Protection IC for 5 Cells Li-ion Battery Pack

FEATURES

- High Accuracy Voltage Detection
  - Over-Voltage Protection
    - V_{OVP}: 3.6V~4.35V (50mV/step)
    - Accuracy: ±25mV
    - Hysteresis voltage: 0V or 0.1V to 0.3V in 50mV/step
  - Under-Voltage Protection
    - V_{UVP}: 2.0V~3.0V (100mV/step)
    - Accuracy: ±80mV
    - Hysteresis voltage: 0V to 1V in 100mV/step
- 3-Levels Over-Current Detection
  - Level-1 Over-Current Protection:
    - V_{OCP1}: 25mV~350mV (25mV/step)
    - Accuracy: ±10mV
  - Level-2 Over-Current Protection:
    - $V_{OCP2}=3*V_{OCP1}$
    - Accuracy: ±30mV
  - Short-Circuit Protection
    - $V_{SCP}=5*V_{OCP1}$
    - Accuracy: ±50mV
- OC/SC release conditions:
  - Charger-Connected ***OR***
  - Load-Opened
- Built-in Over-Temperature Protection
- Built-in Under-Temperature Protection
- Delay times are set by external capacitors
- Low-power Operating States:
  - Normal State: < 30uA
  - Standby State: < 3uA
  - Power-down State: < 1uA
  - Hardware Shut-down State: <0.1uA
- 16-Lead TSSOP Package

APPLICATIONS

- Power-Tools
- Notebook PC/Tablet PC
- UPS Backup Battery Systems

GENERAL DESCRIPTION

The HM8255 is a protection IC which includes high-accuracy voltage detector and current detector to provide Over-Voltage (OV), Under-Voltage (UV), Over-Current (OC), Short-Circuit (SC), Over-Temperature (OT), Under-Temperature (UT) protection for 5-series Li-ion/polymer battery pack used in power-tools, notebook PC applications etc.

The HM8255 provides a specific CTRL pin to control both charge and discharge FET. When CTRL is floating, the HM8255 will enter standby state to save power consumption. Under standby state, discharge FET is turned off while charge FET is turned on. When CTRL is tied to VCC pin, the HM8255 works in normal state, however, both charge and discharge FET are turned off. When CTRL is tied to VSS pin, the HM8255 works in normal state, the state of charge and discharge FET are decided according to safety events.

The HM8255 integrates FET driver. The HM8255 can drive the N-type charge FET and N-type discharge FET at the PACK- side directly.

The HM8255 consumes less than 30uA in normal state from VCC, and it reduces to less than 3uA in standby state and less than 1uA in power-down state. Furthermore, the HM8255 can be powered from a switched supply, providing a technique to reduce battery stack current draw to zero. This device is packaged in a 16-pin TSSOP package.

PRODUCT ORDING INFORMATION

■ Product Name

HM8255 X

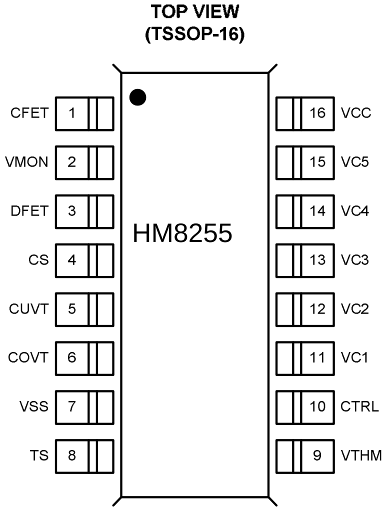
Additional number
Sequentially set from A to Z

■ Product Name List

Product Name	OV Protection Voltage V_{OVP}	OV Release Voltage V_{OVR}	UV Protection Voltage V_{UVP}	UV Release Voltage V_{UVR}	Level-1 DOC Protection Voltage V_{DOCP1}
HM8255A	4.25 ±0.025V	4.15 ±0.025V	2.7 ±0.08V	3.0 ±0.08V	0.1 ±0.01V
HM8255B	4.20 ±0.025V	4.10 ±0.025V	2.5 ±0.08V	3.0 ±0.08V	0.1 ±0.01V
HM8255C	4.20 ±0.025V	4.20 ±0.025V	2.5 ±0.08V	2.9 ±0.08V	0.1 ±0.01V
HM8255D	3.75 ±0.025V	3.55 ±0.025V	2.2 ±0.08V	2.7 ±0.08V	0.1 ±0.01V
HM8255E	3.85 ±0.025V	3.55 ±0.025V	2.2 ±0.08V	2.7 ±0.08V	0.1 ±0.01V
HM8255F	3.65 ±0.025V	3.65 ±0.025V	2.2 ±0.08V	2.7 ±0.08V	0.1 ±0.01V

Note: if a product with the required detection voltage does not appear in the above list, contact our sales office.

