MP2681B

CC/CV Controller
with Full Protection and Indication
One Chip Solution for Power Tools Applications

The Future of Analog IC Technology

DESCRIPTION

The MP2681B is a highly integrated Li-ion or Li-polymer switch-mode battery-charge controller with full protection and status indication. This part integrates a precision voltage reference and charge status indications suitable for AC adapter input and cradle charger applications.

The MP2681B detects automatically the battery cell through a battery ID resistor and regulates the battery voltage according to the corresponding cell configurations: 3S, 4S, and 5S. Then, the AC adapter output is regulated automatically according to the chosen battery configuration. Additionally, if the battery pack does not have an ID resistor, the charge termination voltage can be configured by setting a dedicated voltage to the ID pin, according to the pre-set V_{ID} values representing the battery configuration. The MP2681B charges the battery in three phases: pre-charge, constant current and constant voltage. Charge is terminated when the current reaches a minimum set level. An internal charge timer provides safety back-up. The MP2681B provides a fixed pre-charge mode for deeply-discharged batteries and safety features that include battery temperature monitoring, NTC control, charge time-out, and fault control.

MP2681B is available in a 16-pin SOIC package.

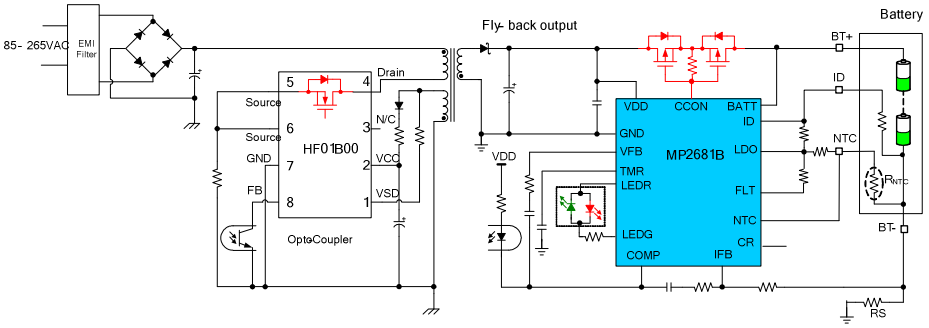
FEATURES

- Constant Voltage and Constant-Current Control
- Pre-Charge Mode for Deeply-Discharged Batteries
- Automatic Battery-Cell Detection
- Two 1MHz Bandwidth Operational Amplifiers Output Connected with OR Logic
- Wide Input-Voltage Range: 5.0V to 30V
- Auto-Recharge
- Charge On/Off Control
- Programmable Internal Timer
- Battery Temperature Monitoring
- Charge-Status Indication
- Power-Line Fault Detection
- Over-Temperature Protection
- 16-pin SOIC Package

APPLICATIONS

- Battery Charger for Portable Tools
- Stand-Alone Fast Charger

TYPICAL APPLICATION



ORDERING INFORMATION

Part Number*	Package	Top Marking
MP2681BGS	SOIC-16	See Below

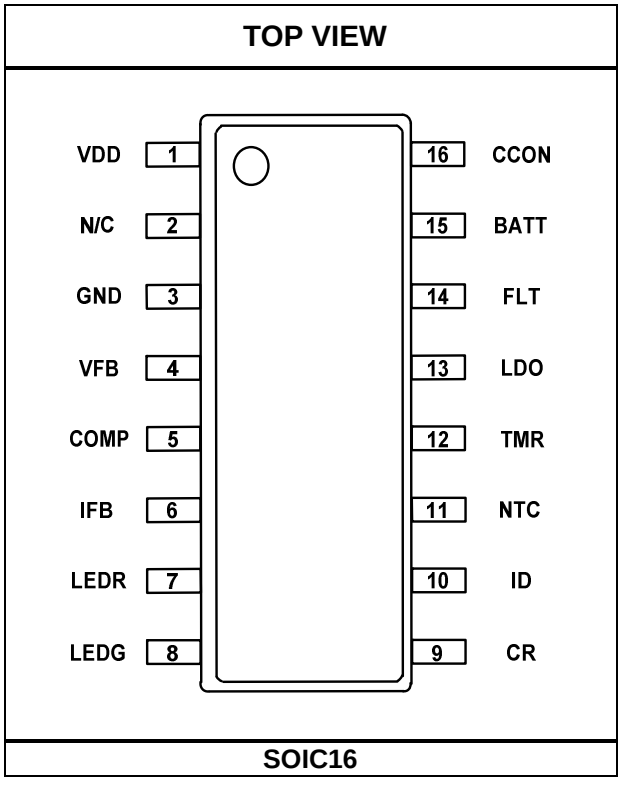
* For Tape & Reel, add suffix –Z (e.g. MP2681BGS–Z).

TOP MARKING

MPSYYWW
MP2681B
LLLLLLLLL

MP2681B: product code of MP2681BGS;
MPS: MPS prefix;
YY: year code;
WW: week code:
LLL: lot number;

PACKAGE REFERENCE



ABSOLUTE MAXIMUM RATINGS (1)

VDD, COMP, BATT to GND ..... -0.3V to +36V
CCON to GND…….. ..... -0.3V to +36V
All Other Pins……..... -0.3V to +6.5V
Continuous Power Dissipation (T_A=+25°C) (2)
……1.6W
Junction Temperature……..150°C
Lead Temperature (Solder)..... 260°C
Storage Temperature…. ..... -65°C to +150°C

Recommended Operating Conditions (3)

VDD to GND……..5.0V to 30V
Operating Junct. Temp. (T_J)..... -40°C to +125°C

Thermal Resistance (4) θ_{JA} θ_{JC}

SOIC-16……	80	…..	35 °C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

VDD= 18V, T_A = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input UVLO	V_{IN}		4.1	4.5	4.9	V
Total Supply Current	I_{DD}	VDD = 18V, No Load	0.4	0.49	0.6	mA
OPERATIONAL MPLIFIER						
Output Sink Current	Icomp_sink	T_A = 25°C, Vcomp=0.5V		15		mA
Output Leakage Current	$I_{COMP\ leakage}$	T_A = 25°C			0.5	μA
VOLTAGE REFERENCE						
LDO Output Voltage	V_{LDO}	I_{LDO}=0mA to 20mA	4.8	5.0	5.2	V
CHARGE CONTORL						
Pre-Charge Threshold	$V_{Pre\ charge}$		2.9	3.0	3.1	V/cell
No-Charge Threshold	$V_{No\ charge}$		1.0	1.2	1.4	V/cell
Battery-Regulation Voltage	V_{BATT}	T_A = 25°C	4.125	4.158	4.175	V/cell
Re-Charge Voltage			3.8	3.95	4.0	V/cell
Pre-Charge Current	I_{TC}	V_{BATT}<3.0V/cell		200		mA
Termination Charge Current	I_{BF}	Fast Charging	5	10	15	%I_{CC}
		Slow Charging		30		%I_{CC}
FLT Sink Current		PIN Voltage=0.4V		17		mA
LEDR/LEDG Sink Current		PIN Voltage=0.4V	8			mA
LEDR/LEDG Source Current		PIN Voltage=V_{LDO}-0.3V			20	mA
PROTECTION						
NTC Control Window	V_{NTC}	R_{NTC}=3.603k, 50°C	23	25	27	%V_{LDO}
		R_{NTC}=4.365k, 45°C	30	32	34	%V_{LDO}
		R_{NTC}=33.105k, 0°C	73	77	82	%V_{LDO}
		R_{NTC}=101.143k, -20°C	85	90	94	%V_{LDO}
		NTC Float (No Battery Detection)	94.5	96	98	%V_{LDO}
Pre-Charge Timer		C_{TMR}=0.1μF		60		min
Total Charge Time	Fast Charge	C_{TMR}=0.1μF		2		hr
	Slow Charge	C_{TMR}=0.1μF		8		hr
Timer Frequency		C_{TMR}=0.1μF		15		Hz
CCON High Threshold	V_{CCON_H}	VDD>V_{BATT}		VDD-0.6V		V
		V_{BATT}>VDD		V_{BATT}-0.6V		V
CCON Low Threshold	$V_{CCON\ L}$			0.3		V

ELECTRICAL CHARACTERISTICS *(continued)*

VDD= 18V, T_A = 25°C, unless otherwise noted.

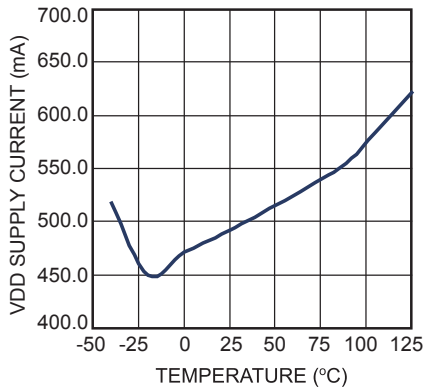
Parameter	Symbol	Condition	Min	Typ	Max	Units
CCON Rise Time	t_{r_CCON}	V_{CCON}:10% to 90% C_{CCON}=10nF		400	500	µs
CCON Fall Time	t_{f_CCON}	V_{CCON}:90% to 10% C_{CCON}=10nF		22	100	µs
CR High Logic	V_{CRH}	Fast Charge	2.5			V
CR Low Logic	V_{CRL}	Slow Charge			0.4	V
Thermal Shutdown (5)	T_{SHTDWN}			150		°C

Notes:
(5). Guaranteed by design

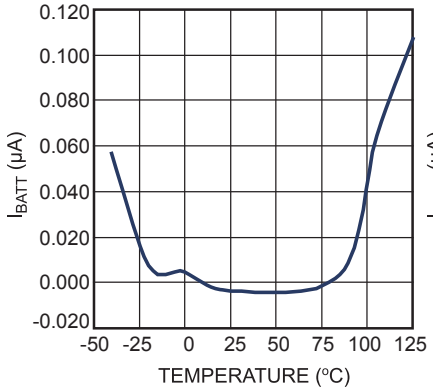
TYPICAL CHARACTERISTICS

VDD= 18V, unless otherwise noted.

