Single Cell Li-Ion Battery Linear Charger

Features

- **4.35V ~ 6.4V Input Voltage Operation**
- **Low Power consumption (Shutdown) < 5μA**
- **Selectable 100mA and 500mA Maximum Input Current**
- **Input-Based Dynamic Power Management for Protection Against Poor USB Sources**
- **6.6V Input Rating with Overvoltage Protection**
- **Integrated Dynamic Power Path Management Function Simultaneously and Independently Powers the System and Charges the Battery**
- **Supports up to 1.5A Charge Current with Current Monitoring Output (ISET)**
- **Programmable Input Current Limit up to 1.5A for Wall Adapters**
- **Battery Disconnect Function with SYSOFF**
- **Programmable Pre-Charge and Fast-Charge Safety Timers**
- **Reverse Current, Short-Circuit and Thermal Protection**
- **NTC Thermistor Input**
- **Status Indication**
- **TQFN3X3-16 Package**

General Description

The G2268 is integrated Li-Ion linear charger and system power path management device operating from either a USB port or an AC adapter with a selectable 100mA and 500mA maximum input current limit function for USB input application. The input dynamic power management (VIN-DPM) prevents the charger from crashing incorrectly configured USB sources.

The G2268 features dynamic power path management (DPPM) that powers the system while simultaneously and independently charging the battery. The DPPM circuit reduces the charge current when the input current limit causes the system output to fall to the DPPM threshold. This feature reduces the number of charge and discharge cycles on the battery, allows for proper charge termination and enables the system to run with a defective or absent battery pack.

G2268 is available in a TQFN3X3-16 package

Applications

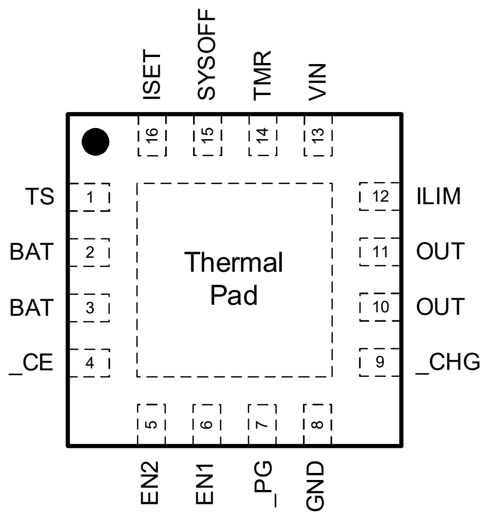
- **Smart Phones**
- **Low-Power Handheld Device**

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)	REMARK
G2268R41U	2268	-40°C to +85°C	TQFN3X3-16	**OBSOLETE**

Note: R4: TQFN3X3-16
1 : Bonding Code
U : Tape & Reel
Green : Lead Free / Halogen Free.

Pin Configuration



G2268 TQFN3X3-16

Note: Recommand connecting the Thermal Pad to the Ground for excellent power dissipation.

Absolute Maximum Ratings

VIN to GND. . . . .-0.3V to + 10V
Other pins to GND. . . . .-0.3V to +6V
Thermal Resistance Junction to Ambient (θ_{JA})
TQFN3X3-16 . . . . 79°C/W
Continuous Power Dissipation (T_A = +25°C)
TQFN3X3-16. . . . . 1.575W

Operating Temperature Range . . . . . .-40°C to 85°C
Junction Temperature . . . . 150°C
Storage Temperature Range . . . .-55°C to 150°C
Reflow Temperature (soldering, 10 sec) . . . . . 260°C
ESD Susceptibility (Human Body Mode) 2KV
ESD Susceptibility (Machine Mode) 200V

Note:

1. Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. Device is ESD sensitive. Handling precaution recommended. The Human Body model is a 100pF capacitor discharged through a 1.5KΩ resistor into each pin.

Electrical Characteristics

(VIN=5V, BAT=3.6V, T_A = 25°C, unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input						
Undervoltage Lockout Threshold	V_{UV}	VIN Rising	3.22	3.32	3.42	V
Undervoltage Lockout Hysteresis	V_{UVSYS}		200	250	300	mV
Automatic Shutdown Threshold	ΔV_{ASDN}	VIN-BAT, VIN rising	55	90	130	mV
Automatic Shutdown Hysteresis	ΔV_{ASDNHS}	VIN-BAT, VIN falling	20	---	---	mV
Over Voltage Protection Threshold	V_{OV}	VIN Rising	6.3	6.5	6.7	V
Over Voltage Protection Hysteresis	V_{OVSYS}		---	320	---	mV
Quiescent Current						
SLEEP Current into BAT pin	I_{BAT}	Input power not detected, no load on OUTpin.	---	5	6	µA
Standby Current into VIN pin	I_{VIN}	EN1=HI, EN2=HI, VIN=6V	---	---	50	µA
VIN supply current	I_{SUPPLY}	_CE=LO, (EN1,EN2) ≠ (HI,HI), I_{OUT} =I_{BAT}=0mA, V_{BAT} > V_{REG}	---	---	1.5	mA
Power Path						
VIN to OUT ON Resistance	R_{ON_IN}	I_{VIN}=1A, VIN=4.3V	---	300	475	mΩ
BAT to OUT ON Resistance	R_{ON_BAT}	BAT>3V, I_{OUT} =1A, VIN=0V	---	50	100	mΩ
VIN DPM Regulation voltage	V_{DPM}	VIN	4.35	4.5	4.63	V
OUT Regulation voltage	V_{OREG}	VIN=6V, I_{OUT}=500mA	5.4	5.5	5.6	V
OUT Regulation voltage in DPPM	V_{DPPM}		---	4.3	---	V
OUT Regulation voltage at Battery Supplement mode	ΔV_{OUT2}	BAT-OUT	---	40	---	mV
Maximum Input Current	$I_{IN,MAX}$	EN1=LO, EN2=LO	90	95	100	mA
		EN1=HI, EN2=LO	450	475	500	mA
		EN1=LO, EN2=HI		K_{ILIM}/R_{ILIM}		A
Maximum Input Current Factor	K_{ILIM}	I_{LIM}=500mA to 1.5A	1500	1610	1720	AΩ
		I_{LIM}=200mA to 500mA	1330	1525	1720	
		I_{LIM}=20mA to 200mA	1330	1525	1720	
Programmable Input Current Limit	$I_{IN,LIM}$	EN1=LO, EN2=HI, R_{ILIM}=76kΩ to 1.1kΩ	20	---	1500	mA
Output Short Circuit Detection at VIN Power up	V_{OUT_SCP1}	VIN>V_{UV}&VIN>(BAT+ΔV_{ASDN})	1.1	1.2	1.3	V
Output Short Circuit Detection Threshold at BAT Supplement Mode	V_{OUT_SCP2}	OUT-SYS	---	250	---	mV

Electrical Characteristics (Continued)