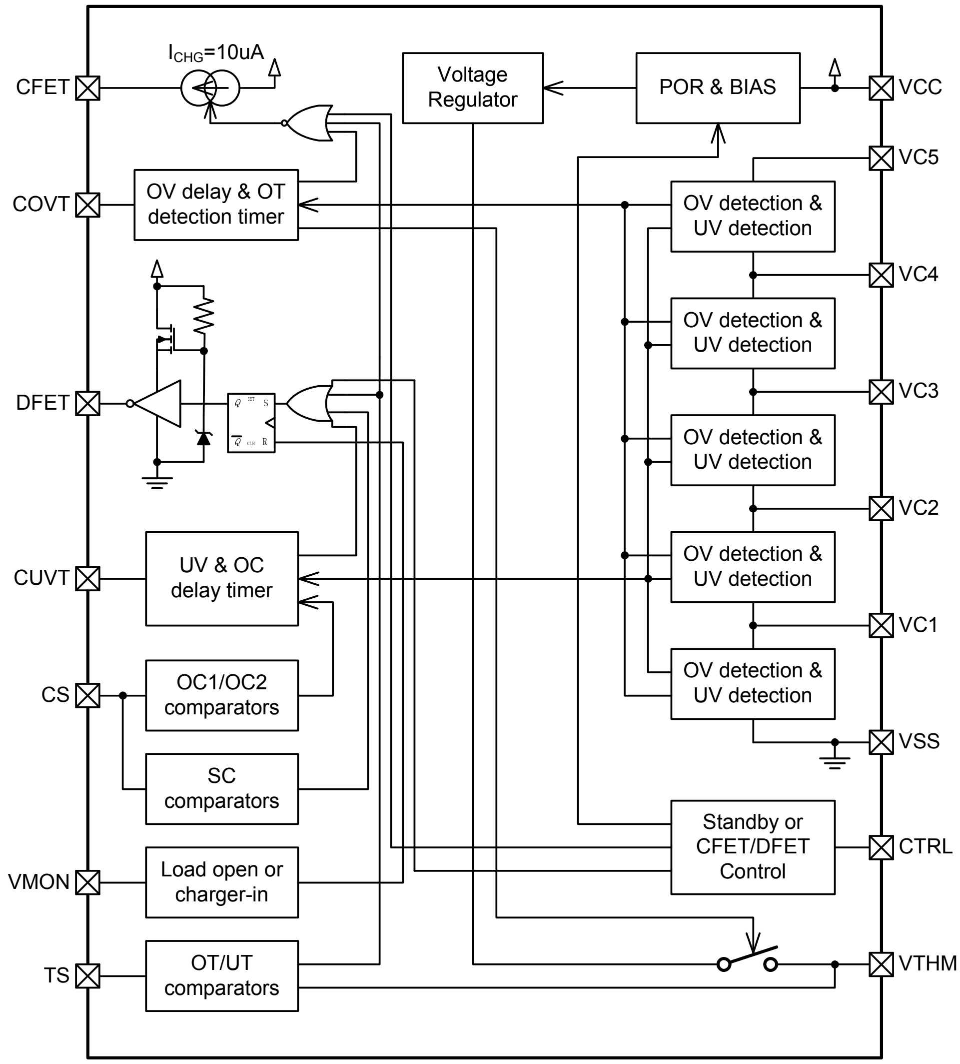
PIN CONFIGURATION



PIN DESCRIPTION

PIN	NAME	PIN DESCRIPTION
1	CFET	Charge power FET control pin
2	VMON	Voltage Monitor input pin to detect if the load is opened after over-current (OC) or short-circuit (SC) occurs
3	DFET	Discharge power FET control pin
4	CS	Connection pin for current sensing resistor
5	CUVT	Capacitor connection pin for under-voltage detection timer
6	COVT	Capacitor connection pin for over-voltage detection timer
7	VSS	Ground pin
8	TS	Connection pin for thermistor
9	VTHM	External Thermistor bias output pin. This is a switched connection for supplying a bias voltage from the internal voltage regulator to an external resistor network composed of resistor and an external NTC resistor for measuring the temperature of the battery module.
10	CTRL	Control of charge FET and discharge FET or switch between normal state and standby state
11	VC1	Connection for positive voltage of cell 1
12	VC2	Connection for positive voltage of cell 2
13	VC3	Connection for positive voltage of cell 3
14	VC4	Connection for positive voltage of cell 4
15	VC5	Connection for positive voltage of cell 5
16	VCC	Power supply pin. Connection for positive voltage of cell 5.

