XC6810 Series

ETR25015-001

Linear Charger IC for Li-ion battery With Ultra-small Package Compatible With Wireless Charging

■GENERAL DESCRIPTION

The XC6810 is a linear charger IC for Li-ion battery with ultra-small package compatible with a wireless charging and contact power supply.

The charging current corresponds to 1mA to 25mA, and it has a current path function that supplies power to the system at the same time as charging.

To realize an ultra-compact system, Battery Over Discharge Protection function, Output Terminal Short Protection function and Battery Voltage Monitor function or Battery Low Voltage Notification function are equipped. And the IC is equipped with a shutdown function and a wake-up function using an external push button to reduce battery consumption when the product is stored or unused.

In addition, there is a type that can indicates the charging status by modulating the input current using the CSO. We also have prepared a type that can notify the charging status to the power supply such as a cradle by two-wire communication.

Ideal for monitoring and displaying the charging status of various wearable devices with the cradle.

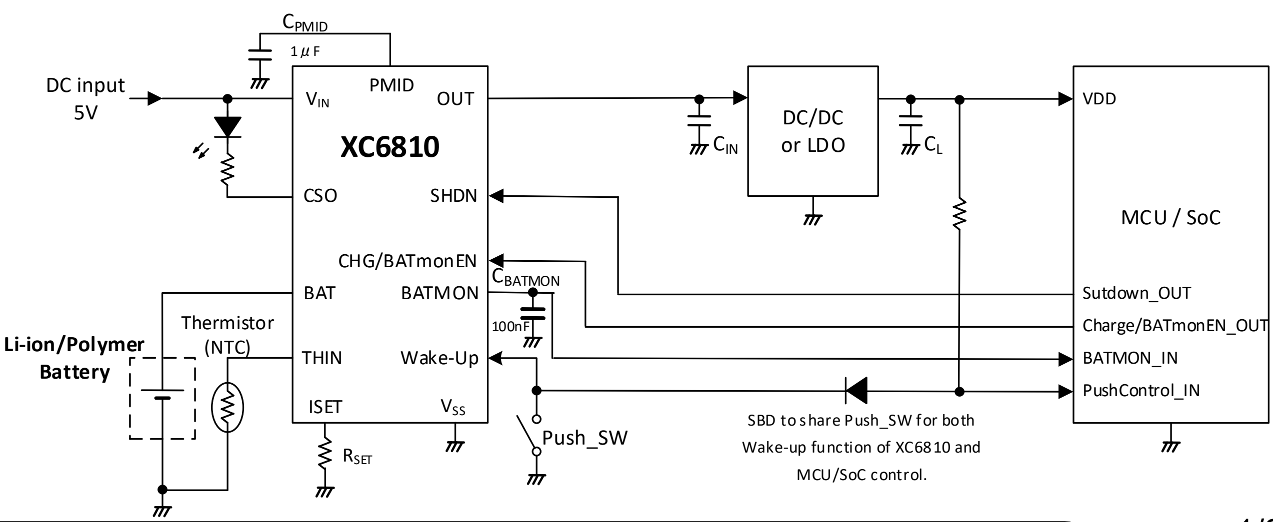
■APPLICATIONS

- Hearing Aid
- Wireless earphones / Headset
- Wearable Devices
- Wireless charging equipment
- IoT devices
- Smartcards

■FEATURES

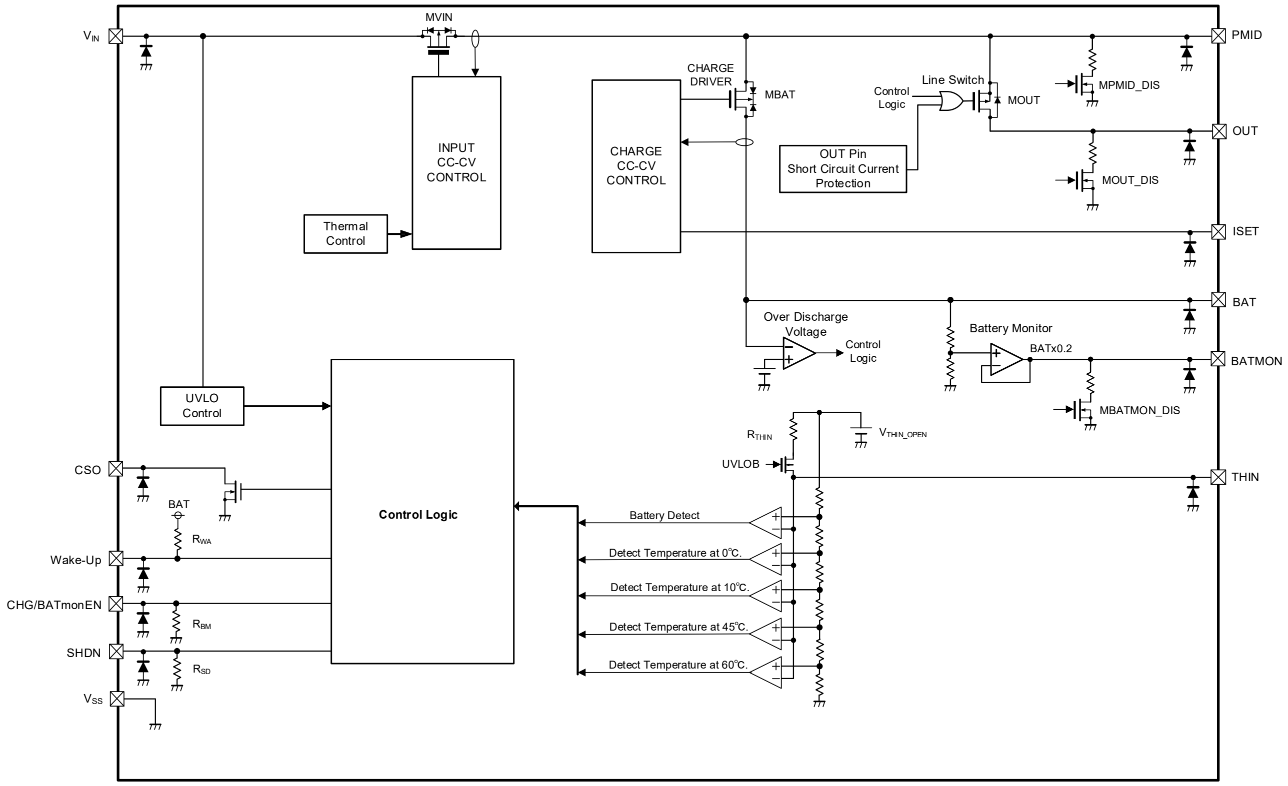
Input Voltage Range	:	3.5V ~ 28.0V
Charge Voltage	:	3.80V ~ 4.40V (0.05V increments)
Charge Current		1mA ~ 25mA, Set by an external resistor
Input Current Limit	:	110mA
BAT Sink Current at Shut Down	:	10nA (TYP.)
Functions	:	Shutdown, Wake-up
	:	Battery Voltage Monitor or Battery Low Voltage Notification
	:	OUT Line Switch Interlocked by UVLO, Charge Enable
	:	Battery Temperature Monitor
	:	Current Path / Input Current Limit
Protection Functions	:	Battery Over Discharge Protection
	:	Output Short Protection
	:	Thermal Control
	:	Reverse Current Prevention
	:	Safty Timer of Charging
	:	UVLO
Operating Ambient Temperature	:	-40℃ ~ 85℃
Package	:	WLP-12-01 (1.17 x 1.57 x 0.33mm)
Environmentally Friendly	:	EU RoHS Compliant, Pb Free

■TYPICAL APPLICATON CIRCUIT



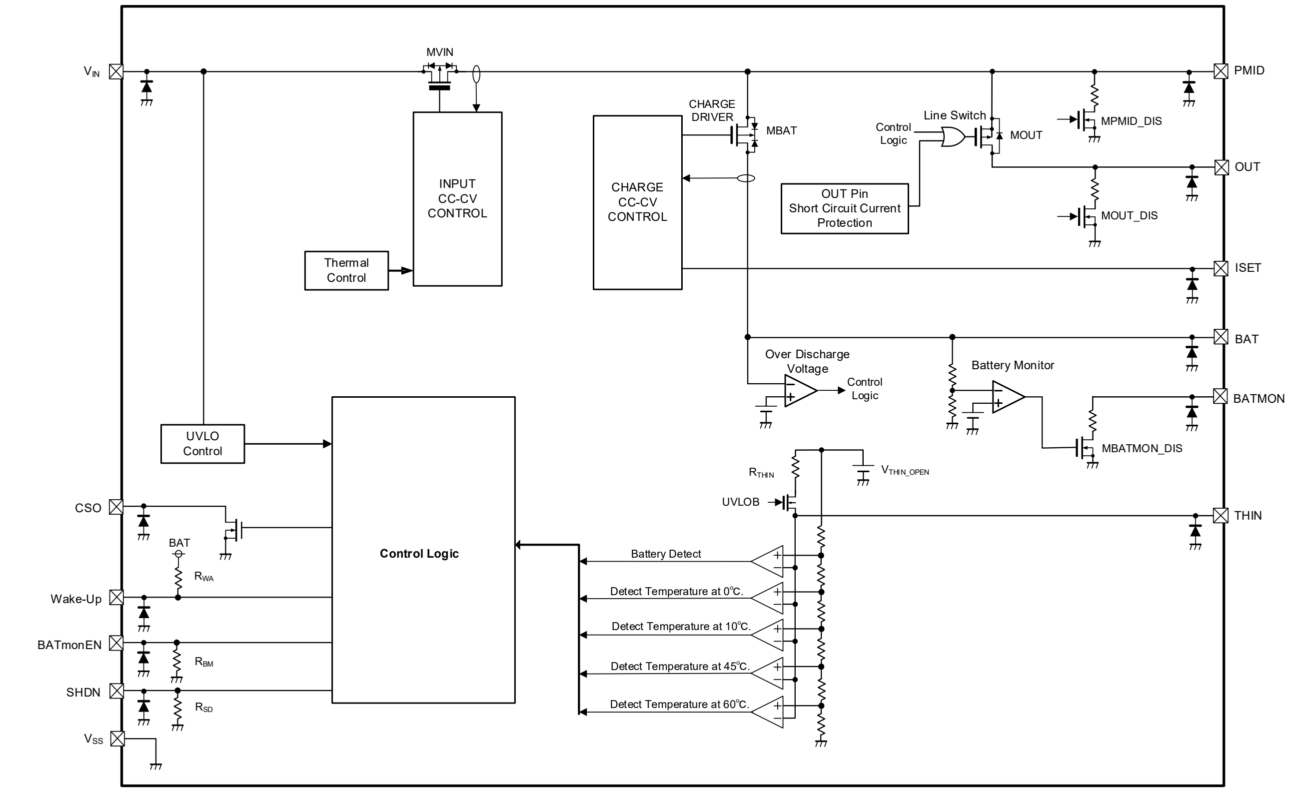
■ BLOCK DIAGRAMS

1) Type A,B,C and Functions A,C,F,G,H,J



*Diodes inside the circuits are ESD protection diodes and parasitic diodes.

2) Type A,B,C and Functions B,D,E



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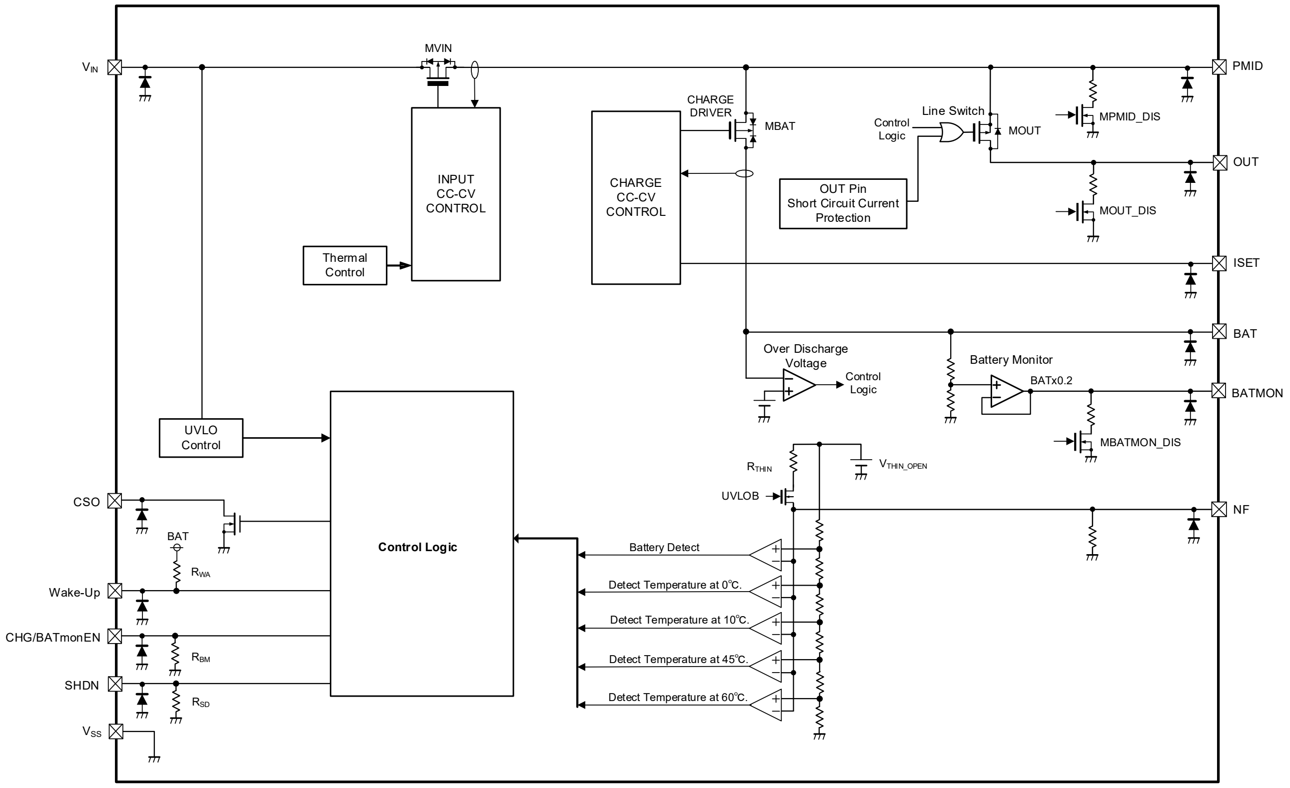
■ BLOCK DIAGRAMS

