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HY2122

Data Sheet

2-Cell LiFePO4
Battery Packs Protection ICs

Table of Contents

1. GENERAL DESCRIPTION	4
2. FEATURES	4
3. APPLICATIONS	4
4. BLOCK DIAGRAM.....	5
5. ORDERING INFORMATION	6
6. MODEL LIST	6
6.1. Delay Time Code-Parameter Option of Delay Time.....	7
6.2. Characteristic Code-Other function Option	7
7. PIN CONFIGURATION AND PACKAGE MARKING INFORMATION	7
8. ABSOLUTE MAXIMUM RATINGS	8
9. ELECTRICAL CHARACTERISTICS	9
9.1. Electrical Characteristics (Except Delay Time Parameter)	9
9.2. Delay Time Combination	10
10. BATTERY PROTECTION IC CONNECTION EXAMPLE	11
11. DESCRIPTION OF OPERATION.....	13
11.1. Normal Status.....	13
11.2. Overcharge Status	13
11.3. Overdischarge Status.....	13
11.4. Discharge Overcurrent Status (Discharge Overcurrent & Short Circuit).....	14
11.5. Charge Overcurrent Status	15
11.6. 0V Battery Charging Function “Available”	15
11.7. 0V Battery Charging Function “Unavailable”	16
12. CHARACTERISTICS (TYPICAL DATA).....	17
13. PACKAGE INFORMATION.....	20
13.1. SOT-23-6.....	20
14. TAPE & REEL INFORMATION	21
14.1. Tape & Reel Information---SOT-23-6 (Type 1).....	21
14.2. Tape & Reel Information---SOT-23-6 (Type 2).....	22
15. REVISION RECORD.....	23

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1. General Description

The series of **HY2122** ICs is best created for 2-cell LiFePO4 battery protection and it also comprises high-accuracy voltage detectors and delay circuits.

These ICs are suitable for protecting 2-cell LiFePO4 battery packs against the problems of overcharge, overdischarge and overcurrent.

2. Features

The features that whole series of HY2122 comprised are as follows:

(1) High-accuracy voltage detection circuit

- Overcharge detection voltage V_{CU_n} ($n=1,2$) 3.60 to 4.00V Accuracy $\pm 25\text{mV}$
- Overcharge release voltage V_{CR_n} ($n=1,2$) 3.40 to 4.00V Accuracy $\pm 50\text{mV}$
- Overdischarge detection voltage V_{DL_n} ($n=1,2$) 1.80 to 2.20V Accuracy $\pm 80\text{mV}$
- Overdischarge release voltage V_{DR_n} ($n=1,2$) 1.80 to 2.50V Accuracy $\pm 100\text{mV}$
- Discharge overcurrent detection voltage (by option)
- Charge overcurrent detection voltage (by option) Accuracy $\pm 30\text{mV}$
- Short-circuiting detection voltage 1.0V(fixed) Accuracy $\pm 0.4\text{V}$

(2) Delay times are generated by an internal circuit (external capacitors are unnecessary).

- Overcharge delay time 1000ms typ.
- Overdischarge delay time 110ms typ.
- Discharge overcurrent delay time 10ms typ.
- Charge overcurrent detection voltage 7ms typ.
- Short circuit delay time 250 μs typ.

(3) Low current consumption (Products with Power-down Function)

- Operation mode 5.0 μA typ., 9.0 μA max. ($V_{DD}=6.4\text{V}$)
- Ultra low power-down current at 0.1 μA max.

(4) High-withstanding-voltage device is used for charger connection pins

(CS pin and OC pin : Absolute maximum rating = 33 V)

