MP2615C

2.1A, 1-Cell or 2-Cell Li-Ion Battery Charger in (3mmx3mm) Package

DESCRIPTION

The MP2615C is a high-efficiency, switch-mode battery charger suitable for single-cell or dual-cell Li-ion or Li-polymer applications. The device is capable of delivering 2.1A of charge current, which can be configured via an accurate current-sense resistor across the entire input range.

The MP2615C regulates the charge current and full battery voltage using two control loops to achieve high-accuracy constant current (CC) charge and constant voltage (CV) charge.

Constant-off-time (COT) control allows the device to operate up to 99% duty cycle when the battery voltage is close to the input voltage. This maintains a relatively high charging current.

The battery temperature and charging statuses are always monitored during each charging cycle. Two status monitor output pins are provided to indicate the battery charging status and input power status. The MP2615C also features internal reverse blocking protection.

The MP2615C is available in a QFN-16 (3mmx3mm) package.

FEATURES

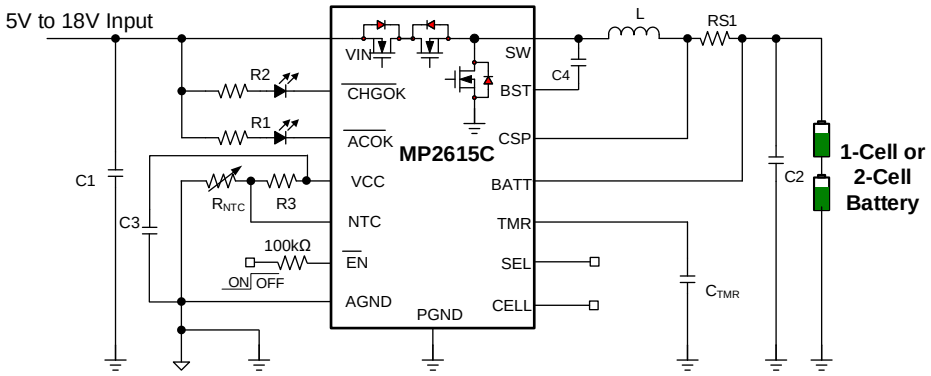
- 4.75V to 18V Operating Input Voltage
- Up to 99% Duty Cycle Operation
- Up to 2.1A Configurable Charging Current
- ±0.75% Full Battery Voltage Accuracy
- 4.1V/Cell and 4.2V/Cell Selection for Full Battery Voltage
- Fully Integrated Power Switches
- Internal Loop Compensation
- No External Reverse Blocking Diode Required
- Preconditioning for Fully Depleted Battery
- Charging Operation Indicator
- Configurable Safety Timer
- Thermal Shutdown Protection
- Cycle-by-Cycle Over-Current Protection
- Battery Temperature Monitoring and Protection
- Available in a QFN-16 (3mmx3mm) Package

APPLICATIONS

- Smartphones
- Portable Handheld Solutions
- Portable Media Players

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TYPICAL APPLICATION



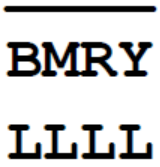
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ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MP2615CGQ	QFN-16 (3mmx3mm)	*See Below*	1

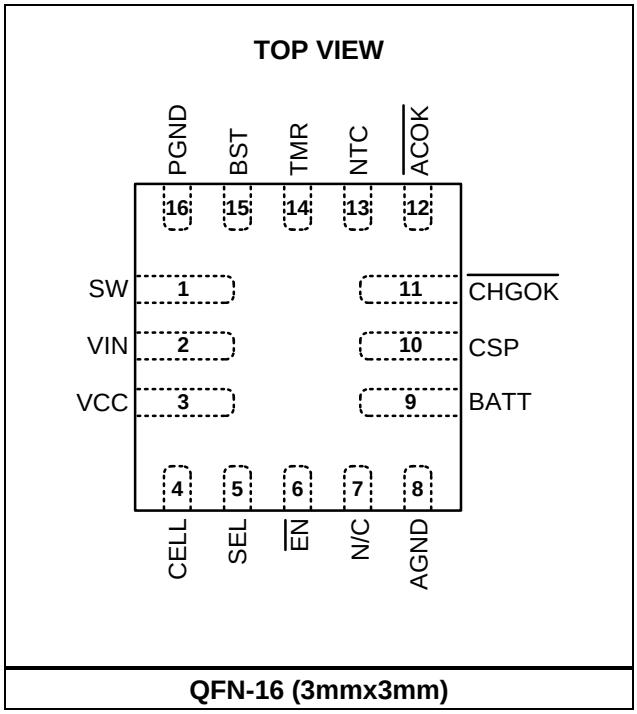
* For Tape & Reel, add suffix –Z (e.g. MP2615CGQ–Z).

TOP MARKING



BMR: Product code of MP2615CGQ
Y: Year code
LLLL: Lot number

PACKAGE REFERENCE



QFN-16 (3mmx3mm)

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PIN FUNCTIONS

Pin #	Name	Description
1	SW	**Switch output.**
2	VIN	**Power supply voltage.**
3	VCC	**Coarse regulator output.** Internally generated 4.5V. Bypass VCC with a 1µF capacitor to AGND. VCC can be used as a low-side switch driver and a pull-up bias voltage NTC resistor divider. Do not connect any external load to VCC.
4	CELL	**Command input for the number of Li-ion cells.** Connect this pin to VCC for single-cell applications. Float the CELL pin or short it to AGND for dual-cell applications.
5	SEL	**Input pin for setting terminal battery voltage.** If SEL is pulled low or floating, V_{BATT} is 4.2V/cell. If SEL is pulled high, V_{BATT} is 4.1V/cell.
6	$\overline{EN}$	**On/off control input.** This pin is pulled to GND with a 1MΩ internal resistor. It is recommended to connect a 100kΩ resistor in series with the EN pin.
7	N/C	**No connection.** Leave this pin floating.
8	AGND	**Analog ground.**
9	BATT	**Positive battery terminal.**
10	CSP	**Battery current-sense positive input.** Connect a resistor (RS1) between CSP and BATT.
11	$\overline{CHGOK}$	**Charging completion indicator.** When this pin goes logic low, the device is charging. The pin becomes an open drain once the charge is completed or suspended.
12	$\overline{ACOK}$	**Valid input supply indicator**. A logic low on this pin indicates the presence of a valid input power supply.
13	NTC	**Thermistor input.** Connect a resistor from this pin to the VCC pin. Connect the thermistor from this pin to ground.
14	TMR	**Internal safety timer control.** Connect a capacitor from this node to AGND to set the timer. Disable the timer by connecting this pin directly to AGND.
15	BST	**Bootstrap pin.** Use a capacitor to drive the power switch's gate above the supply voltage. The capacitor should be connected between the SW and BST pins to form a floating supply across the power switch driver.
16	PGND	**Power ground.**

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ABSOLUTE MAXIMUM RATINGS (1)

V_{SW} .....-0.3V to +23V
V_{IN}, V_{ACOK}, V_{CHGOK}.....-0.3V to +23V
V_{BATT}, V_{CSP}.....-0.3V to +12V
V_{BST} ..... V_{SW} + 6V
All other pins .....-0.3V to +6V
Junction temperature .....150°C
Lead temperature.....260°C
Continuous power dissipation (T_A = 25°C) (2)
..... 2.5W
Operating temperature..... -40°C to +85°C

ESD Ratings

Charged device model (CDM).....1250V

Recommended Operating Conditions (3)

V_{IN}..... 4.75V to 18V
V_{BATT}.....2V to 8.4V
Operating junction temp (T_J) ..... -40°C to +85°C

Thermal Resistance (4) θ_{JA} θ_{JC}

QFN-16 (3mmx3mm)	50	12	°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 can cause excessive die temperature, and the regulator may 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.