3) Type N and Functions A,C,F,G,H,J



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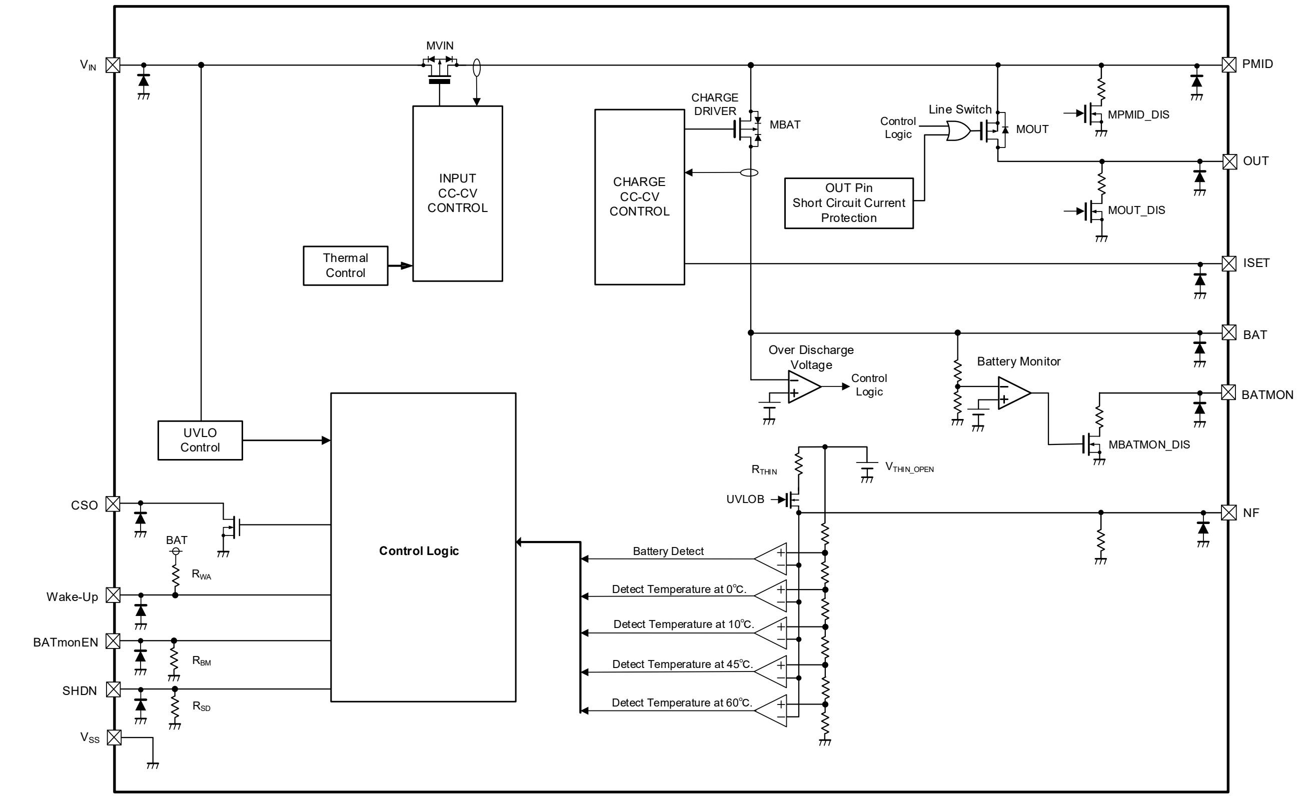
4) Type N and Functions B,D,E



*Diodes inside the circuits are ESD protection diodes and parasitic diodes.

■ PRODUCT CLASSIFICATION

1. Standard Products

●Ordering Information

XC6810①②③④⑤⑥-⑦

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Type	A	4 Temperature Monitor
		B	3 Temperature Monitor
②③	Charge Voltage	41, 42, 43, 4D, 44	Charge Voltage Options 41 →4.10V, 42→4.20V, 43→4.30V, 4D→4.35V, 44→4.40V
④	Functions	C	Refer to Selection Guide
		G	
		H	
		J	
⑤⑥-⑦(*1)	Packages (Order Unit)	0R-G	WLP-12-01 (5,000pcs/Reel)

(*1) "-G" suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

●Selection Guide

Functions	Charge Enable	CSO Output	OUT	Battery Monitor Output
C	No	Battery LED Indicator	Always ON (Current Path function)	0.2 x V_{BAT}
G		Battery Status Indicator		
H	Yes	Battery LED Indicator		
J		Battery Status Indicator		

■PRODUCT CLASSIFICATION

2. Custom products

●Ordering Information

XC6810①②③④⑤⑥-⑦

<table>
<tr><th>DESIGNATOR</th><th>ITEM</th><th>SYMBOL</th><th>DESCRIPTION</th></tr>
<tr><td rowspan="4">①</td><td rowspan="4">Type</td><td>A</td><td>4 Temperature Monitor</td></tr>
<tr><td>B</td><td>3 Temperature Monitor</td></tr>
<tr><td>C</td><td>2 Temperature Monitor</td></tr>
<tr><td>N</td><td>No Temperature Monitor</td></tr>
<tr><td>②③</td><td>Charge Voltage</td><td>38 ~ 44</td><td>Charge Voltage Options
e.g. 4.20V → ②=4, ③=2
4.35V → ②=4, ③=D
0.05V increments : 0.05=A, 0.15=B, 0.25=C, 0.35=D, 0.45=E,
0.55=F, 0.65=G, 0.75=H, 0.85=J, 0.95=K</td></tr>
<tr><td rowspan="9">④</td><td rowspan="9">Functions</td><td>A</td><td rowspan="9">Refer to Selection Guide</td></tr>
<tr><td>B</td></tr>
<tr><td>C</td></tr>
<tr><td>D</td></tr>
<tr><td>E</td></tr>
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●Selection Guide

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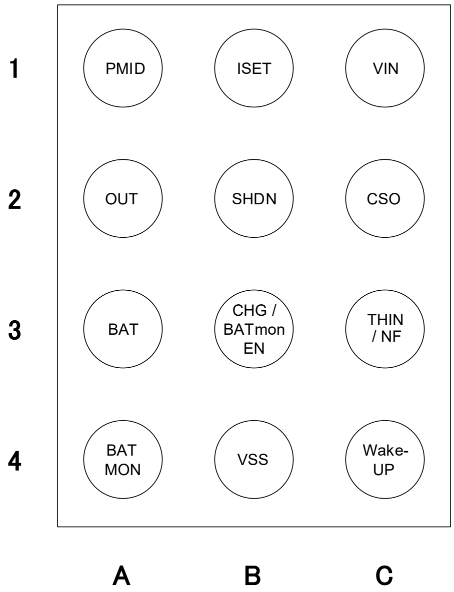
<tr><th>Functions</th><th>Charge Enable</th><th>CSO Output</th><th>OUT</th><th>Battery Monitor Output</th></tr>
<tr><td>A</td><td rowspan="7">No</td><td rowspan="4">Battery LED Indicator</td><td rowspan="2">Cut-off
at UVLO Release State
($V_{IN} \geqq V_{UVLOR}$)</td><td>0.2 x V_{BAT}</td></tr>
<tr><td>B</td><td>Low Battery State : "L"
Other State : "H"</td></tr>
<tr><td>C</td><td rowspan="2">Always ON
(Current Path function)</td><td>0.2 x V_{BAT}</td></tr>
<tr><td>D</td><td rowspan="2">Low Battery State : "L"
Other State : "H"</td></tr>
<tr><td>E</td><td rowspan="3">Battery Status Indicator</td><td rowspan="2">Cut-off
at UVLO Release State
($V_{IN} \geqq V_{UVLOR}$)</td></tr>
<tr><td>F</td><td rowspan="4">0.2 x V_{BAT}</td></tr>
<tr><td>G</td><td rowspan="3">Always ON
(Current Path function)</td></tr>
<tr><td>H</td><td rowspan="2">Yes</td><td>Battery LED Indicator</td></tr>
<tr><td>J</td><td>Battery Status Indicator</td></tr>
</table>

■PIN CONFIGURATION



(BOTTOM VIEW)

■PIN ASSIGNMENT

PIN NUMBER WLP-12-01	PIN NAME	FUNCTIONS
A1	PMID	Input Power Regulated Voltage
A2	OUT	Output Power to The System
A3	BAT	Battery Connection
A4	BATMON	Battery Monitor Output
B1	ISET	Charge Current Setup
B2	SHDN	Shutdown Control Input
B3	BATmonEN	Battery Monitor Enable Input (Functions A,C,F,G)
		No function (Functions B,D,E)
	CHG/BATmonEN	Charge Enable and Battery Monitor Enable Input (Functions H,J)
B4	V_{SS}	Ground
C1	V_{IN}	Power Supply Input
C2	CSO	Charge Status Output
C3	THIN	Battery Temperature Detection (Type A,B,C)
	NF	No function (Type N). * Please do not connect anything.
C4	Wake-Up	Wake Up Control Input

■ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATINGS	UNITS
V_{IN} Voltage	V_{IN}	-0.3 ~ 30	V
BAT Voltage	V_{BAT}	-0.3 ~ 6.6	V
CSO Voltage	V_{CSO}	-0.3 ~ 6.6	V
PMID Voltage	V_{PMID}	-0.3 ~ 6.6	V
Wake-Up Voltage	V_{WAKEUP}	-0.3 ~ 6.6	V
CHG/BATmonEN Voltage	$V_{CHG}/V_{BATmonEN}$	-0.3 ~ 6.6	V
SHDN Voltage	V_{SD}	-0.3 ~ 6.6	V
THIN Voltage (Type A,B,C)	V_{THIN}	-0.3 ~ 6.6	V
NF Voltage (Type N)	V_{NF}	-0.3 ~ 6.6	V
OUT Voltage	V_{OUT}	-0.3 ~ V_{PMID} + 0.3 or 6.6 (*1)	V
BATMON Voltage	V_{BATMON}	-0.3 ~ V_{PMID} + 0.3 or 6.6 (*1)	V
ISET Voltage	V_{ISET}	-0.3 ~ V_{PMID} + 0.3 or 6.6 (*1)	V
Power Dissipation (Ta=25℃)	Pd	890 (JESD51-7 board) (*2)	mW
Junction Temperature	Tj	-40 ~ 125	℃
Storage Temperature	Tstg	-55 ~ 125	℃

All voltages are described based on the V_{SS}.

(*1) Either of lower one, V_{PMID} + 0.3V or 6.6V, is applicable.

(*2) The power dissipation figure shown is PCB mounted and is for reference only.
Please refer to PACKAGING INFORMATION for the mounting condition.

■RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS
V_{IN} Voltage	V_{IN}	0.0	-	28.0	V
BAT Voltage	V_{BAT}	0.0	-	V_{CV}	V
CSO Voltage	V_{CSO}	0.0	-	6.0	V
CSO Current	I_{CSO}	0.0	-	6	mA
Wake-Up Voltage	V_{WAKEUP}	0.0	-	V_{CV}	V
CHG/BATmonEN Voltage	$V_{CHG}/V_{BATmonEN}$	0.0	-	6.0	V
SHDN Voltage	V_{SD}	0.0	-	6.0	V
BATMON Voltage (Functions B,D,E)	V_{BATMON}	0.0	-	6.0	V
BATMON Current (Functions B,D,E)	I_{BATMON}	0.0	-	3	mA
Charge Current Range	I_{CHG}	1	-	25	mA
ISET Resistor	R_{SET}	1.95	-	46	kΩ
Operating Ambient Temperature	Topr	-40	-	85	℃

All voltages are described based on the V_{SS}.

■ELECTRICAL CHARACTERISTICS

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
INPUT VOLTAGE and CURRENTS							
Input Voltage Range	V_{IN}		V_{UVLOR}	5.0	28.0	V	-
Input Operating Voltage Range	V_{IOVR}	Charge is possible to Vcv	4.5	5.0	28.0	V	①
Supply Current	I_{SS}	V_{IN} to V_{SS}, V_{IN}=5V, I_{OUT}=0mA	-	330	460	μA	①
BAT Sink Current at Charge Completion	I_{BSC}	V_{BAT}=4.5V, Charge Completion	-	3.0	6.0	μA	①
BAT Sink Current at Battery Power Mode	I_{BSB}	V_{IN}=V_{SHDN}=0V, I_{OUT}=0mA, BATMON:Open, Wake-Up:Open	-	3.0	6.0	μA	①
BAT Sink Current at Shutdown Mode	I_{BSD}	V_{IN}=0V, Wake-Up:Open, Shutdown Mode	-	10	30	nA	①
CURRENT-PATH MANAGEMENT and INPUT CURRENT LIMIT							
Input Current Limit	I_{INL}		85	110	140	mA	④
PMID Regulation Voltage	V_{PMID}	I_{IN}=60mA	4.6	4.8	5.0	V	②
Discharge Resistance for PMID	R_{PMID_DSCH}		-	25	-	kΩ	⑤
Input Driver On Resistance	R_{VIN}	V_{IN}=4.5V, I_{OUT}=70mA, I_{BAT}=0mA	-	-	2.0	Ω	②
Output Line Switch On Resistance	R_{OUT}	I_{OUT}=70mA, From PMID to OUT	-	0.65	0.85	Ω	②
Discharge Resistance for OUT at Shutdown Mode	R_{OUT_DSCH}	OUT=4.5V	-	300	-	Ω	⑤
BATTERY CHARGE							
Charge Driver On Resistance	R_{CHG}	V_{BAT}=4.2V, From BAT to PMID	-	1.2	1.5	Ω	④
Charge Voltage Range	V_{CV}	Selectable 50mV increments	3.8	-	4.4	V	③
Charge Voltage Accuracy	V_{CVA}	I_{BAT}=2mA	-20	-	20	mV	③
Charge Voltage On Hot Operation	V_{CVH}	I_{BAT}=2mA, Type A	-	V_{CV} x 0.965	-	V	③
Recharge Threshold Voltage	V_{RC}		-	V_{CV}-0.1 or V_{CVH}-0.1	-	V	①
Trickle Charge Threshold Voltage	V_{TRK}	V_{BAT} Rising	2.80	2.90	3.00	V	①
Trickle Charge Hysteresis Voltage	V_{TRKH}		-	100	-	mV	①
Charge Current Range	I_{CHG}		1	-	25	mA	-
Charge Current (MIN.)	I_{CHGMIN}	R_{SET}=46kΩ, V_{BAT}=3.6V	0.85	1.00	1.15	mA	①
Charge Current (TYP.)	I_{CHGTYP}	R_{SET}=4.79kΩ , V_{BAT}=3.6V	9.0	10.0	11.0	mA	①
Charge Current (MAX.)	I_{CHGMAX}	R_{SET}=1.95kΩ, V_{BAT}=3.6V	22.5	25.0	27.5	mA	①
Charge Current On Cold Operation (MIN.)	$I_{CHGCMIN}$	R_{SET}=46kΩ, Type A,B	0.4	0.5	0.6	mA	①
Charge Current On Cold Operation (MAX.)	$I_{CHGCMAX}$	R_{SET}=1.95kΩ, Type A,B	10.0	12.5	15.0	mA	①
Charge Completion Current (MIN.)	I_{COMIN}	R_{SET}=46kΩ	0.07	0.10	0.14	mA	①
Charge Completion Current (MAX.)	I_{COMAX}	R_{SET}=1.95kΩ	2.125	2.500	3.125	mA	①
Trickle Charge Current (MIN.)	$I_{TRKLMIN}$	R_{SET}=46kΩ, V_{BAT}=2.7V	0.08	0.10	0.12	mA	①
Trickle Charge Current (MAX.)	$I_{TRKLMAX}$	R_{SET}=1.95kΩ, V_{BAT}=2.7V	2.00	2.50	3.00	mA	①

