GLF73915

Ultra-Efficient, I_QSmart™ Battery Protection IC with Shipping Mode

Product Specification

DESCRIPTION

The GLF73915 is an I_QSmart™ ultra-efficient, full battery protection IC with an accurate over charge voltage, over discharge voltage, shipping mode, over charge current, and short circuit protection for lithium-Ion/Polymer battery safety.

The over charge and discharge voltage protections keep a rechargeable battery working within the desired safe operating condition. When the battery is charged past the over voltage detection level, the GLF73915 charging switch opens in a preset delay time. As the battery voltage decreases below the over discharge detection voltage level, the GLF73915 discharging switch is turned off immediately to cut off the battery power rail, consuming an ultra-low leakage current (I_{SD}) to save the battery. In addition, when the load current reaches the I_{SC} short circuit protection level, the GLF73915 is turned off and will maintain the off state to avoid any serious damage to system. The short circuit delay time avoids any false trigger which might open the switch.

The GLF73915 provides a shipping mode pin to prevent smart devices with a non-removable battery from discharging during the shipping period. When a charged battery cell is connected the GLF73915 remains in the off state and consumes an ultra-low leakage current (I_{SD}) until the V_{ON} voltage is applied to VOUT pin. Note that the GLF73915 is activated only by a V_{ON} voltage from a charger output.

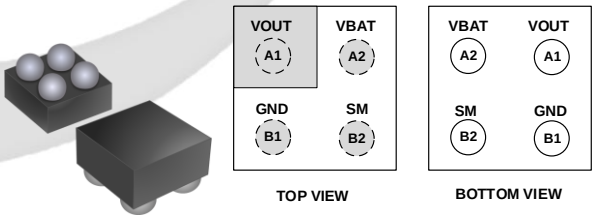
FEATURES

- Over Charge Detection, V_{OC} : 4.35 V_{BAT}
- Over Discharge Detection, V_{OD} :
  - GLF73915-AD12C: 2.80 V_{BAT}
  - GLF73915-AF12C: 2.95 V_{BAT}
- I_{OC}, Over Charge Current Detection
- Load Short Circuit Protection with Delay Time to avoid a false trigger
- Activated by Applying V_{ON} to the VOUT Pin from Charger
- Low R_{ON} : 57 mΩ Typ. at 3.6 V_{BAT}
- Quiescent Current, I_Q = 900 nA Typ. at 3.6 V_{BAT}
- Shutdown Current
  - I_{SD} = 7 nA Typ. at V_{BAT} < V_{OD}
  - I_{SD} = 8 nA Typ. at V_{BAT} = 3.6 V, Shipping Mode
  - I_{SD} = 9 nA Typ. at V_{BAT} = 4.2 V, Shipping Mode
- Latch-off at Over Discharge Detection and Short Circuit Protection. Apply V_{ON} to VOUT pin to turn on
- Shipping Mode Implementation
- 0 V Battery Minimum Voltage for Charging
- Reverse Connection Protection
- Patent Pending Circuit Architecture
- HBM : 8 kV, CDM : 2 kV
- 0.97 mm x 0.97 mm x 0.55 mm Chip Scale Package
  4 Bumps, 0.5 mm Pitch

APPLICATIONS

- BLE Wireless Earphone
- Hearing Aids
- Wearables and Smart IoT Devices

PACKAGE



0.97 mm x 0.97 mm x 0.55 mm WLCSP

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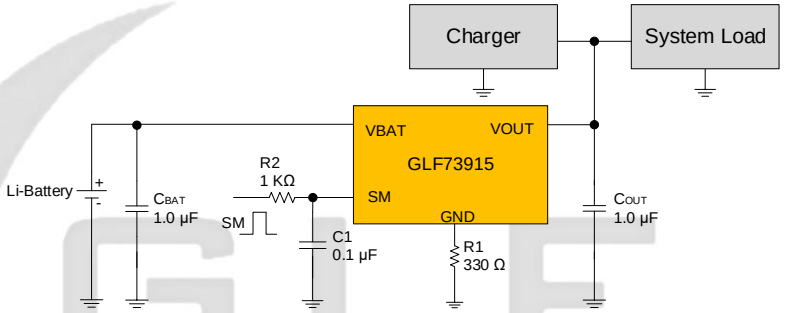
DEVICE INFORMATION

Part Number	Top Mark	R_{ON} (Typ.) V_{BAT}=3.6 V	Over Charge Detection, V_{OC}	Over Discharge Detection, V_{OD}	Over Charge Current, I_{OC}	Short Circuit Current, I_{SC}	V_{BAT}=0 V Charging	Shipping Mode
GLF73915-AD12C	CN	57 mΩ	4.35 V	2.80 V	300 mA	0.5 A	Available	Available
GLF73915-AF12C	IE			2.95 V				

APPLICATION DIAGRAM



Note: The recommended minimum capacitance for both C_{BAT} and C_{OUT} is 1.0 µF.

