



HY2116

Data Sheet

1-Cell Lithium-ion/Lithium Polymer
Battery Packs Protection ICs

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1. General Description

The series of **HY2116** ICs is best created for single-cell lithium-ion/lithium polymer rechargeable battery protection and it also comprises high-accuracy voltage detectors and delay circuits.

These ICs are suitable for protecting single-cell rechargeable lithium-ion/lithium polymer battery packs against the problems of overcharge, overdischarge and overcurrent.

2. Features

The features that whole series of HY2116 comprised are as follows:

(1) High-accuracy voltage detection circuit

- Overcharge detection voltage 4.000 to 4.500V Accuracy: $\pm 25\text{mV}$
- Overcharge release voltage 3.800 to 4.500V Accuracy: $\pm 50\text{mV}$
- Overdischarge detection voltage 2.00 to 3.10V Accuracy: $\pm 50\text{mV}$
- Overdischarge release voltage 2.00 to 3.40V Accuracy: $\pm 50\text{mV}$
- Discharge overcurrent detection voltage 25 to 250mV Accuracy: $\pm 10\text{mV}$
- Charge overcurrent detection voltage (by option)
- Short-circuiting detection voltage 0.85V(fixed) Accuracy: $\pm 0.3\text{V}$

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

(3) Power-down function “Yes” / “No” are selectable (See Model List).

(4) Auto overdischarge recovery function “Yes” / “No” are selectable (See Model List).

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

- Operation mode 3.0 μA typ., 6.0 μA max. (VDD=3.9V)
- Ultra low power-down current at 0.1 μA max. (VDD=2.0V)

(6) High-withstanding-voltage device is used for charger connection pins
(CS pin and OC pin: Absolute maximum rating = 20 V)

(7) 0 V battery charge function “available” / “unavailable” are selectable (See Model List).

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

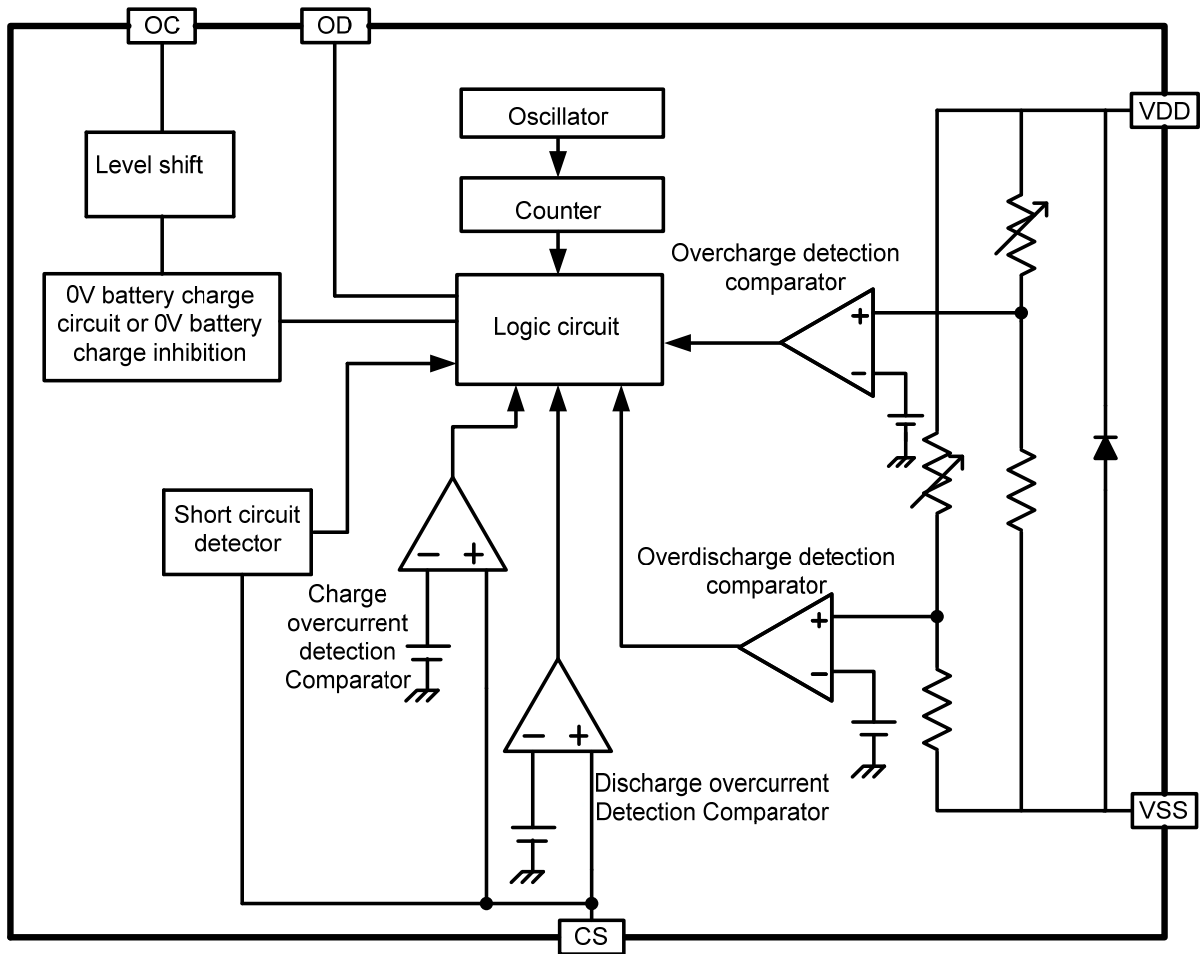
(9) Small package DFN-1.8*2.0-6L & SOT-23-6

(10) The HY2116 series are Halogen-free, green package

3. Applications

- 1-cell lithium-ion rechargeable battery packs
- 1-cell lithium polymer rechargeable battery packs

4. Block Diagram



5. Ordering Information

■ Product name definition

HY2116—#%\$&

- Characteristic code
Alphabetically set from A to Z
- Delay time code
Sequentially set from 1 to 9
- Package type
A: DFN-1.8*2.0-6L
B: SOT-23-6
- Serial code
Alphabetically set from A to Z

6. Model List

6.1. Product Name List

For DFN-1.8*2.0-6L

Table 1 Model list for DFN-1.8*2.0-6L

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}		
HY2116-HA2B	4.420V	4.235V	2.50V	2.70V	200mV	-225mV	2	B

Remark:

1. Table 1 lists out typical value of every electrical parameter. Please refer to Table 8 for detailed electrical characteristics.
2. Table 3 lists out delay time parameters of every corresponding delay time code. Table 4 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.

For SOT-23-6

Table 2 Model list for SOT-23-6

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}		
HY2116-AB6B	4.280V	4.100V	2.40V	2.50V	180mV	-225mV	6	B
HY2116-BB6A	4.350V	4.150V	2.50V	3.00V	150mV	-200mV	6	A
HY2116-CB6B	4.280V	4.100V	2.30V	2.50V	150mV	-225mV	6	B
HY2116-DB6B	4.275V	4.175V	3.00V	3.20V	150mV	-200mV	6	B
HY2116-FB5B	4.300V	4.250V	2.50V	3.00V	200mV	-225mV	5	B
HY2116-OB6A	4.425V	4.225V	2.50V	2.50V	150mV	-200mV	6	A
HY2116-HB2B	4.420V	4.235V	2.50V	2.70V	200mV	-225mV	2	B

Remark:

1. Table 2 lists out typical value of every electrical parameter. Please refer to Table 8 for detailed electrical characteristics.
2. Table 3 lists out delay time parameters of every corresponding delay time code. Table 4 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.

6.2. Delay Time Code-Parameter Option of Delay Time

Table 3 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	1300ms	145ms	12ms	8ms	300μs
2	1000ms	20ms	12ms	8ms	300μs
3	1300ms	145ms	6ms	8ms	300μs
4	250ms	20ms	12ms	8ms	150μs
5	1000ms	145ms	24ms	16ms	300μs
6	1000ms	145ms	12ms	8ms	300μs

Remark:

- Table 3 lists out typical value of every delay time parameters, for detailed delay time combination please refer to Table 9 to Table 14.

