SGM41100
True Monolithic Li-Ion/Li-Ion Polymer Battery Protector in Tiny Thin Package

GENERAL DESCRIPTION

The SGM41100 is a primary protection circuit for Li-ion/Li-ion polymer rechargeable cell with MOSFET switch integrated on a single die. The device is packaged in a tiny and thin package. Its small solution size leaves more space for fitting battery cell in a given cavity. The device is unique selection for small size apparatuses and wearable devices.

The SGM41100 does charging and discharging protection, detects and protects a cell in over-charging, over-discharging, over-current, battery under-voltage, and shutdowns the circuit in deep discharging.

The SGM41100 operates in -40℃ to +85℃ temperature range, is in a thin UTDFN-1.5×2-6L, nominal height 0.5mm package that is convenient to small cell packing designs.

FEATURES

- **Ultra Compact Protection Solution**
- **44mΩ Pass Resistance**
- **1μA Operation Current**
- **Factory Programmable OVP Threshold Options**
  - **4.20V to 4.55V with 0.05V per Step**
- **Over-Charge/Discharge Current Protection**
  - **4 Thresholds Combination Options**
- **Battery Under-Voltage Protection**
  - **2.4V/2.5V/2.8V/3.0V Options**
- **100nA Deep Discharging Shutdown**
- **Exhausted Battery Charging from 0.2V**
- **Input Surge Clamping**
- **Input Over-Voltage Safe**
- **Load Short-Circuit Safe**
- **Reverse Placed Battery Safe**
- **Input Reversed-Attaching Safe**
- **Battery Pack Paralleling Safe**
- **Locked-off for Delivery/Assembly**
- **Available in Green UTDFN-1.5×2-6L Package**

APPLICATIONS

IoT Gadgets
Wearable Devices
Battery Packs

TYPICAL APPLICATION

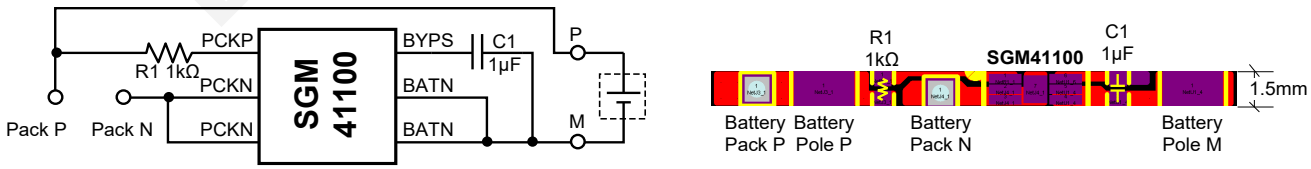


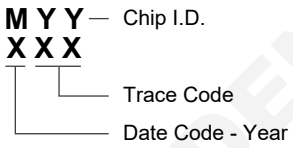
Figure 1. Typical Application Circuit and Demonstration Board Outline

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41100-425P04	UTDFN-1.5×2-6L	-40℃ to +85℃	SGM41100-425P04YUDT6G/TR	MD7 XXX	Tape and Reel, 3000
SGM41100-430P04	UTDFN-1.5×2-6L	-40℃ to +85℃	SGM41100-430P04YUDT6G/TR	MD8 XXX	Tape and Reel, 3000
SGM41100-435P04	UTDFN-1.5×2-6L	-40℃ to +85℃	SGM41100-435P04YUDT6G/TR	M95 XXX	Tape and Reel, 3000
SGM41100-445P04	UTDFN-1.5×2-6L	-40℃ to +85℃	SGM41100-445P04YUDT6G/TR	MD9 XXX	Tape and Reel, 3000
SGM41100-440O04	UTDFN-1.5×2-6L	-40℃ to +85℃	SGM41100-440O04YUDT6G/TR	MH5 XXX	Tape and Reel, 3000

