Battery Protection IC for $LiFePO_4$ Battery Single-Cell Pack

Features

- Low supply current
  Normal operation: 3.5uA typ. @VCC = 3.5V
  Power-down mode: 0.1uA max. @VCC = 2.0V
- Over-charge detection voltage (V_{CU})
  3.5V ~ 4.0V, accuracy: ±25mV
- Over-charge release voltage (V_{HC})
  0.0V ~ 0.4V, accuracy: ±25mV
- Over-discharge detection voltage (V_{DL})
  2.0V ~ 2.5V, accuracy: ±50mV
- Over-discharge release voltage (V_{HD})
  0.0V ~ 0.7V, accuracy: ±50mV
- Over-current detection voltage (V_{IOV1})
  0.15V, accuracy: ±15mV
- Short circuit detection voltage (V_{SHORT})
  0.5V, accuracy: ±100mV
- Charger detection voltage -0.7V
- Reset resistance for over-current protection
  >500KΩ
- Delay time clock is generated with internal circuit

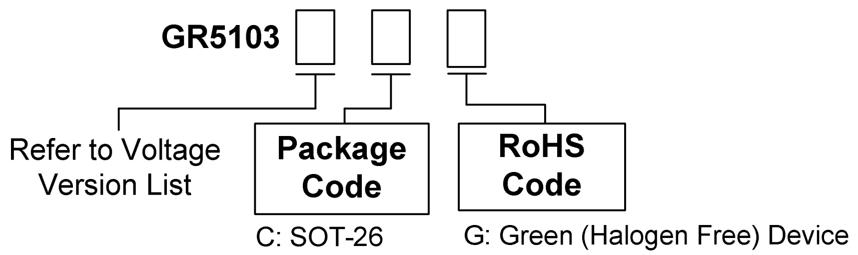
Applications

- $LiFePO_4$ protector of over-charge, over-discharge, excess-current for battery pack
- High precision protector for cell-phones and any other gadgets using on board $LiFePO_4$ battery

Description

The GR5103 series are protection ICs for over-charge/discharge of rechargeable one-cell $LiFePO_4$ excess load current, further include a short circuit protector for preventing large external short circuit and excess charge/discharge-current.

Ordering and Marking Information



SOT-26

03XYW

X – Voltage Code **YW - Date Code**

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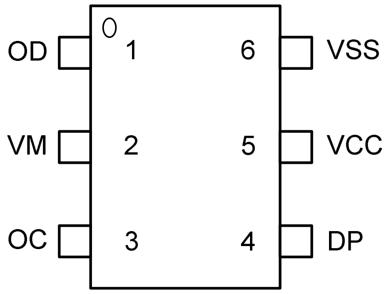
Voltage Version List

Product Name	Package	Over-charge detection voltage V_{CU}(V)	Over-charge release voltage V_{HC}(V)	Over-discharge detection voltage V_{DL}(V)	Over-discharge release voltage V_{HD}(V)	Over-current detection voltage V_{IOV1}(mV)
GR5103A	SOT-26	3.9±0.025	3.69±0.025	2.22±0.05	2.67±0.05	150±15

Pin Configuration

TOP VIEW



Pin Description

Pin No.	Symbol	Description
1	OD	Output of over-discharge detection, CMOS output
2	VM	Voltage detection pin between VM and VSS
3	OC	Output of over-charge detection, CMOS output
4	DP	Test pin for delay time measurement
5	VCC	Power supply pin, the substrate voltage level of the IC
6	VSS	Ground pin for the IC