BLOCK DIAGRAM



TYPICAL APPLICATION DIAGRAM

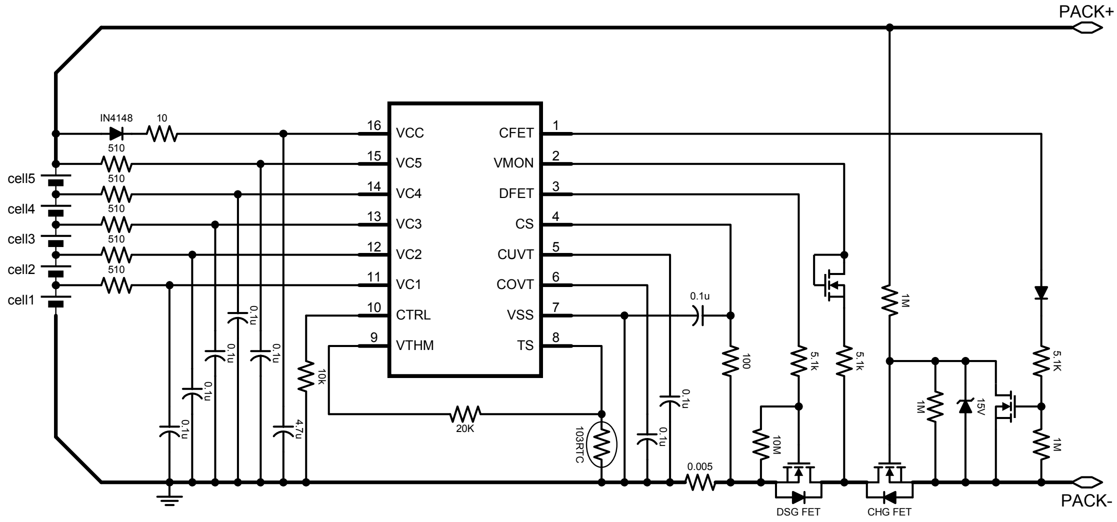


Figure 1, Typical Application Diagram for 5-series cell with N-type Charge-FET & Discharge-FET

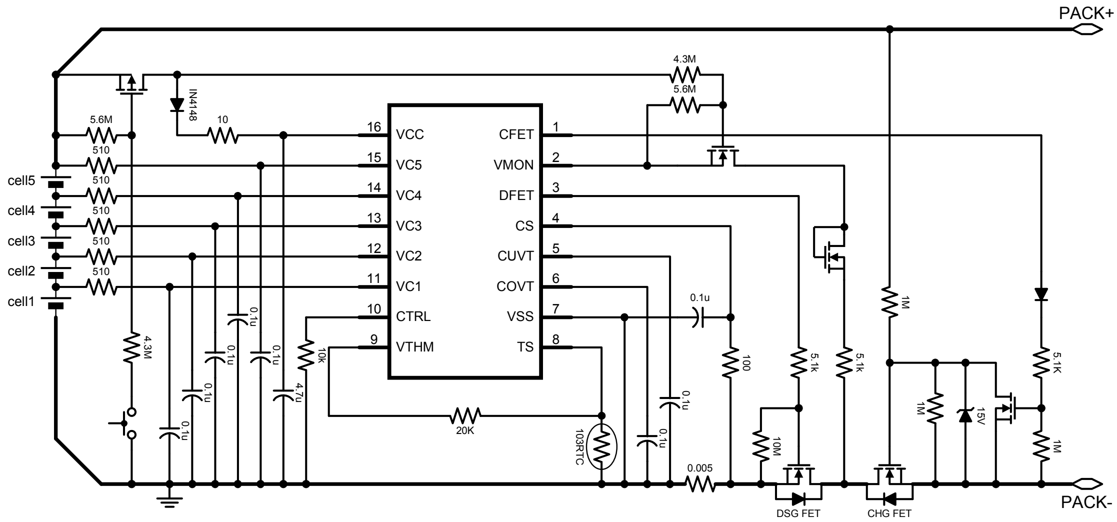


Figure 2, Typical Application Diagram for 5-series cell with hardware shutdown control function