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

MARKING INFORMATION



MODEL: SGM41100-XXXYXX

OVER-VOLTAGE THRESHOLD OPTIONS								
Option Code "**XXX**"	**420**	**425**	**430**	**435**	**440**	**445**	**450**	**455**
Over-Voltage Threshold V_{OV} (V)	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55
UNDER-VOLTAGE THRESHOLD OPTIONS								
Option Code "**Y**"	**M**		**N**		**O**		**P**	
Under-Voltage Threshold V_{UV} (V)	2.4		2.5		2.8		3.0	
CURRENT THRESHOLD COMBINATION OPTIONS								
Option Code "**XX**"	**04**		**06**		**09**		**13**	
Over-Charge Current I_{OC} (A)	0.35		0.51		0.76		1.12	
Over-Discharge Current I_{OD} (A)	0.42		0.61		0.91		1.34	
Short-Circuit Current (A)	1.36		1.96		2.76		2.76	

ABSOLUTE MAXIMUM RATINGS

PCKP to PCKN, 13V (1), 10mA Clamping (2) 5s
PCKP to PCKN ..... -4.5V or +9V (3), continues
PCKP to BATN ..... -4.5V (3) or +5.5V
PCKP to PCKN Short Circuit (4) ..... Continuous
PCKP to PCKN Attachment Inrush/Outrush (5) ..... +9V/-4.5V
PCKP to BATN Attachment Inrush/Outrush (6) ..... ±4.5V
Surge Current (7) ..... ±20A
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering 10 sec) ..... +260℃

NOTES:
1. Evaluation at V_{BAT} = 4.5V.
2. The clamping may reach 10mA at an input voltage >13V.
3. Test with a voltage regulated supply that has 2A current limit and increase the voltage progressively for less han 1V/ms slope rate, apply a voltage onto the device under test from 0V to given voltages.
4. The device is tested after being installed in the Figure 1 circuit board, Clip a 4.5V 5A power source onto the P and M for simulating a battery, short the Pack P and the Pack N with an 80mΩ wire.
5. The device is tested after being installed in the Figure 1 circuit board, clip a 3.2V supply and 2A sinking resistor R_{SINK} as showed in the Figure 2 onto the P and M for inrush test, clip a 4.5V 5A supply for outrush test.
6. The device is tested after being installed in the Figure 1 circuit board with the circuit in the Figure 3.
7. Parallel 2 battery packs with certain source impedance each and voltage difference for having 20A current surge.

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range ..... 0V to 6V
Battery Voltage Range ..... 0 to 4.5V
Environmental Temperature Range ..... -40℃ to +85℃