Absolute Maximum Ratings

Input voltage between VCC and VSS -- VSS-0.3 ~ VSS +12V

OC output pin voltage -- VCC-28 ~ VCC+0.3V

OD output pin voltage -- VSS-0.3 ~ VCC+0.3V

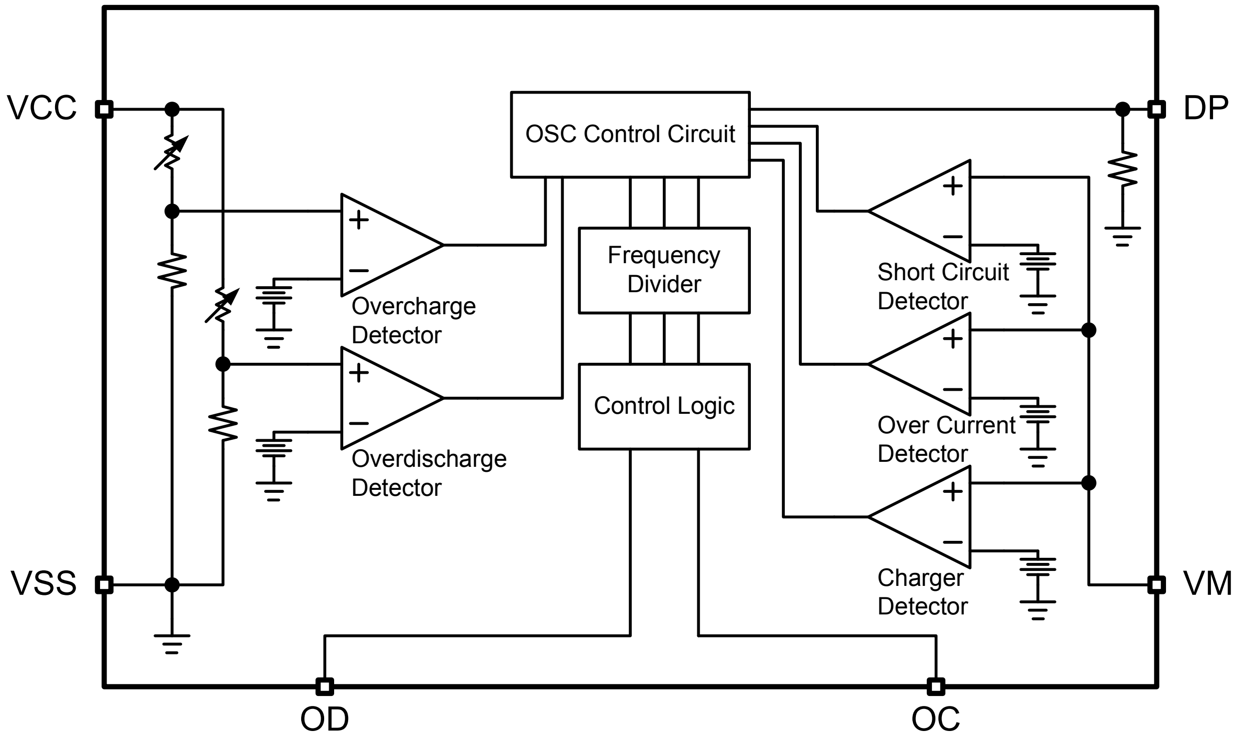
VM input pin voltage -- VCC-20 ~ VCC+0.3V

DP input pin voltage -- VSS-0.3 ~ VCC+0.3V

Operating temperature range -- -40 ~ 85 °C

Storage temperature range --- -40 ~ 125 °C

Block Diagram



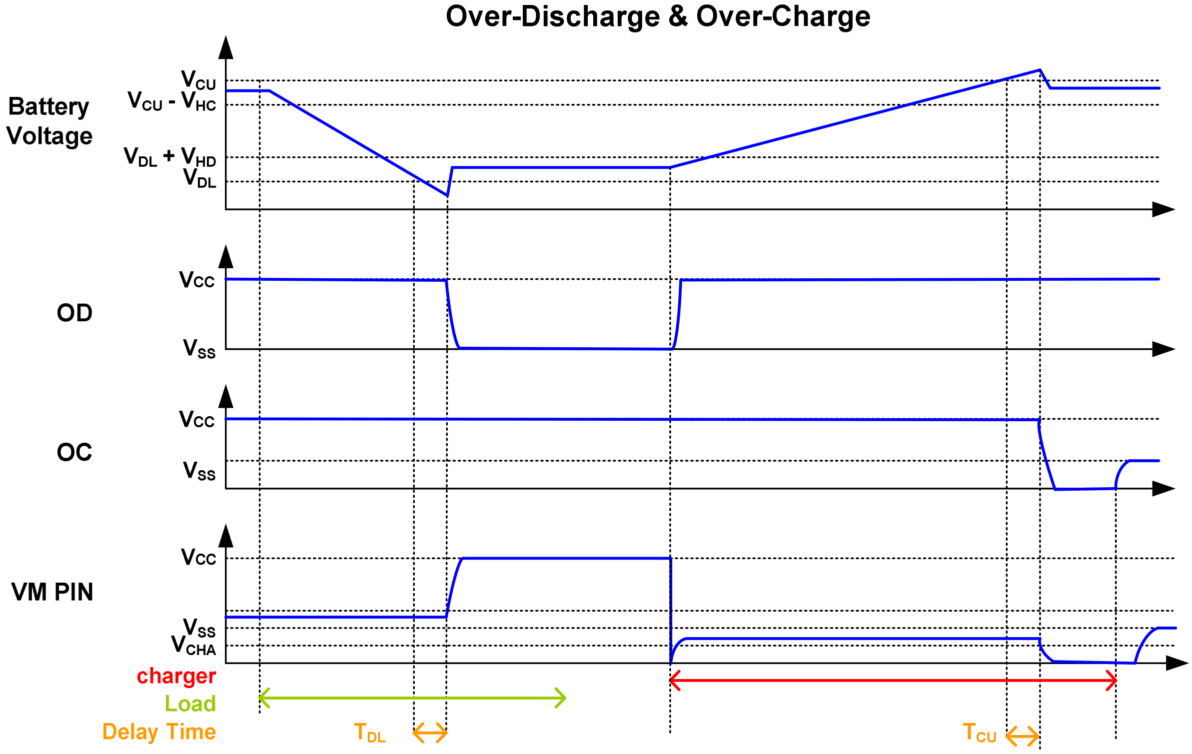
Electrical Characteristics ($T_A = 25℃$)