(5) 0 V battery charge function “available” / “unavailable” are selectable

(6) Wide operating temperature range -40°C to $+85^{\circ}\text{C}$

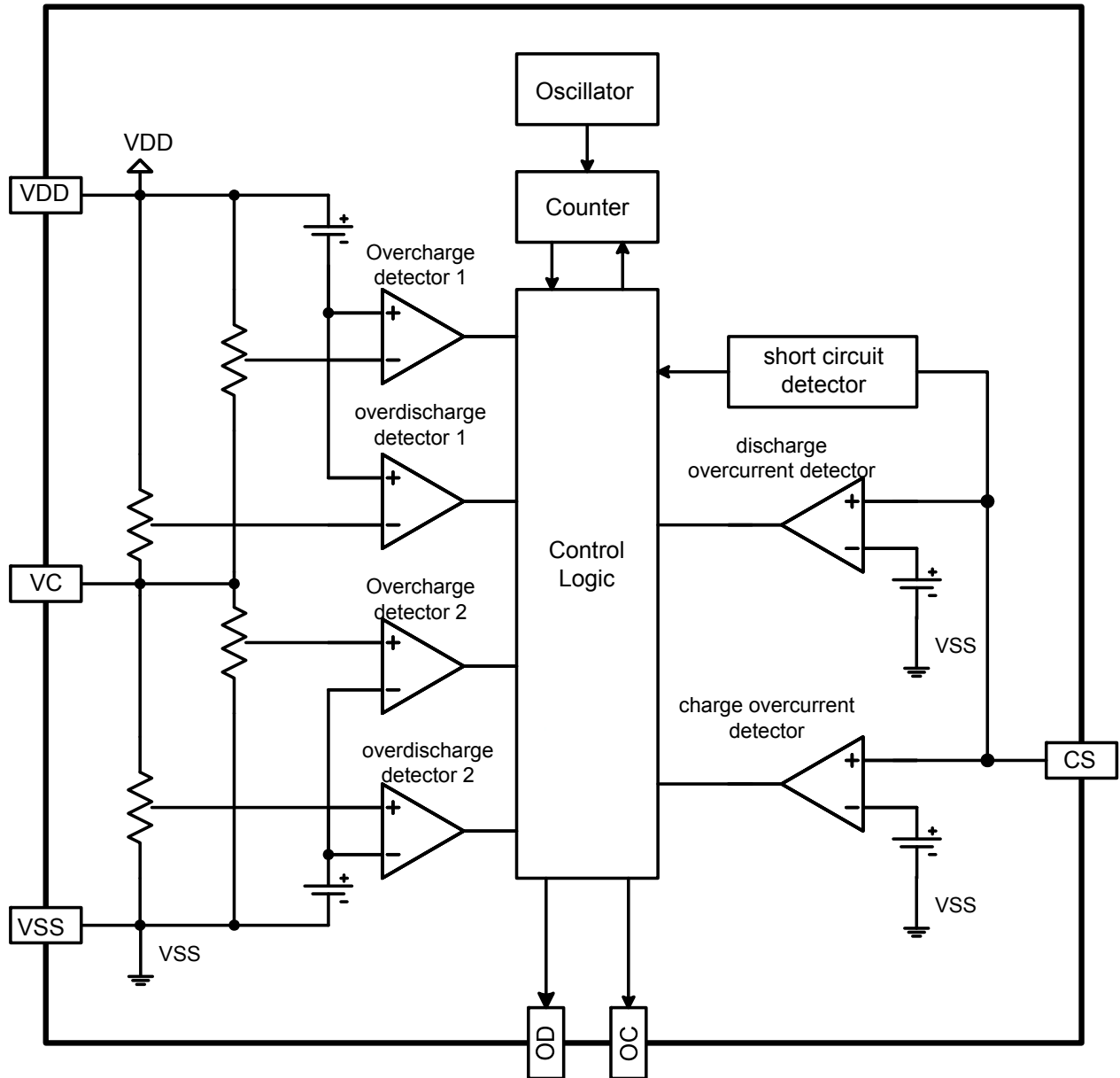
(7) Small package SOT-23-6

(8) The HY2122 series are Halogen-free, green package

3. Applications

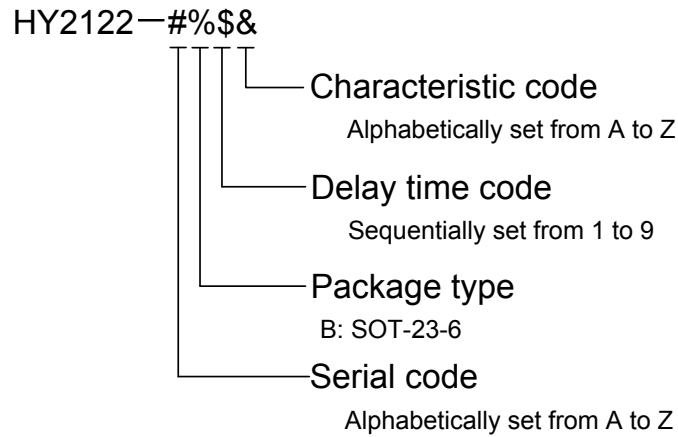
- 2-cell LiFePO4 rechargeable battery packs

4. Block Diagram



5. Ordering Information

■ Product name define



6. Model List

Table 1 Model list

Model	Over-charge detection voltage	Over-charge release voltage	Over-discharge detection voltage	Over-discharge release voltage	Discharge overcurrent detection voltage	Charge overcurrent detection voltage	Delay Time Code	Characteristic Code
	V _{CU}	V _{CR}	V _{DL}	V _{DR}	V _{DIP}	V _{CIP}	-	-
HY2122-AB1A	3.65V	3.45V	2.00V	2.50V	200mV	-200mV	1	A
HY2122-AB1B	3.65V	3.45V	2.00V	2.50V	200mV	-200mV	1	B
HY2122-BB1A	3.75V	3.25V	1.80V	2.30V	200mV	-200mV	1	A
HY2122-EB1A	3.95V	3.50V	2.20V	2.50V	200mV	-200mV	1	A

Remark: 1. Table 1 lists out typical value of every electrical parameter. Please refer to Table 6 for detailed electrical characteristics.

2. Table 2 lists out delay time parameters of every corresponding delay time code. Table 3 lists out characteristic function of every corresponding characteristic code.

3. Please contact our sales office for the products with detection voltage value other than those specified above.

6.1. Delay Time Code-Parameter Option of Delay Time

Table 2 Delay Time Code- Delay Time Parameter Option

Delay Time Code	Overcharge Delay Time	Overdischarge Delay Time	Discharge Overcurrent Delay Time	Charge Overcurrent Delay Time	Short Circuit Delay Time
	T _{OC}	T _{OD}	T _{DIP}	T _{CIP}	T _{SIP}
1	1000ms	110ms	10ms	7ms	250μs

Remark:

1. Table 2 lists out typical value of every delay time parameters, for detailed delay time combination
2. please refer to Table 7.

6.2. Characteristic Code-Other function Option

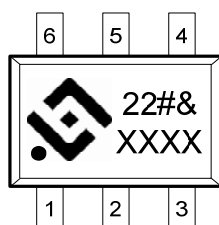
Table 3 Characteristic Code-Other function Option

Characteristic Code	0 V Battery Charge Function	Power-down Function/ Auto Overdischarge Recovery Function
A	Available	With power-down Function
B	Available	With auto overdischarge recovery function
C	Unavailable	With auto overdischarge recovery function

7. Pin Configuration and Package Marking Information

Table 4

Pin No.	Symbol	Description
1	OD	MOSFET gate connection pin for discharge control
2	OC	MOSFET gate connection pin for charge control
3	CS	Input pin for current sense, charger detect pin
4	VC	Input pin of the center voltage between two-cell
5	VDD	Power supply pin
6	VSS	Ground pin



22: Product Name.

#: Serial code. Alphabetically set from A to Z.

&: Characteristic code. Alphabetically set from A to Z.

XXXX: Date code.

8. Absolute Maximum Ratings

Table 5 Absolute Maximum Ratings (VSS=0V, Ta=25°C unless otherwise specified)

Item	Symbol	Rating	Unit
Input voltage between VDD and VSS pin	V _{DD}	VSS-0.3 to VSS+10	V
OC output pin voltage	V _{OC}	VDD-33 to VDD+0.3	V
OD output pin voltage	V _{OD}	VSS-0.3 to VDD+0.3	V
CS input pin voltage	V _{CS}	VDD-33 to VDD+0.3	V
Operating Temperature Range	T _{OP}	-40 to +85	°C
Storage Temperature Range	T _{ST}	-40 to +125	°C
Power dissipation	P _D	250	mW

