

# 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 indicate 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

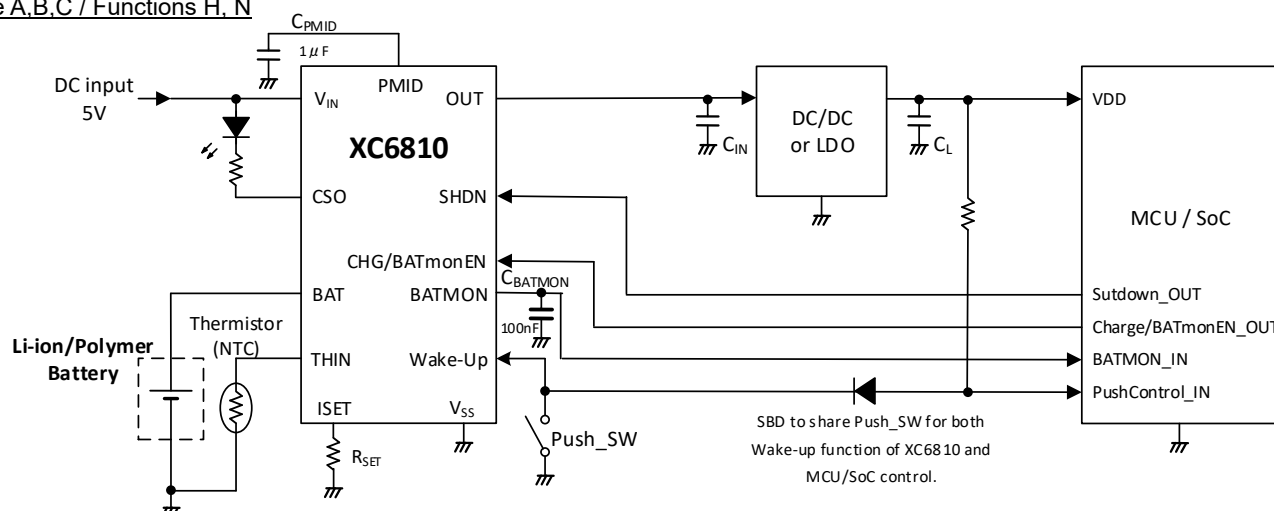
- Hearing Aid
- Wireless earphones / Headset
- Wearable Devices
- Wireless charging equipment
- IoT devices
- Smartcards

## ■ 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
	:	Current Path or
	:	Vout disconnection function with Vin supplied
	:	Battery Temperature Monitor
	:	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°C ~ 85°C
Package	:	WLP-12-01 (1.17 x 1.57 x 0.33mm)
Environmentally Friendly	:	EU RoHS Compliant, Pb Free

