# GLF73610

## Ultra-Efficient, Optimized $I_Q$Smart™ Battery Protection IC with Full Protections

**Product Specification**

## DESCRIPTION

The GLF73610 is a family of $I_Q$Smart™ ultra-efficient, full battery protection ICs with an accurate over charge/discharge voltage, shipping mode, over charge/discharge 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 GLF73610 charging switch opens in a preset delay time. As the battery voltage decreases below the over discharge detection voltage level, the GLF73610 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 GLF73610 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 GLF73610 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 GLF73610 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 GLF73610 is activated only by a $V_{ON}$ voltage from a charger output.

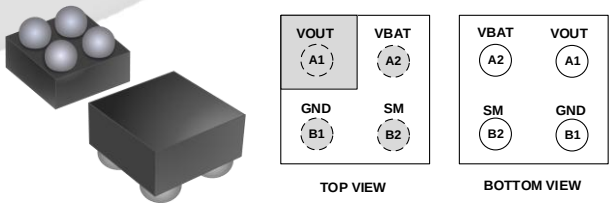
## FEATURES

- Over Charge Detection Voltage, $V_{OC}$
  - Monitor VOUT to release $V_{OC}$
  - $V_{OC}$ high accuracy: ± 0.6 %
- $V_{OD}$, Over Discharge Detection: 2.80 $V_{OUT}$
- $I_{OC}$, Over Charge Current Detection: 330 mA
- $I_{OD}$, Over Discharge Current Detection: 76 mA
- Short Circuit Protection
- Activated by Applying $V_{ON}$ to the VOUT Pin
- Shipping Mode Implementation
- Low $R_{ON}$: 62 mΩ Typ. at 3.7 $V_{BAT}$
- $I_Q$ = 1.48 µA Typ at 3.7 $V_{BAT}$
- Shutdown Current
  - $I_{SD}$ = 6 nA Typ. at $V_{BAT}$ < $V_{OD}$
  - $I_{SD}$ = 8 nA Typ. at $V_{BAT}$ = 3.7 V, Shipping Mode
  - $I_{SD}$ = 10 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
- 0 V Battery Minimum Voltage for Charging
- 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 Aid
- Wearables and Smart IoT Devices