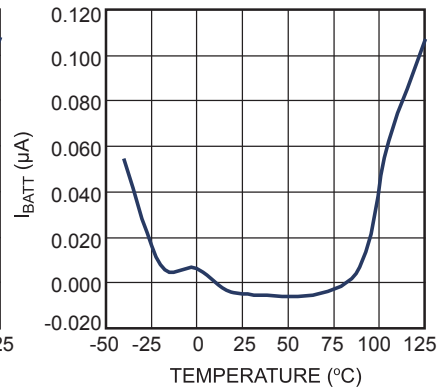
V_{DD} Supply Current vs. Temperature



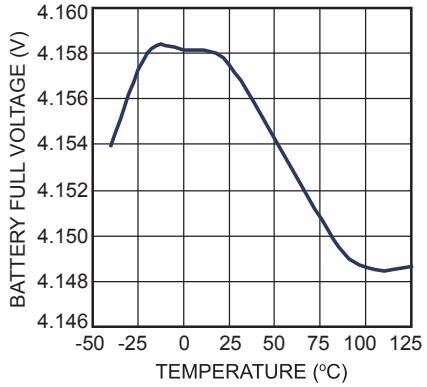
I_{BATT} @ V_{DD} Float vs. Temperature



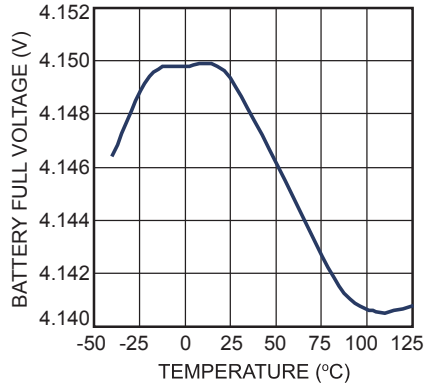
I_{BATT} @ V_{DD}=36V, V_{BATT}=0V vs. Temperature



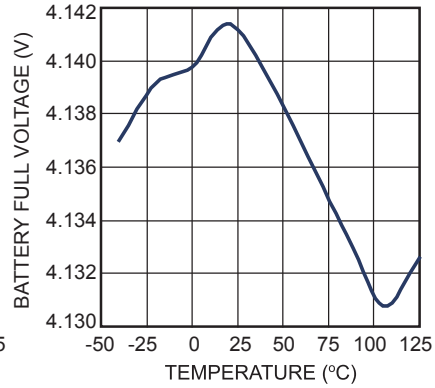
Battery Regulation @ 3 Cell vs. Temperature



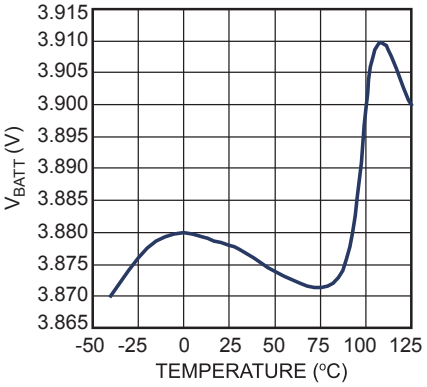
Battery Regulation @ 4 Cell vs. Temperature



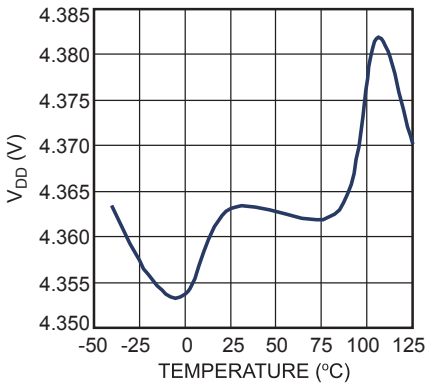
Battery Regulation @ 5 Cell vs. Temperature



Battery Auto-Recharge Threshold vs. Temperature



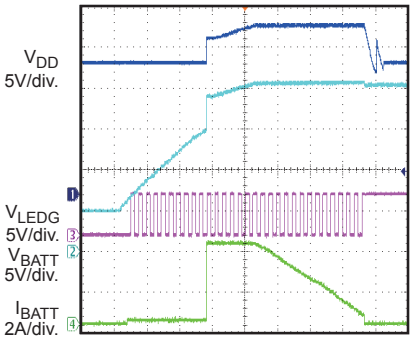
V_{DD} OVP vs. Temperature



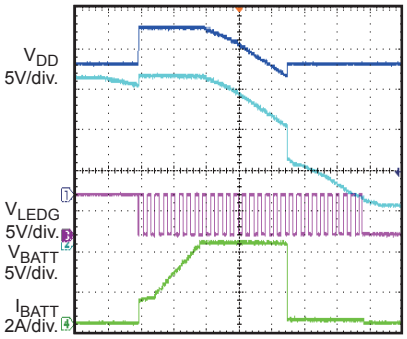
TYPICAL PERFORMANCE CHARACTERISTICS

VDD = 18V, T_A = 25°C, unless otherwise noted.

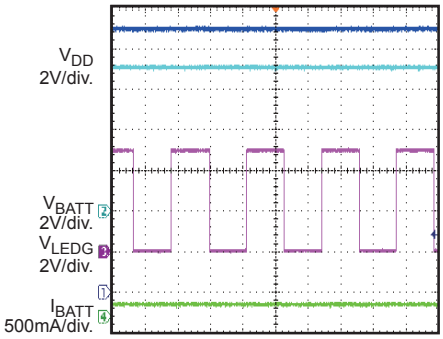
Battery-Charge Curve
5 Cell, I_{CHG}=4A



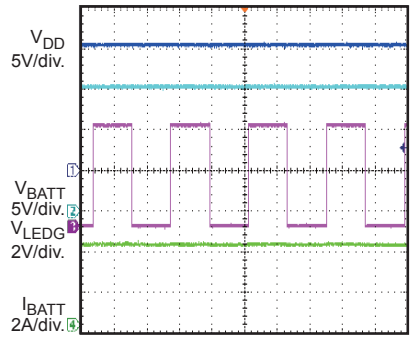
Auto-Recharge
5 Cell, I_{CHG}=4A



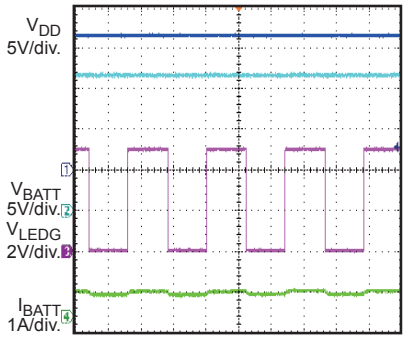
Pre-Charge Steady State
V_{BATT}=7V



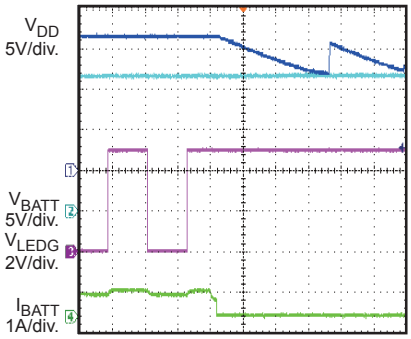
CC-Charge Steady State
V_{BATT}=15V



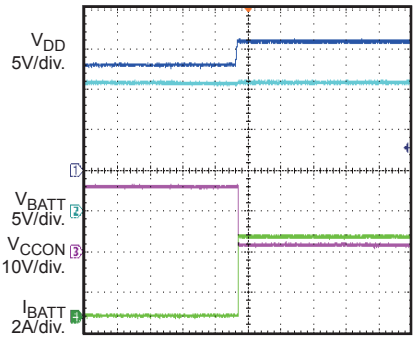
CV-Charge Steady State
V_{BATT}=16.6V



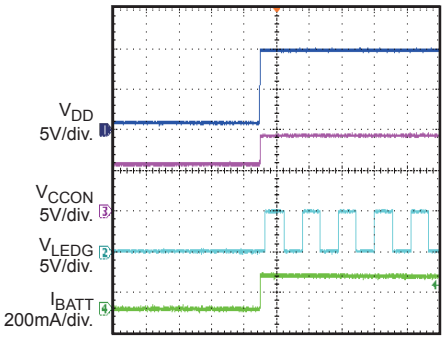
Charge Full
V_{BATT}=16.6V



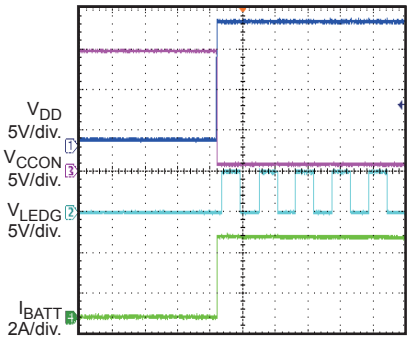
Auto-Recharge
V_{BATT}=15.5V



AC-IN Power ON
3 cell, V_{BATT}=6V



AC-IN Power ON
V_{BATT}=15V

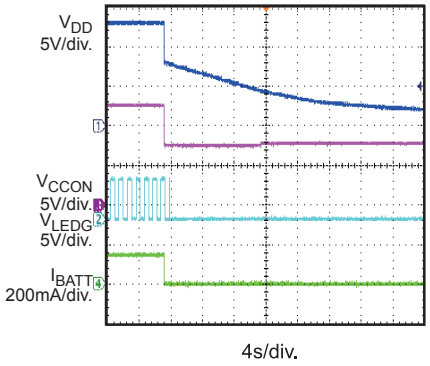


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

VDD = 18V, T_A = 25°C, unless otherwise noted.

