Primary Protector and Switch for Tiny Li-ion or Li-Ion Polymer Battery in XTDFN1x1

Features

- **Ultra-Compact Protection Solution**
- **50mΩ Pass Resistance**
- **Over-Voltage Protection Threshold Option**
  - **4.3V to 5.0V with 0.01V per Step**
- **Battery Under-Voltage Protection**
  - **2.6V/2.7V/2.8V/2.9V Options**
- **Over-Charge /Discharge Current Protection**
  - **0.2A/0.4A/0.6A/0.8A Options**
- **Short-Circuit Protection**
  - **1.5A/3.0A Options**
- **0V Battery Charge or No-Charge Options**
- **Locked-Off for Delivery/Assembly**
- **Low Current Consumption**
  - **Operation: 1uA typ.**
  - **Power-Down: 0.1uA max.**
- **Available in Green XTDFN-1x1-4L Package**

Applications

- Earphone
- Stylus
- Bracelet
- Watch

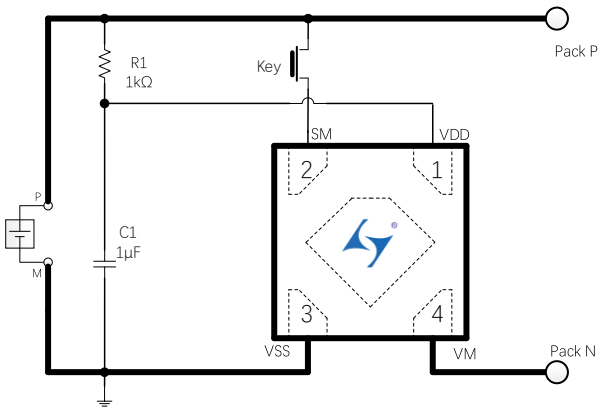
General Description

The LTK45101 is designed for primary protection of Li-Ion/Polymer rechargeable cells. The product integrates all the protections required for safe operation of polymer rechargeable cells. The device is packaged in a tiny and thin package. Its small solution size leaves more space for fitting the battery cell into a given cavity for small size wearable devices.

The LTK45101 integrates all the protections and the required low on-resistance disconnect switch on one die. The protection features include charging and discharging protection, detection and protection of a cell in over-charging, over-discharging, over-current, and battery under-voltage. The product also disconnects the battery pack in the case of deep discharge.

The LTK45101 operates in -40 ℃ to +85 ℃ temperature range, and is in a thin and low profile XTDFN-1x1-4L package.

Typical Application Circuit



Order and Marking Information

LTK45101 □□□□ (Assembly Material / Handling Code / Packge Code)	Packge Code XTDFN 1x1 -4L Handling Code TR: Tape & Reel Assembly Material G: Halogen and Lead Free Device
LTK45101 ES XX YY	X - Data Code Y - Internal Code

Note: LTKCHIP lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish, which are fully compliant with RoHS and compatible with both SnPb and lead-free soldering operations. LTKCHIP lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J STD-020C for MSL classification at lead-free peak reflow temperature.
LTKCHIP reserves the right to make changes to improve reliability or manufacturability without notice and advise customers to obtain the latest version of relevant information to verify before placing orders.

Pin Configuration

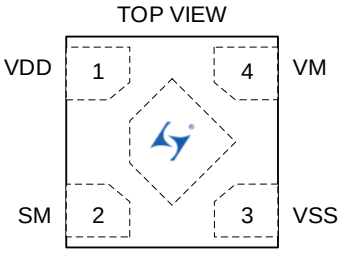


Fig.1 PIN Descriptions of LTK45101

Pin Function Description

NO.	NAME	FUNCTION DESCRIPTION
1	VDD	Device Bias Supply/Battery Voltage Sensing Input.
2	SM	External Off Input. Pull and hold (for a minimum time) high with respect to the VDD, to set the battery switch off state (shipping mode). No state change occurs if this pin voltage level is not changed.
3	VSS	Switch Terminal: Connects to the Negative Pole of the Battery.
4	VM	Switch Terminal: Connects to the Negative Terminal of the System Load.
Exposed Pad	EP	Package Exposed Pad with No Internal Connection. External connection to the VSS is recommended.

