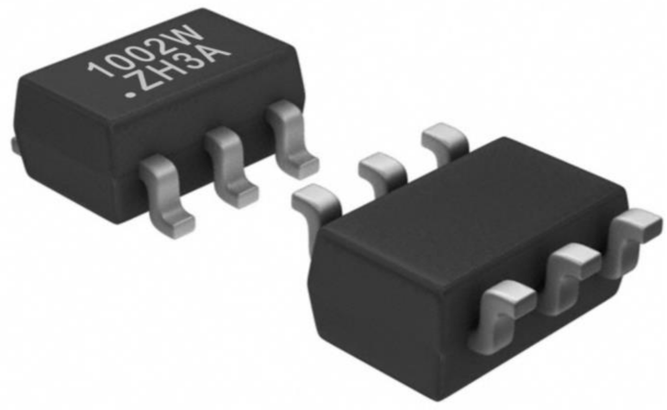


Figure 1. The Physic Photo of AT1002

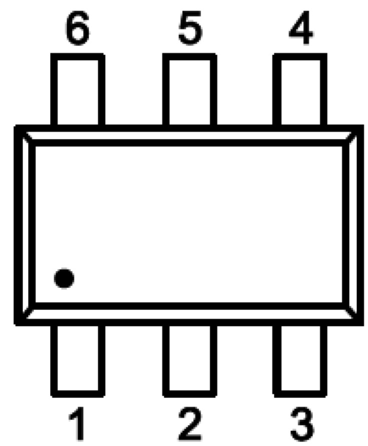


Figure 2. Pin Configuration

FEATURES

- High-Precision Voltage Detection Function:

  Overcharge Protection Voltage: 3.5V to 4.5V, accuracy: ±25mV

  Overcharge Delay Voltage: 0.2V, accuracy ±50mV

  Overdischarge Protection Voltage: 2.0V to 3.0V, accuracy: ±80mV

  Overdischarge Delay Voltage: 0 to 0.6V, accuracy: ±100mV
- Discharge Overcurrent Protection Function:

  Overcurrent Protection Voltage: 0.025V to 0.25V, accuracy: ±15 mV

  Short Circuit Protection Voltage: 0.1V, 0.2V, 0.4V, 1.0V, accuracy: ±30%
- Charging Overcurrent Protection Voltage:

  −0.03V to −0.15V, accuracy: ±30%
- Load Detection Function
- Charger Detection Function
- 0V Charging Function
- Sleep Function: selectable as "Yes" or "No" (see product catalog for details)
- Overdischarge Auto-Recovery Function: selectable as "Yes" or "No" (see product catalog for details)
- Low current consumption:

  Operating Mode: 2.2μA (typ.) @T_A = +25°C

  Current Consumption During Overdischarge (with overdischarge auto-recovery function):
  0.7μA(typ.) @T_A = +25°C

  Sleep Current (with sleep function):
  0.05μA (typ.) @T_A = +25°C
- Lead-free, halogen-free.
- SOT-23-6 Package

APPLICATIONS

- Lithium-Ion Rechargeable Battery

DESCRIPTION

The AT1002 series is equipped with high-precision voltage detection circuits and delay circuits, which enable protection against overcharging, overdischarging, and overcurrent by detecting the battery's voltage and current. It is suitable for the protection circuit of single-cell lithium ion/lithium polymer rechargeable batteries.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Power Supply Voltage	VCC	−0.3 ~ 0.8	V
Input Voltage at VM Pin	VM	VCC−12 ~ VCC+0.3	V
Operating Temperature	T_{OPR}	−40 ~ 85	°C
Storage Temperature	T_{STG}	−40 ~ 125	°C

PIN DESCRIPTION

Table 1: Pin Function

Pin #	Symbol	Description
1	DO	Discharge MOSFET control terminal.
2	VM	Charge and discharge current detection terminal, connected to the negative of the charger or load.
3	CO	Charging MOSFET control terminal.
4	NC	No connection.
5	VCC	Power supply input, connected to the positive terminal of the power supply (battery).
6	VSS	Power Ground, connected to the negative terminal of the power supply (battery).