6.3. Characteristic Code-Other function Option

Table 4 Characteristic Code-Other function Option

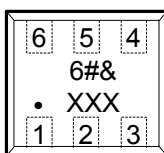
Characteristic Code	0 V Battery Charge Function	Power-down Function/ Auto Overdischarge Recovery Function
A	Available	With power-down Function
B	Available	With auto overdischarge recovery function
C	Unavailable	With auto overdischarge recovery function

7. Pin Configuration and Package Marking Information

- For DFN-1.8*2.0-6L

Table 5 DFN-1.8*2.0-6L

Pin No.	Symbol	Description
1	NC	No connection.
2	OC	MOSFET gate connection pin for charge control
3	OD	MOSFET gate connection pin for discharge control
4	VSS	Ground pin
5	VDD	Power supply pin
6	CS	Input pin for current sense, charger detect pin

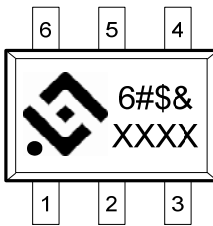


- 6: Product Name.
- #: Serial code. Alphabetically set from A to Z.
- &: Characteristic code. Alphabetically set from A to Z.
- xxx: Date code.

- For SOT-23-6

Table 6 SOT-23-6

Pin No.	Symbol	Description
1	OD	MOSFET gate connection pin for discharge control
2	CS	Input pin for current sense, charger detect pin
3	OC	MOSFET gate connection pin for charge control
4	NC	No connection.
5	VDD	Power supply pin
6	VSS	Ground pin



6: Product Name.

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

\$: Delay time code. Sequentially set from 1 to 9.

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

XXXX: Date code.

8. Absolute Maximum Ratings

Table 7 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-20 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-20 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 8 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	-	8	V
Operating voltage between VDD pin and CS pin	V_{DSOP2}	-	1.5	-	20	V
INPUT CURRENT(with Power-down Function)						
Supply Current	I_{DD}	$V_{DD}=3.9V$	-	3.0	6.0	μA
Power-Down Current	I_{PD}	$V_{DD}=2.0V$	-	-	0.1	μA
INPUT CURRENT(with Auto Overdischarge Recovery Function)						
Supply Current	I_{DD}	$V_{DD}=3.9V$	-	3.0	6.0	μA
Overdischarge Current Consumption	I_{OD}	$V_{DD}=2.0V$	-	0.16	0.5	μA
DETECTION VOLTAGE						
Overcharge Detection Voltage	V_{CU}	4.0V to 4.5V adjustable	$V_{CU}-0.025$	V_{CU}	$V_{CU}+0.025$	V
Overcharge Release Voltage	V_{CR}	3.8V to 4.5V adjustable	$V_{CR}-0.05$	V_{CR}	$V_{CR}+0.05$	V
Overdischarge Detection Voltage	V_{DL}	2.0V to 3.1V adjustable	$V_{DL}-0.05$	V_{DL}	$V_{DL}+0.05$	V
Overdischarge Release Voltage	V_{DR}	2.0V to 3.4V adjustable	$V_{DR}-0.05$	V_{DR}	$V_{DR}+0.05$	V
Discharge Overcurrent Detection Voltage	V_{DIP}	$V_{DD}=3.6V$	$V_{DIP}-10$	V_{DIP}	$V_{DIP}+10$	mV
Short Circuit Detection Voltage	V_{SIP}	$V_{DD}=3.0V$	0.55	0.85	1.15	V
Charge overcurrent detection voltage	V_{CIP}	$V_{DD}=3.6V, V_{CIP} < 225mV$	$V_{CIP}-30$	V_{CIP}	$V_{CIP}+30$	mV
		$V_{DD}=3.6V, V_{CIP} \geq 225mV$	$V_{CIP}-50$	V_{CIP}	$V_{CIP}+50$	mV
CONTROL OUTPUT VOLTAGE(OD&OC)						
OD Pin Output "H" Voltage	V_{DH}		$V_{DD}-0.1$	$V_{DD}-0.02$	-	V
OD Pin Output "L" Voltage	V_{DL}		-	0.1	0.5	V
OC Pin Output "H" Voltage	V_{CH}		$V_{DD}-0.1$	$V_{DD}-0.02$	-	V
OC Pin Output "L" Voltage	V_{CL}		-	0.1	0.5	V
0V BATTERY CHARGE FUNCTION						
0V battery charge starting charger voltage	V_{OCH}	0V battery charging function "available"	1.2	-	-	V
0V battery charge inhibition charger voltage	V_{OIN}	0V battery charging function "unavailable"	-	-	0.5	V

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

Table 9 Electrical Characteristics (VSS=0V, Ta=-20°C~60°C (Note))

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	
SUPPLY POWER RANGE							
Operating voltage between VDD pin and VSS pin	V _{DSOP1}	-	1.5	-	8	V	
Operating voltage between VDD pin and CS pin	V _{DSOP2}	-	1.5	-	20	V	
INPUT CURRENT(with Power-down Function)							
Supply Current	I _{DD}	V _{DD} =3.9V	-	3.0	6.0	μA	
Power-Down Current	I _{PD}	V _{DD} =2.0V	-	-	0.1	μA	
INPUT CURRENT(with Auto Overdischarge Recovery Function)							
Supply Current	I _{DD}	V _{DD} =3.9V	-	3.0	6.0	μA	
Overdischarge Current Consumption	I _{OD}	V _{DD} =2.0V	-	0.16	0.5	μA	
DETECTION VOLTAGE							
Overcharge Detection Voltage	V _{CU}	4.0V to 4.5V adjustable	V _{CU} -0.035	V _{CU}	V _{CU} +0.035	V	
Overcharge Release Voltage	V _{CR}	3.8V to 4.5V adjustable	V _{CR} ≠V _{CU}	V _{CR} -0.055	V _{CR}	V _{CR} +0.055	V
			V _{CR} =V _{CU}	V _{CR} -0.055	V _{CR}	V _{CR} +0.035	V
Overdischarge Detection Voltage	V _{DL}	2.0V to 3.1V adjustable	V _{DL} -0.065	V _{DL}	V _{DL} +0.065	V	
Overdischarge Release Voltage	V _{DR}	2.0V to 3.4V adjustable	V _{DR} -0.085	V _{DR}	V _{DR} +0.085	V	
Discharge Overcurrent Detection Voltage	V _{DIP}	V _{DD} =3.6V	V _{DIP} -20	V _{DIP}	V _{DIP} +20	mV	
Short Circuit Detection Voltage	V _{SIP}	V _{DD} =3.0V	0.55	0.85	1.15	V	
Charge overcurrent detection voltage	V _{CIP}	V _{DD} =3.6V, V _{CIP} <225mV	V _{CIP} -55	V _{CIP}	V _{CIP} +55	mV	
		V _{DD} =3.6V, V _{CIP} ≥225mV	V _{CIP} -60	V _{CIP}	V _{CIP} +60	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}		-	0.1	0.5	V	
OC Pin Output "H" Voltage	V _{CH}		VDD-0.1	VDD-0.02	-	V	
OC Pin Output "L" Voltage	V _{CL}		-	0.1	0.5	V	
0V BATTERY CHARGE FUNCTION							
0V battery charge starting charger voltage	V _{OCH}	0V battery charging function "available"	1.2	-	-	V	
0V battery charge inhibition charger voltage	V _{OIN}	0V battery charging function "unavailable"	-	-	0.5	V	

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

9.2. Delay Time Combination

Table 10 Delay Time Parameter Combination of Delay Time Code: 1

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time (Ta = 25°C)						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	1000	1300	1600	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	115	145	175	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	9	12	15	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	6	8	10	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	200	300	400	μs
Delay Time (Ta = -20°C~60°C (Note))						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	800	1300	1800	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	95	145	195	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	7	12	17	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	5	8	11	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	140	300	460	μs

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

Table11 Delay Time Parameter Combination of Delay Time Code: 2

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time (Ta = 25°C)						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	700	1000	1300	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	15	20	25	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	9	12	15	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	6	8	10	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	200	300	400	μs
Delay Time (Ta = -20°C~60°C (Note))						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	600	1000	1400	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	13	20	27	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	7	12	17	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	5	8	11	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	140	300	460	μs

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

Table 12 Delay Time Parameter Combination of Delay Time Code: 3

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time (Ta = 25°C)						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	1000	1300	1600	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	115	145	175	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	4	6	8	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	6	8	10	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	200	300	400	μs
Delay Time (Ta = -20°C~60°C (Note))						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	800	1300	1800	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	95	145	195	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	3	6	9	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	5	8	11	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	140	300	460	μs

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

Table 13 Delay Time Parameter Combination of Delay Time Code: 4

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time (Ta = 25°C)						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	200	250	300	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	15	20	25	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	9	12	15	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	6	8	10	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	100	150	200	μs
Delay Time (Ta = -20°C~60°C (Note))						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	160	250	340	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	13	20	27	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	7	12	17	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	5	8	11	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	140	300	460	μs

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

Table 14 Delay Time Parameter Combination of Delay Time Code: 5

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time (Ta = 25°C)						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	700	1000	1300	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	115	145	175	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	18	24	30	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	12	16	20	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	200	300	400	μs
Delay Time (Ta = -20°C~60°C (Note))						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	600	1000	1400	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	95	145	195	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	14	24	34	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	10	16	22	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	140	300	460	μs

