Integrated MOS Single-Cell Lithium Battery Protection Chip

The DW03C incorporates a high-precision voltage detection circuit and delay circuit, providing a highly integrated solution for protecting single-cell lithium-ion/ lithium-polymer rechargeable battery packs. The DW03C integrates an advanced low-impedance power MOSFET, a high-precision voltage detection circuit, and a delay circuit onto a single chip.

The DW03C incorporates all essential battery protection functions, including overcharge voltage, over-discharge voltage, overcharge current, over-discharge current, and short-circuit protection, whilst exhibiting exceptionally low power consumption during operation.

The DW03C features an exceptionally compact SOT23 -5 package, rendering it ideally suited for applications within rechargeable battery packs where space constraints are particularly severe.

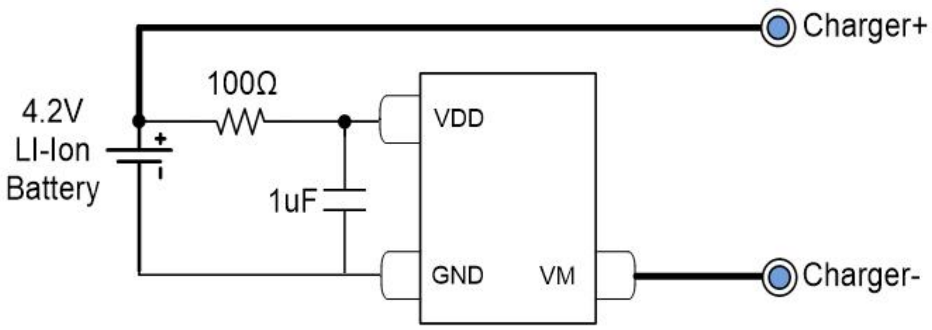
This chip is suitable for all applications in information products requiring long-term power supply from lithium -ion or lithium-polymer rechargeable batteries.

Reverse polarity protection for charger and battery
High-temperature protection for battery
High-temperature protection for battery
Charger detection
Overcharge current protection
Over-discharge self-locking function
Three-stage overcurrent detection:
1. Discharge overcurrent 1
2. Discharge overcurrent 2
3. Load short-circuit protection
Internally integrated equivalent 48mΩ advanced power MOSFET
Low-power current:
Normal operation: 1.5μA typical
Self-locking mode: 0.3μA
Capable of charging to 0V battery
ESD：HBM=4kV
Package：SOT-23-5

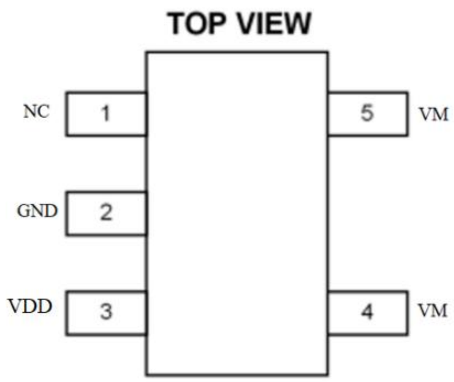
Application

Single-cell lithium-ion rechargeable battery
Single-cell lithium-polymer rechargeable battery