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted)

PARAMETER	SYMBOL	APPLICABLE PIN	RATING
Input Voltage between VCC and VSS	V_{CC}	VCC	V_{SS}−0.3V to V_{SS}+35V
Low-voltage Input pin Voltage	V_{IN_LV}	CS, CUVT, COVT, TS, VTHM	V_{SS}−0.3V to V_{SS} +5.5V
High-voltage Input pin Voltage	V_{IN_HV}	CTRL, SEL	V_{SS}−0.3V to V_{SS}+35V
VMON pin Input Voltage	V_{VMON}	VMON	V_{SS}−5.5V to V_{CC}+0.3V
Cell voltage input voltage: VC(n) to VC(n-1), n=2 to 5; VC1 to VSS	V_{CELL}	VC5, VC4, VC3, VC2, VC1	−0.3V to +7.0V
CFET pin output voltage	V_{CFET}	CFET	V_{CC}−35V to V_{CC}+0.3V
DFET pin output voltage	V_{DFET}	DFET	−0.3V to +15V
HBM ESD rating			±2kV
Operating free-air temperature range	T_A		−40°C to +85°C
Storage temperature range	T_{STG}		−40°C to +125°C
Package thermal resistance (TSSOP16)	θ_{JA}		48.7°C/W

ELECTRICAL CHARACTERISTICS

T_A = +25°C, unless otherwise specified

Parameter	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Over-Voltage (OV) and Under-Voltage (UV) Protection						
Over-Voltage Protection Threshold	V_{OVP}	3.6V to 4.35V in 50mV/step	V_{OVP} −25	V_{OVP}	V_{OVP} +25	mV
Over-Voltage Release Hysteresis Voltage	V_{OVP_HYS}		0V or 0.1 to 0.3V in 50mV/step			mV
Over-Voltage Release Threshold	V_{OVR}	$V_{OVR} = V_{OVP} - V_{OVP\_HYS}$	V_{OVR} −25	V_{OVR}	V_{OVR} +25	mV
Under-Voltage Protection Threshold	V_{UVP}	2.0V to 3.0V in 100mV/step	V_{UVP} −80	V_{UVP}	V_{UVP} +80	mV
Under-Voltage Release Hysteresis Voltage	V_{UVP_HYS}		0 to 1.0V in 100mV/step			mV
Under-Voltage Release Threshold	V_{UVR}	$V_{UVR} = V_{UVP} + V_{UVP\_HYS}$	V_{OVR} −80	V_{OVR}	V_{OVR} +80	mV
Discharge Over-Current (DOC) and Short-Circuit (SC) Protection						
Level-1 Discharge Over-Current Protection Threshold	V_{DOCP1}	25mV to 350mV in 25mV/step	V_{DOCP1} −10	V_{DOCP1}	V_{DOCP1} +10	mV
Level-2 Discharge Over-Current Protection Threshold	V_{DOCP2}	$V_{DOCP2}=3*V_{DOCP1}$	V_{DOCP2} −30	V_{DOCP2}	V_{DOCP2} +30	mV
Short-Circuit Protection Threshold	V_{SCP}	$V_{SCP}=5*V_{DOCP1}$	V_{SCP} −50	V_{SCP}	V_{SCP} +50	mV
Discharge Over-Temperature (DOT) and Charge Over-Temperature (COT) Protection						
Discharge Over-Temperature Protection Threshold	T_{DOTP}		T_{DOTP} −5	T_{DOTP}	T_{DOTP} +5	°C
Discharge Over-Temperature Release Hysteresis	T_{DOTP_HYS}			15		°C
Discharge Over-Temperature Release Threshold	T_{DOTR}	$T_{DOTR} = T_{DOTP} - T_{DOTP\_HYS}$	T_{DOTP} −5	T_{DOTP}	T_{DOTP} +5	°C
Charge Over-Temperature Protection Threshold	T_{COTP}		T_{COTP} −5	T_{COTP}	T_{COTP} +5	°C
Charge Over-Temperature Release Hysteresis	T_{COTP_HYS}			5		°C
Charge Over-Temperature Release Threshold	T_{COTR}	$T_{COTR} = T_{COTP} - T_{COTP\_HYS}$	T_{COTP} −5	T_{COTP}	T_{COTP} +5	°C
Charge Under-Temperature Protection Threshold	T_{CUTP}		T_{CUTP} −5	T_{CUTP}	T_{CUTP} +5	°C
Charge Under-Temperature Release Hysteresis	T_{CUTP_HYS}			5		°C
Charge Under-Temperature Release Threshold	T_{CUTR}	$T_{CUTR} = T_{CUTP} + T_{CUTP\_HYS}$	T_{CUTR} −5	T_{CUTR}	T_{CUTR} +5	°C

