General Description

The EMP2602 is a charger front-end integrated circuit designed to provide protection to Li-ion batteries from abnormal conditions. The device monitors the input voltage and the charging current to make sure both parameters are in normal range. The device will switch off internal MOSFET to disconnect IN from OUT to protect load when any of input voltage or output current exceeds the threshold. The Over Temperature Protection (OTP) function monitors chip temperature to protect the device. The device operates like a linear regulator, maintaining a 5.45V output with wide input voltage range.

The EMP2602 is available in DFN-2x2-8L, DFN-2x2-6L and SOT23-5L package. Standard products are Pb-free and Halogen-free.

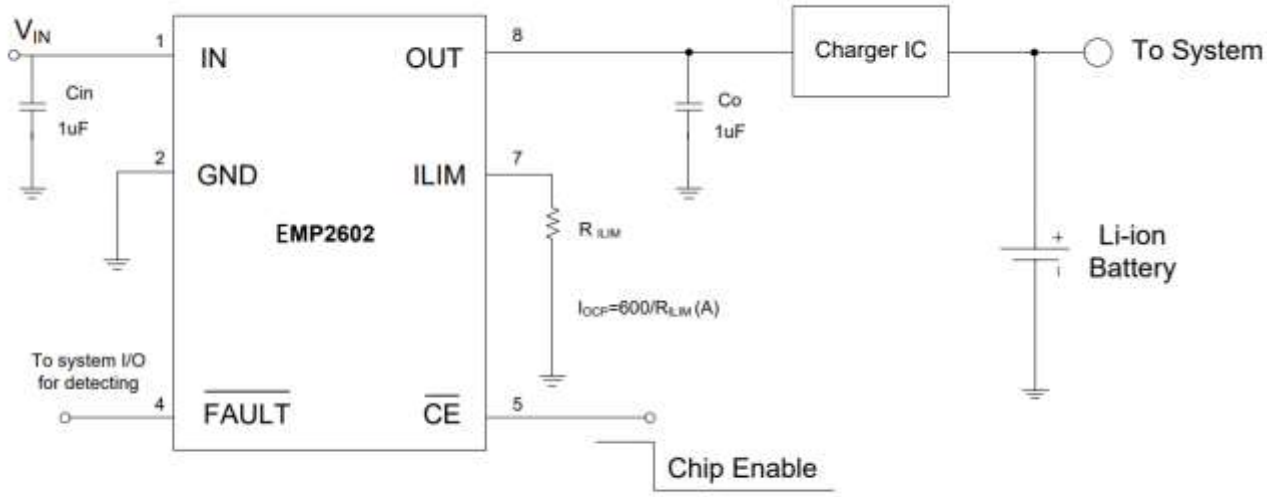
Applications

- GPS
- MID
- Car DVR
- Digital Video

Features

- Maximum Input Voltage: 32V
- Programmable OCP: 0.2A to 3A
- 3 OCP Behaviors: hiccup always, hiccup 16 times and then latch, Constant Current Operation
- Input OVP: 6.8V
- LDO Mode Output: 5.45V
- Ultra-Low Power Path Resistor: 0.12Ω-Typical
- OVP Response Time: Less Than 1us
- Over Temperature Protection
- Soft-Start to Prevent Inrush Current
- Fault Indication Output
- Enable Input to Control Output
- High Immunity of False Triggering Under Transient
- Three Selectable Packages
- RoHS Compliant and Halogen Free

TYPICAL APPLICATION CIRCUIT

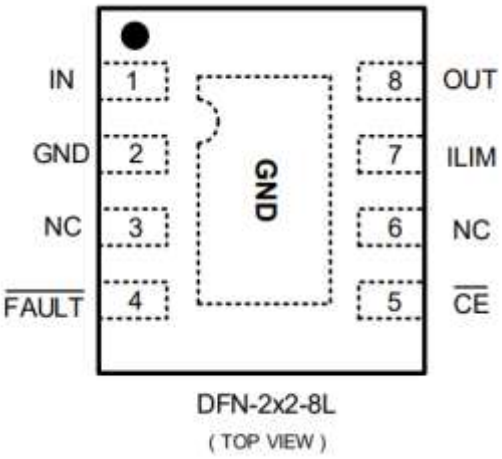


Note: Cin and Co placement close to the VIN pin and VOUT pin.

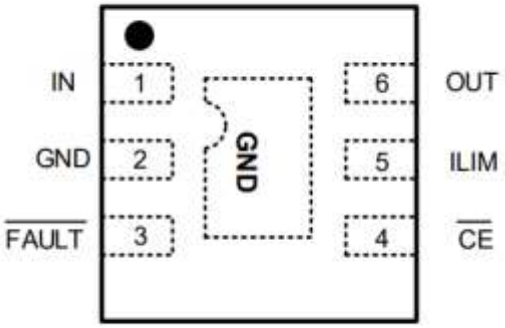
Ordering Information

PART NO	OVP TYPE	PACAKGE	OCP BEHAVIOR	TAPE & REEL	STATUS
EMP2602CD8-68	6.8V	DFN-2x2-8L	hiccup 16 times and then latch up	4000/REEL	Active
EMP2602CD6-68	6.8V	DFN-2x2-6L		4000/REEL	Non-active
EMP2602CS5-68	6.8V	SOT23-5L		3000/REEL	Non-active
EMP2602BD8-68	6.8V	DFN-2x2-8L	hiccup always	4000/REEL	Non-active
EMP2602BD6-68	6.8V	DFN-2x2-6L		4000/REEL	Non-active
EMP2602BS5-68	6.8V	SOT23-5L		3000/REEL	Non-active
EMP2602AD8-68	6.8V	DFN-2x2-8L	Constant Operation Mode (CC)	4000/REEL	Non-active
EMP2602AD6-68	6.8V	DFN-2x2-6L		4000/REEL	Non-active
EMP2602AS5-68	6.8V	SOT23-5L		3000/REEL	Non-active