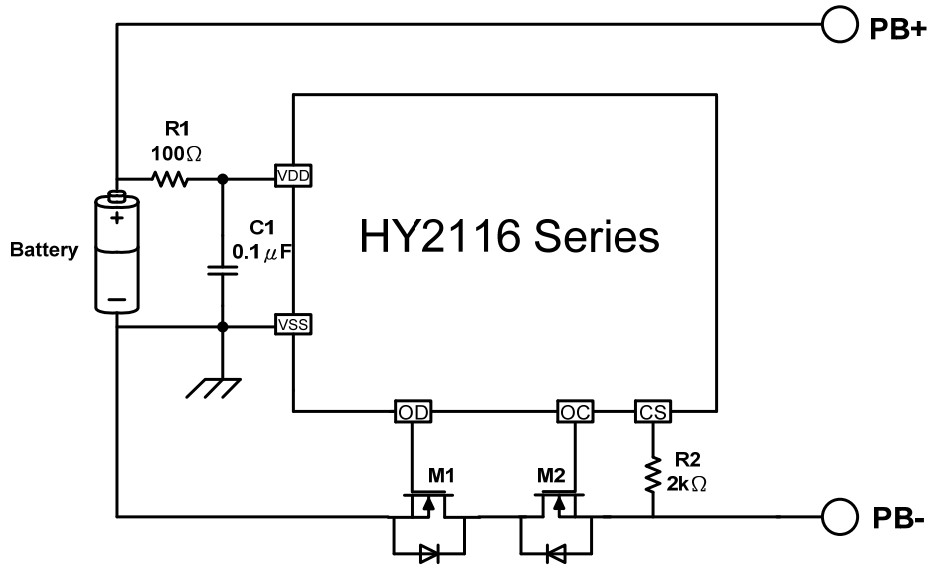
Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

Table 15 Delay Time Parameter Combination of Delay Time Code: 6

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time (Ta = 25°C)						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	700	1000	1300	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	115	145	175	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	9	12	15	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	6	8	10	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	200	300	400	μs
Delay Time (Ta = -20°C~60°C (Note))						
Overcharge Delay Time	T _{OC}	V _{DD} =3.9V→4.5V	600	1000	1400	ms
Overdischarge Delay Time	T _{OD}	V _{DD} =3.6V→2.0V	95	145	195	ms
Discharge Overcurrent Delay Time	T _{DIP}	V _{DD} =3.6V, CS=0.4V	7	12	17	ms
Charge Overcurrent Delay Time	T _{CIP}	V _{DD} =3.6V, CS=-0.4V	5	8	11	ms
Short Circuit Delay Time	T _{SIP}	V _{DD} =3.0V, CS=1.3V	140	300	460	μs

Note: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.

10. Example of Battery Protection IC Connection



Symbol	Device Name	Purpose	Min.	Typ.	Max.	Remark
R1	Resistor	limit current, stabilize VDD and strengthen ESD protection	100Ω	100Ω	200Ω	*1
R2	Resistor	limit current	1kΩ	2kΩ	2kΩ	*2
C1	Capacitor	stabilize VDD	0.01μF	0.1μF	1.0μF	*3
M1	N-MOSFET	Discharge control	-	-	-	*4
M2	N-MOSFET	Charge control	-	-	-	*5

- *1. R1 should be as small as possible to avoid lowering the overcharge detection accuracy due to current consumption. When a charger is connected in reversed, the current flows from the charger to the IC. At this time, if R1 is connected to high resistance, the voltage between VDD pin and VSS pin may exceed the absolute maximum rating.
- *2. If R2 has a resistance higher than 2kΩ, the charging current may not be cut when a high-voltage charger is connected. Please select as large a resistance as possible to prevent current when a charger is connected in reversed.
- *3. C1 will stabilize the supply voltage of VDD, the value of C1 should be equal to or more than 0.01μF.
- *4. If a FET with a threshold voltage equal to or higher than the 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 adjusted.

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 battery voltage is in the range from overdischarge detection voltage (V_{DL}) to overcharge detection voltage (V_{CU}), 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 pin and VSS pin must be shorted or the charger must be connected.

11.2. Overcharge Status

Under the normal status, as soon as the battery voltage becomes higher than the overcharge detection voltage (V_{CU}) during charging and the detection continues longer than the overcharge detection delay time (T_{OC}), the HY2116 series will turn the charging control MOSFET off (OC pin) to stop charging. This condition is called the overcharge status.

The overcharge status can be released by the following two cases:

Condition: disconnect charger

(1) The voltage of the battery cell is equal to or lower than the overcharge release voltage (V_{CR}) due to self-discharge.

(2) When the load is connected, the discharge current will pass through parasitical diode of charging control MOSFET. At this time, CS pin will detect "Diode forward voltage drop (V_f)". When CS pin voltage rises higher than discharge overcurrent detection voltage (V_{DIP}) and battery voltage lowers than overcharge detection voltage (V_{CU}), the overcharge status will be released and back to normal status.

Caution:

When a charger is connected after overcharge detection, the overcharge status is not released even if the battery voltage is below overcharge release voltage (V_{CR}). The overcharge status is released when the CS pin voltage goes over the charge overcurrent detection voltage (V_{CIP}) by removing the charger.

11.3. Overdischarge Status

11.3.1. Products with Power-down Function

When the battery voltage falls below than the overdischarge detection voltage (V_{DL}) during discharging in the normal status and the detection continues longer than the overdischarge detection delay time (T_{OD}), the HY2116 series will turn the discharging control MOSFET off (OD pin) so as to stop discharging. This condition is called the overdischarge status.

When the MOSFET is off, CS pin voltage is pulled up by the resistor to VDD in the IC, at this time, the power consumption is reduced to the lowest. This condition is called the "SLEEP MODE".

The overdischarge status will be released by two 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}).

11.3.2. Products with Auto Overdischarge Recovery Function

When the battery voltage falls below than the overdischarge detection voltage (V_{DL}) during discharging in the normal status and the detection continues longer than the overdischarge detection delay time (T_{OD}), the HY2116 series will turn the discharging control MOSFET off(OD pin) so as to stop discharging. This condition is called the overdischarge status.

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.

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

Under normal condition, the HY2116 continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent detection voltage (V_{DIP}) and the condition lasts beyond the overcurrent delay time (T_{DIP}),

discharging will be suspended by turning off the discharge control MOSFET (OD pin). This condition is called the discharge overcurrent status.

If the voltage of CS pin exceeds the short circuit detection voltage (V_{SIP}) and the condition lasts beyond the short circuit delay time (T_{SIP}), discharging will be suspended by turning off the discharge control MOSFET (OD pin). This condition is called the short circuit status.

When the impedance between PB+ and PB- is higher than discharge overcurrent and short circuit release impedance (300k Ω typ.), the discharge overcurrent status and short circuit status will be released and back to normal operation status. In addition, if the impedance between PB+ and PB- is less than discharge overcurrent and short circuit release impedance, CS pin voltage will descend below than overcurrent detection voltage (V_{DIP}) after the charger is being connected, discharge overcurrent status and short circuit status will be released and back to normal operation status.

Caution:

(1) If the charger is connected incautiously in reversed, the current direction is the same as discharge current in the circuit. If CS pin voltage goes higher than overcurrent detection voltage (V_{DIP}), it will enter into discharge overcurrent protection status to block out in-circuit current.

11.5. Charge Overcurrent Status

When a battery is in the normal status, the voltage of the CS pin is lower than the charge overcurrent detection voltage (V_{CIP}). When the charge current is higher than the specified value and the status lasts beyond the charge overcurrent detection delay time (T_{CIP}), the charge control MOSFET will be turned off and charging is stopped. This status is called the charge overcurrent status.

This IC will be restored to the normal status from the charge overcurrent status when the voltage at the CS pin returns to charge overcurrent detection voltage (V_{CIP}) or higher by removing the charger.