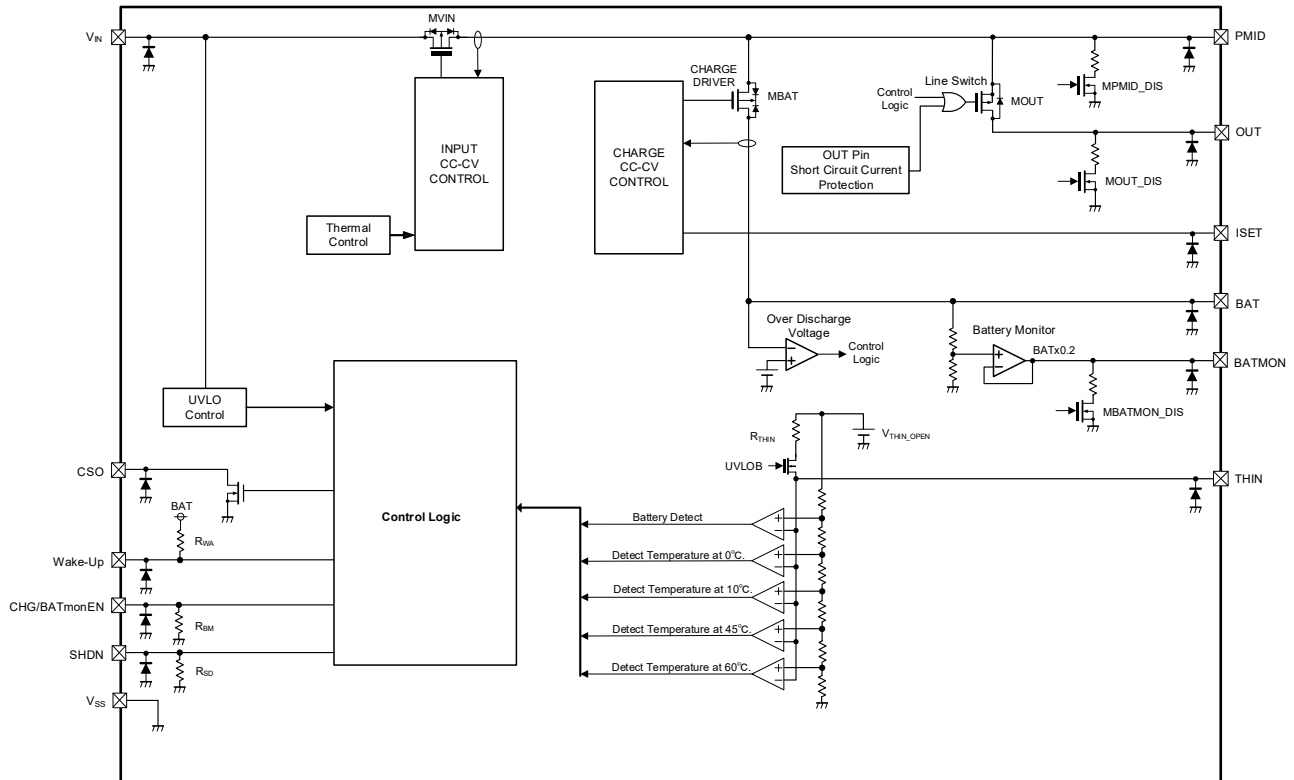
## ■ TYPICAL APPLICATION CIRCUIT

Type A,B,C / Functions H, N



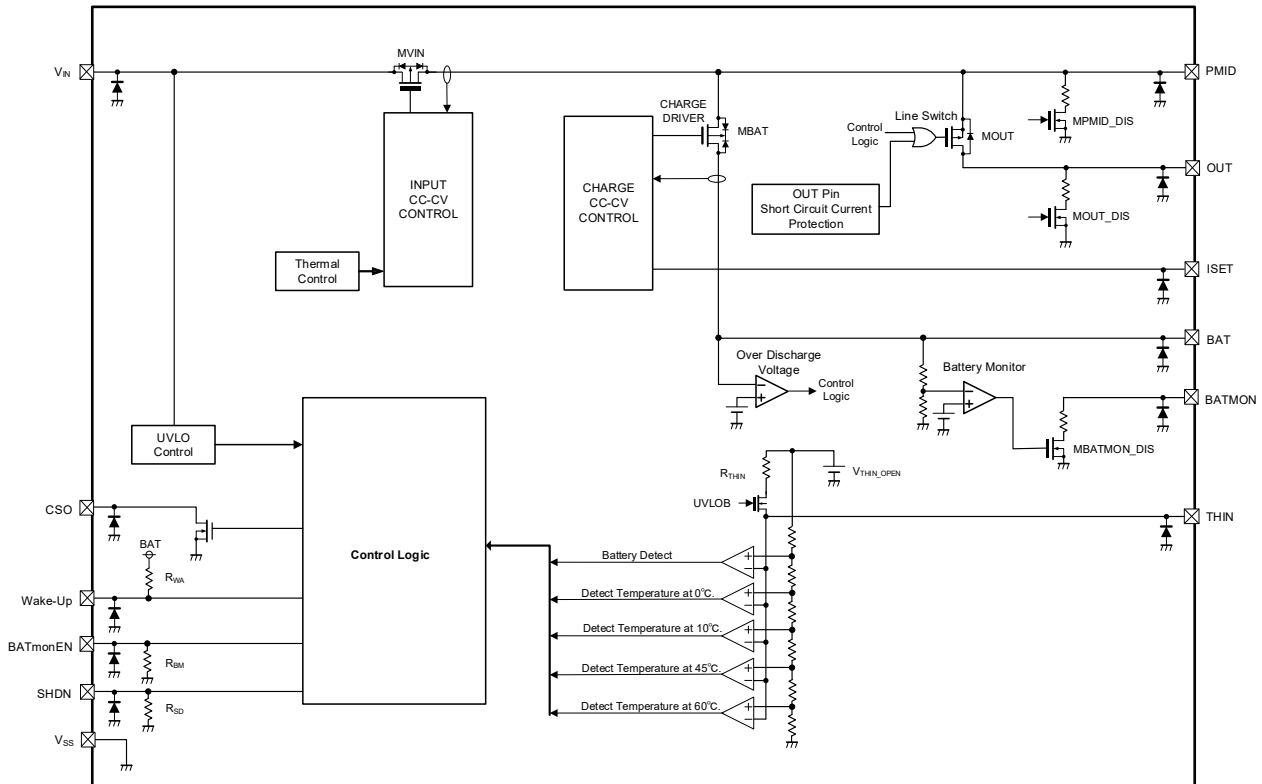
## BLOCK DIAGRAMS

### 1) Type A,B,C and Functions A,C,F,G,H,J,K,M,N,P



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

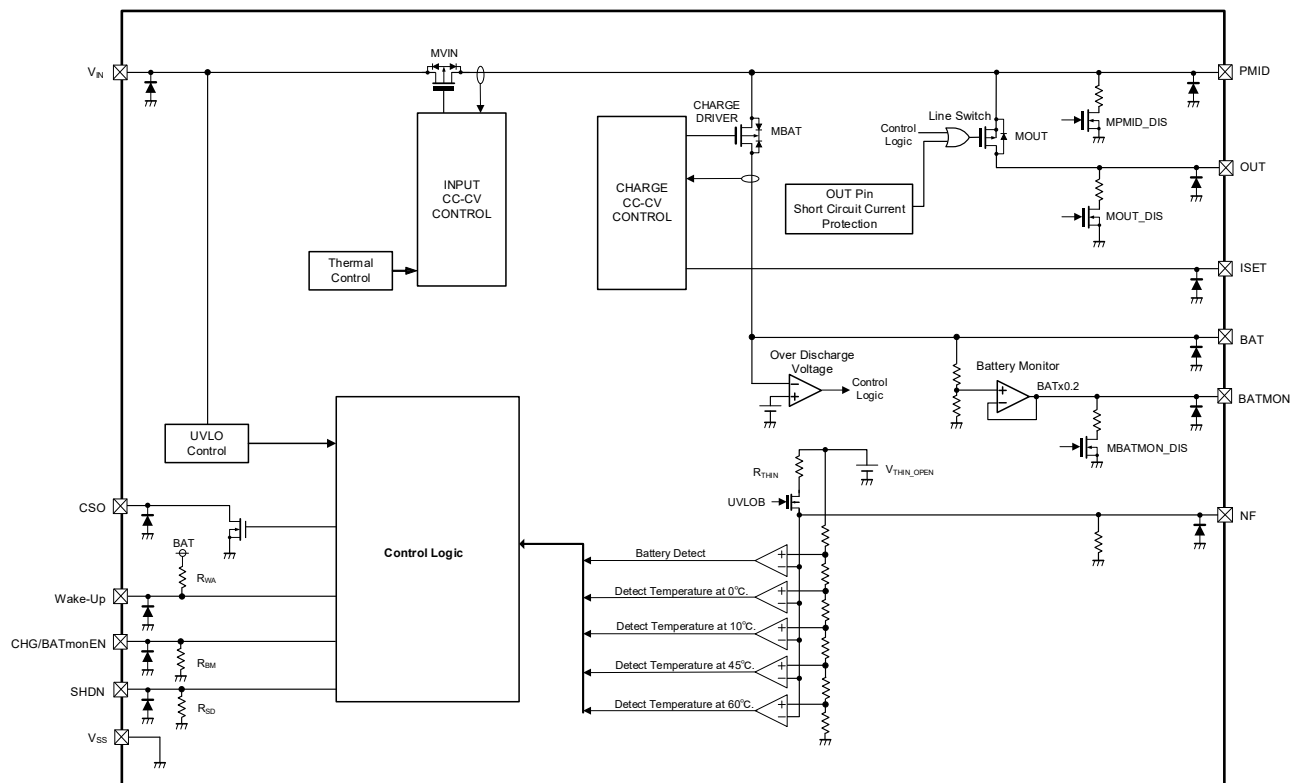
### 2) Type A,B,C and Functions B,D,E



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

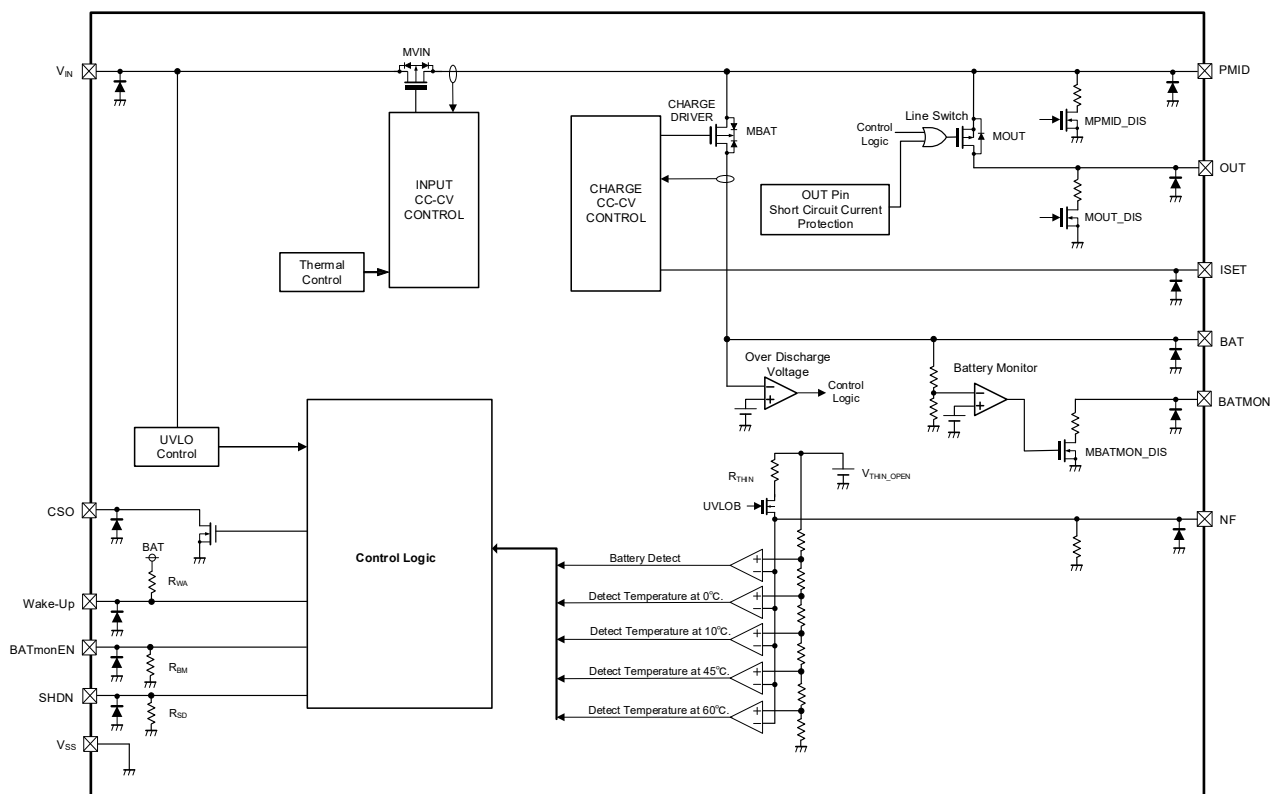
## ■ BLOCK DIAGRAMS

### 3) Type N and Functions A,C,F,G,H,J,K,M,N,P



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

#### 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	
		N	
		P	
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 Indicator1	Always ON (Current Path function)	0.2 x V <sub>BAT</sub>