9. Electrical Characteristics

9.1. Electrical Characteristics (Except Delay Time Parameter)

Table 6 Electrical Characteristics (VSS=0V, Ta=25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
SUPPLY POWER RANGE						
Operating voltage between VDD pin and VSS pin	V_{DSOP1}	-	1.5	-	10	V
Operating voltage between VDD pin and CS pin	V_{DSOP2}	-	1.5	-	33	V
INPUT CURRENT(with Power-down Function)						
Supply Current	I_{DD}	VDD=6.4V	-	5.0	9.0	μA
Power-Down Current	I_{PD}		-	-	0.1	μA
INPUT CURRENT(with Auto Overdischarge Recovery Function)						
Supply Current	I_{DD}	VDD=6.4V	-	5.0	9.0	μA
Power-Down Current	I_{PD}		-	5.0	9.0	μA
DETECTION VOLTAGE						
Overcharge Detection Voltage cell n (*1)	V_{CUn}	3.6V to 4.0V adjustable	$V_{CUn}-0.025$	V_{CUn}	$V_{CUn}+0.025$	V
Overcharge Release Voltage cell n (*1)	V_{CRn}	3.4V to 4.0V adjustable	$V_{CRn}-0.05$	V_{CRn}	$V_{CRn}+0.05$	V
Overdischarge Detection Voltage cell n (*1)	V_{DLn}	1.8V to 2.2V adjustable	$V_{DLn}-0.08$	V_{DLn}	$V_{DLn}+0.08$	V
Overdischarge Release Voltage cell n (*1)	V_{DRn}	1.8V to 2.5V adjustable	$V_{DRn}-0.10$	V_{DRn}	$V_{DRn}+0.10$	V
Discharge Overcurrent Detection Voltage	V_{DIP}		$V_{DIP}-30$	V_{DIP}	$V_{DIP}+30$	mV
Short Circuit Detection Voltage	V_{SIP}	$V_{DD}-V_{SS}=6.0V$	0.6	1.0	1.4	V
Charge Overcurrent Detection Voltage	V_{CIP}		$V_{CIP}-30$	V_{CIP}	$V_{CIP}+30$	mV
CONTROL OUTPUT VOLTAGE(OD&OC)						
OD Pin Output "H" Voltage	V_{DH}		VDD-0.1	VDD-0.02		V
OD Pin Output "L" Voltage	V_{DL}			0.2	0.5	V
OC Pin Output "H" Voltage	V_{CH}		VDD-0.1	VDD-0.02		V
OC Pin Output "L" Voltage	V_{CL}			0.2	0.5	V
0V BATTERY CHARGE FUNCTION						
Charger start voltage(available 0V battery charge function)	V_{0CH}	Available 0V battery charge function	1.2	-	-	V
Battery voltage(unavailable 0V battery charge function)	V_{0IN}	Unavailable 0V battery charge function	-	-	0.5	V

NOTE:

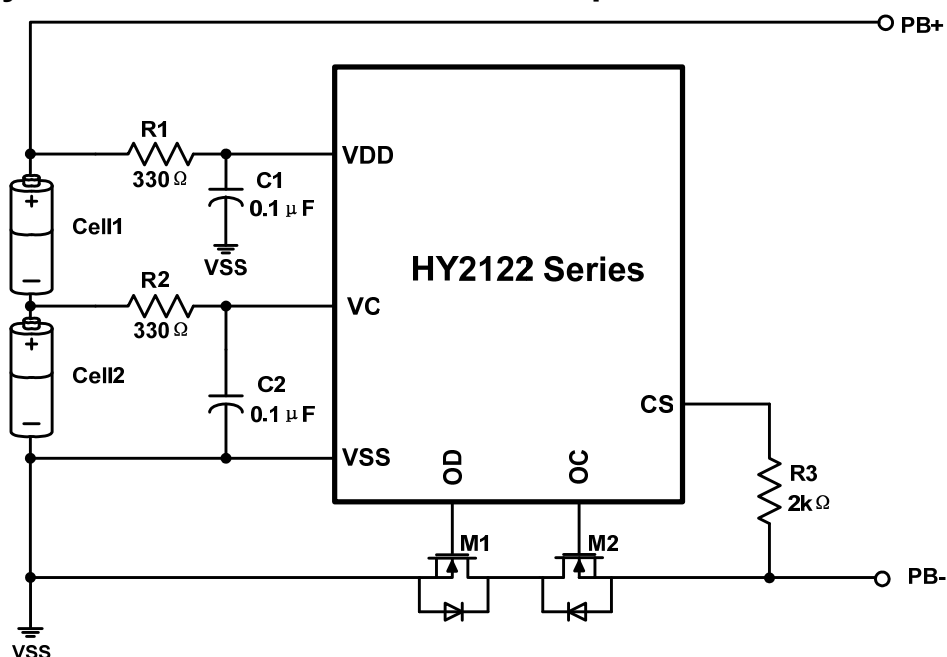
*1. n=1,2.

9.2. Delay Time Combination

Table 7 Delay Time Parameter Combination of Delay Time Code: 1

Item	Symbol	Min.	Typ.	Max.	Unit
Overcharge Delay Time	T _{OC}	700	1000	1300	ms
Overdischarge Delay Time	T _{OD}	70	110	150	ms
Discharge Overcurrent Delay Time	T _{DIP}	6	10	14	ms
Charge Overcurrent Delay Time	T _{CIP}	4	7	10	ms
Short Circuit Delay Time	T _{SIP}	150	250	400	μs

10. Battery Protection IC Connection Example



Symbol	Device Name	Purpose	Min.	Typ.	Max.	Remark
R1	Resistor	limit current, stabilize VDD and strengthen ESD protection	100Ω	330Ω	470Ω	*1
R2	Resistor	limit current, stabilize VC and strengthen ESD protection	100Ω	330Ω	470Ω	*1
R3	Resistor	limit current	1 kΩ	2kΩ	4kΩ	*2
C1	Capacitor	Filter, stabilize VDD	0.01μF	0.1μF	1.0μF	*3
C2	Capacitor	Filter, stabilize VDD	0.01μF	0.1μF	1.0μF	*3
M1	N-MOSFET	Discharge control	-	-	-	*4
M2	N-MOSFET	Charge control	-	-	-	*5

- *1. If R1 or R2 connects with an over-spec resistor, battery accuracy may be influenced due to R1 or R2 voltage drop that caused by current consumption. When a charger is connected in reversed, the current flows from the charger to the IC. At this time, if R1 or R2 is too high, the voltage between VDD pin and VSS pin may exceed the absolute maximum rating.
- *2. If R3 connects with an over-spec resistor, the charging current may not be cut off when a high-voltage charger is connected. Please select as large a resistor as possible to control current when a charger is connected in reversed.
- *3. C1 & C2 can stabilize the supply voltage of VDD, the value of C1 & C2 should be equal to or more than 0.01μF.
- *4. If a MOSFET with a threshold voltage that is the same or more than overdischarge detection voltage is applied, discharging may be stopped before overdischarge is detected.
- *5. If the withstanding voltage between the gate and source is lower than the charger voltage, the FET may be destroyed.

Caution:

1. The above constants may be changed without notice, please download the most up-to-date datasheet on our website. <http://www.hycontek.com>
2. It is advised to perform thorough evaluation and test if peripheral devices need to be amended.