Figure 1. Typical Application

OPERATION DIAGRAM

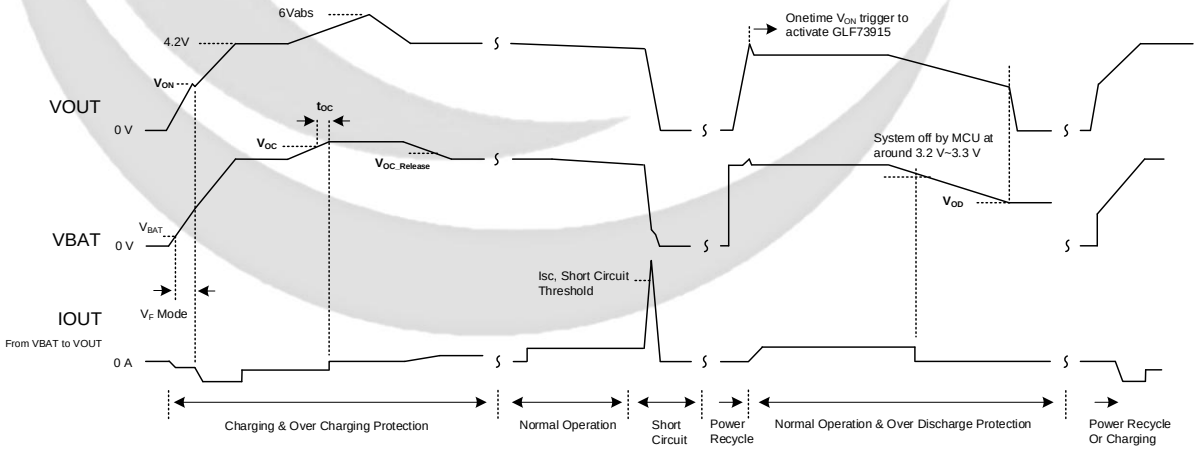


Figure 2. Operation Diagram

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Shipping Mode

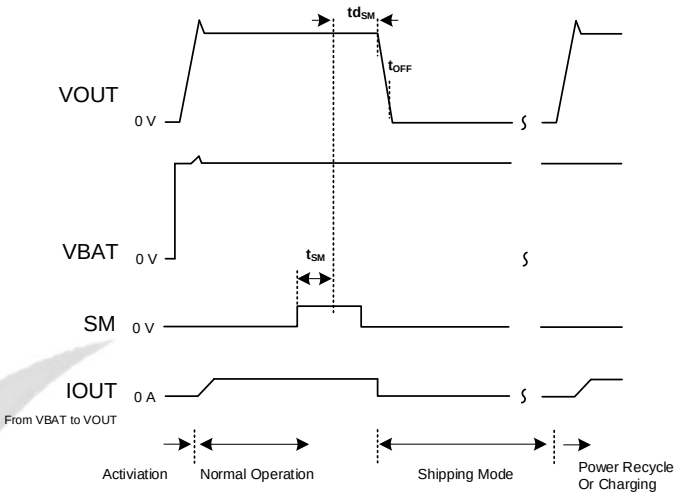

Figure 3. Shipping Mode Operation

FUNCTIONAL BLOCK DIAGRAM

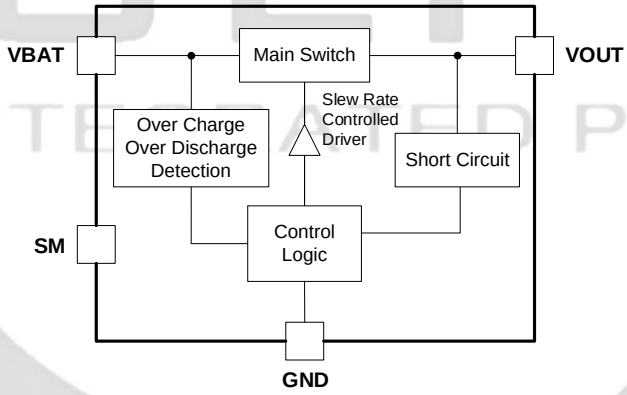

Figure 4. Functional Block Diagram

PIN CONFIGURATION

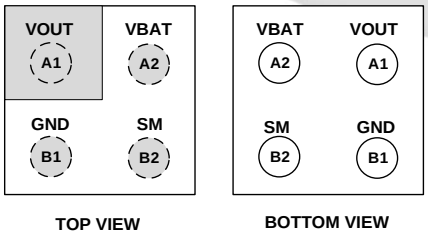

Figure 5. 0.97 mm x 0.97 mm x 0.55 mm WLCSP

PIN DEFINITION

Pin #	Name	Description
A1	VOUT	VOUT pin is connected to the charger output and system load. If the switch is in the off state, applying the appropriate voltage (V_{ON}) to V_{OUT} turns the switch back on.
A2	VBAT	VBAT pin is connected to the positive terminal of a battery pack to monitor the battery voltage. When the V_{BAT} voltage reaches the V_{OD}, the main switch is turned off and maintains the off state to save the battery from discharging.
B1	GND	Ground
B2	SM	Shipping Mode Control. Active high.