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 HY2116 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”

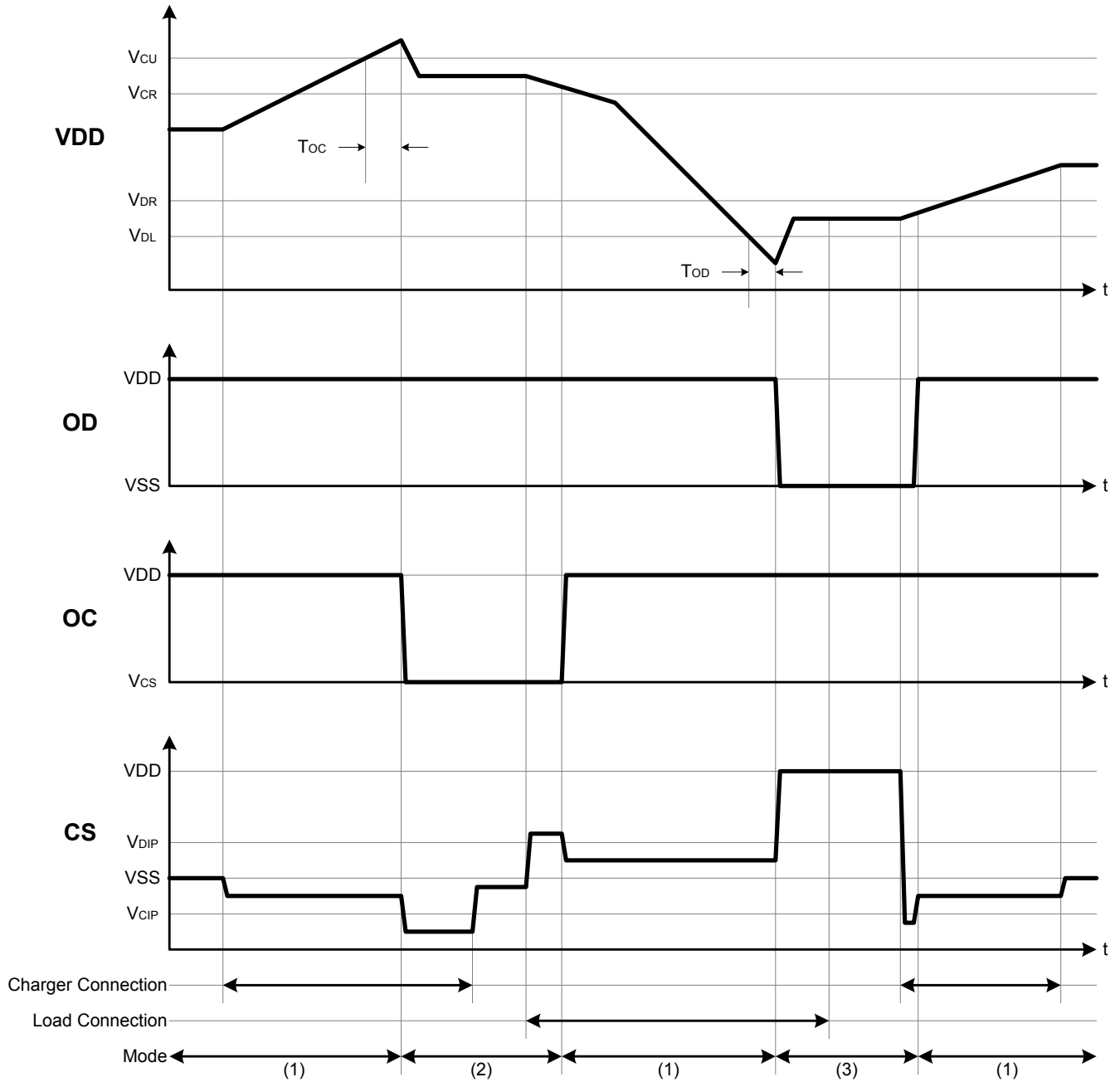
When a battery that is internally short-circuited (0V battery) is connected, the unavailable 0V charging function will prohibit recharging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V_{0IN}) or lower, the charging control MOSFET gate is fixed to the PB- pin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

(1) Overcharge Detection, Overdischarge Detection



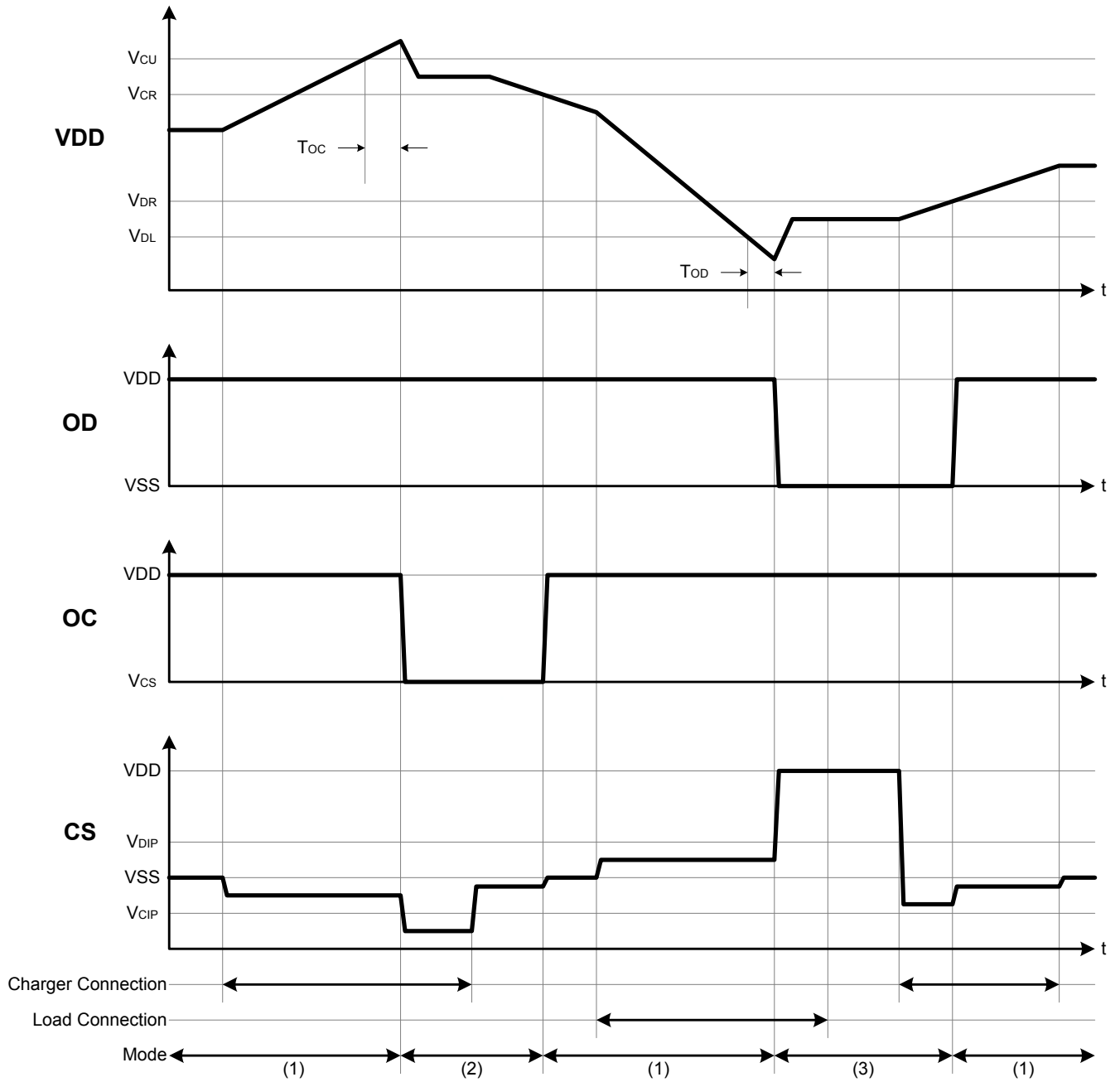
Remark (1) Normal status, (2) Overcharge status, (3) Overdischarge status

Remark:

(a) overcharge release condition: $V_{CS} > V_{DIP}$ & $V_{DD} < V_{CU}$ °

(b) overdischarge release condition: $V_{CS} < V_{CIP}$ & $V_{DD} > V_{DL}$ °

(2) Overcharge Detection, Overdischarge Detection



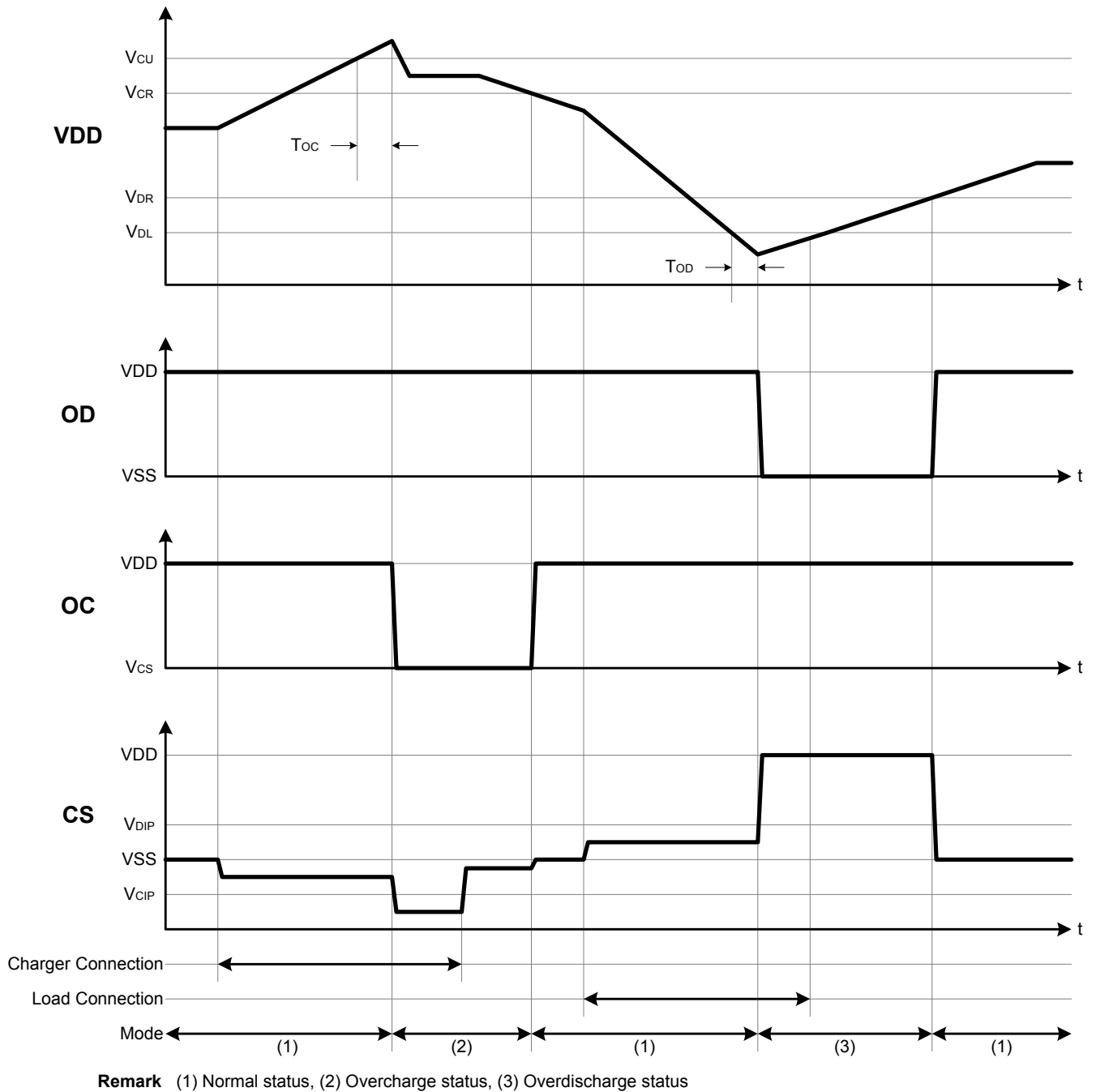
Remark (1) Normal status, (2) Overcharge status, (3) Overdischarge status

Remark:

(a) overcharge release condition: $V_{CIP} < V_{CS} < V_{DIP}$ & $V_{DD} < V_{CR}$ °

(b) overdischarge release condition: $V_{CS} > V_{CIP}$ & $V_{DD} > V_{DR}$ °

(3) Overcharge Detection, Overdischarge Detection (with auto overdischarge recovery function)

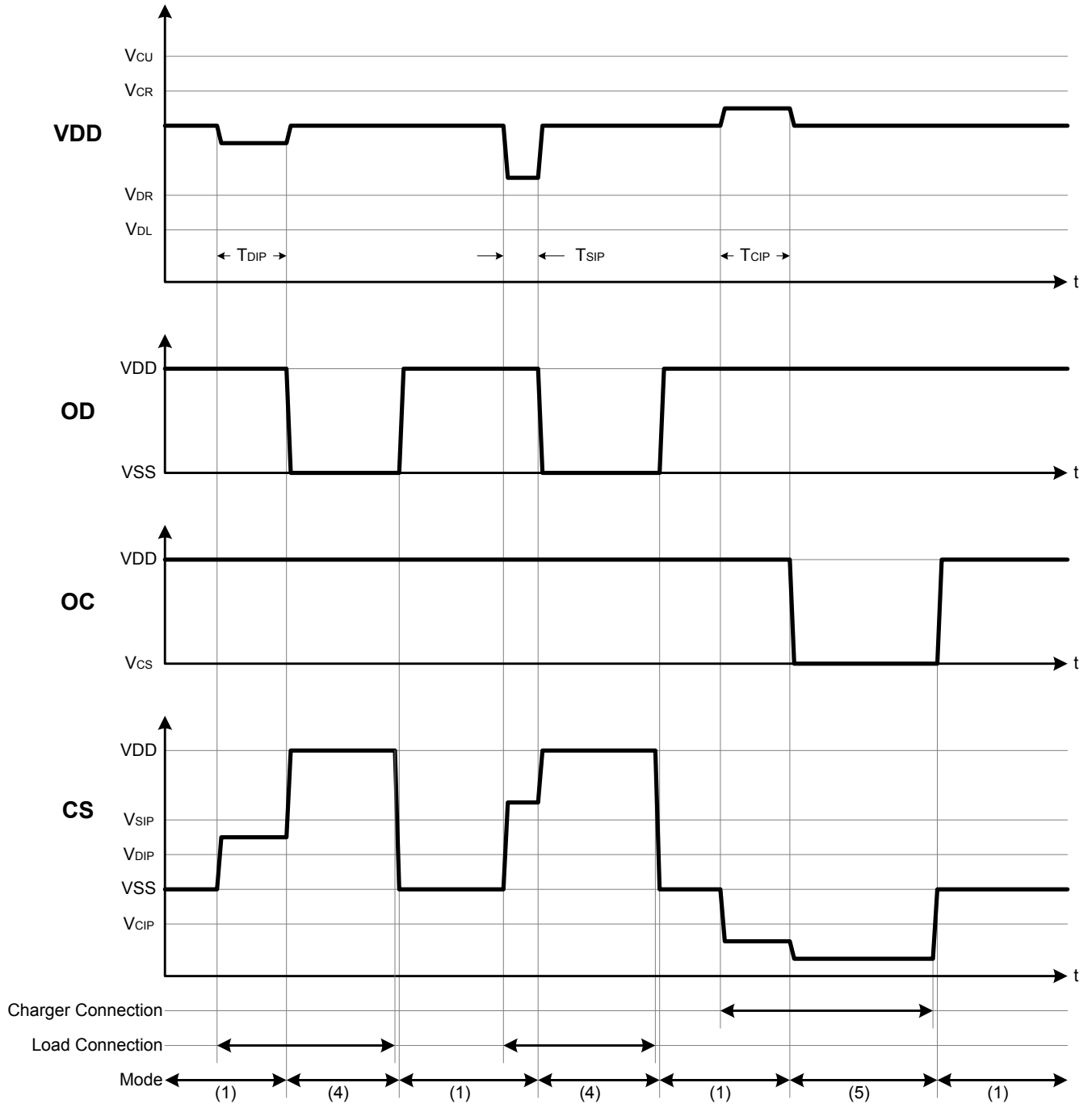


Remark:

(a) overcharge release condition: $V_{CIP} < V_{CS} < V_{DIP}$ & $V_{DD} < V_{CR}$ °

(b) overdischarge release condition: $V_{DD} > V_{DR}$ °

(4) Discharge overcurrent Detection, Short circuit Detection, Charge overcurrent Detection

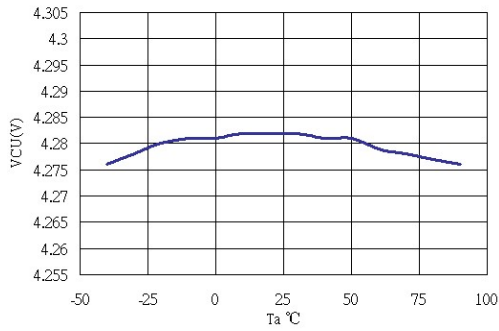


Remark (1) Normal status, (4) Discharge Overcurrent status (Discharge Overcurrent & Short Circuit), (5) Charge Overcurrent status

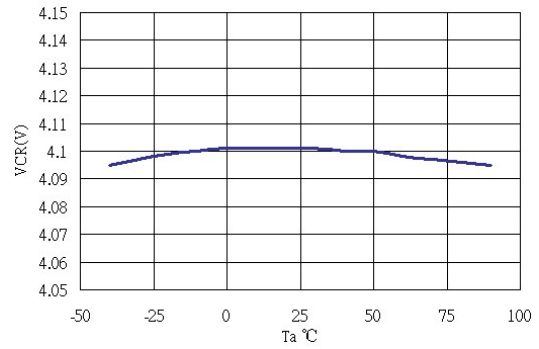
13. Characteristics (Typical Value)

1. Overcharge Detection/Release Voltage, Overdischarge Detection/Release Voltage, Discharge Overcurrent Detection Voltage , Short Circuit Detection Voltage, Charge Overcurrent Detection Voltage and Delay Time.