G		Battery Status Indicator1		
H	Yes	Battery LED Indicator1		
J		Battery Status Indicator1		
N		Battery LED Indicator2		
P		Battery Status Indicator2		

## ■ PRODUCT CLASSIFICATION

### 2. Custom products

#### ● Ordering Information

XC6810①②③④⑤⑥-⑦

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Type	A	4 Temperature Monitor
		B	3 Temperature Monitor
		C	2 Temperature Monitor
		N	No Temperature Monitor
②③	Charge Voltage	38 ~ 44	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, 0.85=J, 0.95=K
④	Functions	A	Refer to Selection Guide
		B	
		C	
		D	
		E	
		F	
		G	
		H	
		J	
		K	
		M	
		N	
		P	
⑤⑥-⑦ <sup>(*)</sup>	Packages (Order Unit)	0R-G	WLP-12-01 (5,000pcs/Reel)

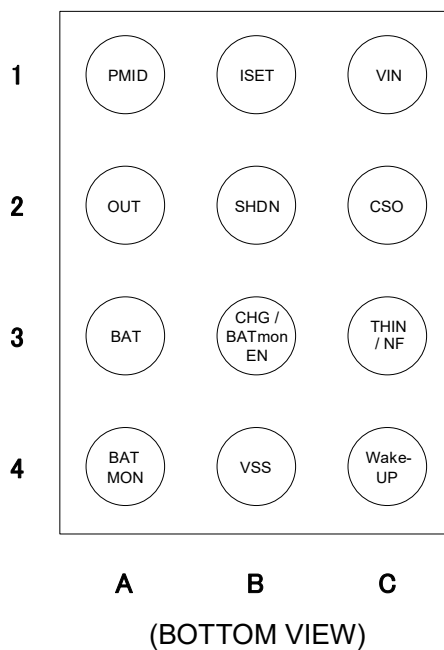
(\*) "-G" suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