11. Description of Operation

11.1. Normal Status

This IC monitors the voltage of the battery connected between the VDD pin and VSS pin and the voltage difference between the CS pin and VSS pin to control charging and discharging.

When the cell1 and cell2 voltage is in the range from overdischarge detection voltage (V_{DLn}) to overcharge detection voltage (V_{CUn}), and the CS pin voltage is in the range from the charge overcurrent detection voltage (V_{CIP}) to discharge overcurrent detection voltage (V_{DIP}), the IC turns both the charging and discharging control MOSFET on. This condition is called the normal status. Under this condition, charging and discharging can both be carried out freely.

Notice: Discharging may not be enacted when the battery is first time connected. To regain normal status, CS and VSS PIN must be shorted or the charger must be connected.

11.2. Overcharge Status

The normal state of the battery voltage between VDD pin and VC pin (the voltage of Cell 1) and the voltage between VC pin and VSS pin (the voltage of Cell2), if either voltage becomes equal or more than the overcharge detector voltage (V_{CUn}), and continued exceed overcharge delay time (T_{OC}) an external charge control Nch MOSFET turns off with OC pin being at "L" level.

To reset the overcharge and make the OC pin level to "H" again after detecting overcharge, in such conditions that a time when the both Cell1 and Cell2 are down to a level lower than overcharge voltage, by connecting a kind of load to VDD after disconnecting a charger from the battery pack. Then, the output voltage of OC pin becomes "H", and it makes an external Nch MOSFET turn on, and charge cycle is available. In other words, once overcharge is detected, even if the supply voltage becomes low enough, if a charger is continuously connected to the battery pack, recharge is not possible.

Further, either or both voltage of Cell1 and Cell2 is higher than the overcharge detector threshold, if a charger is removed and some load is connected, OC outputs "L", however, load current can flow through the parasitic diode of the external charge control Nch MOSFET. After that, when the VDD pin voltage becomes lower than the overcharge detector threshold, OC becomes "H".

Internal fixed output delay times for overcharge detection. If either or both of the voltage of Cell1 or Cell2 keeps its level more than the overcharge detector threshold, and output delay time passes, overcharge voltage is detected. Even when the voltage of Cell1 or Cell2 level becomes equal or higher level than overcharge detection voltage (V_{CUn}) if these voltages would be back to a level lower than the overcharge detector threshold within a time period of the output delay time, the overcharge is not detected.

11.3. Overdischarge Status

Batteries under normal operation mode, voltage of cell 1 that connected to VDD and VC pin or voltage of cell 2 that connected to VC and VSS pin drops lower than overdischarge detection voltage (V_{DLn}) and the mode continues longer than overdischarge detection delay time (T_{OD}) during discharging,

HY2122 series will turn the OD pin output voltage from high level to low level and turn the discharging control MOSFET off (OD pin) so as to stop discharging. This condition is called the “Overdischarge Status”.

11.3.1. Products with Power-down Function

When MOSFET is off, CS pin voltage is pulled up by IC internal resistor to VDD, reducing IC power consumption value to that of in the sleep mode ($<0.1\mu\text{A}$). This condition is called the “Sleep Mode”.

The overdischarge status will be released by two following cases. OD pin output voltage turns from low level to high level, conducting discharge control MOSFET.

- (1) If CS pin voltage lowers than charge overcurrent detection voltage (V_{CIP}) when charger is connected, voltage of cell 1 and cell 2 goes higher than overdischarge detection voltage (V_{DLn}), the overdischarge status is released and back to normal operation mode.
- (2) If CS pin voltage is higher than charge overcurrent detection voltage (V_{CIP}) when charger is connected, voltage of cell 1 and cell 2 goes higher than overdischarge release voltage (V_{DRn}), the overdischarge status is released and back to normal operation mode.

11.3.2. Products with Auto Overdischarge Recovery Function

The overdischarge status will be released by three cases:

- (1) When CS pin voltage is equal to or lower than the charge overcurrent detection voltage (V_{CIP}) by charging and the VDD pin voltage is higher than the overdischarge detection voltage (V_{DL}).
- (2) When CS pin voltage is equal to or higher than the charge overcurrent detection voltage (V_{CIP}) by charging and the VDD pin voltage is higher than the overdischarge release voltage (V_{DR}).
- (3) Without connecting a charger, if the VDD pin voltage is higher than overdischarge release voltage (V_{DR}), the overdischarge status will be released, namely Auto Overdischarge Recovery Function.

Notice :

- ① When voltage of cell 1 and cell 2 lowers than overdischarge detection voltage (V_{DLn}) and stayed within overdischarge detection delay time (T_{OD}), the voltage of cell 1 and cell 2 increases higher than overdischarge detection voltage (V_{DLn}), it will not enter into overdischarge protection mode.
- ② The output type of OD pin is having "H" level of VDD and "L" level of VSS.

11.4. Discharge Overcurrent Status (Discharge Overcurrent & Short Circuit)

The IC continuously monitor discharge current by examining CS pin voltage when batteries under normal operation. Once the voltage of CS pin exceeds that of discharge overcurrent detection voltage (V_{DIP}) and this status lasts longer than discharge overcurrent delay time (T_{DIP}), and voltage output of OD pin changes from high potential to low potential, the MOSFET (OD pin) is disabled and discharge stopped. This status is called “Discharge Over-current Status”.

When CS pin voltage excels short circuit detection voltage (V_{SIP}) and this status lasts longer than short circuit delay tome (T_{SIP}), voltage output of OD pin changes from high potential to low potential. At this time, the MOSFET (OD pin) is disabled and discharge stopped. This status is called “Short Circuit Status”.

Discharge over-current status and short current status is released while the connected impedance between PB+ and PB- is larger than 450k Ω (typ.).

Additionally, when charger is connected, even the impedance between PB+ and PB- lowers than 450k Ω (typ.) and CS pin voltage lowers than discharge overcurrent detection voltage (V_{DIP}), the discharge over-current status or short circuit status will still be released and back to normal operation mode.

11.5. Charge Overcurrent Status

When CS pin voltage lowers than charge overcurrent detection voltage (V_{CIP}) and this status lasts longer than charge overcurrent delay time (T_{CIP}) during charge process of batteries under normal operation, OC pin voltage output will change from high potential to low potential. At this time, MOSFET (OC pin) is disabled and charge stopped. This status is called “Charge Overcurrent Status”.

If CS pin voltage increases higher than charge overcurrent detection voltage (V_{CIP}) by disconnecting charger after enter charge overcurrent status, the charge overcurrent status will be released and restore to normal operation mode.