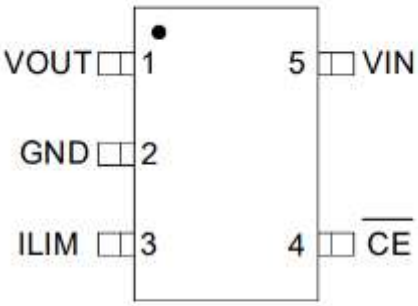
Pin Assignment



DFN-2x2-8L
(TOP VIEW)



DFN-2x2-6L
(TOP VIEW)



SOT23-5
(TOP VIEW)

PIN DESCRIPTION

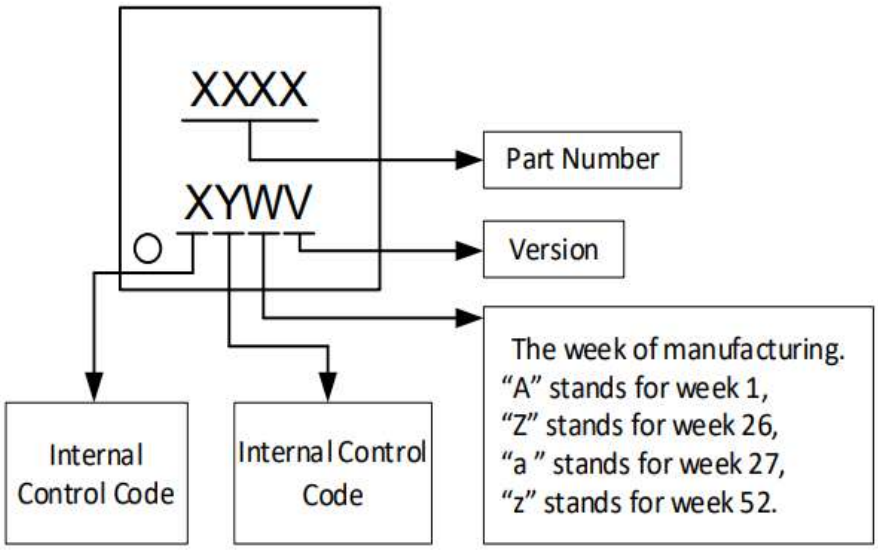
PIN	SYMBOL	I/O	DESCRIPTTION
1	IN	Power	Input Power. Connected to external DC supply and bypass IN to GND with a ceramic capacitor (1μF MIN).
2	GND	Ground	Power ground. Connect to the thermal pad and to the ground rail of the circuit.
3	NC	/	Not connected.
4	$\overline{\text{FAULT}}$	O	This is an open-drain logic output that turns LOW when any protection event occurs. If it is not used, leave it floating.
5	$\overline{\text{CE}}$	I	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 350kΩ.
6	NC	/	Not connected.
7	ILIM	O	Over current protection threshold setting pin. Connect a resistor between this pin and GND to set the OCP threshold: $I_{OCP} = \frac{600}{R_{ILIM}}(A)$
8	OUT	O	Output terminal to the charging system. Bypass OUT to GND with a ceramic capacitor (1μF MIN).
9	Expose Pad	GND	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.

PART NUMBER RULES

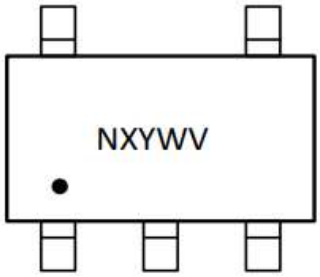
EMP2602[1][2]-[3]

Code	Description
[1]	Product Version: A: OCP CC mode B: OCP hiccup always C: OCP hiccup 16 times and then latch
[2]	Package: D8: DFN-2x2-8L D6: DFN-2x2-6L S5: SOT23-5L
[3]	OVP version: XX: OVP threshold voltage Example: 68: 6.8V

MARKING DESCRIPTION



DFN Package



SOT23-5L

"N": Product code, here use "D" stands for " EMP2602".
"X": Package factory
"Y": Wafer foundry vendor.
"W": The week of manufacturing. "A" stands for week 1,
"Z" stands for week 26,
"a" stands for week 27,
"z" stands for week 52.
"V": OVP voltage + OCP mode code.

ABSOLUTE MAXIMUM RATINGS (Note)

SYMBOL	ITEMS		VALUE	UNIT
IN	Input Voltage		-0.3~32	V
OUT	Output Voltage		-0.3~7	V
All other pins	$\overline{FAULT}$, $\overline{CE}$, ILIM		-0.3~6	V
I_{OMAX}	Output Load Current		3	A
I_{SINK}	$\overline{FAULT}$ Pin Sink Current		15	mA
P_{DMAX}	Power Dissipation*1	DFN-2x2-8L	1	W
$R_{\theta JA}$	Thermal Resistance*2		75	℃/W
P_{DMAX}	Power Dissipation*1	DFN-2x2-6L	1	W
$R_{\theta JA}$	Thermal Resistance*2		75	℃/W
P_{DMAX}	Power Dissipation*1	SOT23-5L	0.5	W
$R_{\theta JA}$	Thermal Resistance*2		170	℃/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: *Exceeding these limits might damage the device. Exposure to absolute maximum rating conditions may affect device reliability.*