## PRODUCT CLASSIFICATION

### ● Selection Guide

Functions	Charge Enable	CSO Output	OUT	Battery Monitor Output	
A	No	Battery LED Indicator1	Cut-off at UVLO Release State ( $V_{IN} \geq V_{UVLOR}$ )	$0.2 \times V_{BAT}$	
B				Low Battery State : “L” Other State : “H”	
C			Always ON (Current Path function)	$0.2 \times V_{BAT}$	
D				Low Battery State : “L” Other State : “H”	
E		Battery Status Indicator1			
F		Cut-off at UVLO Release State ( $V_{IN} \geq V_{UVLOR}$ )	$0.2 \times V_{BAT}$		
G		Always ON (Current Path function)			
H	Yes			Battery LED Indicator1	
J				Battery Status Indicator1	
K	No			Battery LED Indicator2	
M				Battery Status Indicator2	
N	Yes			Battery LED Indicator2	
P				Battery Status Indicator2	

## ■ PIN CONFIGURATION



## ■ PIN ASSIGNMENT

PIN NUMBER	PIN NAME	FUNCTIONS
WLP-12-01		
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,K,M)
		No function (Functions B,D,E)
	CHG/BATmonEN	Charge Enable and Battery Monitor Enable Input (Functions H,J,N,P)
B4	V <sub>SS</sub>	Ground
C1	V <sub>IN</sub>	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 <sub>IN</sub> Voltage	V <sub>IN</sub>	-0.3 ~ 30	V
BAT Voltage	V <sub>BAT</sub>	-0.3 ~ 6.6	V
CSO Voltage	V <sub>CSO</sub>	-0.3 ~ 6.6	V
PMID Voltage	V <sub>PMID</sub>	-0.3 ~ 6.6	V
Wake-Up Voltage	V <sub>WAKEUP</sub>	-0.3 ~ 6.6	V
CHG/BATmonEN Voltage	V <sub>CHG</sub> /V <sub>BATmonEN</sub>	-0.3 ~ 6.6	V
SHDN Voltage	V <sub>SD</sub>	-0.3 ~ 6.6	V
THIN Voltage (Type A,B,C)	V <sub>THIN</sub>	-0.3 ~ 6.6	V
NF Voltage (Type N)	V <sub>NF</sub>	-0.3 ~ 6.6	V
OUT Voltage	V <sub>OUT</sub>	-0.3 ~ V <sub>PMID</sub> + 0.3 or 6.6 <sup>(*)1</sup>	V
BATMON Voltage	V <sub>BATMON</sub>	-0.3 ~ V <sub>PMID</sub> + 0.3 or 6.6 <sup>(*)1</sup>	V
ISET Voltage	V <sub>ISET</sub>	-0.3 ~ V <sub>PMID</sub> + 0.3 or 6.6 <sup>(*)1</sup>	V
Power Dissipation (Ta=25°C)	P <sub>d</sub>	890 (JESD51-7 board) <sup>(*)2</sup>	mW
Junction Temperature	T <sub>j</sub>	-40 ~ 125	°C
Storage Temperature	T <sub>stg</sub>	-55 ~ 125	°C

All voltages are described based on the V<sub>SS</sub>.

(\*)1 Either of lower one, V<sub>PMID</sub> + 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 <sub>IN</sub> Voltage	V <sub>IN</sub>	0.0	-	28.0	V
BAT Voltage	V <sub>BAT</sub>	0.0	-	V <sub>CV</sub>	V
CSO Voltage	V <sub>CSO</sub>	0.0	-	6.0	V
CSO Current	I <sub>CSO</sub>	0.0	-	6	mA
Wake-Up Voltage	V <sub>WAKEUP</sub>	0.0	-	V <sub>CV</sub>	V
CHG/BATmonEN Voltage	V <sub>CHG</sub> / V <sub>BATmonEN</sub>	0.0	-	6.0	V
SHDN Voltage	V <sub>SD</sub>	0.0	-	6.0	V
BATMON Voltage (Functions B,D,E)	V <sub>BATMON</sub>	0.0	-	6.0	V
BATMON Current (Functions B,D,E)	I <sub>BATMON</sub>	0.0	-	3	mA
Charge Current Range	I <sub>CHG</sub>	1	-	25	mA
ISET Resistor	R <sub>SET</sub>	1.95	-	46	kΩ
Operating Ambient Temperature	T <sub>opr</sub>	-40	-	85	°C

All voltages are described based on the V<sub>SS</sub>.



# ELECTRICAL CHARACTERISTICS

Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
<b>INPUT VOLTAGE and CURRENTS</b>							
Input Voltage Range	$V_{IN}$		$V_{UVLOR}$	5.0	28.0	V	-
Input Operating Voltage Range	$V_{IOVR}$	Charge is possible to V <sub>cv</sub>	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
<b>CURRENT-PATH MANAGEMENT and INPUT CURRENT LIMIT</b>							
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
<b>BATTERY CHARGE</b>							
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	-	$V_{CV} \times 0.965$	-	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.)	$I_{CHGMIN}$	$R_{SET}=46k\Omega$ , $V_{BAT}=3.6V$	0.85	1.00	1.15	mA	①
Charge Current (TYP.)	$I_{CHGTYP}$	$R_{SET}=4.79k\Omega$ , $V_{BAT}=3.6V$	9.0	10.0	11.0	mA	①
Charge Current (MAX.)	$I_{CHGMAX}$	$R_{SET}=1.95k\Omega$ , $V_{BAT}=3.6V$	22.5	25.0	27.5	mA	①
Charge Current On Cold Operation (MIN.)	$I_{CHGCMIN}$	$R_{SET}=46k\Omega$ , Type A,B	0.4	0.5	0.6	mA	①
Charge Current On Cold Operation (MAX.)	$I_{CHGCMAX}$	$R_{SET}=1.95k\Omega$ , Type A,B	10.0	12.5	15.0	mA	①
Charge Completion Current (MIN.)	$I_{COMIN}$	$R_{SET}=46k\Omega$	0.07	0.10	0.14	mA	①
Charge Completion Current (MAX.)	$I_{COMAX}$	$R_{SET}=1.95k\Omega$	2.125	2.500	3.125	mA	①
Trickle Charge Current (MIN.)	$I_{TRKLMIN}$	$R_{SET}=46k\Omega$ , $V_{BAT}=2.7V$	0.08	0.10	0.12	mA	①
Trickle Charge Current (MAX.)	$I_{TRKLMAX}$	$R_{SET}=1.95k\Omega$ , $V_{BAT}=2.7V$	2.00	2.50	3.00	mA	①