Typical Application Circuit Diagram



Pin configuration

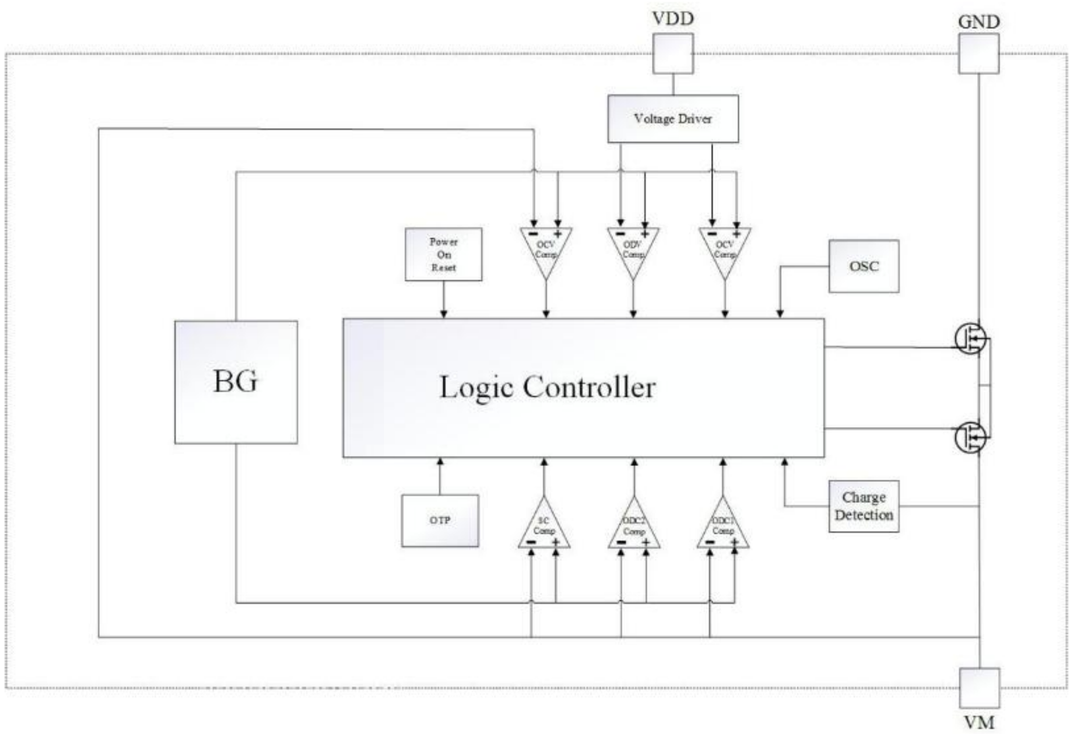


SOT23-5

Pin definitions

Pin	Symbol	Description
1	NC	Suspended
2	GND	Ground terminal, battery negative terminal
3	VDD	Chip power supply terminal
4	VM	Charge and discharge current detection terminal, connected to the charger's negative terminal
5	VM	Charge and discharge current detection terminal, connected to the charger's negative terminal

Internal framework diagram



Limit parameters

Description	Symbol	Range	Unit
Power supply input pin voltage range	V_{DD}	-0.3 ~ 8	V
VM input pin voltage	V_{OM}	-6 ~ 6	V
Operating temperature range	T_{OP}	-40~+85	℃
Storage temperature range	T_{ST}	-55~+145	℃
Wet bulb temperature operating range	T_J	-40~+145	℃
Permissible power consumption	Internal restrictions		
Welding temperature resistance (10 seconds)	-	260	℃
Thermal resistance of the package (to the environment)	θ_{JA}	180	℃/W
Encapsulation thermal resistance (with housing connection)	θ_{JC}	130	℃/W
Terminal block thermoresistor	$R_{\theta JB}$	45	℃/W
Crown-forming characteristic parameters	ψ_{JT}	35	℃/W
Connection Plate Specification Parameters	ψ_{JB}	45	℃/W

Note: Operating beyond the specified ‘ limit parameters’ may cause permanent damage to the device. While operation within the limit parameter specifications is possible, performance characteristics are not guaranteed. Prolonged operation at limit conditions may adversely affect the device's reliability and service life.