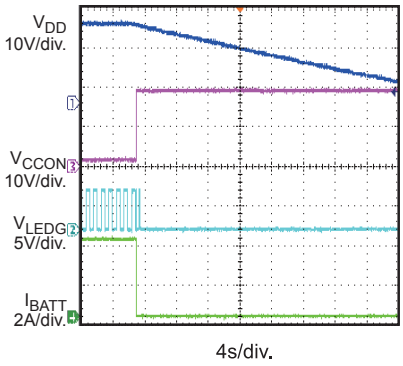
AC-IN Power OFF

V_{BATT}=8V



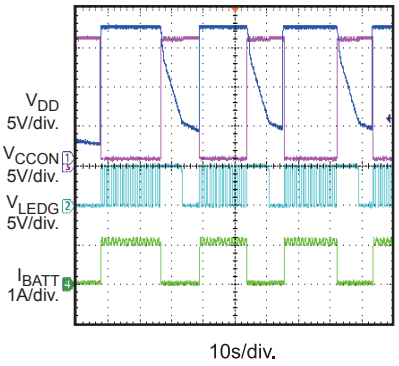
AC-IN Power OFF

5cell,V_{BATT}=19V,ICHG=4A



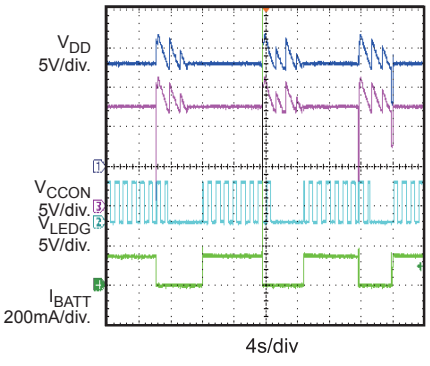
AC-IN Power ON/ OFF

V_{BATT}=16.6V



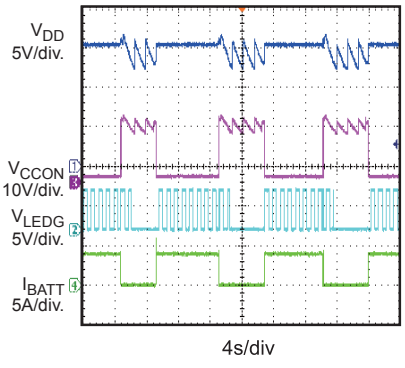
Battery Insertion/ Removal

V_{BATT}=8V



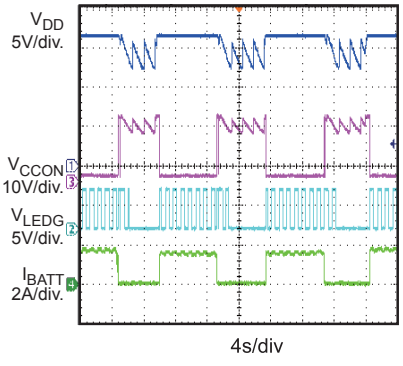
Battery Insertion/ Removal

V_{BATT}=15V



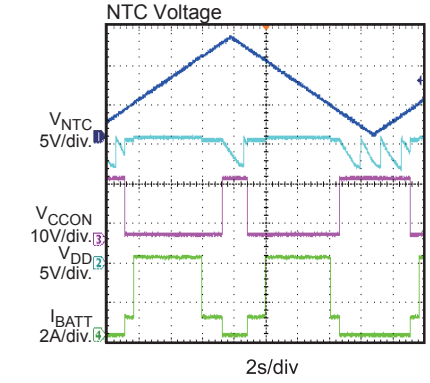
Battery Insertion/ Removal

V_{BATT}=16.6V



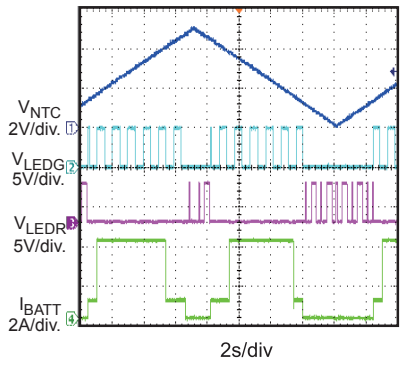
NTC Fault Control

V_{BATT}=15.5V, Ramp Up and Down NTC Voltage



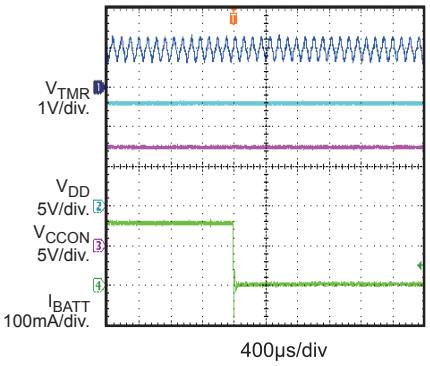
NTC Fault Indication

V_{BATT}=15.5V



Timer-Out Protection

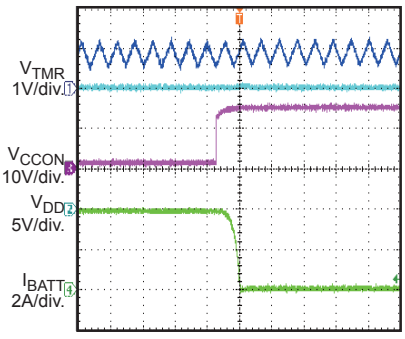
CTMR=150pF,V_{BATT}=10V



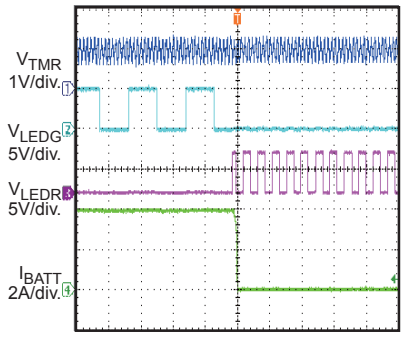
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

VDD = 18V, T_A = 25°C, unless otherwise noted.

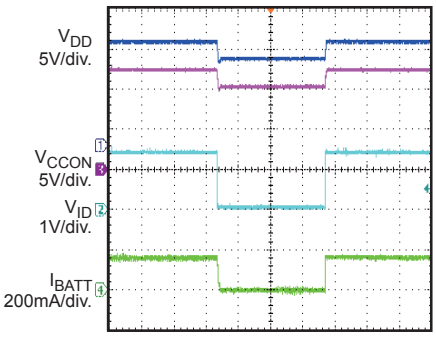
Timer-Out Protection
CTMR=150pF,V_{BATT}=15V



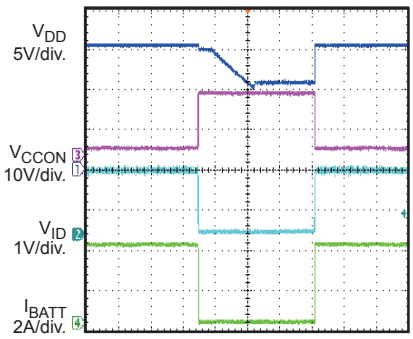
Timer-Out Indication
CTMR=150pF,V_{BATT}=15.5V