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ABSOLUTE MAXIMUM RATINGS

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions; extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter		Min.	Max.	Unit
V_{BAT}, V_{OUT}, V_{SM}	Each Pin Voltage Range to GND		- 0.3	6	V
P_D	Power Dissipation at T_A = 25°C			1.2	W
T_{STG}	Storage Temperature		- 65	150	°C
T_J	Maximum Junction Temperature			150	°C
T_A	Operating Ambient Temperature		- 40	85	°C
θ_{JA}	Thermal Resistance, Junction to Ambient			85	°C/W
ESD	Electrostatic Discharge Capability	Human Body Model, JESD22-A114	± 8		kV
		Charged Device Model, JESD22-C101	± 2		

ELECTRICAL CHARACTERISTICS

Values are at T_A = 25 °C unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{OC}	Over Charge Voltage Detection	V_{BAT} increases until switch turns off	4.25	4.35	4.45	V
		V_{BAT} increases until switch turns off, T_A = 55 °C (1)		4.39		
V_{OC_HYS}	Over Charge Voltage Protection Release Hysteresis	V_{BAT} decreases and switch turns on		80		mV
t_{VOC}	Over Charge Voltage Protection Delay	V_{BAT} > V_{OC}, Blanking time until switch turns off		530		ms
V_{OD}	Over Discharge Voltage Detection	V_{BAT} decreases until switch turns off GLF73915-AD12C	2.72	2.80	2.88	V
		V_{BAT} decreases until switch turns off, T_A = 55 °C (1) GLF73915-AD12C		2.887		
		V_{BAT} decreases until switch turns off GLF73915-AF12C	2.88	2.95	3.02	
		V_{BAT} decreases until switch turns off, T_A = 55 °C (1) GLF73915-AF12C		2.98		
V_{OD_HYS}	Over Discharge Voltage Protection Release Hysteresis	V_{BAT} increases and switch turns on (3)		150		mV
V_{ON}	ON Voltage applied to VOUT Pin to turn on switch	V_{OUT} to turn on switch, V_{BAT} = 4.3 V (2)	3.8			V
		V_{OUT} to turn on switch, V_{BAT} = 4.3 V , T_A = 55 °C (1)(2)		3.9		
V_F	Forward Voltage	From VOUT to VBAT pin, V_{BAT} < 3.0 V		0.4		V
I_{OC}	Over Charge Current Detection	V_{BAT} = 3.6 V	0.21	0.30	0.39	A
t_{IOC}	Over Charge Current Protection Delay			40		ms
I_{SC}	Short Circuit Shutdown	V_{BAT} = 3.6 V		0.5		A
t_{SC}	Short Circuit Protection Delay Time	V_{BAT} = 3.6 V (1)		0.5		ms
I_Q	Quiescent Current with Switch On	V_{BAT} = 3.6 V, I_{OUT} = 0 mA, Switch = ON		0.9		µA
		V_{BAT} = 4.2 V, I_{OUT} = 0 mA, Switch = ON		1.0	1.4	
		V_{BAT} = 4.2 V, I_{OUT} = 0 mA, Switch = ON, Ta = 55°C (1)		1.1		

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ELECTRICAL CHARACTERISTICS (CONTINUED)

Values are at T_A = 25 °C unless otherwise noted.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
I_{SD}	Shutdown Current from VBAT	V_{BAT} = 4.2 V, V_{OUT} = 0 V, Shipping Mode			9	30	nA
		V_{BAT} = 3.6 V, V_{OUT} = 0 V, Shipping Mode			8		
		V_{BAT} = 2.5 V, V_{OUT} = 0 V			7		
		V_{BAT} = 2.5 V, V_{OUT} = 0 V, T_A = 55 °C (1)			15		
R_{ON}	On-Resistance	V_{BAT} = 4.2 V, I_{OUT} = 200 mA	T_A = 25 °C		53	58	mΩ
			T_A = 55 °C (1)		57		
		V_{BAT} = 3.6 V, I_{OUT} = 200 mA	T_A = 25 °C		57	63	
			T_A = 55 °C (1)		62		
		V_{BAT} = 3.3 V, I_{OUT} = 200 mA	T_A =25 °C		60	66	
t_{OFF}	Turn-Off Time (1)	C_{OUT} = 1.0 µF, R_{OUT} = 150 Ω, V_{OUT} = V_{OD} to 0V			330		µs
V_{SM}	SM Input Logic High Voltage	V_{BAT} = 2.5 V - 5.5 V		1.2			V
t_{SM}	SM Valid Pulse Width (1)	V_{BAT} = 3.3 V - 4.2 V		15			ms
td_{SM}	Shipping Mode Delay (1)	V_{BAT} = 3.3 V - 4.2 V		0.4	0.5	0.6	s
R_{SM}	SM Pull Down Resistance (1)	Internal Resistance			500		kΩ
R_{DSC}	Output Discharge Resistance (1)	SM = High, I_{FORCE} = 10mA			85		Ω