Operational Characteristics Parameters

Unless otherwise specified, T = 25°C, VDD = 3.6V

Symbol	Parameters	Testing	Min	Typ	Max	Unit
Power consumption current						
I_{DD}	Operating current	V_{DD}=3.6V		1.5	3	µA
I_{PD}	Standby current	V_{DD}=1.5V		0.3	1	µA
Voltage detection parameters						
V_{CU}	Overcharge detection voltage		4.25	4.30	4.35	V
V_{CR}	Overcharge recovery voltage		4.1	4.15	4.20	V
V_{DL}	Over-discharge detection voltage		2.3	2.4	2.5	V
V_{DR}	Overdischarge recovery voltage		2.9	3.0	3.1	V
V_{CHA}	Charger voltage detection		-0.1	-0.18	-0.28	mV
Current detection parameters						
I_{CIP}	Charging Overcurrent Detection Current	V_{DD} =3.6V	2.7	3.9	5.8	A
I_{DIP1}	Overcurrent Detection Current 1 during Discharge	V_{DD} =3.6V	2.8	3.7	5.2	A
I_{DIP2}	Overcurrent Detection Current 2 during Discharge	V_{DD} =3.6V	5.0	7.0	9.0	A
V_{SIP}	Load short-circuit detection current	V_{DD} =3.6V	8.0	10.0	14.0	A
Temperature detection parameters						
T_{SHD+}	Over-temperature detection temperature			155		℃
T_{SHD-}	Recovery temperature			120		℃
Detection delay time						
T_{CU}	Overcharge protection delay time			100		ms
T_{DL}	Over-discharge protection delay time			100		ms
T_{DIP1}	Overcurrent Protection 1 Delay Time	V_{DD} =3.6V		6		ms
T_{DIP2}	Overcurrent Protection 2 Delay Time	V_{DD} =3.6V		2		ms
T_{SIP}	Load short-circuit protection delay time	V_{DD} =3.6V		350		µs
Internal resistance of power MOSFETs						
Ron	Internal power MOS equivalent resistance	VDD=3.6V, I_{VM}=1A	40	48	55	mΩ

Function Description

The DW03C monitors the voltage and current of the battery and protects single-cell rechargeable lithium batteries from damage caused by overcharge voltage, over-discharge voltage, overcharge current, over-discharge current, and short circuits by disconnecting the charger or load. The system peripheral circuitry is simple. The MOSFET is built-in, with a typical equivalent resistance of 48mΩ.

1. Normal operating condition

If no abnormalities are detected, the output tube remains open, allowing free switching between charging and discharging processes. This condition is referred to as normal operating mode.

2. Overcharge Condition

During normal charging conditions, when the battery voltage exceeds the overcharge detection voltage (V_{CU}) and persists for the overcharge voltage detection delay time (T_{CU}) or longer, the DW03C will shut off the MOSFET to halt charging. This condition is referred to as an overcharge voltage situation.
Overcharge voltage conditions will be released under the following two circumstances:
(1) When the battery voltage falls below the overcharge release voltage (VCR), the DW03C activates the output transistor and returns to normal operating mode.
(2) When a load is connected for discharge, the DW03C activates the output transistor and returns to normal operating mode.
The discharge mechanism proceeds as follows:
Upon connecting the load, discharge current immediately flows through the internal parasitic diode of the output transistor, causing the VM voltage to rise to 0.7V (equivalent to the diode's forward voltage drop).
After detecting this voltage, the DW03C switches the overcharge voltage threshold to VCU. Subsequently, when the battery voltage falls below the overcharge detection voltage (VCU),
The DW03C immediately returns to normal operating mode. However, if the battery voltage exceeds the overcharge detection voltage (Vcu), the chip will not resume normal operation even with a load connected. It must wait until the battery voltage falls below the overcharge detection voltage (Vcu). Additionally, during load discharge, if the VM voltage equals or falls below the overcurrent detection voltage, the chip will not return to normal operating mode.
Note: When the battery is charged beyond the overcharge detection voltage (VCU) and the battery voltage does not drop below the overcharge detection voltage (VCU), the overcurrent protection will not activate even when a heavy load capable of causing overcurrent is applied, unless the battery voltage falls below the overcharge detection voltage (VCU). However, in practice, the battery possesses internal resistance. When a heavy load is connected to the battery, the battery voltage will immediately drop, at which point the overcurrent protection will activate.

