1. General Description

The WP8713 is a protection IC which includes high-accuracy voltage detector and current detector to provide Overcharge, Over-Discharge, Discharge-Overcurrent, Short-Circuit, Charge-Overcurrent, Over-Temperature, Under-Temperature protection for 4-series to 7-series Li-ion and Li-polymer battery pack.

WP8713 integrates FET driver. The WP8713 can drive the N-type charge FET and discharge FET directly.

The WP8713 consumes less than 32uA in normal state, and it reduces to less than 3uA in Power-down state. This device is packaged in a 24-Lead TSSOP package.

2. Features

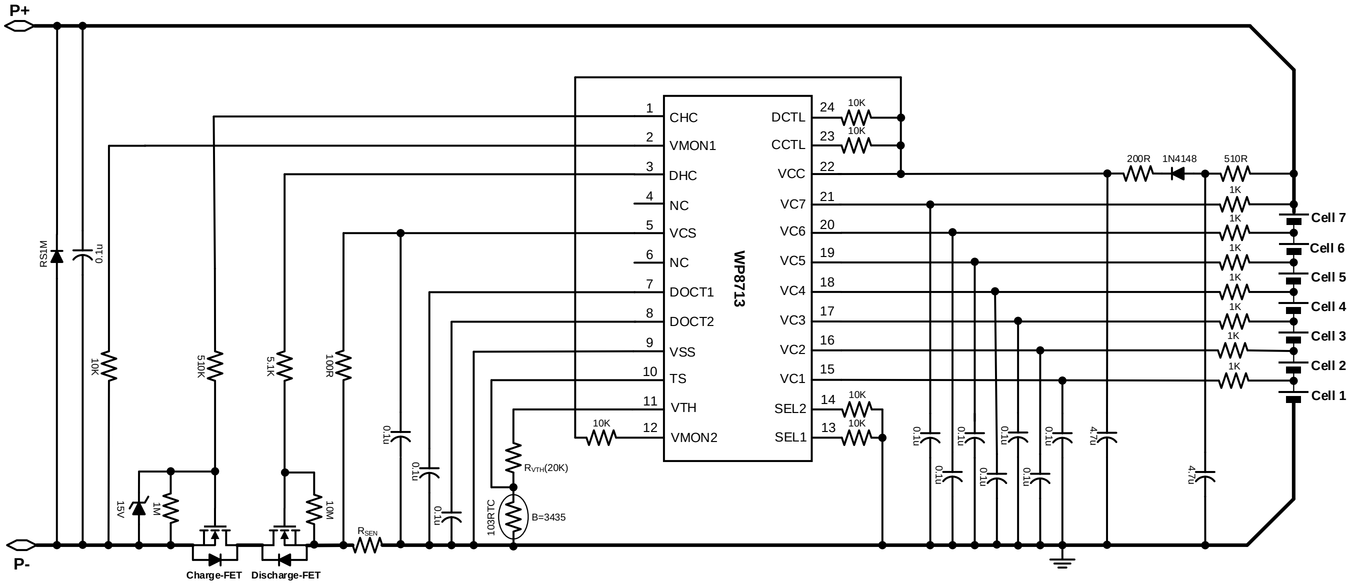
- High Accuracy Voltage Detection:
  - Overcharge Detection Voltage: 3.60V to 4.45V(50mV Step) Accuracy: ±25mV (T_A = +25°C)
  - Overcharge Hysteresis Voltage: 0.1V,0.15V,0.2V
  - Over-Discharge Detection Voltage: 2.0V to 3.0V(0.1V Step) Accuracy: ±50mV (T_A = +25°C)
  - Over-Discharge Hysteresis Voltage: 0.1V,0.2V,0.3V,0.5V
- Charge Overcurrent Detection:
  Charge Overcurrent Detection Voltage:
  - -10mV to -50mV(10mV Step) Accuracy：±5mV (T_A = +25℃)
  - -100mV to -250mV (50mV Step) Accuracy：±10mV (T_A = +25℃)
- Charge Overcurrent release conditions：Charger remove
- 3-Levels Discharge-Overcurrent Detection:
  - Level 1 Discharge-Overcurrent Detection Voltage: 50mV to 200mV (50mV Step) Accuracy：±10% (T_A = +25°C)
  - Level 2 Discharge-Overcurrent Detection Voltage: 100mV,200mV,250mV,300mV Accuracy：±10% (T_A = +25°C)
  - Short-Circuit Detection Voltage: 200mV,400mV,500mV,800mV Accuracy：±20% (T_A = +25°C)
- Overcharge, Over-Discharge, Discharge-Overcurrent, Charge-Overcurrent Delay times are set by external capacitors
- Discharge-Overcurrent and Short-Circuit release conditions：Charger connected or load opened.
- Built-in battery pack breaking line protection.
- Built-in Charging and Discharging Over-Temperature Protection.
- Built-in Charging and Discharging Under-Temperature Protection.
- Use SEL1 and SEL2 pins to choose 4, 5, 6 or 7 series battery pack
- Low-power Operating State:
  - Normal State: < 32uA
  - Power-down State: < 3uA
- 24-Lead TSSOP Package.

3. Applications

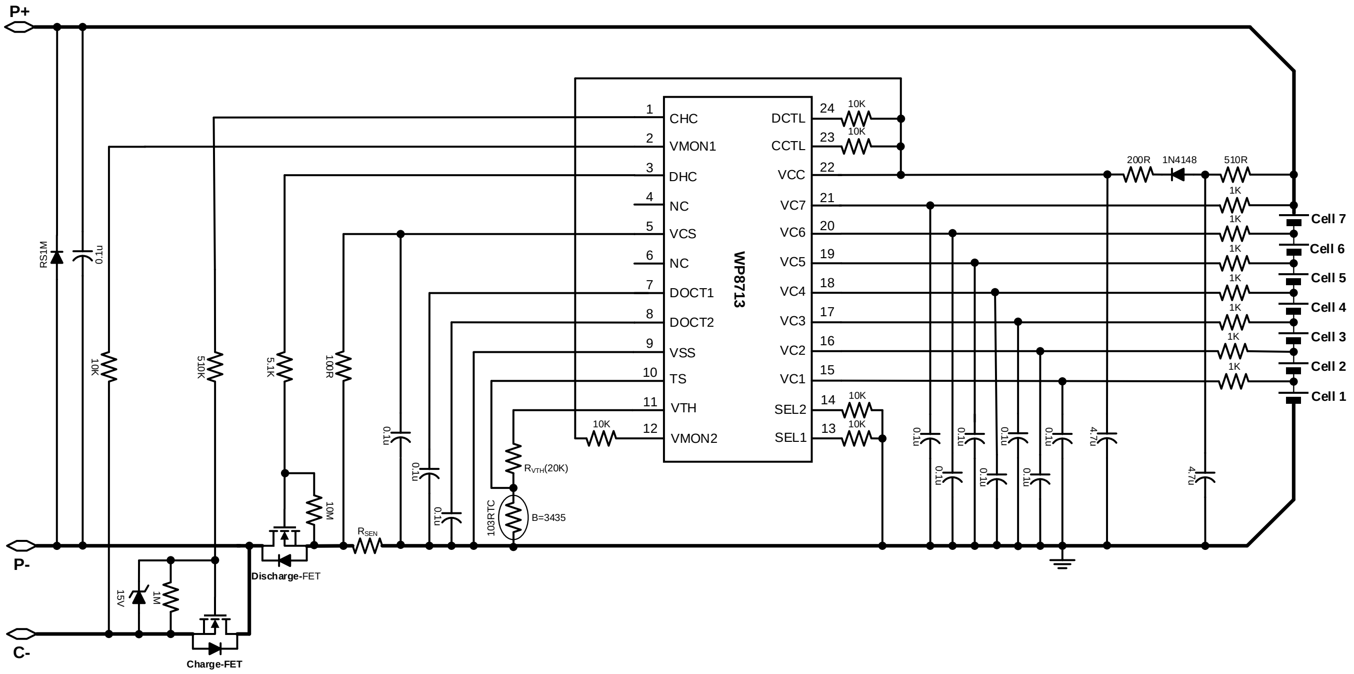
- Vacuum cleaner
- Mower
- Massage machine