Unless otherwise stated, V_{IN}=5V, C_{PMID}=1μF

■ELECTRICAL CHARACTERISTICS

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
BATTERY VOLTAGE MONITOR							
Battery Voltage Monitor Output	V_{BATMON}	Functions A,C,F,G,H,J	-	0.2 x V_{BAT}	-	V	①
Battery Voltage Monitor Output Accuracy	$V_{BATMONA}$	Functions A,C,F,G,H,J	-5.0	-	5.0	%	①
Battery Voltage Monitor Output Current	I_{BATMON}	Functions A,C,F,G,H,J	-5.0	-	5.0	μA	②
Battery Voltage Monitor Supply Current	I_{SSBM}	Functions A,C,F,G,H,J From PMID, BATmonEN="H"	-	0.55	0.80	μA	①
Battery Voltage Monitor Output Discharge Shunt Resistance	$R_{BATMONDCR}$	Functions A,C,F,G,H,J BATMON=1.0V	-	1.0	-	kΩ	②
Low Battery Monitor Voltage Threshold	V_{BAT_LBMVT}	Functions B,D,E	2.95	3.00	3.05	V	②
Low Battery Monitor Voltage Hysteresis	$V_{BAT\_LBMVHYS}$	Functions B,D,E	-	80	-	mV	②
Low Battery Monitor Output Resistance	R_{LBMV}	Functions B,D,E BATMON=1.0V	-	1.0	-	kΩ	②
PROTECTION							
UVLO Release Voltage	V_{UVLOR}	V_{IN} rising	3.4	3.6	3.8	V	①
UVLO Detect Voltage	V_{UVLOD}	V_{IN} falling from above V_{UVLOR}	-	V_{UVLOR} - 0.1	-	V	①
Battery Over Discharge Voltage Lockout Threshold	V_{BAT_DOVP}		2.70	2.80	2.90	V	①
Battery Over Discharge Voltage Lockout Hysteresis (*1)	$V_{BAT\_DOVPHYS}$		-	88	-	mV	①
Battery Reverse Current Protection Threshold	V_{BAT_REVTH}	V_{IN}-V_{BAT}, V_{IN} falling	-	60	-	mV	①
OUT Short Circuit Current Threshold	I_{OUTSCC}	V_{PMID} > 2.5V	70	150	300	mA	②
OUT Short Circuit Current Deglitch Time	t_{DET_OUTSCC}		-	6.0	-	ms	②
OUT Short Circuit Current Auto Recovery Time	t_{RCVR_OUTSCC}		-	2.0	-	s	②
Thermal Control Start Temperature (*1)	T_{CS}		-	90	-	℃	①
Thermal Control END Temperature (*1)	T_{CE}	I_{IN} less than 1.5mA	-	-	110	℃	①
SHDN, Wake-Up and CHG/BATmonEN							
SHDN "L" Voltage	V_{SDL}		V_{SS}	-	0.3	V	①
SHDN "H" Voltage	V_{SDH}		1.1	-	6.0	V	①
SHDN Pull-down Resistance	R_{SD}		-	110	-	kΩ	①
Wake-Up "L" Voltage	V_{WAL}		V_{SS}	-	0.3	V	①
Wake-Up Pull-up Resistance	R_{WA}		300	-	-	kΩ	①
CHG/BATmonEN "L" Voltage	V_{BML}	Functions A,C,F,G,H,J	V_{SS}	-	0.3	V	①
CHG/BATmonEN "H" Voltage	V_{BMH}	Functions A,C,F,G,H,J	1.1	-	6.0	V	①
CHG/BATmonEN Pull-down Resistance	R_{BM}	Functions A,C,F,G,H,J	7.5	-	-	MΩ	①

Unless otherwise stated, V_{IN}=5V, C_{PMID}=1μF

(*1) Design target

■ELECTRICAL CHARACTERISTICS

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
NTC MONITOR (*3)							
THIN Connected Resistance	R_{THIN}	V_{THIN}=0V	9.8	10.0	10.4	kΩ	①
THIN Open Voltage	V_{THIN_OPEN}	Type A,B,C	1.94	2.00	2.06	V	⑤
Battery Connect Detection (*1)	V_{TD}	Type A,B,C	77.0	80.0	83.0	%(*2)	-
Battery Remove Detection (Hysteresis) (*1)	V_{TDH}	At temperature fall	-	3.0	-	%(*2)	-
Thermistor Detection at 0℃	V_{T0}	Type A,B,C	71.13	73.13	75.13	%(*2)	①
Thermistor Detection Hysteresis at 0℃ (*1)	V_{T0H}	At temperature rise	-	2.0	-	%(*2)	①
Thermistor Detection at 10℃	V_{T10}	Type A,B	62.19	64.19	66.19	%(*2)	①
Thermistor Detection Hysteresis at 10℃ (*1)	V_{T10H}	At temperature fall	-	2.0	-	%(*2)	①
Thermistor Detection at 45℃	V_{T45}	Type A,B,C	30.96	32.96	34.96	%(*2)	①
Thermistor Detection Hysteresis at 45℃ (*1)	V_{T45H}	At temperature fall	-	2.0	-	%(*2)	①
Thermistor Detection at 60℃	V_{T60}	Type A	21.16	23.16	25.16	%(*2)	①
Thermistor Detection Hysteresis at 60℃ (*1)	V_{T60H}	At temperature fall	-	2.0	-	%(*2)	①

Unless otherwise stated, V_{IN}=5V, C_{PMID}=1μF

(*1) Design target

(*2) The comparator detect voltage and hysteresis width are indicated as percentages of V_{THIN_OPEN}.
$V_{Txx} = V_{Txx'} / V_{THIN\_OPEN}$ ($V_{Txx'}$: The voltage when the charging voltage or charging current is changed by sweeping the voltage when the external voltage applied to the THIN)

(*3) Type N does not include thermistor temperature monitoring function and Battery detection function.

■ELECTRICAL CHARACTERISTICS

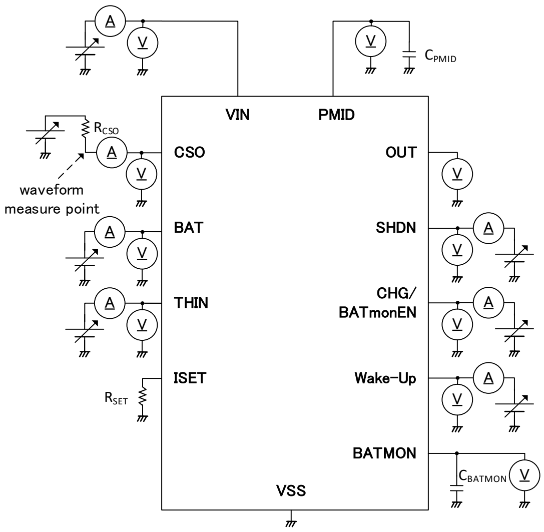
Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
Battery Charging Timers							
Trickle Charge Hold Time (*1)	t_{TRK}		-	0.5	-	hr	①
Main Charge Hold Time (*1)	t_{CHG}		-	10	-	hr	①
Push Button Timer							
Wake-Up Deglitch Time	t_{WUD}		-	256	-	ms	①
System Timers							
Start Up Time (*1)	t_{START}	To Start Charging	-	50	-	ms	①
Charge Completion Deglitch	t_{DGL_COMP}		-	30	-	ms	①
Recharge Detect Deglitch	t_{DGL_RECHG}		-	30	-	ms	①
Trickle Detect Deglitch	$t_{DGL\_TRICKLE}$		-	30	-	ms	①
CSO Battery LED Indicator (Functions A,B,C,D,H)							
Charge	f_{CSO_CHG}	CSO Nch Open Drain = ON	-	ON	-	-	①
Complete	f_{CSO_COMP}		-	OFF	-	-	①
Error	f_{CSO_ERR}		6.5	8.0	9.0	Hz	①
No Battery	f_{CSO_NOBAT}	CSO Nch Open Drain = OFF	-	OFF	-	-	①
CSO On Voltage	V_{CSOON}	I_{CSO}=1mA	-	-	0.5	V	④
CSO Leakage Current	I_{LCSO}	V_{CSO}=5.5V	-	-	0.1	μA	①
CSO Battery Status Indicator (Functions E,F,G,J)							
Battery Charging less than 60%	f_{CHG_L}		26	32	40	kHz	①
Battery 60% Charging	f_{CHG_60PER}		13	16	19	kHz	①
Battery 90% Charging	f_{CHG_90PER}		6.0	8.0	10.0	kHz	①
Charge Complete Status	f_{CHG_COMP}		3.0	4.0	5.0	kHz	①
Error Status	f_{CHG_ERR}		0.8	1.0	1.2	kHz	①
No Battery	f_{CHG_NOBAT}	CSO Nch Open Drain = OFF		OFF			①
Battery 60% Charging Threshold Voltage	V_{CHG_60PER}		3.680	3.720	3.777	V	①
Battery 90% Charging Threshold Voltage	V_{CHG_90PER}		4.04	4.08	4.12	V	①
CSO Sink Current (*1)	I_{CSO_STATE}	Constant current control	-	1.0	-	mA	①

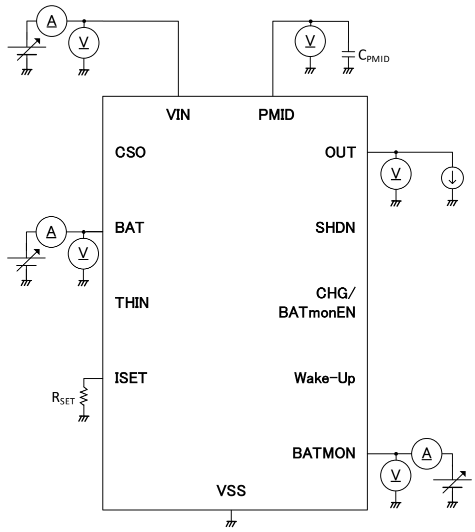
Unless otherwise stated, V_{IN}=5V, C_{PMID}=1μF
(*1) Design target