Device Description

Model: LTK45101-AAABCDEF	
Over-Voltage Threshold	
Option Code "**AAA**"	4.30V ~ 5.00V, 10mV Step Threshold voltage as the code directly, e.g. 445: 4.45V
Under-Voltage Threshold Options	
Option Code "**B**"	2.6V / 2.7V / 2.8V / 2.9V
Charge/Discharge Over-Current Threshold Options	
Option Code "**C**"	0.2A / 0.4A / 0.6A / 0.8A
Others Threshold Options	
Short-Circuit Limit Current	1.5A / 3.0A
No Charge Threshold	0V charge / 1.5V / 2.1V / 2.4V
Battery Off Delay (Shipping Mode)	0.5s / 4s
Over-Voltage Trigger Delay Time	512ms / 1s
Over-Voltage Release Delay Time	1ms / 14ms
Under-Voltage Trigger Delay Time	64ms / 128ms
Under-Voltage Release Delay Time	1ms / 4ms
Over-Charge-Current Trigger Delay Time	16ms / 32ms / 64ms / 64ms
Over-discharge-Current Trigger Delay Time	32ms / 64ms / 128ms / 256ms / 512ms / 1s / 2s / 4s
Short-Circuit Trigger Delay Time	0.28ms / 0.56ms

Version	Auto activate Power-Up	ocd retry / one time latch	scp retry / one time latch	Shipping mode	0V / 0.9V / 1.5V / 2.1V / 2.4V charge
LTK45101	Yes	retry	retry	Yes SM to pull up for shipping	<2.4V no charge
	Yes	One time	One time 20KΩ	No Connect VSS	0V charge
	Yes	One time	One time 25KΩ	No Connect VSS	0V charge
	Yes	One time	One time 25KΩ	Yes （GPIO 100KΩ/2.2uF）	0V charge
	No	Retry	Retry	No Connect VSS	<1.5V no charge