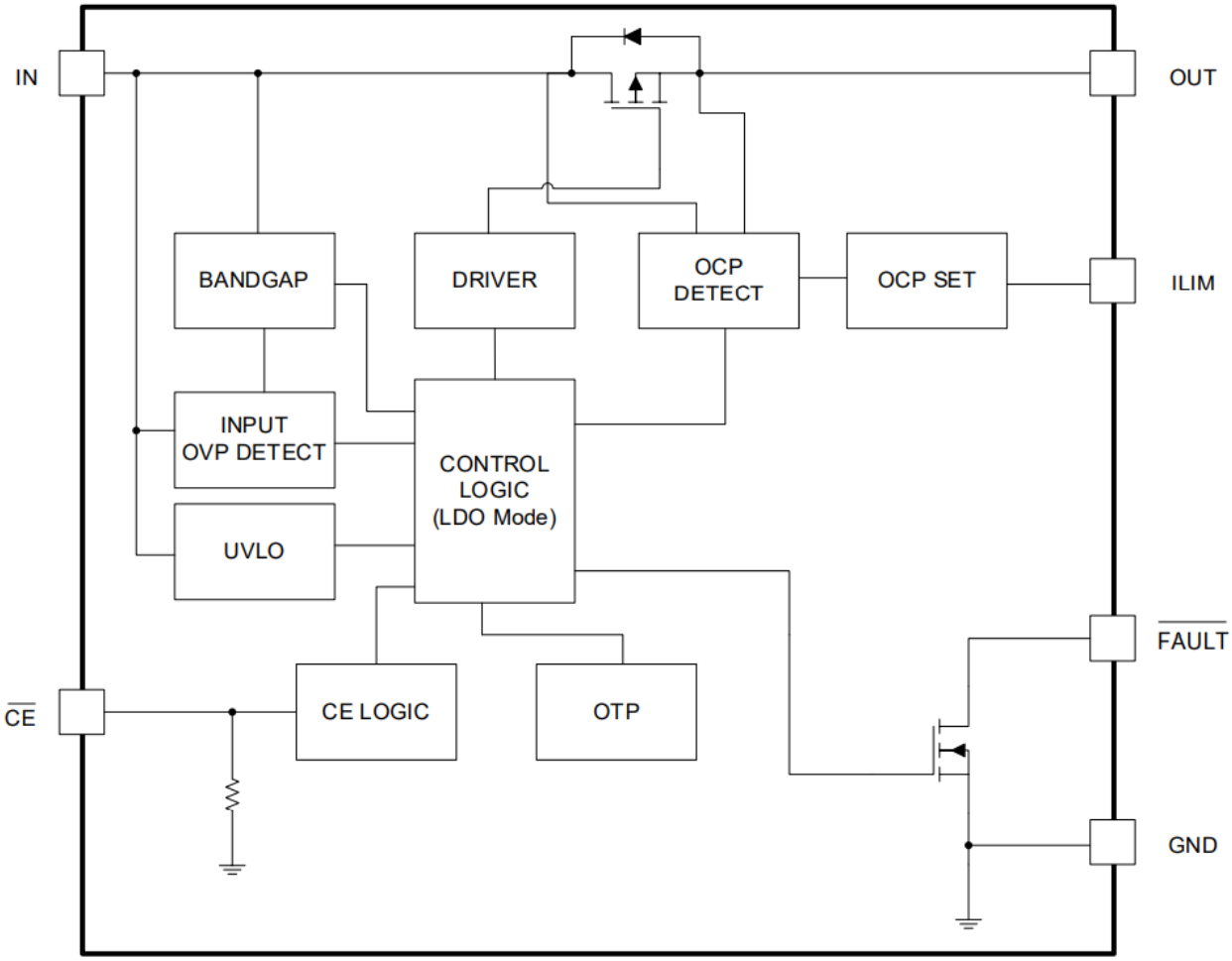
**1: Surface mounted on FR-4 Board using 1 square inch pad size, dual side, 1oz copper.*

**2: Power dissipation is calculated by* $P_D = (V_{IN}-V_{OUT}) \times I_{OUT}$

RECOMMENDED OPERATING RANGE

SYMBOL	ITEMS	VALUE	UNIT
IN	Input Supply Voltage	3.5 to 20	V
OUT	Output Current	0.2～2	A
T_{OPR}	Operating Temperature	-40 to +85	℃

SIMPLIFIED BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

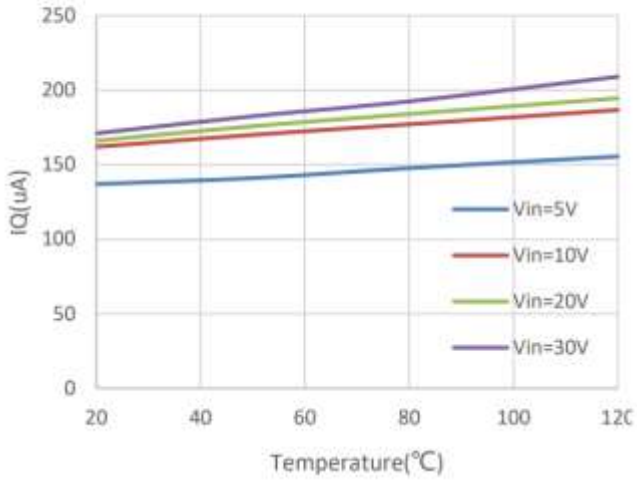
V_{IN} = 5V, R_{ILIM} = 0.6K, $\overline{CE}$ floating, T_A = 25℃, C_{IN}=C_{OUT}=1μF, unless otherwise noted.