SELECTION GUIDE

Part No.	V_{OC}	V_{OCR}	V_{OD}	V_{ODR}	V_{EC1}	V_{SHORT}	V_{CHA}	Overcharge Self-recovery	Sleep
AT1002-W	4.425	4.225	2.400	3.000	0.220	1.000	−0.180	N	N
AT1002-Y	3.650	3.450	2.550	2.950	0.150	1.000	−0.180	N	Y
AT1002-X	4.375	4.175	2.400	3.000	0.220	1.000	−0.180	N	N
AT1002-J	3.750	3.600	2.100	2.320	0.200	1.000	−0.150	N	Y
AT1002-UD	4.280	4.080	2.400	2.500	0.225	1.000	−0.100	N	N

BLOCK DIAGRAM

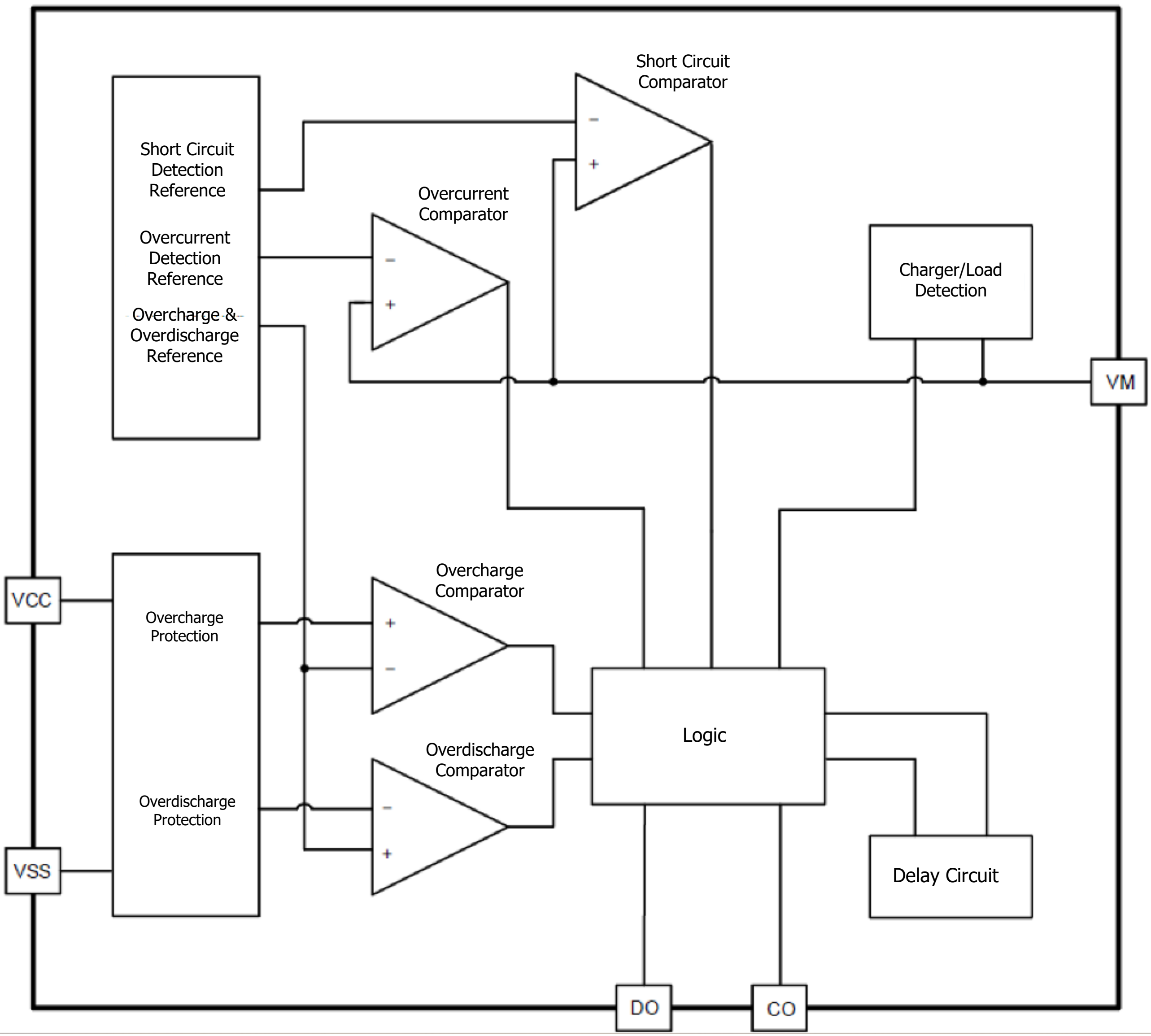


Figure 3. Block Diagram

ELECTRICAL CHARACTERISTICS

(At T_A = +25°C, V_{IN} = 12V, unless otherwise noted.)