Functional Block Diagram

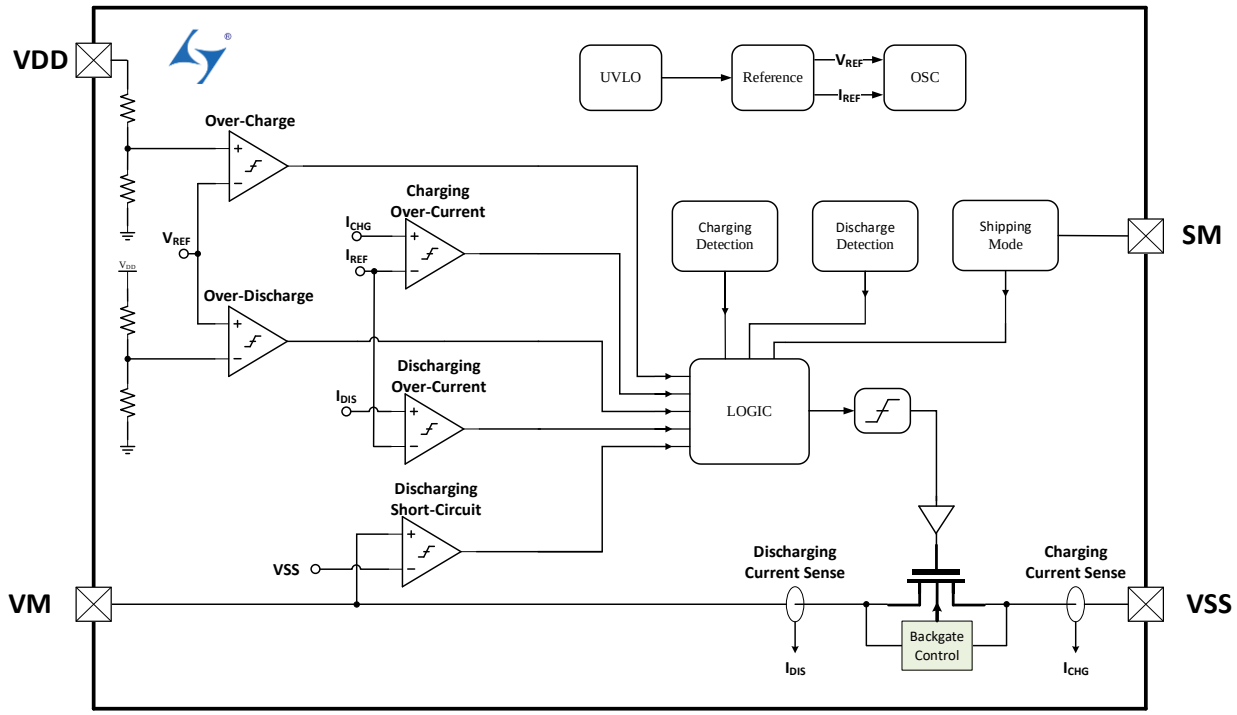


Fig.2 Simplified Functional Block Diagram of LTK45101

Absolute Maximum Ratings (1)

Parameter		Rating
VDD to VM	Continues	-5V or +9V(2)
	5s, 10mA surge clamping	13V (3)
VM to VSS		-4.5V(3) or +5.5V
Junction Temperature Range, T_J		-40℃ to +150℃
Storage Temperature Range, T_{STG}		-40℃ to +150℃
Soldering Temperature Range, T_{SDR}		260℃

Note 1. Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Operation above these absolute maximum ratings may cause degradation or permanent damage to the devices. These are stress ratings only and do not necessarily imply functional operation below these limits.

2. Tested with a regulated voltage source with 2A current limit and less than 1V/ms slew rate. Source is applied from 0V and then the voltage is increased to the specified level.

3. Evaluated with V_{BAT} = 4.5V.

Recommended Operating Conditions

Parameter	Min.	Max.	Unit
Supply Voltage: Pack P to Pack N	0	6	V
Battery Voltage	0	5	
Ambient Temperature Range	-40	85	°C
Junction Temperature Range	-40	125	

Electrical Characteristics

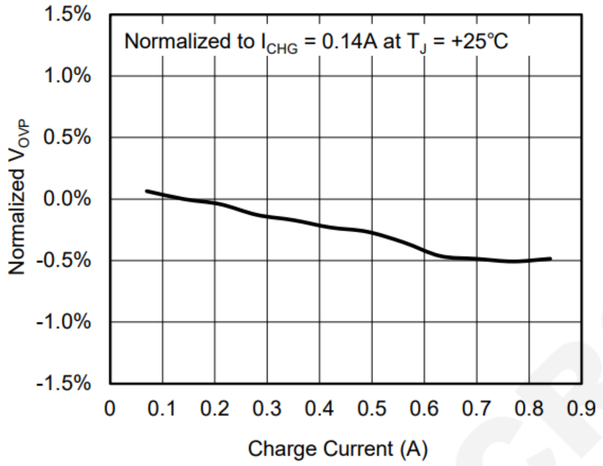
(Battery voltage V_{BAT} = 3.8V, Full = -40℃ to +85℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Operation Voltage Range (1)	V_{CHG_OP}	Normal charging source voltage range	Full	-0.5		6	V
Normal On Voltage Range (1)	V_{NORM_ON}	The maximum voltage range possibly keeps continuous on in charging	Full	2.5		4.6	V
Switch On-Resistance	R_{ON}	T_A = +25℃			50		mΩ
		T_A = -20℃ to +60℃					
Operating Current (VDD current)	I_{OP}	T_A = +25℃			1.3	2.5	μA
		T_A = -20℃ to +60℃				10	
Shutdown Current	I_{SHDN}	Shutdown occurred due to battery low or due to SM input control			50	100	nA
Shutdown Voltage	V_{SHDN}	Following the shift of V_{UVLOr}		1.6	1.7	1.8	V
Over-Voltage Detection Delay	t_{OVPD}	Timing and error decided by t_{UI}			512		ms
Under-Voltage Detection Delay	t_{UVPD}	Timing and error decided by t_{UI}			512		ms
Discharge Over Current Detection Delay	t_{ODD}	Timing and error decided by t_{UI}			32		ms
Discharge Over Current Retry Delay Time	t_{RETRY}	Timing and error decided by t_{UI}			512		ms
Charge Over Current Detection Delay	t_{OCD}	Timing and error decided by t_{UI}			32		ms
Discharge Short-Circuit Cut-off Delay	t_{DSC}	Short with 100mΩ resistor			0.3		ms
Charge Battery Over-Voltage							
Over-Voltage Threshold Error	V_{OVERR}	Voltage Error to the nominal threshold voltage V_{OVP} (V)		20		20	mV
			-20℃ to +60℃	45		35	
OV Release Hysteresis	V_{OVHYS}			150	200	250	mV
Discharge Battery Under-Voltage							
Battery Under-Voltage Threshold Error	V_{UVERR}	Voltage Error to the nominal threshold voltage V_{UVP}	-20℃ to +60℃	-100		100	mV
Battery Under-Voltage Threshold	V_{UV}				2.6		V
					2.7		
					2.8		
					2.9		
UV Release Hysteresis	V_{UVHYS}				200		mV