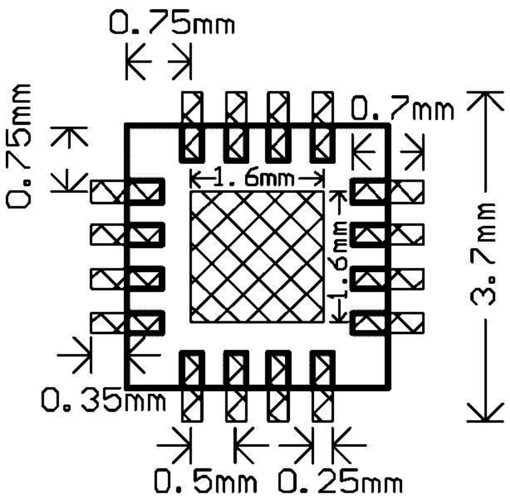
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Linear Charger						
Source Current for BAT pin short-circuit Detection	$I_{BAT,SC}$	BAT=1.5V	4	7.5	11	mA
BAT pin short-circuit detection threshold	$V_{BAT,SC}$		1.6	1.8	2.0	V
BAT Regulation voltage	$V_{BAT,REG}$	Loading=20mA	4.16	4.2	4.24	V
BAT Pre-charge Threshold	V_{PRECH}	BAT rising	2.9	3.0	3.1	V
BAT Pre-charge Threshold Hysteresis	ΔV_{PRECH}		---	200	---	mV
Fast Charge Current Range	I_{CHG}	$I_{CHG} = K_{ISET}/ R_{ISET}$	100	---	1500	mA
Fast Charge Current	I_{CHG}		K_{ISET} / R_{ISET}			A
Fast Charge Current Factor	K_{ISET}		797	890	975	AΩ
Pre-charge Current	I_{PRECH}		K_{PRECH} / R_{ISET}			A
Pre-charge Current Factor	K_{PRECH}		70	88	106	AΩ
Termination current Ratio to Fast Charge	I_{TERM}	(EN1,EN2) ≠ (LO,LO)	9	10	11	%
		(EN1,EN2) = (LO,LO)	2.7	3.3	4.0	
Re-Charge Threshold	ΔV_{RECHG}	Battery re-charge threshold $= V_{REGX} - \Delta V_{RECHG}$	60	100	140	mV
Sink Current for battery detection	$I_{BAT,DET}$	BAT=2.5V	5	7.5	10	mA
Timer						
Power Good Deglitch Time	$t_{/PGOOD}$	Time measured from VIN: 0->5V	---	1.875	---	ms
VIN Over Voltage Blanking Time	t_{OVP}		---	50	---	µs
VIN Over Voltage Recovery Time	t_{OVPREC}	Time measured from VIN: 7->5V	---	1.875	---	ms
Pre-Charge to Fast-Charge Deglitch Time	t_{PF}		---	32	---	ms
Fast-Charge to Pre-Charge Deglitch Time	t_{FP}		---	32	---	ms
Termination Deglitch Time	t_{TERMI}		---	32	---	ms
Recharge Deglitch Time	t_{RECHG}		---	64	---	ms
Input power loss to OUT LDO Turn-off Deglitch Time	t_{NO_VIN}		---	32	---	ms
Battery Installation Deglitch Time	t_{NO_BAT}		---	250	---	ms
Pack Temperature Fault Detection Deglitch Time	t_{TS}		---	32	---	ms
Output Short Circuit Deglitch Time at Battery Supplement Mode	t_{OUT_SCP2}		---	250	---	µs
Output Short Circuit Recovery Time at Battery Supplement Mode	$t_{OUT\_SCP2\_R}$		---	64	---	ms
Pre-charge Safety Timer Value	t_{PRECH}	TMR = floating	1800	2250	2700	s
		18kΩ < R_{TMR} < 100kΩ	R_{TMR} x K_{TMR}			
Charge Safety Timer Value	t_{MAXCHG}	TMR = floating	14000	18000	21600	s
		18kΩ < R_{TMR} < 100kΩ	8 x R_{TMR} x K_{TMR}			
Charge Time Factor	K_{TMR}		36	48	60	s/kΩ
Thermistor Monitor						
NTC bias current	I_{NTC}	VIN>V_{UV}&VIN>(BAT+ΔV_{ASDN})	72	75	78	µA
Hot temperature trip point	V_{HOT}	Battery Charging, TS Falling	270	300	330	mV
Hot temperature trip point hysteresis	$V_{HOT,HYS}$	Battery Charging, TS Rising from V_{HOT}	---	30	---	mV
Cold temperature trip point	V_{COLD}	Battery Charging, TS Rising	2000	2100	2200	mV
Cold temperature trip point hysteresis	$V_{COLD,HYS}$	Battery Charging, TS Falling from V_{COLD}	---	300	---	mV
TS function disable threshold	V_{DIS}	TS unconnected	V_{IN}-0.2			V
Thermal Regulation						
Thermal Regulation Temperature	T_{REG}		---	125	---	°C
Thermal Shutdown Temperature	T_{SHDN}	Temperature Rising	---	155	---	°C
Thermal Shutdown Hysteresis	T_{SHDN_HYS}		---	25	---	°C

Electrical Characteristics (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Logic Levels On EN1, EN2, _CE						
Logic low input voltage	V_{IL}		0	---	0.4	V
Logic high input voltage	V_{IH}		1.4	---	6	V
Input source current	I_{IH}	V_{IH} =1.4V	---	---	10	μA
Logic Levels On SYSOFF						
Logic low input voltage	V_{IL}		0	---	0.4	V
Logic high input voltage	V_{IH}		1.4	---	6	V
Input sink current	I_{IL}	V_{IL} = 0V	---	---	1	μA
Logic Levels On _PG, _CHG						
Output low voltage	V_{OL}	I_{SINK} =5mA	---	---	0.3	V

Minimum Footprint PCB Layout Section

TQFN3X3-16



Pin Descriptions

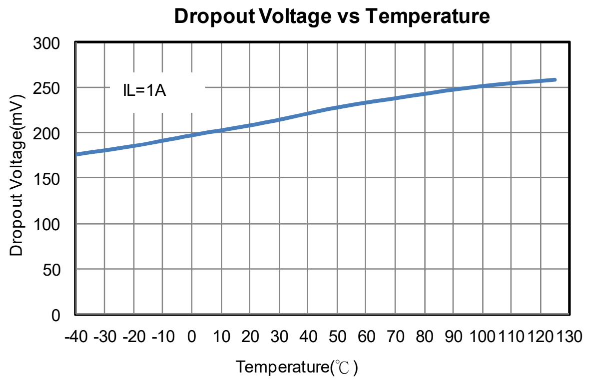
PIN	NAME	FUNCTION
1	TS	External NTC Thermistor Input. TS monitors a 10kΩ NTC thermistor.
2,3	BAT	Charger Power Stage Output and Battery Sense Input. Connect BAT to the positive terminal of the battery. Bypass BAT to GND with a 4.7µF to 47µF ceramic capacitor.
4	_CE	Charge Enable Active Low Input. Connect this pin to a low logic to enable the battery charger.
5	EN2	Input Current Limit Configuration Inputs. See Table 1 for the description of the operation states.
6	EN1	
7	_PG	Open-drain Power Good Status Indication Output. This pin is pulled to GND when a valid input source is detected.
8	GND	Ground.
9	_CHG	Open-drain Charging Indication Output. This pin is pulled to GND when the battery is charging. See Table 2 for the descriptions of the different charger states.
10,11	OUT	System Supply Output. OUT provides a regulated output when the input is below the OVP threshold and above the regulation voltage. When the input is out of the operation range, OUT is connected to BAT except when SYSOFF is high. Bypass OUT to GND with a 4.7µF to 47µF ceramic capacitor.
12	ILIM	Adjustable Current Limit Programming Input. Charging is disable when ILIM left unconnected.
13	VIN	Input Power Connection. Bypass VIN to GND with a 1µF to 10µF ceramic capacitor.
14	TMR	Timer Programming Input. The timers are set to the default values when this pin is left unconnected.
15	SYSOFF	System Disable Input. Connect SYSOFF low for normal operation. SYSOFF is internally pulled up to BAT through a larger resistor.
16	ISET	Fast Charge Current Programming Input.
-	EP	Exposed Thermal Pad. The thermal pad must be connected to the same potential as the GND pin.

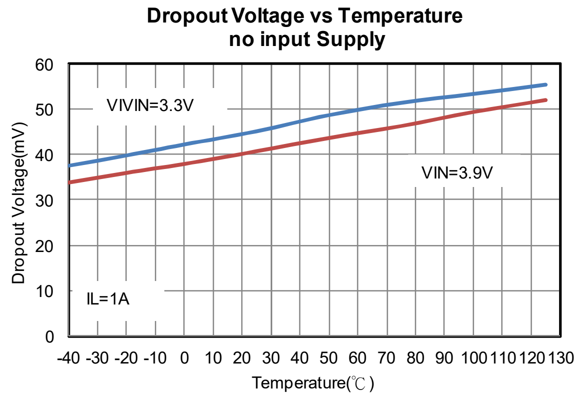
EN2	EN1	MAXIMUM INPUT CURRENT INTO VIN PIN
0	0	100mA. USB100 mode.
0	1	500mA. USB500 mode.
1	0	Set by an external resistor from ILIM to GND
1	1	Standby. USB suspend mode.