## PACKAGE

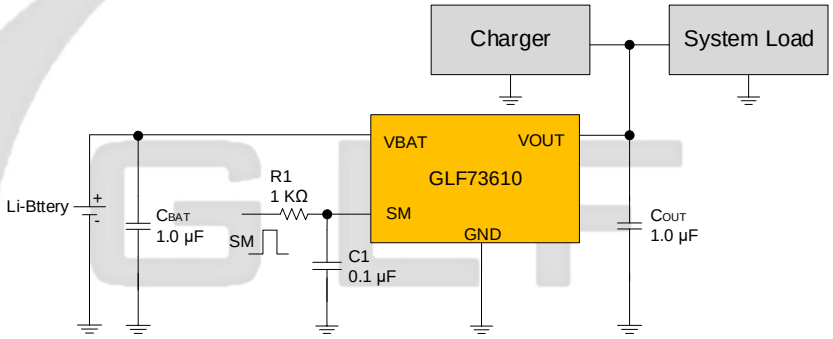



0.97 mm x 0.97 mm x 0.55 mm WLCSP

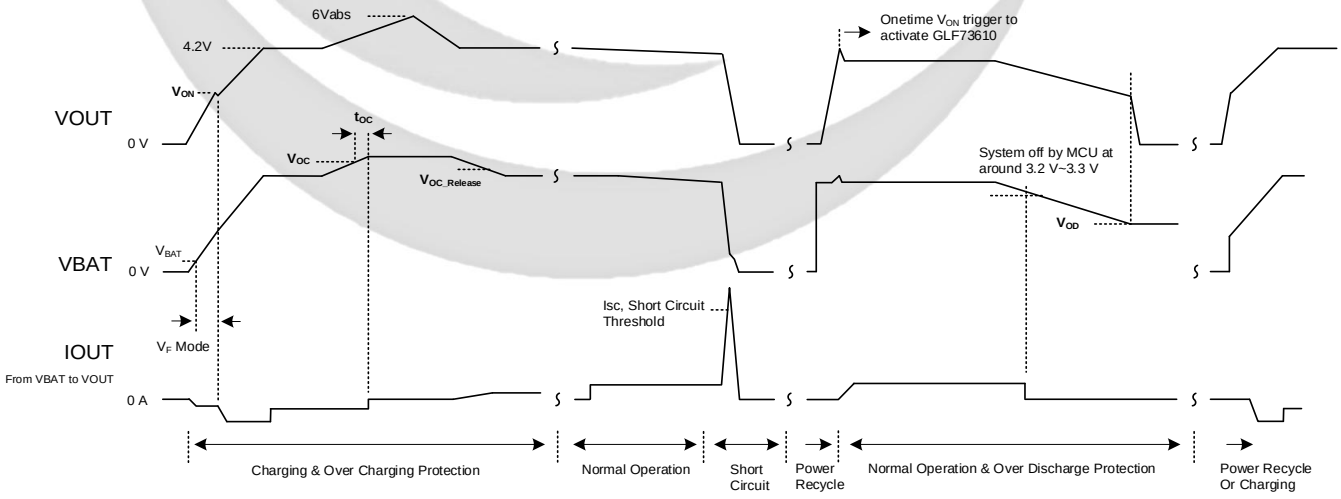
## DEVICE INFORMATION

| Part Number | Top Mark | $R_{ON}$ (Typ.) $V_{BAT}$=3.7 V | Over Charge Detection $V_{OC}$ | Over Discharge Detection $V_{OD}$ | Over Charge Current $I_{OC}$ | Over Discharge Current $I_{OD}$ | Short Circuit Current, $I_{SC}$ |
|---|---|---|---|---|---|---|---|
| GLF73610-DE23C | FD | 62 mΩ | 4.275 V | 2.80 V | 330 mA | 76 mA | 250 mA |
| GLF73610-CE23C | BY | | 4.450 V | | | | |
| GLF73610-GE23C | FG | | 4.475 V | | | | |
| GLF73610-HE23C | FH | | 4.525 V | | | | |