SYMBOL	ITEMS	CONDITIONS	MIN	TYP	MAX	UNIT
DC Characteristics and Power-On-Reset						
V_{IN}	Normal Operation voltage		3.2		20	V
UVLO	Under voltage lockout threshold	V_{IN} increasing from 0~3V	2.8	3.0	3.2	V
$V_{HYS-UVLO}$	Under voltage lockout hysteresis	V_{IN} decreasing from 3~0V		0.6		V
I_Q	Input quiescent current	V_{IN}=5.0V, $\overline{CE}$ =0, I_{OUT}=0A		140	200	μA
I_{SHDN}	Input shutdown current	$\overline{CE}$ =5V, I_{OUT}=0A		30	60	μA
t_{DGL}	Deglitch time, Input power detected status			64		ms
t_{SS}	Output soft-start time	Output rising time		8		ms
Input Over-Voltage-Protection (OVP)						
V_{OUT}	Output Voltage	5.6V<Vin< V_{OVP}- $V_{HYS-OVP}$	5.3	5.45	5.6	V
V_{OVP}	OVP threshold		6.6	6.8	7	V
$V_{HYS-OVP}$	OVP hysteresis			250		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		8		ms
Over-Current-Protection (OCP)						
I_{OCP}	Over current protection	V_{IN} = 5V, OCP: 0.2A~3A CC mode (A version)	-10		+10	%
		V_{IN} = 5V, OCP: 0.2A~3A Hiccup mode (B&C version)	-10		+20	%
t_{OCP}	Over current protection blanking time			150		μs
$t_{ON(OCP)}$	Over current recover delay	Hiccup delay time		64		ms
Over-Temperature-Protection (OTP)						
T_{OTP}	OTP threshold			145		℃
$T_{OTP-HYS}$	OTP hysteresis			10		℃
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			350		KΩ
Logic Levels ON $\overline{FAULT}$						
V_{OL}	Output low voltage	I_{SINK}=5mA		0.1	0.2	V
I_{LKG}	Output logic high leakage current	$V_{\overline{FAULT}}$=5V			1	μA
Power MOSFET						
R_{ON}	On resistance	I_{OUT}=0.5A		120		mΩ

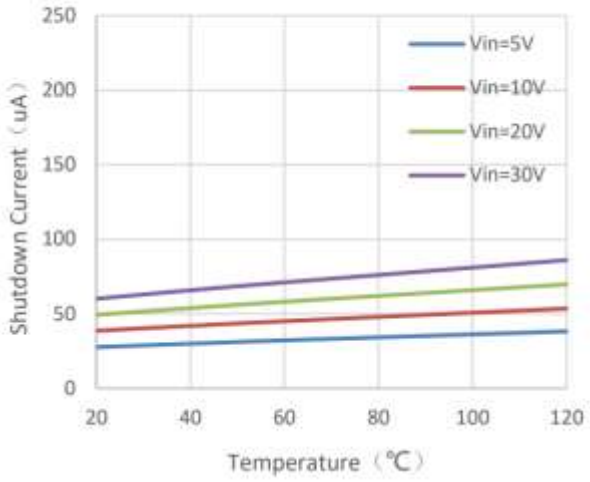
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 5V, R_{ILIM} = 1.2K, $\overline{CE}$ floating, T_A = 25℃, C_{IN}=C_{OUT}=1μF, unless otherwise noted.