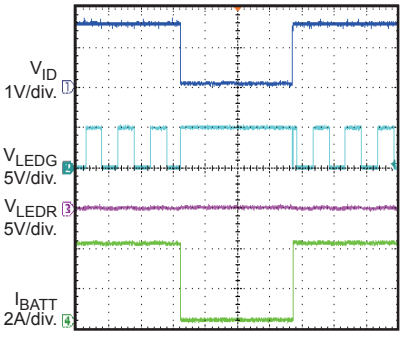
ID Short Protection
V_{BATT}=10V



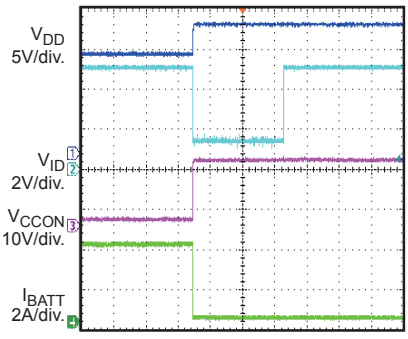
ID Short Protection
V_{BATT}=15V



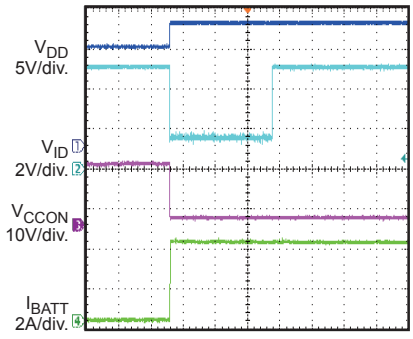
ID Short Indication
V_{BATT}=15V



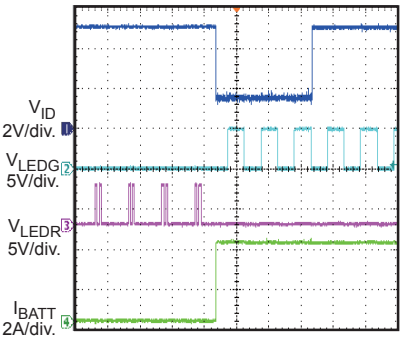
ID Open Protection
V_{BATT}=12V



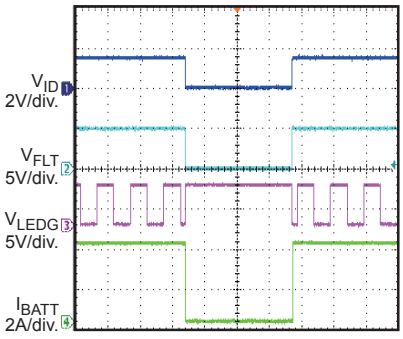
ID Open Protection
V_{BATT}=15V



ID Open Indication
V_{BATT}=15V



Faut Signal under ID Short
V_{BATT}=15V



PIN FUNCTIONS

Package Pin #	Name	Description
1	VDD	Power Supply Input. Bypass VDD to GND with a capacitor (at least 4.7μF).
2	NC	No Connected.
3	GND	Ground.
4	VFB	Voltage Feedback. Connect VFB to the compensation of the voltage-regulation loop externally.
5	COMP	Output Common to Voltage Regulation and Current-Limitation Loops. Connect COMP to the cathode of the opto-coupler.
6	IFB	Current Feedback. Connect IFB to the current-sense resistor.
7	LEDR	Charging Status Indicator (see Table 3 for indication).
8	LEDG	Charging Status Indicator (see Table 3 for indication).
9	CR	Charge-Rate Setting. Pull CR to logic high to set the charger in fast-charge or pull CR to logic low to set the charger in slow-charge. Floating CR sets the charger in fast-charge as the default setting.
10	ID	Battery Type Detection. Connect to the ID resistor output of the battery pack. ID is used to detect the battery type.
11	NTC	Battery Temperature Monitoring (see Figure 2 for proper connection).
12	TMR	Timer Setting. Connect TMR to a capacitor from TMR to GND to set the oscillator cycle. The timer-setting period changes according to the oscillation cycle. **Short TMR to ground to disable the timer.**
13	LDO	LDO Output for Pulling High Voltage of NTC, FLT, and ID.
14	FLT	Drain Output to Detect a Charge-Fault Condition. FLT is pulled low when a fault occurs. Connect FLT to the battery-pack pin (if available). Pull FLT high to LDO through a resistor.
15	BATT	Battery Sense Voltage Input.
16	CCON	External Charge On/Off Control MOSFET Gate Control. CCON cuts off the charge path when a fault occurs or protection is triggered.

OPERATION

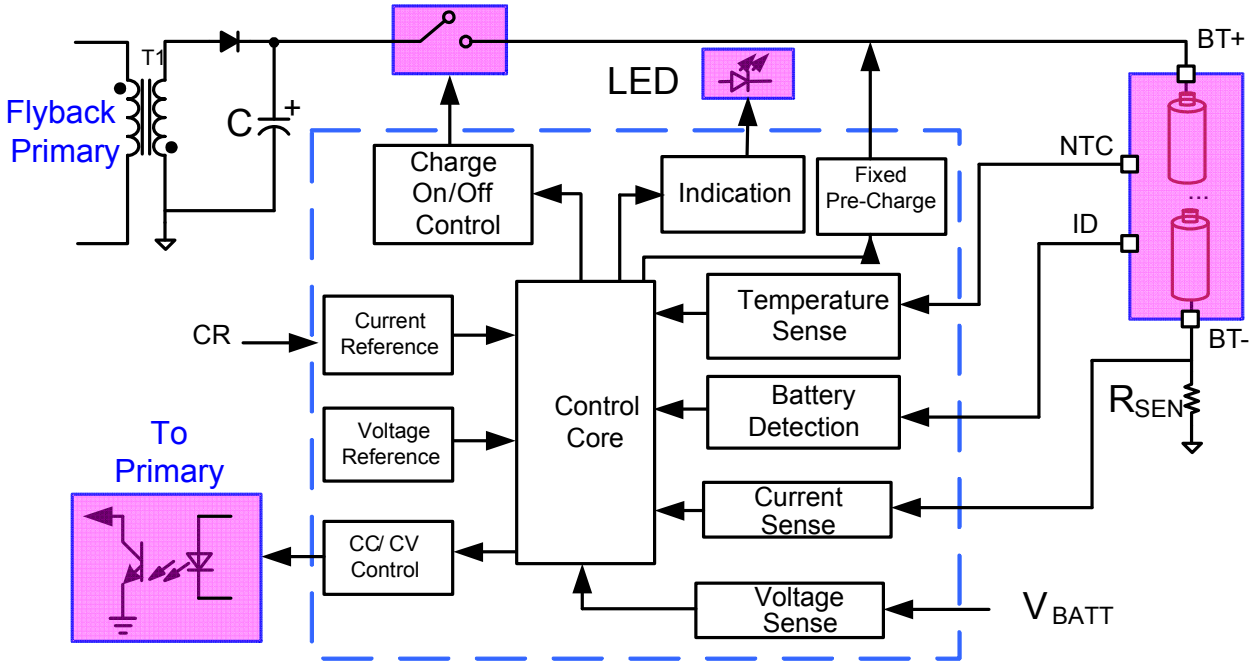


Figure 1. Functional Block Diagram

Charge Voltage Setting

The MP2681B supports 3 different types of battery configurations: 3S, 4S, and 5S using a dedicated ID resistor pin. When a battery pack configuration is detected through the ID resistor, automatically the charge voltage is set internally; different battery pack implementations require different ID resistor values. The MP2681B ID is connected to the ID resistor in the battery pack and pulled up to LDO by a resistor (see Figure 2). Every battery configuration has a pre-set V_{ID} value. As such, the MP2681B compares V_{ID} to its internal reference to figure out the inserted battery configuration. As the battery changes among the six pre-set configurations, the MP2681B detects such conditions, and it modifies automatically the resistor divider from VDD (see Figure 3). Charge current, as well as other charge parameters, change accordingly.

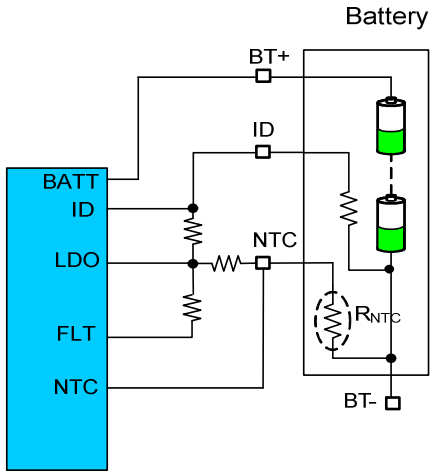


Figure 2. Battery-Pack Pin Connection

Additionally, if the battery pack does not have an ID resistor, the charge-termination voltage can be configured by setting a dedicated voltage to ID (according to the pre-set V_{ID} values representing each battery configuration).

Table 1 summarizes all the charge-voltage settings for the MP2681B. The real ID voltage threshold for every battery pack is about ±65mV wider than the ones listed in the table, taking into consideration reference variations, comparator offsets, and hysteresis.

Table1. Charge-Voltage Setting Summary

ID Resistor		Detect Voltage	Operation Mode	Battery Spec	VDD	VBATT
Float	NTC Float	V_{ID} > 2.65V	Sleep Mode	No Battery	10.8V	0
	NTC OK		Default Mode	3S	12.44V	12.44V
1.8k		0.3V < V_{ID} < 0.7V	Automatic Mode	3S	12.44V	12.44V
6.8k		0.95V < V_{ID} < 1.6V		4S	16.59V	16.59V
15k		1.75V < V_{ID} < 2.65V		5S	20.74V	20.74V
Short		V_{ID} < 0.3V	Sleep Mode	Unknown	10.8V	0

ID voltage is detected out of range based on the values specified in Table 1 (possibly caused by the insertion of a wrong battery-pack configuration). The MP2681B detects this fault condition and cuts off the external MOSFET to stop charging and protect the battery. Under this condition, the output voltage is set to a default value of 10.8V, causing the MP2681B to enter sleep mode. Also, the MP2681B provides a fault indication. No battery condition is detected when both NTC and ID are floating; when there is no battery, the indication is off. If the NTC is ok (while ID is floating), it means the battery has no ID resistor, and the MP2681B will default set it as a 3 cell condition.

The MP2681B compares the VFB voltage to its internal voltage reference in order to maintain voltage regulation. If this voltage is higher than 2.075V, the output of the voltage-loop operational amplifier decreases; the opto-coupler current will increase, reducing the output voltage of the PWM controller.

Figure 3 shows the CC and CV control circuit.