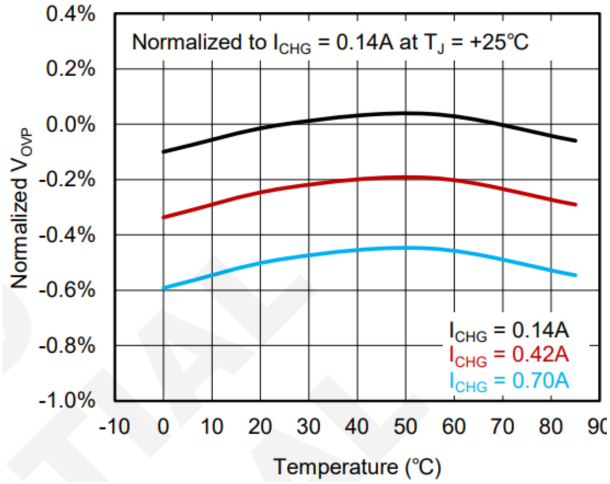
Typical Performance Characteristics

(T_J = +25℃, ICHG = IDIS = 50mA, VBAT = 3.7V, unless otherwise noted.)

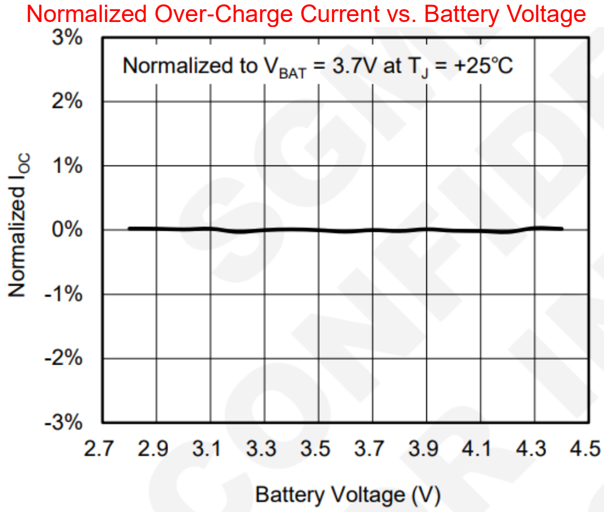
Normalized Over-Charge Voltage vs. Charge Current