OVERSTRESS CAUTION

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

ESD SENSITIVITY CAUTION

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

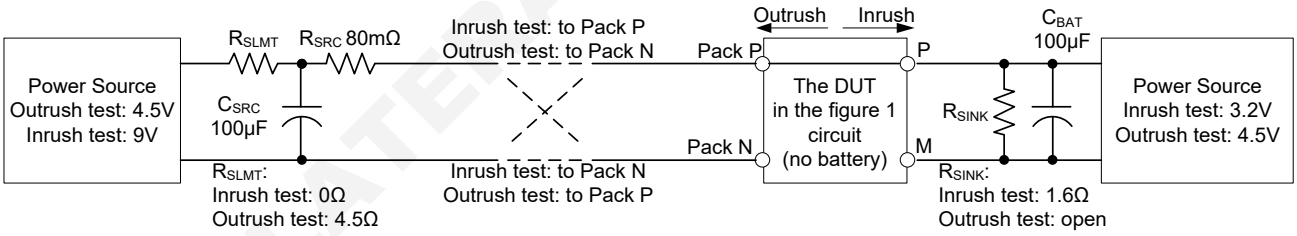


Figure 2. Test Set-Up for Pack P to Pack N Attachment Inrush/Outrush

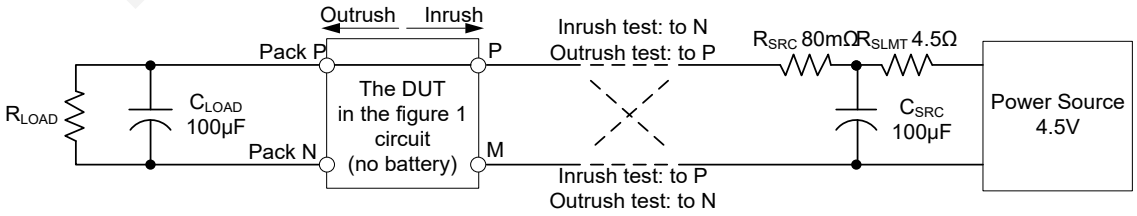
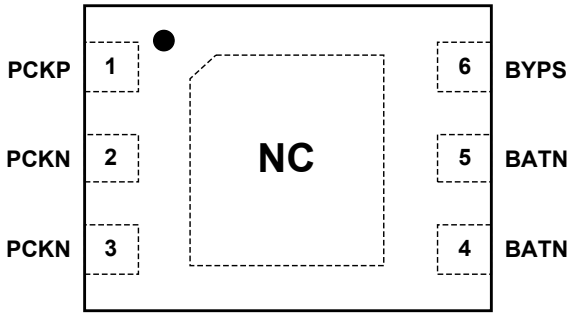


Figure 3. Test Set-up for Pack P to BATN Attachment Inrush/Outrush

PIN CONFIGURATION

(TOP VIEW)



UTDFN-1.5×2-6L

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	PCKP	P	Power Input and Output, the Battery Pack Anode. The default state after battery attached is close or locked-off, dependent on the external circuitry; Clip a capacitor of 200nF between the PCKN and the BATN for defaulting close.
2, 3	PCKN	P	Power Input and Output, the Battery Pack Cathode. Short this pin to the BATN pin to release off the locked open state, make the output path close.
4, 5	BATN	G	Ground of internal circuit; connect to the battery cathode end.
6	BYPS	I/O	Bypass Pin and Disconnection Lock-Off Triggering Input. Place a 1μF capacitor between this pin and the BATN pin. Shorting this pin to the PCKN momently makes the circuit into locked open state.
Thermal Pad	NC	NC	Not Connected.

NOTE: I/O: input or output; G: ground; P: power for the circuit; NC: not connected.

ELECTRICAL CHARACTERISTICS

(T_A = +25℃, V_{PCKP} = 5V, I_{CHG} = I_{DIS} = 100mA, V_{BAT} = 3.5V, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Over-Charge Voltage Threshold	V_{OV}	SGM41100-420_ _ _		4.20		V
		SGM41100-425_ _ _		4.25		
		SGM41100-430_ _ _		4.30		
		SGM41100-435_ _ _		4.35		
		SGM41100-440_ _ _		4.40		
		SGM41100-445_ _ _		4.45		
		SGM41100-450_ _ _		4.50		
		SGM41100-455_ _ _		4.55		
Over-Voltage Threshold Error (1)	$V_{OVERROR}$			30 (2)		mV
OV Release Hysteresis	V_{OVHYS}			-90		mV
Battery Under Voltage Threshold	V_{UV}	SGM41100-_ _ _M _ _		2.4		V
		SGM41100-_ _ _ N_ _		2.5		
		SGM41100-_ _ _ O_ _		2.8		
		SGM41100-_ _ _ P_ _		3.0		
Under-Voltage Threshold Error (1)	$V_{UVERROR}$			50 (2)		mV
UV Release Hysteresis	V_{UVHYS}			90		mV
Shutdown Voltage	V_{SHDN}			1.67		V
Over-Discharge Current	I_{OD}	SGM41100-_ _ _ _ _04		0.42		A
		SGM41100-_ _ _ _ _06		0.61		
		SGM41100-_ _ _ _ _09		0.91		
		SGM41100-_ _ _ _ _13		1.34		
Over-Charge Current	I_{OC}	SGM41100-_ _ _ _ _04		0.35		A
		SGM41100-_ _ _ _ _06		0.51		
		SGM41100-_ _ _ _ _09		0.76		
		SGM41100-_ _ _ _ _13		1.12		
Pass Resistance	R_P			44		mΩ
Operation Current	I_{OP}			1.0		μA
Shutdown Current	I_{SHDN}			0.1		μA
Over-Voltage Detection Delay	t_{OVPD}			1		s
Under-Voltage Detection Delay	t_{UVPD}			0.13		s
Over-Discharge Current Detection Delay	t_{ODD}			64		ms
Over-Discharge Current Retry Time	t_{RETRY}			0.26		s
Over-Discharge Current Retries	N			8		Times
Over-Charge Current Detection Delay	t_{OCD}			64		ms
Discharge Short-Circuit Detection Delay	t_{OCSD}			0.12		ms
Discharge Short-Circuit Scale Ratio	DS_{SR}	Times to I_{OD} for option 13.		2		
		Times to I_{OD} for other options.		3		