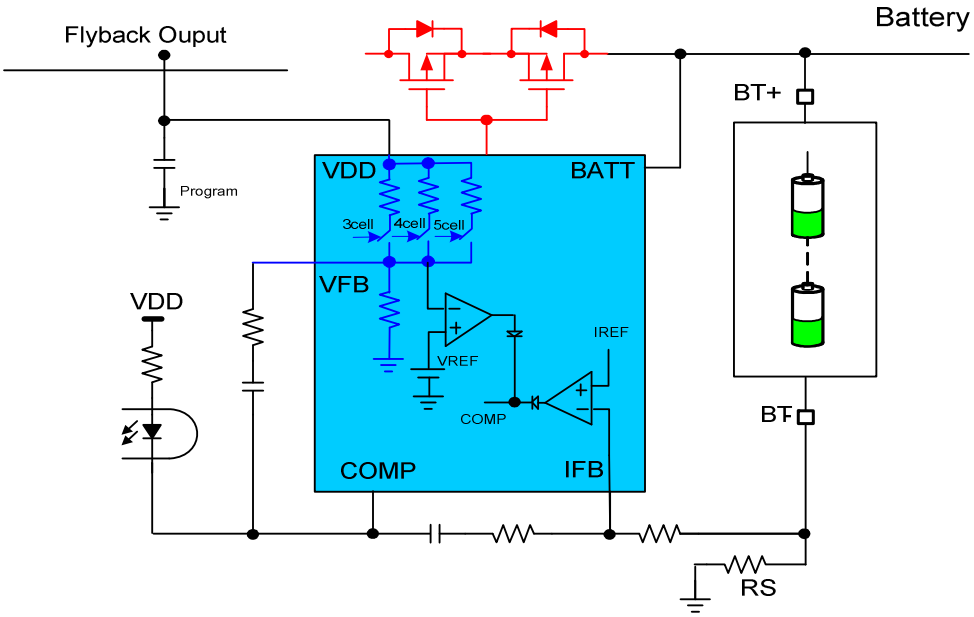


Figure 3. CC/CV Control Circuit of MP2681B

Charge-Current Setting

The current limitation (I_{CHG}) is performed by sensing the voltage across the sense resistor (RS) and comparing it to the charge-current reference (V_{IREF}). When the sense voltage on RS is higher than V_{IREF}, the output of the current-limitation loop operational amplifier decreases. The opto-coupler current increases and tends to reduce the output voltage by the way of the PWM controller (see Figure 3).

Choose the sense resistor RS according to the charge current and the following formula:

$$RS = \frac{V_{IREF}}{I_{CHG}}$$

The charge-current reference is controlled by CR to set the charge rate. If CR is logic high, V_{IREF} is fixed at 0.16V internally; the charge current can be programmed only by changing the sense resistor. Pull CR low to set the IC in slow-charge. V_{IREF} is set to 0.016V to decrease the charge current without changing the external resistor. With CR, the MP2681B can set the charger in fast or slow charge automatically. Floating CR sets the charger in fast-charge as per the default setting.

To avoid large currents flowing into the battery, the MP2681B implements an over-current protection scheme. When voltage over 500mV is detected on IFB, the MP2681B cuts off the charge-current path to the battery.

Pre-Charge Mode

Before the charging cycle starts, the MP2681B senses the battery voltage.

If the battery voltage is lower than 1.0V/cell, the MP2681B acts as if there is a dead battery, and it never starts charging. If the battery voltage is lower than 3.0V/cell, the MP2681B goes into pre-charge mode. The external MOSFET is off in this mode, and the output-voltage control of the flyback is set at a default value of 3.2V/cell. The MP2681B acts as a constant current source, supplying a constant 150mA current to charge the battery pack through BATT.

This period lasts until the battery voltage increases over the 3.0V/cell threshold or during time-out. A fixed timer starts when pre-charge mode starts. The MP2681B sets the time period for pre-charge at 60min with a 0.1uF timer capacitor (C_{TMR}). Changing the capacitor value will change the time period only during charge mode but not during pre-charge mode

The pre-charge mode ensures that any deeply discharged battery will be charged safely.

Charge Cycle (Mode Change: CC→ CV)

At the end of the pre-charge cycle (and when the battery voltage is at least equal to 3.0V/cell), the external MOSFET is turned on, and the MP2681B enters constant-current charge mode. This mode of operation will stay as long as the battery voltage does not cross the full, pre-set charge threshold.

After the battery voltage is over 3.0V/cell, the IC begins to charge at the programmed constant current rate (I_{CHG}). This is referred to the constant current in CC mode. Once the output voltage reaches the battery-regulation voltage, the charger operates in constant-voltage (CV) mode until the battery is fully charged. During this time, the charge current starts to decrease down to the I_{BF} threshold (usually 10% of the programmed constant-current value).

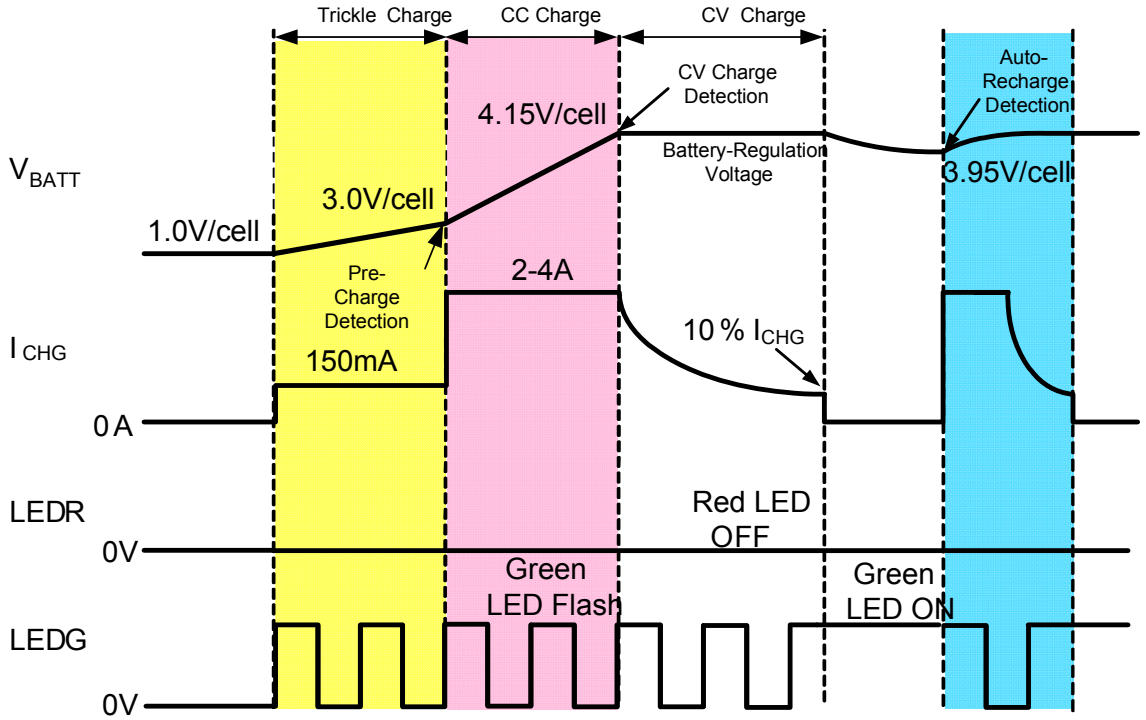


Figure 4. Typical Charge Profile

Charge Termination

The charge cycle is considered complete when the charge current reaches the programmed termination-current threshold (I_{BF}). Please refer to Figure 4 for a complete view of the charging cycle and LED operation.

Automatic Re-Charge

The MP2681B allows the battery to be re-charged automatically when the battery voltage drops below the auto-recharge threshold (3.95V/cell). The MP2681B re-sets the reference voltage to the normal charging value and turns on the CCON driver to re-start the charge cycle until the I_{BF} condition is met again.

LDO Output

The MP2681B implements a 5V LDO which provides a pull-up voltage for the NTC, ID resistor, and FLT detection. It supplies up to 20mA current. When VDD is higher than 5V, the LDO output is regulated at 5V. If the VDD input voltage is lower than 5V, the FET is fully on and the LDO output is nearly equal to the input voltage VDD.

Timer Operation

The MP2681B provides a safety timer in case of a defective battery pack.

During pre-charge mode the charge timer is fixed with a set capacity. During CC and CV charge mode, the timer duration is proportional to the charge rate. The timer will start counting every time the charger process starts up (as in initial power-up or automatic re-charge). The timer will limit pre-charge time to T1 oscillating cycles on TMR. If the charger stays in pre-charge mode for longer than T1 cycles, the MP2681B terminates the charging operation by disconnecting the battery from the charger. The output voltage is regulated to the default value. The timer-fault indication is set by flashing LEDR and keeping LEDG low. After a fault-reporting condition, the charger can be re-initiated only by recycling the power supply. The timer limit in the pre-charge mode is fixed, and it will not change when the IC is set to slow-charge or fast-charge mode via CR.

If the charger goes through pre-charge successfully within the allowed time limit, it will start CC charge and then CV charge. If the total charge time exceeds T2 cycles (and the battery full has not been reached), the MP2681B terminates the charger; then the CCON output is pulled high to turn off the switch and stop charge. Also, the timer-out fault indication will be set (by flashing LEDR and LEDG low). This function prevents charging a dead battery for a prolonged duration of time. Table 2 shows the timer for the pre-charge and total-charge duration limit.

Table 2. Timer Cycles

T1	T2
57600	Fast:115200
	Slow:460800

TMR is used to set the internal oscillator frequency. The timer function can be disabled by shorting TMR to ground, although this is not recommended.