## APPLICATION DIAGRAM




## OPERATION DIAGRAM



## FUNCTIONAL BLOCK DIAGRAM

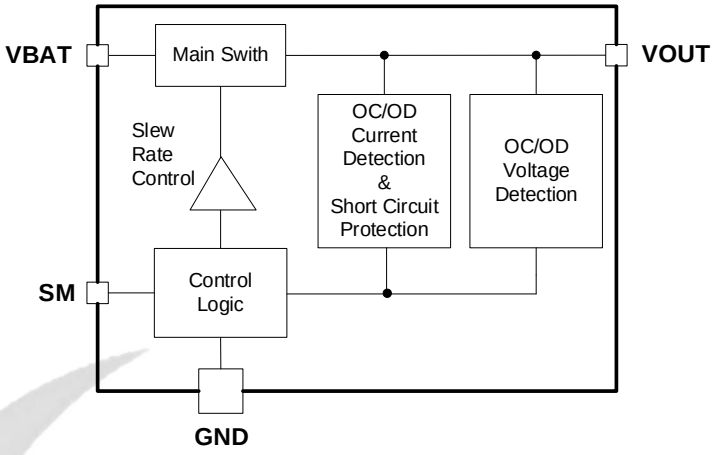



**Figure 1. Functional Block Diagram**

## PIN CONFIGURATION

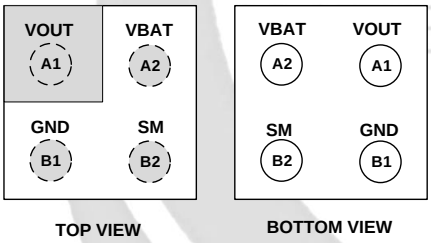



**Figure 2. 0.97mm x 0.97mm x 0.55mm WLCSP**

## 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. |

## 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 |
|---|---|---|---|---|---|
| $V_{BAT}$, $V_{OUT}$, 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 Junction Temperature | | - 65 | 150 | °C |
| $T_A$ | Operating Temperature Range | | - 40 | 85 | °C |
| $\theta_{JA}$ | 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 $V_{BAT}$ = 3.6 V, $T_A$ = 25°C unless otherwise noted.