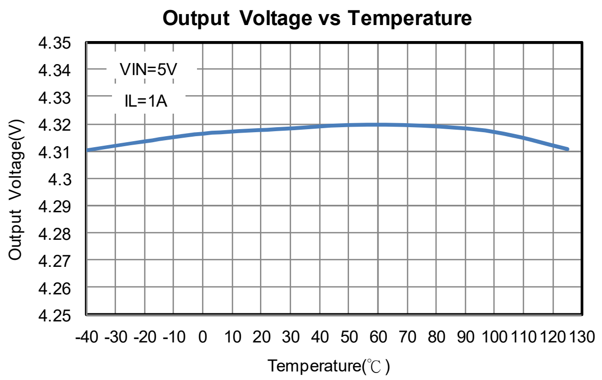
Table 1. EN1/EN2 Setting

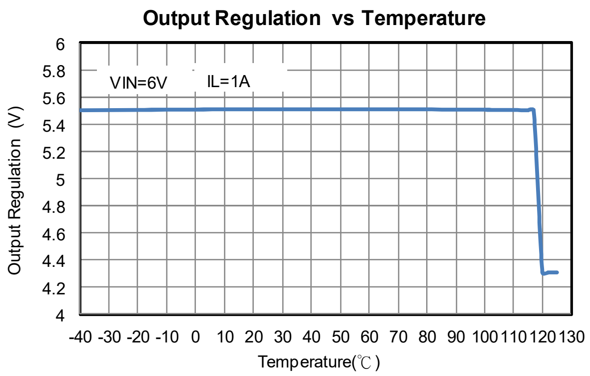
Typical Characteristics

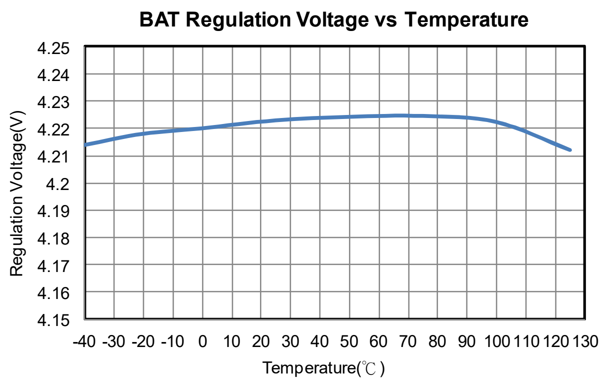
V_{IN} = 6V, EN1=1, EN2=0, G2268 application circuit, T_A = 25°C, unless otherwise noted.

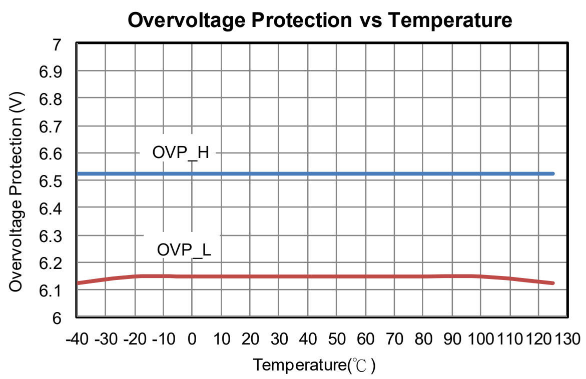




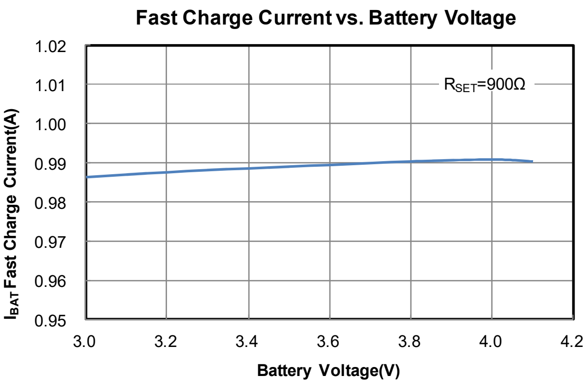


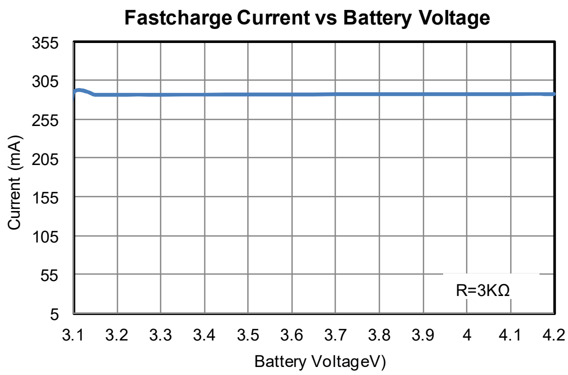


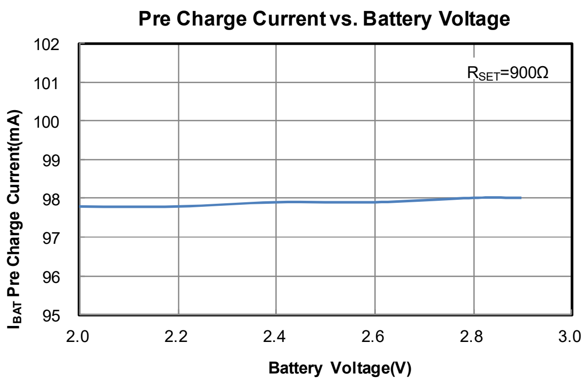


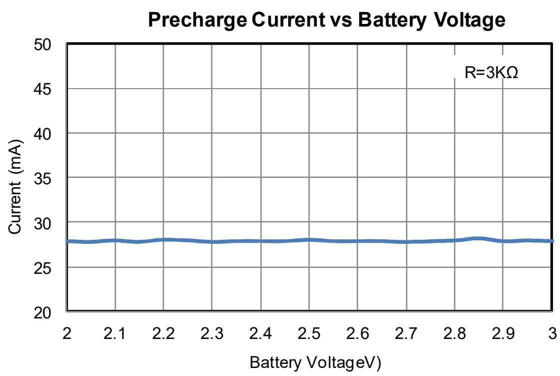


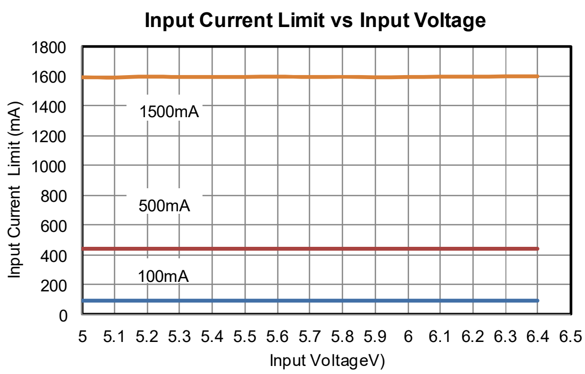
Typical Characteristics (Continued)

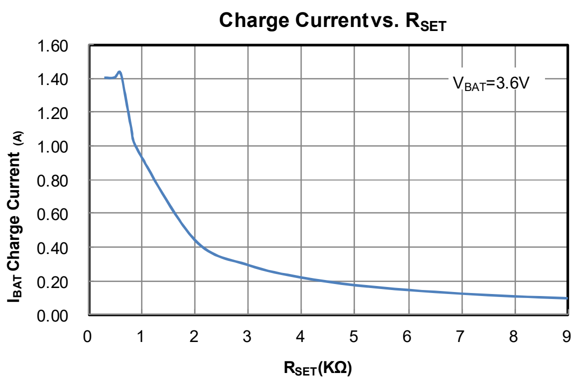






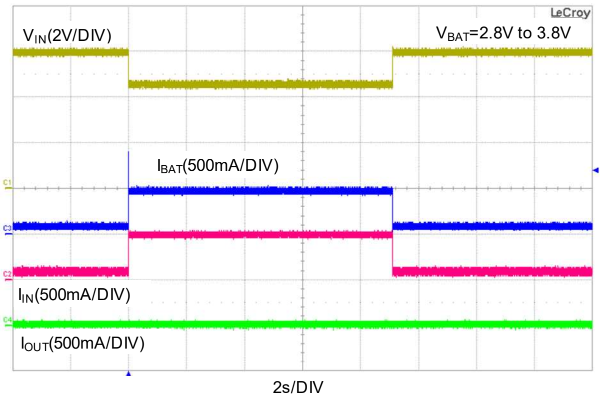




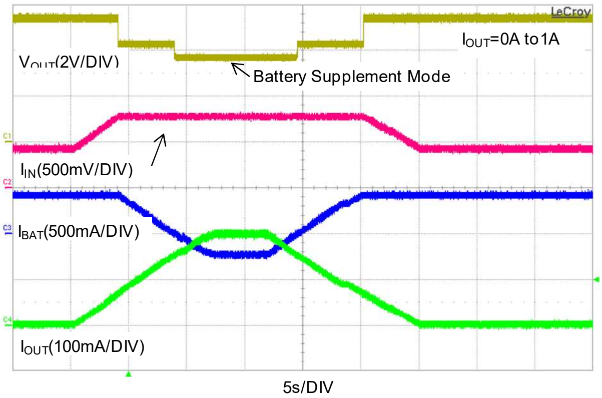


Typical Characteristics (Continued)