■TEST CIRCUITS

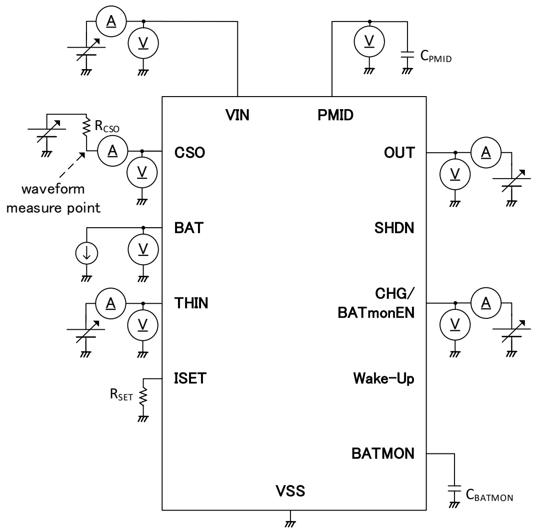
1) Test Circuit①



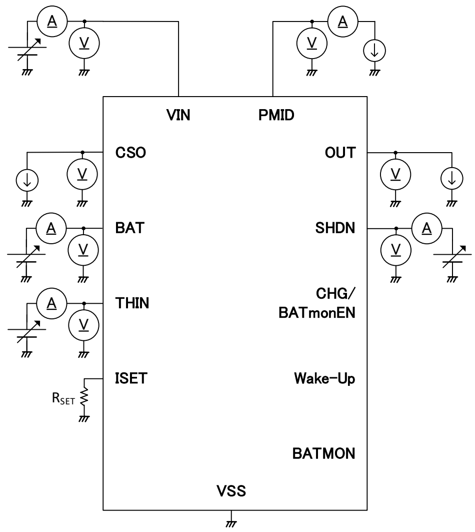
2) Test Circuit②



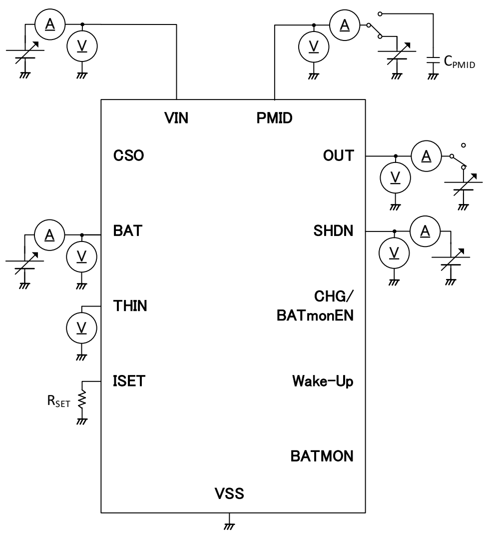
3) Test Circuit③



4) Test Circuit④



5) Test Circuit⑤



■OPERATIONAL EXPLANATION

<Operation Mode >

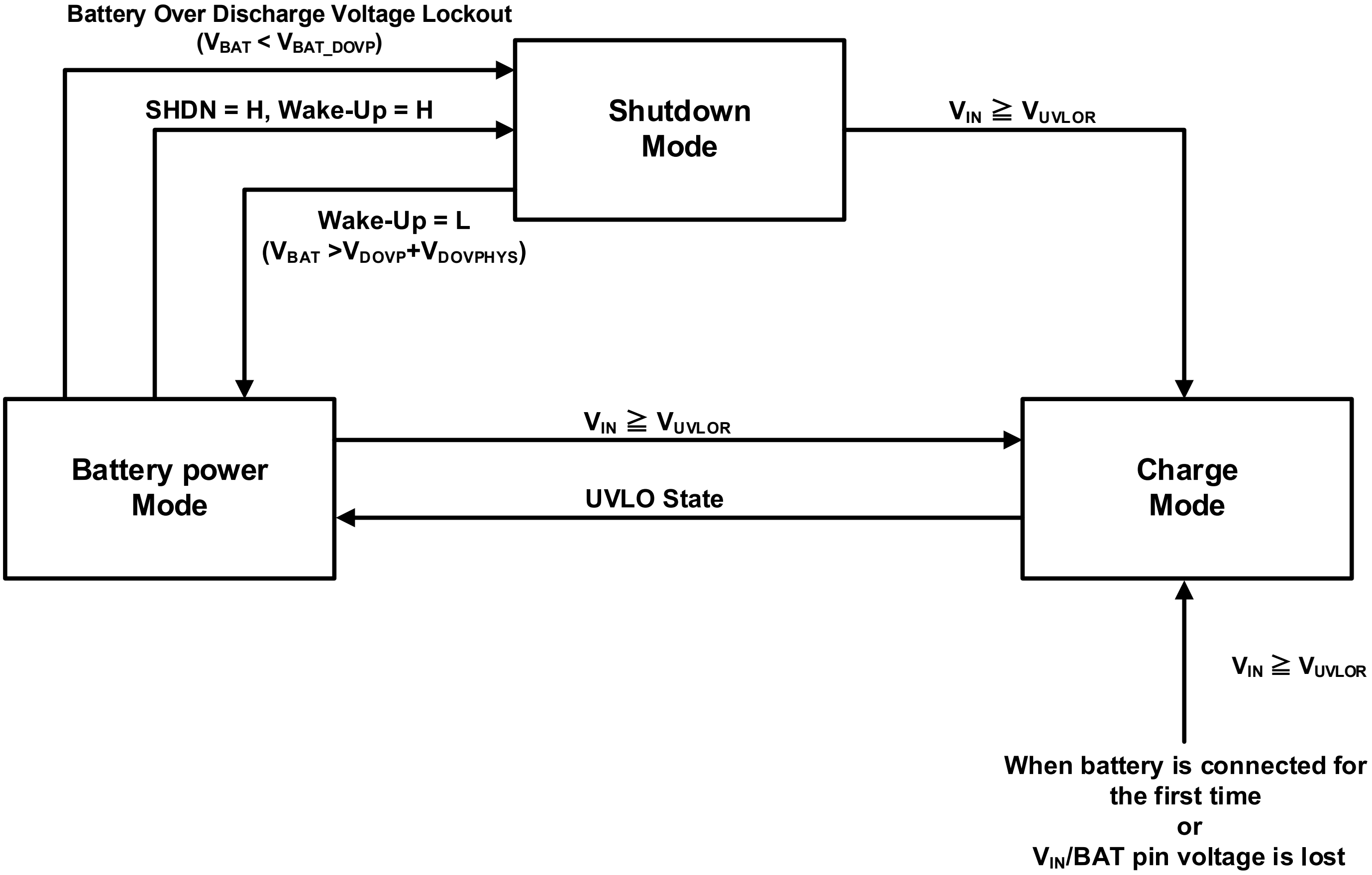


Figure 1. Mode State Diagram1

■When the battery is connected for the first time and V_{IN} / BAT voltage is lost in Mode State.

If a Li-ion battery is connected to BAT pin for the first time, when the voltage of V_{IN} / BAT is lost, the operation mode inside the IC will be undefined.

To determine the operation mode, input a voltage to VIN after connecting the Li-ion battery to release the UVLO. It shifts to Charge Mode and confirms the operation mode.

■OPERATIONAL EXPLANATION

< Operation Mode >

Table 1. Operation Mode Function List

Operation Mode	Functions	Switch State			Pin State and Voltage Path		
		V_{IN}-PMID	PMID-BAT	PMID-OUT	PMID	BAT	OUT
Shutdown Mode	-	OFF	OFF	OFF	GND	Open	GND
Battery Power Mode	-	OFF	ON	ON	from BAT	from Battery	from PMID
Charge Mode	A,B,E,F	ON	ON	OFF	from V_{IN} and BAT	from / to Battery	GND
	C,D,G,H,J			ON			from PMID

■Shutdown Mode State

Shutdown Mode significantly reduces the battery current consumption.
In Shutdown Mode, the Pch driver between the BAT and PMID is turned off to shut off the battery and system.

When V_{IN} becomes less than 3.5V (V_{UVLOD}) or BAT voltage, UVLO function is operating and the condition (a) or (b) is satisfied, the mode changes to Shutdown Mode.

(a) Shutdown function operates during Battery Power Mode
(Wake-Up="H" (OPEN or "H" voltage is input) and SHDN="H")

(b) Battery over-discharge voltage protection function operates during Battery Power Mode
(The BAT voltage falls below the over-discharge voltage threshold of 2.8V (V_{BAT_DOVP})).

The way for shift from Shutdown Mode to another mode is as follows.

(c) The UVLO state is released and shift to Charge Mode
(When V_{IN} rises above 3.6V (V_{UVLOR}) and BAT voltage)

(d) The wake-up function is operated and shift to Battery Power Mode.
(When V_{BAT}＞ (V_{BAT_DOVP} + $V_{BAT\_DOVPHYS}$) and input to Wake-Up="L" continuously for 256ms.)

■Battery Power Mode State

In Battery Power Mode, the battery voltage is output from the OUT through the built-in Line Switch between the PMID and the OUT.

The way for shift from Battery Power Mode to another mode is as follows.

(e) When the battery over-discharge voltage protection function is operates, it shifts to Shutdown Mode.
(Battery voltage falls below over-discharge voltage threshold 2.8V (V_{BAT_DOVP}) for 256ms)

(f) After releasing UVLO, it shifts to Charge Mode.

■Charge Mode State

Charge Mode is an operation mode for charging a Li-ion battery.

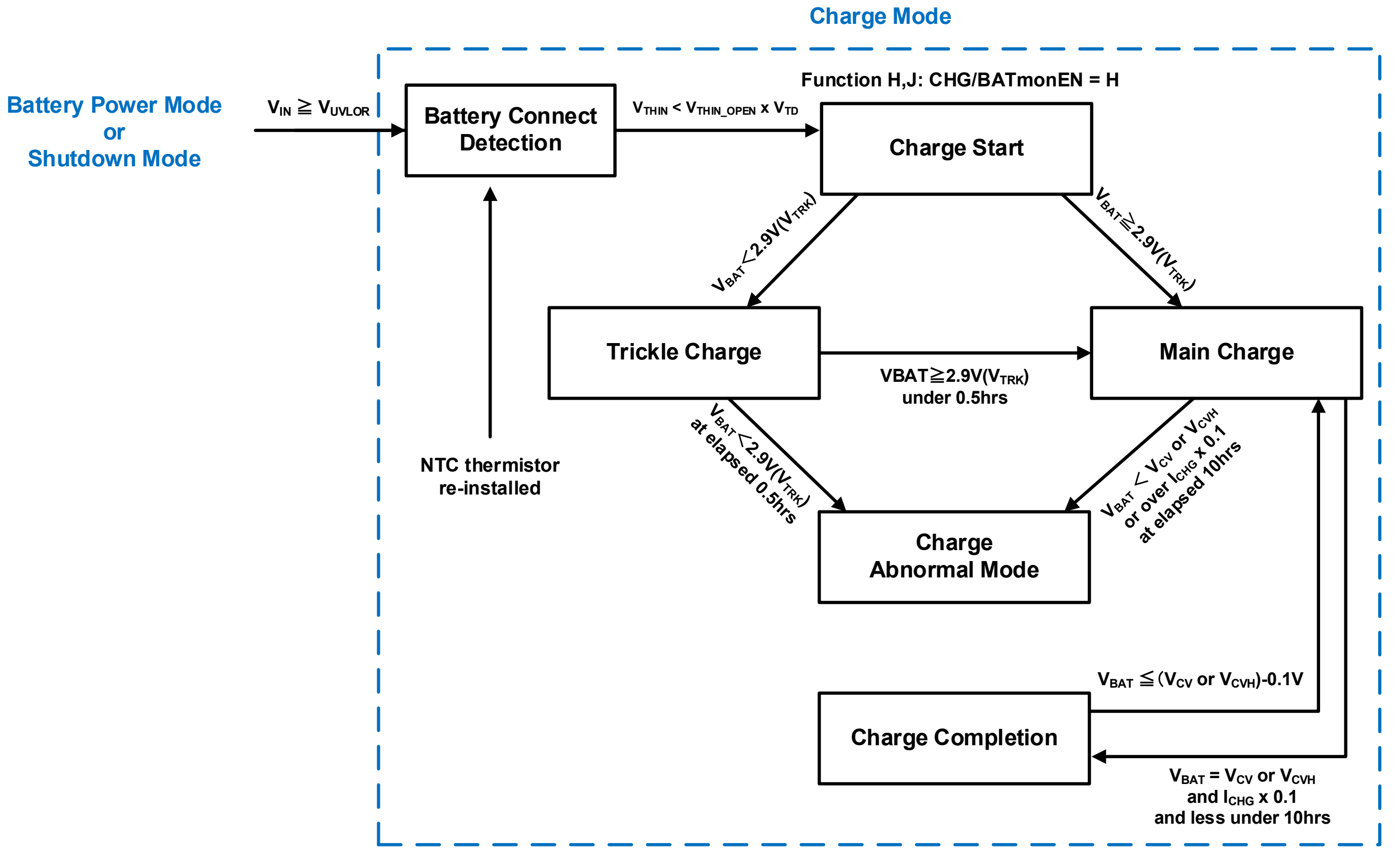
After shifting from another mode to Charge Mode by releasing UVLO, when battery connection detection (V_{TD}) is operates, charging will start after 50ms (t_{START}). If it shift from another mode to Charge Mode, the previous charge status and timer information will not be inherited.

In functions A,B,E,F, the built-in Line Switch is linked to the UVLO function. When the UVLO release state ($V_{IN} \geqq V_{UVLOR}$) is reached, the Line Switch is turned off and the power supply to the OUT is cut off.

In functions C,D,G,H,J, supply power to the OUT to turn on the Line Switch.

■OPERATIONAL EXPLANATION

＜Charge function (Charge Mode details)＞



■Charge Mode State

●Trickle charging

If the BAT voltage is less than 2.9V (V_{TRK}), the Li-ion battery will be charged with one-tenth of the main charging current. If the BAT voltage rises to 2.9V (V_{TRK}) within 0.5hours (t_{TRK}), it shifts to main charging after 30ms($t_{DGL\_TRICKLE}$). If the BAT voltage is less than 2.9V(V_{TRK}) after 0.5hours(t_{TRK}), the IC changes to the error state and stops charging the Li-ion battery.

●Main charging

When the condition for transition from trickle charging to the main charging is satisfied, the Li-ion battery is charged with the charging current set by the external resistance (R_{SET}) connected to the ISET. If BAT voltage rises to the charge voltage (V_{CV} or V_{CVH}) within 10hours(t_{CHG}), the charging current drops to one-tenth of the charging current set by the external resistor (R_{SET}), and after 30ms(t_{DGL_COMP}) elapses, the state changes to charge completed and charging stops.

If the charge current is higher than the charge completed current after 10hours(t_{CHG}), an error state occurs and charging stops. The main charging current can be set between 1mA (I_{CHGMIN}) and 25mA (I_{CHGMAX}) with an external resistor (R_{SET}). The charging current value (I_{CHG}) set by R_{SET} is approximated by the following formula.

$$I_{CHG}\ [\text{mA}] = 46 / R_{SET}\ [\text{k}\Omega]$$

●Charging completed

In main charging, the BAT voltage rises to the charging voltage (V_{CV} or V_{CVH}) within 10hours (t_{CHG}), and the charging current drops to one-tenth of the charging current set by the external resistor (R_{SET}). Then, after 30ms (t_{DGL_COMP}) has elapsed, the IC changes to the charging completed state.

When the charging is complete, the Li-ion battery will stop charging.

●Recharge Function

When the BAT voltage drops from the charging voltage (V_{CV} or V_{CVH}) to the recharging voltage V_{CV}-0.1 or V_{CVH}-0.1V (V_{RC}) after charging is completed, charging automatically resumes after 30ms (t_{DEG_RECHG}) elapsed.

●Error state

If trickle charging has elapsed for 0.5hours (t_{TRK}) or main charging has elapsed for 10hours (t_{CHG}), it is determined that there is an abnormal condition and charging stops.

■OPERATIONAL EXPLANATION

● Current Path Function (Functions C,D,G,H,J)

During charging, power is supplied to the system through the OUT and charging to the Li-ion battery at the same time.

● Charge Control Function (Functions H,J)

Functions H and J charge the Li-ion battery connected to the BAT while applying the “H” voltage(V_{BMH}) to the CHG/BATmonEN. When the "L" voltage (V_{BML}) is applied to the CHG/BATmonEN or the internal pull-down resistance (R_{BM}) reaches the "L" voltage in the High impedance state, charging is stopped and the timer count is paused.

When the CHG/BATmonEN is set to “H” voltage again, charging will continue from the charge state and timer when it was set to "L" before.

● Li-ion battery (NTC thermistor) temperature monitoring / battery connection detection (Type A,B,C)

<u>Battery connection detection (NTC thermistor connection detection)</u>

If the Li-ion battery has a built-in NTC thermistor, the connection of the NTC thermistor is detected by monitoring the THIN voltage. When the THIN voltage falls below 80.0% (V_{TD}) of V_{THIN_OPEN}, it is recognized that the battery is connected and the battery connection is detected.

If the THIN voltage higher than 83.0% (V_{TD}+V_{TDH}) of V_{THIN_OPEN} by removing the Li-ion battery etc., charging will stop, but Charge Mode will be maintained.

If the THIN voltage drops below 80.0% (V_{TD}) of V_{THIN_OPEN} again, charging will start again after 50ms (t_{START}) has elapsed. However, in this case, the charging status and timer information will not be inherited.

<u>Li-ion battery temperature monitoring function</u>

For Type A,B and C by monitoring the THIN voltage, the temperature of the Li-ion battery can be monitored via the NTC thermistor connected to the THIN. The charging current and charging voltage are controlled by the temperature of the Li-ion battery for safe charging.

Please refer to the following pages for the operation details of each type.

NTC temperature detection conforms to the characteristics of Murata NCP15XH103F03RC.