ELECTRICAL CHARACTERISTICS (CONT.)

T_A = +25°C, unless otherwise specified

Parameter	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Discharge state detection voltage	V_{IN_DSG}	V_{CS}>V_{IN_DSG}, it is considered as discharge state; otherwise, it is considered as charge state.	2	4	6	mV
External Programmable Protection Delay and Release Delay Time						
Over-Voltage Protection Delay time	t_{OVP}	C_{COVT}=0.1uF	0.7	1.0	1.3	S
Under-Voltage Protection Delay time	t_{UVP}	C_{CUVT}=0.1uF	0.7	1.0	1.3	S
Under-Voltage Power-down Delay time	t_{UV_PD}	C_{CUVT}=0.1uF	3.5	5.5	7.5	S
Level-1 Discharge Over-Current Protection Delay time	t_{DOCP1}	C_{CUVT}=0.1uF	0.7	1.0	1.3	S
Level-2 Discharge Over-Current Protection Delay time	t_{DOCP2}	C_{CUVT}=0.1uF	0.07	0.1	0.13	S
Short-Circuit Protection Delay time	t_{SCP}	Internal fixed delay time, No RC filter in front of CS pin	100	250	500	μS
Temperature detection period time	t_{TDET}	C_{COVT}=0.1uF	0.5	1.0	1.5	S
POWER SUPPLY (VCC)						
Input voltage Range	V_{CC}		4.0		20	V
Supply Current	I_{VCC_NOR}	Normal state, V_{CELL}=3.5V		20	30	μA
	I_{VCC_STDBY}	Standby state, V_{CELL}=3.5V CTRL pin is floating		2.0	3.0	μA
	I_{VCC_PD}	Power-down state, V_{CELL}=1.8V CTRL pin is tied to VSS pin		0.6	1.0	μA
Power-On-Reset Voltage	V_{POR}			4.8	6.0	V
Voltage regulator for discharge driver	V_{VREGH}	V_{CC}>V_{VREGH}+1V	9.0	10.5	12	V
		V_{CC}<V_{VREGH}+1V	V_{CC} −1.5	V_{CC} −1	V_{CC} −0.5	V
CELL INPUTS (VC5, VC4, VC3, VC2, VC1)						
VC5 sink current in normal state	I_{VC5}	V_{CELL}=3.5V		10.0	12.0	μA
VC(n) sink current in normal state, n=1 to 3	I_{VCX}	V_{CELL}=3.5V	−0.3		+0.3	μA
INPUT VOLTAGE (CTRL)						
CTRL input voltage, High	V_{CTRLH}		V_{CC} −2.5			V
CTRL input voltage, Low	V_{CTRLL}				1.5	V
DRIVER CIRCUIT (CFET, DFET)						
CFET pin sink current	I_{CFET}	V_{CELL}=3.5V, V_{CFET}=V_{CC}–1V		Hi-Z		μA
		V_{CELL}=V_{OVP}+0.2V, V_{CFET}=V_{CC}–1V	7.0	10.0	13.0	μA
DFET pin output voltage	V_{DFETH}	V_{CELL}=3.5V, V_{CS}=0V		= V_{VREGH}		V
	V_{DFETL}	V_{CELL}=3.5V, V_{CS}>=V_{DOCP1}			0.4	V

FUNCTIONAL DESCRIPTION

Normal Status

When all of the battery voltages are in the range from V_{OVP} and V_{UVP}, the discharge current is lower than the specified value (the CS pin voltage is lower than V_{DOCP1}), the charge temperature is lower than T_{COTP}, and the discharge temperature is lower than T_{DOTP}, the HM8255 works in normal status, the charging and discharging FETs are turned on.