NOTES:

1. Total errors including test error, precondition side effect and aging drift.

2. This data is estimation from limited characterization, may have change after the completion of qualification for final production.

FUNCTION DESCRIPTION

The SGM41100 monitors voltage and current applied on battery cell connected between PCKP and BATN, and breaks the connection between battery and pack terminal with its internal switches when abnormality is identified.

Voltage Related Protections

When battery voltage reaches over-voltage threshold (V_{OV}), the charging path is cut off. The path closes again when the battery voltage falls back about V_{OVHYS} below the threshold, or discharging happens.

When the battery voltage falls below V_{UV}, the discharging path opens, to protect the battery from being over discharged. If the battery voltage falls low further, at about 1.67V, the SGM41100 is turned into shutdown for further reducing current consumption, which helps keeping battery from harmful exhausted condition as long as possible. The path closes again when a charging supply is applied and the battery voltage rises to about 110mV above the threshold.

Charge an exhausted battery: When a battery is deeply discharged and its voltage is below V_{SHNT}, it could be charged through the switch's body diode, until the battery voltage goes below 0.2V. The SGM41100 does not provide over-charging current protection until the battery voltage goes higher over V_{SHNT}. The body diode path is not kept when the battery voltage is below 0.2V; an additional charging path is desired for charging a battery whose voltage is less than 0.2V.

Current Related Protections

When over-discharging current condition occurs and keeps for t_{ODD}, the discharging path opens. The path closes again in t_{RETRY} for retrying. The SGM41100 keeps retires for mot more than N times if the over-current condition remains and battery voltage is not lower than V_{UV}. If the over-current condition remains after N retries, the SGM41100 enters lock-off state and keeps until being activated.

After over-charging current is identified, the SGM41100 enters the lock-off state and keeps until being activated.

Short-circuit protection: When discharge current exceeds 3× or 2× of the over-current threshold (3× for _04/_06/_09 options, 2× for _13 option), discharging path cuts off instantly in t_{OCSD}, in order to protect the battery from potential current over stress. After cutting off, the SGM41100 stays in the lock-off state until being activated.

Burst load outrush: The device does not break the discharging path actively for less than t_{OCSD}, allows to power burst loads, which is normal in applications.

When an over-charging current condition is identified, charging path is cut off. It restores close when the input voltage drops about 30mV lower than the battery voltage.

Parallel battery packs: When paralleling 2 battery packs with SGM41100s built in, a momentary current rush causes the over-current protection in the one with lower voltage, if the voltage difference between 2 cells is big enough. The protection releases only when the one with the higher battery voltage discharges to a slightly lower voltage than the one in protection, and then both cells conduct together.

It is highly recommended to force the packs into a locked open state firstly (by connecting the BYPS to the PCKN momentarily once) before being paralleled to avoid current over-stress. After being paralleled, the lock open states release progressively when a charging supply is applied and pack voltage goes higher.

Battery delivery state: It is recommended to deliver a battery pack in a lock-off state to avoid unintentionally shorting in production handling or transportation. The circuit in the Figure 1 turns the SGM41100 into a lock-off state by battery attachment, or the state could be set by momentarily shorting the BYPS and PCKN.