11.6. 0V Battery Charging Function “Available”

This function is used to recharge a connected battery which voltage is 0V due to self-discharge. When the 0V battery charge starting charger voltage (V_{0CH}) or a higher voltage is applied between the battery+ (PB+) and battery- (PB-) pins by connecting a charger, the charging control MOSFET gate is fixed to the VDD pin voltage.

When the voltage between the gate and the source of the charging control MOSFET becomes equal to or higher than the turn on voltage due to the charger voltage, the charging control MOSFET is turned on to initiate charging. At this time, the discharging control MOSFET is off and the charging current flows through the internal parasitic diode in the discharging control MOSFET. When the battery voltage becomes equal to or higher than overdischarge detection voltage (V_{DL}), the HY2122 series will enter into the normal status.

Caution

- (1) Some battery providers do not recommend charging for a completely self-discharged battery. Please ask the battery provider to determine whether to enable or prohibit the 0V battery charging function.
- (2) The 0V battery charge function has higher priority than the charge overcurrent detection function. Consequently, a product in which use of the 0V battery charging function is enabled to forcibly charge a battery and the charge current cannot be detected when the battery voltage is lower than overdischarge detection voltage (V_{DL}).

11.7. 0V Battery Charging Function “Unavailable”

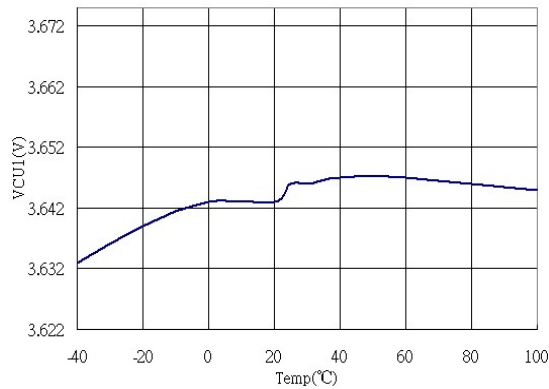
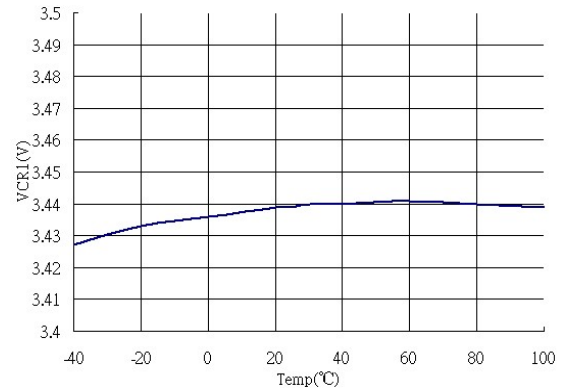
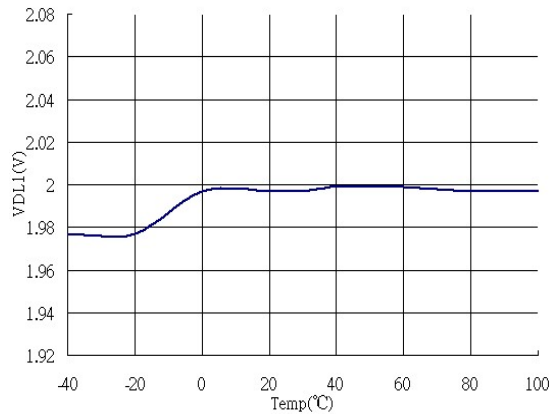
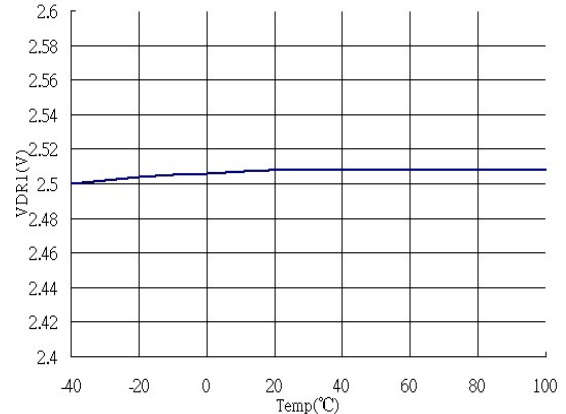
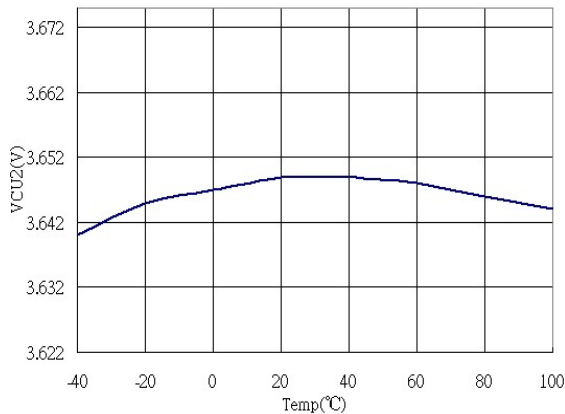
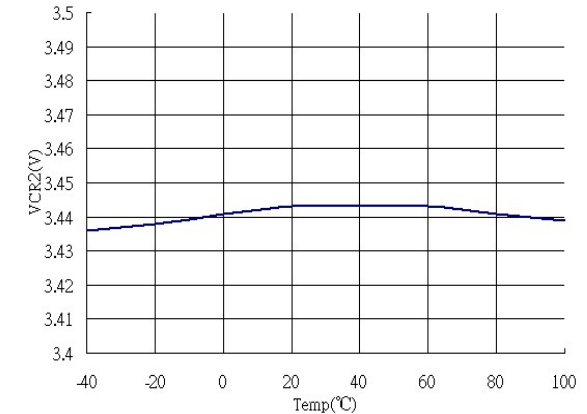
When a battery that is internally short-circuited (0V battery) is connected, the unavailable 0V charging function will prohibit recharging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V_{0IN}) or lower, the charging control MOSFET gate is fixed to the PB- pin voltage to prohibit charging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V_{0IN}) or higher, charging can be implemented.

Caution

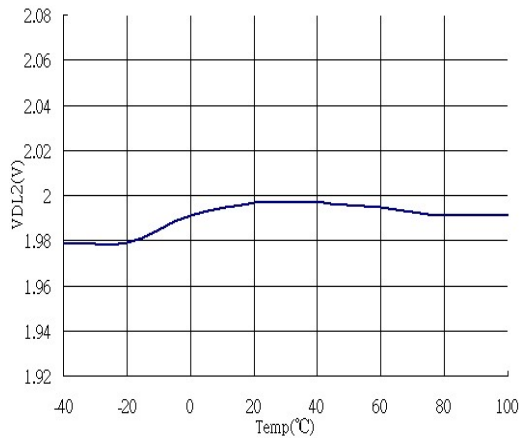
(1) Some battery providers do not recommend charging for a completely self-discharged battery. Please ask the battery provider to determine whether to enable or prohibit the 0V battery charging function.