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ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, V_{CELL} = 0V, V_{SEL} = 0V, C1 = 22µF, C2 = 22µF, T_A = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input Voltage and Current						
Input voltage	V_{IN}	V_{CELL} = 4V	4.5	5	18	V
		V_{CELL} = 0V	8.75	12	18	
Under-voltage lockout rising threshold	V_{UVLO}		3.55	3.75	3.95	V
Under-voltage lockout threshold hysteresis				225		mV
Supply current	I_{SHDN}	$\overline{EN}$ = 4V, shutdown current		0.27		mA
	I_Q	$\overline{EN}$ = 0V, quiescent current		1.1		
Power MOSFET						
High-side switch on resistance	$R_{H_DS(ON)}$	Measured from VIN to SW		110		mΩ
Low-side switch on resistance	$R_{L_DS(ON)}$			110		mΩ
Switch leakage		$\overline{EN}$ = 4V, V_{SW} = 0V		0	1	µA
Frequency and Time Parameter						
Switching frequency	f_{SW}	V_{BATT} = 7.5V		760		kHz
Foldback frequency		V_{BATT} = 0V		160		kHz
Minimum off time (5)	t_{OFF}	V_{BATT} = 9V		200		ns
Charging Parameter						
Terminal battery voltage	V_{BATT_FULL}	V_{SEL} = 0V	4.168	4.2	4.231	V/cell
		V_{SEL} = 4V	4.069	4.1	4.131	
Battery over-voltage threshold	V_{BOVP}	V_{CELL} = 0V, V_{SEL} = 0V	8.34	8.71	9.08	
		V_{CELL} = 0V, V_{SEL} = 4V	8.14	8.51	8.88	
		V_{CELL} = 4V, V_{SEL} = 0V	4.17	4.36	4.54	
		V_{CELL} = 4V, V_{SEL} = 4V	4.07	4.26	4.44	
Recharge threshold at V_{BATT}	V_{RECH}	V_{SEL} = 0V		4.0		
		V_{SEL} = 4V		3.9		
Recharge hysteresis				150		mV/cell
Trickle-charge voltage threshold	V_{TC}	V_{SEL} = 0V		3		V/cell
		V_{SEL} = 4V		2.91		
Trickle charge hysteresis				225		mV/Cell
Peak current limit		Constant current charge	3.2			A
		Trickle		2.2		
CC current	I_{CC}	RS1 = 25mΩ	1.9	2.1	2.3	A
Trickle charge current	I_{TC}		5%	10%	15%	I_{CC}
Termination current threshold	I_{BF}		5%	10%	15%	I_{CC}
V_{IN} minimum headroom (reverse blocking)		V_{IN} - V_{BATT}		300		mV

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ELECTRICAL CHARACTERISTICS *(continued)*

V_{IN} = 12V, V_{CELL} = 0V, V_{SEL} = 0V, C1 = 22µF, C2 = 22µF, T_A = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Maximum current-sense voltage (CSP to BATT)	V_{SENSE}		45	50	55	mV
CSP, BATT current	I_{CSP}, I_{BATT}	Charging disabled			3	µA
ACOK/CHGOK open-drain sink current		V_{DRAIN} = 0.3V	5			mA
VCC Regulator Output						
VCC output voltage	V_{CC}		4.2	4.5	4.75	V
VCC load regulation	ΔV_{CC}	I_{LOAD} = 0 to 10mA			10	mV
EN Control						
$\overline{EN}$ input low voltage					0.4	V
$\overline{EN}$ input high voltage			1.8			V
$\overline{EN}$ input current	I_{EN}	$\overline{EN}$ = 4V		4		µA
		$\overline{EN}$ = 0V		0.2		
Logic						
CELL input low voltage	V_L				0.4	V
CELL input high voltage	V_H		1.8			V
SEL input low voltage	V_L				0.4	V
SEL input high voltage	V_H		1.8			V
Timer Protection						
Trickle charge time	$t_{TRICKLE_TMR}$	C_{TMR} = 0.47µF		30		min
CC/CV charge time	t_{TOTAL_TMR}	C_{TMR} = 0.47µF		165		
NTC Protection						
NTC cold temp rising threshold	V_{COLD}	R_{NTC} = NCP18X103, 0°C	72	73.3	74.6	% of V_{CC}
NTC cold temp rising threshold hysteresis				2		
NTC hot temp falling threshold	V_{HOT}	R_{NTC} = NCP18X103, 50°C	29.5	31.1	32.2	
NTC hot temp falling threshold hysteresis				2		
Thermal Protection						
Thermal shutdown (5)	T_{SHDN}			150		°C
Thermal shutdown hysteresis (5)				20		°C
Reverse Leakage Blocking						
Battery reverse leakage current	$I_{LEAKAGE}$	V_{CELL} = 0V			3	µA
		V_{CELL} = 4V			0.5	µA

Notes:

5) Guaranteed by design.

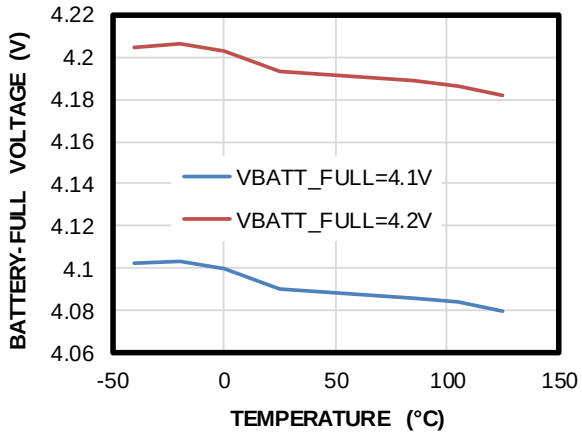
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TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 12V, C1 = C2 = 22µF, SEL = float/high, CELL = float/high, RS1 = 25mΩ, unless otherwise noted.