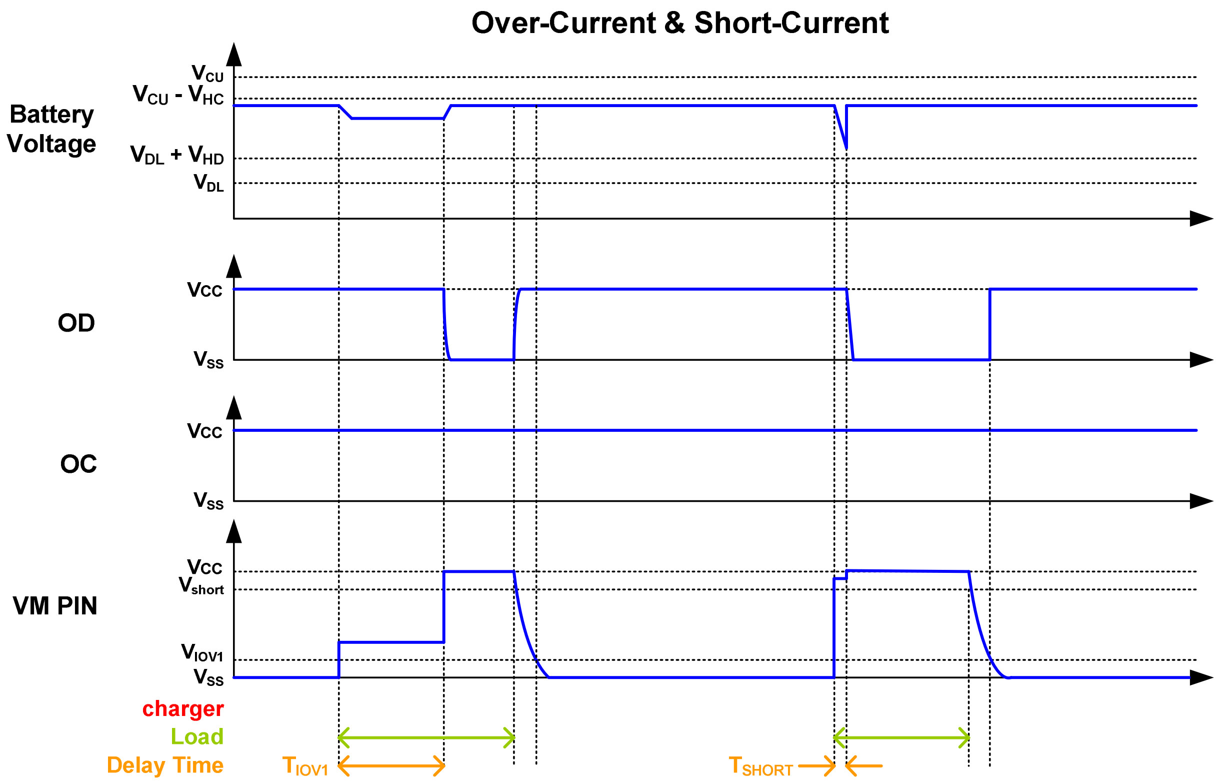
Parameter	Conditions	Symbol	Min	Typ	Max	Unit
CURRENT CONSUMPTION						
Supply current	VCC = 3.0V	I_{OPE}	1.0	3.5	7.0	μA
Power-down current	VCC = 2.0V	I_{PDN}			0.1	μA
OPERATING VOLTAGE						
Operating input voltage	VCC-VSS	V_{DSOP}	1.8		8.0	V
DETECTION VOLTAGE						
Over-charge detection voltage		V_{CU}	V_{CU} -0.025	V_{CU}	V_{CU} +0.025	V
Over-charge hysteresis voltage		V_{HC}	V_{HC} -0.025	V_{HC}	V_{HC} +0.025	V
Over-discharge detection voltage		V_{DL}	V_{DL} -0.050	V_{DL}	V_{DL} +0.050	V
Over-discharge hysteresis voltage		V_{HD}	V_{HD} -0.050	V_{HD}	V_{HD} +0.050	V
Over-current detection voltage		V_{IOV1}	V_{IOV1} -0.015	V_{IOV1}	V_{IOV1} +0.015	V
Short current detection voltage	VCC = 3.5V	V_{SHORT}	0.4	0.5	0.6	V
Charger detection voltage		V_{CHA}	-1.0	-0.7	-0.2	V
DELAY TIME						
Over-charge detection delay time	VCC = 4.3V	T_{CU}	64	80	96	mS
Over-discharge detection delay time	VCC = 2.4V	T_{DL}	32	40	48	mS
Over-current detection delay time	VCC = 3.5V	T_{IOV1}	5	10	15	mS
Short current detection delay time	VCC = 3.5V	T_{SHORT}	60		200	μS
OUTPUT THRESHOLD						
OC/OD high voltage	VCC = 3.9V	V_{OH}	3.4	3.7		V
OC/OD low voltage	VCC = 2.4V	V_{OL}		0.1	0.5	V