Notes: 1. By design; characterized, not production tested.
2. V_{ON} at different V_{BAT} and different temperature refers to Figure 9 and Figure 10
3. Enabled charger is connected to the VOUT pin.

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TYPICAL PERFORMANCE CHARACTERISTICS

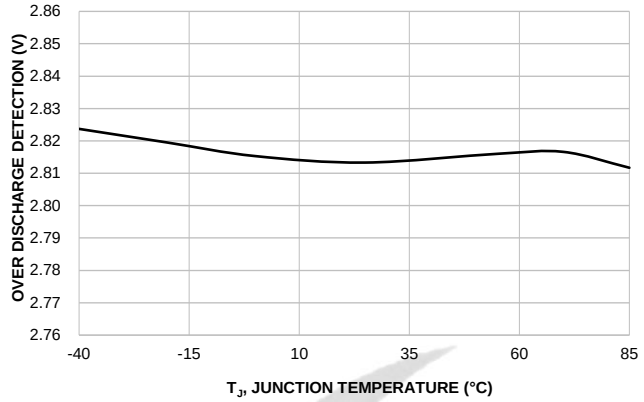

Figure 6. Over Discharge Voltage Detection vs. Temperature (GLF73915-AD12C)

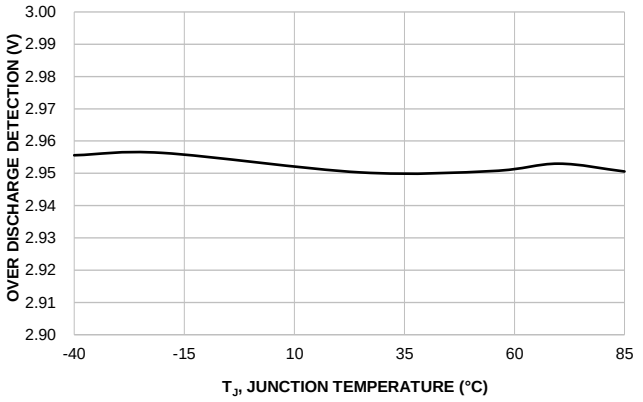

Figure 7. Over Discharge Voltage Detection vs. Temperature (GLF73915-AF12C)