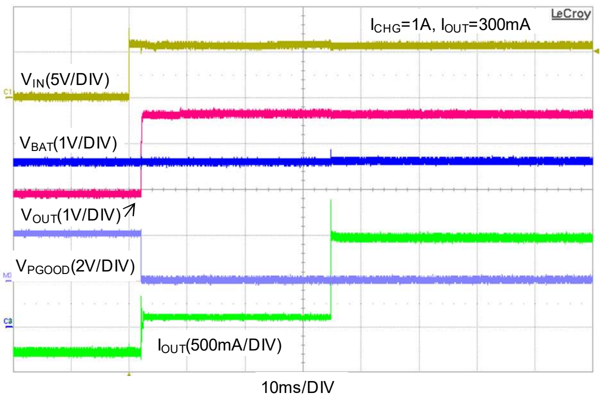
V_{IN}DPM



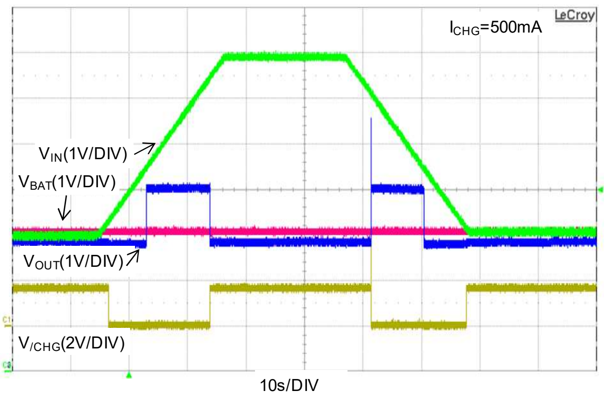
DPPM



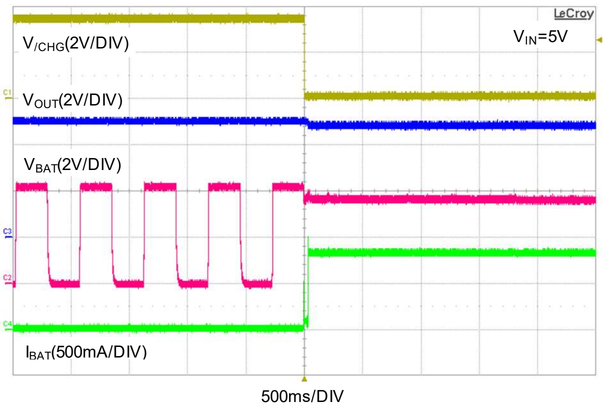
V_{IN} Plug-In



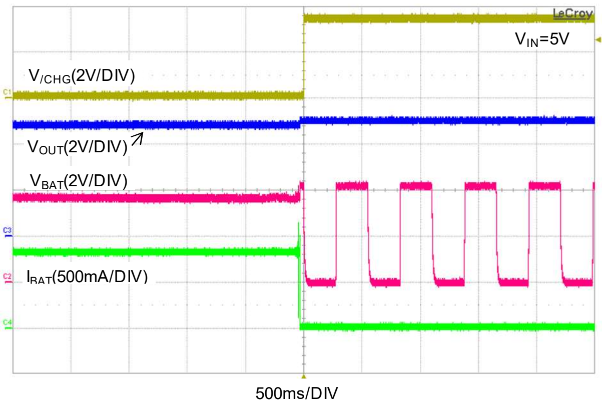
OVP



Battery Inserted

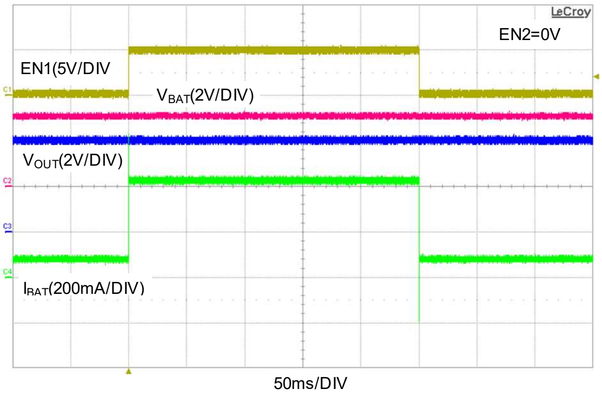


Battery Removed

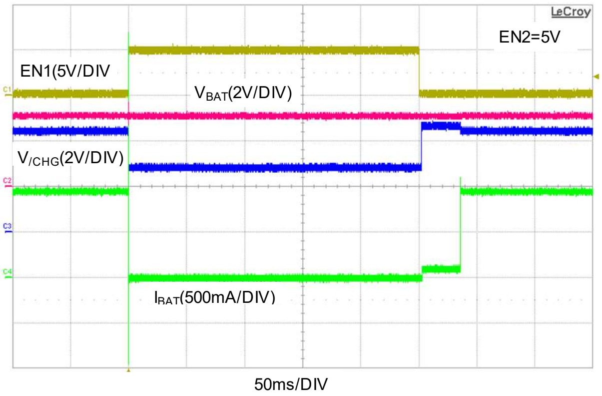


Typical Characteristics (Continued)

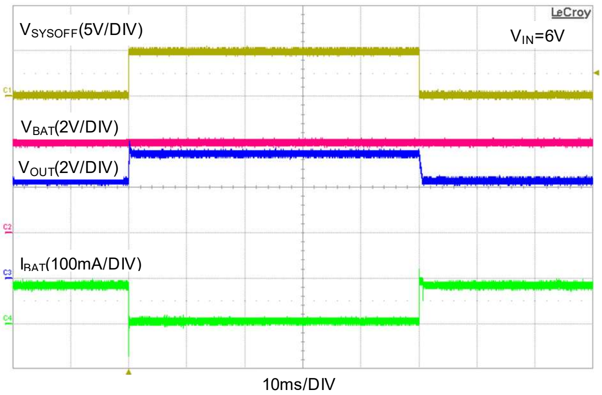
Charger 100mA/500mA Using EN1



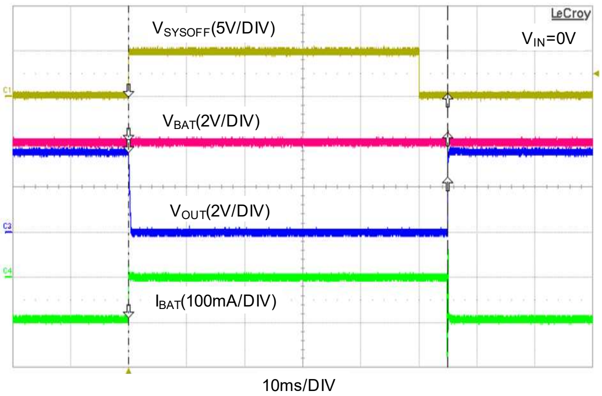
Charger ON/OFF Using EN1



System ON/OFF



System ON/OFF



Function Description

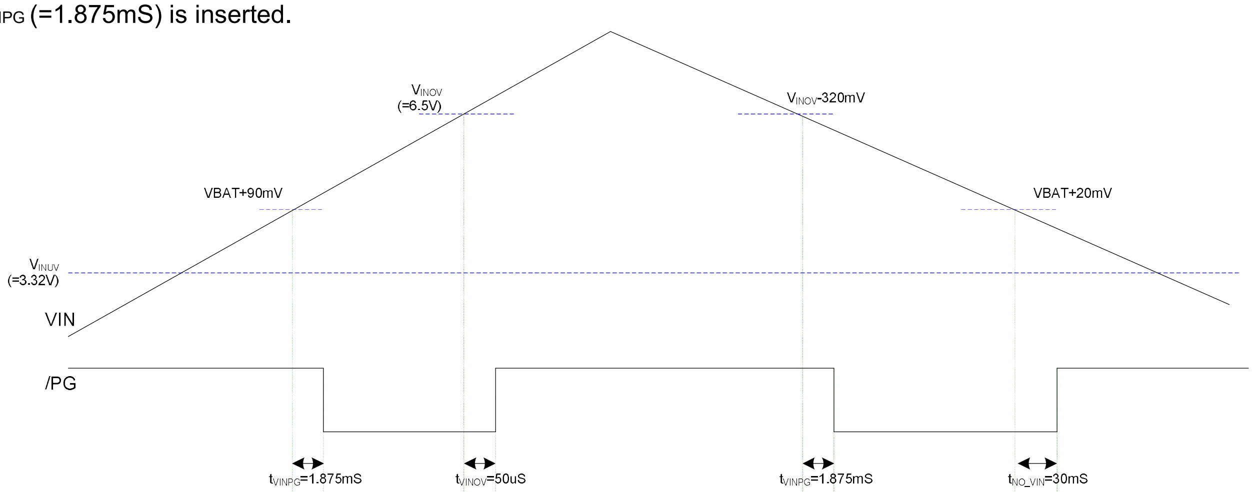
VIN Power Good

_PG, with open drain output, is used to indicate the VIN voltage meets below conditions:

- $V_{VIN} > V_{UV}$
- $V_{VIN} > V_{BAT}+\Delta V_{ASDN}$
- $V_{VIN} < V_{OV}$

The condition of $V_{VIN} > V_{BAT}+\Delta V_{ASDN}$ is asserted with deglitch time t_{VINPG} (=1.875mS). After the condition is asserted,deglitch time t_{NO_VIN} (=30mS) is inserted.

VIN over voltage condition is asserted with deglitch time t_{VINOV} (=50μS).After the condition is asserted, deglitch time t_{VINPG} (=1.875mS) is inserted.



VIN Over-Voltage Protection (OVP)

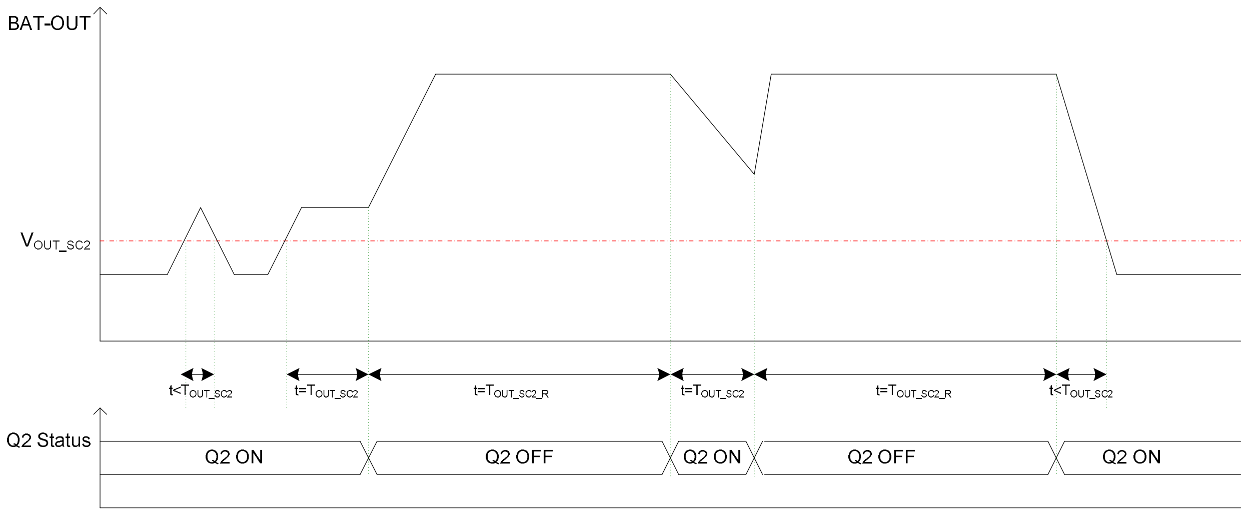
The G2268 Li-ion charger accepts VIN input voltage up to 10V without damage. When VIN>VIN_{OVP} for a period longer than T_{VINOVP}, the Q1 FET that connects VIN to SYS is OFF and the battery charging is stopped. When in VIN OVP mode, the OUT is connected to battery through Q2 FET is fully ON. Once the OVP function is removed, the safety timer are reset and a new charge cycle will be indicated by the /CHG output.

VIN Under-Voltage Lockout (UVLO)

The G2268 Li-ion charger remains in power down mode when the input voltage VIN is below the under-voltage threshold VIN_{UVLO}. In power down mode, the Q1 FET that connects VIN to OUT is OFF, and the Q2 FET that connects BAT to OUT is ON. The V_{OUT_SC2} circuit is active and monitors for overload conditions on OUT.

BAT to OUT Short Circuit Protection (OUT SCP)

The V_{OUT_SCP2} circuit is used for overload condition on OUT. When (BAT-OUT)>V_{OUT_SCP2} for a period longer than t_{OUT_SCP}, the Q2 FET that connects BAT to OUT is turned OFF and the internal recovery timer starts. After the time $t_{OUT\_SCP\_R}$ is reached, the Q2 FET is turned ON for a period t_{OUT_SCP} to see if the overload condition is removed.



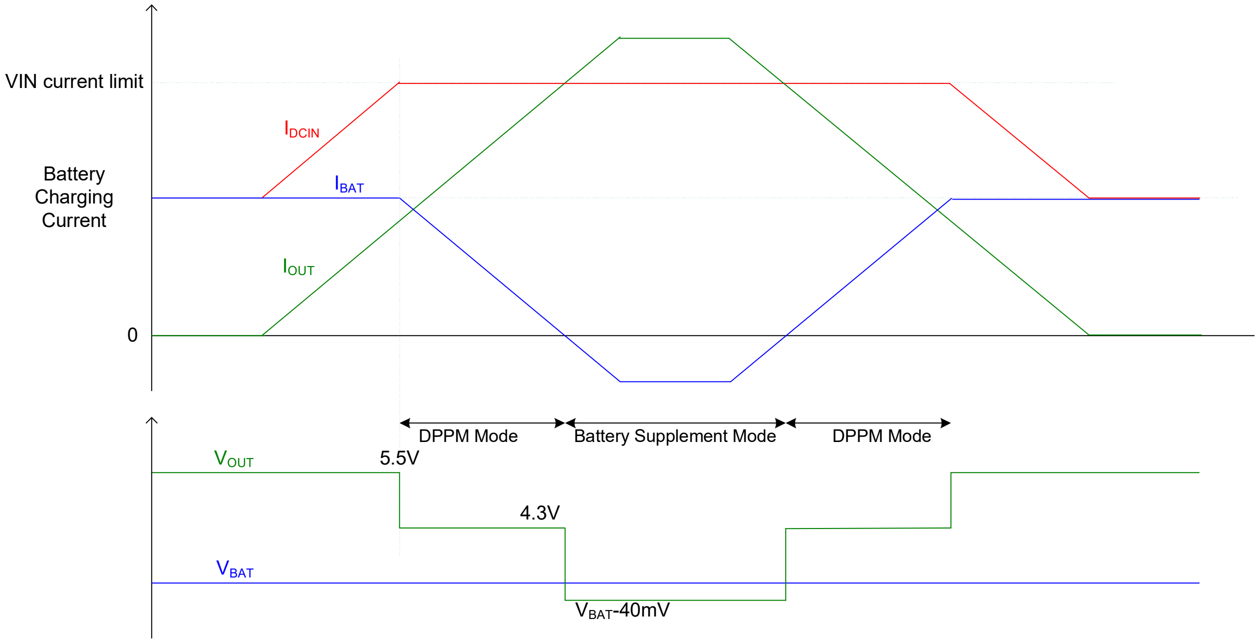
Dynamic Power Path Management

VIN-DPM mode is utilized in G2268 Li-ion charger for preventing it from crashing poorly designed or incorrectly configured VIN power source. If VIN voltage falls below V_{DPM} (4.5V typ.), the battery charging current is reduced to prevent the VIN voltage falling further.

DPPM mode is utilized in G2268 Li-ion charger to maintain OUT voltage in the increasing OUT output current. When the sum of the battery charging current and the OUT current exceeds VIN input current limit, the OUT voltage falls. The battery charging current is reduced to prevent the OUT voltage falling further. IN DPPM mode, the battery charging termination detection is halted.

In DPPM mode, if the battery charging current is reduced to zero and the OUT current increases beyond the VIN input current limit, the battery supplements the OUT load. In Battery Supplement Mode, the battery charging termination detection is halted.

If the OUT load keeps increasing until (BAT-OUT)>V_{OUT_SCP2}, the BAT to OUT short circuit protection is active.



