FM2113(file No.：S&CIC1162) One Cell Lithium-ion/Polymer Battery Protection IC

DESCRIPTION

FM2113 series are high precision protection ICs for over-charge and over-discharge of rechargeable one-cell Li-ion or Li-polymer battery.It integrates the high precision protection capability for over-charge,over-discharge, excess-current discharge, and battery short.

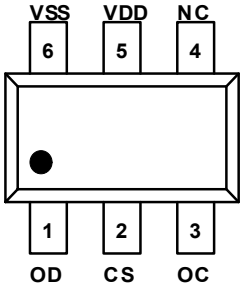
FEATURES

- High precision protection voltage threshold (over-charge/over-discharge)
- Delay Times are generated inside
- Self recovery function of over discharge
- Operation Current Consumption：3.0uA typ 3.0uA typ（VDD=3.9V）
- High voltage withstand design is adopted for the terminal connecting the charger (CS terminal and OC terminal, absolute maximum rating is 20V)
- Allow variable 0V battery charge
- Wide operating temperature range：-40℃~+85℃
- Small SOT23-6 Package

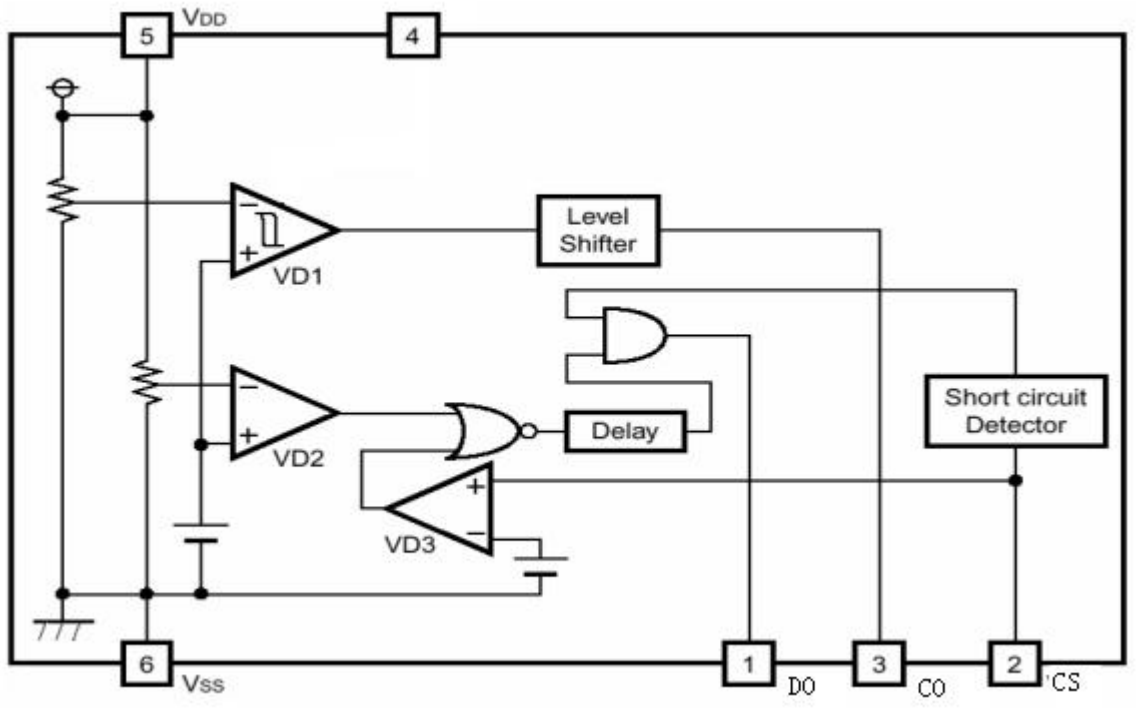
APPLICATIONS

- rechargeable one-cell Li-ion battery pack
- rechargeable one-cell Li-polymer battery pack

PIN GENERAL VIEW AND EXPLANATION

SOT23-6	ORDER	NAME	FUNCTION
	1	OD	**Discharge Control Output** Connect to the Gate of the external discharge controller N-MOSFET Q2.
	2	CS	**Discharge Current Sense Input** Connect this to the Source of external charge controller N-MOSFET Q1 by a resistance (normally 1kΩ), then the voltage drop on Q1 and Q2, which cause by the discharge current can be sensed.
	3	OC	**Charge Control Output** Connect to the Gate of the external charge controller N-MOSFET Q1.
	4	NC	**Not Connected**
	5	VDD	**Power Supply Input** Connect to the positive of power supply (battery normally), a 0.1μF ceramic capacitor is required for decoupling.
	6	VSS	**Ground** Connect to the negative of power supply.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