Electrical Characteristics (T_A = -40 ~ 90℃)

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
CURRENT CONSUMPTION						
Supply current	VCC = 3.5V	I_{OPE}	1.0	3.5	7.0	μA
Power-down current	VCC = 2.0V	I_{PDN}			0.1	μA
OPERATING VOLTAGE						
Operating input voltage	VCC-VSS	V_{DSOP}	1.8		8.0	V
DETECTION VOLTAGE						
Over-charge detection voltage		V_{CU}	V_{CU} -0.055	V_{CU}	V_{CU} +0.040	V
Over-charge hysteresis voltage		V_{HC}	V_{HC} -0.025	V_{HC}	V_{HC} +0.025	V
Over-discharge detection voltage		V_{DL}	V_{DL} -0.080	V_{DL}	V_{DL} +0.080	V
Over-discharge hysteresis voltage		V_{HD}	V_{HD} -0.050	V_{HD}	V_{HD} +0.050	V
Over-current detection voltage		V_{IOV1}	V_{IOV1} -0.021	V_{IOV1}	V_{IOV1} +0.021	V
Short current detection voltage	VCC = 3.5V	V_{SHORT}	0.4	0.5	0.6	V
Charger detection voltage		V_{CHA}	-1.0	-0.7	-0.2	V
DELAY TIME						
Overcharge detection delay time	VCC = 4.3V	T_{CU}	48	80	112	mS
Over discharge detection delay time	VCC = 2.4V	T_{DL}	24	40	56	mS
Over-current detection delay time	VCC = 3.5V	T_{IOV1}	5	10	15	mS
Short current detection delay time	VCC = 3.5V	T_{SHORT}	60		200	μS