12. Characteristics (Typical Data)

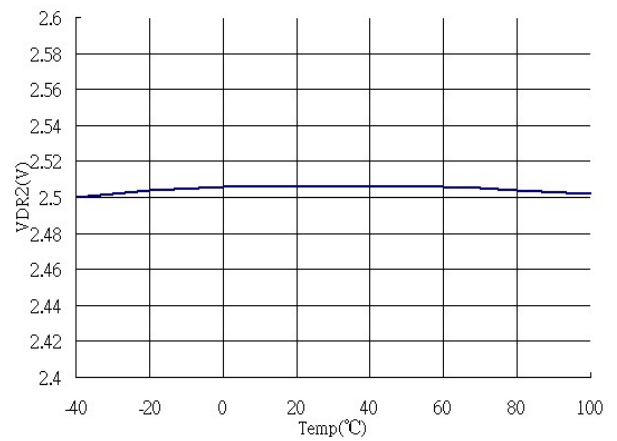
12.1. Overcharge Detection / Release Voltage, Overdischarge Detection / Release Voltage, Discharge overcurrent Detection Voltage, Short circuit Detection Voltage, Charge overcurrent Detection Voltage and Delay Time

(1) V_{CU1} vs. T_a (2) V_{CR1} vs. T_a (3) V_{DL1} vs. T_a (4) V_{DR1} vs. T_a (5) V_{CU2} vs. T_a (6) V_{CR2} vs. T_a 