| Symbol | Parameter | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $V_{OC}$ | Over Charge Voltage Detection | GLF73610-DE23C | $V_{BAT}$ increases until switch turns off | 4.250 | 4.275 | 4.300 | V |
| | | | Ta= 55 °C (1) | | 4.268 | | |
| | | GLF73610-CE23C | $V_{BAT}$ increases until switch turns off | 4.425 | 4.450 | 4.475 | |
| | | | Ta= 55 °C (1) | | 4.444 | | |
| | | GLF73610-GE23C | $V_{BAT}$ increases until switch turns off | 4.450 | 4.475 | 4.500 | |
| | | | Ta= 55 °C (1) | | 4.471 | | |
| | | GLF73610-HE23C | $V_{BAT}$ increases until switch turns off | 4.500 | 4.525 | 4.550 | |
| | | | Ta= 55 °C (1) | | 4.520 | | |
| $V_{OC\_HYS}$ | Over Charge Voltage Protection Release Hysteresis | $V_{BAT}$ decreases and switch turns on | | | 150 | | mV |
| $t_{VOC}$ | Over Charge Voltage Protection Delay Time | $V_{BAT}$ > $V_{OC}$, Blanking time until switch turns off | | | 560 | | ms |
| $V_{OD}$ | Over Discharge Voltage Detection | $V_{BAT}$ decreases until switch turns off | | 2.72 | 2.80 | 2.90 | V |
| | | Ta=55 °C (1) | | | 2.79 | | |
| $V_{OD\_HYS}$ | Over Discharge Voltage Protection Release Hysteresis | $V_{BAT}$ increases and switch turns on | | | 150 | | mV |
| $t_{VOD}$ | Over Discharge Voltage Protection Delay Time | $V_{BAT}$ < $V_{OD}$, Blanking time until switch turns off | | | 40 | | ms |
| $V_{ON}$ (1) | ON Voltage applied to VOUT to turn on switch | $V_{OUT}$ to turn on switch, $V_{BAT}$ ≥ 3.1 V | | | 3.6 | | V |
| | | Ta= 55 °C | | | 3.6 | | |
| $I_{OC}$ | Over Charge Current Detection | | | 260 | 330 | 400 | mA |
| $t_{IOC}$ | Over Charge Current Detection Delay Time | | | | 40 | | ms |
| $I_{OD}$ | Over Discharge Current Detection | | | 50 | 76 | 98 | mA |
| $t_{IOD}$ | Over Discharge Current Detection Delay Time | | | | 20 | | ms |
| $I_{SC}$ | Short Circuit Current Detection | | | | 250 | | mA |
| $t_{SC}$ | Short Circuit Delay Time | | | | 400 | | µs |
| $I_Q$ | Quiescent Current with Switch On | $V_{BAT}$ = 3.7 V, $I_{OUT}$= 0 mA, Switch = ON | | | 1.48 | | µA |
| | | $V_{BAT}$ = 4.2 V, $I_{OUT}$= 0 mA, Switch = ON | | | 1.55 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | $V_{BAT}$ = 4.2 V, $I_{OUT}$= 0 mA, Switch = ON Ta= 55°C (1) | | 1.66 | | |
| $I_{SD}$ | Shutdown Current from VBAT When Main Switch is Off | $V_{BAT}$ = 4.2 V, $V_{OUT}$ = 0 V, Shipping Mode | | 10 | | nA |
| | | $V_{BAT}$ = 3.7 V, $V_{OUT}$ = 0 V, Shipping Mode | | 8 | | |
| | | $V_{BAT}$ = 2.5 V, $V_{OUT}$ = 0 V | | 6 | | |
| | | $V_{BAT}$ = 2.5 V, $V_{OUT}$ = 0 V, Ta=55 °C (1) | | 8 | | |
| $R_{ON}$ | On-Resistance | $V_{BAT}$= 4.2 V, $I_{OUT}$= 40 mA | Ta= 25 °C | 58 | | mΩ |
| | | | Ta= 55 °C (1) | 62 | | |
| | | $V_{BAT}$= 3.7 V, $I_{OUT}$= 40 mA | Ta= 25 °C | 62 | | |
| | | | Ta= 55 °C (1) | 66 | | |
| | | $V_{BAT}$= 3.3 V, $I_{OUT}$= 40 mA | Ta= 25 °C | 67 | | |
| $t_{OFF}$ (1) | Turn-Off Time | $C_{OUT}$= 1.0 µF, $R_{OUT}$= 150 Ω, $V_{OUT}$ = $V_{OD}$ to 0 V | | 340 | | µs |
| $V_{SM}$ | SM Input Logic High Voltage | $V_{BAT}$= 2.5 V to 5.5 V | 1.2 | | | V |
| $t_{SM}$ | SM pulse width | $V_{BAT}$ = 3.3 V to 4.2 V | | 20 | | ms |
| $td_{SM}$ | Shipping Mode Delay | $V_{BAT}$ = 3.3 V to 4.2 V | 570 | 610 | 650 | ms |
| $R_{SM}$ | SM pull down resistance | Internal Resistance | | 400 | | kΩ |