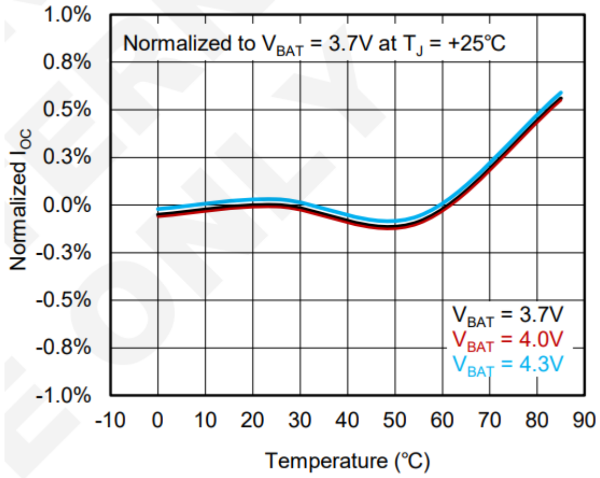
Normalized Over-Charge Voltage vs. Temperature



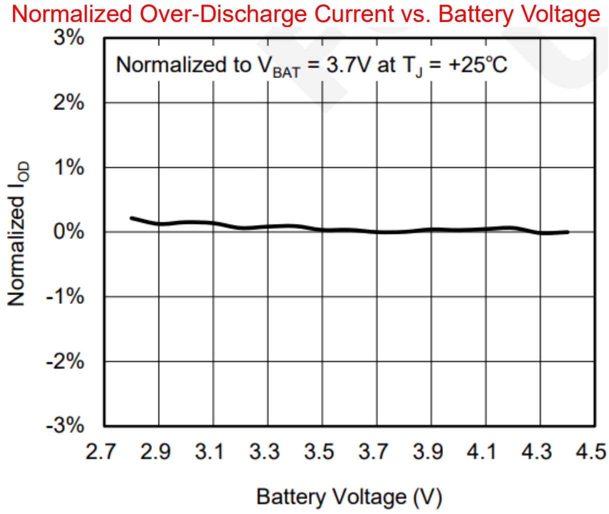
Normalized Over-Charge Current vs. Battery Voltage



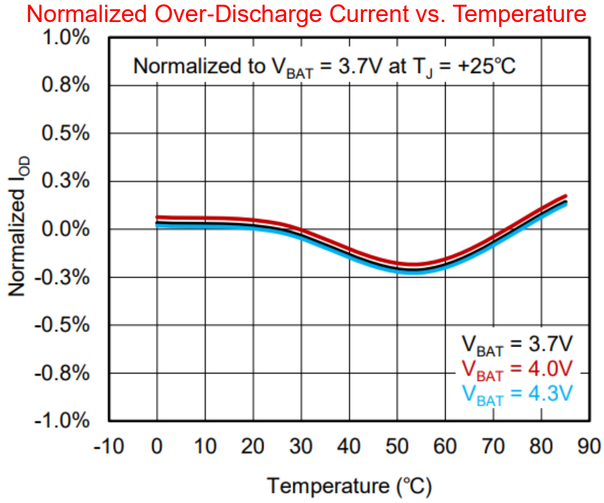
Normalized Over-Charge Current vs. Temperature



Normalized Over-Discharge Current vs. Battery Voltage



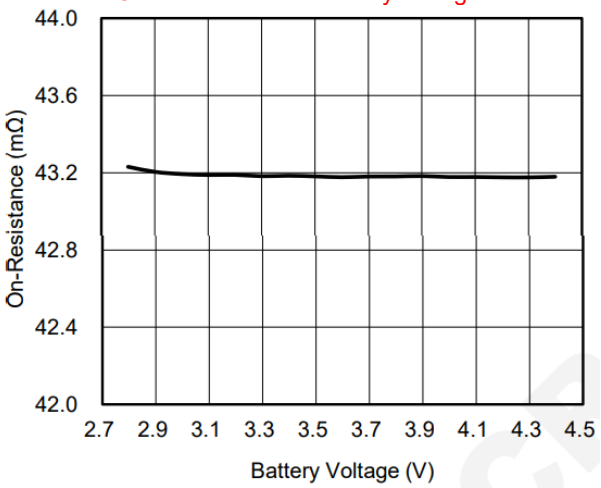
Normalized Over-Discharge Current vs. Temperature