Unless otherwise stated,  $V_{IN}=5V$ ,  $C_{PMID}=1\mu F$

## ELECTRICAL CHARACTERISTICS

Ta=25°C

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

Unless otherwise stated, V<sub>IN</sub>=5V, C<sub>PMID</sub>=1μF

(\*) Design target

## ■ ELECTRICAL CHARACTERISTICS

Ta=25°C

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

Unless otherwise stated, V<sub>IN</sub>=5V, C<sub>PMID</sub>=1μF

<sup>(\*)1</sup> Design target

<sup>(\*)2</sup> The comparator detect voltage and hysteresis width are indicated as percentages of V<sub>THIN\_OPEN</sub>.

V<sub>Txx</sub> = V<sub>Txx'</sub> / V<sub>THIN\_OPEN</sub> (V<sub>Txx'</sub>: The voltage when the charging voltage or charging current is changed by sweeping the voltage when the external voltage applied to the THIN)

<sup>(\*)3</sup> Type N does not include thermistor temperature monitoring function and Battery detection function.

## ELECTRICAL CHARACTERISTICS

Ta=25°C

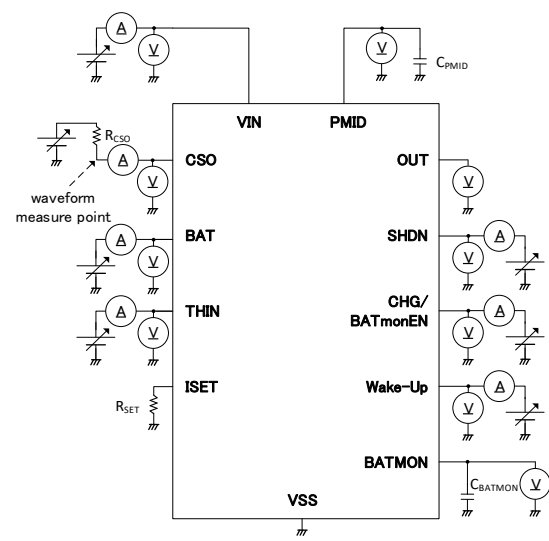
PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
<b>Battery Charging Timers</b>							
Trickle Charge Hold Time <sup>(*)</sup>	t <sub>TRK</sub>		-	0.5	-	hr	①
Main Charge Hold Time <sup>(*)</sup>	t <sub>CHG</sub>		-	10	-	hr	①
<b>Push Button Timer</b>							
Wake-Up Deglitch Time	t <sub>WUD</sub>		-	256	-	ms	①
<b>System Timers</b>							
Start Up Time <sup>(*)</sup>	t <sub>START</sub>	To Start Charging	-	50	-	ms	①
Charge Completion Deglitch	t <sub>DGL_COMP</sub>		-	30	-	ms	①
Recharge Detect Deglitch	t <sub>DGL_RECHG</sub>		-	30	-	ms	①
Trickle Detect Deglitch	t <sub>DGL_TRICKLE</sub>		-	30	-	ms	①
<b>CSO Battery LED Indicator (Functions A,B,C,D,H,K,N)</b>							
Charge	f <sub>CSO_CHG</sub>	CSO Pin Nch Open Drain = ON	-	ON	-	-	①
Charge Complete	f <sub>CSO_COMP</sub>		-	OFF	-	-	①
Charge Stop	f <sub>CSO_STOP</sub>	Functions A,B,C,D,H	-	OFF	-	-	①
		Functions K,N	-	ON	-	-	①
Error	f <sub>CSO_ERR</sub>		6.5	8.0	9.0	Hz	①
No Battery	f <sub>CSO_NOBAT</sub>	CSO Pin Nch Open Drain = OFF	-	OFF	-	-	①
CSO On Voltage	V <sub>CSOON</sub>	I <sub>CSO</sub> =1mA	-	-	0.5	V	④
CSO Leakage Current	I <sub>LCSO</sub>	V <sub>CSO</sub> =5.5V	-	-	0.1	μA	①
<b>CSO Battery Status Indicator (Functions E,F,G,J,M,P)</b>							
Battery Charging less than 60%	f <sub>CHG_L</sub>		26.0	32.0	40.0	kHz	①
Battery 60% Charging	f <sub>CHG_60PER</sub>		13.0	16.0	19.0	kHz	①
Battery 90% Charging	f <sub>CHG_90PER</sub>		6.0	8.0	10.0	kHz	①
Charge Complete Status	f <sub>CHG_COMP</sub>		3.0	4.0	5.0	kHz	①
Charge Stop Status	f <sub>CHG_STOP</sub>	Functions E,F,G,J	3.0	4.0	5.0	kHz	①
		Functions M,P	1.5	2.0	2.5	kHz	①
Error Status	f <sub>CHG_ERR</sub>		0.8	1.0	1.2	kHz	①
No Battery	f <sub>CHG_NOBAT</sub>	CSO Pin Nch Open Drain = OFF		OFF			①
Battery 60% Charging Threshold Voltage	V <sub>CHG_60PER</sub>		3.680	3.720	3.777	V	①
Battery 90% Charging Threshold Voltage	V <sub>CHG_90PER</sub>		4.04	4.08	4.12	V	①
CSO Sink Current <sup>(*)</sup>	I <sub>CSO_STATE</sub>	Constant current control	-	1.0	-	mA	①