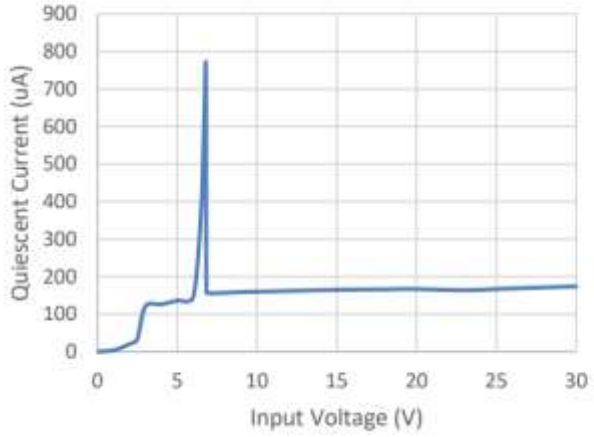
IQ vs Temperature



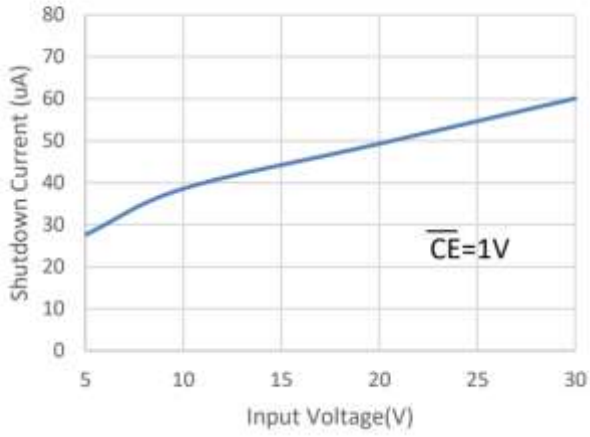
Shutdown Current vs. Temperature



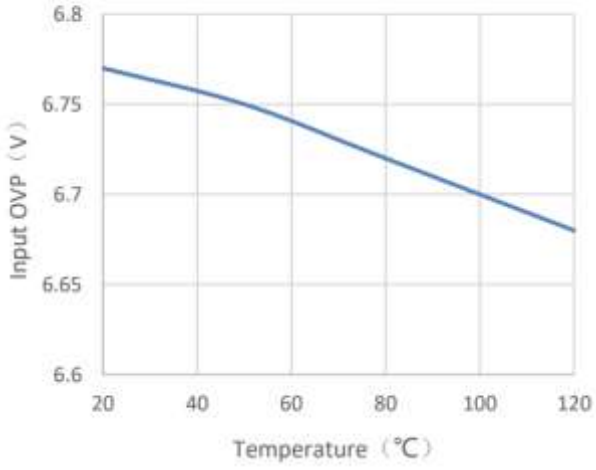
Quiescent Current vs. Input Voltage



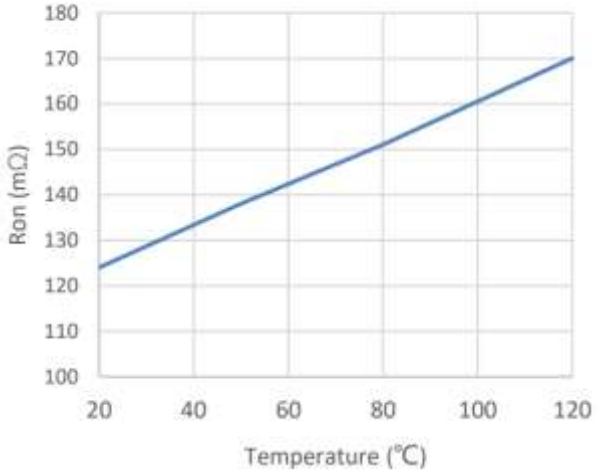
Shutdown Current vs. Input Voltage



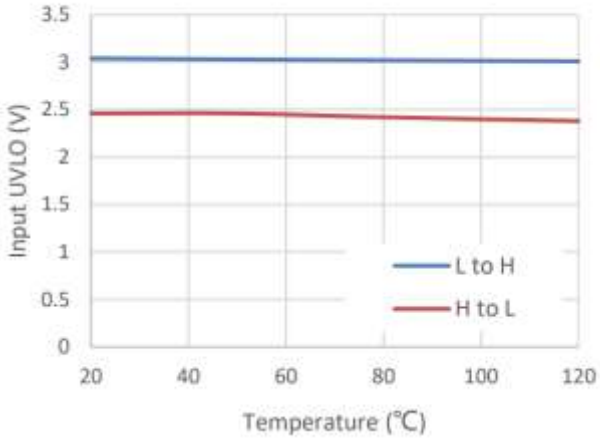
Input OVP vs. Temperature



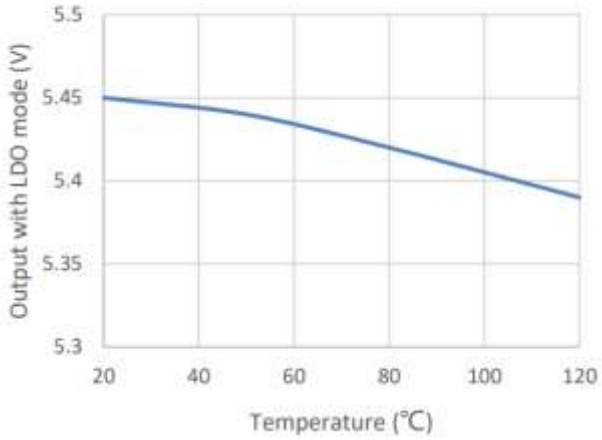
Ron vs. Temperature



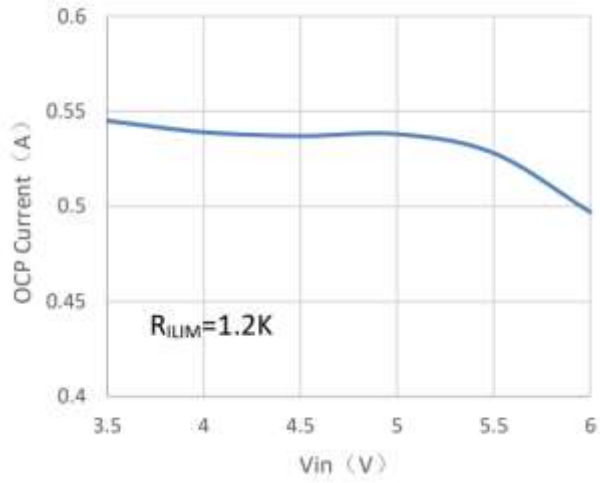
UVLO vs. Temperature



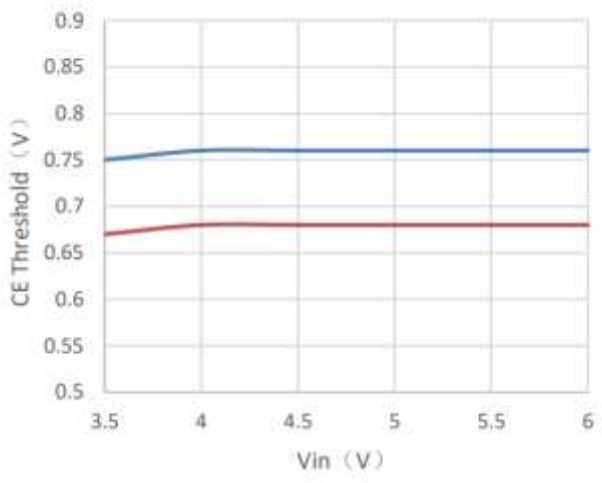
LDO Output vs. Temperature



OCP vs. Vin



CE Threshold vs. Vin

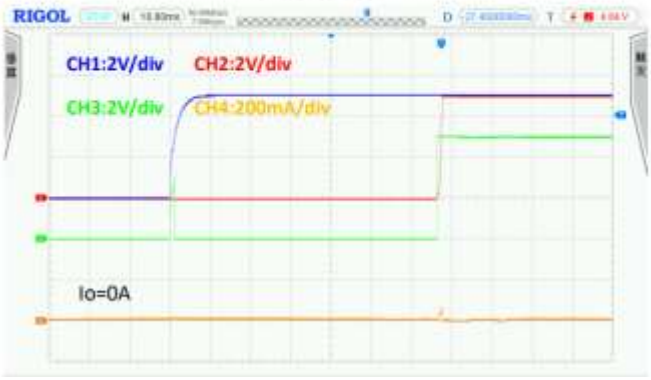


TYPICAL PERFORMANCE WAVEFORM

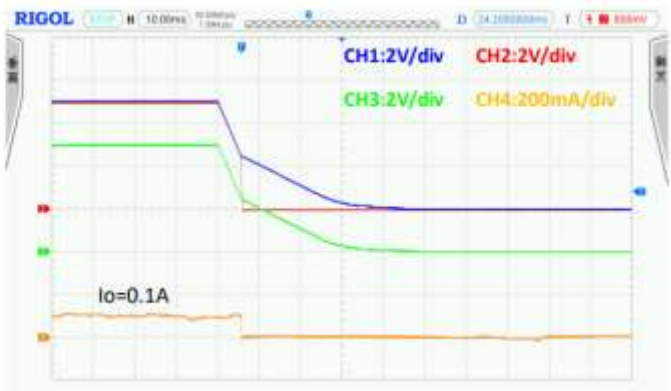
Power ON/OFF

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

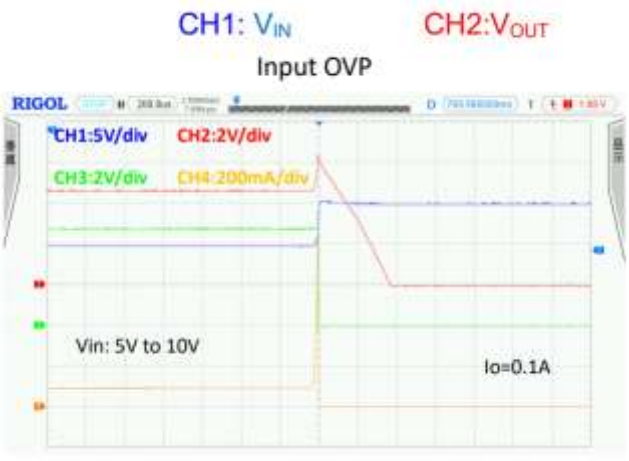
Power ON

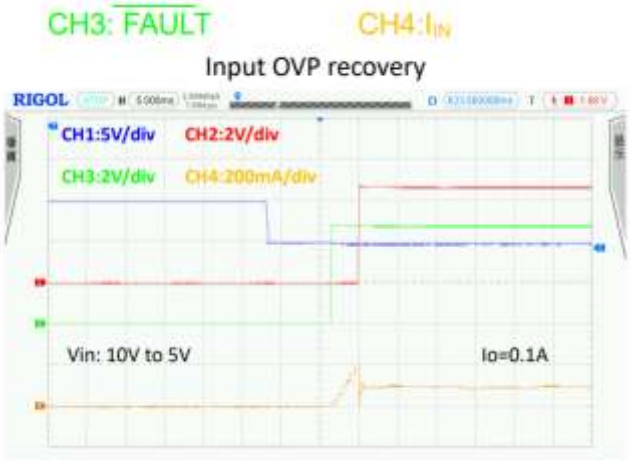


Power OFF

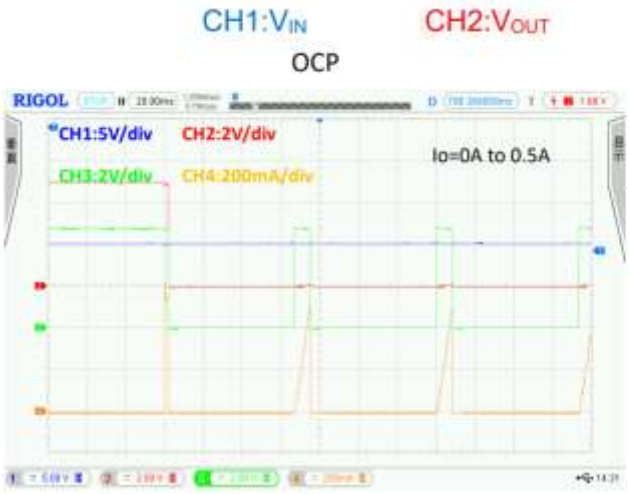


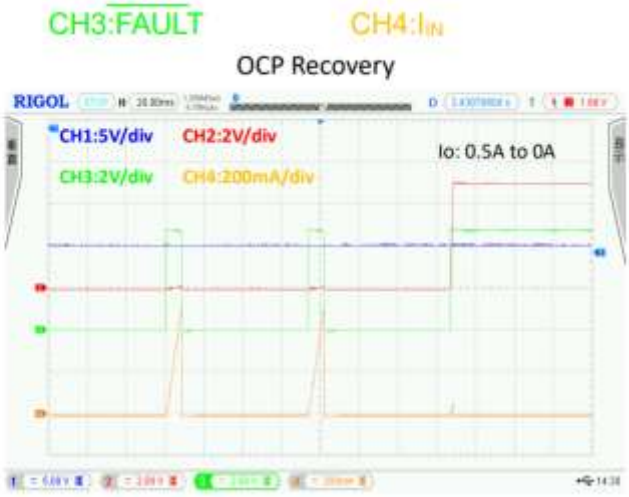
Input OVP





OCP (Always hiccup behavior, HP2606B family)





APPLICATION INFORMATION

The EMP2602 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 charge current. The device operates like a linear regulator, maintaining a 5.45V output with input voltage up to the input over-voltage threshold (V_{OVP} = 6.8V). If the input voltage exceeds V_{OVP}, the IC turn off the internal MOSFET and disconnects the system from input power. Additionally, EMP2602 monitors the output current, and will disconnect the system in case of output short or excessive current. The IC also monitors its die temperature and switches the MOSFET off if it exceeds over temperature thresholds.

The IC can be controlled by a processor through $\overline{CE}$ pin, and also provides status information through $\overline{FAULT}$ pin to the host.

Power Up