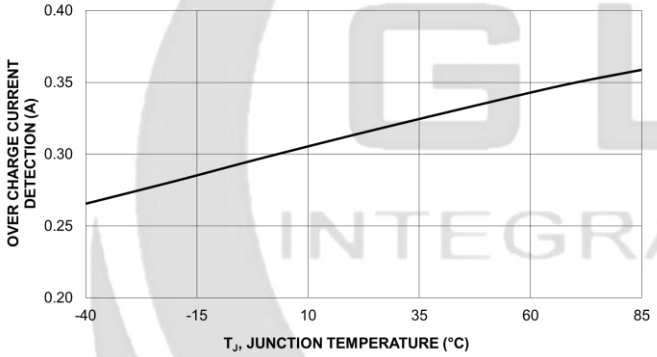

Figure 8. Over Charge Current Detection vs. Temperature

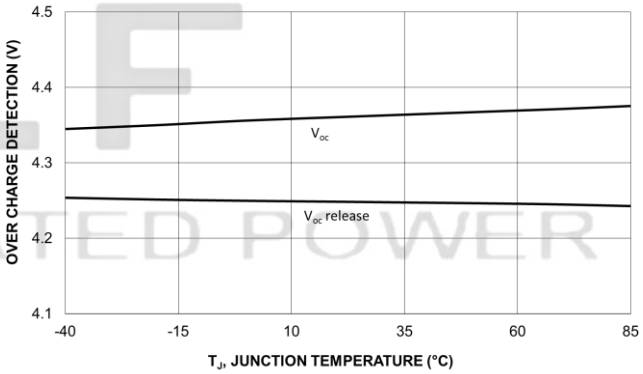

Figure 9. Over Charge Voltage Detection vs. Temperature

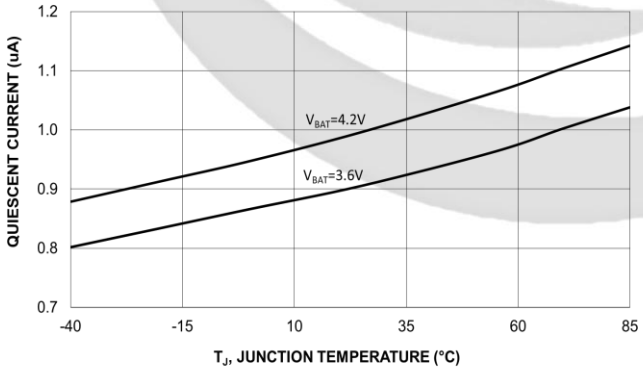

Figure 10. Quiescent Current vs. Temperature

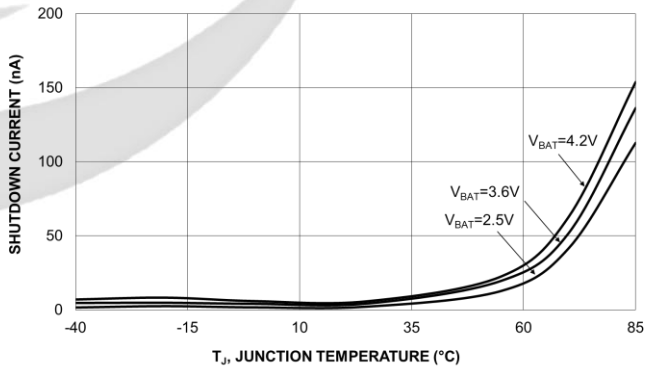

Figure 11. Shutdown Current vs. Temperature

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TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

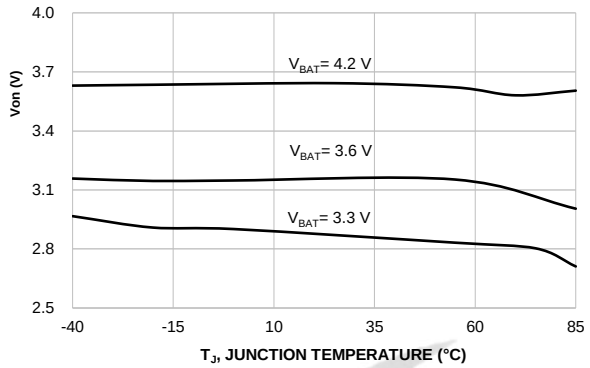

Figure 12. V_{ON} vs. Temperature

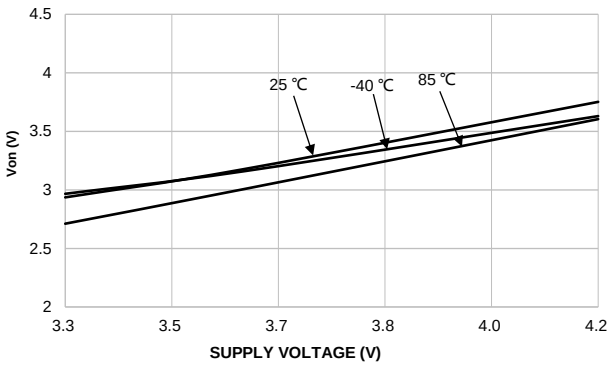

Figure 13. V_{ON} vs. Supply Voltage

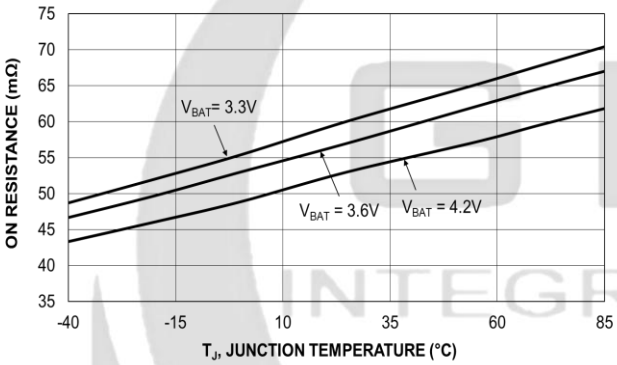

Figure 14. On-Resistance vs. Temperature

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APPLICATION INFORMATION

The GLF73915 is an IQSmart™ ultra-efficient battery protection IC with the accurate over charge voltage, shipping mode, over charge current, and short circuit protection for lithium-Ion/Polymer battery safety. The best in class efficiency makes it ideal for the design of hearing devices, wearable devices, and tiny IoT devices.

Charging Activation and 0 V Battery Charging

The GLF73915 is activated to turn on the main charging switch only by applying the on voltage (V_{ON}) to the VOUT pin, when a charger IC is enabled. The minimum battery voltage to charge is 0 V. With a deeply discharged battery, the GLF73915 does not turn on both the charge and discharge path and the pre-charge current flows through an internal diode (V_F) until the battery voltage reaches 3.1 V. As the battery voltage increases beyond 3.1 V, the charge and discharge path switches will be fully activated to reduce the voltage drop and save power dissipation during both constant-current and constant-voltage charging modes.