Unless otherwise stated, V<sub>IN</sub>=5V, C<sub>PMID</sub>=1μF

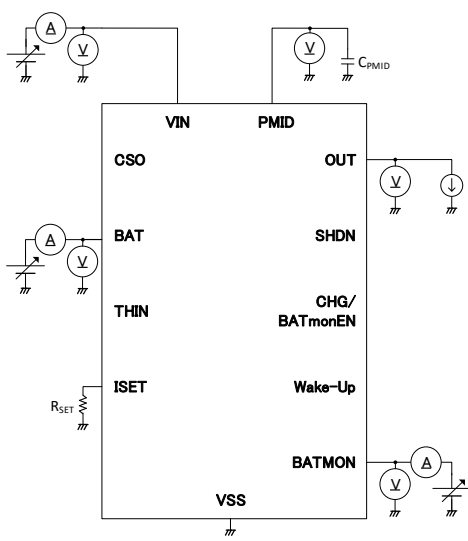
<sup>(\*)</sup> Design target

# TEST CIRCUITS

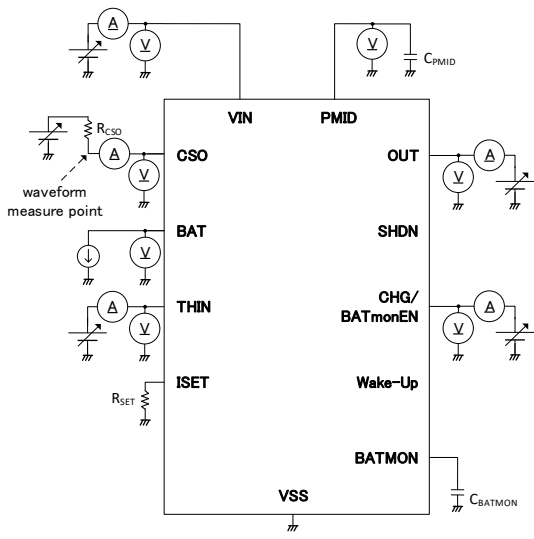
1) Test Circuit①



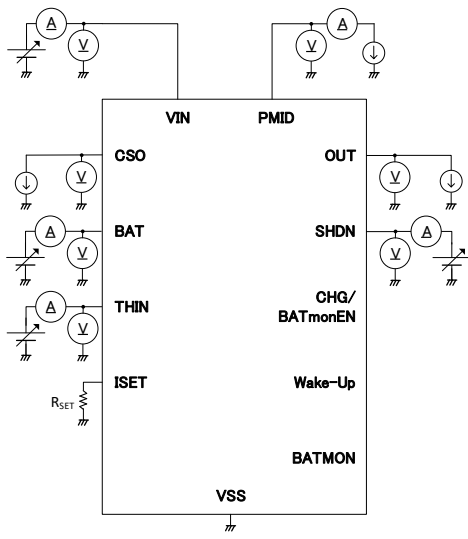
2) Test Circuit②



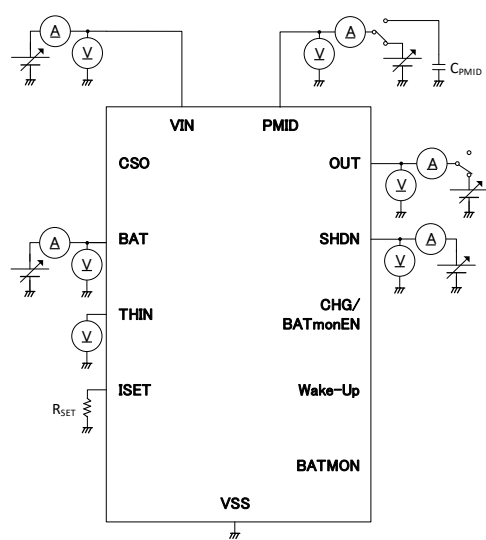
3) Test Circuit③



4) Test Circuit④



5) Test Circuit⑤



## OPERATIONAL EXPLANATION

<Operation Mode >

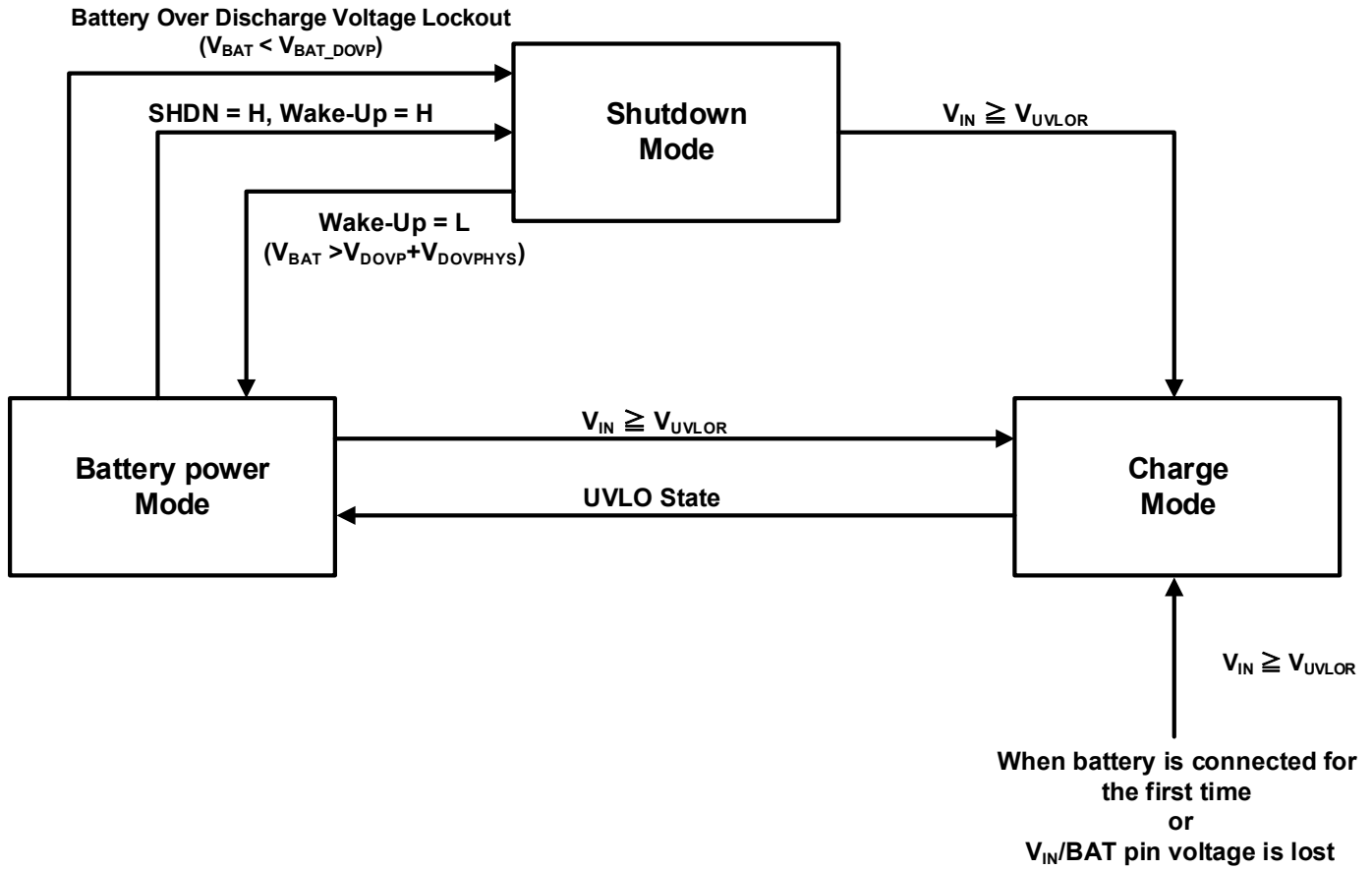


Figure 1. Mode State Diagram1

■ 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  $V_{IN}$  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 <sub>IN</sub> -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 <sub>IN</sub> and BAT	from / to Battery	GND
	C,D,G,H,J,K,M,N,P			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<sub>IN</sub> becomes less than 3.5V (V<sub>UVLOD</sub>) 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 over-discharge voltage threshold 2.8V (V<sub>BAT\_DOVP</sub>) for 256ms)