Notes: 1. By design; characterized, not production tested.
2. All values of delay timing were characterized but not tested in production.

## TYPICAL PERFORMANCE CHARACTERISTICS

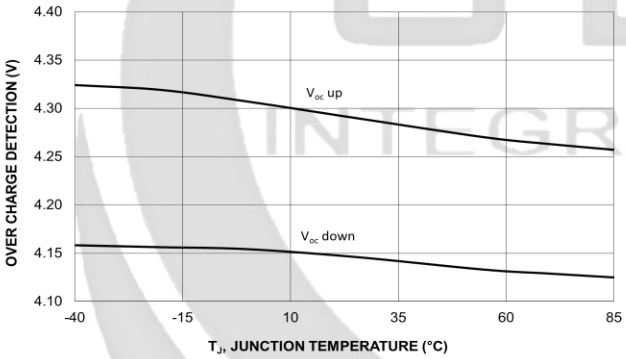



**Figure 3. Over Charge Voltage Detection vs. Temperature, GLF73610-DE23C**

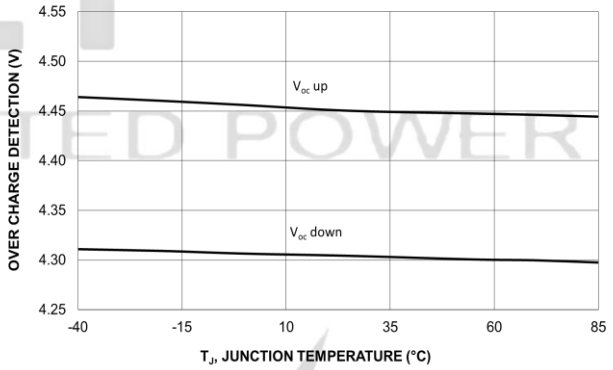



**Figure 4. Over Charge Voltage Detection vs. Temperature, GLF73610-CE23C**

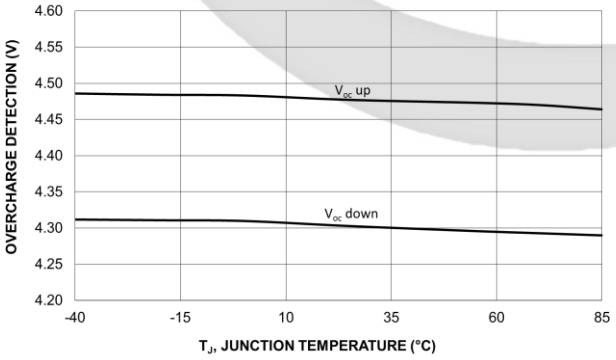



**Figure 5. Over Charge Voltage Detection vs. Temperature, GLF73610-GE23C**

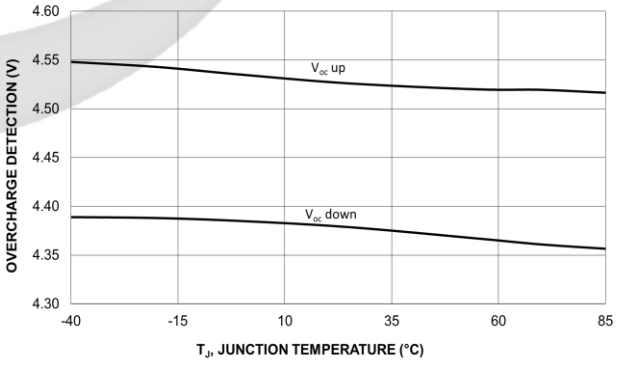



**Figure 6. Over Charge Voltage Detection vs. Temperature, GLF73610-HE23C**

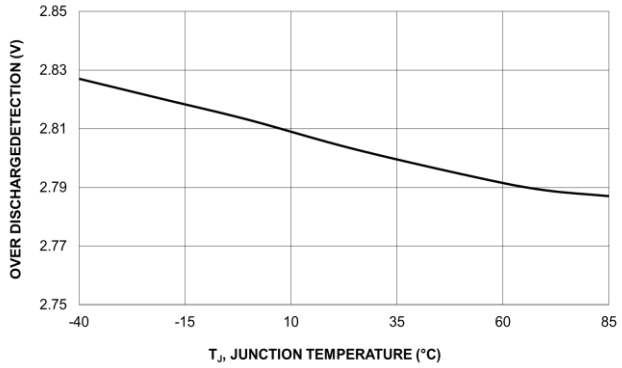



**Figure 7. Over Discharge Voltage Detection vs. Temperature**

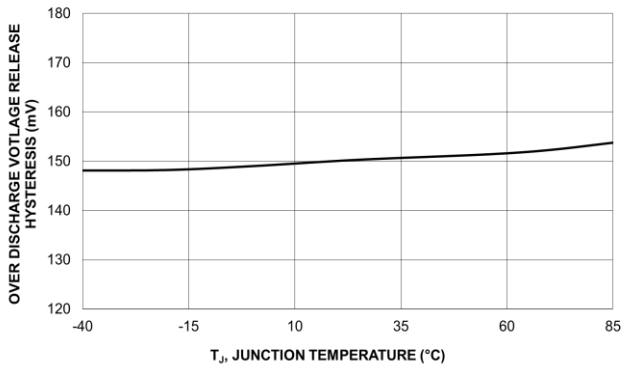



**Figure 8. Over Discharge Voltage Detection Release Hysteresis vs. Temperature**

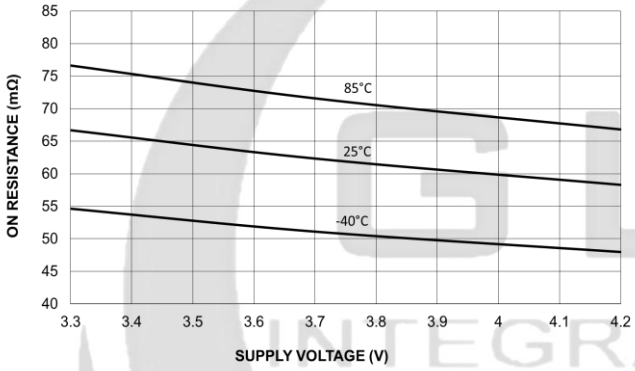



**Figure 9. On-Resistance vs. Supply Voltage**

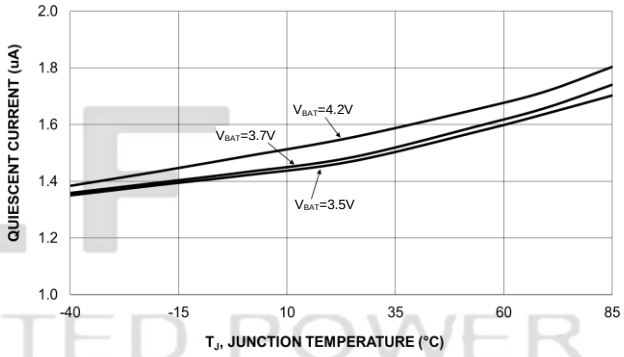



**Figure 10. Quiescent Current vs. Temperature**

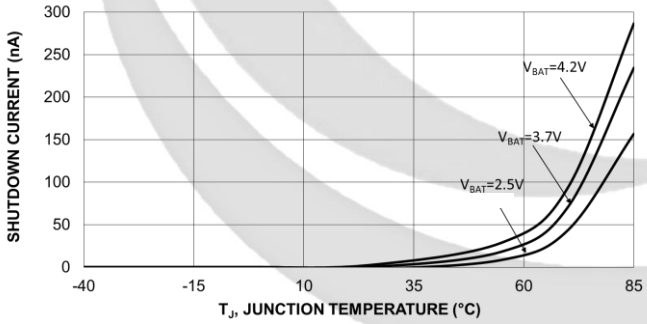



**Figure 11. Shutdown Current vs. Temperature**

## APPLICATION INFORMATION

The GLF73610 is an $I_Q$Smart™ 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 GLF73610 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 GLF73610 does not turn on both the charge and discharge path and the pre-charge current flows through an internal diode until the battery voltage reaches the over discharge voltage detection level ($V_{OD}$). The GLF73610 provides a hiccup charging mode when the charge mode changes from the pre-charge to the constant current charge mode. The main switch of the GLF73610 turns on and off in 60 ms period and pulse current charges