4. Typical Application

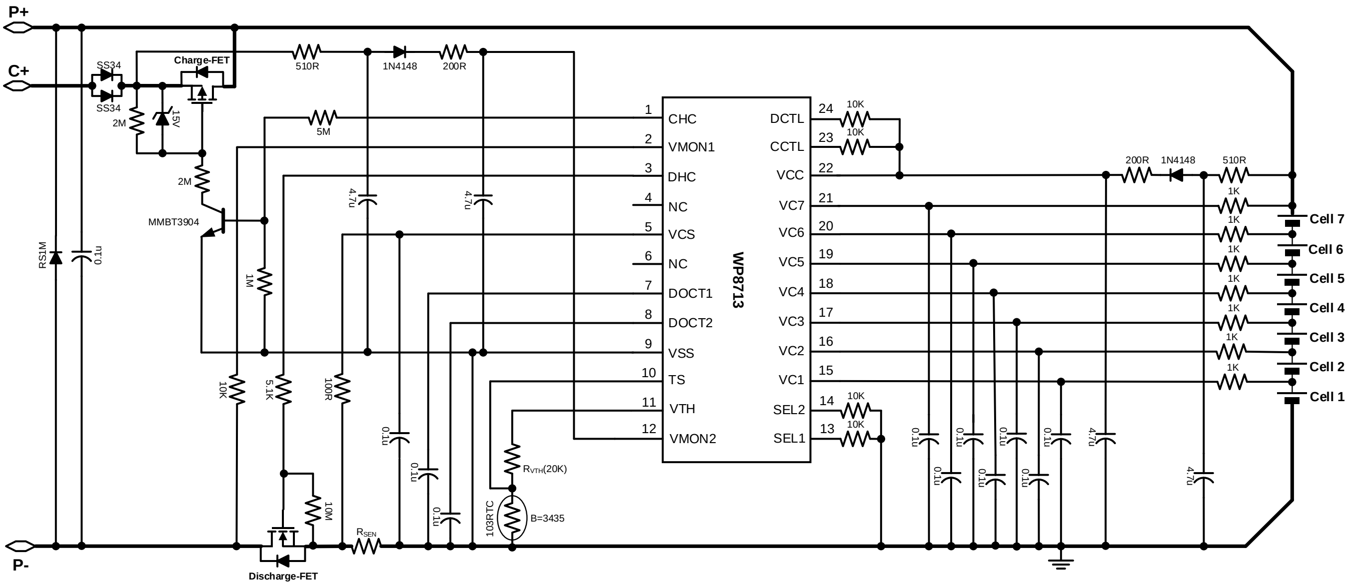
4.1 Typical Application Diagram 1 for 7-series cell with N-type Charge-FET & Discharge-FET



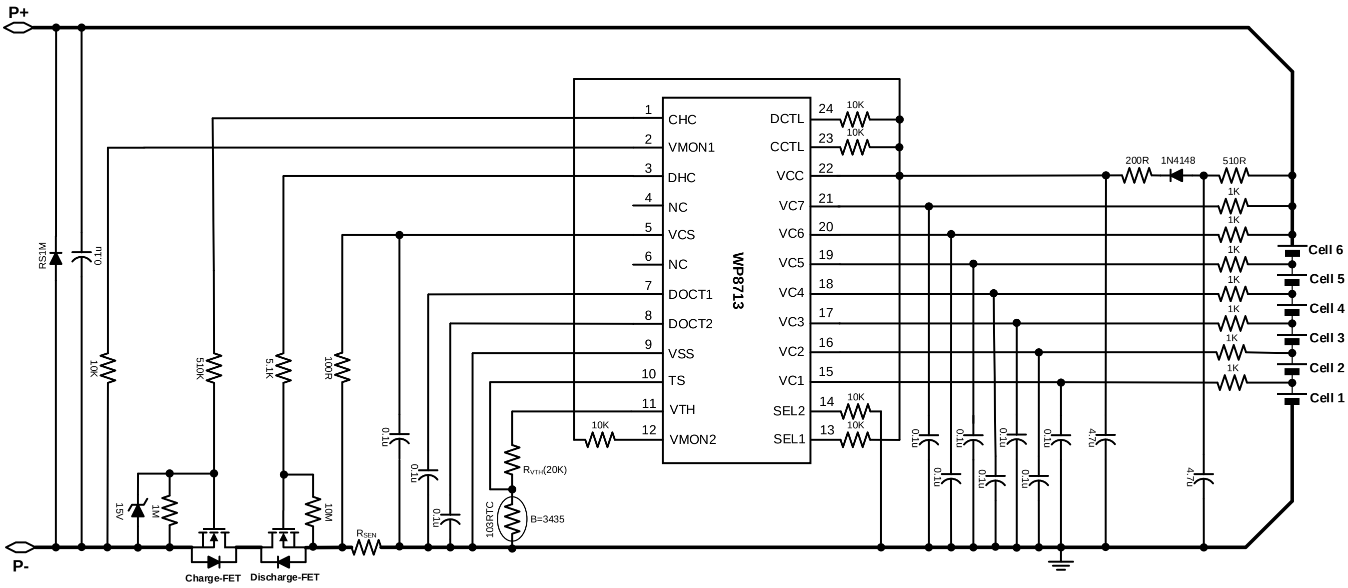
4.2 Typical Application Diagram 2 for 7-series cell with N-type Charge-FET & Discharge-FET



4.3 Typical Application Diagram for 7-series cell with P-type Charge-FET & Discharge-FET

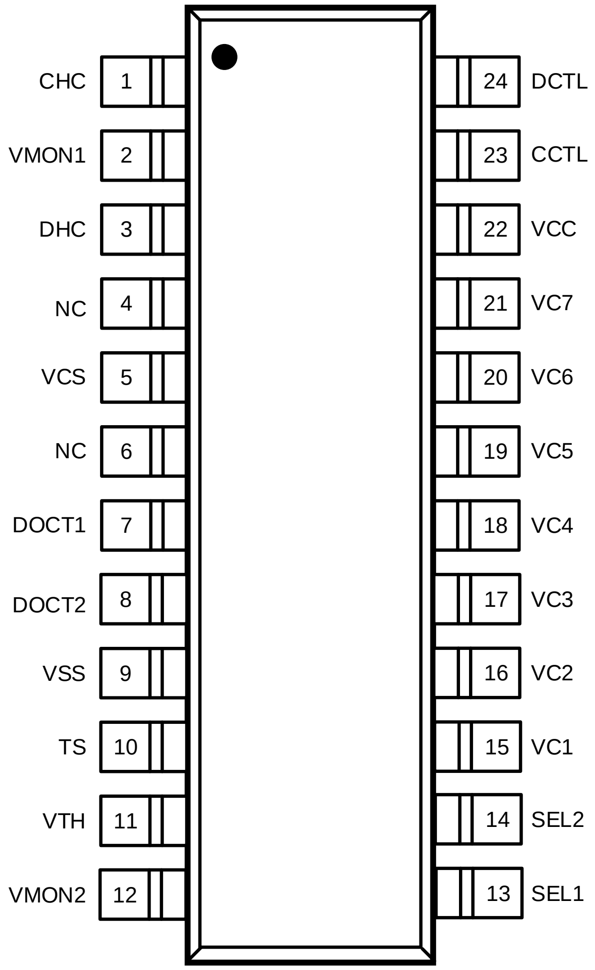


4.4 Typical Application Diagram for 6-series cell with N-type Charge-FET & Discharge-FET



5. Pin Configuration

(Top View)



TSSOP 24

6. Pin Description

PIN NUMBER	PIN NAME	PIN FUNCTION
1	CHC	Charge power FET control pin
2	VMON1	Load-opened and charger-connected detection pin
3	DHC	Discharge power FET control pin
4	NC	No Connection
5	VCS	Charge and Discharge Overcurrent detection pin
6	NC	No Connection
7	DOCT1	Capacitor connection pin for docp1, cocp, ovp, uvp, uv_pd & tdet detection delay timer
8	DOCT2	Capacitor connection pin for discharge-Overcurrent 2 Detection timer
9	VSS	Ground pin
10	TS	Connection pin for temperature detection by negative temperature coefficient thermistor
11	VTH	External thermistor bias output pin, setting and adjusting the temperature of protection
12	VMON2	Charger-connected detection pin
13	SEL1	Pin for switching 4-series or 5-series or 6-series or 7-series cell
14	SEL2	Pin for switching 4-series or 5-series or 6-series or 7-series cell
15	VC1	Connection for positive voltage of cell 1 and negative voltage of cell 2
16	VC2	Connection for positive voltage of cell 2 and negative voltage of cell 3
17	VC3	Connection for positive voltage of cell 3 and negative voltage of cell 4
18	VC4	Connection for positive voltage of cell 4 and negative voltage of cell 5
19	VC5	Connection for positive voltage of cell 5 and negative voltage of cell 6
20	VC6	Connection for positive voltage of cell 6 and negative voltage of cell 7
21	VC7	Connection for positive voltage of cell 7
22	VCC	Power supply pin. Connection for positive voltage of cell 7
23	CCTL	Control pin for charge FET
24	DCTL	Control pin for discharge FET