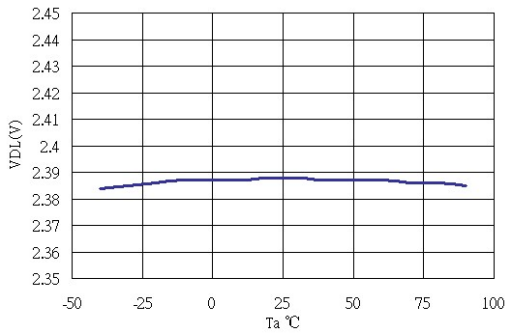
(1) V_{CU} vs. T_a



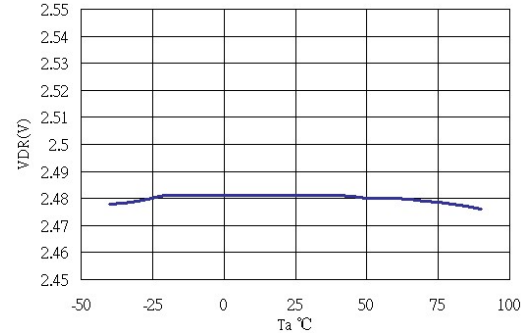
(2) V_{CR} vs. T_a



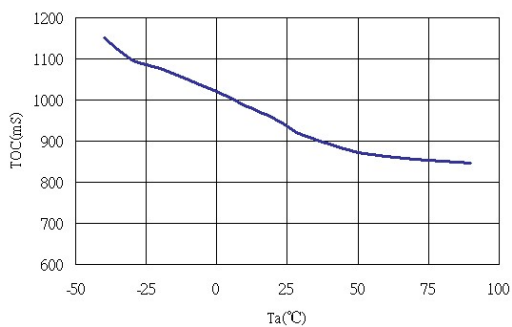
(3) V_{DL} vs. T_a



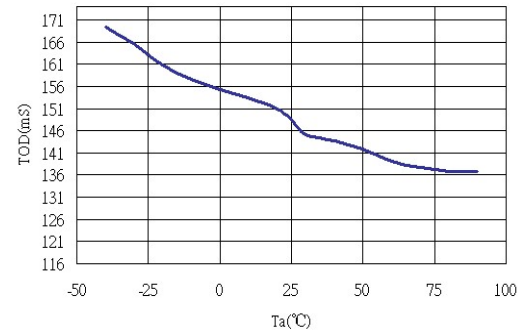
(4) V_{DR} vs. T_a



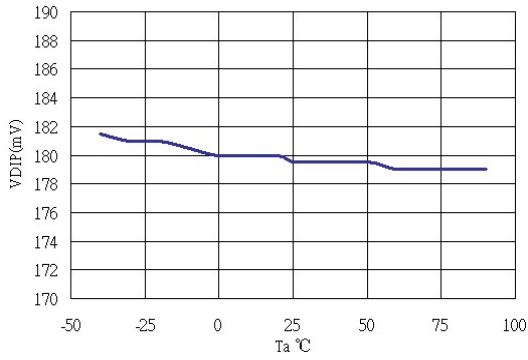
(5) T_{OC} vs. T_a



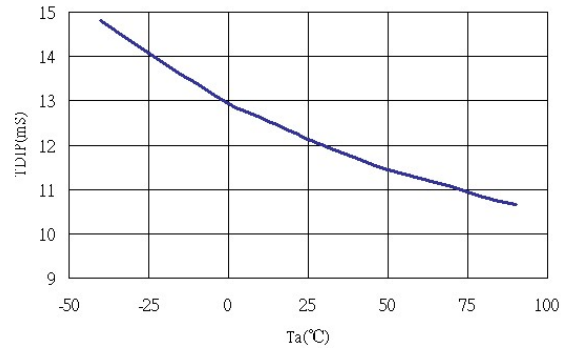
(6) T_{OD} vs. T_a



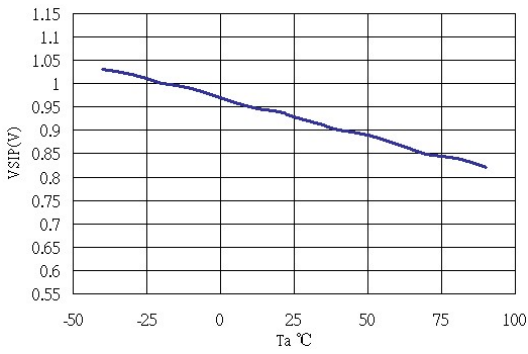
(7) V_{DIP} vs. T_a



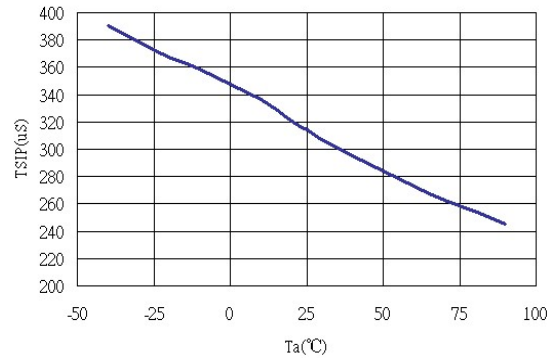
(8) T_{DIP} vs. T_a



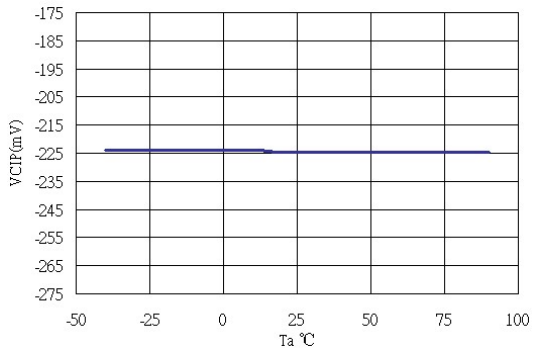
(9) V_{SIP} vs. T_a



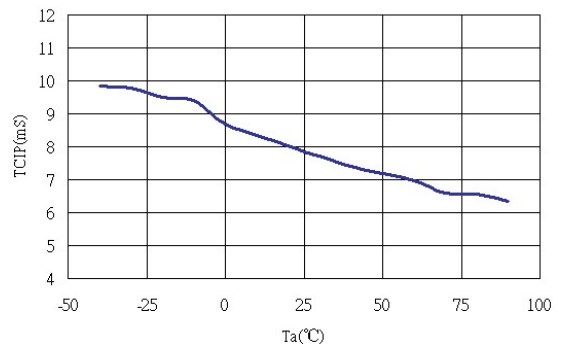
(10) T_{SIP} vs. T_a



(11) V_{CIP} vs. T_a

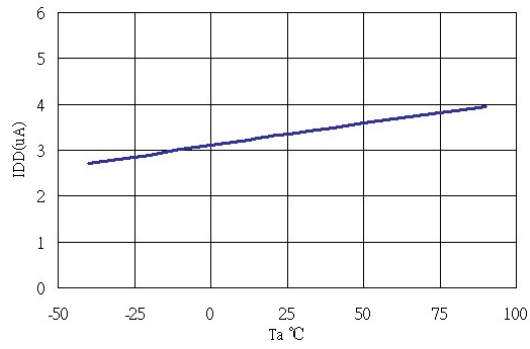


(12) T_{CIP} vs. T_a

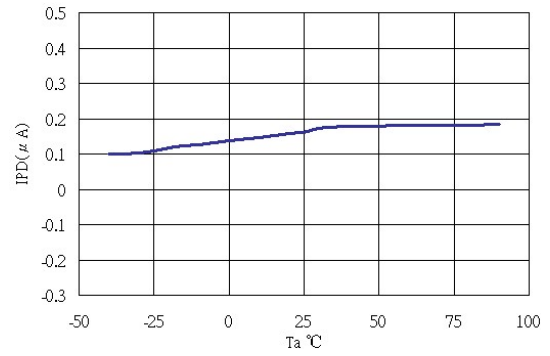


2. Current Consumption

(13) I_{DD} vs. T_a



(14) I_{PD} vs. T_a

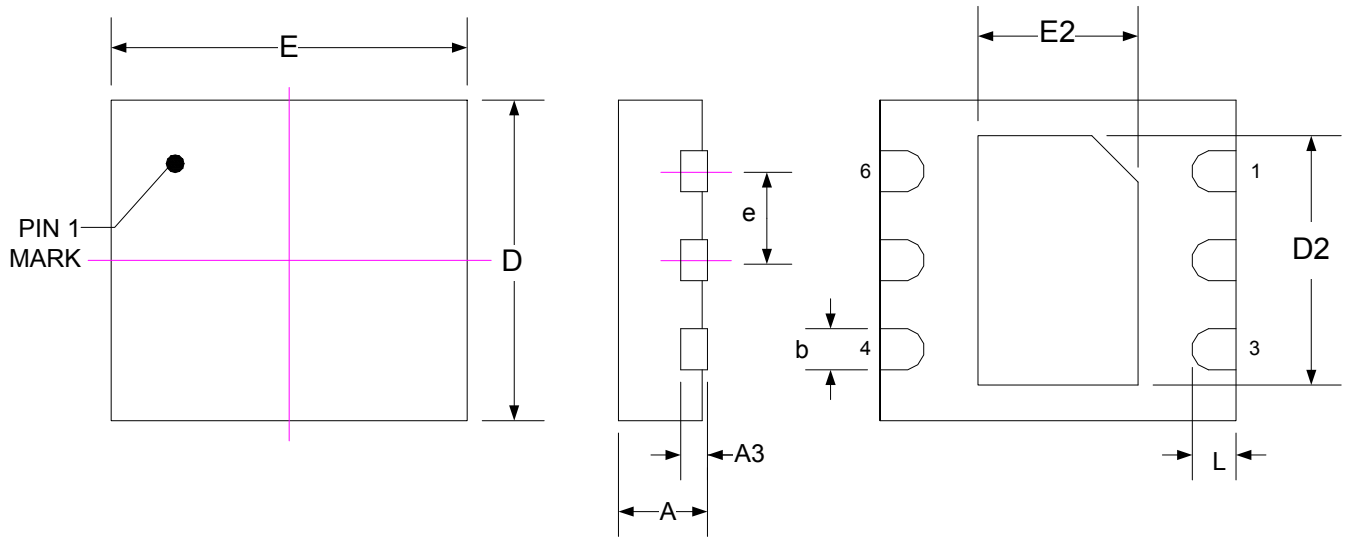


14. Package Information

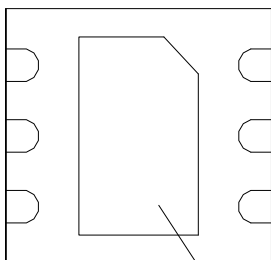
14.1. DFN-1.8*2.0-6L Outline

Note:

1. All dimensions are in millimeters.
2. The pad & body metal color are silver.



SYMBOLS	MIN	NOM	MAX