The EMP2602 has a threshold of 3.0V power on reset (UVLO) with a built-in hysteresis of 600mV. Before the input voltage reaches the UVLO threshold, the EMP2602 is off. When the input voltage is over the EMP2602 will delay for 64ms and then the soft-start will be activated. The 64ms delay allows any transient at the input during a power supply hot insertion to settle down before the IC starts to operate.

During the soft-star transition, the EMP2602 slowly turns on the internal MOSFET to reduce the inrush current.

Enable Control

The EMP2602 offers an enable ($\overline{CE}$) input. When the $\overline{CE}$ pin is pulled to logic high (>1.5V), the EMP2602 will shut down. When the $\overline{CE}$ pin is pulled to logic low (<0.4V), The EMP2602 operating is enabled. 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 and OTP). When the fault conditions are removed then the $\overline{FAULT}$ pin indicates a HIGH signal. During power on, the Fault pin is pull down when UVLO threshold is reached and then a 64ms timer begins to run. When the timer is timeout, soft start circuit begins to work and the Fault pin is back to High state to indicate normal status. If abnormal conditions happen after soft start process is end, the fault will be pull down to indicate abnormal conditions until the fault conditions are removed.

Over Temperature Protection (OTP)

The EMP2602 monitors its own internal temperature to prevent thermal failures. The chip turns off the MOSFET when the internal temperature reaches over temperature thresholds. The IC will resume after the internal temperature is cooled down below recovery threshold

Input Over Voltage Protection

The EMP2602 monitors input voltage to prevent the abnormal input voltage leading to output system failures. The EMP2602 input OVP threshold is set by the internal resistor. When the input voltage exceeds the threshold, the 2602 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 range, The EMP2602 re-enables the MOSFET.

Short Circuit Protection (SCP)