The timer frequency according to the TMR capacitor is as follows:

$$T(s)= 0.6\times C(uF)$$

Smart Negative-Temperature Coefficient (NTC) Protection

The MP2681B monitors continuously the battery temperature by measuring the voltage on the NT, which is generated by a negative temperature coefficient (NTC) thermistor and an external voltage divider. The controller compares this voltage against its internal thresholds to determine if charging is allowed. To initiate a charge cycle, the voltage on NTC must be within the V_{T1} to V_{T4} thresholds (see Figure 5). If the V_{NTC} is outside of this range, the controller suspends charge and waits until the battery temperature is back within the V_{T1} to V_{T4} range. During the V_{T2} and V_{T3} range, the charge current is usually set at a 2C rating corresponding to I_{CHG} set by the user. If the NTC voltage is between V_{T1} and V_{T2} the MP2681B decreases the charge current to $I_{CHG}/4$. When the IC is in pre-charge or slow-charge mode, the charge current is set to low and NTC will not have any effect on the charge current. Figure 5 shows the charge-current setting by the NTC window control.

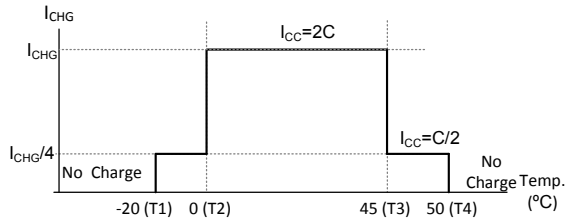


Figure 5. NTC control window

CCON

The CCON is a driver output pin used to turn on/off the external MOSFET to connect or cut off the charge path according to the charge condition. If the MP2681B is under normal charge operation, the CCON is pulled low. If a fault occurs, CCON is pulled high to cut off the charge path.

Status Indication

The MP2681B integrates two driver outputs (LEDG and LEDR). Connecting a bi-color back-to-back LED between these two pins can output a variety of indication states to help distinguish each operation, including: charging, charge termination, NTC fault, timer out, ID open, ID out pf range, ID short, and power-line fault.

Table 3 summarizes the status of the two indication LEDs under the different charge states based on the LEDR and LEDG outputs (see Figure 6).

Table 3. LED Indicator Table

Condition	Red LED	Green LED	CCON
Charging	OFF	Flash	Low
Charging Finish/ID Short	OFF	ON	High
NTC Fault	Flash	OFF	High
Timer Fault ID Out of Range	Flash	OFF	High
Power-Line Fault	Flash	OFF	High
NTC Float (No Battery)	OFF	OFF	High

Power Supply

The MP2681B does not operate when VDD voltage is under the UVLO threshold. The charge starts to work when the output voltage is 200mV higher than the battery voltage. Also, the MP2681B integrates over-voltage protection on VDD to protect the battery. When the power supply is under the UVLO threshold (or VBATT+200mV), and when the VDD voltage is 100mV/cell over the battery-limit value (4.15V/cell), the power supply is detected as invalid and the MP2681B turns off the external power switch to stop charging.

Battery-Voltage Sense

BATT is used to sense the battery voltage. It is connected to the positive output of the battery pack. The MP2681B detects the battery voltage through BATT to enable the correct charge setting. During start-up (after the supply voltage is above the UVLO threshold), the MP2681B detects the battery voltage. If V_{BATT} is lower than 1.0V/cell (dead or no battery) the MP2681B will not start charging. This condition stays as long as V_{BATT} exceeds 1.0V/cell. If the battery voltage detected is lower than 3.0V/cell, the MP2681B goes into pre-charge mode and a fixed constant current of 150mA will flow from BATT to the battery pack to charge the battery. In pre-charge mode, the external MOSFET stays off to cut off the charge path; the output voltage is set at the default 3.2V/cell. During normal charge operation (if the battery is removed), the MP2681B detects this condition through V_{BATT}<1.0V/cell. The MP2681B regulates the reference voltage to set the flyback output to the default value of 10.8V. It will never start charging unless V_{BATT} is higher than 1.0V/cell.

Fault Protection

FLT is an open-drain output, and it is pulled low when a fault condition is assessed. Connect FLT to the LDO output through a resistor. Under any fault condition including NTC fault, timer out, and ID fault, FLT is pulled low. Meanwhile, the MP2681B pulls CCON high to cut off immediately the flyback output from the battery and regulates the reference voltage to set the flyback output to the default 3.2V/cell.

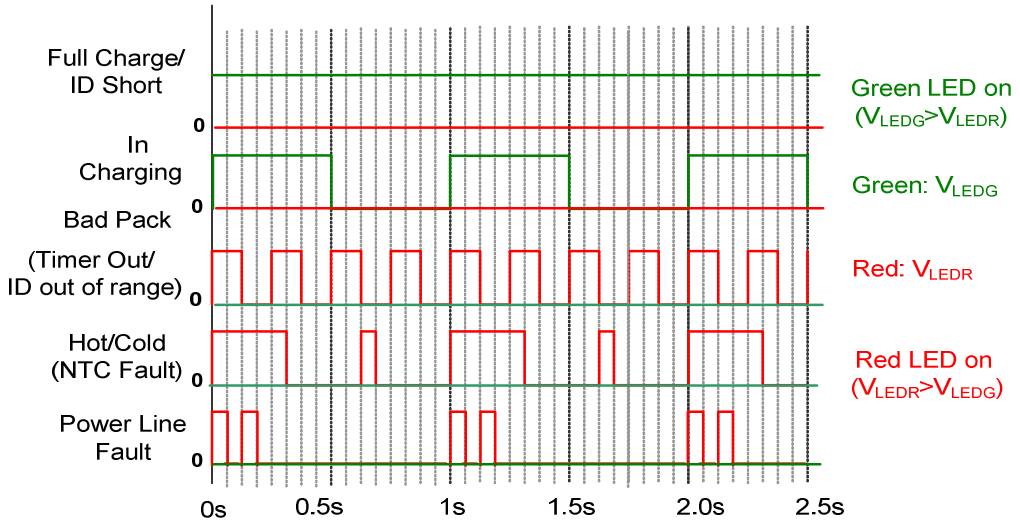
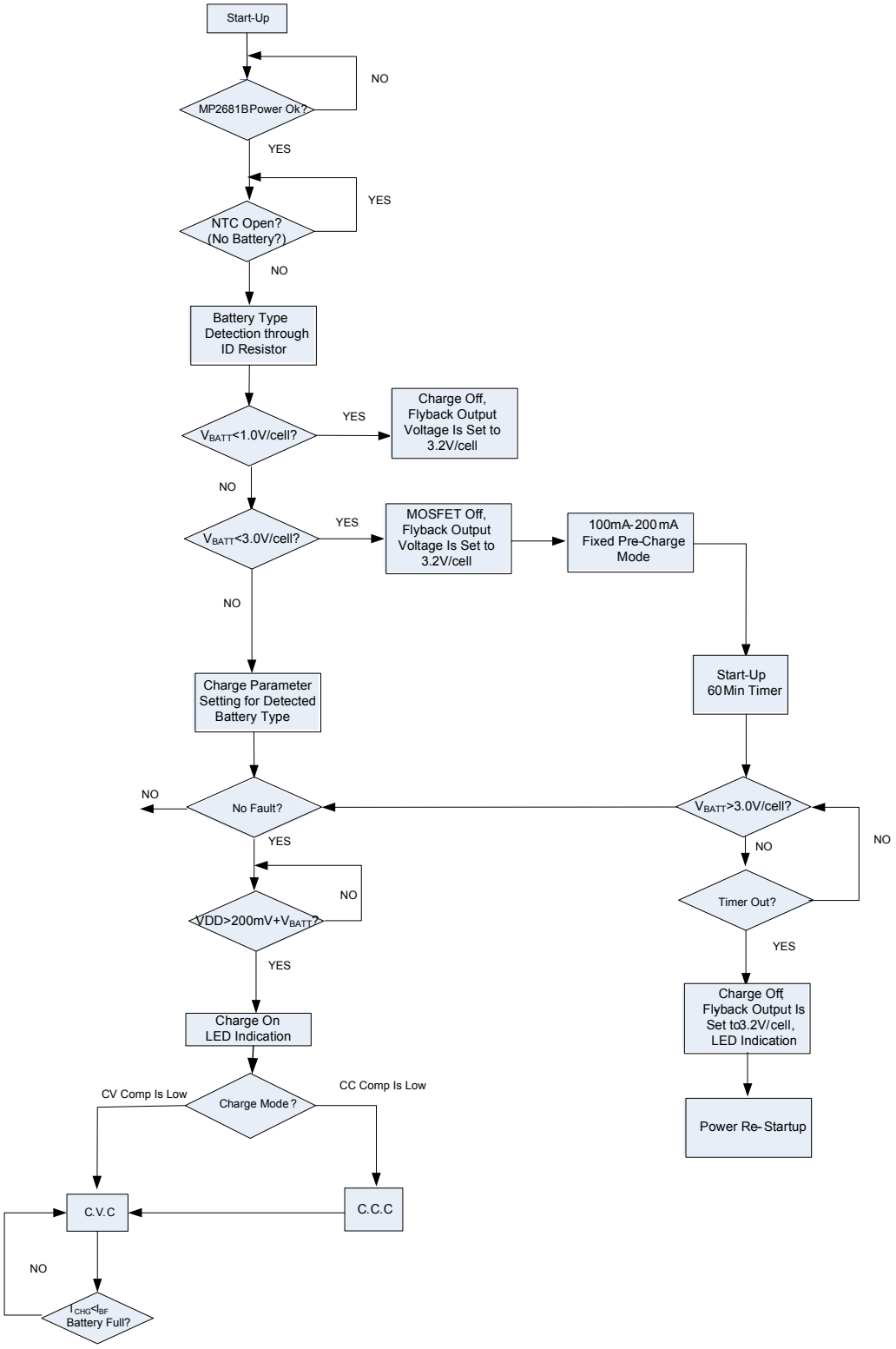