7. Production Model List

Part Number	Overcharge Detection voltage, V_{OVP}	Overcharge release voltage, V_{OVR}	Over-Discharge Detection voltage, V_{UVP}	Over-Discharge release voltage, V_{UVR}	0V Battery Charge Function
WP8713-ATE1R	4.25±0.025V	4.15±0.03V	2.7±0.05V	3.0±0.06V	enable
WP8713-BTE1R	4.20±0.025V	4.05±0.03V	2.7±0.08V	3.0±0.08V	enable
WP8713-CTE1R	3.65±0.025V	3.50±0.03V	2.5±0.08V	3.2±0.06V	disable
WP8713-DTE1R	4.175±0.025V	4.025±0.03V	2.8±0.05V	3.1±0.06V	enable
WP8713-ETE1R	3.75±0.025V	3.55±0.03V	2.5±0.05V	2.8±0.06V	enable

Part Number	Level 1 Discharge Overcurrent Detection voltage, V_{DOCP1}	Charge Overcurrent Detection voltage, V_{COCP}	Short-current Detection voltage, V_{SCP}	Charge Overcurrent Detection voltage, V_{COCP}	Discharge state detection voltage, V_{IN_DGS}
WP8713-ATE1R	0.1±0.01V	0.2±0.02V	0.4±0.04V	-20mV±5mV	2mV±1.5mV
WP8713-BTE1R	0.05±0.005V	0.1±0.01V	0.2±0.02V	-20mV±5mV	2mV±1.5mV
WP8713-CTE1R	0.05±0.005V	0.1±0.01V	0.2±0.02V	-30mV±5mV	2mV±1.5mV
WP8713-DTE1R	0.05±0.005V	0.1±0.01V	0.2±0.02V	-20mV±5mV	2mV±1.5mV
WP8713-ETE1R	0.05±0.005V	0.1±0.01V	0.2±0.02V	-20mV±5mV	2mV±1.5mV

8. Absolute Maximum Ratings

T_A=25 °C (unless otherwise noted)[1]

PARAMETER	SYMBOL	RATING	APPLICABLE PIN
High-voltage input pin voltage	V_{IN_HV}	V_{SS} – 0.3V to V_{SS}+ 35V	VCC, VCS, TS
Low-voltage input pin voltage	V_{IN_LV}	V_{SS} – 0.3V to V_{SS} + 5.5V	DOCT1, DOCT2, VTH
High-voltage input pin voltage	V_{IN_HV1}	V_{SS} – 0.3V to V_{SS}+ 35V	SEL1,SEL2
VMON1 pin input Voltage	V_{VMON1}	V_{SS} – 0.3V to V_{CC} + 0.3V	VMON1
High-voltage input pin voltage	V_{IN_HV2}	V_{SS} – 0.3V to V_{SS}+ 5.5V	DCTL,CCTL,VMON2
Cell voltage input voltage: VC(n) to VC(n-1),n=2 to 7;VC1 to VSS	V_{CELL}	V_{SS} – 0.3V to V_{SS} + 35V	VC5, VC4, VC3, VC2, VC1
CHC pin input Voltage	V_{CHC}	V_{CC} – 40V to V_{CC} + 0.3V	CHC
DHC pin input Voltage	V_{DHC}	V_{SS} – 0.3V to V_{CC} + 0.3V	DHC
HBM ESD rating		±2kV	
Operating temperature range	T_A	-40°C to +85°C	
Storage temperature range	T_{STG}	-40°C to +125°C	
Package thermal resistance	θ_{JA}	110°C/W	

NOTE1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

9. Electrical Characteristics

(T_A=25°C, unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
Overcharge & Over-Discharge Protection						
V_{OVP}	Overcharge Detection Voltage	3.6V~4.45V(Step 50mV)	V_{OVP} - 0.025	V_{OVP}	V_{OVP} + 0.025	V
V_{OVP_HYS}	Overcharge Hysteresis Voltage	0.1V, 0.15V, 0.2V		V_{OVP_HYS}		V
V_{OVR}	Overcharge Release Voltage	$V_{OVR} = V_{OVP} - V_{OVP\_HYS}$	V_{OVR} - 0.030	V_{OVR}	V_{OVR} + 0.030	V
V_{UVP}	Over-Discharge Detection Voltage	2.0V~3.0V(Step 0.1V)	V_{UVP} - 0.050	V_{UVP}	V_{UVP} + 0.050	V
V_{UVP_HYS}	Over-Discharge Hysteresis Voltage	0.1V, 0.2V, 0.3V, 0.5V		V_{UVP_HYS}		V
V_{UVR}	Over-Discharge Release Voltage	$V_{UVR} = V_{UVP} + V_{UVP\_HYS}$	V_{UVR} - 0.060	V_{UVR}	V_{UVR} + 0.060	V
V_{IN_DSG}[2]	Discharge State Detection Voltage	2mV	V_{IN_DSG} -1.5	V_{IN_DSG}	V_{IN_DSG} +1.5	mV
V_{COCP}	Charge Overcurrent Protection Threshold Voltage	-10mV~-50mV (Step 10mV)	V_{COCP} - 5	V_{COCP}	V_{COCP} +5	mV
		-100mV~-250mV (Step 50mV)	V_{COCP} - 10	V_{COCP}	V_{COCP} +10	
Discharge Overcurrent & Short-Current Protection						
V_{DOCP1}	Level 1 Discharge-Overcurrent Detection Voltage	50mV~200mV(Step 50mV)	0.9* V_{DOCP1}	V_{DOCP1}	1.1* V_{DOCP1}	mV
V_{DOCP2}	Level 2 Discharge-Overcurrent Detection Voltage	100mV, 200mV, 250mV, 300mV	0.9* V_{DOCP2}	V_{DOCP2}	1.1* V_{DOCP2}	mV
V_{SCP}	Short-Current Detection Voltage	200mV, 400mV, 500mV, 800mV	0.9* V_{SCP}	V_{SCP}	1.1* V_{SCP}	mV
Over-Temperature & Under-Temperature Protection						
T_{DOTP}	Discharge Over-Temperature Protection Threshold	Setting by R_{VTH}	T_{DOTP} - 5	T_{DOTP}	T_{DOTP} + 5	°C
T_{DOTP_HYS}	Discharge Over-Temperature Release Hysteresis			15		°C

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
T_{DOTR}	Discharge Over-Temperature Release Threshold	$T_{DOTR} = T_{DOTP} – T_{DOTP\_HYS}$	T_{DOTR} - 5	T_{DOTR}	T_{DOTR} + 5	°C
T_{COTP}	Charge Over-Temperature Protection Threshold	Setting by R_{VTH}	T_{COTP} - 5	T_{COTP}	T_{COTP} + 5	°C
T_{COTP_HYS}	Charge Over-Temperature Release Hysteresis			5		°C
T_{COTR}	Charge Over-Temperature Release Threshold	$T_{COTR} = T_{COTP} – T_{COTP\_HYS}$	T_{COTR} - 5	T_{COTR}	T_{COTR} + 5	°C
T_{DUTP}	Discharge Under-Temperature Protection Threshold	Setting by R_{VTH}	T_{DUTP} - 5	T_{DUTP}	T_{DUTP} + 5	°C
T_{DUTP_HYS}	Discharge Under - Temperature Release Hysteresis			10		°C
T_{DUTR}	Discharge Under - Temperature Release Threshold	$T_{DUTR} = T_{DUTP} + T_{DUTP\_HYS}$	T_{DUTR} - 5	T_{DUTR}	T_{DUTR} + 5	°C
T_{CUTP}	Charge Under - Temperature Protection Threshold	Setting by R_{VTH}	T_{CUTP} - 5	T_{CUTP}	T_{CUTP} + 5	°C
T_{CUTP_HYS}	Charge Under - Temperature Release Hysteresis			5		°C
T_{CUTR}	Charge Under - Temperature Release Threshold	$T_{CUTR} = T_{CUTP} + T_{CUTP\_HYS}$	T_{CUTR} - 5	T_{CUTR}	T_{CUTR} + 5	°C
External Programmable Protection Delay Time						
t_{OVP}	Overcharge protection delay time	C_{DOCT1}=0.1μF	0.7	1.0	1.3	s
t_{UVP}	Over-Discharge protection delay time	C_{DOCT1}=0.1μF	0.7	1.0	1.3	s
t_{UV_PD}	Power-Down delay time	C_{DOCT1}=0.1μF	4.3	6.2	8.1	s
t_{DOCP1}	Discharge-Overcurrent protection 1 delay time	C_{DOCT1} = 0.1μF	0.7	1.0	1.3	s