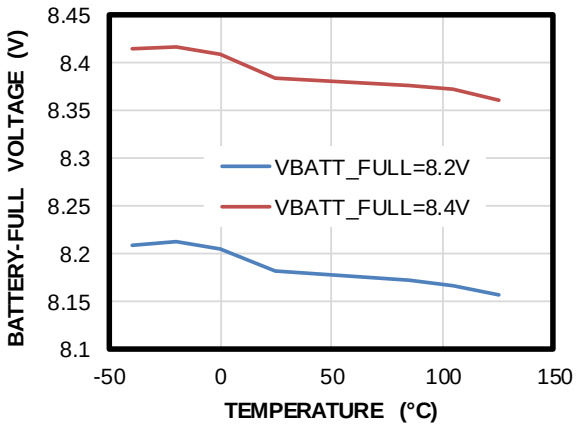
Battery-Full Voltage vs. Temperature

1-cell



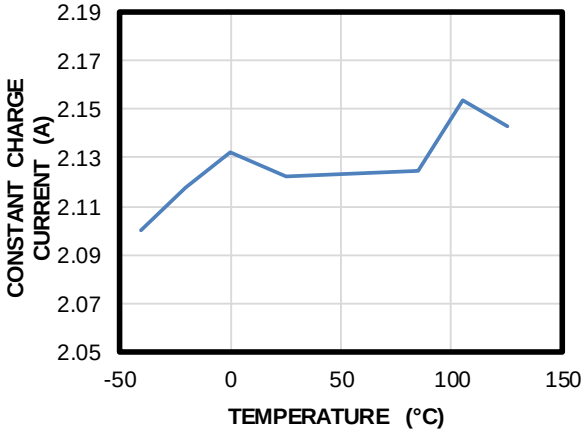
Battery-Full Voltage vs. Temperature

2-cell



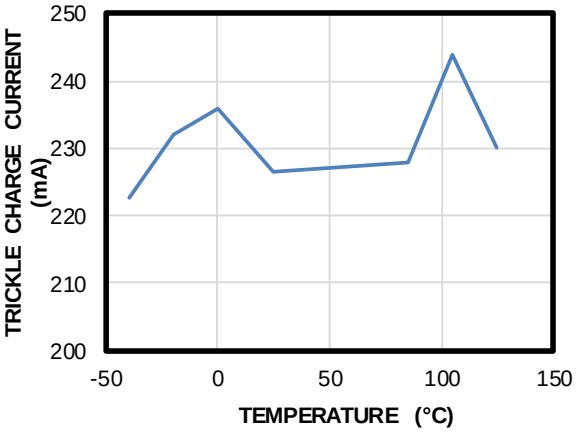
Constant Charge Current vs. Temperature

RS1 = 25mΩ



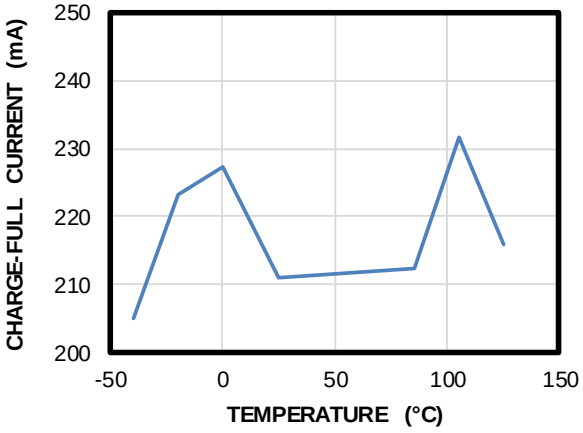
Trickle Charge Current vs. Temperature

RS1 = 25mΩ

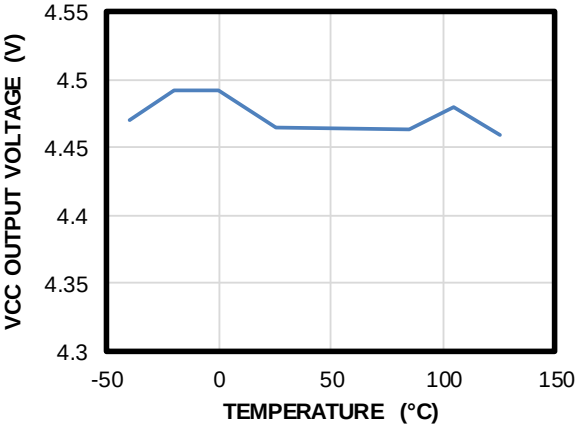


Charge-Full Current vs. Temperature

RS1 = 25mΩ



VCC Output Voltage vs. Temperature



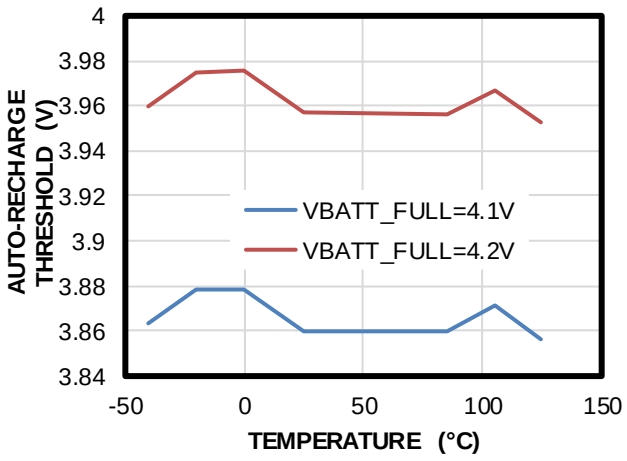
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TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 12V, C1 = C2 = 22µF, SEL = float/high, CELL = float/high, RS1 = 25mΩ, unless otherwise noted.

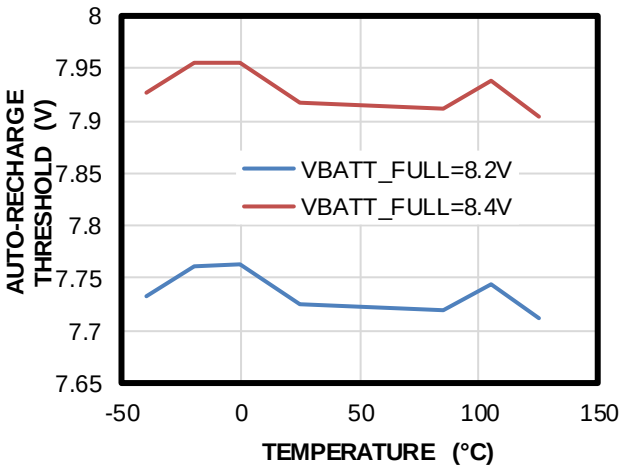
Auto-Recharge Threshold Voltage vs. Temperature

1-cell



Auto-Recharge Threshold Voltage vs. Temperature

2-cell



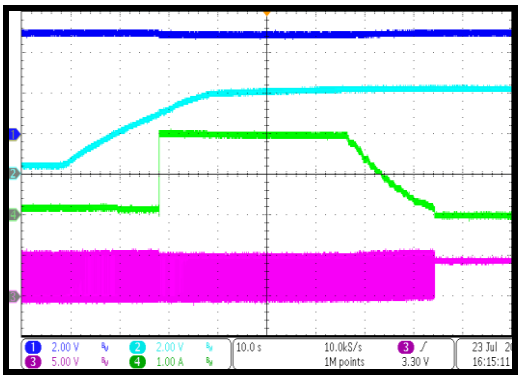
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TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 5V/9V, C1 = C2 = 22µF, SEL = float/high, CELL = float/high, L = 6.8µH, RS1 = 25mΩ, battery simulator, T_A = 25°C, unless otherwise noted.

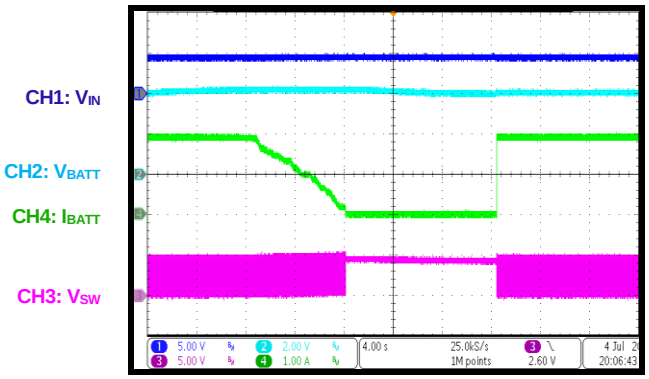
Battery Charge Curve

V_{IN} = 5V, 1-cell, $V_{BATTREG}$ = 4.2V



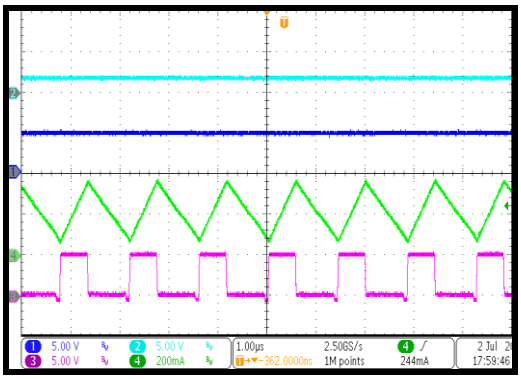
Auto-Recharge

V_{IN} = 5V, 1-cell, $V_{BATTREG}$ = 4.2V



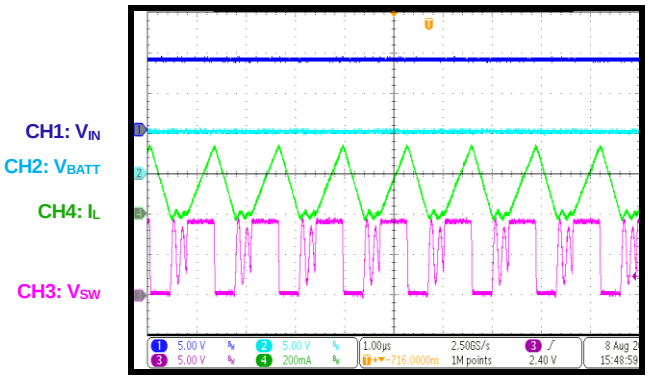
Trickle Charge Steady State

V_{IN} = 5V, 1-cell, V_{BATT} = 1.9V



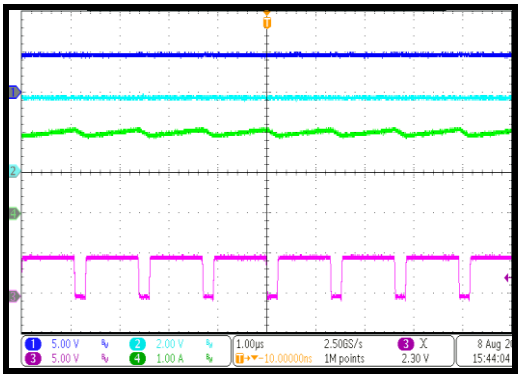
Trickle Charge Steady State

V_{IN} = 9V, 2-cell, V_{BATT} = 5.2V



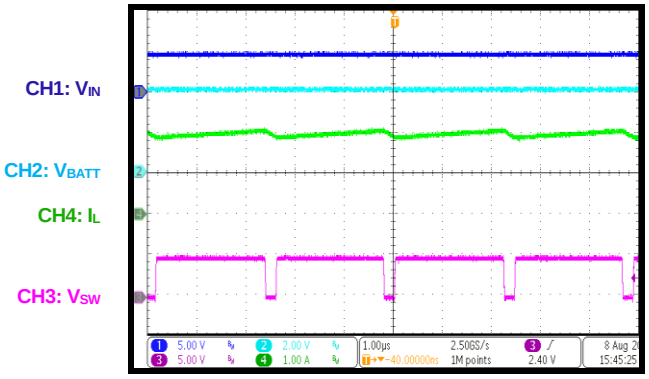
CC Charge Steady State

V_{IN} = 5V, 1-cell, V_{BATT} = 3.6V



CC Charge Steady State (COT)

V_{IN} = 5V, 1-cell, V_{BATT} = 4V



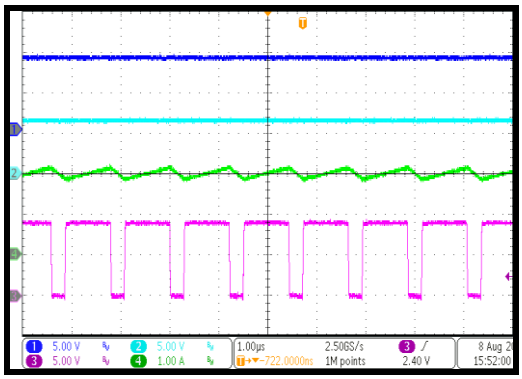
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TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 5V/9V, C1 = C2 = 22µF, SEL = float/high, CELL = float/high, L = 6.8µH, RS1 = 25mΩ, battery simulator, T_A = 25°C, unless otherwise noted.