Figure 6. Schematic plot of the output voltage at LEDG/LEDR

CONTROL FLLOWCHART



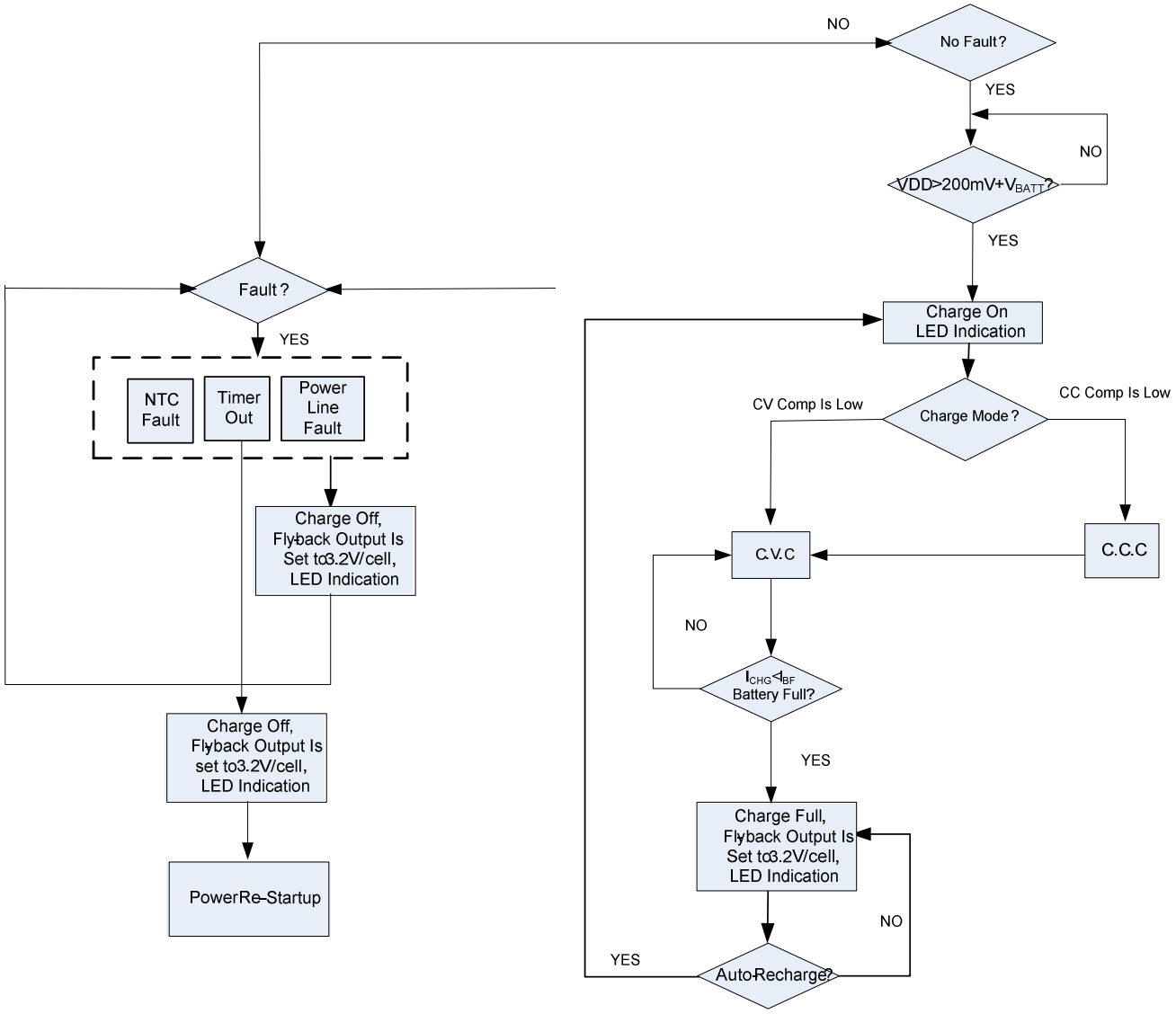


Figure 7. MP2681B Control Flow Chart

OPERATION WAVEFORM

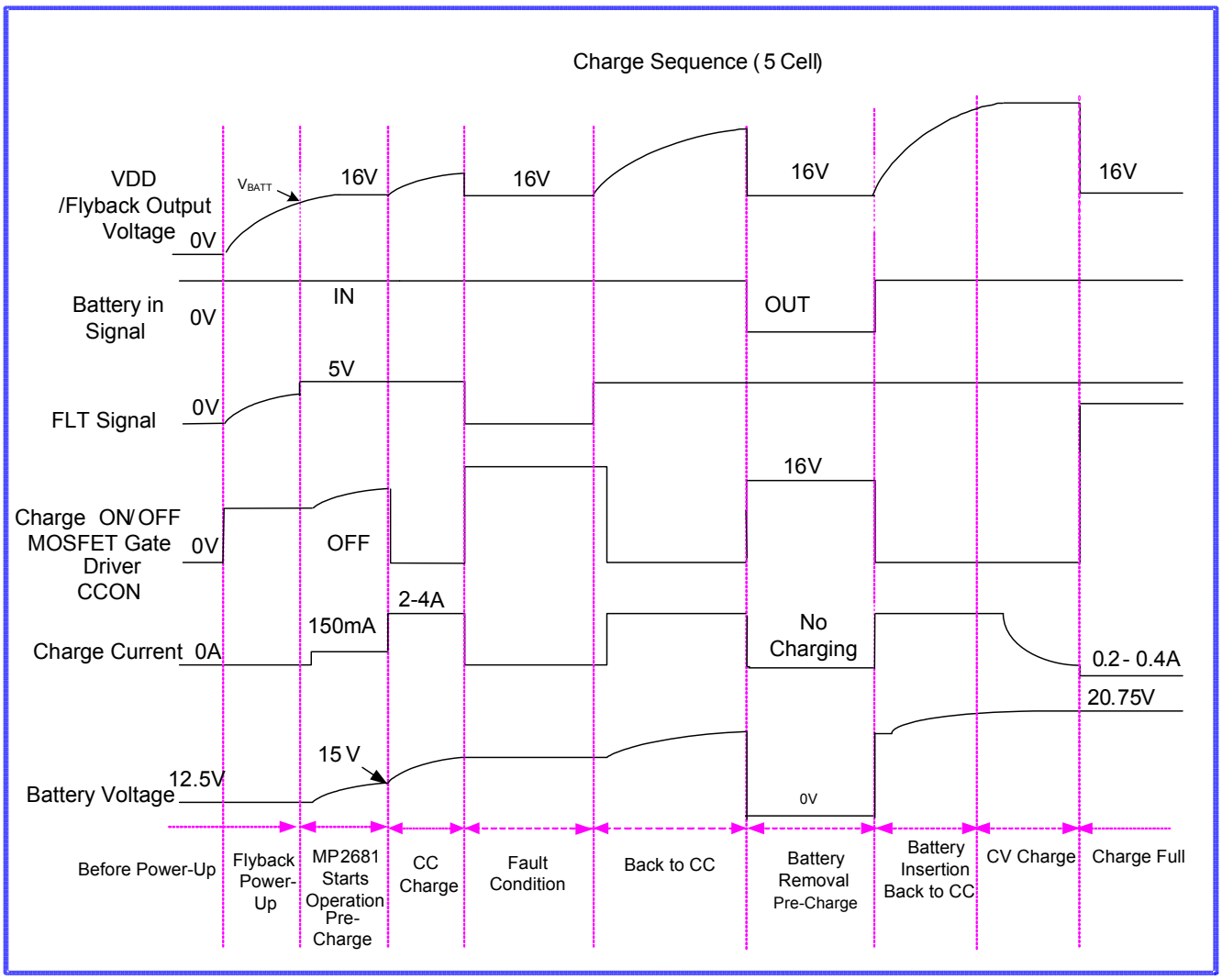


Figure 8. MP2681B Charge Sequence (5 Cell)

APPLICATION INFORMATION

COMPONENT SELECTION

Setting the VDD Voltage

VDD voltage is regulated based on the battery specifications, according to the ID resistor.

Refer to Table 1 for the relationship between the ID voltage and the VDD voltage.

Setting the Charge Current

The current limitation (I_{CHG}) is performed by sensing the voltage across the sense resistor RS and comparing it to the charge-current reference (V_{IREF}), refer to formula (1):

$$RS = \frac{V_{IREF}}{I_{CHG}} \quad (1)$$

The charge-current reference is controlled by CR to set the charge rate. If CR is logic high, V_{IREF} is fixed at 0.16V internally. Pull CR low to set the charger in slow-charge (V_{IREF} is set to 0.016V).