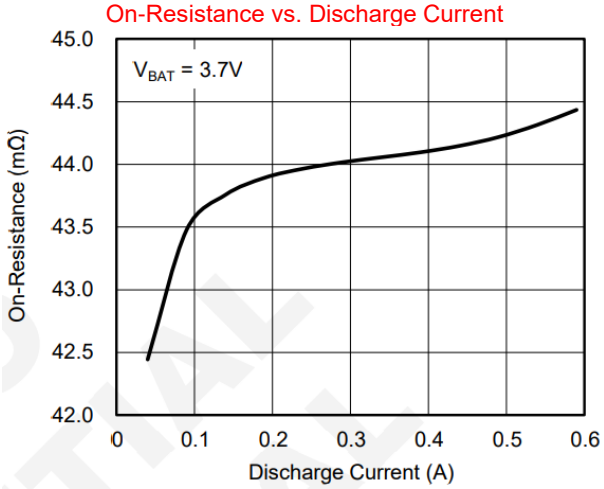
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

TJ = +25℃, ICHG = IDIS = 50mA, VBAT = 3.7V, unless otherwise noted.

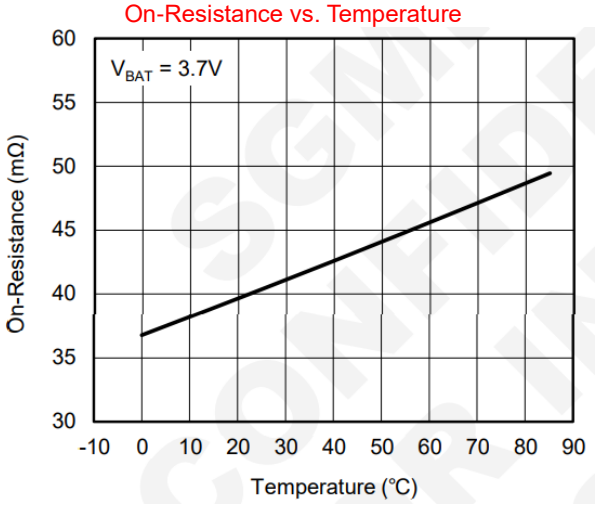
On-Resistance vs. Battery Voltage



On-Resistance vs. Discharge Current



On-Resistance vs. Temperature



Application Information

LTK45101 are Li-Ion/Li-Ion polymer battery protectors with integrated battery switch. They provide a full set of protection functions on voltage and current conditions and can disconnect the battery using the integrated switch. To reduce the power consumption, the battery voltage and current are measured periodically (polling), but the short circuit condition is continuously monitored when the switch is on so that the device can instantly respond and turn off the switch if a suspicious short is detected in the load.

Voltage related protections: The battery voltage, sensed between the VDD and VSS pins, is monitored periodically (with deglitch time) while the charge input and battery connection are detected instantly.

During charge, in every detection cycle, the battery is checked for over-voltage. If that occurs, the battery switch is turned into charge block mode to prohibit any further charging and allows current only in the discharge direction. The charge will be unblocked when the battery voltage drops to a safe level due to discharge. The battery over-voltage threshold (V_{OV}) depends on the selected "AAA" code of the device.

If the battery voltage is not in the over-voltage range, it is checked every detection cycle for low voltage. When a low battery voltage is detected ($V_{BAT} < V_{UVP}$) the battery switch will block battery discharge direction and the device goes to the lossless off-state. The battery low voltage threshold (V_{UVP}) depends on the selected "B" code of the device.