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
t_{DOCP2}	Discharge-Overcurrent protection 2 delay time	C_{DOCT2} = 0.1μF	70	120	170	ms
t_{SCP}	Short-Current Protection delay time		100	250	500	μs
t_{COCP}	Charge-Overcurrent protection time	C_{DOCT1} = 0.1μF	260	440	620	ms
t_{TDET}	Temperature detection period time	C_{DOCT1} = 0.1μF	0.7	1.0	1.3	s
Power Supply(V_{CC})						
V_{CC}	Input Voltage		V_{SS}+4.0		V_{SS}+35	V
I_{VCC_NOR}	Supply Current	Normal state, V_{CELL} = 3.5V Measure V_{CC} Pin Current		27	32	μA
I_{VCC_PD}	Sleep Current	Power-down state, V_{CELL} = 1.8V Measure V_{CC} Pin Current		2.2	3.0	μA
V_{POR}	Power-On-Reset voltage			4.8	6.0	V
V_{VREGH}	Discharge FET driver voltage	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	
Cell Inputs(VC7,VC6VC5,VC4,VC3,VC2,VC1)						
I_{VC7}	V_{C7} current in normal stat	V_{CELL} = 3.5V		0.8	1.5	μA
I_{VCX}	$V_{C(n)}$ current in normal state, n = 1 to 6	V_{CELL} = 3.5V	-0.5		+0.5	μA
Input Voltage(SEL1,SEL2,CCTL,DCTL,VMON2)						
V_{XCTLH}	CCL,DCTL Input Voltage, High		V_{CC}-0.1			V
V_{XCTLL}	CCL,DCTL Input Voltage, Low				V_{CC}-0.5	V
V_{VMON2H}	VMON2 Input Voltage, High		V_{CC}-0.5			V
V_{VMON2L}	VMON2 Input Voltage, Low				V_{CC}-0.3	V
V_{SELH}	SEL1,SEL2 Input Voltage, High		1.5			V
V_{SELL}	SEL1,SEL2 Input Voltage, Low				0.4	V

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
Drive Circuit(CHC,DHC)						
I_{CHC}	CHC pin outflow current	V_{CELL} = 3.5V, V_{CHC} = V_{CC} – 3V	8	11	14	μA
		V_{CELL} = V_{OVP}+0.2V, V_{CHC} = V_{CC}–3V		Hi-Z		μA
V_{DHCH}	DHC pin output voltage	V_{DCS} = 0V		V_{VREGH}		V
V_{DHCL}		$V_{DCS} \geq V_{DOCP1}$			0.4	V
0V Battery Charge Function						
V_{0VCHA}	0V No-charging threshold		1	1.2	1.6	V

NOTE2: When $V_{CS} > V_{IN\_DSG}$, the battery pack is considered to be in discharge state. Otherwise, the battery pack is considered charged. The V_{IN_DSG} state can be refreshed after the t_{TDET} time.

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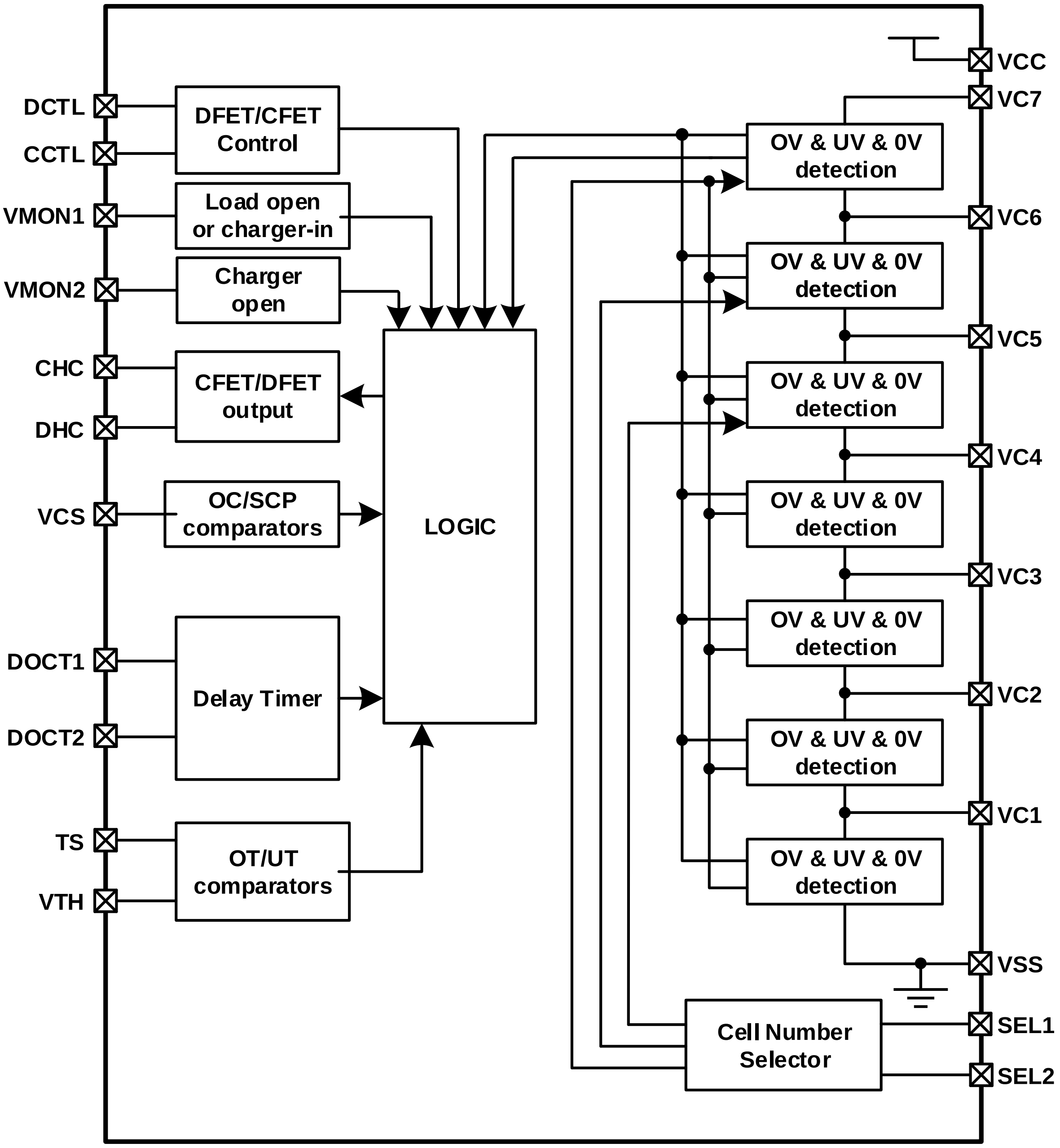
10. Structure Diagram



11. Function Description

11.1 Normal Operation State

When all the battery voltages are between V_{OVP} and V_{UVP}, the discharge current is lower than the specified value (the VCS 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 WP8713 works in normal state, the charging and discharging FETs are turned on.

11.2 Overcharge State

When any one of the battery voltages becomes higher than VOVP and the state continues for t_{OVP} or longer, the CHC pin of WP8713 becomes Hi-Z. Refer to typical application diagram 1, the source side and gate side of charging FET will be shorted together, thus the charging FET is turned off to stop charging. This is called the Overcharge State.

In Overcharge State, if a load is connected and the VCS pin voltage is higher than discharging detection voltage V_{IN_DSG}, the WP8713 will turn on charging FET immediately to avoid the over-heat of charging FET due to its body diode conduction. Before the Overcharge State is released, if the load is removed, the charging FET will be turned off again.

The Overcharge State is released only when all battery voltages become V_{OVR} or lower.

11.3 Over-Discharge State

When any one of the battery voltages becomes lower than V_{UVP} and the state continues for t_{UVP} or longer, the DHC pin voltage becomes VSS level, and the discharging FET is turned off to stop discharging. This is called the Over-Discharge State.

In the over-discharge state, if the charger is connected and the VCS pin voltage is lower than -2mV, WP8713 will immediately turn on the discharge tube to avoid the charge current flowing through the parasitic diode of the discharge tube and causing the discharge tube to overheat. If the charger is removed before the over discharge state is lifted, the discharge tube will be turn off again

The Over-Discharge State is released when both of the following two conditions hold: All battery voltages become V_{UVR} and higher (the VMON1 pin voltage is lower than 1.5V -- Load is removed); The charger is connected (VMON1 pin voltage is lower than -0.3V) and the VCS pin voltage is lower than -2mV, while all the battery voltage is changed to VUVP or higher.

11.4 Power-Down State

Over-voltage state takes precedence over under-voltage state. In Over-Discharge State, if no Overcharge State exists and when the state continues for t_{UV_PD} or longer, the WP8713 enters the Power-Down State.

In Over-Discharge State, if Overcharge State exists, the WP8713 will not enter Power-Down State. In Power-Down State, the VMON1 pin voltage is pulled up to VCC level by the internal pull-up resistor. The output voltage of CHC pin is VCC, DHC pin is VSS.

The Power-Down State is released when the following condition holds: The VMON1 pin voltage is lower than VCC-3V (A charger is connected).

11.5 Charge-Overcurrent State

During charging, when VCS voltage falls below V_{COCP} and it continues for t_{COCP} or longer, the CHC pin of WP8713 becomes Hi-Z to turn off the charging FET to stop charging. This is called the Charge-Overcurrent Condition.