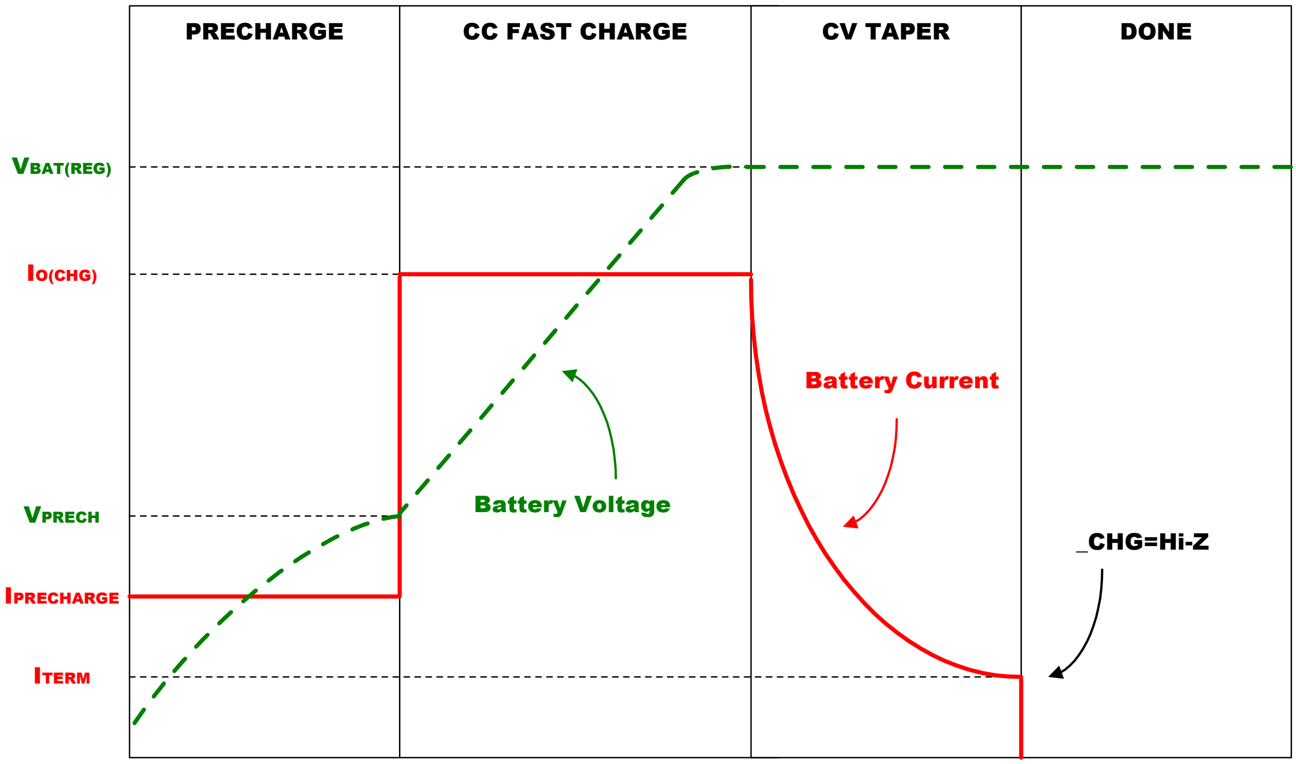
VIN not Connected

When no input source is connected to VIN, OUT is powered strictly from battery. During this mode, the Q2 FET that connects BAT to OUT is fully on, and the OUT voltage is not regulated, but the OUT short circuit protection is active.

Battery Charging

Set _CE low to initiate battery charging. First, the device checks for a short-circuit on the BAT pin by sourcing $I_{BAT(SC)}$ to the battery and monitoring the voltage. When the BAT voltage exceeds $V_{BAT(SC)}$, the battery charging continues. The battery is charged in three phases: conditioning pre-charge, constant current fast charge (current regulation) and a constant voltage tapering (voltage regulation). In all charge phases, an internal control loop monitors the IC junction temperature and reduces the charge current if an internal temperature threshold is exceeded.

In the pre-charge phase, the battery is charged at with the pre-charge current (I_{PRECHG}). Once the battery voltage crosses the V_{PRECH} threshold, the battery is charged with the fast-charge current (I_{CHG}). As the battery voltage reaches $V_{BAT(REG)}$, the battery is held at a constant voltage of $V_{BAT(REG)}$ and the charge current tapers off as the battery approaches full charge. When the battery current reaches I_{TERM}, the _CHG pin indicates *charging done* by going high-impedance.

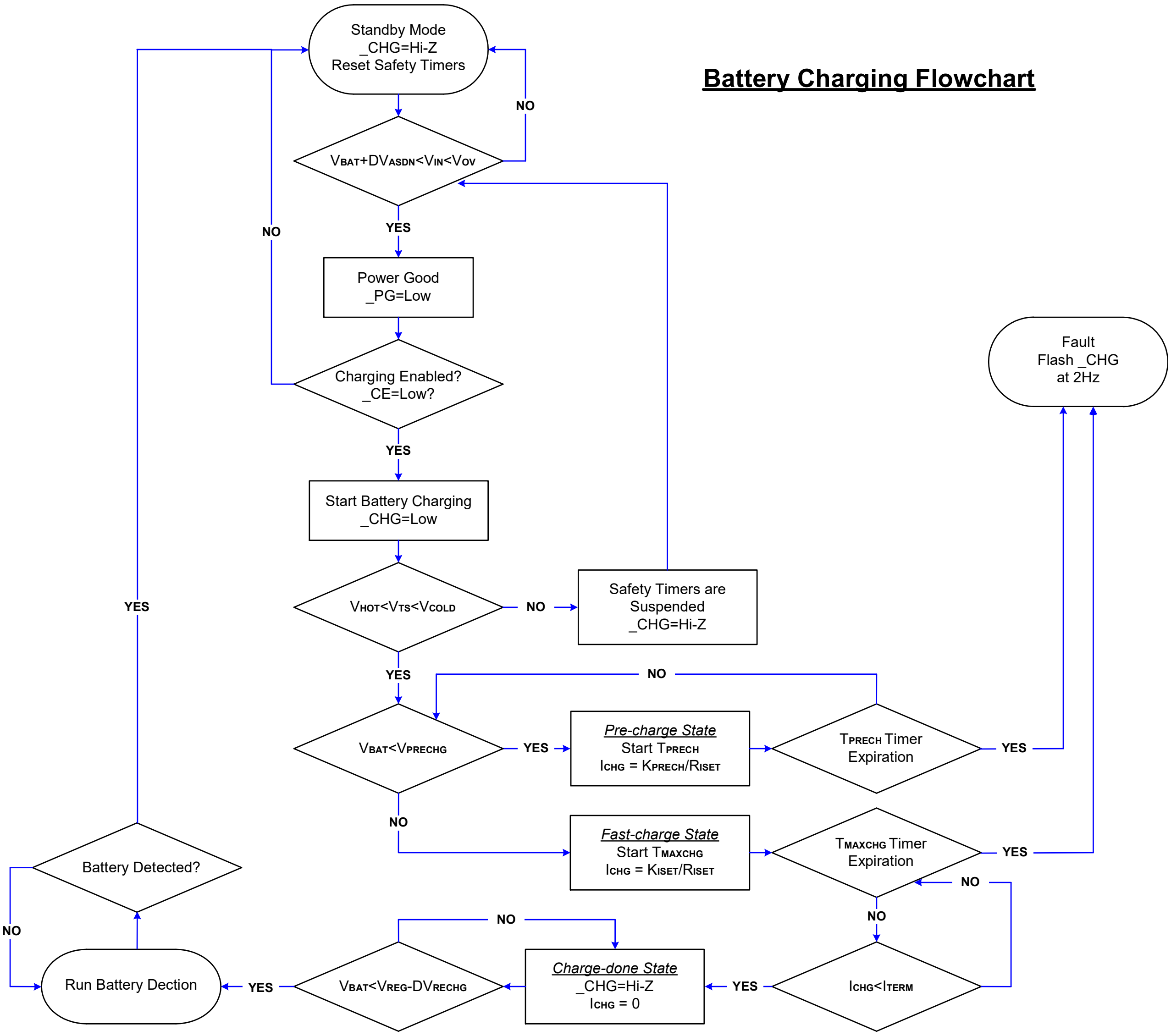


Note that termination detection is disabled whenever the charge rate is reduced because of the actions of the thermal loop, the DPPM loop or the $V_{IN(LOW)}$ loop.The value of the fast-charge current is set by the resistor connected from the ISET pin to GND, and is given by the equation:

$I_{CHG} = K_{ISET}/R_{ISET}$

The charge current limit is adjustable up to 1.5A. The valid resistor range is 1kΩ to 76kΩ. If I_{CHG} is programmed as greater than the input current limit, the battery will not charge at the rate of I_{CHG}, but at the slower rate of $I_{IN(MAX)}$ (minus the load current on the OUT pin, if any). In this case, the charger timers will be proportionately slowed down.