Over Charging and Discharging Voltage Protection

When the voltage of a battery increases to the over-charge voltage detection level (V_{OC}), the charge path is turned off to stop charging the battery after a preset over-charge detection delay time (t_{VOC}) in order to avoid a false trigger. The charging path is turned on again when the VOUT voltage falls by 80 mV. The charging path is not turned off if the battery voltage returns to a voltage less than the detection level within the delay time. The charging path turns on again as the battery voltage decreases below the over-charge release voltage level (V_{OC} - V_{OC_HYS}). When the battery voltage drops to the over-discharge detection voltage level (V_{OD}), the GLF73915 will immediately turn off the discharge path, consume ultra-low leakage current and save the battery, GLF73915 remain turned off until the battery is charged higher than (V_{OD} + V_{OD_HYS}). Note: When the battery voltage remains higher than the V_{OC} detection voltage, the load current can flow through the internal body diode of the GLF73915 until the VBAT voltage drops below (V_{OC}-V_{OC_HYS}). The internal discharge switch of the GLF73915 will automatically turn on.

Over Charging Current and Short Circuit Protection

If an overcharging current is detected during the constant current charging mode, the GLF73915 will close the charging path in a preset detection delay time(t_{IOC}). When the charging current drops below I_{OC}, the charging path will not turn on again and can be activated by plugging out the charger and reconnecting with charging current lower than I_{OC}. When the discharge current from the battery exceeds the short circuit detection level (I_{SC}), the discharging path of the GLF73915 will be turned off after a preset delay time (t_{SC}) in order to avoid a false detection. After the short circuit protection event, the GLF73915, GLF73915 maintains in the off state and needs a power recycle of a system to apply V_{ON} to VOUT pin in order to be reactivated.

Shipping Mode

The GLF73915 supports a Shipping Mode that fully disables both the charging and discharging paths to minimize current consumption and preserve the battery's pre-charged capacity during storage or shipment. Shipping Mode can be entered by applying a logic-high signal to the SM pin for a minimum of 15 ms, as specified by V_{SM} and t_{SM} in the Electrical Characteristics table. This function does not require a charger connection and can be initiated during normal operation by the system controller. While in Shipping Mode, the GLF73915 enters an ultra-low quiescent current state, effectively isolating the battery from the system. To exit Shipping Mode and re-enable the output, apply a static voltage of 3.8 V (V_{ON}) or higher to the VOUT pin. A rising edge is not required for this activation, as shown by V_{ON} in the Electrical Characteristics table. Note that residual voltages below 2.8 V on VOUT will not trigger activation. To avoid unintended entry into Shipping Mode due to noise or transients on the SM pin, it is recommended to implement an RC filter at the SM input.

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Reverse Connection Protection

It is recommended to use a resistance of 300 Ω or higher to limit the current through the device at conditions that a battery cell or a charger is connected in reverse. The R1 resistance value can be selected between 100 Ω and 1 kΩ.

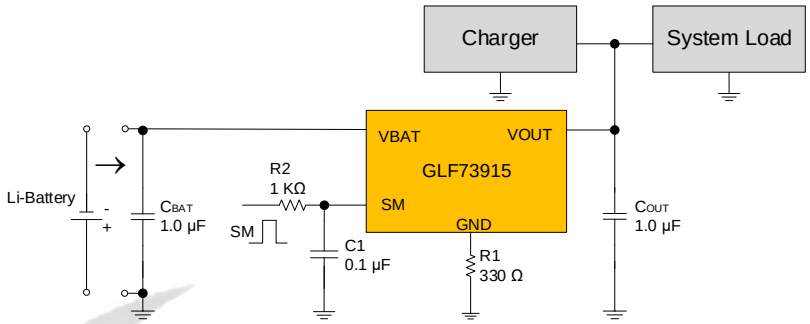

Figure 14. Reverse Connection

Input and Output Capacitors

It is recommended to place a minimum 1.0 µF input capacitor near the VBAT pin to reduce input supply voltage dips caused by inrush current during startup. Using at least a 1.0 µF input capacitor can also prevent surges or errors that may occur when the battery is first connected. Additionally, it is recommended to use a minimum 1.0 µF output capacitor to minimize voltage dips at the output pin when the switch is turned off. Voltage dips can be caused by parasitic inductance in the PCB traces or by load inductance. If load inductance is present, the output capacitor can improve output voltage stability and system reliability. The output capacitor must be placed as close as possible to the VOUT pin.

Board Layout

All traces should be as short as possible to minimize parasitic inductance effects. Wide traces for VBAT, VOUT, and GND will help reduce voltage drops, and parasitic effects during dynamic operation as well as improve the thermal performance at high load currents.