If a conducting state right after battery attachment is wanted, clipping a 220nF capacitor between the BATN and PCKN makes.

Pack activation: Apply a charging input in the range suitable for charging, or else short the PCKN to BATN momentarily once, to release the pack from lock off state for turning it into conducting state.

FUNCTION DESCRIPTION (continued)

Surge, ESD and Reversed Attachment

The SGM41100 absorbs voltage surge applied between PCKP and PCKN, by passing the surge current through its switch and the battery. Surge may occur when attaching the pack or battery cell.

The SGM41100 survives either if a cell is placed reversely or a charge input is reversely attached, but not both in the same time. Any of the reversed attachments, short circuit, inrush surge and outrush, causes over-stress. Do not test those cases in normal production inspection, as this kind of test itself may cause performance degradation or even damage the device.

Cautions for Evaluation Test

Kinds of electronic load simulator may have excessive inrush current, kinds of BPM tester may have voltage transition surge, which may trigger the protection of the SGM41100. Careful attention is desired for doing such evaluations with those kinds of equipment; external surge limits within the conditions specified in the absolute ratings part of this datasheet may be required.

Select Protection Parameters

Battery models from different vendors may be specialized for different dedicate applications; consult the battery vendor for protection limits for specific battery model. Parameters for the protection circuit should not overstep those limits. Parameters might be selected for match with the charger's or against the application need within those limits.

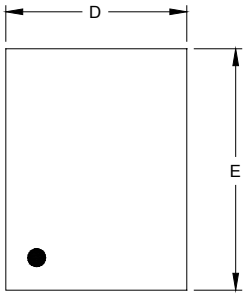
Parameters of the protection circuit and of the charger circuit affecting same variables should be set in proper order. For example, the over-voltage threshold be 50mV~100mV higher than it.

Cautions on parameter miss-alignment: If the V_{OV} is lower than the battery charger's full of charge voltage, the protection circuit cuts off the battery charge path before the battery is fully charged, and turns itself into the lock off state; if the I_{OC} is lower than the charge current, the protection circuit also turns itself into the lock off state. In both cases, the charge input should fall firstly and then re-apply for activating the protection circuit from the lock off state to the conducting state. If the input keeps unchanged, the battery will not be charged even it voltage falls deeply.

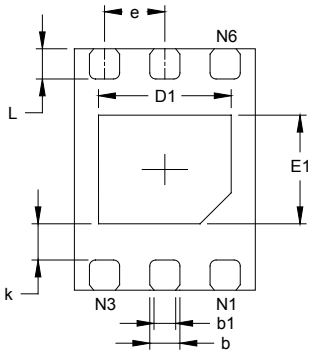
If the V_{UV} is lower than the large fast charge voltage range threshold, when the battery voltage is in the range between V_{UV} and the threshold mentioned above, the charge current goes through the body diode path in the protection circuit, in which the charge over-current does not work and the diode voltage drop incurs more power loss and heat that may damage the protection circuit.