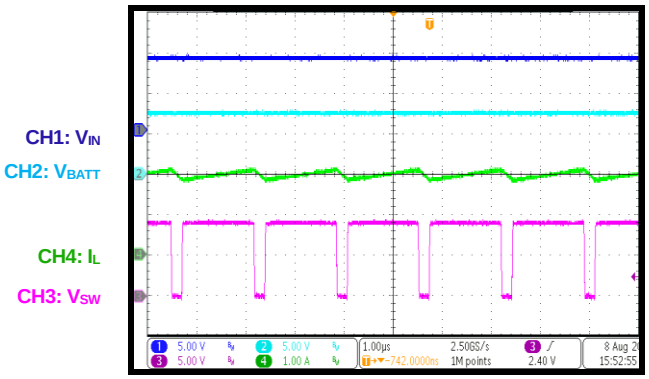
CC Charge Steady State

V_{IN} = 9V, 2-cell, V_{BATT} = 6.5V



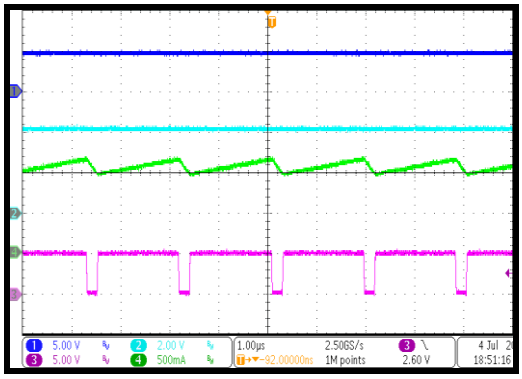
CC Charge Steady State (COT)

V_{IN} = 9V, 2-cell, V_{BATT} = 7.5V



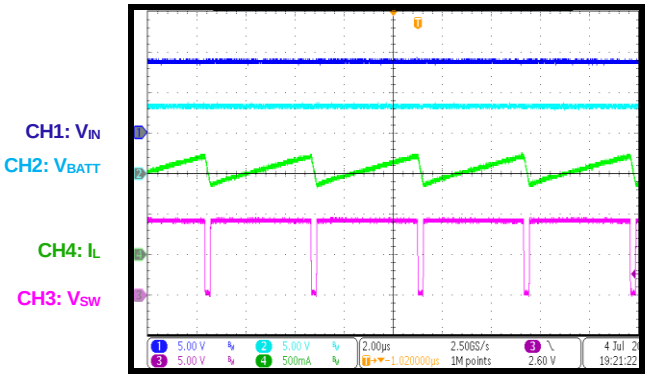
CV Charge Steady State

V_{IN} = 5V, 1-cell, V_{BATT} = 4.17V



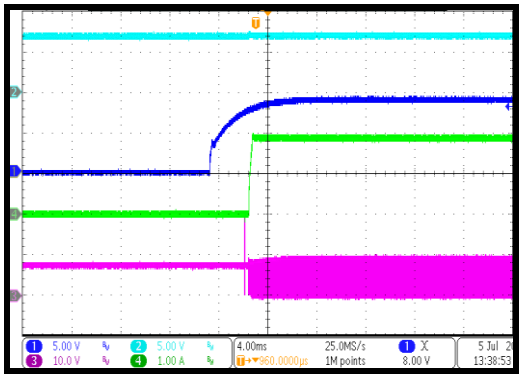
CV Charge Steady State

V_{IN} = 9V, 2-cell, V_{BATT} = 8.35V



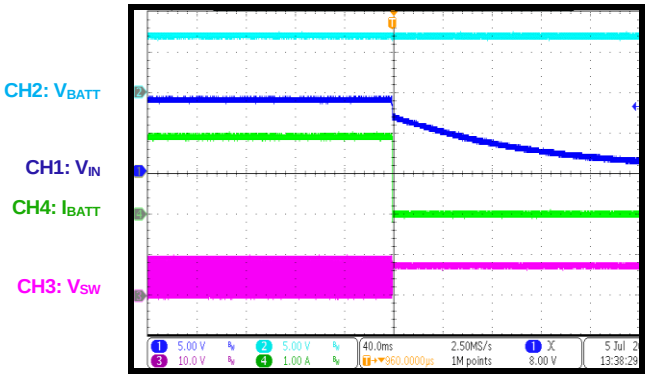
Start-Up, CC Charge Mode

V_{IN} = 9V, 2-cell, V_{BATT} = 7V



Shutdown, CC Charge Mode

V_{IN} = 9V, 2-cell, V_{BATT} = 7V



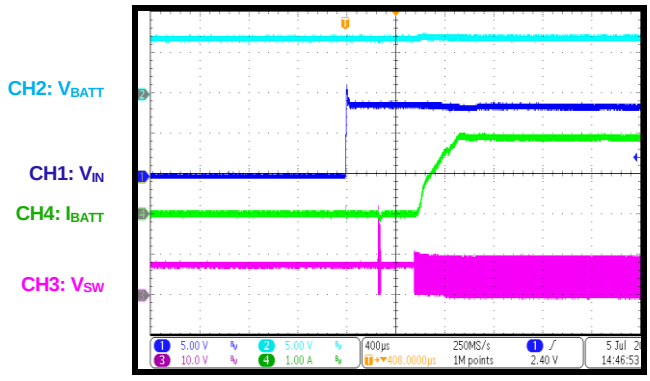
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TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

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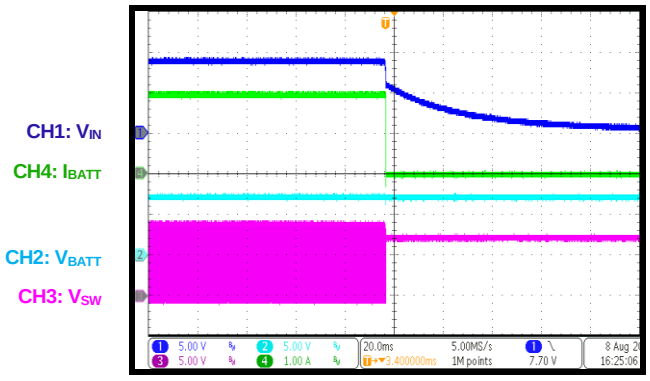
VIN Hot Insertion, CC Charge Mode