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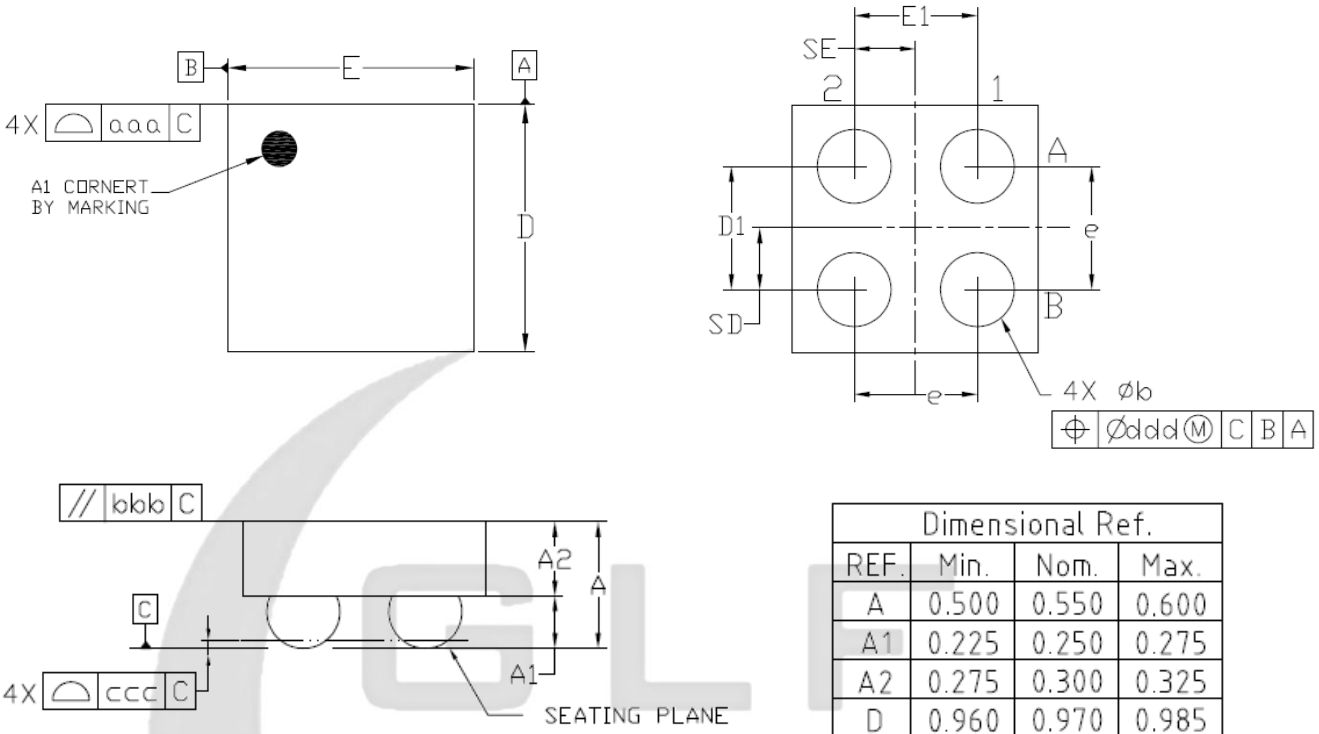
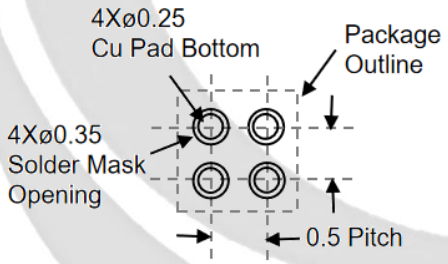
PACKAGE OUTLINE



Dimensional Ref.			
REF.	Min.	Nom.	Max.
A	0.500	0.550	0.600
A1	0.225	0.250	0.275
A2	0.275	0.300	0.325
D	0.960	0.970	0.985
E	0.960	0.970	0.985
D1	0.450	0.500	0.550
E1	0.450	0.500	0.550
b	0.260	0.310	0.360
e	0.500 BSC		
SD	0.250 BSC		
SE	0.250 BSC		
Tol. of Form&Position			
aaa	0.10		
bbb	0.10		
ccc	0.05		
ddd	0.05		

Recommended Footprint



Notes

1. All DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.

PACKAGING INFORMATION

Part Number	Package	Pins	Pitch	Top Mark	Moisture Sensitivity Level	Environmental Information
GLF73915-AD12C	0.97 mm x 0.97 mm x 0.55 mm WLCSP	4	0.5mm	CN	MSL1	ROHS+HF
GLF73915-AF12C				IE		