3. Overvoltage Condition

Over-Discharge Mode: When the battery voltage drops below the over-discharge detection voltage, and remains below this threshold for the over-discharge detection voltage delay time (T_{DL}), the DW03C shuts off the MOSFET to halt discharge. Low-Power Mode: Following a discharge protection event, the VM terminal is pulled high via the R_{VMD} resistor (V_M to V_{DD}). Simultaneously, when V_{DD} - V_M falls below 1.0V, the chip's power consumption reduces to sleep mode power consumption (I_{PD}). In both over-discharge mode and low-power mode, the V_M and V_{DD} terminals are internally shorted through the R_{VMD} resistor.

The following conditions can restore normal operation:
Sleep mode is canceled when a charger is connected and the VM voltage is below the charge detection voltage (V_{CHA}). At this point, the discharge FET remains off. When the battery voltage rises to the over-discharge detection voltage (V_{DL}) or higher (see note), the DW03C turns on the FET to enter normal operating mode.
Note: If a charger is connected while the battery is in an over-discharged state, and the VM terminal voltage is not lower than the charge detection voltage (V_{CHA}), and the battery voltage reaches the over-discharge release voltage (V_{DR}) or higher, the over-discharge condition is released.

4. Overcurrent State

In normal operating mode, when the discharge current equals or exceeds the set value (VM voltage equals or exceeds the overcurrent detection voltage) and the duration reaches the over-discharge current detection delay time, the DW03C turns off the discharge FET and stops discharging. This condition is referred to as an over-discharge current situation (including over-discharge current 1, over-discharge current 2, and load short-circuit current). During over-discharge current conditions, VM and GND are shorted by the RVMS resistor. When a load is connected, the VM voltage equals V_{DD} minus the voltage across the load resistance. Since the RVMS resistor connects VM to GND, when the load disconnects, the VM voltage is pulled to ground potential. When the VM potential is detected to be below the Overcurrent 1 detection voltage, the chip returns to normal operation.

5. Short-Circuit Protection Status

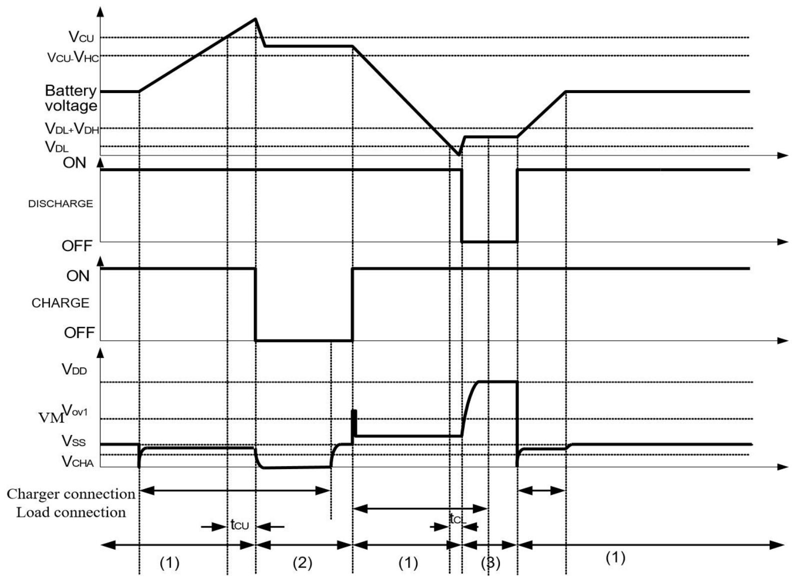
If the VM voltage exceeds the short-circuit protection voltage (VSIP) and persists beyond the short-circuit detection delay time (TSIP), the DW03C will disconnect from the load to halt discharge. When the VM voltage falls below the short-circuit protection voltage (VSIP)—such as when the load is removed or a charger is connected—the load short-circuit condition is resolved.

6. Allows charging of 0V batteries

When the battery voltage drops below 1.2V, connecting the charger will initiate charging.
Upon initial connection to the protection circuit, the circuit may fail to enter normal mode, preventing discharge. If this occurs, setting the VM pin voltage equal to GND voltage (by shorting VM to GND or connecting the charger) will restore normal operation.