PACKAGE OUTLINE DIMENSIONS

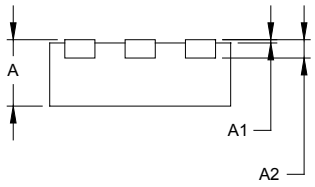
UTDFN-1.5×2-6L



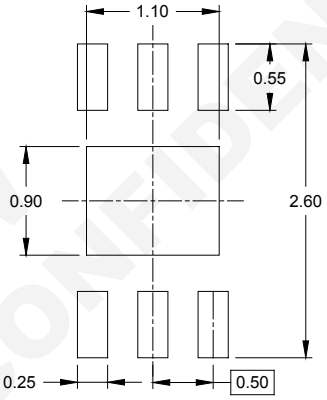
TOP VIEW



BOTTOM VIEW



SIDE VIEW

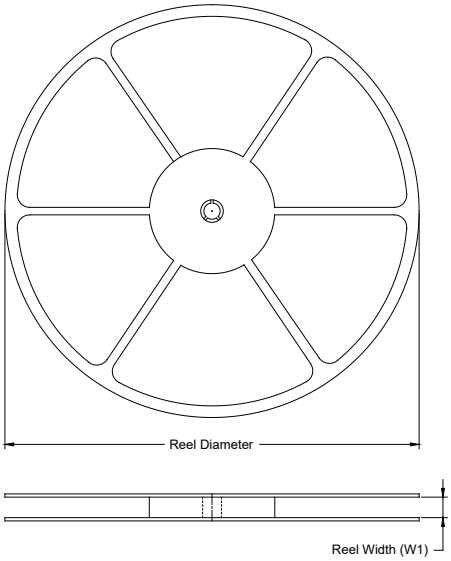


RECOMMENDED LAND PATTERN (Unit: mm)

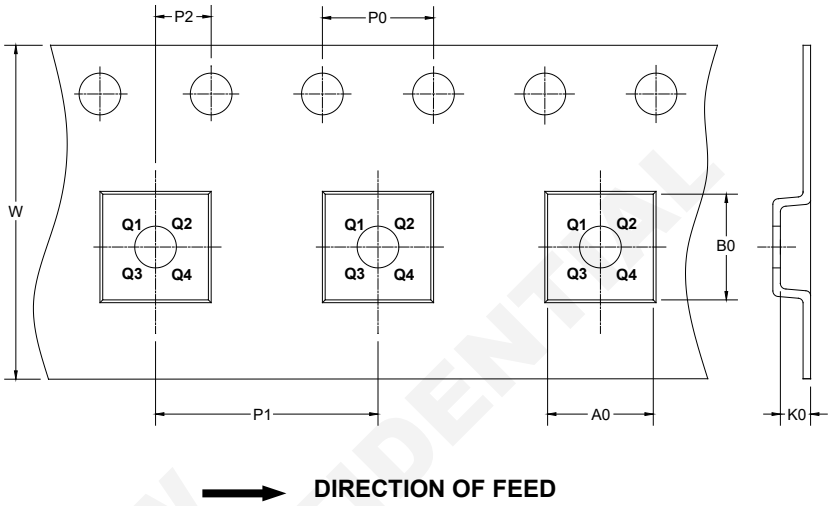
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
A2	0.152 REF		0.006 REF	
D	1.400	1.600	0.055	0.063
D1	1.000	1.200	0.039	0.047
E	1.900	2.100	0.075	0.083
E1	0.800	1.000	0.031	0.039
k	0.300 REF		0.012 REF	
b	0.200	0.300	0.008	0.012
b1	0.180 REF		0.007 REF	
e	0.500 BSC		0.020 BSC	
L	0.200	0.300	0.008	0.012

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



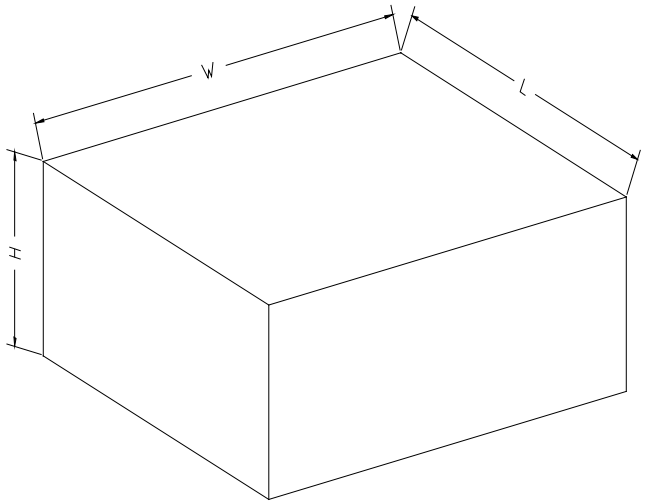
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
UTDFN-1.5×2-6L	7″	9.5	1.70	2.30	0.75	4.0	4.0	2.0	8.0	Q2

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002