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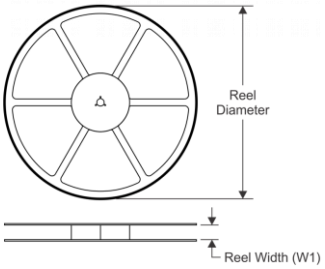
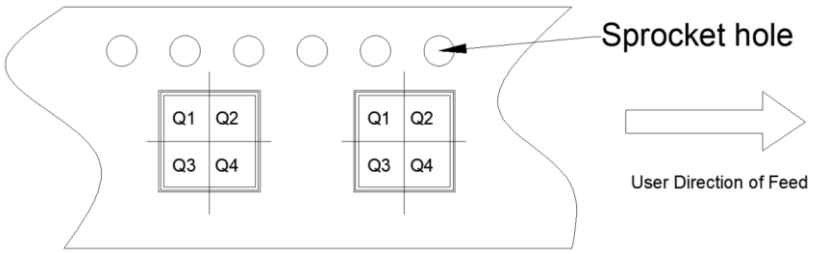
TAPE AND REEL INFORMATION

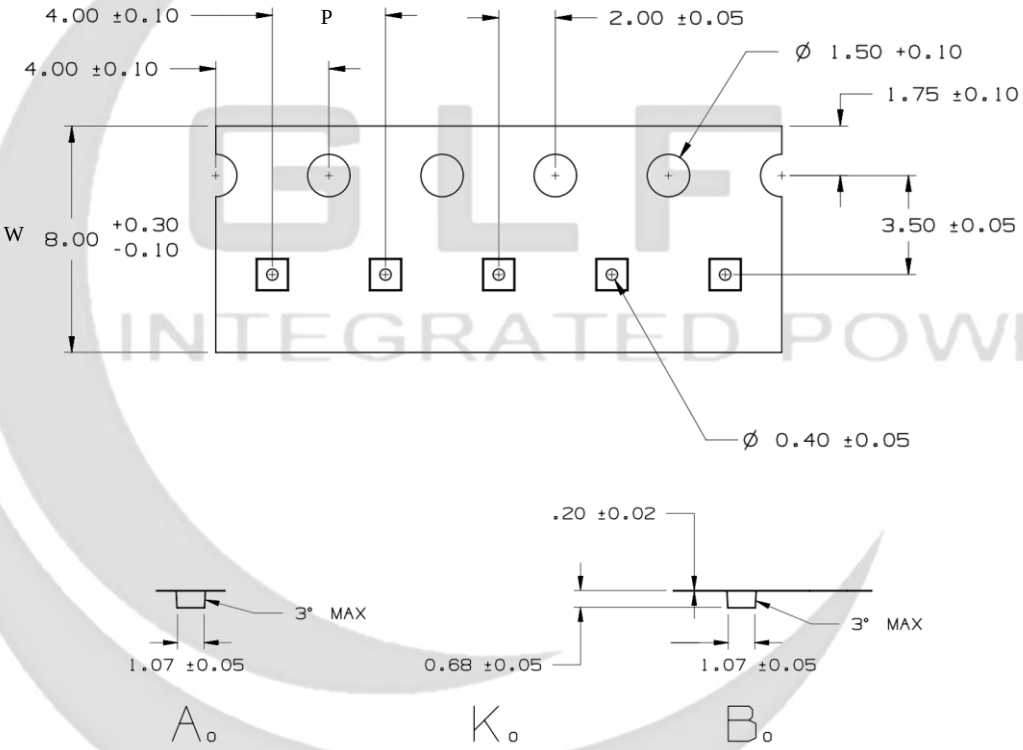
REEL DIMENSIONS



QUADRANT ASSIGNMENTS PIN 1 ORIENTATION TAPE



TAPE DIMENSIONS



Device	Package	Pins	SPQ	Reel Diameter (mm)	Reel Width W1	A0	B0	K0	P	W	Pin1
GLF73915-AD12C	WLCSP	4	3000	180	9	1.07	1.07	0.68	4	8	Q1
GLF73915-AF12C											

Remark:

A0: Dimension designed to accommodate the component width

B0: Dimension designed to accommodate the component length

K0: Dimension designed to accommodate the component thickness

W: Overall width of the carrier tape

P: Pitch between successive cavity centers

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SPECIFICATION DEFINITIONS

Document Type	Meaning	Product Status
Target Specification	This is a target specification intended to support exploration and discussion of critical needs for a proposed or target device. Parameters including the typical, minimum, and maximum values are desired, or target. GLF reserves the right to change contents at any time without warning or notification. A target specification will not guarantee the future production of the device.	Design / Development
Preliminary Specification	This is a draft version of a product specification which is under internal review and subject to change. GLF reserves the right to change the specification at any time without warning or notification. A preliminary specification will not guarantee the future production of the device.	Qualification
Product Specification	This document represents the characteristics of the device.	Production

DISCLAIMERS

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