the battery until the charge mode is completely transferred to the constant current mode. As the battery voltage increases beyond the over discharge voltage detection, 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 ($t_{OC}$) in order to avoid a false trigger. The charging path is turned on again when the VOUT voltage falls by 150 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 voltage of a battery decreases to the over-discharge detection voltage level, the GLF73610 discharging path is turned off consuming an ultra-low leakage current to save the battery. The GLF73610 remains in the off state until a higher voltage is applied to the VOUT pin.

### Over Charging and Discharging Current, Short Circuit Protection

If an over-charging current is detected during the constant current charging mode, the GLF73610 will shut off the charging path in a preset detection delay time. When the over-discharging current condition occurs for the detection delay($t_{IOD}$), the discharge path turns off. During the operation, if the discharge current from the battery exceeds the short circuit detection level ($I_{SC}$), the discharging path 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 GLF73610 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 GLF73610 provides system designers with the SM pin to turn off safely both discharging and charging path to prevent a pre-charged battery capacity from discharging at all. During the shipping mode when the GLF73610 is completely off, it consumes an ultra-low current to maintain the battery capacity. The GLF73610 is activated again by applying $V_{ON}$ to the VOUT pin when a charger is applied. An RC filter circuit can be added in front of SM to prevent interference when the shipping mode is not enabled.