A	0.40	0.48	0.55
A3	0.127 REF.		
b	0.18	0.23	0.28
D	1.725	1.80	1.875
E	1.925	2.00	2.075
D2	1.30	1.40	1.50
E2	0.80	0.90	1.00
L	0.20	0.25	0.30
e	0.50 BSC		

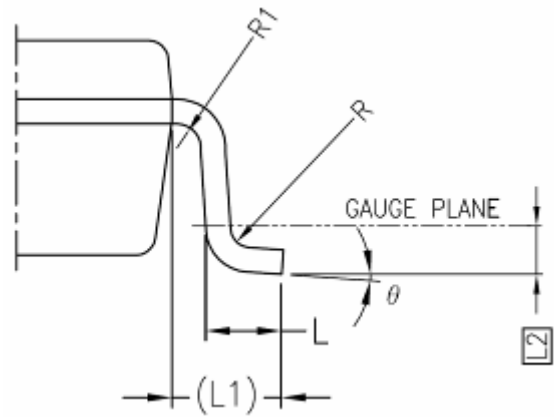
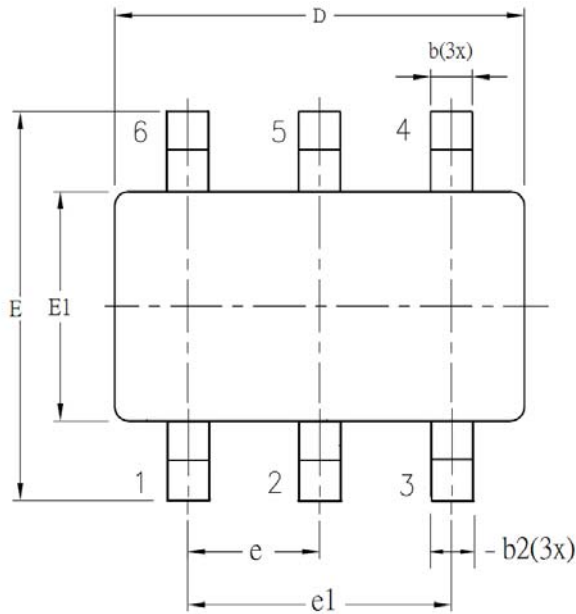


Exposed pad

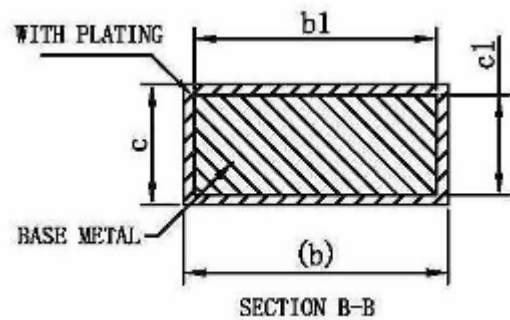
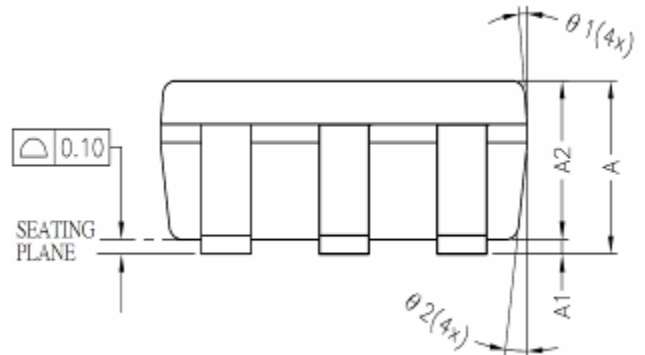
Remark : please take the exposed pad floating or connected to VDD.

14.2. SOT-23-6 Outline

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°

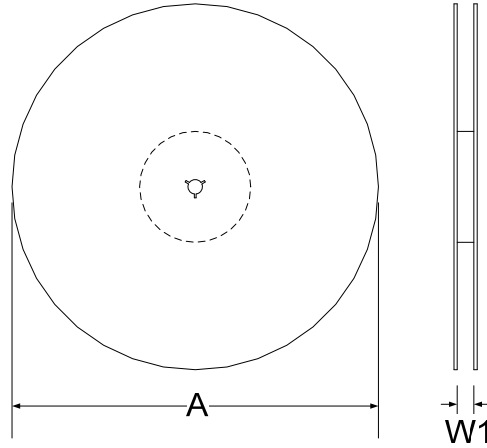


15. Tape & Reel Information

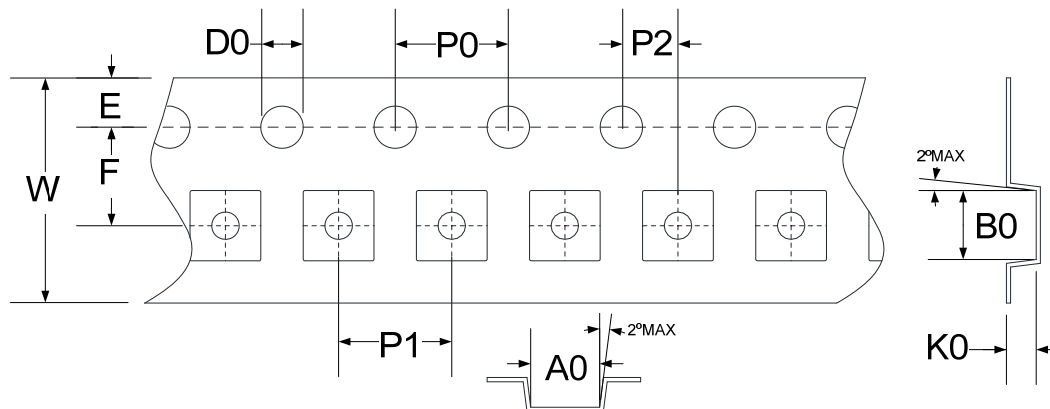
15.1. Tape & Reel Information---DFN-1.8*2.0-6L

Unit : mm

15.1.1. Reel Dimensions



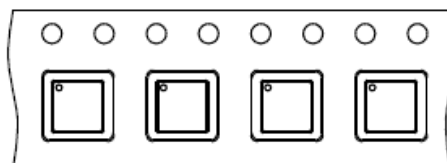
15.1.2. Carrier Tape Dimensions



SYMBOLS	Reel Dimensions		Carrier Tape Dimensions									
	A	W1	A0	B0	K0	P0	P1	P2	E	F	D0	W
Spec.	178	9.4	2.20	2.20	0.68	4.00	4.00	2.00	1.75	3.50	1.50	8.00
Tolerance	± 2.00	± 1.50	± 0.05	± 0.05	± 0.05	± 0.10	± 0.10	± 0.05	± 0.10	± 0.10	± 0.10	$+0.30/-0.10$

Note: 10 Sprocket hole pitch cumulative tolerance is $\pm 0.20\text{mm}$.