・Battery Power Mode NTC thermistor / temperature monitoring

Normally, the voltage output from the THIN is output only in Charge Mode, and temperature monitoring using the NTC thermistor is possible only in Charge Mode.

For Battery Power Mode, there is no output from the THIN.

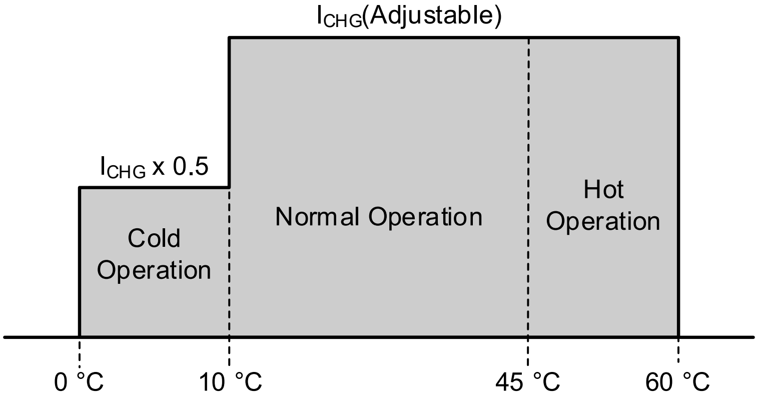
However, since the FET between the THIN and the reference voltage is turned off, it is possible to apply the voltage to the NTC thermistor from the outside.

This makes it possible to monitor the temperature of Li-ion battery using an NTC thermistor even during the Battery Power Mode, and it is possible to monitor the battery temperature by MCU etc.

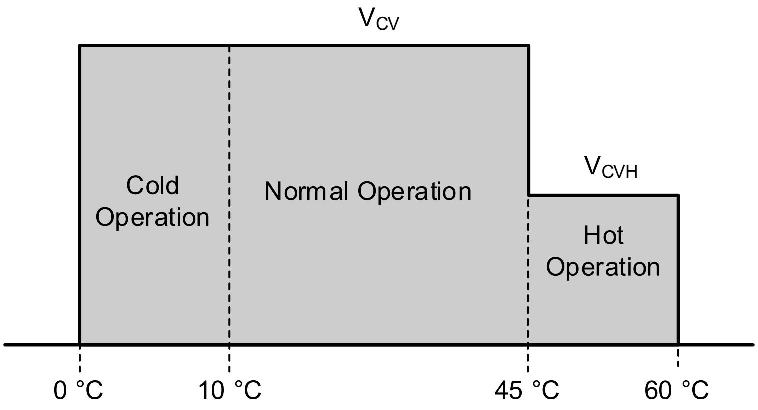
■OPERATIONAL EXPLANATION

Li-ion battery temperature monitoring function (Continued)

■Type A (4 temperatures monitoring,0℃, 10℃, 45℃, 60℃)



Charge Current vs. Thermistor Temperature (Type A)



Charge Voltage vs. Thermistor Temperature (Type A)

Cold Operation

When (V_{T0})<Thermistor Temperature≦10℃(V_{T10}) , the charge current is limited to I_{CHG} × 0.5.
During Cold Operation, the charge current is limited to I_{CHG}× 0.1.
When Thermistor Temperature≦0℃(V_{T0}), the charging and timer counting are temporarily stopped.
The CSO outputs the charge state even while charging is stopped.

Normal Operation

When 10℃(V_{T10})<Thermistor Temperature<45℃(V_{T45}), charging takes place with the charge current I_{CHG} and the charge voltage at V_{CV}.

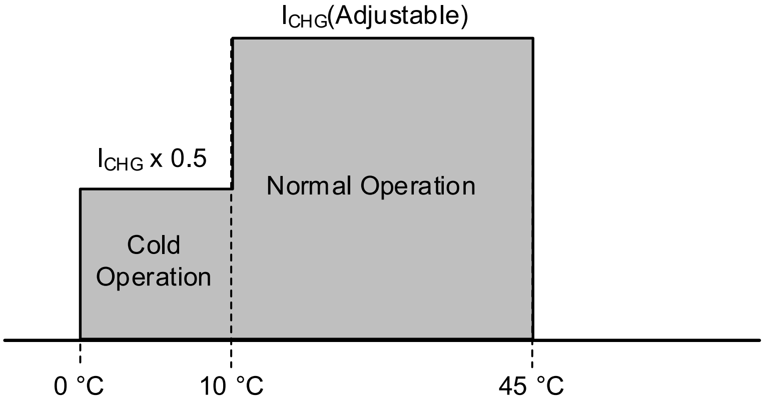
Hot Operation

When 45℃(V_{T45})≦Thermistor Temperature<60℃(V_{T60}), the charge voltage changes to V_{CVH} and charging continues.
When 60℃(V_{T60}) ≦Thermistor Temperature, charging and timer counting are temporarily stopped.
The CSO outputs the charge state even while charging is stopped.

■OPERATIONAL EXPLANATION

Li-ion battery temperature monitoring function (Continued)

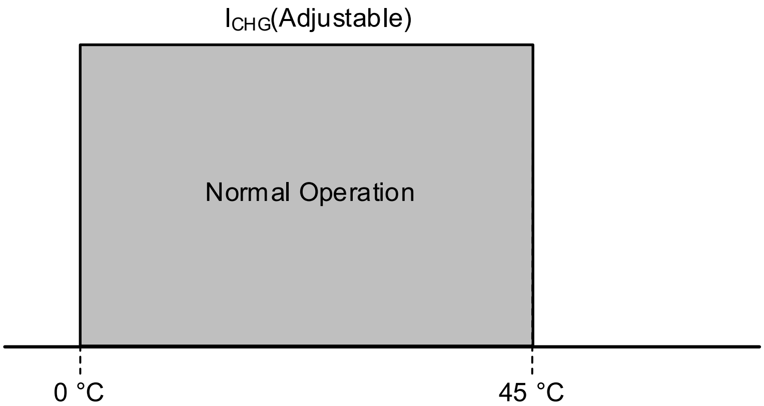
■ Type B (3 temperatures monitoring,0℃, 10℃, 45℃)



Charge Voltage vs. Thermistor Temperature (Type B)

Comparing to the type A, type B does not monitor at 60°C, charging and timer counting are temporarily stopped at 45℃≦ Thermistor Temperature. The CSO outputs the charge state even while charging is stopped.

■Type C (2 temperatures monitoring, 0℃, 45℃)



Charge Voltage vs. Thermistor Temperature (Type C)

Comparing to the type A, type C does not monitor at 10℃(V_{T10}) and 60℃(V_{T60}), when Thermistor Temperature≦0℃(V_{T0}) or Thermistor Temperature≧45℃(V_{T45}), charging and timer counting are temporarily stopped. The CSO outputs the charge state even while charging is stopped.

■OPERATIONAL EXPLANATION

<Shutdown Function / Wake Up Function>

■Shutdown Function

When the V_{IN} is less than 3.5V (V_{UVLOR}) or the Li-ion battery voltage, the UVLO function is active. When a "H" level voltage (V_{SDH}) is input to the SHDN in this state, it shifts to Shutdown Mode on its rising edge. During Shutdown Mode operates, the P-channel driver between the BAT and PMID is turned off to disconnect the battery and system.

The SHDN has a built-in pull-down resistor (R_{SD}).

■Wake Up Function

When the V_{IN} is higher than 3.6V (V_{UVLOR}) and the Li-ion battery voltage, the UVLO function is released. the Shutdown function is released. Or, if the V_{IN} is lower than 3.5V (V_{UVLOR}) or the BAT voltage (V_{BAT}) is higher than 2.888V (V_{BAT_DOVP} + $V_{BAT\_DOVPHYS}$), When a "L" level voltage (V_{WAL}) is continuously input to the Wake-Up for 256ms (t_{WUD}) or longer, the device shifts to Battery Power Mode.

The Wake-Up has a built-in pull-up resistor (R_{WA}).

<Protection Function>

■Input Current Limit Function

The input current is limited to 110mA (I_{INL}) by the Pch driver flowing between the V_{IN} and the PMID.

■UVLO Function

When the V_{IN} falls below 3.5V (V_{UVLOD}) or below the Li-ion battery voltage, UVLO is detected. The Pch driver between the V_{IN} and the PMID is turned off. The device shifts to Battery Power Mode, and charging stops.

When the V_{IN} is higher than 3.6V (V_{UVLOR}) and the Li-ion battery voltage, UVLO is released. The device shifts to Charge Mode.

■ Thermal Control Function

A thermal control function is built in to prevent destruction and thermal runaway due to IC heat generation.

When the chip temperature reaches 90°C (T_{CS}), the input current limit is reduced. Even if the thermal control function works, it does not enter an abnormal state and the CSO output does not change.

■Reverse Current Prevention Function

To prevent reverse current from the Li-ion battery to charger, the voltage difference between the BAT voltage (V_{BAT}) and the V_{IN} voltage are monitored. When the V_{IN} voltage drops to V_{BAT} + 60mV (V_{BAT_REVTH}), the Pch driver between the V_{IN} and the PMID is turned off. It also prevents reverse current flow to the V_{IN} side through the parasitic diode of the Pch driver.

When the V_{IN} voltage exceeds V_{BAT} + 60mV (V_{BAT_REVTH}), this function is released and the Pch driver is turned ON.

■Battery Over Discharge Protection Function

During Battery Power Mode period, if the Li-ion battery voltage falls below 2.8V (V_{BAT_DOVP}) for 256ms continuously, the device enters Shutdown Mode.

In Shutdown Mode, the Pch driver between the BAT and PMID is turned off to disconnect the battery and system.

The battery over-discharge voltage protection function is released when a voltage of 3.6V (V_{UVLOR}) or more is applied to the V_{IN} and the UVLO is released.

■Output Terminal Short Protection

When a current is higher than the over discharge current (I_{OUTSCC}) flows through the Line Switch between the PMID and OUT for 6ms (t_{DEG_OUTSCC}). Line Switch is turned off once and turned on again after 2s (t_{RCVR_OUTSCC}).

■OPERATIONAL EXPLANATION

Table 2. Each function Supported operating modes

Function	Operation Mode			Status after detection
	Shutdown Mode	Battery Power Mode	Charge Mode	
Input Current Limit	-	-	Active	No Change (Limit input current to I_{INL})
UVLO	Active	Active	Active	UVLO State : Battery Power Mode UVLO State → UVLO Release : Charge Mode
Thermal Control	-	-	Active	No Change (Limit input current corresponding to Tj)
Battery Reverse Current	-	-	Active	Battery Power Mode
Battery Discharge Voltage Lockout	-	Active	-	Shutdown Mode
OUT Short Circuit	-	Active	Active	No Change (PMID - OUT Line Switch : 2s Period OFF)
Shutdown	-	Available	-	Shutdown Mode
Wake-up	Available	-	-	Battery Power Mode

■OPERATIONAL EXPLANATION

＜Charging status output CSO＞

■Battery LED Indicator Function : Functions A,B,C,D,H

Each charging state is indicated by ON-OFF of CSO (Nch open drain output). Good for displaying charging status with LED drive.

Table 3. CSO output pattern (Functions A,B,C,D,H : Battery LED Indicator)

<table>
<tr><th>STATUS</th><th>Condition</th><th>LED (CSO Output)</th></tr>
<tr><td colspan="2">Trickle Charge</td><td>ON (Low impedance)</td></tr>
<tr><td colspan="2">Main Charge</td><td>ON (Low impedance)</td></tr>
<tr><td colspan="2">Charge Complete</td><td>OFF (High impedance)</td></tr>
<tr><td>Charge Disable Status
(Charge Enable=L, Function H)</td><td>Safety Timer Pause</td><td>OFF (High impedance)</td></tr>
<tr><td>Charge Abnormal State</td><td>Safety Timer Active</td><td>8Hz Oscillation</td></tr>
<tr><td>No Battery (THIN OPEN)</td><td>Safety Timer Pause</td><td>OFF (High impedance)</td></tr>
<tr><td>No Battery (THIN Connected)</td><td>Charge Complete⇔Recharge</td><td>ON⇔OFF</td></tr>
<tr><td>No Power</td><td>UVLO or
Battery Reverse Current Protection</td><td>OFF (High impedance)</td></tr>
<tr><td colspan="2">Shutdown Mode</td><td>OFF (High impedance)</td></tr>
</table>

■OPERATIONAL EXPLANATION

＜Charging status output CSO (Continued)＞

■Battery Status Indicator Function : Functions E,F,G,J

The battery voltage capacity and charge status during charging are shown by turning the CSO ON / OFF at the frequencies shown in Table 4. Good for monitoring the charging status with MCU / SoC.

Regarding the connection of the CSO, if digital output is required to monitor the charging status with the MCU / SoC, connect a pull-up resistor to the CSO.

When notify the input side of charging information using two-wire communication, connect the CSO directly to the V_{IN}.

Since the CSO of Functions E, F, G, and J perform constant current control of 1mA (I_{CSO_STATE}) during ON, the input current is modulated according to the ON-OFF of the CSO to charge the power supply side of the V_{IN} voltage. It is possible to notify the status.

Table 4. CSO output pattern (Functions E,F,G,J : Battery Status Indicator)

STATUS	Condition	CSO
Battery Charging less than 60%		32kHz Oscillation
Battery 60% Charging		16kHz Oscillation
Battery 90% Charging		8kHz Oscillation
Charge Complete Status		4kHz Oscillation
Charge Disable Status (Charge Enable=L, Function H)	Charge Stop Safety Timer Pause	Frequency Oscillation corresponding to Battery Charging
Charge Abnormal State	Safety Timer Active	1kHz Oscillation
No Battery (THIN Open)	Charge Stop Safety Timer Reset	OFF (High impedance)
No Battery (THIN Connected)	Charge Complete⇔Recharge	ON⇔OFF
No Power	UVLO or Battery Reverse Current	OFF (High impedance)
Shutdown Mode		OFF (High impedance)

When the charging voltage of the Li-ion battery is 4.2V, the charging rate is calculated by the following formula.

$$V_{CHG} = (V_{BAT}-3.0V) / (V_{CV}-3.0V) \times 100\ [\%]$$

Table 5 shows a guideline for the charging rate when using a Li-ion battery with a charging voltage other than 4.2V.