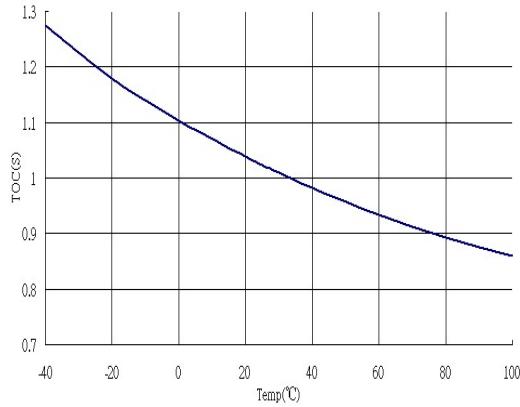
(7) V_{DL2} vs. T_a



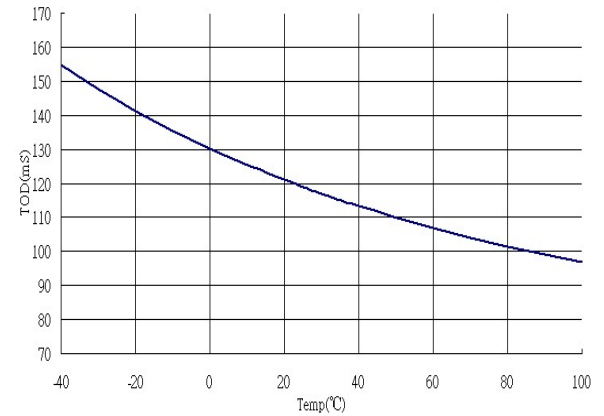
(8) V_{DR2} vs. T_a



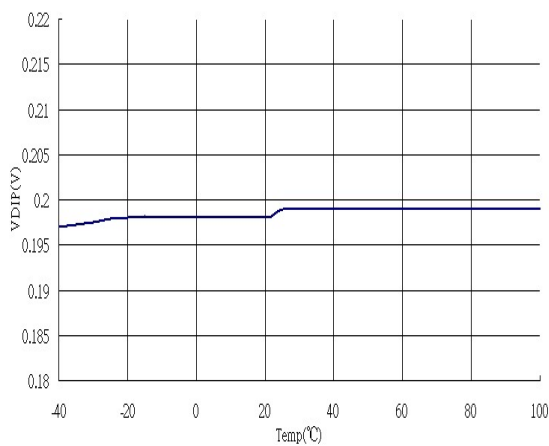
(9) T_{OC} vs. T_a



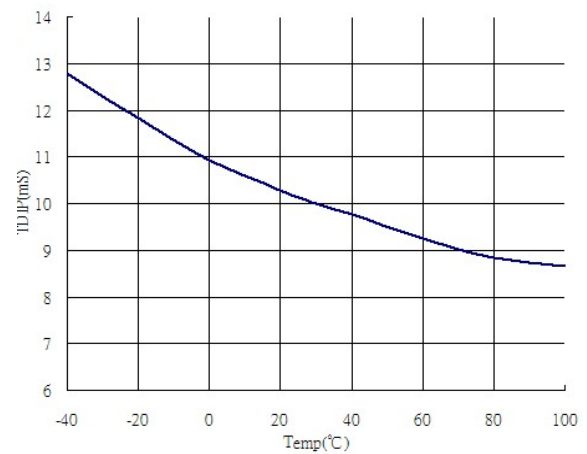
(10) T_{OD} vs. T_a



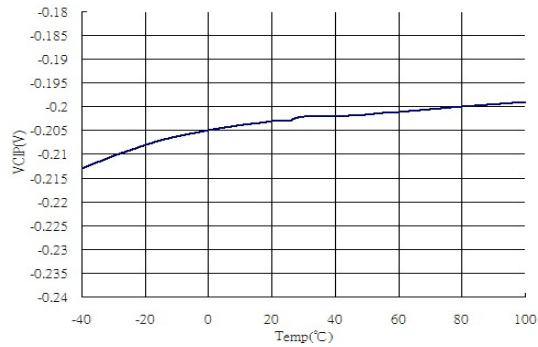
(11) V_{DIP} vs. T_a



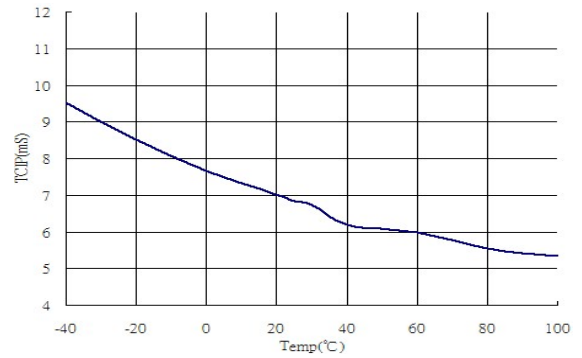
(12) T_{DIP} vs. T_a



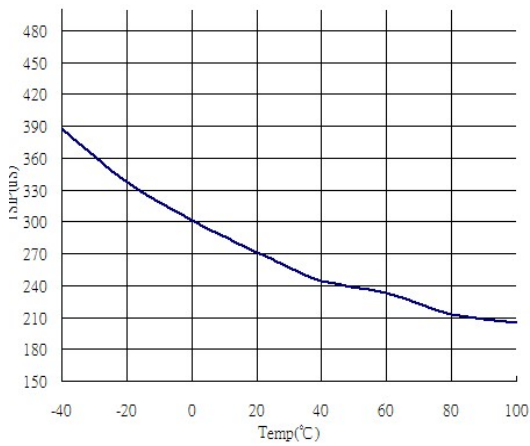
(13) V_{CIP} vs. T_a



(14) T_{CIP} vs. T_a

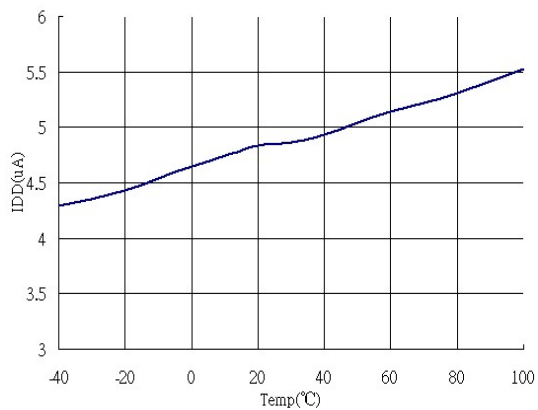


(15) T_{SIP} vs. T_a

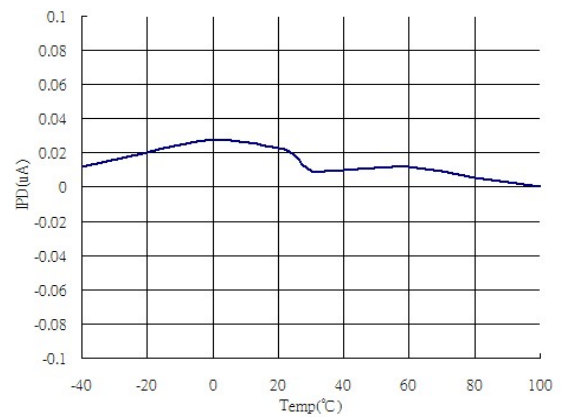


12.2. Current Consumption

(16) I_{DD} vs. T_a



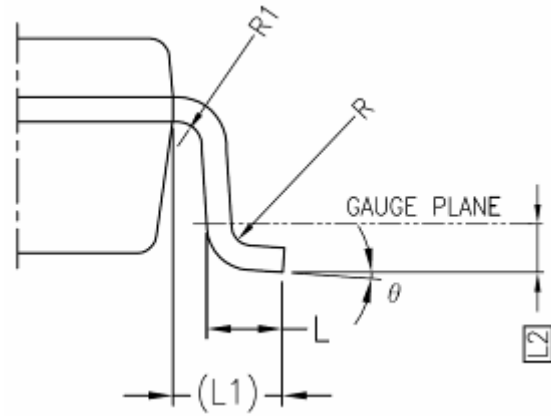
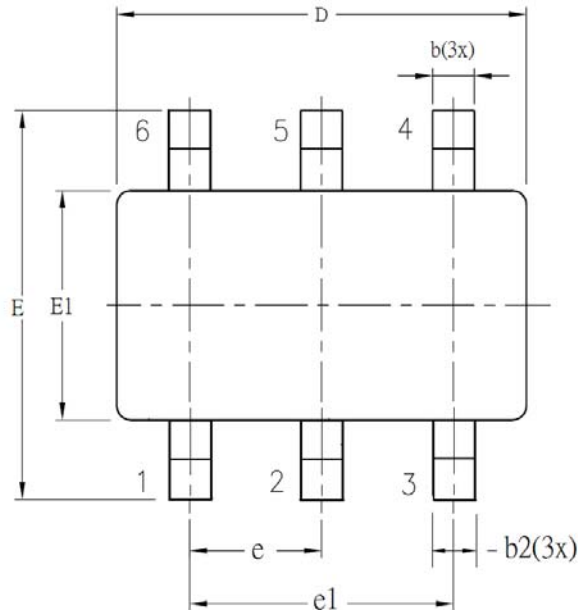
(17) I_{PD} vs. T_a



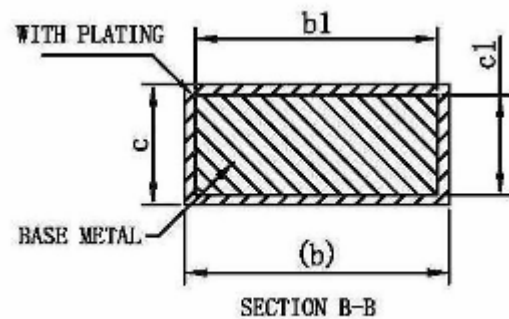
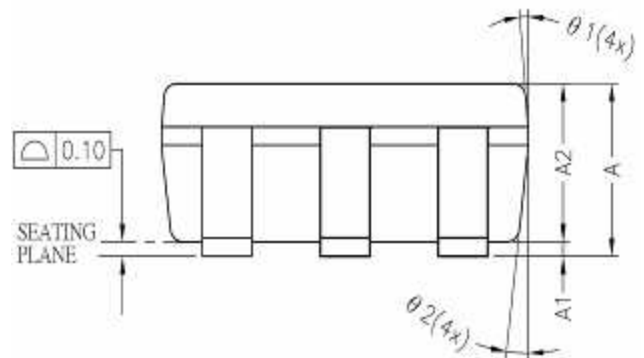
13. Package information

13.1. SOT-23-6

NOTE: All dimensions are in millimeters.