Table 2.

Parameter		Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Normal Operating Current		I_{VCC}	VCC = 3.5V	-	2.2	5.0	μA
Standby Current (With Standby Function)		I_{PDN}	VCC = 1.5V	-	0.05	0.5	μA
Current Consumption During Over-Discharge (With Over-Discharge Auto-Recovery Function)		I_{OPED}	VCC = 1.5V	-	0.7	1.5	μA
Overcharging	Protection Voltage	V_{OC}	VCC = 3.5→4.7V	V_{OC}−0.025	V_{OC}	V_{OC}+0.025	V
	Release Voltage	V_{OCR}	VCC = 4.7→3.5V	V_{OCR}−0.05	V_{OCR}	V_{OCR}+0.05	V
	Protection Delay	t_{OC}	VCC = 3.5→4.7V	40	80	120	ms
Overdischarge	Protection Voltage	V_{OD}	VCC = 3.5→2.0V	V_{OD}−0.08	V_{OD}	V_{OD}+0.08	V
	Release Voltage	V_{ODR}	VCC = 2.0→3.5V	V_{ODR}−0.1	V_{ODR}	V_{ODR}+0.1	V
	Protection Delay	t_{OD}	VCC = 3.5→2.0V	20	40	60	ms
Discharge Overcurrent	Protection Voltage	V_{EC}	VM−VSS = 0→0.3V	V_{EC}−0.015	V_{EC}	V_{OD}+0.015	V
	Protection Delay	t_{EC}	VM−VSS = 0→0.3V	5	10	15	ms
	Release Delay	t_{ECR}	VM−VSS = 0.3→0V	1	2	4	ms
Charging Overcurrent	Protection Voltage	V_{CHA}	VM−VSS = 0→0.3V	V_{CHA}*70%	V_{CHA}	V_{CHA}*130%	V
	Protection Delay	T_{CHA}	VM−VSS = 0→0.3V	5	10	15	ms
	Release Delay	T_{CHAR}	VM−VSS = 0.3→0V	1	2	4	ms
Short Circuit	Protection Voltage	V_{SHORT}	VM−VSS = 0→1.5V	V_{SHORT}*70%	V_{SHORT}	V_{SHORT}*130%	V
	Protection Delay	T_{SHORT}	VM−VSS = 0→1.5V	120	280	504	μs
	Release Delay	T_{SHORTR}	VM−VSS = 1.5→0V	1	2	4	ms
0V Charging Charger Start-Up Voltage		V_{0VCH}	Function allowing charging to 0V battery	0	0.7	1.5	V

FUNCTION DESCRIPTION

1. Overcharge Status

When the battery voltage rises above VOC and persists for a period of time TOC, the output of the CO terminal will reverse, turning off the charging control MOSFET, and stopping the charging, which is referred to as overcharge status. When the battery voltage drops below the overcharge release voltage VOCR and persists for a period of time TOCR, the overcharge status will be released and return to normal.

To release the overcharge status, there are two cases:

1). Disconnect the charger without connecting the load and $V_{CHA}<V_{VM}<V_{EC}$. When the battery voltage drops to the overcharge release, the overcharge status will be released. When the battery voltage drops to below the overcharge release V_{OCR}, the overcharge status will be released.

2). Disconnect the charger and connect the load. If $V_{VM}>V_{EC}$, then only when $V_{CC}<V_{OC}$, the overcharge status will be released, and this function is called load detection function.

Note: If overcharging is detected and the charger remains connected, even if the cell voltage drops below V_{OCR}, the overcharging status cannot be released. The overcharge discharge status can only be released by disconnecting the charger and ensuring $VV_M> V_{CHA}$.

2. Overdischarge Status

When the battery voltage drops below V_{OD} and persists for a period t_{OD}, the output of the DO terminal will reverse, turning off the discharge control MOSFET, stopping the discharge, referred to as the overdischarge status. When the battery voltage rises above the overdischarge release voltage VODR and persists for a period t_{ODR}, the overdischarge status will be released and return to normal.

To release the overdischarge status and return to normal, there are several cases:

1). Connect the charger. If the VM terminal voltage is lower than the charging overcurrent protection voltage (V_{CHA}) when the battery voltage is higher than the overdischarge protection voltage (V_{OD}), the overdischarge status will be released, returning to normal working state. This function is called charger detection function.