（VSS=0V，TA=25℃，unless otherwise specified）

项目	符号	规格	单位
Operating input voltage	V_{DD}	VSS-0.3~VSS+10	V
OC input voltage	V_{OC}	VDD-20~VDD+0.3	V
OD input voltage	V_{OD}	VSS-0.3~VSS+0.3	V
CS input voltage	V_{CS}	VDD-20~VDD+0.3	V
Operating temperature range	T_{OP}	-40~+85	℃
Storage temperature range	T_{ST}	-40~+125	℃
Power dissipation	P_D	250	mW

Electrical characteristics

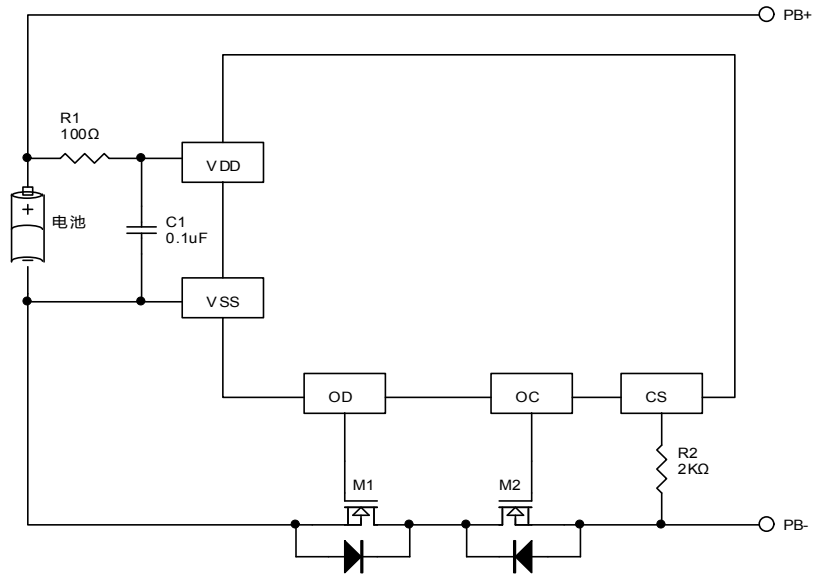
➢ Electrical parameters （VSS=0V，TA=25℃，unless otherwise specified,）

Item		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
input voltage							
V_{DD}-V_{SS} Operating input voltage		V_{DSOP1}	--	1.5	--	8	V
V_{DD}-CS Operating input voltage		V_{DSOP2}	--	1.5	--	20	V
Current consumption							
Operating Current		I_{DD}	V_{DD}=3.9V	--	3.0	6.0	uA
Standby Current		I_{OD}	V_{DD}=2.0V	--	--	0.1	uA
Detection voltage							
Overcharge Detection Voltage	FM2113A.	V_{CU}	--	4.350		4.375	V
	FM2113B.			4.375	4.400	4.425	
	FM2113C.			4.425		4.450	
	FM2113D.			4.325		4.350	
Overcharge Release Voltage		V_{CR}	--	4.150	4.200	4.250	V
Overdischarge Detection Voltage		V_{DL}	--	2.720	2.800	2.880	V
Overdischarge Release Voltage		V_{DR}	--	2.920	3.000	3.080	V
Overdischarge Current Detection Voltage		V_{DIP}	V_{DD}=3.6V	120	150	180	mV
Short protection voltage		V_{SIP}	V_{DD}=3.0V	0.7	1.0	1.3	V
Output voltage of control terminal							
OD output high voltage		V_{DH}	--	V_{DD}-0.1	V_{DD}-0.02	--	V
OD output low voltage		V_{DL}	--	--	0.1	0.5	V
OC output high voltage		V_{CH}	--	V_{DD}-0.1	V_{DD}-0.02	--	V
OC output low voltage		V_{CL}	--	--	0.1	0.5	V
charging 0V battery							
0V charge allow threshold		V_{0CH}	Charger Voltage	1.2	--	--	V

➢ Delay Time

Item	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Overcharge Voltage Detection Delay Time	T_{OC}	V_{DD}=3.9V→4.5V	70	100	150	ms
Overdischarge Voltage Detection Delay Time	T_{OD}	V_{DD}=3.6V→2.0V	70	100	150	ms
Overdischarge Current Detection Delay Time	T_{DIP}	V_{DD}=3.6V，CS=0.4V	5	10	15	ms
Overcharge Current Detection Delay Time	T_{CIP}	V_{DD}=3.6V，CS=-0.2V	4	7	11	ms
Short protection delay time	T_{SIP}	V_{DD}=3.0V，CS=0.3V	200	300	400	us

Application Circuits



Symbol	Device name	MIN.	TYP.	MAX.	
R1	resistance	100Ω	100Ω	200Ω	*1
R2	resistance	1KΩ	2KΩ	2KΩ	*2
C1	capacitance	0.01uF	0.1uF	1.0uF	*3
M1	N-MOSFET	--	--	--	*4
M2	N-MOSFET	--	--	--	*5

remarks ： *1、If the resistance of R1 is too large, the voltage drop will be produced on R1 due to the current consumption, which will affect the detection voltage accuracy. When the charger is reversely connected, the current flows from the charger to the IC. If R1 is too large, the voltage between vdd-vss terminals may exceed the absolute maximum rated value.