If there is a short circuit in output, for family B and C, IC will detect the zero output voltage and then turn off the internal MOSFET. After shutting down for 64ms, IC will automatically restart and repeat hiccup if short circuit condition still presents. For A family, IC will maintain constant current and this current will flow through the ground due to the shorted output. Depending on current level and thermal performance, IC could trigger over temperature protection eventually.

Over Current Protection (OCP)

The EMP2602 monitors the output current to prevent the output short or excessive charging battery current. The OCP (Over Current Protection) threshold can be set by the ILIM pin. It can be set by the resistor connected between the ILIM pin and GND. The OCP threshold can be calculated by the following equation:

$$I_{OCP} = \frac{600}{R_{ILIM}} (A)$$

(Refer to Figure 1)

EMP2602 family has a builtin 180us delay timer to prevent any transient noise from triggering the OCP. If the output current reached OCP level, there are 3 different operation modes in MP2602 family.

EMP2602A family will maintain the constant current operation at the set IOCP level with +/- 10% output current control accuracy. The $\overline{FAULT}$ pin will trigger low to indicate IC constant current set level is reached.

EMP2602B family will turn off the internal MOSFET and the $\overline{\text{FAULT}}$ pin indicate a low signal. After OCP protection, EMP2602B will automatically reinitiate soft start process after 64ms period. EMP2602B family will keep OCP protection and restart hiccup continuously until over current condition is removed.

EMP2602C family allow IC triggers OCP and restart for 16 times. Then internal MOSFET will be turned off permanently unless the input power is recycled or the enable pin is toggled. When OCP triggers, the $\overline{\text{FAULT}}$ pin indicate a low signal. During over current conditions, if output voltage collapse to zero, IC will detect the low output and trigger short circuit protection as described above.