The Charge-Overcurrent Condition is released when any of the following two condition holds:

1) For the figure 1 , figure 2 and figure 4, the application circuit：Remove charger makes VMON1 pin voltage higher than 0.1V.
2) For the figure 3,the application circuit：Remove charger makes VMON2 pin voltage lower than VCC - 0.15V.

11.6 Discharge-Overcurrent State

WP8713 has three Discharge-Overcurrent Detection levels (V_{DOCP1}, V_{DOCP2} and V_{SCP}) and three Discharge-Overcurrent Detection delay times (t_{DOCP1}, t_{DOCP2} and t_{SCP}) corresponding to each Discharge-Overcurrent Detection level.When the discharging current becomes higher than the specified value (the voltage on V_{CS} pin is greater than V_{DOCP1}) and the state continues for t_{DOCP1} or longer, the WP8713 enters Discharge Over current Condition, in which the DHC pin voltage becomes VSS level to turn off the discharging FET to stop discharging.

Operation of Discharge-Overcurrent Detection level-2 (V_{DOCP2}) and discharge-overcurrent delay time 2 (t_{DOCP2}) is same as V_{DOCP1} and t_{DOCP1}.

In Discharge-Overcurrent Condition, discharging FET is turned off, thus the VMON1 pin is pulled up to VCC level by the load. The overcurrent state is released when the following condition holds: The VMON1 pin voltage is lower than 1.5V (a charger is connected or the load is removed).

11.7 Over-Temperature or Under-Temperature Condition

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

In normal state, the WP8713 will do the temperature detection every t_{TDET}, see figure 1 for temperature detection timing chart.

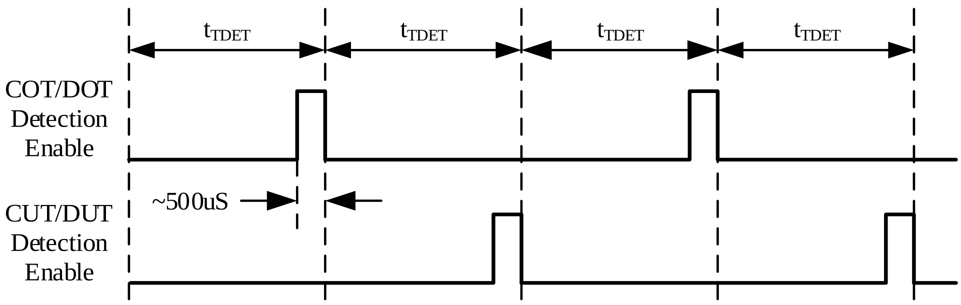


Figure1 Temperature Detection Timing

As shown in figure 2 temperature protection IC can use R_{VTH}+ R_T or R_{VTH} + R_T | | R_2.

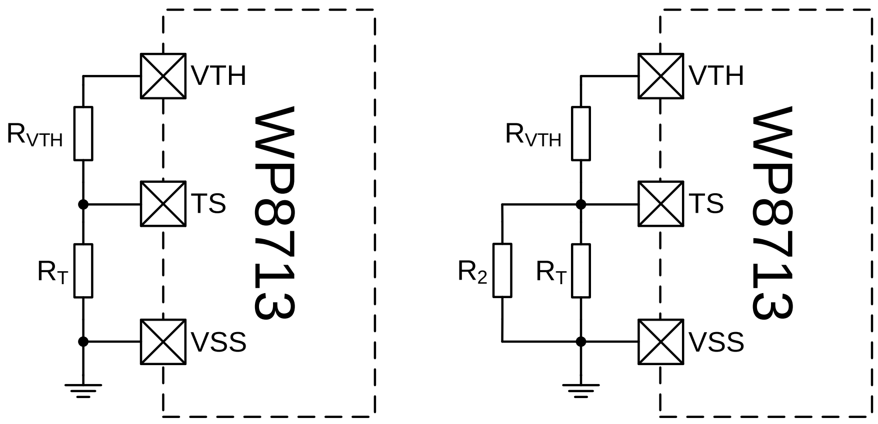


Figure2 (a) R_{VTH}+R_T (b) R_{VTH}+R_T||R_2

It is recommended to use AT103 NTC thermistor with B value of 3435. At the same time, you can adjust the temperature protection threshold by changing the resistance R_{VTH}. Replacing a thermistor with a 10K resistor will result in all temperature protection being eliminated. Table 1 shows the temperature protection points corresponding to common R_{VTH} resistance values in R_{VTH}+R_T mode.

Table1 R_{VTH} Resistance Values in R_{VTH}+R_T Mode

R_T	R_{VTH}	DOTP	COTP	DUTP	CUTP
B=3435 AT103 Mode NTC	20K	71°C	51°C	-20°C	0°C
	20K	66°C	46°C	-23°C	-3°C
10K	20K	No	No	No	No

VTH + R_T | | R_2 way can lower the threshold low temperature protection or set low temperature protection will not happen. Table 2 R_{VTH} + R_T | | R_2 way common value for each point temperature protection.

Table2 R_{VTH}+R_T||R_2 Values for Each Point Temperature Protection

R_T	R_2	R_{VTH}	DOTP	COTP	DUTP	CUTP
B=3435 AT103 Mode NTC	20K	20K	67°C	44°C	No	No
	50K	20K	69°C	48°C	No	-17°C

When the battery pack temperature becomes higher than T_{DOTP} in discharging state and the state continues for 2×t_{TDET} or longer, the DHC pin voltage becomes VSS level and the CHC pin of WP8713 becomes Hi-Z, both the charging and discharging FETs are turned off to stop charging and discharging. This is called the Discharge Over-Temperature State. The Discharge Over-Temperature State released condition: The battery pack temperature becomes T_{DOTR} or lower.

When the battery pack temperature becomes higher than T_{COTP} in charging state and the state continues for 4×t_{TDET} or longer, the CHC pin of WP8713 becomes to Hi-Z, and the charging FET is turned off to stop charging. This is called the Charge Over-Temperature State. In Charge Over-Temperature State, when the battery pack temperature becomes higher than TDOTP in discharging state and the state continues for 2×t_{TDET} or longer the DHC pin voltage becomes VSS level, if a load is connected and the VCS pin voltage is higher than discharging detection voltage V_{IN_DSG}, the WP8713 will turn on charging FET immediately to avoid the over-heat of charging FET due to its body diode conduction. Before the Charge Over-Temperature Condition is released, if the load is removed, the charging FET will be turned off again.

The charging over-temperature state is released only when the battery pack temperature becomes T_{COTR} or lower.

When the battery pack temperature becomes lower than T_{DUTP} in discharging state and the state continues for 2×t_{TDET} or longer, the DHC pin voltage becomes VSS level and the CHC pin of WP8713 becomes Hi-Z, both the charging and discharging FETs are turned off to stop charging and discharging. This is called the Discharge Under-Temperature State. This Condition is released when the following condition holds: The battery pack temperature becomes T_{DUTR} or higher.

When the battery pack temperature becomes lower than T_{CUTP} in charging state and the state continues for 4×t_{TDET} or longer, the CHC pin of WP8713 becomes to Hi-Z, thus the charging FET is turned off to stop charging. This is called the Charge Under-Temperature State.

In Charge Under-Temperature Condition, if a load is connected and the VCS pin voltage is higher than discharging detection voltage V_{IN_DSG}, the WP8713 will turn on charging FET immediately to avoid the over-heat of charging FET due to its body diode conduction. Before the Charge Under-Temperature State is released, if the load is removed, the charging FET will be turned off again.

The Charge Under-Temperature State is released only when the battery pack temperature becomes T_{CUTR} or higher.

11.8 0V Battery Charging Function

The WP8713 provides 0V battery no-charge function, this function can also be disable. When any one cell is lower than V_{0VCHA} and the charger is prohibited. Battery charging enable as long as the voltage of WP8713 power pin VCC is higher than the initial charging threshold voltage (power-on-reset voltage) V_{POR}, the charging tube gate control pin CHC can output current to open the charging tube to charge the battery pack, even if the battery cell voltage reduced to 0V.

11.9 Battery Pack Breaking Line Protection

If any battery power line are breaking, the CHC pin becomes Hi-Z and DHC pin voltage becomes VSS level to turn off the discharging FET to stop discharging and charging.

Breaking line protection release condition: pin VC1、VC2、VC3、VC4、VC5、VC6 and VC7 to the battery cell is normal.

11.10 Delay Time Setting

The Overcharge protection delay time (t_{OVP}), temperature detection period time (t_{TDET}), Over-Discharge protection delay time (t_{UVP}), the Power-Down delay time (t_{UV_PD}) and level-1 Discharge-Overcurrent protection delay time (t_{DOCP1}) and Charge-Overcurrent protection delay time (t_{COCP}) are determined by the external capacitor connected to DOCT1 pin. The level-2 Discharge-Overcurrent protection delay time (t_{DOCP2}) is determined by the external capacitor connected to DOCT2 pin. Short-Circuit detection delay time (t_{SCP}) is fixed internally to be 250us (typical).