*2、R2 is connected with too large resistance, which may lead to the situation that the charging current cannot be cut off when the high voltage charger is connected. However, in order to control the current when the charger is reverse connected, please select a larger resistance value as far as possible.

*3、C1 can stabilize VDD voltage,Do not connect capacitors below 0.01 μ F.

*4、When the threshold voltage of MOSFET is above the over discharge detection voltage, the discharge may be stopped before the over discharge protection.

*5、When the withstand voltage between gate and source is below the charger voltage, n-MOSFET may be damaged.

FUNCTIONAL DESCRIPTION

➢ Normal Condition

Under normal conditions, FM2113 is powered by battery, its VDD terminal voltage is between the overvoltage charging protection threshold VCU and the overvoltage discharge protection threshold VDL, and the CS terminal voltage is between the charger detection voltage and the over-current discharge protection threshold , and the N-MOS transistor is on. At this time, the battery can be charged by charger or discharged by load.

Note: when the cell is connected for the first time, it may not discharge. At this time, short circuit the CS terminal and VSS terminal, or connect the charger, the normal working state can be restored.

➢ Over-Charge Detector

The VD1 monitors VDD pin voltage. When the VDD voltage crosses over charge detector threshold VCU from a low value to a value higher than the VCU, the VD1 can sense a over-charging and an external charge control Nch-MOS-FET turns to “OFF” with CO pin being at “L” level.

There can be two cases to reset the VD1 making the CO pin level to “H” again after detecting over-charge:

When the charger is not connected,

（1）The first case is in such conditions that a time when the VDD voltage is coming down to a level lower than V_{CR}.

（2）in the second case, connecting a kind of loading to VDD after disconnecting a charger from the battery pack can make the VD1 resetting when the VDD level is in between VCU and V_{CR}..After detecting over-charge with the VDD voltage of higher than VCU, connecting system load to the battery pack makes load current allowable through parasitic diode of external charge control FET. The CO level would be high when the VDD level is coming down to a level below the VCU by continuous drawing of load current.

Note: if the battery entering the overcharge state is still connected to the charger, even if the battery voltage is lower than the overcharge release voltage (VCR), the overcharged state cannot be released. When the charger is disconnected, the over charging state can be released only when the CS terminal voltage rises above the charging over current detection voltage (VCIP).

➢ **Over-Discharge Detector**

When the battery voltage drops below VDL and the duration of this state exceeds the over discharge detection delay time (TOD), FM2113 will close the MOSFET (OD terminal) for discharge control and stop discharging. This state is called "over discharge state".

There are three ways to release the over discharge state

(1) Connect the charger. If the CS terminal voltage is lower than the charge over current detection voltage (VCIP), when the battery voltage is higher than the over discharge detection voltage (VDL), the over discharge state will be released and return to the normal working state.

(2) Connect the charger. If the CS terminal voltage is higher than the charge over current detection voltage (VCIP), when the battery voltage is higher than the over discharge release voltage (VDR), the over discharge state will be released and return to the normal working state.

(3) When the charger is not connected, if the battery voltage recovers to higher than the over discharge release voltage (VDR), the over discharge state will be released and return to the normal working state, i.e. "there is over discharge self recovery function".

➢ Excess Current Detector, Short Circuit Protector

Under normal working condition, FM2113 continuously detects the discharge current by detecting the CS terminal voltage. Once the CS terminal voltage exceeds the discharge over-current detection voltage (vdip) and the duration of this state exceeds the discharge over-current detection delay time (TDIP), the MOSFET (OD terminal) for discharge control is closed and the discharge is stopped. This state is called "discharge over-current state".

Once the CS terminal voltage exceeds the load short-circuit detection voltage (VSIP) and the duration of this state exceeds the load short-circuit detection delay time (TSIP), the MOSFET (OD terminal) for discharge control is also closed and the discharge is stopped. This state is called "load short circuit state".

When the impedance between the positive electrode (Pb +) and the negative electrode (Pb -) is greater than the discharge over-current / load short-circuit release impedance (the typical value is about 300K Ω), the discharge over-current state and load short-circuit state are released and return to normal working state. In addition, even if the impedance between the battery positive pole (Pb +) and the battery negative pole (Pb -) is less than the discharge over-current / load short-circuit release impedance, when the charger is connected and the CS terminal voltage is reduced below the discharge over-current protection voltage (vdip), the discharge over-current state or load short-circuit state will be released and return to the normal working state.

note:

(1) If the charger is connected reversely, the current direction in the circuit is consistent with the current direction when discharging. If the voltage of CS terminal is higher than the discharge over-current detection voltage (vdip), the discharge over-current protection state can be entered to cut off the current in the circuit to play the role of protection.