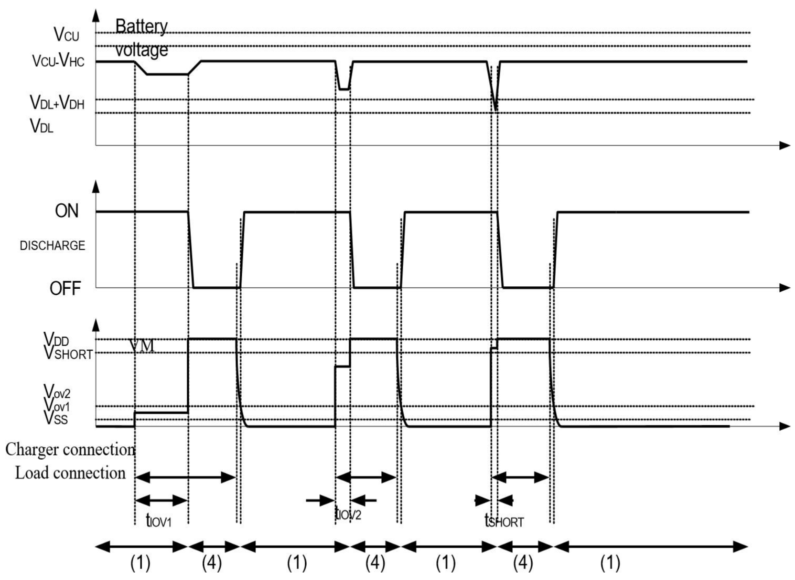
Sequence Diagram

Overcharge detection, over-discharge detection



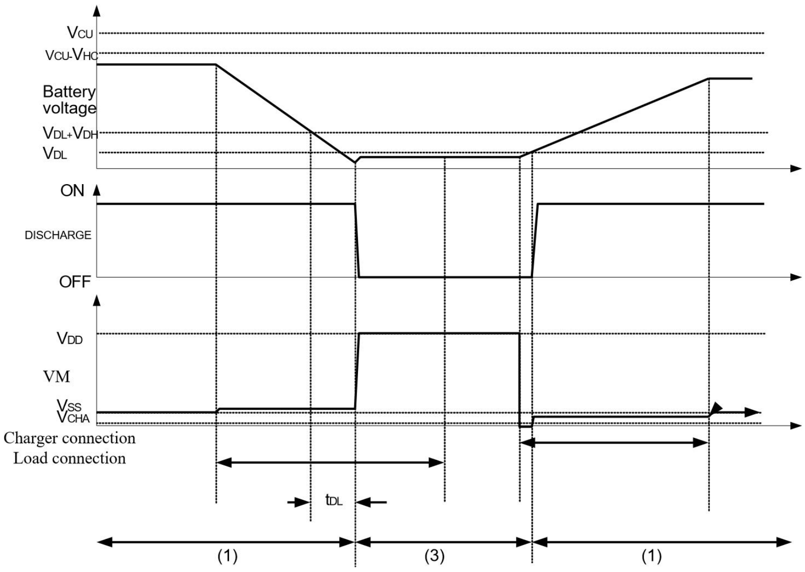
Note: (1) Normal conditions (2) Overcharge conditions (3) Overdischarge conditions