V_{IN} = 9V, 2-cell, V_{BATT} = 7V



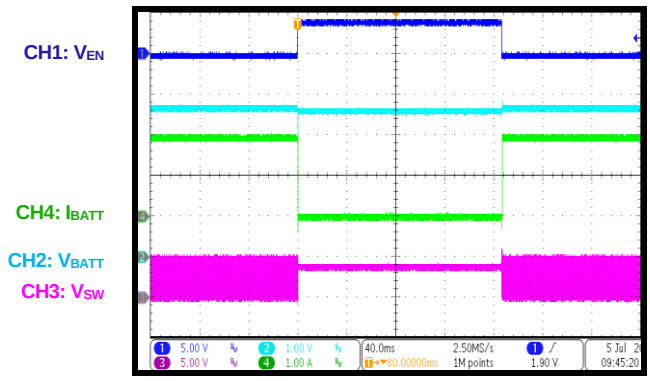
VIN Removal, CC Charge Mode

V_{IN} = 9V, 2-cell, V_{BATT} = 7V



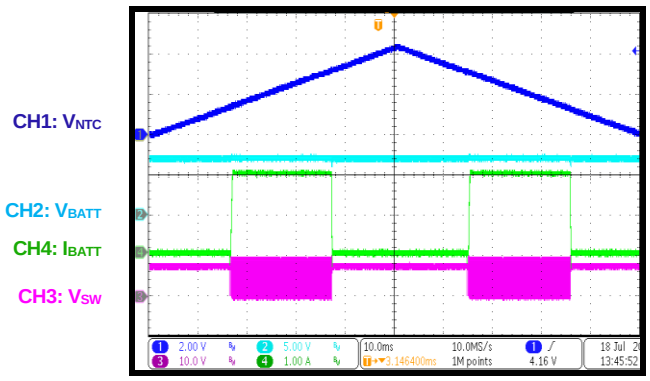
EN On/Off

V_{IN} = 5V, 1-cell, V_{BATT} = 3.6V



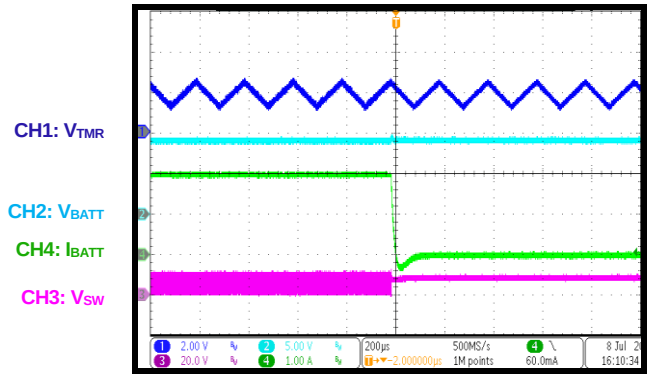
NTC Fault Control

V_{IN} = 9V, 2-cell, V_{BATT} = 7V



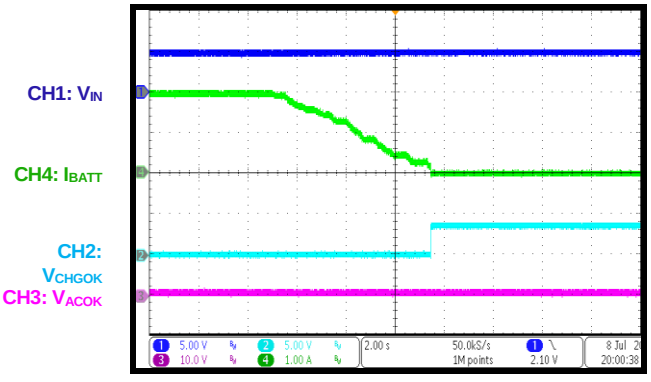
Timeout

V_{IN} = 9V, 2-cell, V_{BATT} = 7V, I_{CC} = 2A, C_{TMR} = 470pF



Charge-Full Indication

V_{IN} = 5V, 1-cell, V_{BATT} = 3.6V



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FUNCTIONAL BLOCK DIAGRAM

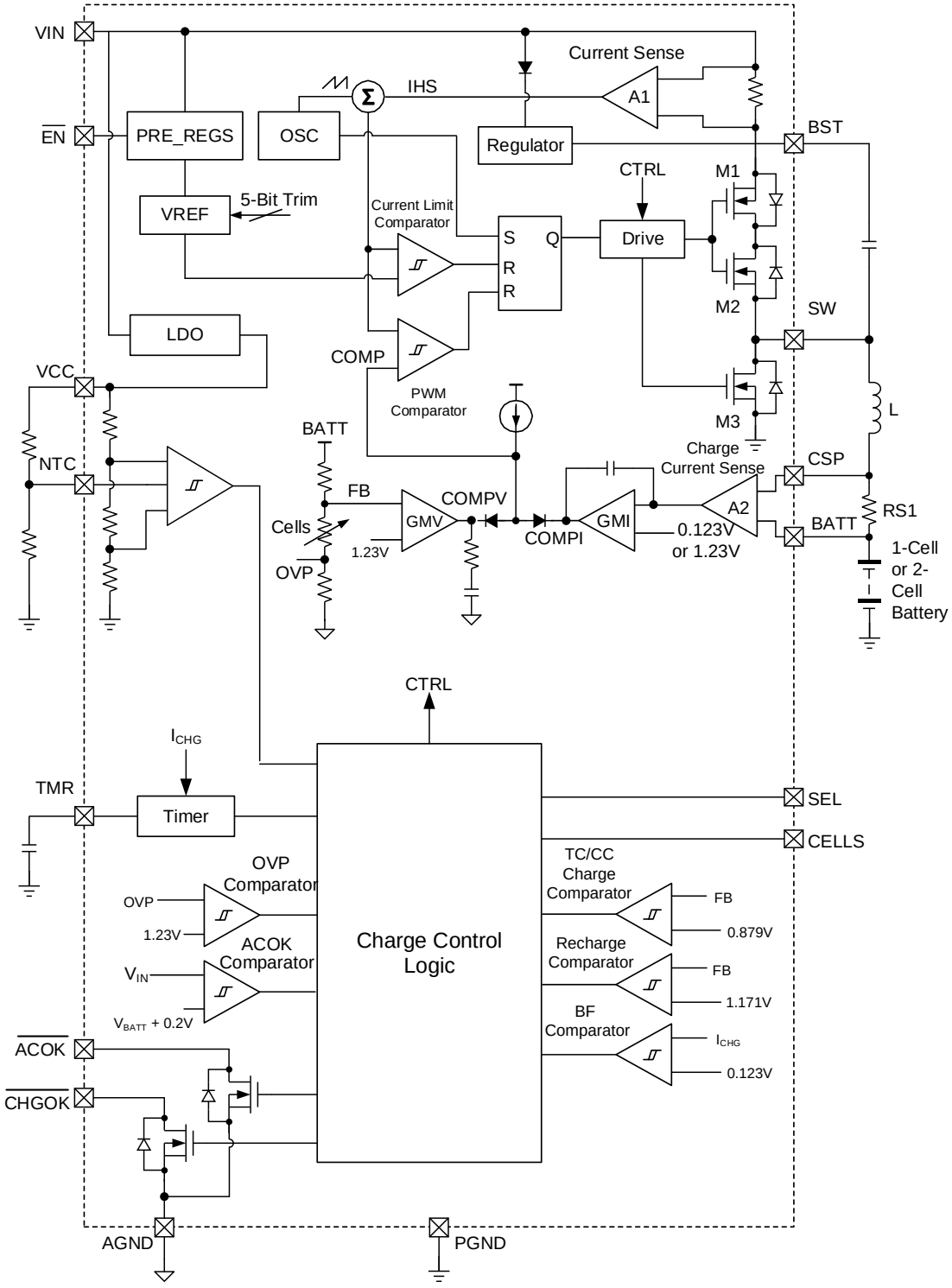


Figure 1: Functional Block Diagram

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OPERATION

The MP2615C is a peak current mode control switching charger for single-cell or dual-cell Li-ion and Li-polymer batteries. The MP2615C integrates both the high-side and low-side MOSFETs of the synchronous buck converter to provide high efficiency and reduce PCB size.

Charge Cycle (Mode Change: TC to CC to CV)

The MP2615C regulates the charge current (I_{CHG}) and battery voltage (V_{BATT}) using two control loops to achieve highly accurate constant current (CC) charge and constant voltage (CV) charge.

If V_{BATT} is below V_{TC}, the MP2615C remains in trickle charge mode, and the output of the charge current loop (COMPI) dominates the control (see Figure 2). The battery is charged by a trickle charge current (I_{TC}) until the battery voltage reaches V_{TC}. If the charger remains in trickle charge mode until the trickle charge timer is triggered, charging is terminated.

The MP2615C enters CC charge mode once the battery voltage exceeds V_{TC}. In this mode, the charge current increases from I_{TC} to I_{CC} to fast charge the battery.

If the battery voltage exceeds the battery-full voltage (V_{BATT_FULL}), the charger enters CV mode. In CV mode, the battery voltage is regulated at V_{BATT_FULL}, and the charge current falls naturally due to the existing equivalent internal resistance of the battery. Figure 4 shows an operation flowchart.

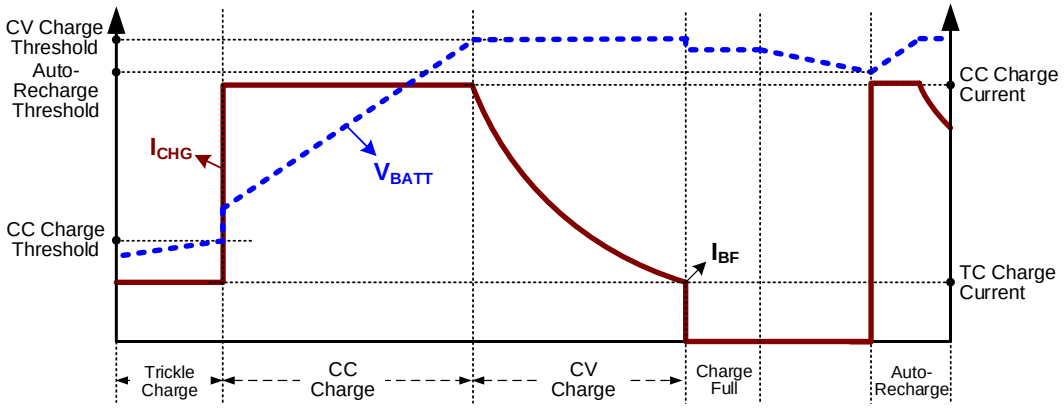


Figure 2: Li-Ion Battery Charge Profile

Charge Full Termination and Auto-Recharge

If the charge current drops below the termination threshold (I_{BF}) during the CV charge phase, the charger stops charging and the $\overline{\text{CHGOK}}$ pin becomes an open drain. The timer resets and turns off. Once the battery voltage drops below the recharge threshold (V_{RECH}) (4.0V/cell while the SEL pin is connected to AGND), recharging automatically begins and the timer restarts a new charge cycle.