The battery charging flow follows some certain conditions, the flow chart is shown as below:



Battery Detection and Recharge

The G2268 automatically detects if a battery is connected or removed. Once a charge cycle is complete, the battery voltage is monitored. When the battery voltage falls below V_{RCH}, the battery detection routine is run.

During battery detection, current ($I_{BAT(DET)}$) is pulled from the battery for a duration t_{DET} to see if the voltage on BAT falls below V_{PRECH}. If not, charging begins. If it does, then it indicates that the battery is missing or the protector is open. Next, the precharge current is applied for t_{DET} to close the protector if possible. If $V_{BAT} < V_{RCH}$, the protector is closed and charging is initiated. If $V_{BAT} > V_{RCH}$, then the battery is determined to be missing and the detection routine continues.

Battery Disconnect (SYSOFF input)

The G2268 features a SYSOFF input that allows the user to turn the FET Q2 off and disconnect the battery from the OUT pin. This is useful for disconnecting the system load from the battery, factory programming where the battery is not installed or for host side impedance track fuel gauging, such as the case where the battery open circuit voltage level must be detected before the battery charges or discharges. The _CHG output remains low when SYSOFF is high. Connect SYSOFF to GND, to turn Q2 on for normal operation.

SYSOFF is internally pulled to VBAT.

Dynamic Charge Timers

The G2268 contains internal safety timers for the pre-charge and fast-charge phases to prevent potential damage to the battery and the system. The timers begin at the start of the respective charge cycles.
The timer values are programmed by connecting a resistor from TMR to GND. The resistor value is calculated using the following equations:

$t_{PRECHG} = K_{TMR} \times R_{TMR}$
$t_{MAXCHG} = 8 \times K_{TMR} \times R_{TMR}$

Leave TMR unconnected to select the internal default timers. Disable the timers by connecting TMR to GND.
Reset the timers by toggling the _CE pin, or by toggling EN1, EN2 pin to put the device in and out of USB suspend mode (EN1 = HI, EN2 = HI).

If the pre-charge timer expires before the battery voltage reaches V_{PRECH}, the G2268 indicates a fault condition. Additionally, if the battery current does not fall to I_{TERM} before the fast charge timer expires, a fault is indicated.
The _CHG output flashes at approximately 2Hz to indicate a fault condition. The fault condition is cleared by toggling _CE or the input power, entering/ exiting USB suspend mode, or an OVP event.

Status Indicators (_PG, _CHG)

The G2268 contains two open-drain outputs that signal its status. The _PG output signals when a valid input source is connected. _PG is low when $V_{BAT} + \Delta V_{ASDN} < V_{IN} < V_{OV}$. When the input voltage is outside of this range, _PG is high impedance.

The charge cycle after power-up, _CE going low, or exiting OVP is indicated with the _CHG pin on (low - LED on), whereas all refresh (subsequent) charges will result in the _CHG pin off (open - LED off). In addition, the _CHG signals timer faults by flashing at approximately 2Hz.

Input State	_PG OUTPUT
$V_{IN} < V_{UV}$	High-impedance
$V_{UV} < V_{IN} < V_{BAT} + \Delta V_{ASDN}$	High-impedance
$V_{BAT} + \Delta V_{ASDN} < V_{IN} < V_{OV}$	Low
$V_{IN} > V_{OV}$	High-impedance

Table 2. Power Good State Indicator

Charger State	_CHG OUTPUT
Charging	Low
Charging suspended by thermal loop	Low
Battery Pack too cold or too hot	Low
Safety timer expired	Flash at 2Hz
Charging done	High impedance
Recharging after termination	High impedance
IC disabled or no valid input power	High impedance
Battery absent	High impedance

Table 3. Charger State Indicator

Thermal Regulation and Thermal Shutdown

The G2268 contains a thermal regulation loop that monitors the die temperature. If the temperature exceeds T_{REG} (125°C Typ.), the device automatically reduces the charging current to prevent the die temperature from increasing further. In some cases, the die temperature continues to rise despite the operation of the thermal loop, particularly under high VIN and heavy OUT system load conditions. Under these conditions, if the die temperature increases to T_{SHDN} (155°C Typ.), the input FET Q1 is turned OFF. FET Q2 is turned ON to ensure that the battery still powers the load on OUT. Once the device die temperature cools by $T_{SHDN\text{-}HYS}$, the input FET Q1 is turned on and the device returns to thermal regulation. Continuous over-temperature conditions result in a "hiccup" mode.
Note that this feature monitors the die temperature of the chip. This is not synonymous with ambient temperature. Self heating exists due to the power dissipated in the IC because of the linear nature of the battery charging algorithm and the LDO associated with OUT.

Battery Pack Temperature Monitoring

The G2268 features an external battery pack temperature monitoring input. The TS input connects to the NTC thermistor in the battery pack to monitor battery temperature and prevent dangerous over-temperature conditions. During charging, I_{NTC} is sourced to TS and the voltage at TS is continuously monitored. If, at any time, the voltage at TS is outside of the operating range (V_{COLD} to V_{HOT}), charging is suspended. The timers maintain their values but suspend counting. When the voltage measured at TS returns to within the operation window, charging is resumed and the timers continue counting. When charging is suspended due to a battery pack temperature fault, the _CHG pin remains low and continues to indicate charging. For applications that do not require the TS monitoring function, connect a 10kΩ resistor from TS to GND to set the TS voltage at a valid level and maintain charging.

The allowed temperature range for 103AT-2 type thermistor is 0°C to 50°C. However, the user may increase the range by adding two external resistors. See the Figure below for the circuit details. The values for Rs and Rp are calculated using the following equations:

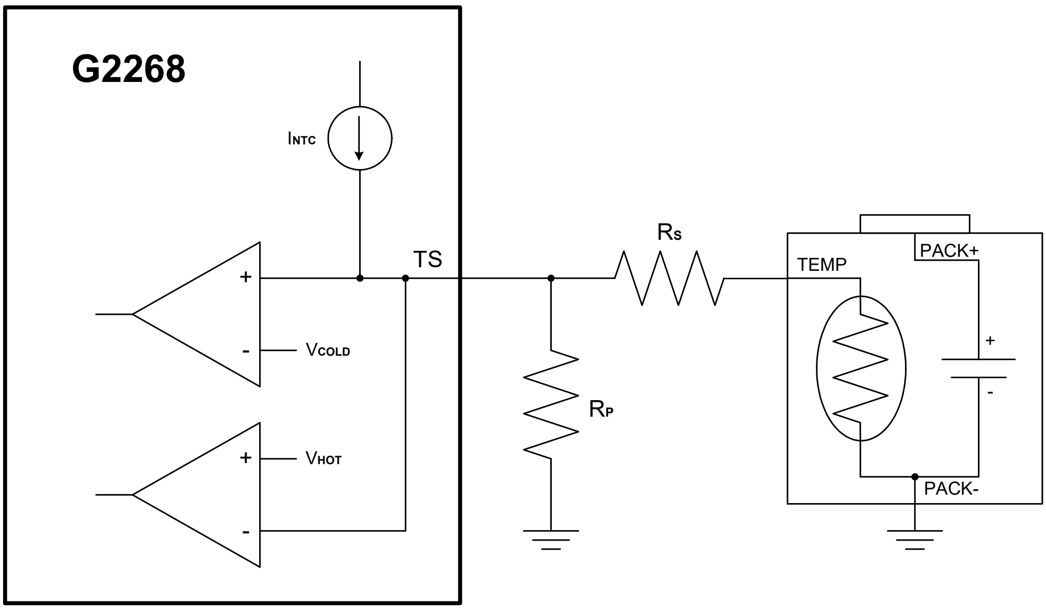
$$R_S = \frac{-(R_{TH}+R_{TC}) \pm \sqrt{(R_{TH}+R_{TC})^2 - 4\left[R_{TH}\times R_{TC} + \frac{V_H \times V_C}{(V_H - V_C)\times I_{TS}}\times (R_{TC}-R_{TH})\right]}}{2}$$