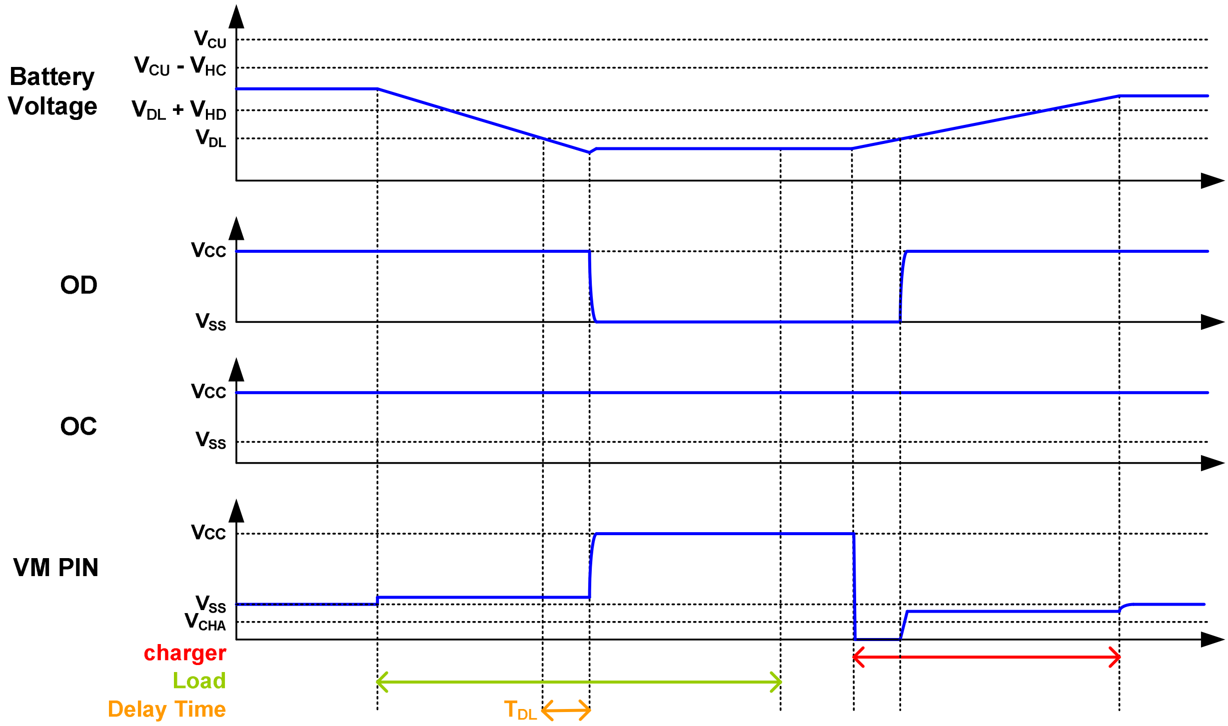
Timing Chart



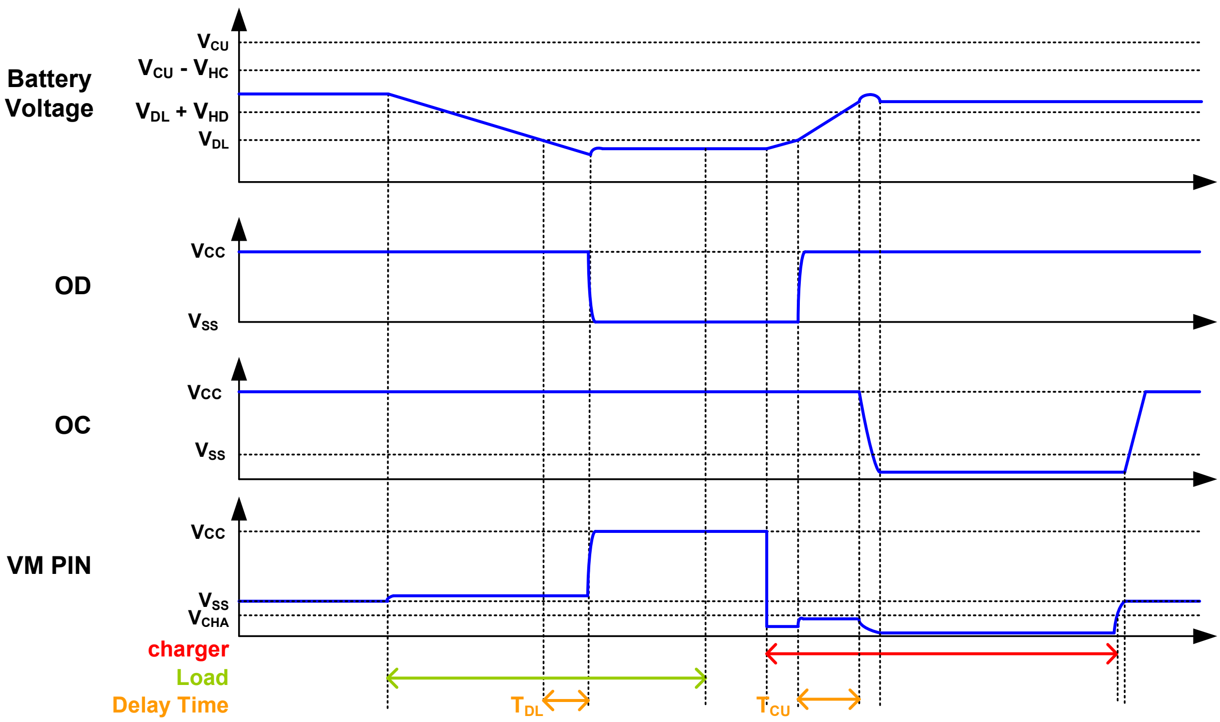


Timing Chart (Cont.)

Charger Detection



Abnormal Charge Current Detection



Description of Operation

Normal Status

This IC monitors the voltage of the battery connected between the VCC pin and VSS pin and the voltage difference between the VM pin and VSS pin to control charging and discharging. When the battery voltage is in the range from over-discharge detection voltage (V_{DL}) to over-charge detection voltage (V_{CU}), and the VM pin voltage is not more than the discharge over-current detection voltage (V_{IOV1}), the IC turns both the charging and discharging control FETs on. This condition is called the normal status, and in this condition charging and discharging can be carried out freely. The resistance (R_{VMD}) between the VM pin and VCC pin, and the resistance (R_{VMS}) between the VM pin and VSS pin are not connected in the normal status. Caution when the battery is connected for the first time, discharging pin may not be enabled. Please short the VM pin and VSS pin or connect the charger to restore the normal status.