2). Connect the charger. If the VM terminal voltage is higher than the charging overcurrent protection voltage (V_{CHA}), when the battery voltage is higher than the overdischarge release voltage (V_{ODR}), the overdischarge status will be released, returning to normal working state.

3). If it is a product with overdischarge unlock function (sleep recovery), when the charger is not connected, the battery voltage restores to above the overdischarge release voltage (V_{ODR}), the overdischarge status will be released, returning to normal working state.

4). If it is a product with overdischarge lock function (sleep lock), then VM must be made ≤0V by connecting the charger, and then meet the conditions of 1 or 2 above to release the overdischarge status, returning to normal working state.

3. Discharge Overcurrent Status

When the battery is in a discharge state, the VM terminal voltage increases with the increase of discharge current. When the VM terminal voltage is higher than VEC and persists for a period TEC, the chip considers that a discharge overcurrent occurs; when the VM terminal voltage is higher than V_{SHORT} and persists for a period t_{SHORT}, the chip considers a short circuit. When either of the above two states occurs, the output of the DO terminal will reverse, turning off the discharge control MOSFET, stopping the discharge.

If the equivalent resistance of the load increases or the load is disconnected, so that VM<VDD-1.0V, the discharge overcurrent status can be released, returning to normal state.

4. Overcurrent Protection:

During the charging process of the battery in normal working state, if the VM terminal voltage is lower than the charging overcurrent protection voltage (V_{CHA}), and this state persists for more than the charging overcurrent protection delay time (T_{CHA}), then the MOSFET used for charging control will be turned off, stopping the charging, and this state is called charging overcurrent status. After entering the charging overcurrent protection state, if the VM terminal voltage rises above the charging overcurrent protection voltage (V_{CHA}) by disconnecting the charger, the charging overcurrent status will be released, returning to normal working state.

5. 0V Charging Function:

This function is used to recharge batteries that have discharged to 0V. When the voltage between the charger connected to the battery positive pole (P+) and the battery negative pole (P-) is higher than the charger's starting voltage for charging 0V batteries (V_{0VCH}), the gate of the charging control MOSFET is fixed to the potential of the VDD terminal. Due to the voltage difference between the gate and source of the MOSFET caused by the charger voltage, which is higher than its conduction voltage, the charging control MOSFET conducts (the CO terminal is turned on), and charging begins. At this time, the discharge control MOSFET remains off, and the charging current passes through its internal parasitic diode. When the battery voltage is higher than the overdischarge protection voltage (V_{OD}), the IC enters normal working state.

