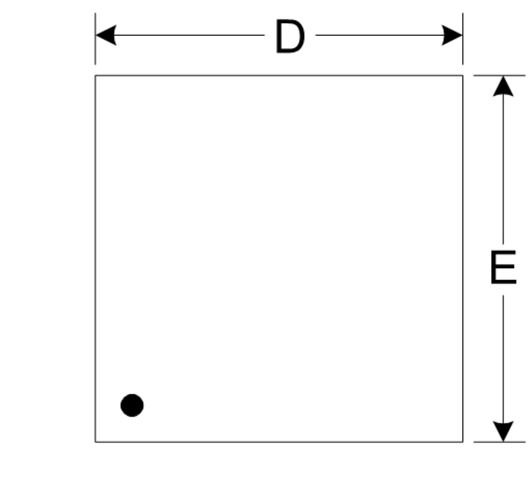
Selecting RVB

The PW2601 monitors the battery voltage by the VB pin. The PW2601 will be turned off when the battery voltage exceeds the 4.35V battery OVP threshold. The VB pin is connected to the battery pack positive terminal via an isolation resistor (RVB) and the resistor is an important component. The RVB determines some parameters such as battery OVP threshold error and VB pin leakage current. Generally, it is necessary to decrease the RVB for reducing the battery OVP threshold error. However, this will increase the VB pin leakage current. So, it is an important issue to get a trade-off between the battery OVP threshold error and the VB pin leakage current. The resistance between 10kΩ to 100KΩ is recommended for RVB.

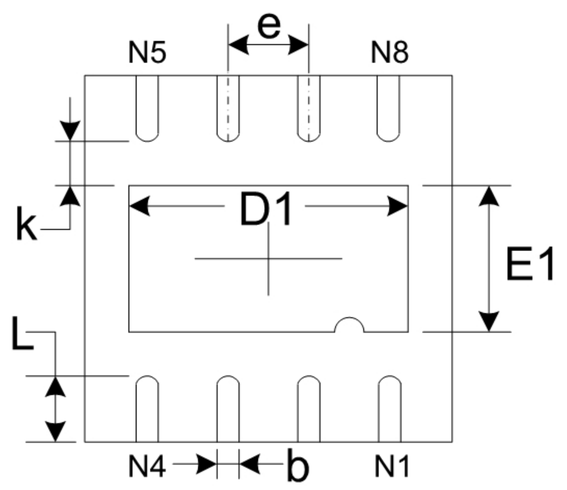
If the battery OVP function is not required, the VB pin can be connected to GND.

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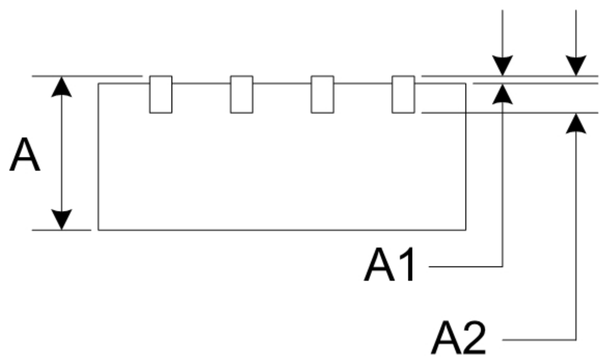
PACKAGE DESCRIPTION



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E	1.900	2.100	0.075	0.083
E1	0.500	0.700	0.020	0.028
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
k	0.200 MIN		0.008 MIN	
L	0.250	0.450	0.010	0.018

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