Table 5. Examples of V_{CHG},V_{BAT} and STATUS

V_{CV}	Battery Charging less than 60%	Battery 60% Charging	Battery 90% Charging
	V_{BAT} < 3.72V	3.72V ≦ V_{BAT} < 4.08V	4.08V ≦ V_{BAT}
3.80V	V_{CHG} < 90%	90% ≦ V_{CHG}	-
4.20V	V_{CHG} < 60%	60% ≦ V_{BAT} < 90%	90% ≦ V_{CHG}
4.35V	V_{CHG} < 53%	53% ≦ V_{BAT} < 80%	80% ≦ V_{CHG}

＜Battery low voltage notification function / Battery voltage monitor function＞

■Battery low voltage notification function : Functions B,D,E

When the BAT voltage falls below V_{BAT_LBMVT}, the battery is in a low voltage state. The Nch open drain output connected to the BATMON is turned ON and the BATMON is set to ”L”(Low impedance).

When the BAT voltage is higher than V_{BAT_LBMVT} + $V_{BAT\_LBMVHYS}$, the battery low voltage state is released. The Nch open drain output is turned off, and the BATMON is set to "H" (High impedance). This function works regardless of the BATmonEN status.

Table 6. Battery low voltage notification function and charge status and BATMON output

Functions	Mode	BATmonEN	Low Battery State	BATMON Output
B,D,E	Shutdown Mode	-	-	“H” (High impedance)
	Battery Power Mode, / Charge Mode	-	No ($V_{BAT\_LBMVT} + V_{BAT\_LBMVHYS} \leqq V_{BAT}$)	“H” (High impedance)
			Yes ($V_{BAT} < V_{BAT\_LBMVT}$)	“L” (GND)

■ Battery voltage monitor function / Battery voltage monitor Enable / Charge control function : Functions A,C,F,G,H,J

Battery voltage monitor function

During apply a "H" voltage (V_{BMH}) to the BATmonEN, the voltage divided by the BAT voltage (V_{BAT}) can be output from the BATMON to monitor the Li-ion battery voltage.

$$V_{BATMON} = 0.2 \times V_{BAT}$$

If use this function, connect a capacitor 100nF between the BATMON and the V_{SS}.

Battery voltage monitor Enable : Functions A,C,F,G

When a "L" voltage (V_{BML}) is applied to the BATmonEN or the voltage is set to High impedance, the voltage becomes "L" or less due to the internal pull-down resistance (R_{BM}), then the capacitor connected to the BATMON is discharged by the internal pull-down discharge resistor ($R_{BATMONDCR}$).

Table 7. Battery voltage monitor function and charge status and BATMON output

Functions	Mode	BATmonEN	Charge State	BATMON Output
A,C,F,G	Shutdown Mode	-	-	GND or High impedance
	Charge Mode / Battery Power Mode	“H”	No Change	0.2 x V_{BAT}
	Charge Mode / Battery Power Mode	“L”	No Change	GND

Charge control function / Battery voltage monitor Enable : Functions H,J

The Li-ion battery connected to the BAT is charged while a "H" (V_{BMH}) voltage or higher is applied to the CHG/BATmonEN. During apply a "L" (V_{BML}) voltage or less to the CHG/BATmonEN, or put it in the High impedance state, when the internal pull-down resistance (R_{BM}) reaches the “L” voltage, charging is stopped and the timer count is paused.

When apply a "H" voltage to CHG/BATmonEN again, charging will continue from the charge state and timer when it was set to "L" before.

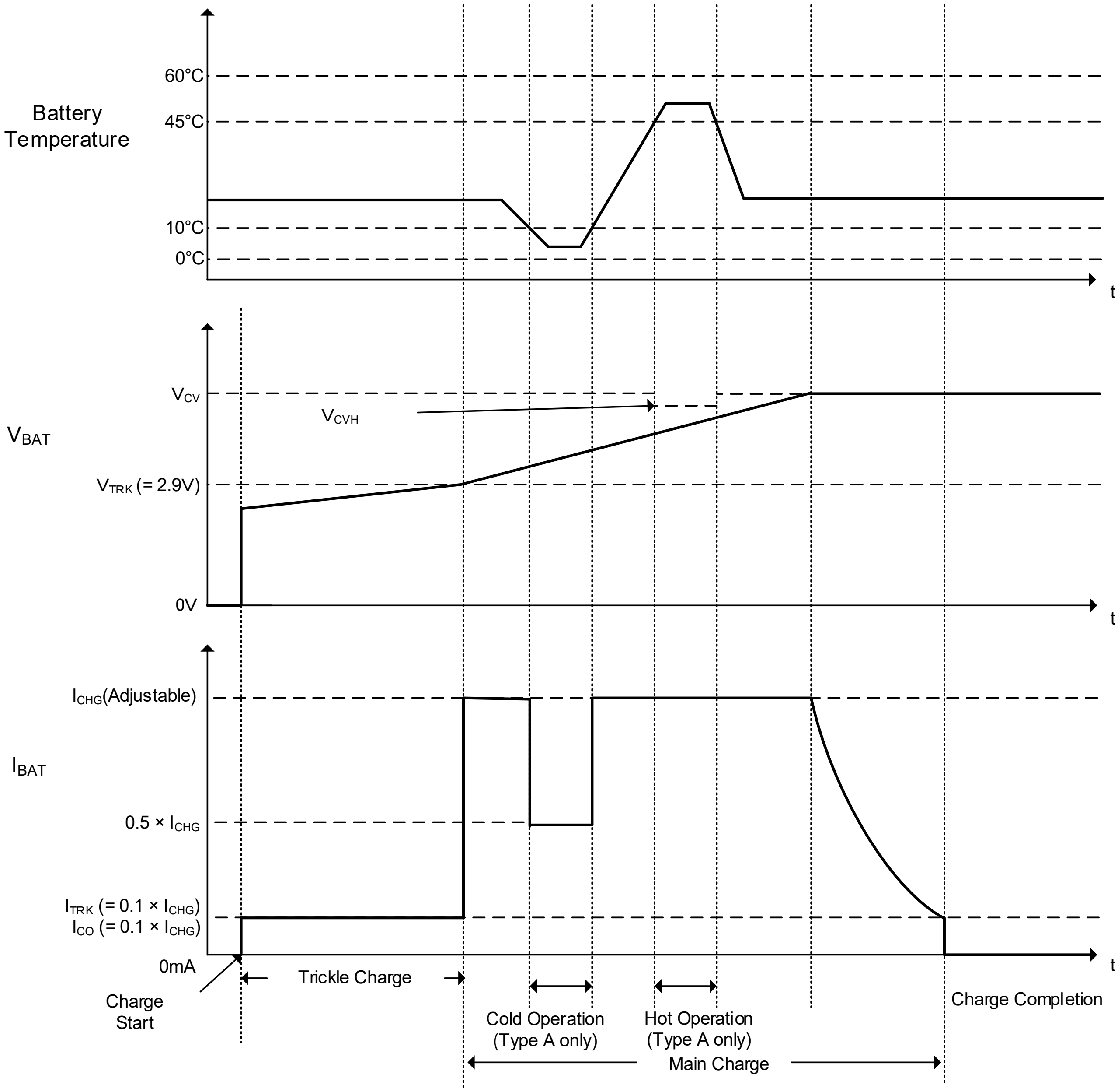
Table 8. Charge control function and charge status and BATMON output

Functions	Mode	CHG/BATmonEN	Charge State	BATMON Output
H,J	Shutdown Mode	-	-	GND or High impedance
	Charge Mode	“H”	Charge Enable	0.2 x V_{BAT}
		“L”	Charge Disable (Timer pause)	GND
	Battery Power Mode	“H”	Charge Disable	0.2 x V_{BAT}
		“L”		GND

■OPERATIONAL EXPLANATION

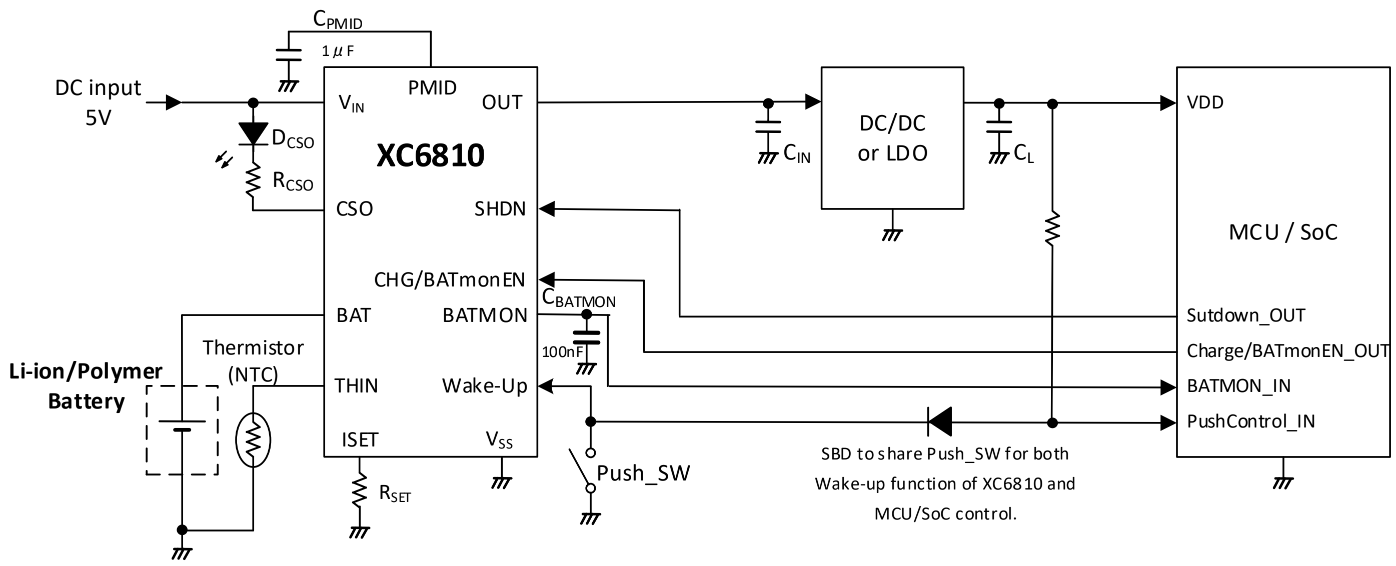
<Charge timing chart>

Type A (4 temperatures monitoring 0℃, 10℃, 45℃, 60℃)



■TYPICAL APPLICATION CIRCUIT

Type A,B,C / Functions H



【Typical Examples】

	FUNCTIONS	MANUFACTURER	PRODUCT NUMBER	Description
C_{PMID} (*1)	-	Murata	GRM033R60J105MEA2	1μF/10V (0.6x0.3x0.35mm)
R_{SET}	-	-	-	1.95kΩ to 46kΩ

	FUNCTIONS	MANUFACTURER	PRODUCT NUMBER	Description
C_{BATMON} (*1,2,3)	A,C,E,F,G,H,J	Murata	GRM155R71E104KE14	100nF/25V (1.0x0.5x0.55mm)
	B,D,E	-	-	-
R_{PULL}	A,C,E,F,G,H,J	-	-	-
	B,D,E	-	-	100kΩ

	FUNCTIONS	MANUFACTURER	PRODUCT NUMBER	Description
R_{CSO}	E,F,G,J	-	-	To MUC/SoC: 100kΩ 2-wire communication: Short
	A,B,C,D,H	-	-	10kΩ
D_{CSO}	A,B,C,D,H	Wurth Elektronik	150 060 RS7 500 0	Emitting Color: Red, VF: 2V

	TYPE	MANUFACTURER	PRODUCT NUMBER	Description
NTC	A,B,C	Murata	NCP15XH103F03RC	Resistance: 10kΩ @ 25°C B-constant (25 - 50°C): 3380K
	N	-	-	-

(*1) Some ceramic capacitors have an effective capacitance that is significantly lower than the nominal value due to the DC bias and ambient temperature.

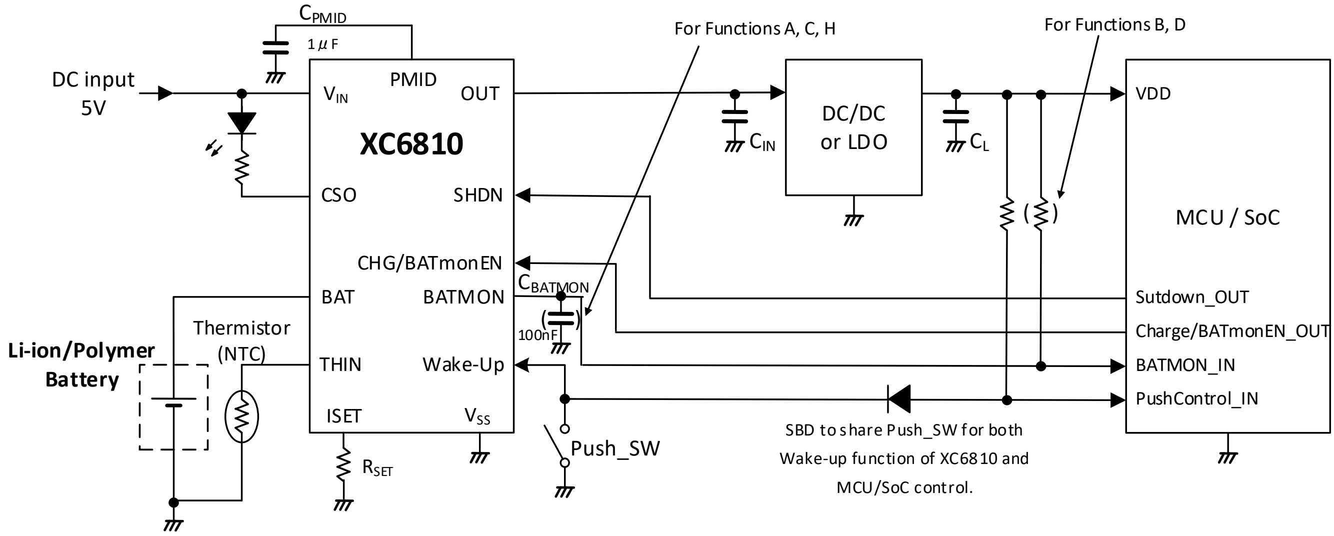
For the capacitance used for this IC, use an appropriate ceramic capacitor according to the DC bias usage conditions (ambient temperature), and make sure that the effective capacitance value is almost the same as the recommended component.

If a capacitor that greatly deviates from the effective capacitance value of the recommended component is used, the terminal voltage of PMID and BATMON may become unstable or the IC may not operate normally.