Constant-Off-Time (COT) Charge Mode

The MP2615C uses the floating ground method to drive the buck converter's high-side MOSFET (HS-FET). While the HS-FET is off, the BST capacitor is recharged, and the voltage across the capacitor is used as the HS-FET's gate driver. Thus a minimum off time of 200ns is required to maintain sufficient voltage at the BST capacitor.

When the 200ns minimum off time is achieved due to a large duty cycle, the MP2615C enters constant-off-time (COT) charge mode. In this mode, the switching frequency is slightly reduced to achieve a 99% duty cycle.

Charge Status Indication

The MP2615C has two open-drain status outputs: the $\overline{\text{CHGOK}}$ and $\overline{\text{ACOK}}$ pins. The $\overline{\text{ACOK}}$ pin goes low when the input voltage exceeds the battery voltage and the under-voltage lockout (UVLO) threshold by 300mV. The $\overline{\text{CHGOK}}$ pin indicates the status of the charge cycle.

Table 1 lists the operation for both $\overline{\text{CHGOK}}$ and

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$\overline{ACOK}$ according to the charger status.

Table 1: Charging Status Indication

$\overline{ACOK}$	$\overline{CHGOK}$	**Charger Status**
Low	Low	Charging
Low	High impedance	• End of charging • NTC fault has occurred • Timer ran out • $\overline{EN}$ disabled • Thermal shutdown
High impedance	High impedance	• V_{IN} absent • V_{IN} - V_{BATT} < 0.3V

Safety Timer Operation

The MP2615C has an internal safety timer to terminate charging during timeout. The capacitor (C_{TMR}) connected between the TMR pin and GND is used to set the internal oscillator period, calculated with Equation (1):

$$t_P(\text{seconds}) = 0.46 \times C_{TMR}(\mu F) \quad (1)$$

This timer limits the maximum trickle charge time to 8192 internal oscillating periods. If the charger remains in trickle charge mode for longer than the maximum oscillating periods, charging is terminated and $\overline{CHGOK}$ becomes an open drain to indicate a timeout fault. If the charge cycle successfully completes trickle charge within the allowed time limit, it enters CC charge mode and the timer continues to count the oscillating periods. When the battery is fully charged, the timer turns off and clears the counter, waiting for the auto-recharge to restart.

If the charge time during CC/CV mode exceeds 49152 oscillating periods, and the battery-full condition has not been met, charging is terminated and a timeout fault is indicated by floating the $\overline{CHGOK}$ pin. The charger can exit the timeout fault state (and restart the on-chip safety timer) when one of the following conditions occurs:

- The battery voltage falls below the auto-recharge threshold (V_{RECH})
- A power-on reset (POR) event occurs
- The $\overline{EN}$ pin is toggled

The timer can be disabled by pulling the TMR pin to AGND.

The trickle mode charge time can be estimated with Equation (2):

$$t_{TRICKLE_TMR}(\text{minutes}) = 62.8 \times C_{TMR}(\mu F) \quad (2)$$

If C_{TMR} is 0.47µF, the trickle charge time is about 30 minutes. The CC/CV mode charge time can be calculated with Equation (3):

$$t_{TOTAL_TMR}(\text{hours}) = 6.28 \times C_{TMR}(\mu F) \quad (3)$$

In this case, if C_{TMR} is 0.47µF, the CC/CV charge time is 2.95 hours.

Negative Thermal Coefficient (NTC) Thermistor

The NTC pin allows the MP2615C to sense the battery temperature using the negative thermal coefficient (NTC) resistor in the battery pack. This ensures a safe operating environment for the battery. A resistor with an appropriate value should be connected from the VCC pin to the NTC pin, and the thermistor should be connected from the NTC pin to AGND. The voltage on the NTC pin is determined by the resistor divider, which has a divide ratio that depends on the battery temperature. When the voltage at the NTC pin falls out of the NTC window range, charging pauses until the battery temperature returns to within the normal operating range.

As a result, the MP2615C stops charging and reports this condition to the status pins. Charging automatically resumes after the temperature returns to within a safe range.

Short-Circuit Protection

The MP2615C has an internal comparator to check for battery short-circuit conditions. If V_{BATT} falls below 2V, the device detects a battery short status, and the cycle-by-cycle peak current limit falls to about 2.2A to limit the current spike during the battery short transition. The switching frequency also folds back to minimize the power loss.

Thermal Shutdown Protection

To prevent the chip from overheating while it charges, the MP2615C monitors the junction temperature (T_J) of the die. If T_J reaches the thermal shutdown threshold (T_{SHTDWN}) of 150°C, the charger converter turns off. Once T_J falls below 130°C, charging resumes.

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INPUT POWER START-UP TIMING FLOW