Over-Voltage (OV) Status

When any one of the battery voltages becomes higher than V_{OVP} and the state continues for t_{OVP} or longer, the CFET pin becomes to sink 10uA current. Refer to figure 1, the source side and gate side of charging FET is shorted together, thus the charging FET is turned off to stop charging. This is called the over-voltage status. In over-voltage status, if a load is connected and the CS pin voltage is higher than discharging detection voltage V_{IN_DSG}, the HM8255 will turn on charging FET immediately to avoid the over-heat of charging FET due to its body diode conduction. Before the over-voltage status is released, if the load is removed, the charging FET will be turned off again. The over-voltage status is released only when all battery voltages become V_{OVR} or lower.

Under-Voltage (UV) Status

When any one of the battery voltages becomes lower than V_{UVP} and the state continues for t_{UVP} or longer, the DFET pin voltage becomes V_{SS} level, and the discharging FET is turned off to stop discharging. This is called the under-voltage status. The under-voltage status is released when both of the following two conditions hold:

- **a)** All battery voltages become V_{UVR} and higher
- **b)** The VMON pin voltage is lower than 1.0V (Load is removed or charger is connected)

Power-Down (PD) Status

Over-voltage status takes precedence over under-voltage status. In under-voltage status, if no over-voltage status exists and when the state continues for t_{UV_PD} or longer, the HM8255 enters the power-down status. In under-voltage status, if over-voltage status exists, the HM8815 will not enter power-down status. In power-down status, the VMON pin voltage is pulled up to V_{CC} level by the internal pull-up resistor. In power-down status, almost all the circuits of the HM8255 stop and the current consumption is I_{VCC_PD} or lower. The conditions of each output pin are listed as following:

- **a)** CFET pin: Hi-Z
- **b)** DFET pin: V_{SS}

The power-down status is released when the following condition holds:

- **a)** The VMON pin voltage is V_{CC}−3V or lower (A charger is connected)

Over-Current (OC) Status

The HM8255 has three over-current detection levels (V_{DOCP1}, V_{DOCP2} and V_{SCP}) and three over-current detection delay times (t_{DOCP1}, t_{DOCP2}, and t_{SCP}) corresponding to each over-current detection level. When the discharging current becomes higher than the specified value (the voltage on CS pin is greater than V_{DOCP1}) and the state continues for t_{DOCP1} or longer, the HM8255 enters over-current status, in which the DFET pin voltage becomes V_{SS} level to turn off the discharging FET to stop discharging. Operation of over-current detection level-2 (v_{DOCP2}) and over-current detection delay time 2 (t_{DOCP2}) is the same as for V_{DOCP1} and t_{DOCP1}.

In over-current status, discharging FET is turned off, thus the VMON pin is pulled up to V_{CC} level by the load. The over-current status is released when one of the following conditions hold:

- **a)** The VMON pin voltage is lower than 1.0V (a charger is connected or the load is removed)

Over-Temperature (OT) or Under-Temperature Status

When the CS pin voltage is bigger than V_{IN_DSG}, the battery pack is regarded as in discharging status. Otherwise, the battery pack is regarded as in charging status.

In normal status, the HM8255 will do the temperature detection every t_{TDET}, see figure 3 for temperature detection timing chart.

When the battery pack temperature becomes higher than T_{DOTP} in discharging status and the state continues for 4xt_{TDET} or longer, the DFET pin voltage becomes V_{SS} level and the CFET pin becomes to sink 10uA current, both the charging and discharging FETs are turned off to stop charging and discharging. This is called the discharging over-temperature status. The discharging over-temperature status is released when both of the following two conditions hold:

a) The battery pack temperature becomes T_{DOTR} or lower.

b) The VMON pin voltage is lower than 1.0V (Load is removed or charger is connected)

When the battery pack temperature becomes higher than T_{COTP} in charging status and the state continues for $4xt_{TDET}$ or longer, the CFET pin becomes to sink 10uA current, the charging FET is turned off to stop charging. This is called the charging over-temperature status. In charging over-temperature status, if a load is connected and the CS pin voltage is higher than discharging detection voltage V_{IN_DSG}, the HM8255 will turn on charging FET immediately to avoid the over-heat of charging FET due to its body diode conduction. Before the charging over-temperature status is released, if the load is removed, the charging FET will be turned off again. The charging over-temperature status is released only when the battery pack temperature becomes T_{COTR} or lower.