Table3 Setting of Each Delay Time

Symbol	MIN	TYP	MAX	Capacitor	UNIT
t_{OVP}	7.00	10.0	13.0	×C_{COVT}[μF]	s
t_{TDET}	7.00	10.0	13.0	×C_{COVT}[μF]	s
t_{UVP}	7.00	10.0	13.0	×C_{CUVT}[μF]	s
t_{UV_PD}	43.0	62.0	81.0	×C_{CUVT}[μF]	s
t_{DOCP1}	7.00	10.0	13.0	×C_{COCT}[μF]	s
t_{DOCP2}	0.70	1.00	1.30	×C_{COCT}[μF]	s
t_{COCP}	3.0	4.5	6.0	×C_{COCT}[μF]	s

11.11 SEL1 & SEL2 Pin

SEL1 and SEL2 pins are used to select and protect a 4, 5, 6 or 7-cell battery pack. SEL1 and SEL2 pin are connected to VSS or VCC, and the float is equivalent to VSS, as shown in Table 4.

Table4 Conditions Set by SEL1/2 Pin

SEL1	SEL2	Condition
VCC	VCC	4 cell
VSS	VCC	5 cell
VCC	VSS	6 cell
VSS	VSS	7 cell

The connection mode between the battery cells and the input terminals are shown in Table 5 for different battery pack series applications.

Table5 The Different Terminal Conection Way

Input Terminal	4 Serial	5 Serial	6 Serial	7 Serial
VSS-VC1	Battery1	Battery1	Battery1	Battery1
VC1-VC2	Battery2	Battery2	Battery2	Battery2
VC2-VC3	Battery3	Battery3	Battery3	Battery3
VC3-VC4	Battery4	Battery4	Battery4	Battery4
VC4-VC5	Short Connected[3]	Battery5	Battery5	Battery5
VC5-VC6	Short Connected[3]	Short Connected[3]	Battery6	Battery6
VC6-VC7	Short Connected[3]	Short Connected[3]	Short Connected[3]	Battery7

NOTE3: Each input terminal must pass RC before it can be short-circuit.

11.12 CCTL & DCTL Pin

The WP8713 have two control pins. The CCTL pin is used to control the CHC pin output voltages and the DCTL pin is used to control the DHC pin output voltages. The CCTL and DCTL pin take precedence over the battery protection circuit inside the chip. Table 6 and Table 7 shows the pin voltages of CCTL and DCTL and the corresponding states of CHC pin and DHC pin.

Table6 Conditions Set by CCTL Pin

CCTL	CHC
High	Normal Status[4]
Floating	Hi-Z
Low	Hi-Z

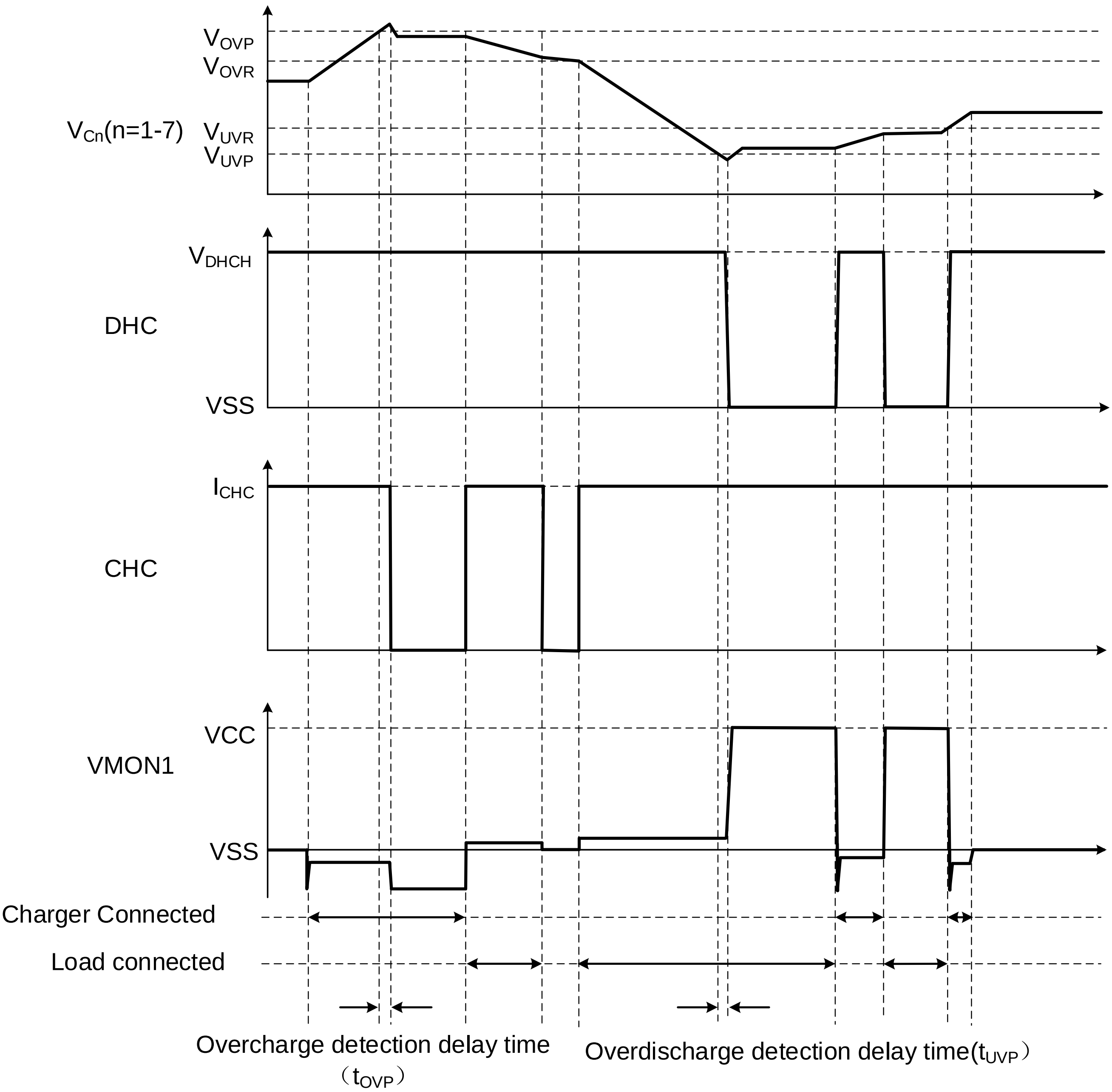
Table7 Conditions Set by DCTL Pin

DCTL	CHC
High	Normal Status[4]
Floating	VSS
Low	VSS

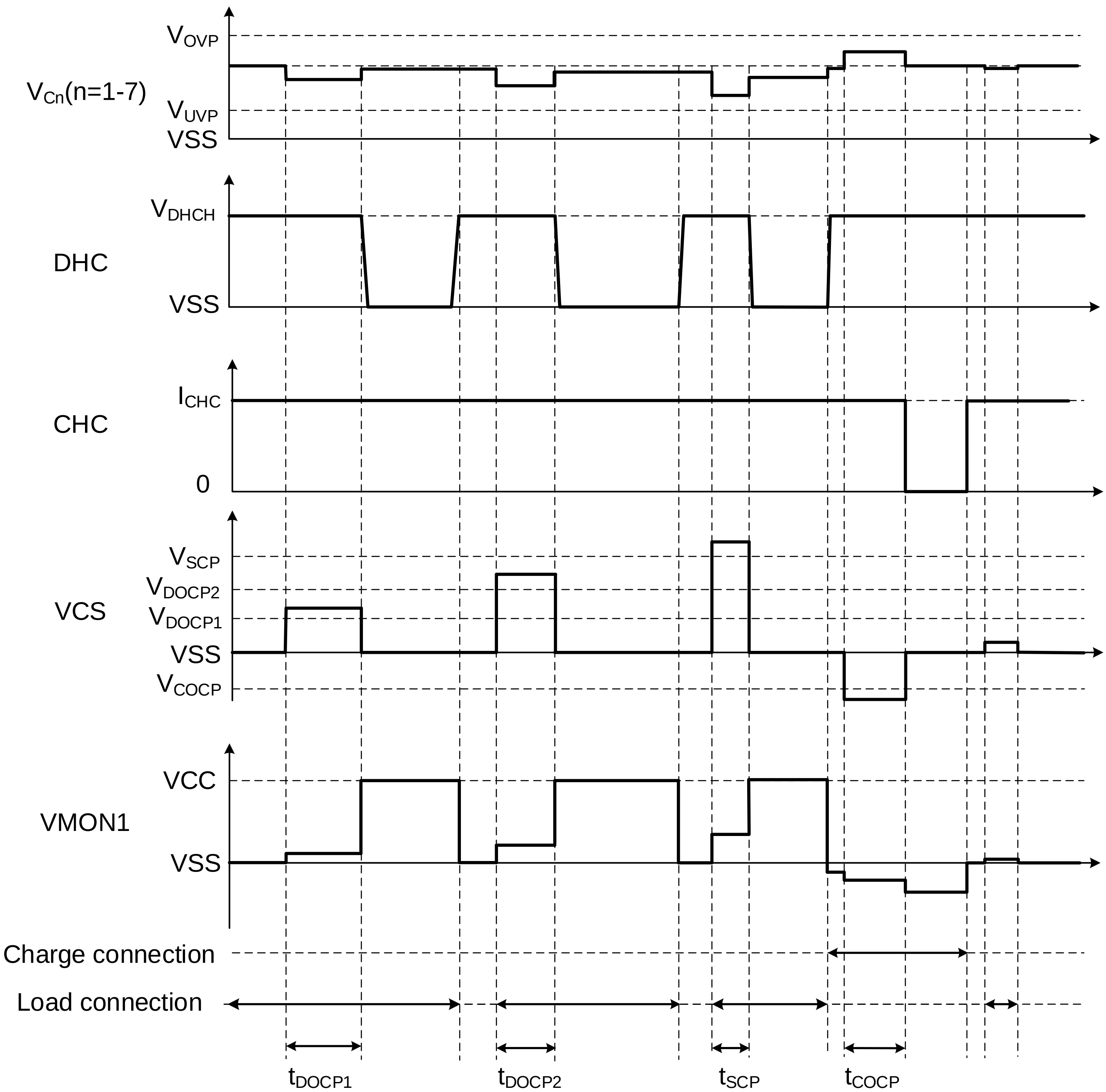
NOTE4: The status is controlled by the voltage detector.