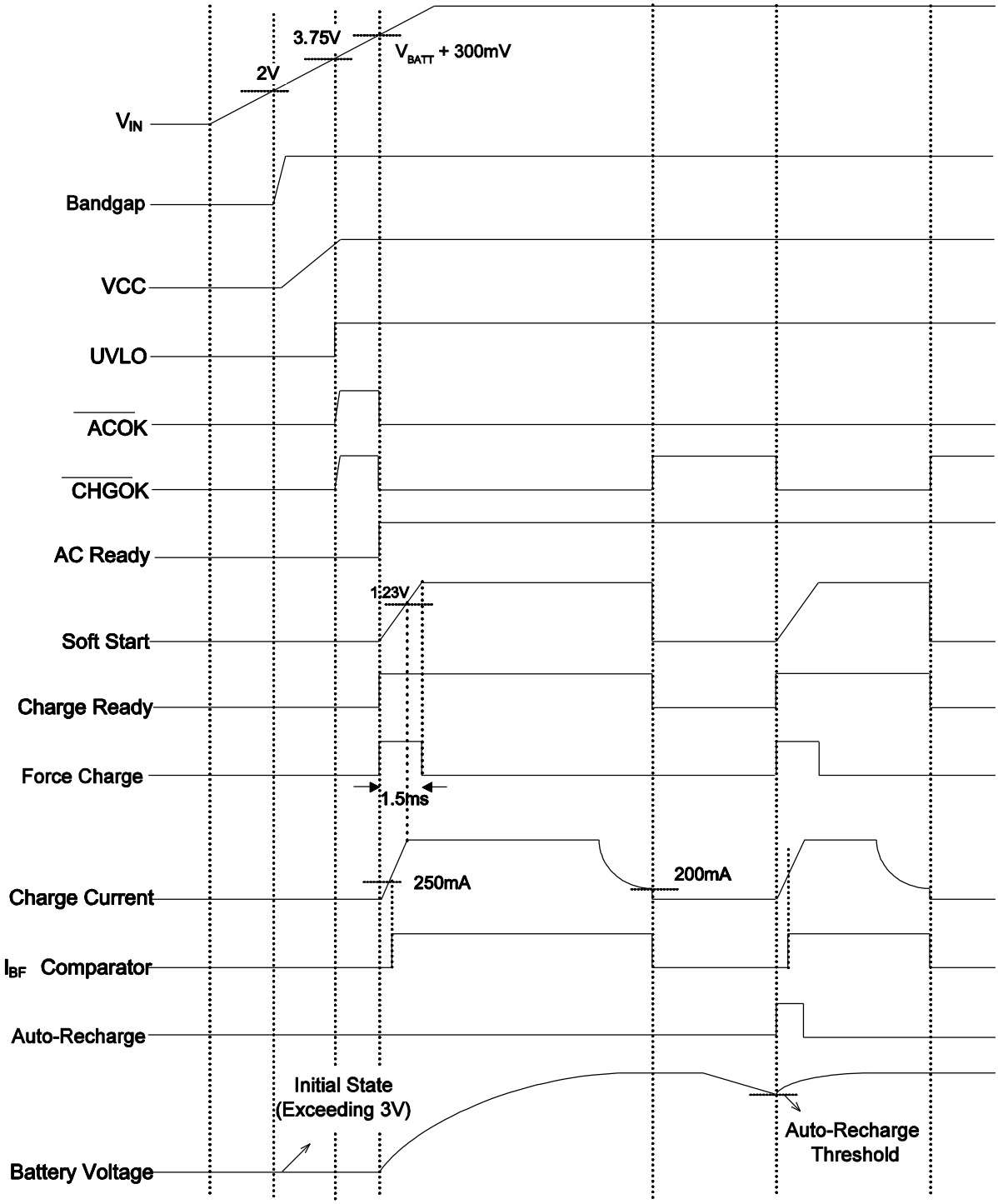


Figure 3: Input Power Start-Up Timing Diagram

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OPERATION FLOWCHART

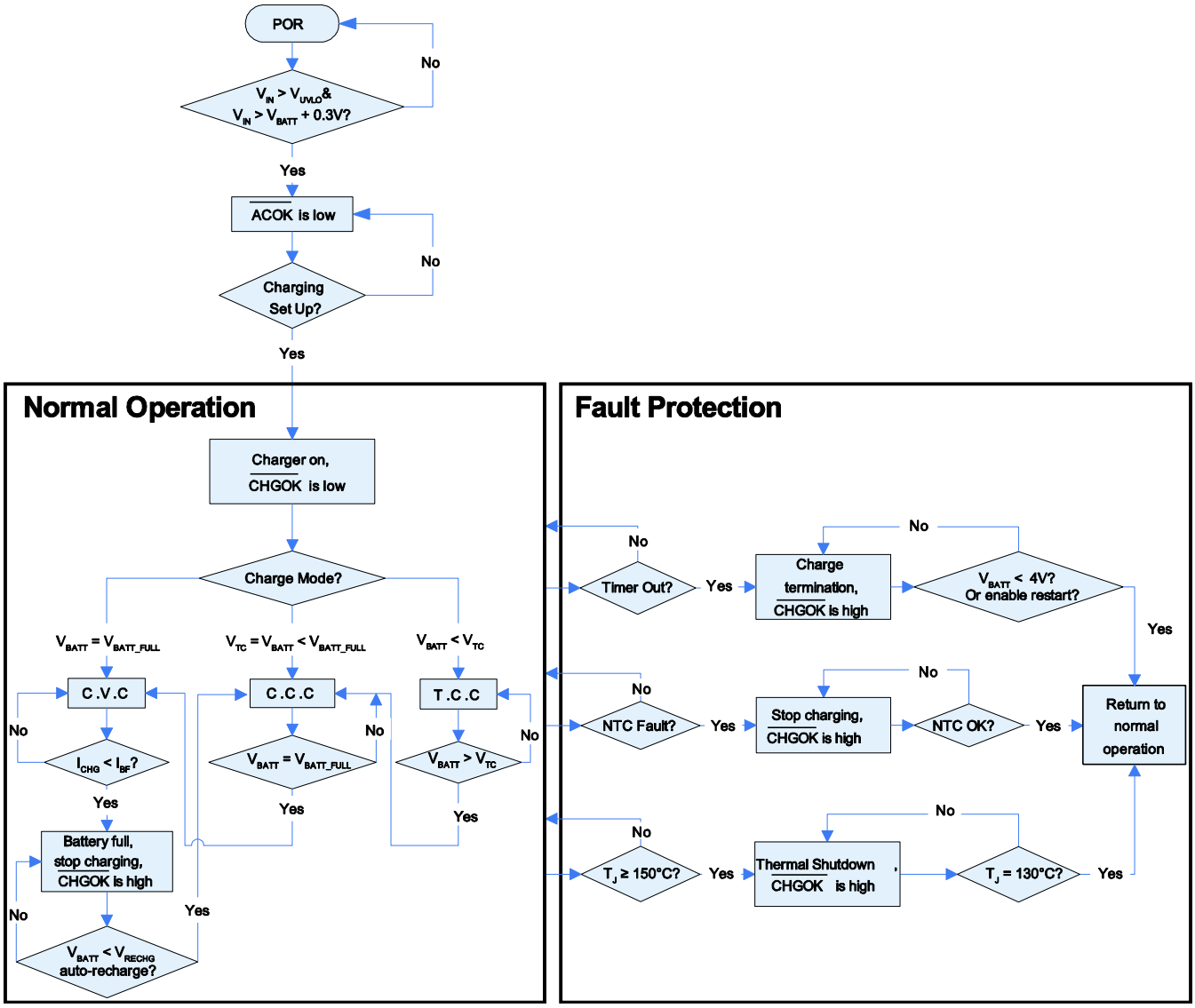


Figure 4: Operation Flowchart

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APPLICATION INFORMATION

COMPONENT SELECTION

Charge Current Setting

The MP2615C's constant charge current (I_{CC}) can be set via the sense resistor (RS1) (see the Typical Application Circuit section on page 18). Calculate the constant current (CC) charge with Equation (4):

$$I_{CC} = \frac{52.5mV}{RS1(m\Omega)}(A) \quad (4)$$

If I_{CC} is 2.1A, choose RS1 to be 25mΩ.

The trickle charge current (I_{TC}) can be estimated with Equation (5):

$$I_{TC} = 0.10 \times I_{CC} \quad (5)$$

Selecting the Inductor

To select the optimal inductor, a tradeoff should be made between cost, size, and efficiency. An inductor with a lower-value inductance has the benefit of a smaller size, but also has higher ripple currents, magnetic hysteretic losses, and output capacitance. Conversely, a higher-value inductor lowers the ripple current and allows for the use of smaller output filter capacitors, but it also results in higher inductor DC resistance (DCR) loss.

Based on practical experience, the inductor ripple current should not exceed 30% of the maximum charge current under the worst-case conditions. For the MP2615C, with a typical 12V input voltage to charge a 2-cell battery, the maximum inductor current ripple occurs at the corner point between trickle charge and CC charge (V_{BATT} = 6V). The inductance can be calculated with Equation (6):

$$L = \frac{V_{IN}\text{-}V_{BATT}}{\Delta I_{L_MAX}} \frac{V_{BATT}}{V_{IN} \times f_{SW}} \quad (6)$$

Where V_{IN} is the input voltage, V_{BATT} is the CC charge threshold, and f_{SW} is the switching frequency.

ΔIL_MAX is the maximum inductor ripple current, which is usually 30% of the CC charge current, calculated with Equation (7):

$$\Delta I_{L_MAX} = 0.30 \times I_{CC} \quad (7)$$

If V_{BATT} = 6V and f_{SW} = 760kHz, the calculated inductance is 6.6µH. The inductor saturation current must exceed 2.6A and have some tolerance. To optimize efficiency, choose an inductor with a DC resistance below 50mΩ.

NTC Resistor Divider Selection

Figure 5 shows how an internal resistor divider sets the cold temperature threshold and hot temperature threshold at 73.3% of V_{CC} and 31.1% of V_{CC}, respectively.

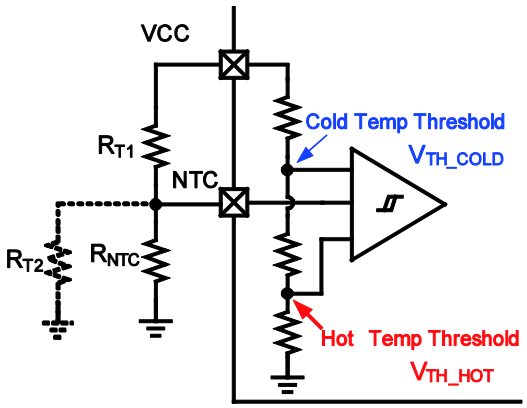


Figure 5: NTC Functional Block

The thermistor (NCP18XH103) in Figure 5 has the following electrical characteristics:

- At 0°C, R_{NTC_COLD} = 27.445kΩ
- At 50°C, R_{NTC_HOT} = 4.1601kΩ

For a given NTC thermistor, select values for R_{T1} and R_{T2} to set the NTC window. Assuming that the NTC window is between 0°C and 50°C, the cold and hot thresholds can be calculated with Equation (8) and Equation (9), respectively:

$$\frac{R_{T2}//R_{NTC_COLD}}{R_{T1} + R_{T2}//R_{NTC_COLD}} = V_{COLD} = 73.3\% \quad (8)$$

$$\frac{R_{T2}//R_{NTC_HOT}}{R_{T1} + R_{T2}//R_{NTC_HOT}} = V_{HOT} = 31.1\% \quad (9)$$

The required battery temperature range can be paired with Equation (8) and Equation (9) to calculate R_{T1} and R_{T2}.

Selecting the Input Capacitor

The input capacitors (C1) from the typical application circuit absorb the maximum ripple current from the buck converter, which can be

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estimated with Equation (10):

$$I_{RMS_MAX} = I_{CC} \frac{\sqrt{V_{TC} \times (V_{IN_MAX} - V_{TC})}}{V_{IN_MAX}} \quad (10)$$

If I_{CC} = 2A, V_{TC} = 6V, and V_{IN_MAX} = 18V, the maximum ripple current is 1A. Select the input capacitors so that the temperature rise due to the ripple current does not exceed 10°C. It is recommended to use ceramic capacitors with X5R or X7R dielectrics because of their low ESR and small temperature coefficients. For most applications, use a 22µF capacitor.

Selecting the Output Capacitor

The output capacitor (C2) is in parallel with the battery. C2 absorbs the high-frequency switching ripple current and smooths the output voltage. Its impedance must be below the battery's to ensure it absorbs the ripple current. Use a ceramic capacitor because it has a lower ESR and smaller size. The output voltage ripple can be calculated with Equation (11):

$$\Delta R_O = \frac{\Delta V_O}{V_O} = \frac{1 - \frac{V_O}{V_{IN}}}{8 \times C_O \times f_{SW}^2 \times L} \quad (11)$$

To guarantee u0.5% battery-full voltage accuracy, the maximum output voltage ripple should not exceed 0.5% (e.g. 0.1%). The maximum output voltage ripple occurs at the minimum battery voltage of the CC charge and the maximum input voltage.