TYPICAL APPLICATION

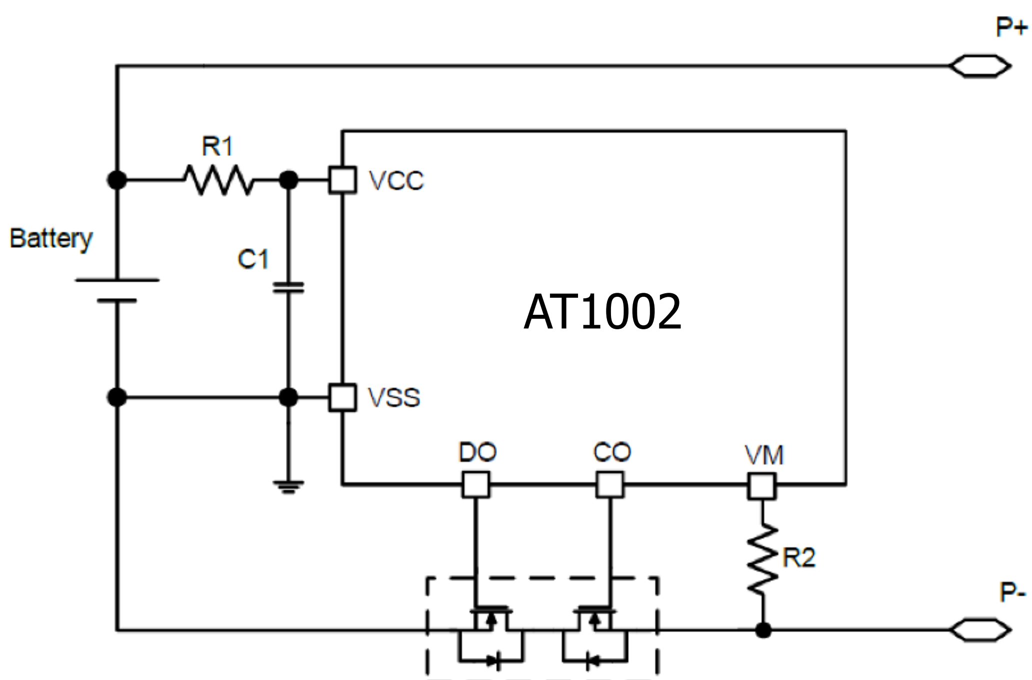
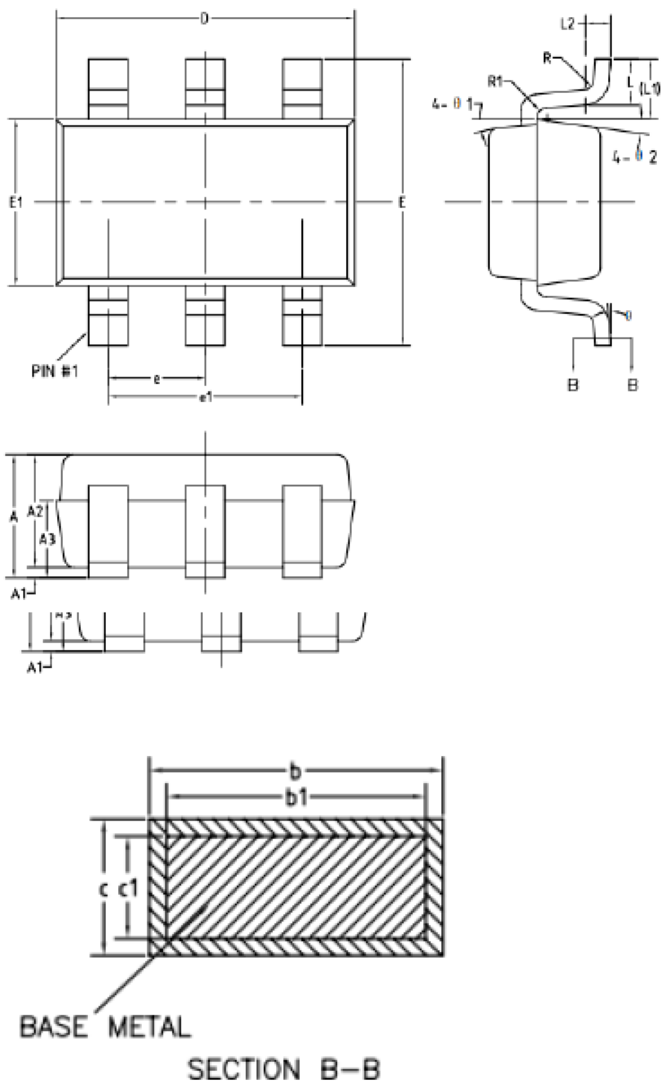


Figure 4. Application Circuit

No.	Symbol	Typ.	Range	Unit
1	R_1	1	1 ~ 1.5	kΩ
2	R_2	2	1 ~ 3	kΩ
3	C_1	0.1	≥1	μF

OUTLINE DIMENSIONS



SYMBOL	MIN	NOM	MAX
A	-	-	1.45
A1	0	-	0.15
A2	0.90	1.15	1.30
A3	0.60	0.65	0.70
b	0.39	-	0.49
b1	0.35	0.40	0.45
c	0.08	-	0.22
c1	0.08	0.13	0.20
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.85	0.95	1.05
e1	1.80	1.90	2.00
L	0.35	0.45	0.60
L1	0.35	0.60	0.85
L2	0.25BSC		
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	-	8°
θ1	7°	9°	11°
θ2	8°	10°	12°

Figure 5. Outline Dimensions

ORDERING INFORMATION

Part Number	Buy Now
AT1002	* *

NOTICE

1. It is important to carefully read and follow the warnings, cautions, and product-specific notes provided with electronic components. These instructions are designed to ensure the safe and proper use of the component and to prevent damage to the component or surrounding equipment. Failure to follow these instructions could result in malfunction or failure of the component, damage to surrounding equipment, or even injury or harm to individuals. Always take the necessary precautions and seek professional assistance if unsure about proper use or handling of electronic components.
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