SYM BOL	ALL DIMENSIONS IN MILLIMETERS		
	MINIMUM	NOMINAL	MAXIMUM
A	-	1.30	1.40
A1	0	-	0.15
A2	0.90	1.20	1.30
b	0.30	-	0.50
b1	0.30	0.40	0.45
b2	0.30	0.40	0.50
c	0.08	-	0.22
c1	0.08	0.13	0.20
D	2.90 BSC		
E	2.80 BSC		
E1	1.60 BSC		
e	0.95 BSC		
e1	1.90 BSC		
L	0.30	0.45	0.60
L1	0.60 REF		
L2	0.25 BSC		
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	4°	8°
$\theta 1$	5°	-	15°
$\theta 2$	5°	-	15°

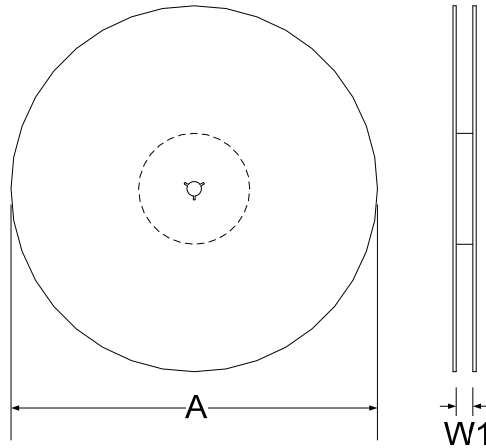


14. Tape & Reel Information

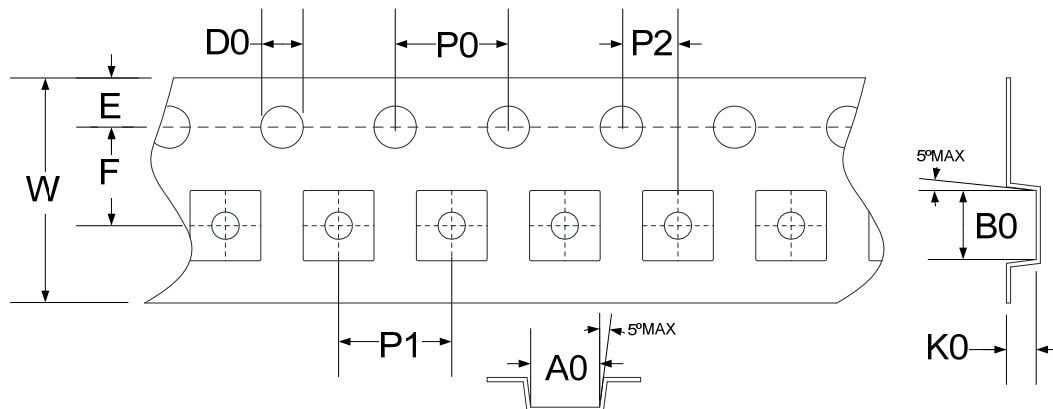
14.1. Tape & Reel Information---SOT-23-6 (Type 1)

Unit : mm.

14.1.1. Reel Dimensions



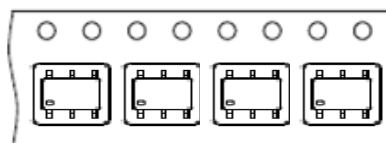
14.1.2. Carrier Tape Dimensions



SYMBOLS	Reel Dimensions		Carrier Tape Dimensions									
	A	W1	A0	B0	K0	P0	P1	P2	E	F	D0	W
Spec.	178	9.0	3.30	3.20	1.50	4.00	4.00	2.00	1.75	3.50	1.50	8.00
Tolerance	±0.50	+1.50/-0	±0.10	±0.10	±0.10	±0.10	±0.10	±0.05	±0.10	±0.05	+0.1/-0	±0.20

Note: 10 Sprocket hole pitch cumulative tolerance is ±0.20mm.

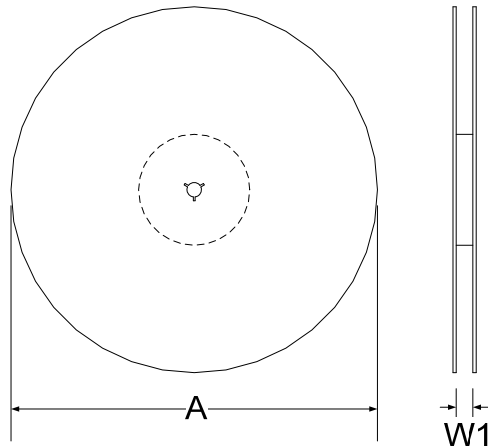
14.1.3. Pin1 direction



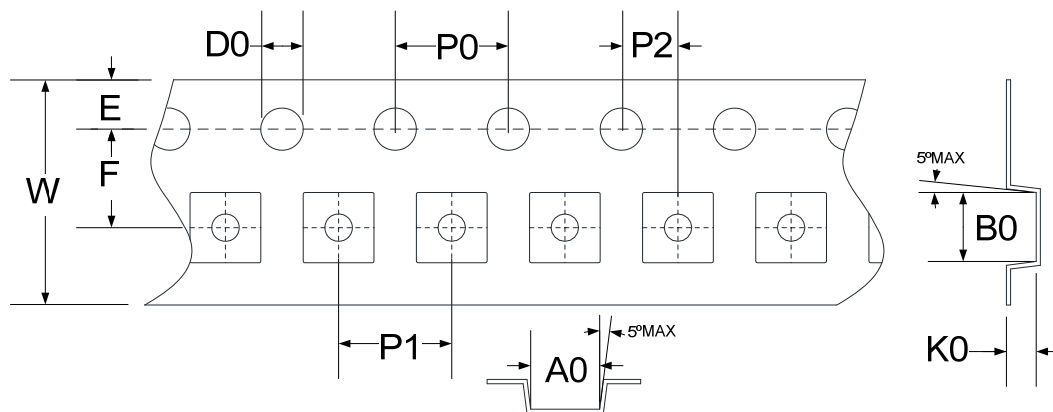
14.2. Tape & Reel Information---SOT-23-6 (Type 2)

Unit : mm.

14.2.1. Reel Dimensions



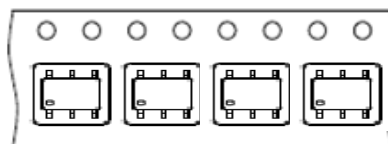
14.2.2. Carrier Tape Dimensions



SYMBOLS	Reel Dimensions		Carrier Tape Dimensions									
	A	W1	A0	B0	K0	P0	P1	P2	E	F	D0	W
Spec.	178	9.4	3.17	3.23	1.37	4.00	4.00	2.00	1.75	3.50	1.55	8.00
Tolerance	±2.00	±1.50	±0.10	±0.10	±0.10	±0.10	±0.10	±0.05	±0.10	±0.05	±0.05	+0.30/-0.10

Note: 10 Sprocket hole pitch cumulative tolerance is ±0.20mm.

14.2.3. Pin1 direction



15. Revision record

Major differences are stated thereafter:

Version	Page	Revision Summary
V01	-	First Edition
V02	7	Revise SOT-23-6 package marking rule.
V03	21-22	Add in Tape and Reel information.