Overcurrent Detection During Discharge



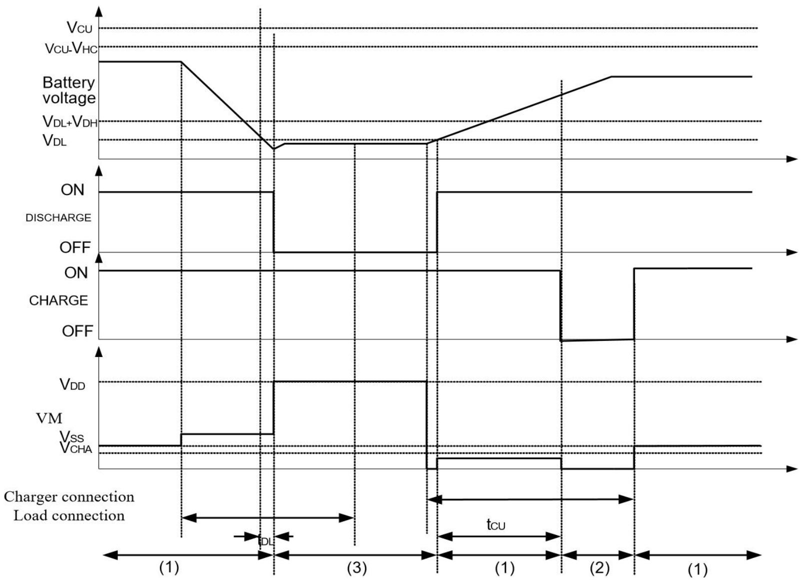
Note: (1) Normal conditions (2) Overcharge conditions (3) Overdischarge conditions
(4) Overcurrent conditions

Charger Detection



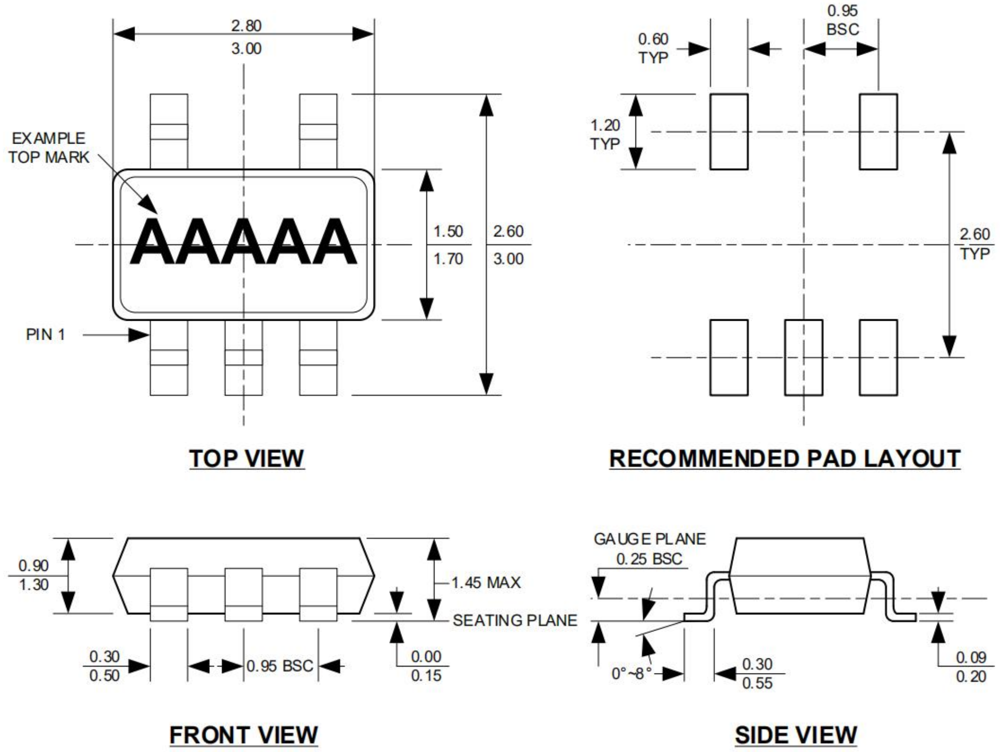
Note: (1) Normal conditions (2) Overcharge conditions (3) Overdischarge conditions

Abnormal Charging Detection



Note: (1) Normal conditions (2) Overcharge conditions (3) Overdischarge conditions

Packaging Instructions



SOT23-5

Note: 1. Units are in millimeters.

2. Package length excludes mold flash, protrusions, or gate burrs.
3. Package width excludes interlayer flash or protrusions.
4. Lead coplanarity (bottom of leads after molding) shall be 0. Maximum 0.004 inches.
5. Drawings comply with JEDEC MS-012, Revision BA.
6. Drawings are not drawn to scale.