12. Timing Diagram

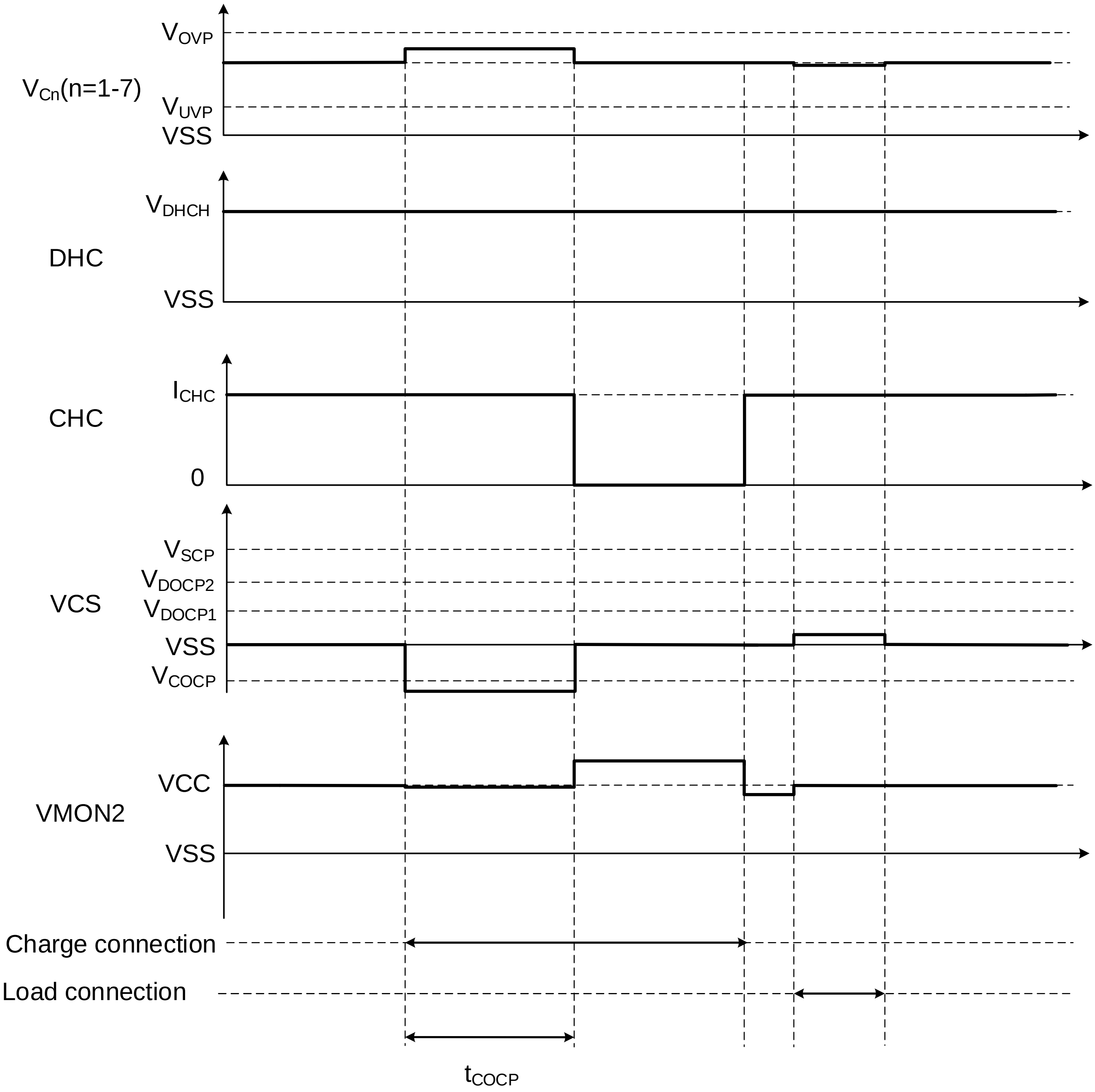
12.1 Overcharge & Over-Discharge Operations