Timer Setting

TMR is used to set the internal oscillator frequency. Refer to timer-setting formulas below:

Pre-charge timer

$$T_{Pre\text{-}1P}(s) = 34560 \times C(uF) \quad (2)$$

Total-charge timer:

Fast charge:

$$T_{Total\text{-}1P\text{-}fast}(s) = 69120 \times C(uF) \quad (3)$$

Slow charge:

$$T_{Total\text{-}1P\text{-}slow}(s) = 276480 \times C(uF) \quad (4)$$

Choosing the Resistor for NTC Sensor

Figure 9 shows an internal resistor-divider reference circuit to limit the four temperature thresholds at 90%·LDO, 77%·LDO, 32%·LDO, and 25%·LDO, respectively (to specify operation under cold, cool, warm, and hot conditions). For a given NTC thermistor, select appropriate R_{T1} and R_{T2} to set the NTC window:

$$\frac{R_{T2}//R_{NTC\_Cold}}{R_{T1}+R_{T2}//R_{NTC\_Cold}} = \frac{V_{T1}}{LDO} = 90\% \quad (5)$$

$$\frac{R_{T2}//R_{NTC\_Cool}}{R_{T1}+R_{T2}//R_{NTC\_Cool}} = \frac{V_{T2}}{LDO} = 77\% \quad (6)$$

$$\frac{R_{T2}//R_{NTC\_Warm}}{R_{T1}+R_{T2}//R_{NTC\_Warm}} = \frac{V_{T3}}{LDO} = 32\% \quad (7)$$

$$\frac{R_{T2}//R_{NTC\_Hot}}{R_{T1}+R_{T2}//R_{NTC\_Hot}} = \frac{V_{T4}}{LDO} = 25\% \quad (8)$$

R_{NTC_Hot} is the value of the NTC resistor at the highest temperature of the required temperature-operation range. R_{NTC_Cold} is the value of the NTC resistor at the lowest temperature.

The two resistors (R_{T1} and R_{T2}), allow the high-temperature limit and low-temperature limit to be programmed independently.

It should satisfy the 4 equations above. Refer to Figure 9 for NTC function block.

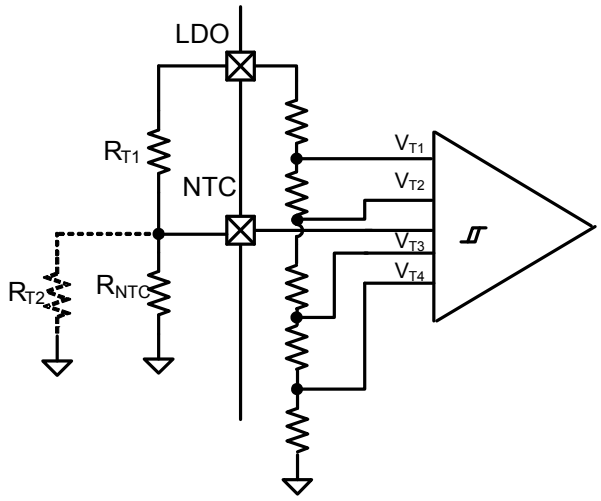


Figure 9. NTC Function Block

PCB Layout Guidelines

Efficient PCB layout is critical to meet specified noise, efficiency, and stability requirements. Refer to Figure 10 and the following design considerations to improve circuit performance:

1) Route the power stage adjacent to their grounds. Trace lengths in the high-current paths and the current-sense resistor trace.

2) Keep the power ground away from all small control signals, especially the feedback network.

3) Place the input capacitor as close as possible to VDD and PGND.

4) IFB and VFB are sensitive. Make the compensation components between FB and COMP close to the pins.

5) The PCB should have a ground plane connected directly to the return of all components through vias (two vias per capacitor for power-stage capacitors, one via per capacitor for small-signal components). If possible, it is recommended to place vias inside the PGND pads. Typically, a star-ground design approach is used to keep circuit-block currents isolated (high-power/low-power, small-signal), which reduces noise-coupling and ground-bounce issues.

6) A single ground plane for this design produces good results. With the small layout and single ground plane, ground-bounce is not an issue. The segregated components minimize coupling between signals.

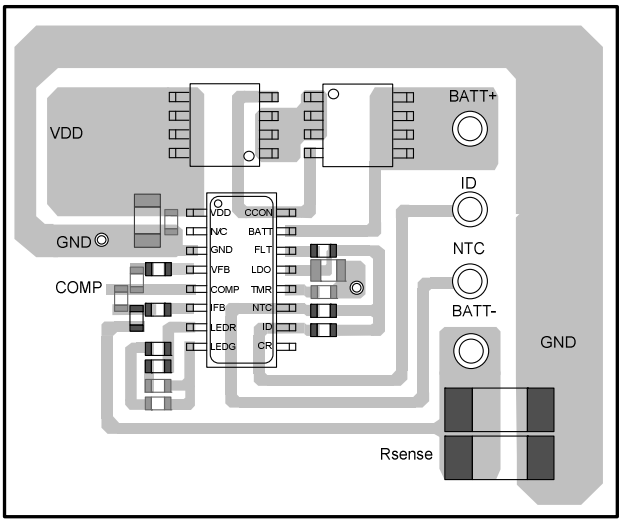
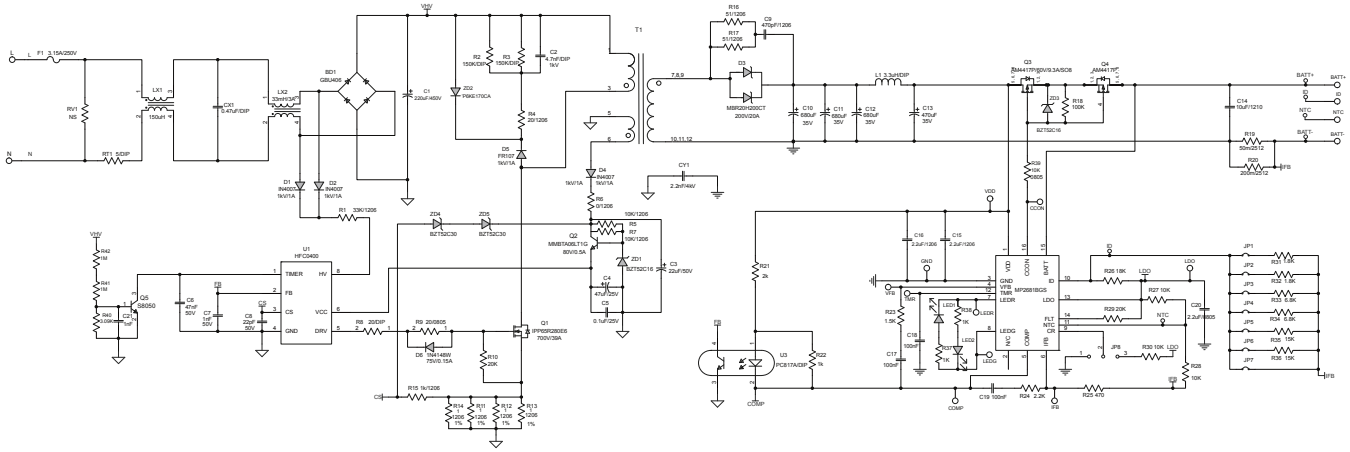


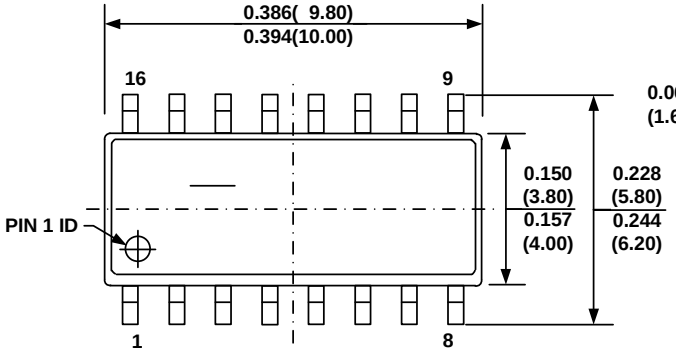
Figure 10. Recommended PCB Layout

TYPICAL APPLICATION CIRCUITS

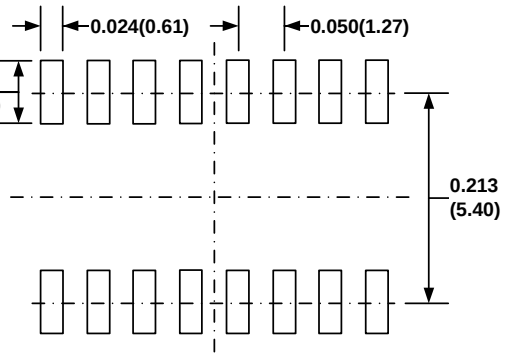


PACKAGE INFORMATION

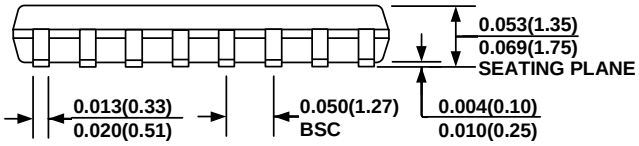
SOIC-16



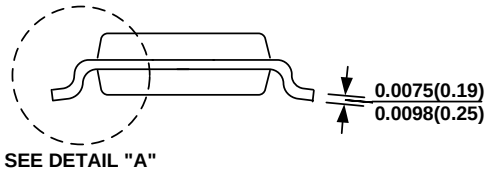
TOP VIEW



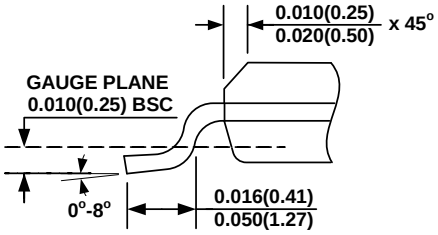
RECOMMENDED LAND PATTERN



FRONT VIEW



SIDE VIEW



DETAIL "A"

NOTE:

1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5) DRAWING CONFORMS TO JEDEC MS-012, VARIATION AC.
6) DRAWING IS NOT TO SCALE.