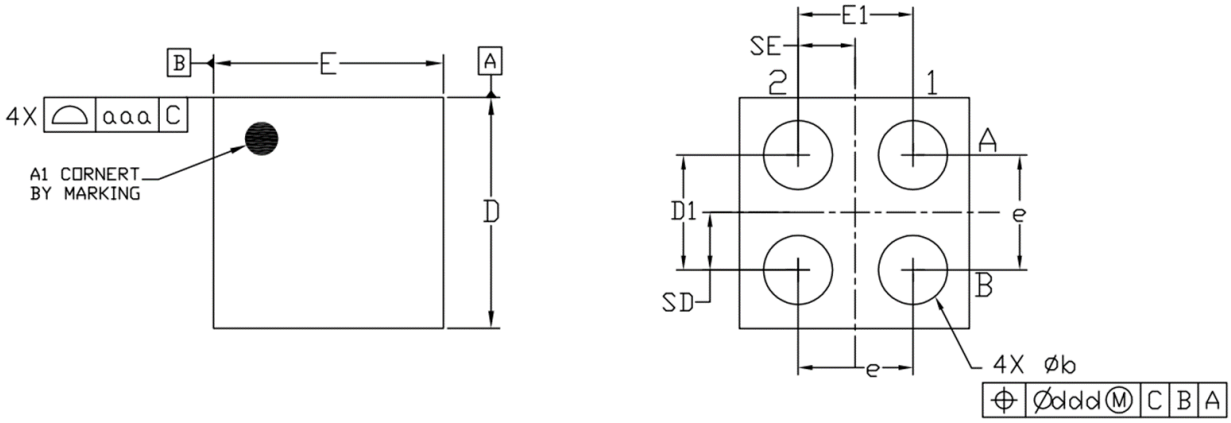
### Input and Output Capacitors

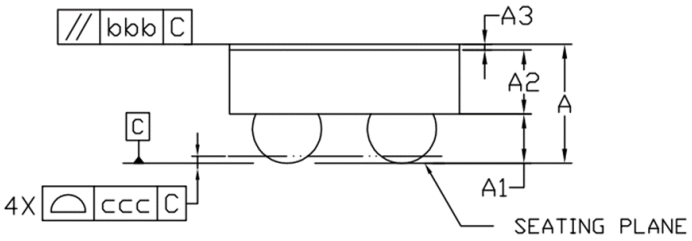
Input and output capacitors are not required for GLF73610 operation. However, a 1.0μF capacitor is recommended to be placed close to the VBAT and VOUT pins in order to mitigate any unexpected electrical noise or the transient voltage peak caused by a hot-plugging voltage source.

### 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.

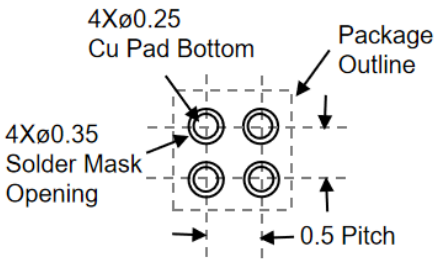
## PACKAGE OUTLINE




| Dimensional Ref. | | | |
|---|---|---|---|
| REF. | Min. | Nom. | Max. |
| A | 0.500 | 0.550 | 0.600 |
| A1 | 0.225 | 0.250 | 0.275 |
| A2 | 0.255 | 0.275 | 0.300 |
| A3 | 0.020 | 0.025 | 0.030 |
| 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**




## PACKAGING INFORMATION

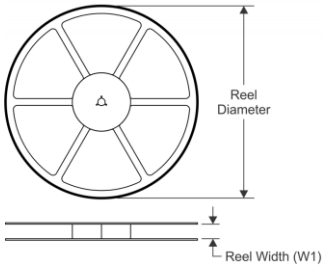
| Part Number | Package | Pins | Pitch | Top Mark | Moisture Sensitivity Level | Environmental Information |
|---|---|---|---|---|---|---|
| GLF73610-DE23C | 0.97 mm x 0.97 mm x 0.55 mm WLCSP | 4 | 0.5mm | FD | MSL1 | ROHS+HF |
| GLF73610-CE23C | | | | BY | | |
| GLF73610-GE23C | | | | FG | | |
| GLF73610-HE23C | | | | FH | | |

Notes

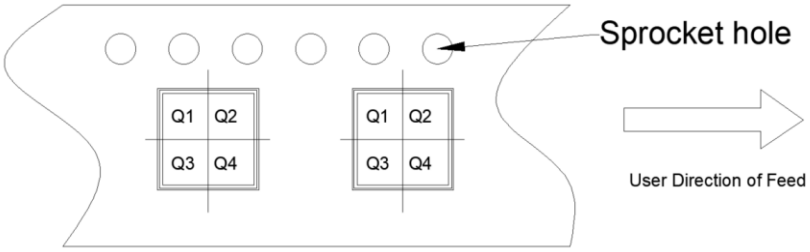
1. ALL DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES)
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
3. A3: BACKSIDE LAMINATION