12.2 Discharge-Overcurrent & Charge-Overcurrent Operations

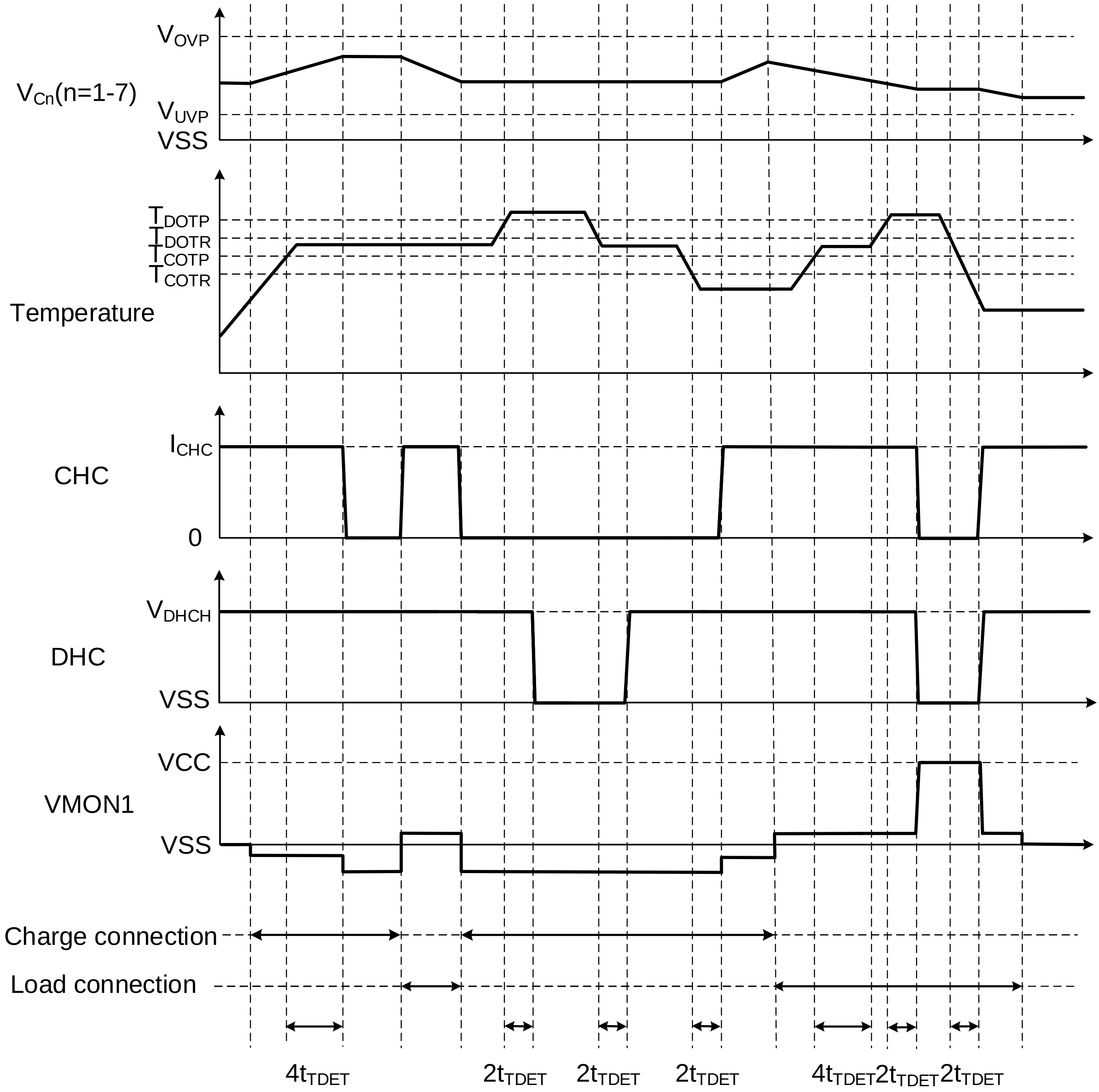


12.3 Charge-Overcurrent Operations[5]

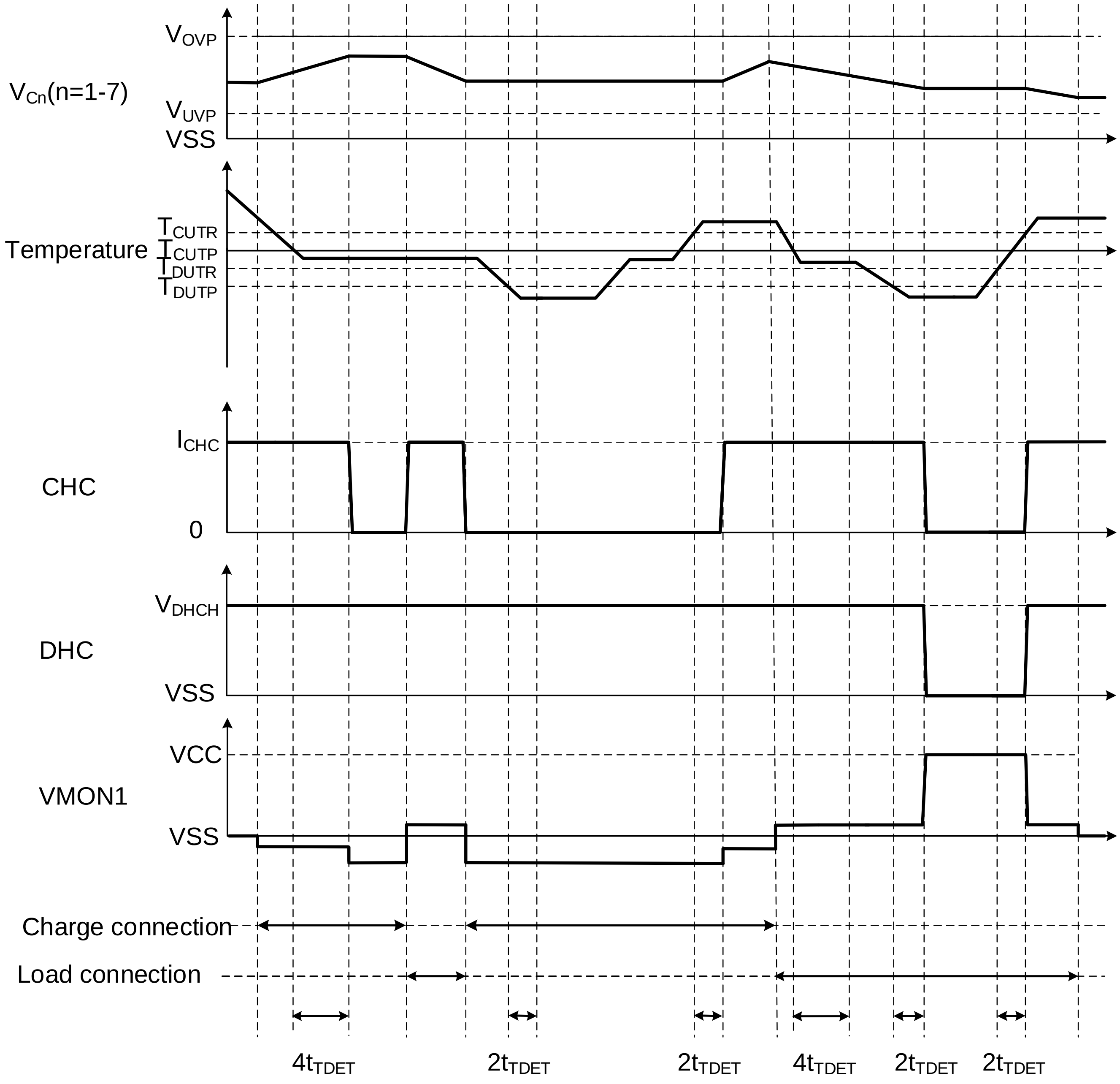


NOTE5: Applicable to the P-type Charge-FET & Discharge-FET circuit.

12.4 Over-Temperature Operations



12.5 Under-Temperature Operations



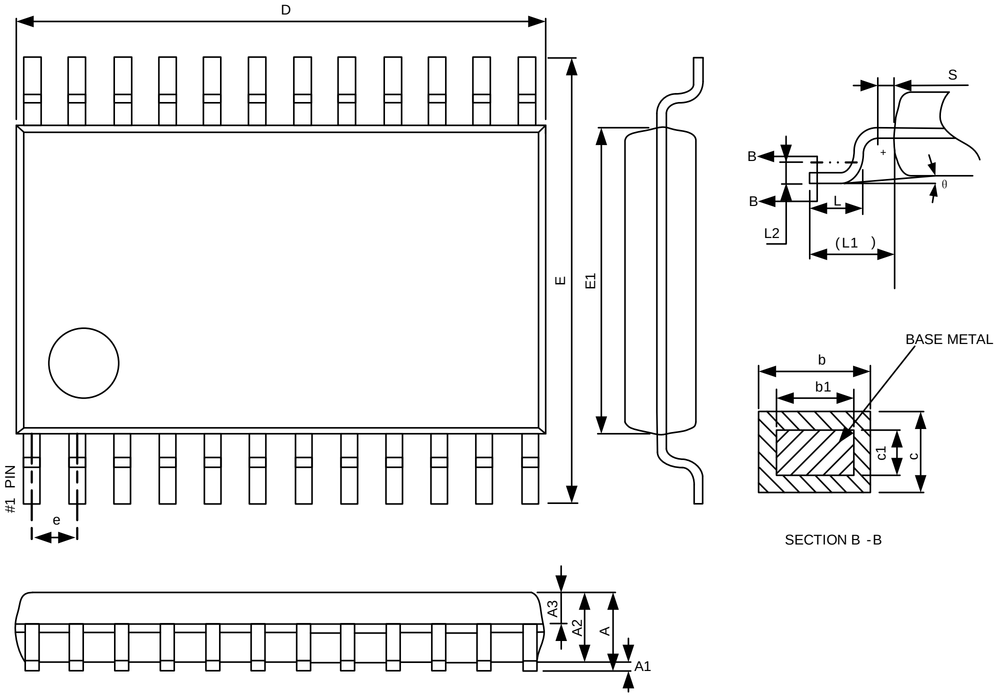
13. Naming Conventions

WP A B C D-E FFF G

WP: WAYON Regulator
A: 8 – Li-ion Battery Protection
B: 7 – Number of cells，4 to 7 Series
C: 1 – Protection Type，Primary Protection
D: Serial Number
E: Model Number
FFF: TE1 – Package, TSSOP-24
G: R – Reel

14. Package Information

TSSOP-24



SYMBOL	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.80	0.90	1.00
A3	0.34	0.39	0.44
b	0.20	-	0.29
b1	0.19	0.22	0.25
c	0.10	-	0.19
c1	0.10	0.13	0.15
D	7.70	7.80	7.90
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
h	0.45	0.60	0.75
L1	1.00BSC		
L2	0.25BSC		
θ	0°	-	8°

NOTE: All sizes are in millimeters (angles are measured in degrees).

15. Ordering Information

PART NUMBER	PACKAGE	PACKING QUANTITY
WP8713-ATE1R	TSSOP-24	3k/Reel
WP8713-BTE1R	TSSOP-24	3k/Reel
WP8713-CTE1R	TSSOP-24	3k/Reel
WP8713-DTE1R	TSSOP-24	3k/Reel
WP8713-ETE1R	TSSOP-24	3k/Reel

STATEMENTS

WAY-ON provides data sheets based on the actual performance of the device, and users should verify actual device performance in their specific applications. The device characteristics and parameters in this data sheet can and do vary from application to application, and actual device performance may change over time. This information is intended for developers designing with WAY-ON products. Users are responsible for selecting the appropriate WAY-ON product for their application and for designing and verifying the application to ensure that your application meets the appropriate standards or other requirements, and users are responsible for all consequences. Specifications are subject to change without notice.

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Specifications are subject to change without notice.
The device characteristics and parameters in this data sheet can and do vary in different applications and actual device performance may vary over time.
Users should verify actual device performance in their specific applications.