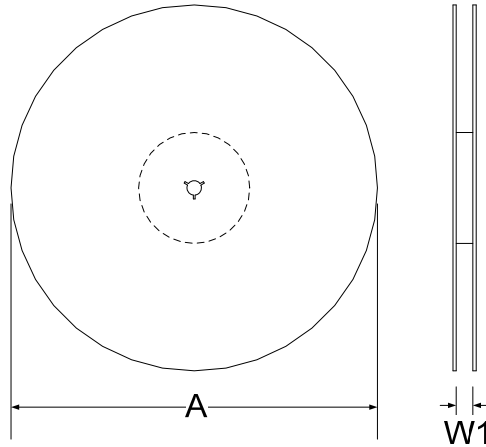
15.1.3. PIN1 direction



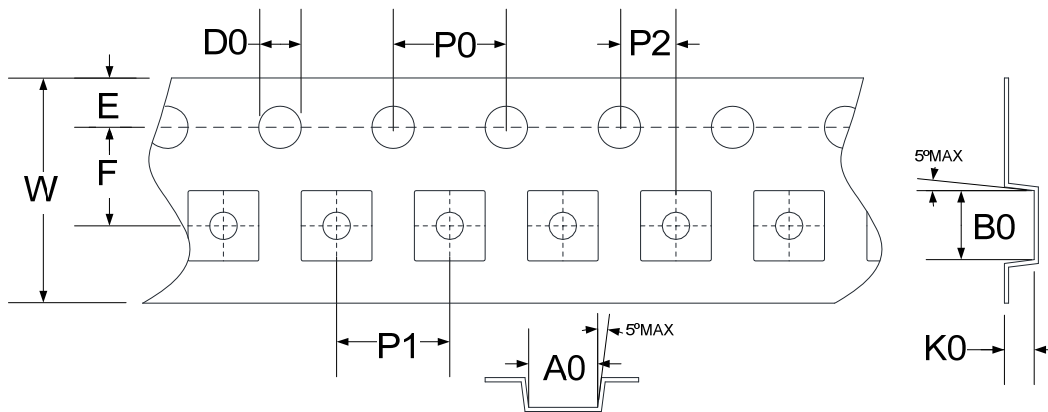
15.2. Tape & Reel Information---SOT-23-6 (Type 1)

Unit : mm.

15.2.1. Reel Dimensions



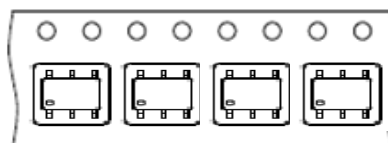
15.2.2. Carrier Tape Dimensions



SYMBOLS	Reel Dimensions		Carrier Tape Dimensions									
	A	W1	A0	B0	K0	P0	P1	P2	E	F	D0	W
Spec.	178	9.0	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	±0.10	±0.05	±0.10	±0.05	+0.1/-0 ±0.20

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

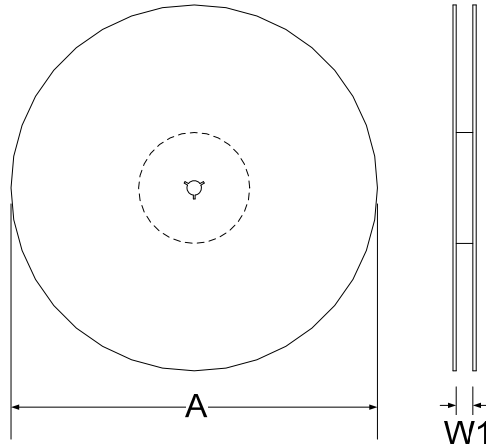
15.2.3. Pin1 direction



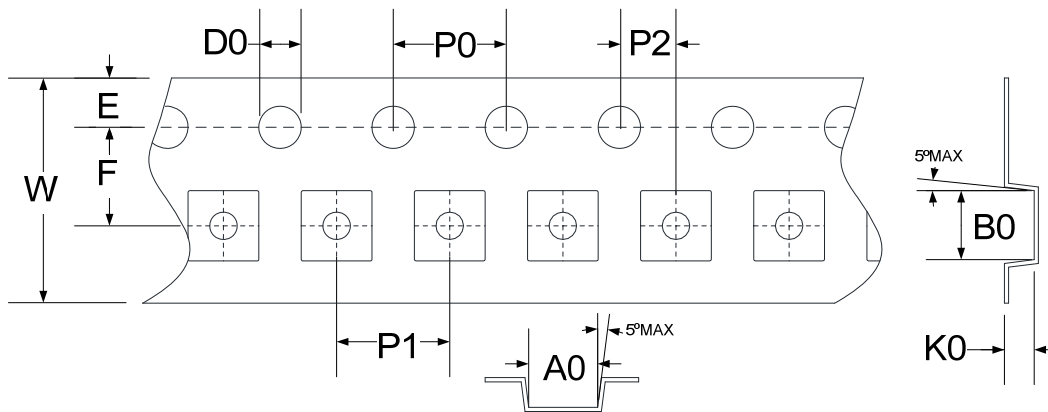
15.3. Tape & Reel Information---SOT-23-6 (Type 2)

Unit : mm.

15.3.1. Reel Dimensions



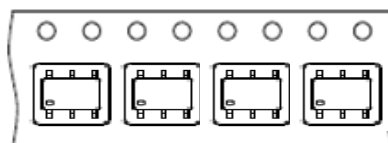
15.3.2. Carrier Tape Dimensions



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	±0.10	±0.05	±0.10	±0.05	±0.05	+0.30/-0.10

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

15.3.3. Pin1 direction



16. Revision Recor

Major differences are stated thereafter:

Version	Page	Revision Summary
V01	-	First Edition.
V02	2	Reorder directory.
	17-26	1. Add in Timing Chart.
		2. Adjust chapters and pages after the chapter 12.
	24	Add in DFN-6L Outline.
	All	Add in new model no.: HY2116FB5B、HY2116-HA2B and HY2116HB2B.
V03	10-14	Add in the Electrical Characteristics range value of “Ta=-20°C~60°C”.
	29-31	Add in Tape & Reel Information.

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[CM1104-MBB](#) [XC6801A421MR-G](#) [ISL95521BHRZ](#) [ISL95521BIRZ](#) [MP2639AGR-P](#) [S-82D1AAE-A8T2U7](#) [S-82D1AAA-A8T2U7](#) [S-8224ABA-I8T1U](#) [MC33772CTC0AE](#) [BQ28Z610DRZR-R1](#) [MCP73832-4ADI/MC](#) [MCP73832T-2DCIMC](#) [MCP73833T-AMIMF](#)
[MCP73833T-AMI/UN](#) [MCP73838-NVI/MF](#) [MCP73213-A6BI/MF](#) [MCP73831-2ACI/MC](#) [MCP73831T-2ATIMC](#) [MCP73832-2ACI/MC](#)
[MCP73832T-3ACIMC](#) [MCP73833T-FCI/MF](#) [MCP73853-IML](#) [BQ25895RTWR](#) [BQ29704DSER](#) [BQ78Z100DRZR](#) [ISL78610ANZ](#)
[FAN5403UCX](#) [NCP367DPMUECTBG](#) [FAN54015BUCX](#) [MAX8934BETI+](#) [BQ24311DSGR](#) [BQ25100HYFPR](#) [BQ29707DSER](#)
[MAX17048G+T10](#) [BQ24130RHRLR](#) [BQ25120AYFPR](#) [BQ29703DSER](#) [BQ771807DPJR](#) [BQ25120AYFPT](#) [MAX17055ETB+T](#)
[MAX17710GB+T](#) [MAX14634EWC+](#) [BQ25121AYFPR](#)