Over-charge Status

When the battery voltage becomes higher than over-charge detection voltage (V_{CU}) during charging in the normal status and detection continues for the over-charge detection delay time (T_{CU}) or longer, the GR5103 series turns the charging control FET off to stop charging. This condition is called the over-charge status. The resistance (R_{VMD}) between the VM pin and VCC pin, and the resistance (R_{VMS}) between the VM pin and VSS pin are not connected in the overcharge status. The over-charge status is released in the following two cases:

(1) In the case that the VM pin voltage is higher than or equal to charger detection voltage (V_{CHA}), and is lower than the discharge over-current detection voltage (V_{IOV1}), GR5103 series releases the over-charge status when the battery voltage falls below the over-charge release voltage (V_{HC}).

(2) In the case that the VM pin voltage is higher than or equal to the discharge over-current detection voltage (V_{IOV1}), GR5103 series releases the over-charge status when the battery voltage falls below the over-charge detection voltage (V_{CU}). When the discharge is started by connecting a load after the over-charge detection, the VM pin voltage rises more than the voltage at VSS pin due to the voltage of the parasitic diode. This is because the discharge current flows through the parasitic diode in the charging control FET. If this VM pin voltage is higher than or equal to the discharge over-current detection voltage (V_{IOV1}), GR5103 series releases the over-charge status when the battery voltage is lower than or equal to the over-charge detection voltage (V_{CU}).

Over-discharge Status

When the battery voltage falls below over-discharge detection voltage (V_{DL}) during discharging in the normal status and the detection continues for the over-discharge detection delay time (T_{DL}) or longer, the GR5103 series turns the discharging control FET off to stop discharging. This condition is called the over-discharge status. Under the over-discharge status, the VM pin voltage is pulled up by the resistor between the VM pin and VCC pin in the IC (R_{VMD}). When voltage difference between the VM pin and VSS pin then is 0.5 V (Typ.) or higher, the current consumption is reduced to the power-down current consumption (I_{PDN}). This condition is called the power-down status. The resistance (R_{VMS}) between the VM pin and VSS pin is not connected in the power-down status and the over-discharge status. The power-down status is released when a charger is connected and the voltage difference between the VM pin and VSS pin becomes 0.5 V (typ.) or lower. When a battery in the over-discharge status is connected to a charger and provided that the VM pin voltage is lower than charger detection voltage (V_{CHA}), the GR5103 series releases the over-discharge status and turns the discharging FET on when the battery voltage reaches over-discharge detection voltage (V_{DL}) or higher. When a battery in the over-discharge status is connected to a charger and provided that the VM pin voltage is not lower than charger detection voltage (V_{CHA}), the GR5103 series releases the over-discharge status when the battery voltage reaches over-discharge release voltage (V_{DU}) or higher.

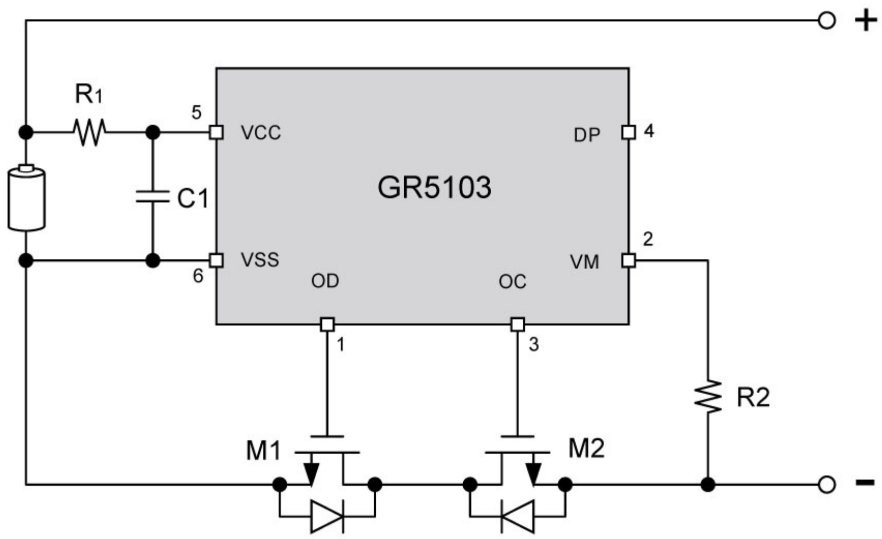
Discharge Over-current Status (Discharge Over-current or Short-circuiting)