When the battery pack temperature becomes lower than T_{CUTP} in charging status and the state continues for $4xt_{TDET}$ or longer, the CFET pin becomes to sink 10uA current, the charging FET is turned off to stop charging. This is called the charging under-temperature status. In charging under-temperature status, if a load is connected and the CS pin voltage is higher than discharging detection voltage V_{IN_DSG}, the HM8255 will turn on charging FET immediately to avoid the over-heat of charging FET due to its body diode conduction. Before the charging under-temperature status is released, if the load is removed, the charging FET will be turned off again. The charging under-temperature status is released only when the battery pack temperature becomes T_{CUTR} or higher.

An example of external temperature-sensing circuit is shown in figure 4. In normal status, the HM8254 continuously turns on VTHM output for 500uS every t_{TDET}. In this way, the external temperature is monitored. When the VTHM output turns on, the HM8255 compares the external temperature voltage with two internal voltage dividers that are set to 1/10*VTHM (discharging state) or 2/11.5*VTHM (charging state). When the thermistor voltage is lower than 1/10*VTHM (discharging state) or 2/11.5*VTHM (charging state), the discharging over-temperature or charging over-temperature condition exists. When the thermistor voltage is bigger than 11/19*VTHM, the charging under-temperature condition exists. To set the external over-temperature limit, set the value of R_1 resistor to the 9 times the resistance of the thermistor at the discharging over-temperature threshold. For example, for 103-type NTC thermistor, set the R_1 to be 20k will set the DOT, COT and CUT thresholds to be 70°C, 50°C and 0°C. Set the R_1 to be 24k will set the DOT, COT and CUT thresholds to be 65°C, 45°C and −3°C.

Using a 10k resistor in place of thermistor will cause COT, DOT and CUT never occurs. Parallel the thermistor with two diodes (e.g. 1N4148) will cause CUT never occurs as shows in figure 4.

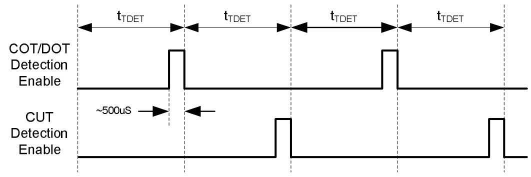


Figure 3, temperature detection timing

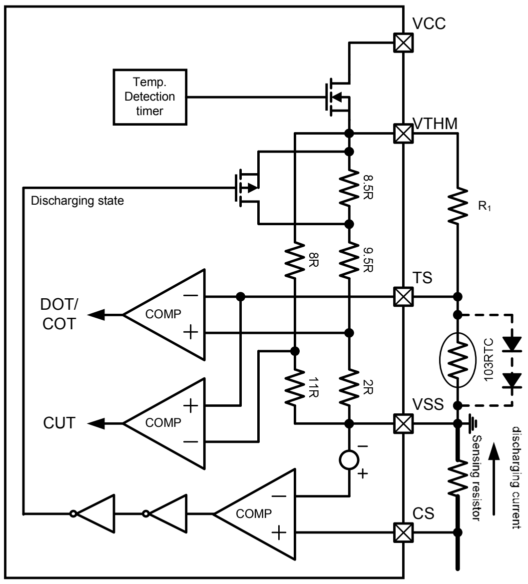


Figure 4, external temperature-sensing circuit

0V Battery Charge Function

The HM8255 provides 0V battery charge function.

Delay time setting

The over-voltage protection delay time (t_{OVP}), temperature detection period time (t_{TDET}) are determined by the external capacitor connected to COVT pin. The under-voltage protection delay time (t_{UVP}), the under-voltage power-down delay time (t_{UV_PD}) and level-1/2 over-current protection delay time (t_{DOCP1} and t_{DOCP2}) are determined by the external capacitor connected to CUVT pin. Short-Circuit detection delay time (t_{SCP}) is fixed internally to be 250uS (typical).

Min. Typ. Max.
t_{OVP} [s] = (7.00, 10.0, 13.0) x C_{COVT} [uF]
t_{TDET} [s] = (5.00, 10.0, 15.0) x C_{COVT} [uF]
t_{UVP} [s] = (7.00, 10.0, 13.0) x C_{CUVT} [uF]
t_{UV_PD} [s] = (35.0, 55.0, 75.0) x C_{CUVT} [uF]
t_{DOCP1} [s] = (7.00, 10.0, 13.0) x C_{CUVT} [uF]
t_{DOCP2} [s] = (0.70, 1.00, 1.30) x C_{CUVT} [uF]