■APPLICATON CIRCUIT EXAMPLES

(a) DC 5V input : CSO LED drive (Functions A,B,C,D,H)

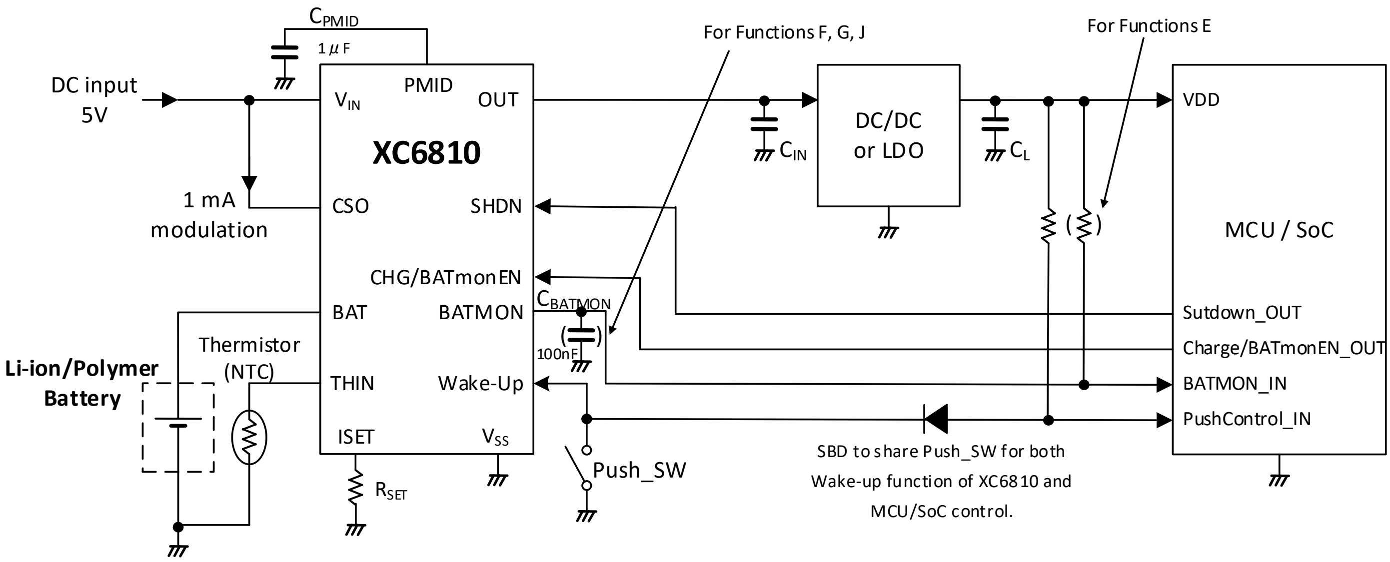
A circuit that connects an LED to the CSO and drives the LED. It is possible to display the charging status by the LED.



Functions	Battery Monitor Output	CSO Output	OUT: DC input Supply ($V_{IN} \geqq V_{UVLOR}$)	OUT: DC input Open (UVLO State)	Charge Enable
A	0.2 x V_{BAT}	Battery LED Indicator	GND	V_{PMID} (=V_{BAT})	No
C			V_{PMID}		
H					Yes
B	Low Battery State : “L” Other State : “H”		GND		No
D			V_{PMID}		

(b) DC 5V input : Two-wire communication (Function E,F,G,J)

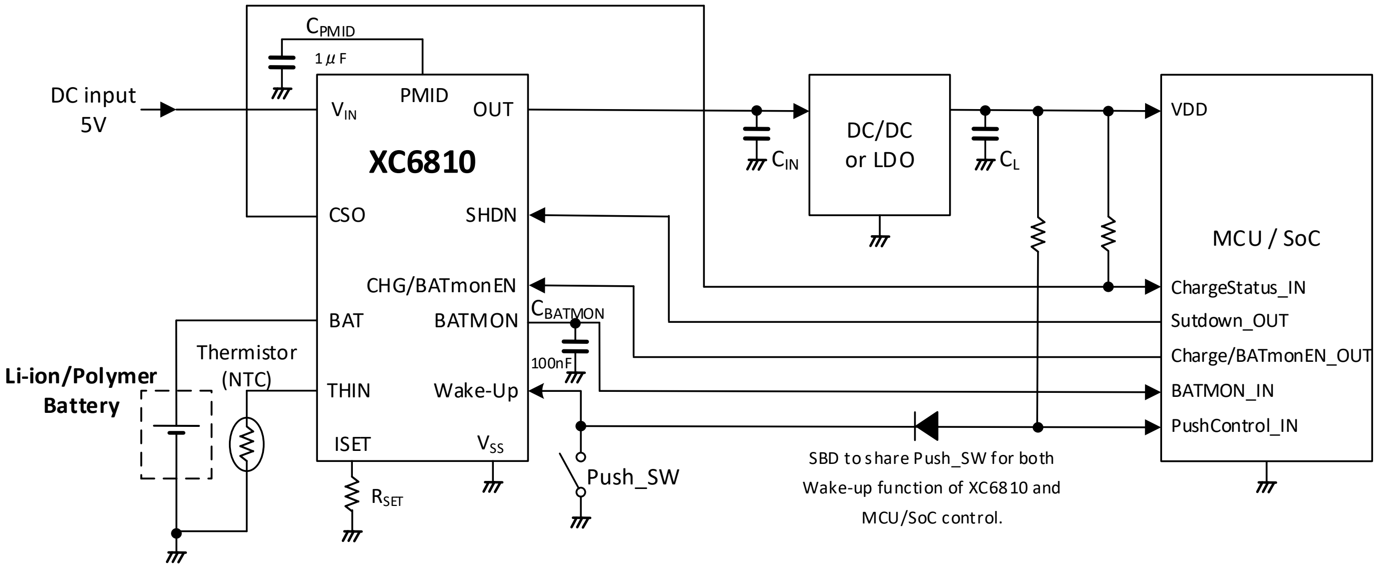
By connecting CSO to DC input, the current from the DC input is modulated, and the cradle can monitor and display the charge status using two-wire communication.



Functions	Battery Monitor Output	CSO Output	OUT: DC input Supply ($V_{IN} \geqq V_{UVLOR}$)	OUT: DC input Open (UVLO State)	Charge Enable
E	Low Battery State : “L” Other State : “H”	Battery Status Indicator	GND	V_{PMID} (=V_{BAT})	No
F	0.2 x V_{BAT}				
G			V_{PMID}		
J					Yes

(c) DC 5V input : Charging level monitoring by MCU using CSO signal (Function G,J)

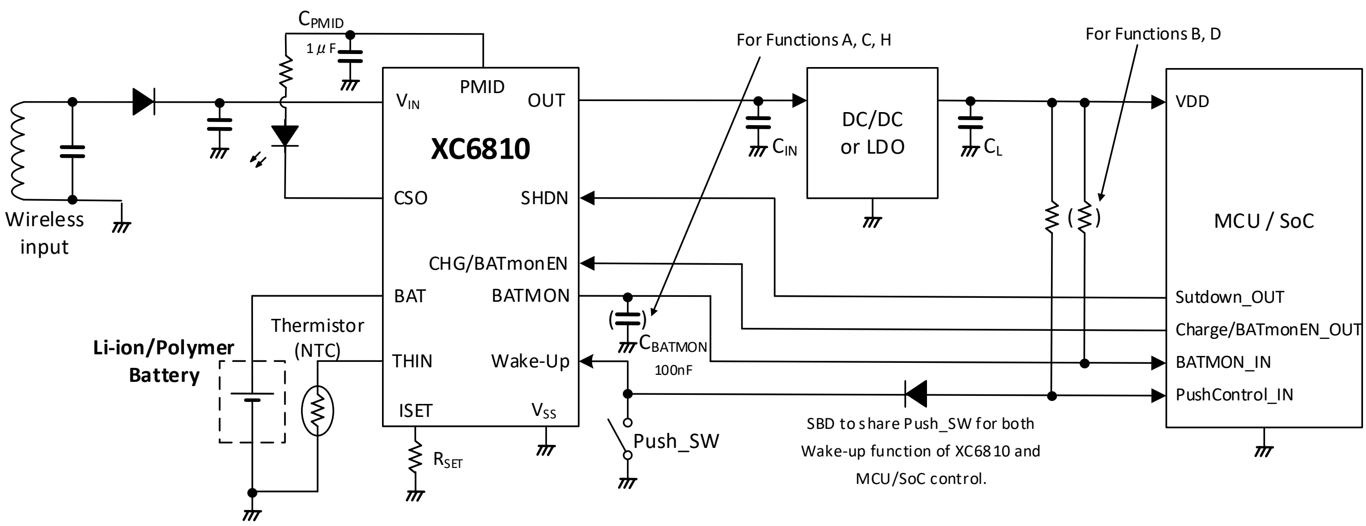
The charge level is output from CSO to MCU / SoC. Since the MCU / SoC needs to operate during charging to monitor the CSO, the operation voltage is supplied to OUT through the Current Path.



Functions	Battery Monitor Output	CSO Output	OUT		Charge Enable
			DC input Supply ($V_{IN} \geqq V_{UVLOR}$)	DC input Open (UVLO State)	
G	0.2 x V_{BAT}	Battery Status Indicator	V_{PMID}	V_{PMID} (=V_{BAT})	No
J					Yes

(d) Wireless power supply（Function A,B,C,D,H)

This is an example of a wireless power supply circuit. Since the rectified output of the wireless power supply may generate a high voltage, the anode of the LED connected to CSO is taken from the constant voltage output PMID.



Functions	Battery Monitor Output	CSO Output	OUT		Charge Enable
			DC input Supply ($V_{IN} \geqq V_{UVLOR}$)	DC input Open (UVLO State)	
A	0.2 x V_{BAT}	Battery LED Indicator	GND	V_{PMID} (=V_{BAT})	No
C			V_{PMID}		
H					Yes
B	Low Battery State : "L" Other State : "H"		GND		No
D			V_{PMID}		

■NOTES ON USE

1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded. Also, if use the conditions outside the recommended operating range, the IC may not operate normally or may cause deterioration.

2. Where wiring impedance is high, operations may become unstable. Please strengthen V_{IN}, V_{SS}, BAT, PMID and OUT wiring in particular. If necessary, add capacitance between OUT and GND to suppress voltage fluctuations in OUT lines.

3. Always avoid applying a voltage lower than the V_{SS} voltage to each input, including transient voltage fluctuations.

4. Please mount a output capacitor(C_{PMID}) and a charging current setting resistor (R_{SET}) as close to the IC as possible.

5. This IC uses an external thermistor to detect and control temperature with high accuracy. Please sufficiently test the position of the external thermistor to ensure that it enables accurate temperature detection.

6. Reversing the polarity of the battery may cause destruction and is extremely dangerous. Never reverse the polarity of the battery.

7. Short-circuiting to neighboring pins may cause malfunctioning and destruction. Exercise sufficient caution when mounting and using the IC.

8. If a large ripple voltage occurs at the V_{IN}, the IC may malfunction. If necessary, add a capacitance between V_{IN} and GND to suppress voltage fluctuations in the V_{IN} line.

9. Do not connect anything other than a resistor to the ISET.

10. If the input voltage is low for a product with a high charging voltage, the reverse current protection function stops charging at a voltage lower than the set voltage.

11. This IC has a built-in lithium battery protection function, however, if a protection circuit is not provided in the battery or between the battery and the BAT of this IC, please make a decision after carefully considering the safety of your entire product.

12. Torex places an importance on improving our products and their reliability. We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.

13. Note on mounting (WLP)

a) Mount pad design should be optimized for user's conditions.

b) Sn-AG-Cu is used for the package terminals. If eutectic solder is used, mounting reliability is decreased. Please do not use eutectic solder paste.

c) When underfill agent is used to increase interfacial bonding strength, please take enough evaluation for selection. Some underfill materials and applied conditions may decrease bonding reliability.

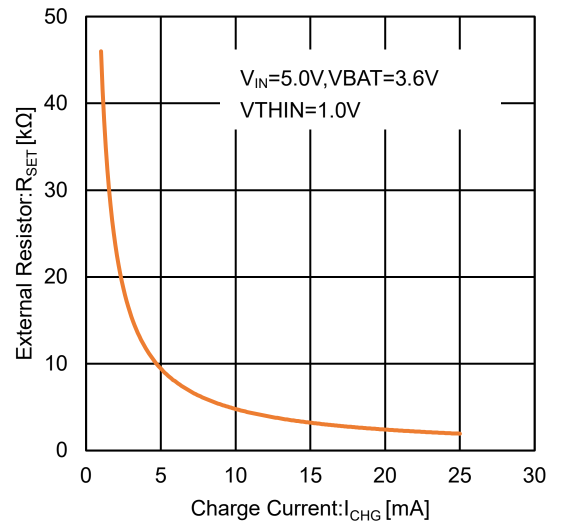
d) The IC has exposed surface of silicon material in the top marking face and sides so that it is weak against mechanical damages. Please take care of handling to avoid cracks and breaks.

e) The IC has exposed surface of silicon material in the top marking face and sides. Please use the IC with keeping the circuit open (avoiding short-circuit from the out).

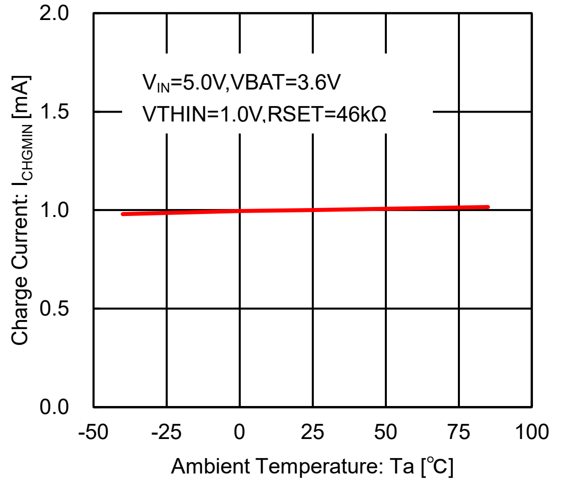
f) Semi-transparent resin is coated on the circuit face of the package. Please be noted that the usage under strong lights may affects device performance.