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<sub>IN</sub> rises above 3.6V (V<sub>UVLOR</sub>) and BAT voltage)

(d) The wake-up function is operated and shift to Battery Power Mode.

(When V<sub>BAT</sub> > (V<sub>BAT\_DOVP</sub> + V<sub>BAT\_DOVP<sub>PHYS</sub></sub>) 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 operated, it shifts to Shutdown Mode.

(The BAT voltage falls below over-discharge voltage threshold 2.8V (V<sub>BAT\_DOVP</sub>) 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.

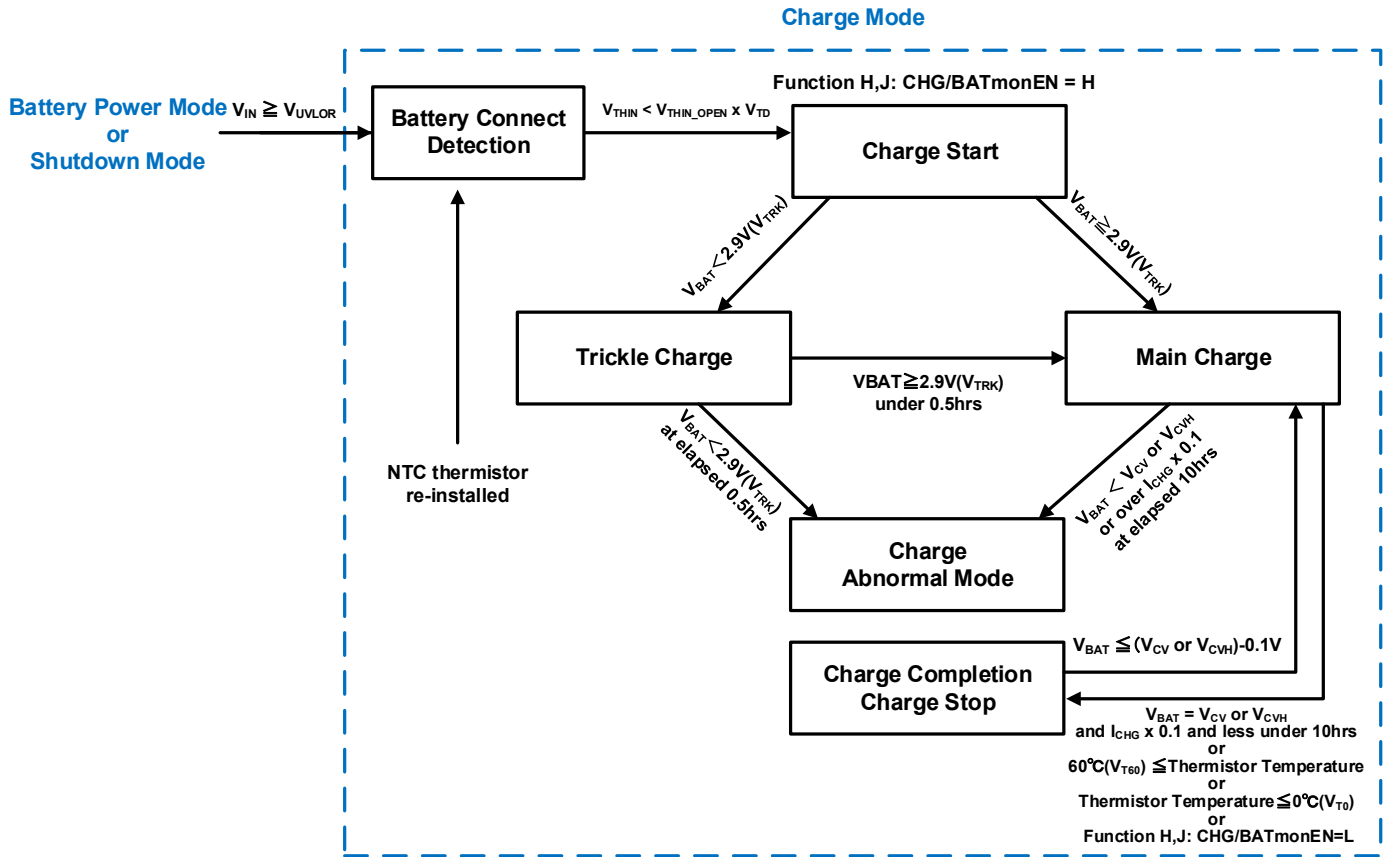
After shifting from another mode to Charge Mode by releasing UVLO, when battery connection detection (V<sub>TD</sub>) is operated, charging will start after 50ms (t<sub>START</sub>). If it shift from another mode to Charge Mode, the previous charge status and timer information will not be inherited.