The system can operate even without a battery if a charging voltage above the under-voltage lockout threshold (V_{BUVL} = 2.4V typical) is applied. In such case the input voltage is compared to the battery voltage, and if it is larger, the switch will turn on for charging. Depending on the part number these cases may follow:

1. For the LTK45101 (the option with charge prohibition at low voltage), first the battery voltage is compared to V_{BUVL} (2.4V) and if $V_{BAT} < V_{BUVL}$ the voltage monitoring is disabled and the device remains in charge block mode. If $V_{BAT} > V_{BUVL}$ the switch is turned on for charging and normal measurement (polling) starts similar to the LTK45101.
2. For the LTK45102 (zero voltage charging option), the switch will turn on to start normal operation with battery connected and is kept on as long as $V_{BAT} > V_{UVP}$. If $V_{BAT} < V_{UVP}$ the switch is turned into discharge block mode. Note that by blocking the discharge, the battery voltage may rise above V_{BUVL} again and causes oscillation.

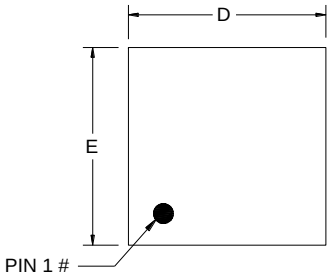
When a battery is already attached, if a system voltage transient (connection) occurs and its voltage exceeds V_{SUVLOr} (1.8V), the system attachment is detected and the battery attaching timer will start. After the battery switch turns on and the normal measurement cycles (polling) begin.

Current related protections: The battery current (I_{BAT}) is monitored periodically while the battery switch is on. Both charge and discharge are protected against over current, each with its own threshold and pulling period (t_{OCD} for charging, t_{ODD} for discharging). Charge or discharge is blocked if the corresponding over current is detected. Charge block is released when charge status is invalidated by detecting a switch forward voltage above V_{DISCHG} = 50mV. Discharge recovery is by hiccup mode and the block is removed t_{RETRY} after it is detected. If a discharge overcurrent is detected again, it is blocked for another t_{RETRY} time.

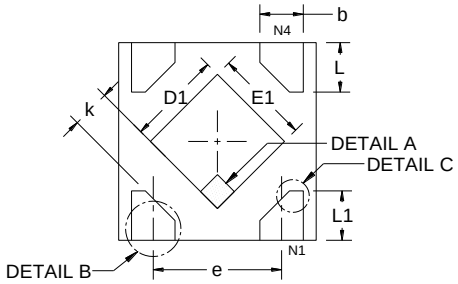
Load short protection: If the discharge current exceeds I_{DSC} (1.5A or 3.0A depending on "D" code), the battery switch turns into discharge block mode and the battery attaching timer starts for retrying (hiccup).

Package Outline Dimensions

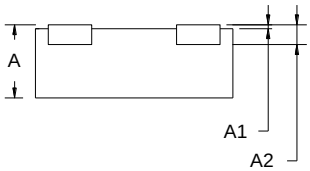
XTDFN-1×1-4L



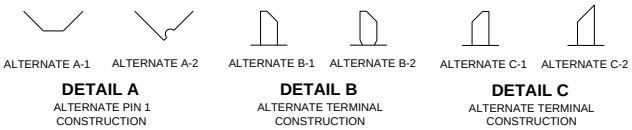
TOP VIEW

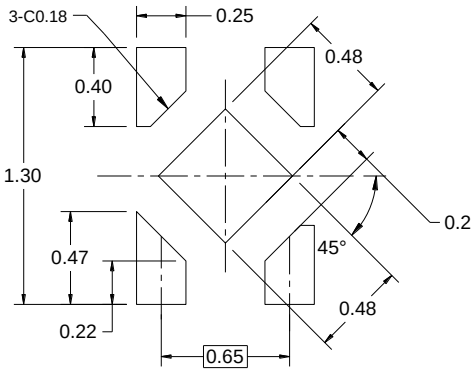


BOTTOM VIEW



SIDE VIEW





RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.340	0.370	0.400
A1	0.000	0.020	0.050
A2	0.100 REF		
b	0.170	-	0.300
D	0.950	1.000	1.050
E	0.950	1.000	1.050
D1	0.430	0.480	0.530
E1	0.430	0.480	0.530
L	0.200	0.250	0.300
L1	0.200	-	0.370
e	0.650 BSC		
k	0.150	-	-