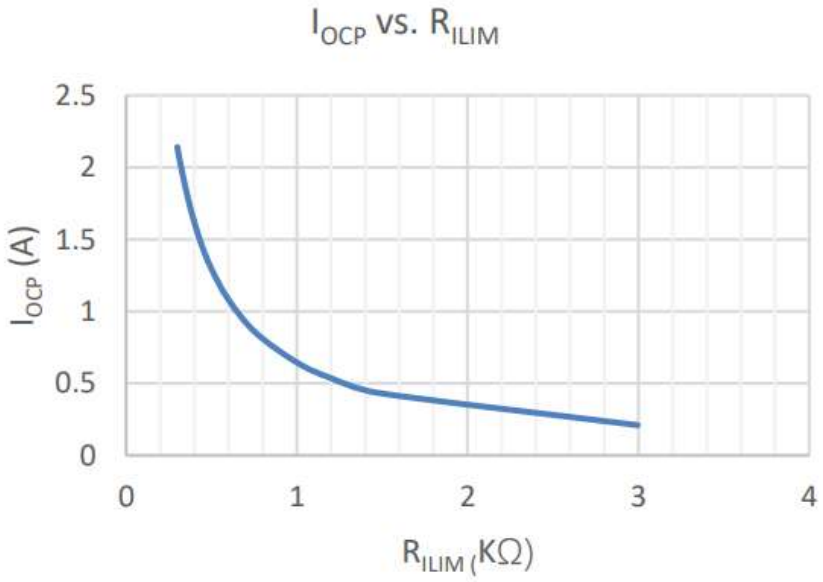
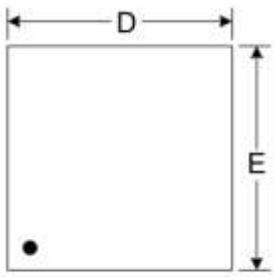


Figure 1

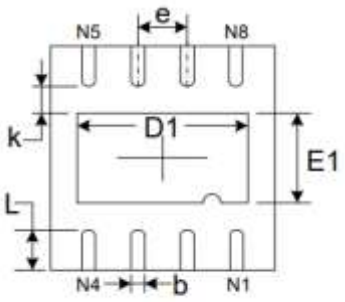
PACKAGE OUTLINE

Package	DFN-2x2-8L	Devices per reel	4000Pcs	Unit	mm

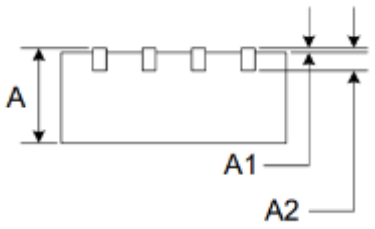
Package Dimension：



TOP VIEW



BOTTOM 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

PACKAGE OUTLINE

Package	DFN-2x2-6L	Devices per reel	4000Pcs	Unit	mm

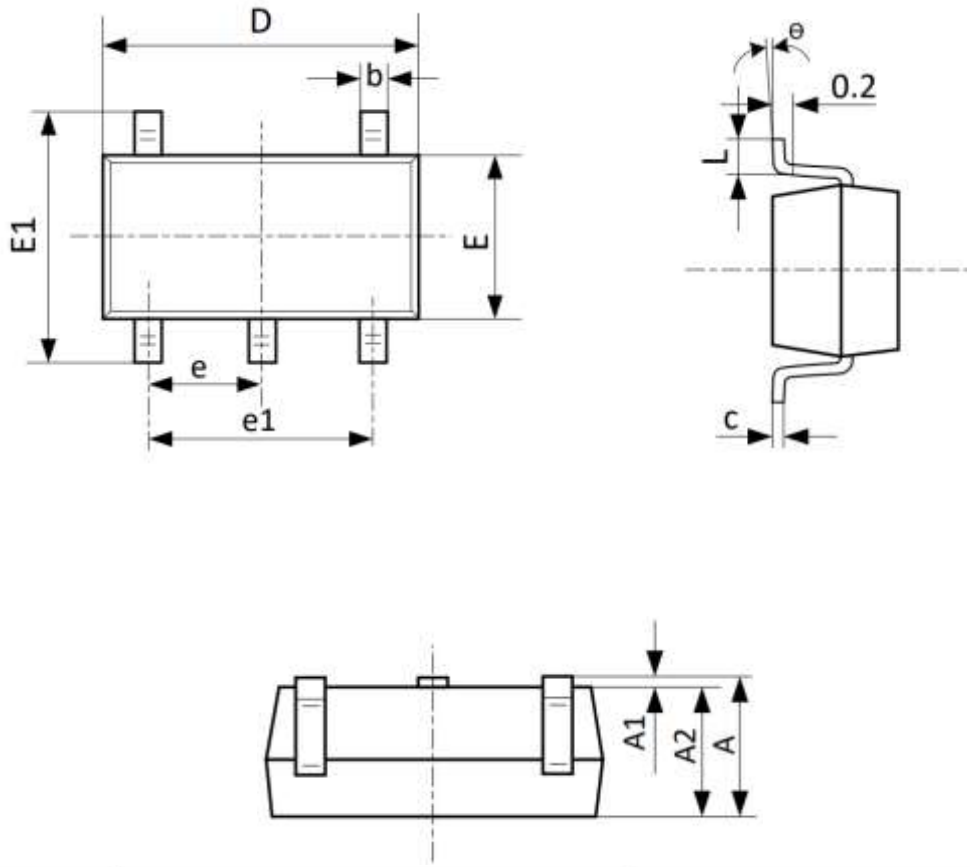
Not available now

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A				
A1				
A2				
D				
D1				
E				
E1				
b				
e				
k				
L				

PACKAGE OUTLINE

Package	SOT23-5L	Devices per reel	3000Pcs	Unit	mm

Package Dimension：



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0℃	8℃	0℃	8℃

Revision History

Version No.	Date	Description
Preliminary	2021-03-11	- Initial Preliminary release
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