When a battery is in the normal status, the voltage of the VM pin is equal to or higher than the discharge over-current detection voltage because the discharge current is higher than the specified value and the status lasts for the discharge over-current detection delay time, the discharge control FET is turned off and discharging is stopped. This status is called the discharge over-current status. In the discharge over-current status, the VM pin and VSS pin are shorted by the resistor between VM pin and VSS pin (R_{VMS}) in the IC. However, the voltage of the VM pin is at the VCC potential due to the load as long as the load is connected. When the load is disconnected, the VM pin returns to the VSS potential. This IC detects the status when the impedance between the Bat+ pin and Bat- pin increases and is equal to the impedance that enables automatic restoration and the voltage at the VM pin returns to discharge over-current detection voltage (V_{IOV1}) or lower, the discharge over-current status is restored to the normal status. Even if the connected impedance is smaller than automatic restoration level, the GR5103 series will be restored to the normal status from discharge over-current detection status when the voltage at the VM pin becomes the discharge over-current detection voltage (V_{IOV1}) or lower by connecting the charger. The resistance (R_{VMD}) between the VM pin and VCC pin is not connected in the discharge over-current detection status.

Detection for Abnormal Charging Current

During charging a battery which is in the normal status, if the VM pin voltage becomes lower than the charger detection voltage (V_{CHA}) and this status is held longer than the over-charge detection delay time (T_{CU}), GR5103 turns off the charge-control FET to stop charging. This is detection for abnormal charging current. This function works in the case that the OD pin voltage is high, and the VM pin voltage becomes lower than the charger detection voltage (V_{CHA}). Thus if the abnormal charger current flows in the battery in the over-discharge status, GR5103 turns off the charge-control FET to stop charging; the OD pin voltage goes high that the battery voltage becomes higher than the over-discharge detection voltage, and after the over-charge detection delay time (T_{CU}). The status irregular charging current detection is released by the lower potential difference between the VM and VSS pin than the charger detection voltage (V_{CHA}).

Typical Application Circuit



Constant for External Components

Symbol	Part	Purpose	Min.	Typ.	Max.	Remarks
M1	N-channel MOSFET	Discharge control	—	—	—	Threshold voltage ≤ Over-discharge detection voltage gate to source withstanding voltage ≥ charger voltage
M2	N-channel MOSFET	Charge control	—	—	—	Threshold voltage ≤ Over-discharge detection voltage gate to source withstanding voltage ≥ charger voltage
R1	Resistor	ESD protection, for power fluctuation	300Ω	470Ω	1KΩ	Resistance should be as small as possible to avoid lowering of the overcharge detection accuracy caused by VCC pin current
C1	Capacitor	For power fluctuation	0.022uF	0.1uF	1.0uF	Install a capacitor of 0.022uF or higher between VCC and VSS
R2	Resistor	Protection for reverse connection of a charger	300Ω	2KΩ	4KΩ	Select a resistance as large as possible to prevent large current when a charger is connected in reverse