CTRL pin

The HM8255 has control pin. The CTRL pin is used to control the CFET and DFET pin output voltages. The CTRL pin takes precedence over the battery protection circuit. When the CTRL pin is high level, both the charging and discharging FETs are turned off. When CTRL pin is low level, the charging and discharging FETs are controlled by the voltage detector. When CTRL pin is floating, the HM8255 enters standby status. In standby status, almost all the circuits of the HM8255 stop and the current consumption is I_{VCC_STDBY} or lower. This feature provides the possibility for the battery pack to save power even if the battery pack is at full capacity, thus long storage time is available. Under standby status, discharging FET is turned off, however, when a charger is connected, the charging FET will be turned on, thus make sure that the charger is not connected under standby status.

Table 1, conditions set by CTRL pin

CTRL pin	CFET pin	DFET pin
High	Source 10uA	V_{SS}
Open	Hi-Z	V_{SS}
Low	Normal status*1	

Normal status*1

*1. The status is controlled by the voltage detector

Hardware Shutdown

To completely shut down the HM8255, a PMOS switch can be connected to VCC, or VCC can be driven from an isolated power supply. Figure 5 shows an example of a switched VCC. If the switch is open, no current will flow through the 4.3M and 5.6M resistor, TP0610K will be completely shut off to reduce total supply current of HM8255 to less than 1nA. If the switch is on, TP0610K will be turned on.

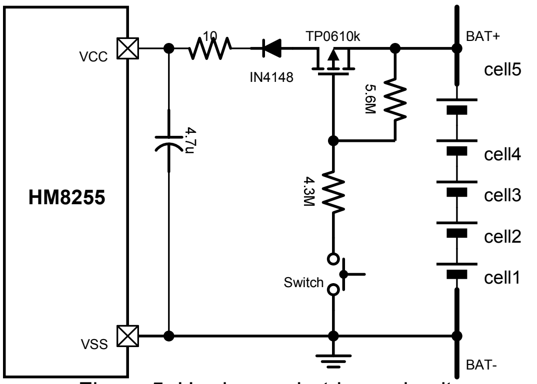
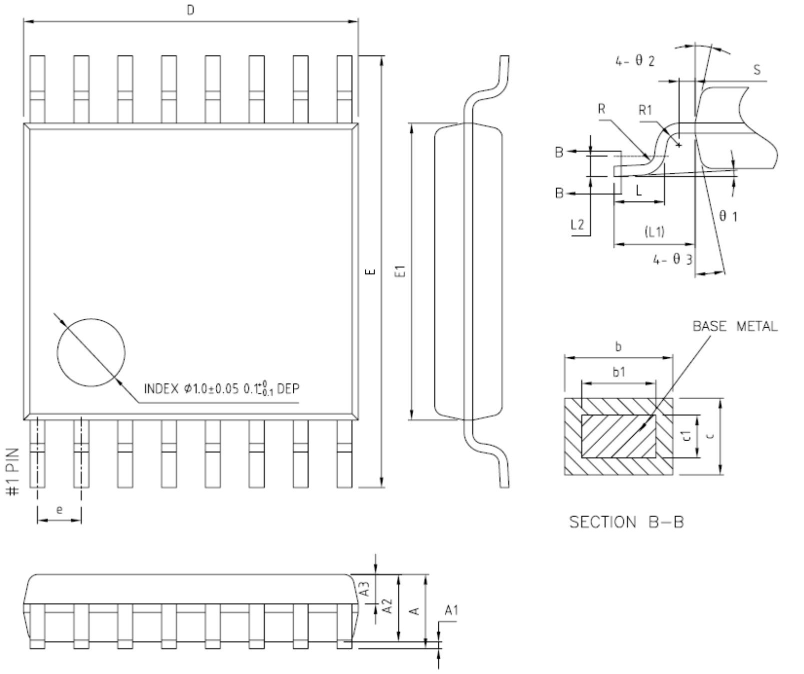


Figure 5, Hardware shutdown circuit

PACKAGE INFORMATION

16-Lead TSSOP Package Outline Diagram



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.20
A1	0.05	–	0.15
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	–	0.28
b1	0.20	0.22	0.24
c	0.10	–	0.19
c1	0.10	0.13	0.15
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00REF		
L2	0.25BSC		
R	0.09	–	–
R1	0.09	–	–
S	0.20	–	–
θ1	0°	–	8°
θ2	10°	12°	14°
θ3	10°	12°	14°