- **Overcharge current condition**

If the CS pin voltage drops below the charger detection voltage during charging under the normal condition and it continues for the overcharge detection delay time or longer, the FM2113 turns the charging control FET off and stops charging. This action is called OverCharge Current condition.
OverCharge detection works when the discharging control FET is on and the CS pin voltage drops below the charger detection voltage . When an abnormal charge current flows into a battery in the over-discharge condition, the FM2113 consequently turns the charging control FET off and stops charging after the battery voltage becomes the over-discharge detection voltage and the overcharge detection delay time (TCIP)elapses.

Overcharge current condition is released when the voltage difference between CS pin and GND pin becomes lower than the charger detection voltage by separating the charger.

- **Allow oV Battery Charging Function**

This function is used to recharge the battery which has been self discharged to 0V. When the charger voltage between the battery positive pole (Pb +) and the battery negative pole (Pb -) is higher than the "charger starting voltage (v0ch)" for charging 0V battery, the gate of MOSFET for charging control is fixed as the potential of VDD terminal. Because the voltage difference between gate and source of MOSFET is higher than its on voltage, MOSFET for charge control is on (OC terminal), Start charging. At this time, the discharge control MOSFET is still off, and the charging current flows through its internal parasitic diode. When the battery voltage is higher than the over discharge detection voltage (VDL), FM2113 enters into normal working state.

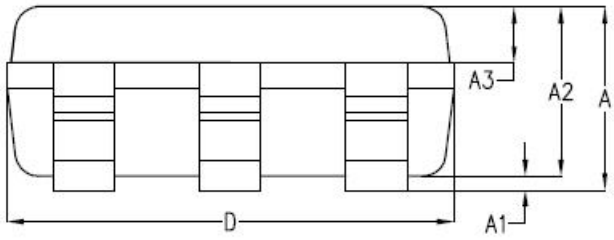
note：

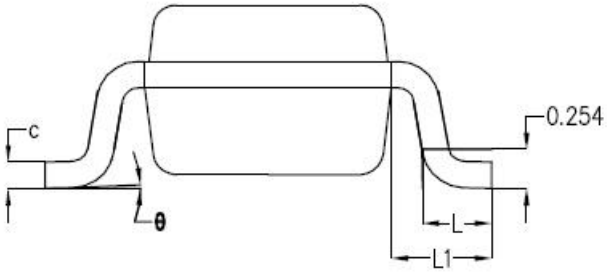
1. Some completely self discharging batteries are not allowed to be recharged, which is determined by the characteristics of lithium batteries. Please ask the battery supplier to confirm whether the purchased battery has the function of "allow charging 0V battery" or "prohibit charging 0V battery".

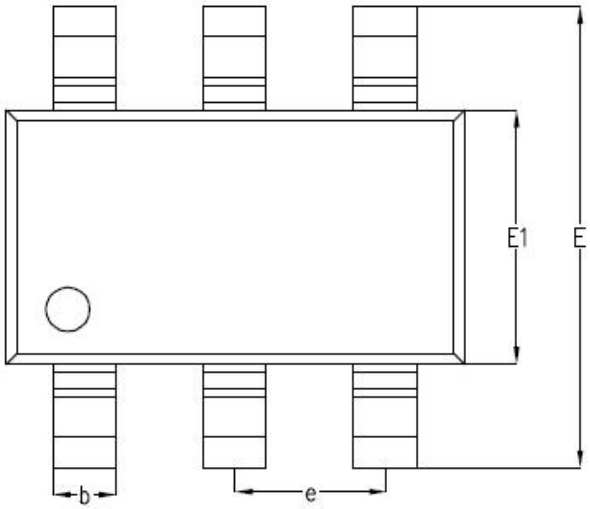
2. "Allow charging 0V battery" has higher priority than "charging over current detection function". So. IC with the function of "allow charging 0V battery" will be forced to charge when the battery voltage is low. When the battery voltage is lower than the over discharge detection voltage (VDL), the charging over-current state cannot be detected.

PACKAGE INFORMATION

SOT23-6







SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	-	1.19	1.24
A1	-	0.05	0.09
A2	1.05	1.10	1.15
A3	0.31	0.36	0.41
b	0.35	0.40	0.45
c	0.12	0.17	0.22
D	2.85	2.90	2.95
E	2.80	2.90	3.00
E1	1.55	1.60	1.65
e	0.95BSC		
L	0.37	0.45	0.53
L1	0.65BSC		
θ	0°	2°	8°