Package Information

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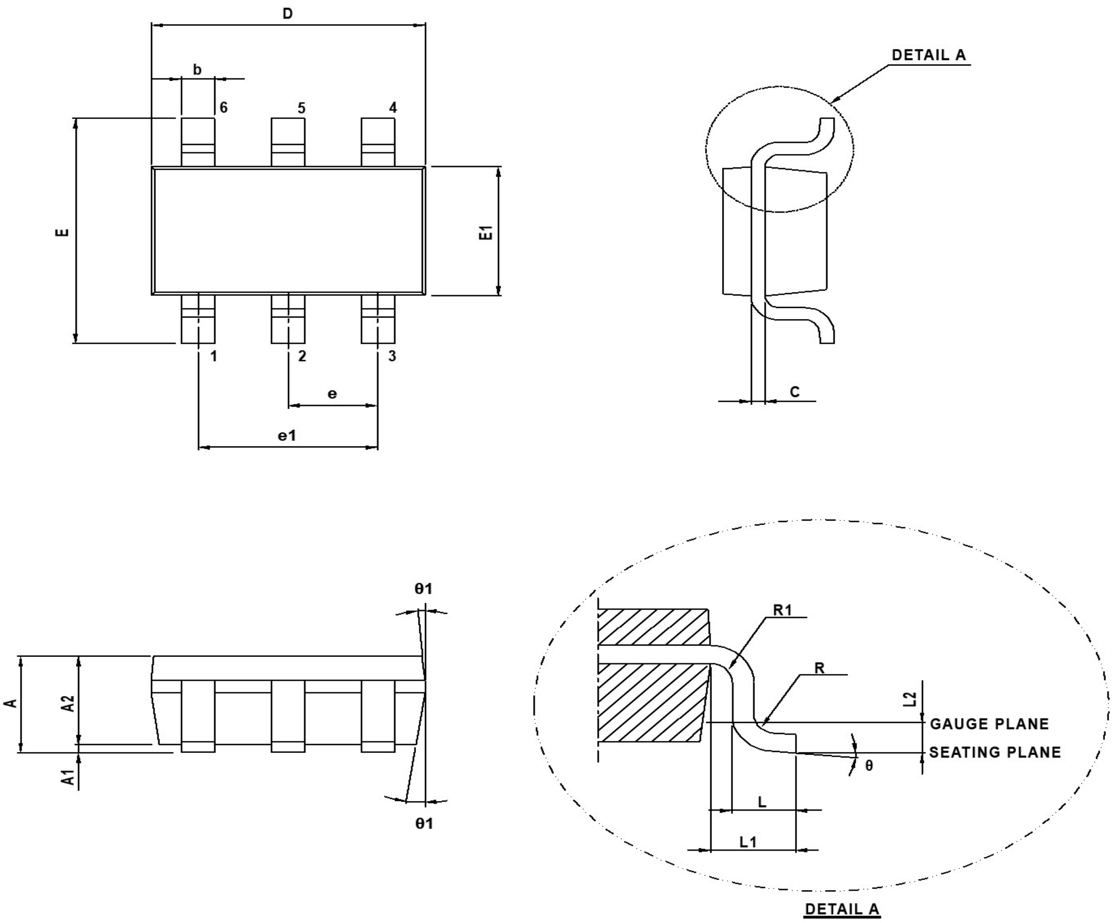
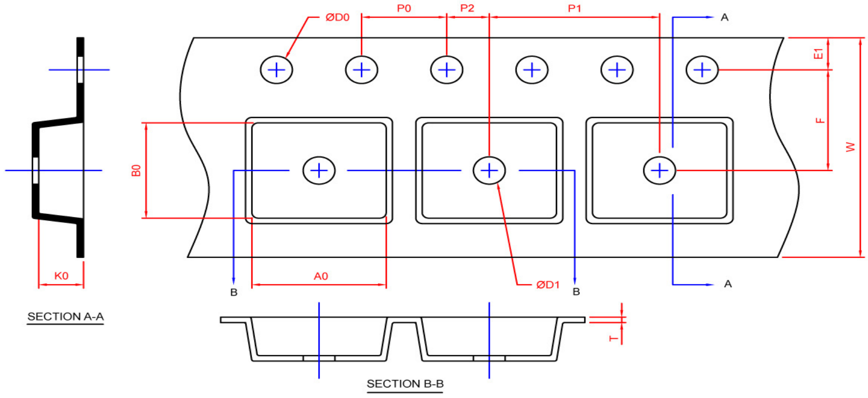


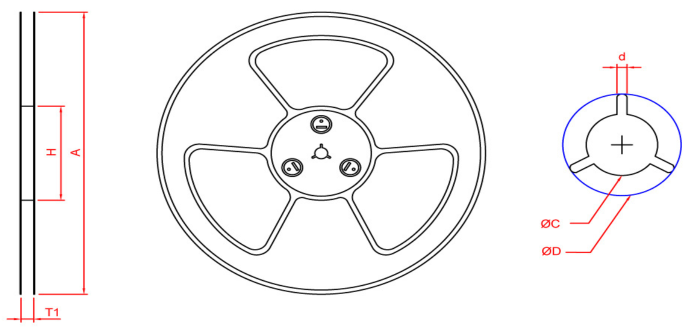
Symbols	MIN.	NOM.	MAX.
A	-	-	1.45
A1	0.00	-	0.15
A2	0.90	1.15	1.30
b	0.30	-	0.50
C	0.08	-	0.22
D	2.90 BSC.		
E	2.80 BSC.		
E1	1.60 BSC.		
e	0.95 BSC.		
e1	1.90 BSC.		
L	0.30	0.45	0.60
L1	0.60 REF.		
L2	0.25 BSC.		
R	0.10	-	-
R1	0.10	-	0.25
θ	0^{o}	4^{o}	8^{o}
$\theta 1$	5^{o}	10^{o}	15^{o}

* VARIATION (ALL DIMENSIONS SHOWN IN MM)

Carrier Tape & Reel Dimensions

SOT-26





Application	A	H	T1	C	d	D	W	E1	F
SOT-26	178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20

(mm)

Application	Carrier Width	Cover Tape Width	Devices Per Reel
SOT -26	8	5.3	3000