If V_{IN_MAX} = 18V, V_{CC_MIN} = V_{TC} = 6V, L = 6.8µH, f_{SW} = 760kHz, and ΔR_{O_MAX} = 0.1%, the output capacitor can be calculated with Equation (12):

$$C_O = \frac{1 - \frac{V_{TC}}{V_{IN_MAX}}}{8 \times f_{SW}^2 \times L \times \Delta R_{O_MAX}} = 21.3\mu F \quad (12)$$

In this case, choose a 22µF ceramic capacitor.

PCB Layout Guidelines

Proper PCB layout is important to meet specified noise, efficiency and stability requirements. For the best results, refer to Figure 6 and follow the guidelines below:

1. Route the power stage adjacent to the grounds.
2. Aim to minimize the high-side switching node (SW, inductor) trace lengths in the high-current paths and the current-sense resistor trace.
3. Keep the switching node short, and route it away from the feedback network.
4. Connect the charge current-sense resistor to CSP (pin 10) and BATT (pin 9). Minimize the length and area of this circuit loop.
5. Place the input capacitor as close as possible to the VIN and PGND pins.
6. Place the output inductor as close as possible to the IC, and connect the output capacitor between the inductor and PGND of the IC. This minimizes the current path loop area from the SW pin through the LC filter and back to the PGND pin.
7. Connect AGND and PGND at a single point.

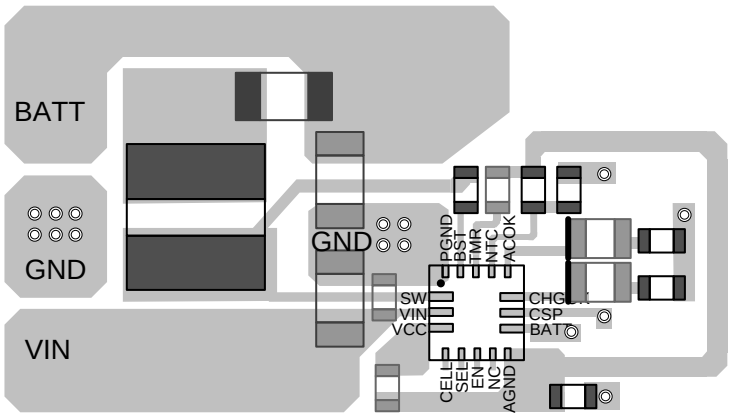


Figure 6: Recommended PCB Layout

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TYPICAL APPLICATION CIRCUIT

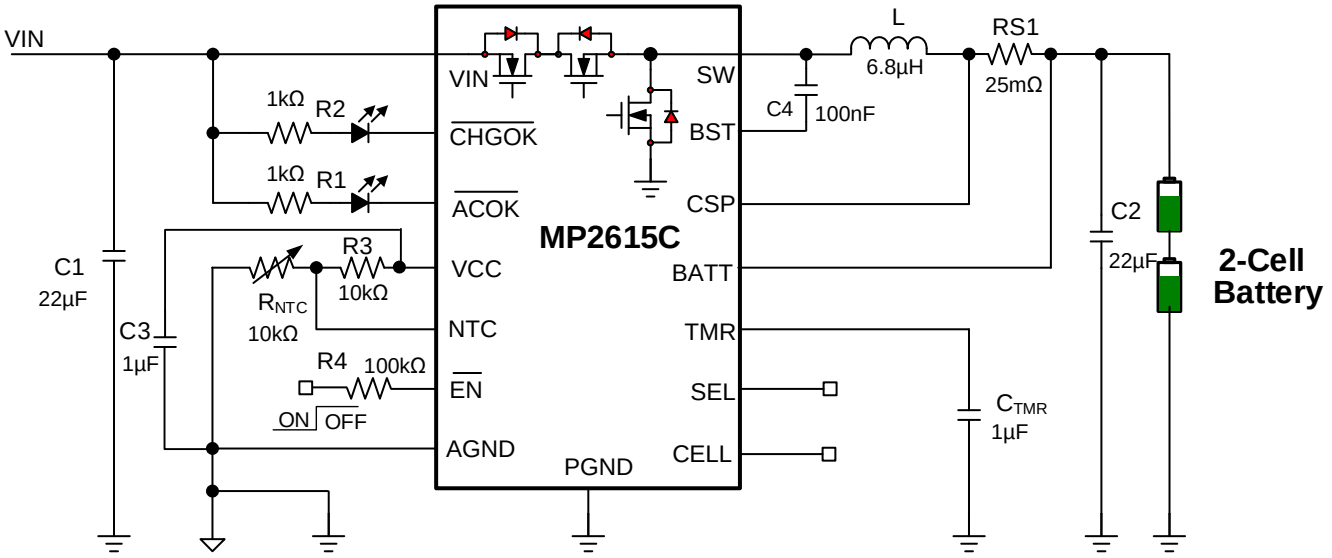
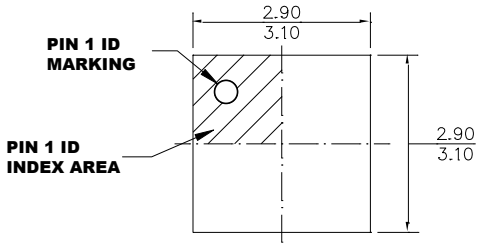


Figure 7: Typical Application Circuit to Charge a 2-Cell Battery with 12V V_{IN}

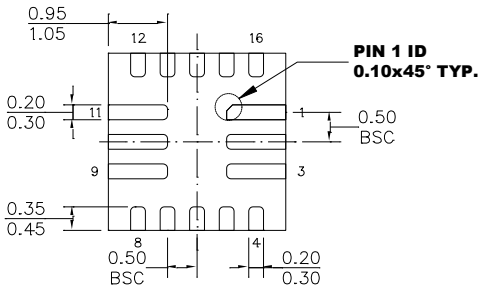
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PACKAGE INFORMATION

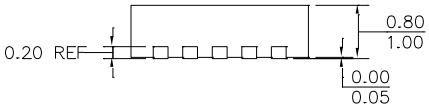
QFN-16 (3mmx3mm)



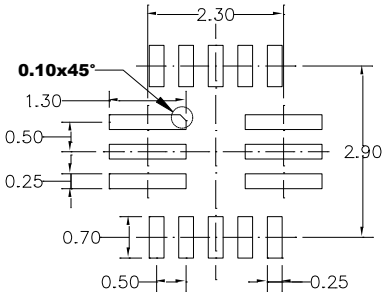
TOP VIEW



BOTTOM VIEW



SIDE VIEW



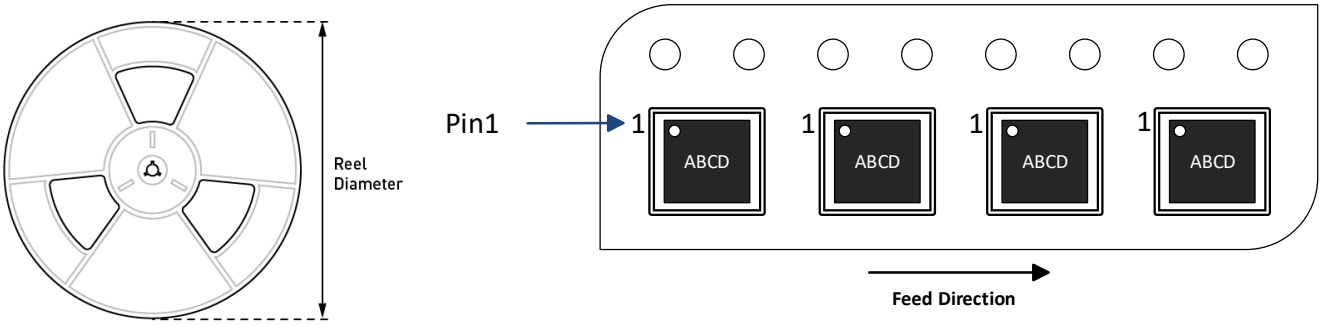
RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETERS MAX.
4) JEDEC REFERENCE IS MO-220.
5) DRAWING IS NOT TO SCALE.

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CARRIER INFORMATION



Part Number	Package Description	Quantity/ Reel	Quantity/ Tube	Quantity/ Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MP2615CGQ–Z	QFN-16 (3mmx3mm)	5000	N/A	N/A	13in	12mm	8mm

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Revision History

Revision #	Revision Date	Description	Pages Updated
1.0	9/11/2020	Initial Release	-

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