## TAPE AND REEL INFORMATION

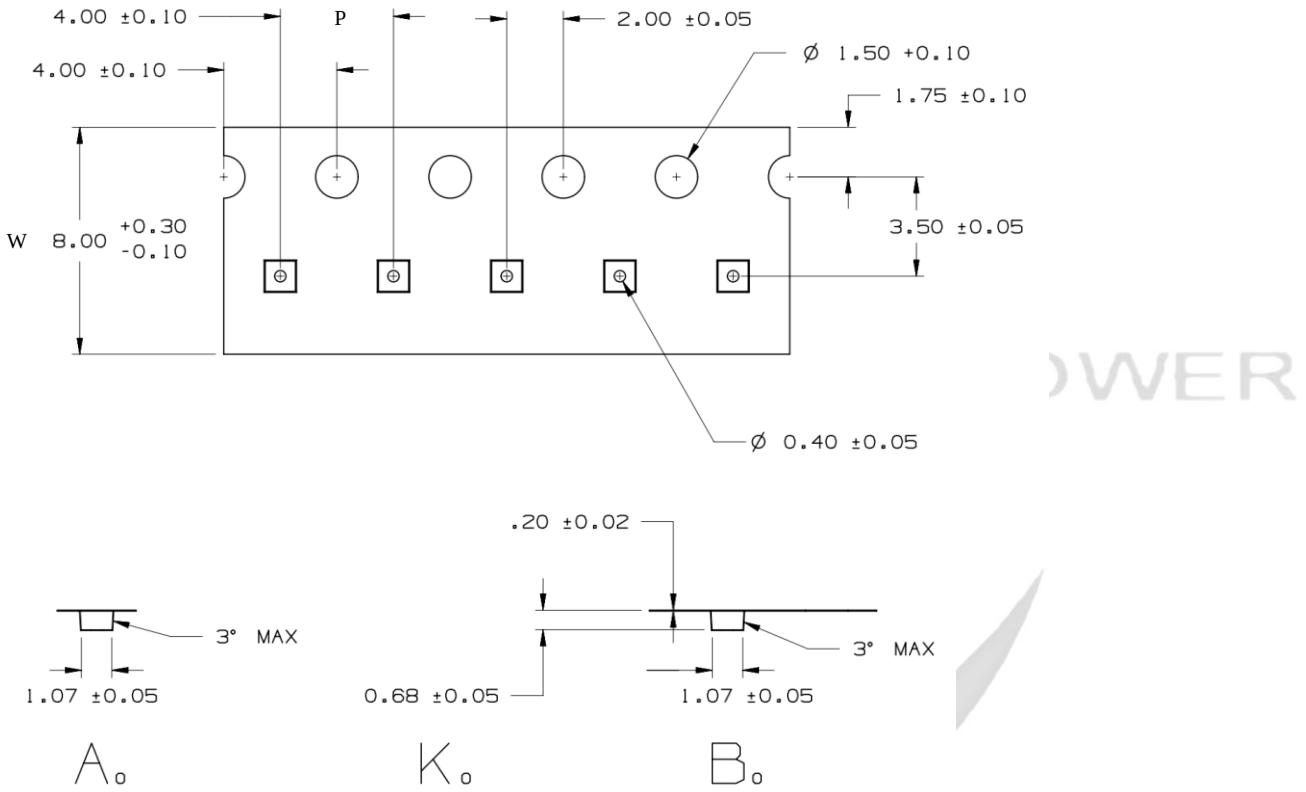
**REEL DIMENSIONS**




**QUADRANT ASSIGNMENTS PIN 1 ORIENTATION TAPE**




**TAPE DIMENSIONS**







| Device | Package | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 | A0 | B0 | K0 | P | W | Pin1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GLF73610 | WLCSP | 4 | 3000 | 180 | 9 | 1.07 | 1.07 | 0.68 | 4 | 8 | Q1 |

Remark:

A0: Dimension designed to accommodate the component width

B0: Dimension designed to accommodate the component length

C0: Dimension designed to accommodate the component thickness

W: Overall width of the carrier tape

P: Pitch between successive cavity centers

## 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. Spec limits including typical, minimum, and maximum values are desired, or target, limits. GLF reserves the right to change limits at any time without warning or notification. A target specification in no way guarantees future production of the device in question. | Design / Development |
| Preliminary Specification | This is a draft version of a product specification. The specification is still 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 in no way guarantees future production of the device in question. | Qualification |
| Product Specification | This document represents the anticipated production performance characteristics of the device. | Production |

## DISCLAIMERS

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