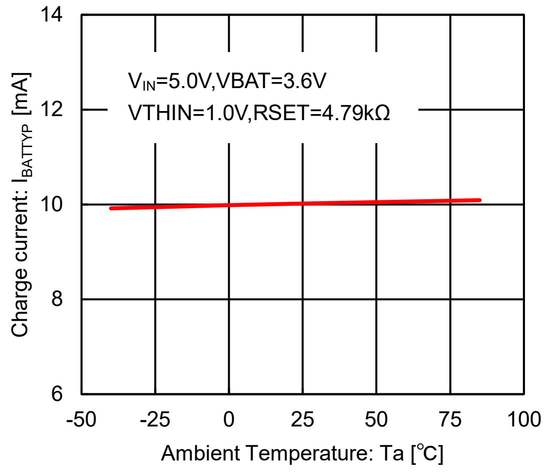
■TYPICAL PERFORMANCE CHARACTERISTICS

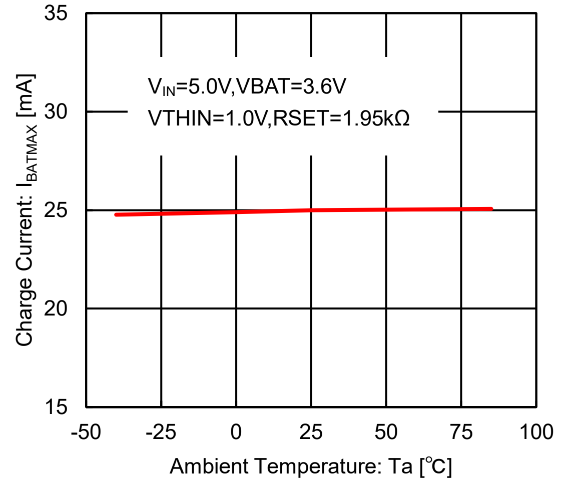
(1) Charge Current vs. External Resistor (Normal Operation)



(2) Charge Current vs. Ambient Temperature (Normal Operation)

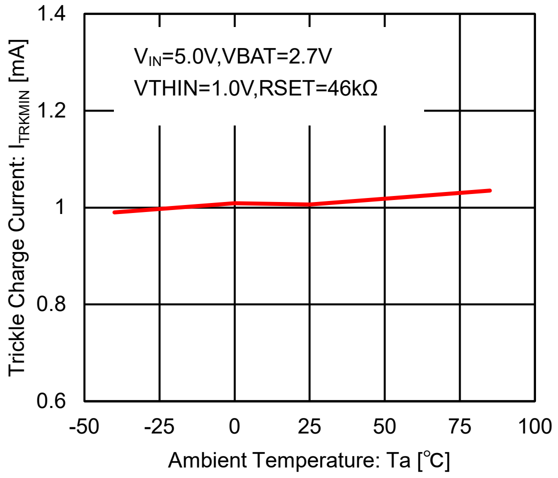


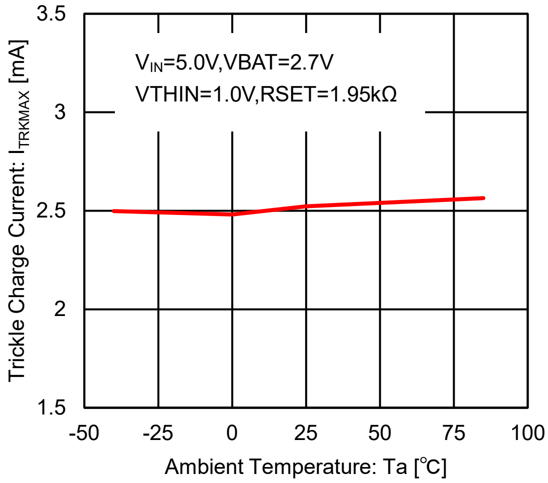




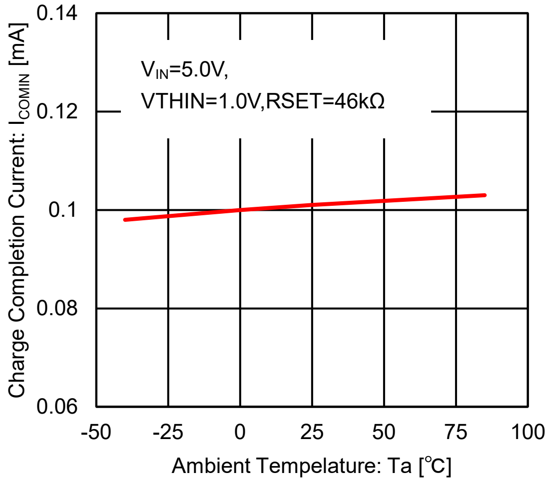
■TYPICAL PERFORMANCE CHARACTERISTICS

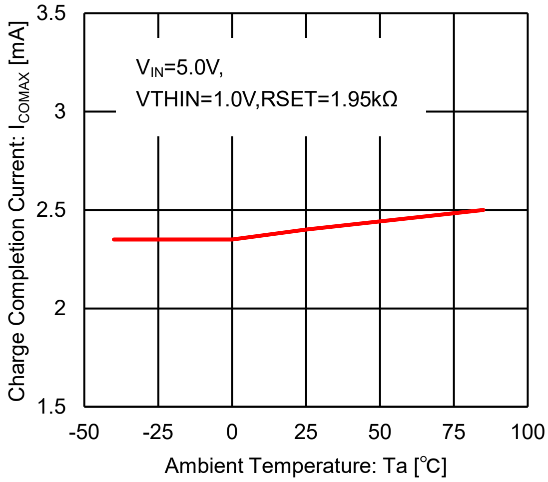
(3) Trickle Charge Current vs. Ambient Temperature





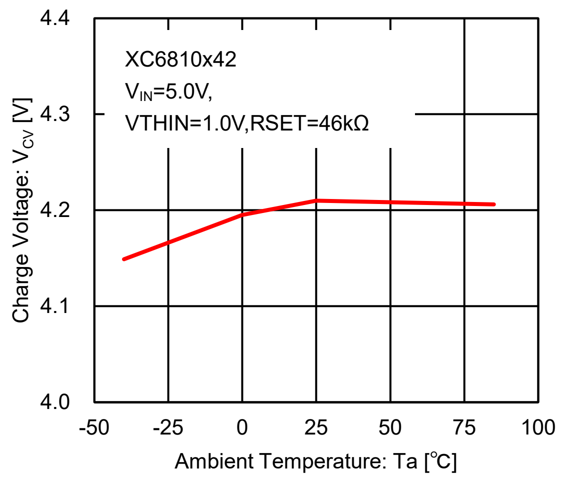
(4) Charge Completion Current vs. Ambient Temperature

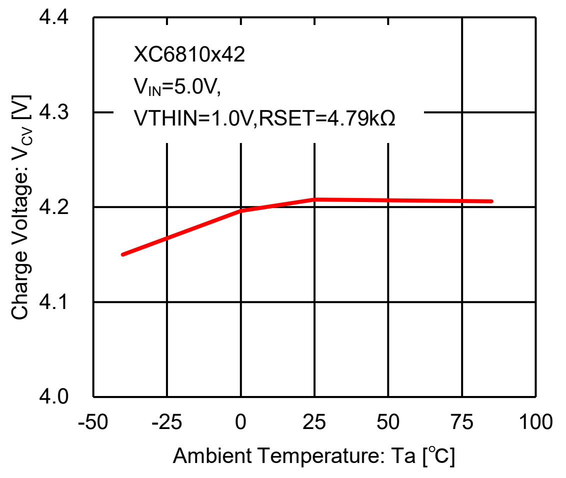


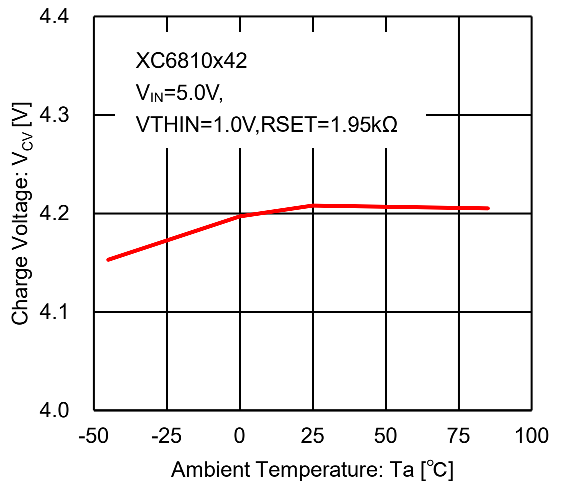


■TYPICAL PERFORMANCE CHARACTERISTICS

(5) Charge Voltage vs. Ambient Temperature

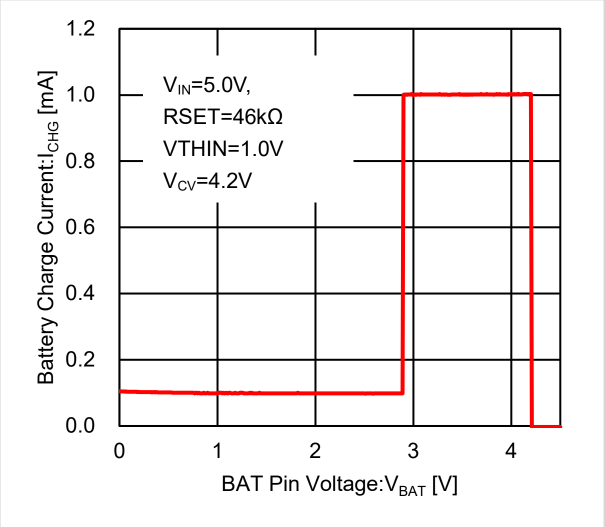


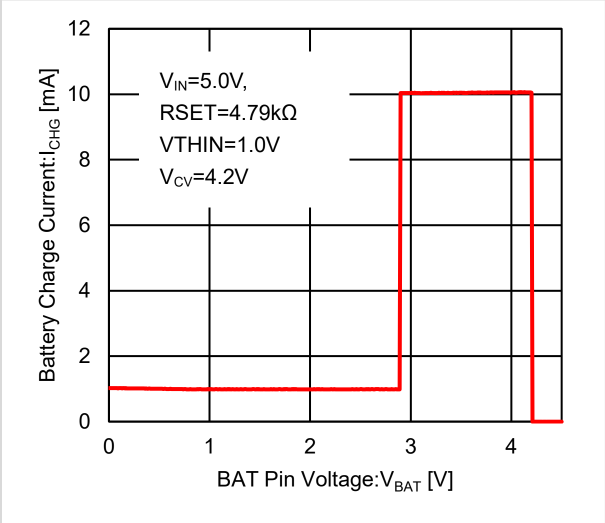


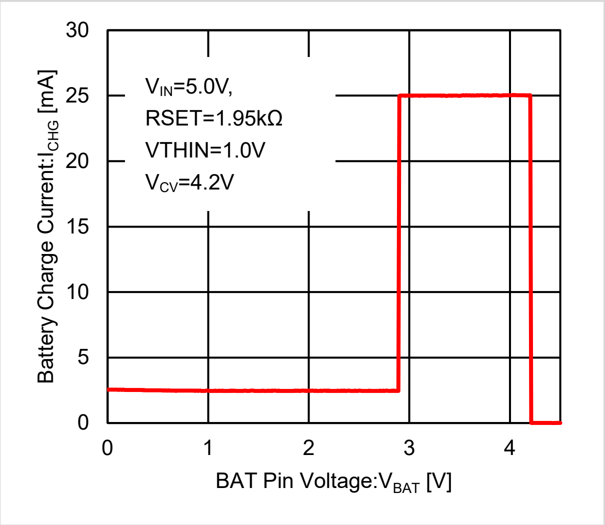


■TYPICAL PERFORMANCE CHARACTERISTICS

(6) Battery Charge Current vs. BAT Pin Voltage







■PACKAGING INFORMATION

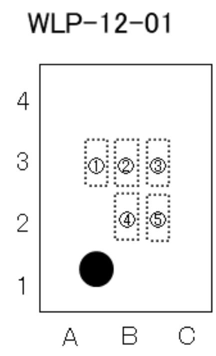
For the latest package information go to, www.torexsemi.com/technical-support/packages

PACKAGE	OUTLINE / LAND PATTERN	THERMAL CHARACTERISTICS
WLP-12-01	WLP-12-01 PKG	WLP-12-01 Power Dissipation

■MARKING RULE

① represents product series.

MARK	PRODUCT SERIES
A	XC6810A***0R-G
B	XC6810B***0R-G
C	XC6810C***0R-G
N	XC6810N***0R-G



② represents CV Voltage.

MARK	CV VOLTAGE	PRODUCT SERIES
A	3.80V	XC6810*38*0R-G
B	3.85V	XC6810*3J*0R-G
C	3.90V	XC6810*39*0R-G
D	3.95V	XC6810*3K*0R-G
E	4.00V	XC6810*40*0R-G
F	4.05V	XC6810*4A*0R-G
H	4.10V	XC6810*41*0R-G
K	4.15V	XC6810*4B*0R-G
L	4.20V	XC6810*42*0R-G
M	4.25V	XC6810*4C*0R-G
N	4.30V	XC6810*43*0R-G
P	4.35V	XC6810*4D*0R-G
R	4.40V	XC6810*44*0R-G

③ represents Functions.

MARK	PRODUCT SERIES
A	XC6810***A0R-G
B	XC6810***B0R-G
C	XC6810***C0R-G
D	XC6810***D0R-G
E	XC6810***E0R-G
F	XC6810***F0R-G
Z	XC6810***G0R-G
H	XC6810***H0R-G
Y	XC6810***J0R-G

④,⑤ represents production lot number.
01～09, 0A～0Z, 11～9Z, A1～A9, AA～AZ, B1～ZZ repeated.
(G, I, J, O, Q, W excluded. No character inversion used.)

1. The product and product specifications contained herein are subject to change without notice to improve performance characteristics. Consult us, or our representatives before use, to confirm that the information in this datasheet is up to date.

2. The information in this datasheet is intended to illustrate the operation and characteristics of our products. We neither make warranties or representations with respect to the accuracy or completeness of the information contained in this datasheet nor grant any license to any intellectual property rights of ours or any third party concerning with the information in this datasheet.

3. Applicable export control laws and regulations should be complied and the procedures required by such laws and regulations should also be followed, when the product or any information contained in this datasheet is exported.

4. The product is neither intended nor warranted for use in equipment of systems which require extremely high levels of quality and/or reliability and/or a malfunction or failure which may cause loss of human life, bodily injury, serious property damage including but not limited to devices or equipment used in 1) nuclear facilities, 2) aerospace industry, 3) medical facilities, 4) automobile industry and other transportation industry and 5) safety devices and safety equipment to control combustions and explosions. Do not use the product for the above use unless agreed by us in writing in advance.

5. Although we make continuous efforts to improve the quality and reliability of our products; nevertheless Semiconductors are likely to fail with a certain probability. So in order to prevent personal injury and/or property damage resulting from such failure, customers are required to incorporate adequate safety measures in their designs, such as system fail safes, redundancy and fire prevention features.

6. Our products are not designed to be Radiation-resistant.

7. Please use the product listed in this datasheet within the specified ranges.

8. We assume no responsibility for damage or loss due to abnormal use.

TOREX SEMICONDUCTOR LTD.