$$R_P = \frac{V_H \times (R_{TH}+R_S)}{I_{TS}\times (R_{TH}+R_S) - V_H}$$

where

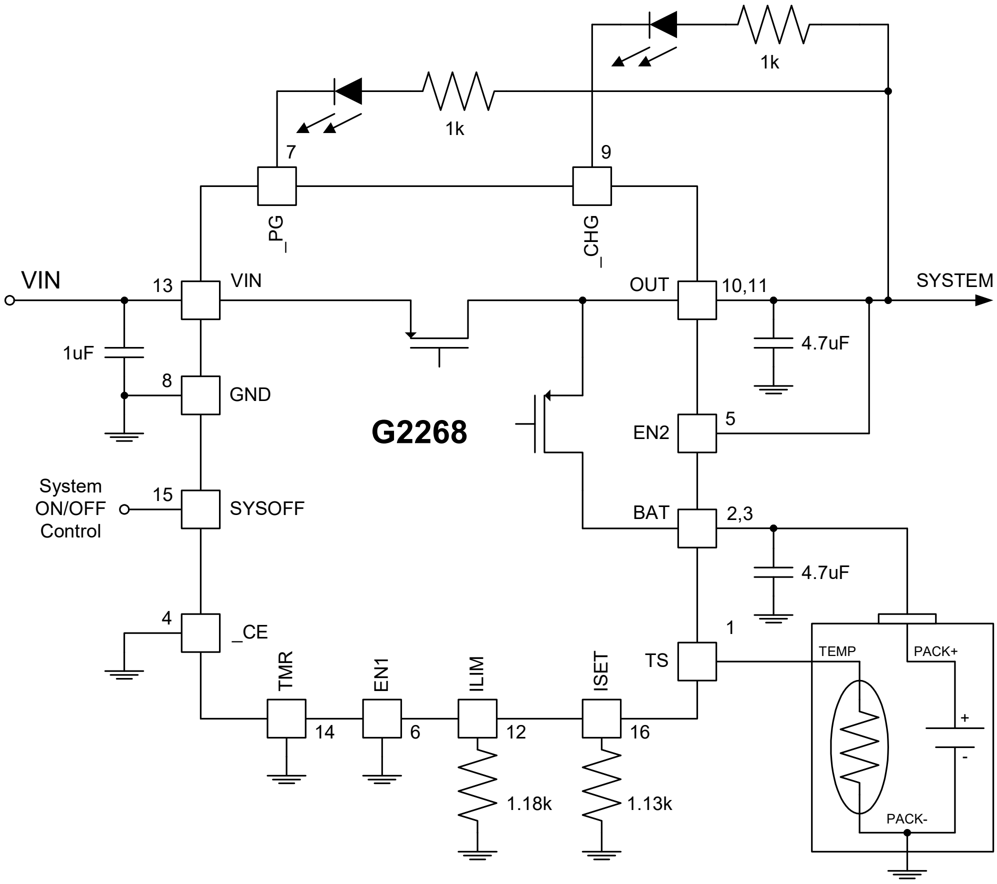
- R_{TH}: Thermistor Hot Trip Value found in thermistor data sheet
- R_{TC}: Thermistor Cold Trip Value found in thermistor data sheet
- V_H: IC's Hot Trip Threshold = 0.3 V nominal
- V_C: IC's Cold Trip Threshold = 2.1 V nominal
- I_{TS}: IC's Output Current Bias = 75 µA nominal
- NTC Thermsitor Semitec 103AT-4

Cold Temp Resistance and Trip Threshold; Ω (℃)	Hot Temp Resistance and Trip Threshold; Ω (℃)	External Bias Resistance Rs (Ω)	External Bias Resistance Rp (Ω)
28000 (-0.6)	4000(51)	0	∞
28480(-1)	3536(55)	487	845000
28480(-1)	3021(60)	1000	549000
33890(-5)	4026(51)	76.8	158000
33890(-5)	3536(55)	576	150000
33890(-5)	3021(60)	1100	140000

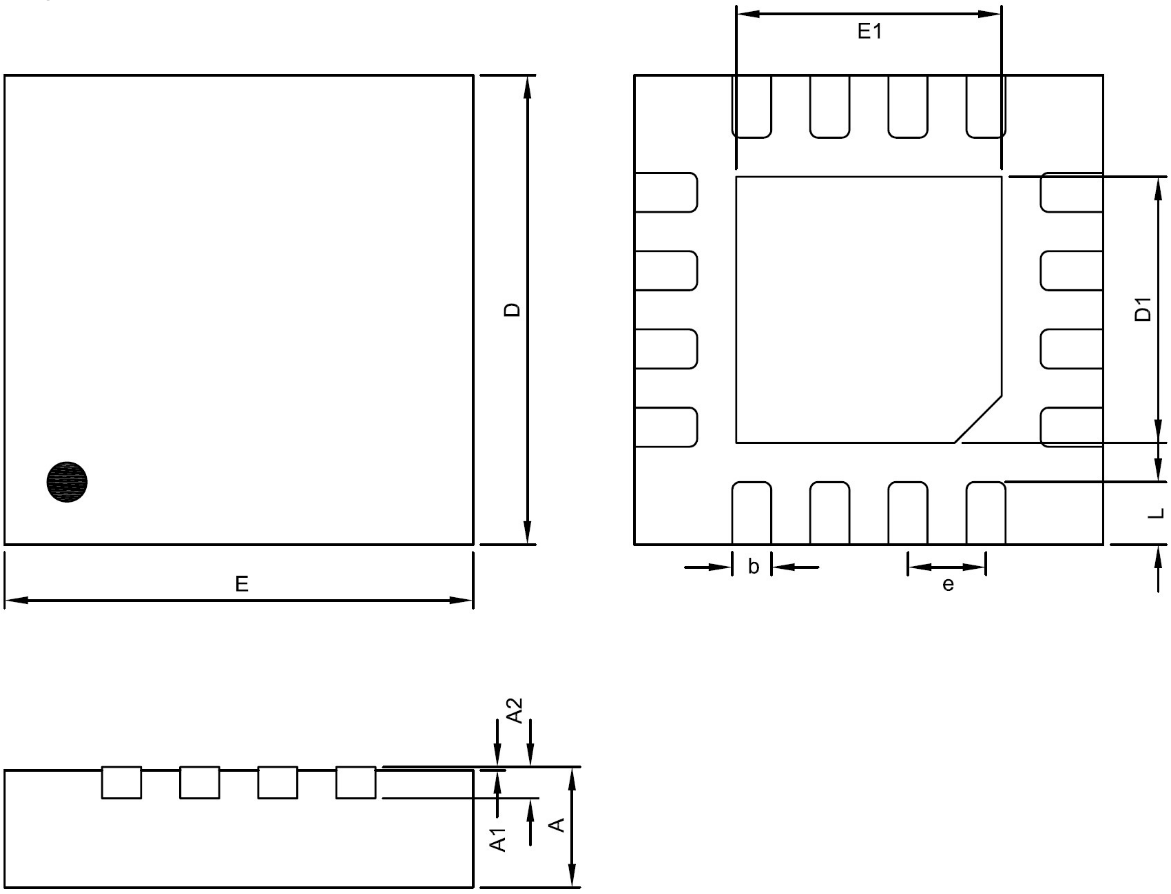


Extended TS Pin Thresholds

Application Circuit



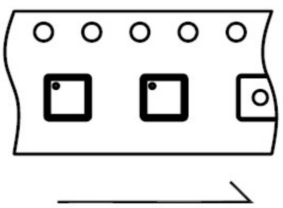
Package Information



TQFN3X3-16 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.20 REF			0.0079 REF		
D	2.95	3.00	3.05	0.1161	0.1181	0.1201
E	2.95	3.00	3.05	0.1161	0.1181	0.1201
D1	1.60	1.70	1.80	0.0630	0.0669	0.0689
E1	1.60	1.70	1.80	0.0630	0.0669	0.0689
b	0.18	0.25	0.30	0.0071	0.0098	0.0118
e	0.50 BSC			0.0197 BSC		
L	0.35	0.40	0.45	0.0138	0.0157	0.0177

Taping Specification



Feed Direction

PACKAGE	Q'TY/ REEL
TQFN3X3-16	3,000 ea