In functions A,B,E,F, the built-in Line Switch is linked to the UVLO function. When the UVLO release state (V<sub>IN</sub> ≥ V<sub>UVLOR</sub>) 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,K,M,N,P supply power to the OUT to turn on the Line Switch.

## OPERATIONAL EXPLANATION

<Charge function (Charge Mode details)>



### Charge Mode State

#### ● Trickle charge

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 charge abnormal mode and stops charging the Li-ion battery.

#### ● Main charge

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 ( $t_{CHG}$ ), charge abnormal mode 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.

$$R_{SET} [k\Omega] = 46 \times I_{CHG}^{-0.983} [mA]$$

#### ● Charge 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 or stopped, charging automatically resumes after 30ms ( $t_{DEG\_RECHG}$ ) elapsed.

#### ● Charge Abnormal

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 a charge abnormal condition and charging stops.



## ■ OPERATIONAL EXPLANATION

### ● Current Path Function (Functions C,D,G,H,J,K,M,N,P)

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,N,P)

Functions H,J,N,P 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 pin is set to "H" voltage again, if the BAT voltage is lower than the recharge voltage  $V_{CV}-0.1V$  or  $V_{CVH}-0.1V(V_{RC})$ , it will be charged continually from the charge state when it was set to "L" before and timer.

If the BAT voltage is higher than the recharge voltage  $V_{CV}-0.1V$  or  $V_{CVH}-0.1V(V_{RC})$ , the charge stop state is maintained until it drops to the recharge voltage  $V_{CV}-0.1V$  or  $V_{CVH}-0.1V(V_{RC})$ .

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

#### Battery connection detection (NTC thermistor connection detection)

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.

#### Li-ion battery temperature monitoring function

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.

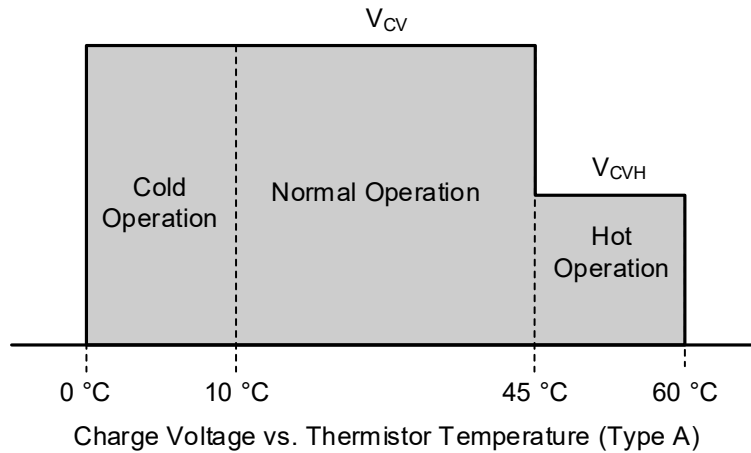
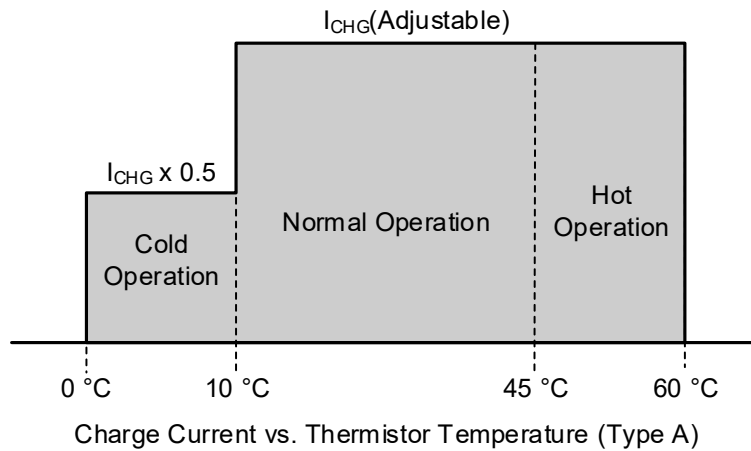
However, since the FET between the THIN and the reference voltage is turned off, it is possible to apply the voltage to the NTC thermistor from the outside.

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°C, 10°C, 45°C, 60°C)



#### **Cold Operation**

When  $(V_{T0}) < \text{Thermistor Temperature} \leq 10^\circ\text{C}(V_{T10})$ , the charge current is limited to  $I_{CHG} \times 0.5$ .

During Cold Operation, the charge current is limited to  $I_{CHG} \times 0.1$ .

When Thermistor Temperature  $\leq 0^\circ\text{C}(V_{T0})$ , the charging and timer counting are temporarily stopped.

The recharge function does not operate when charging is stopped by the temperature monitoring function.

#### **Normal Operation**

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

#### **Hot Operation**

When  $45^\circ\text{C}(V_{T45}) \leq \text{Thermistor Temperature} < 60^\circ\text{C}(V_{T60})$ , the charge voltage changes to  $V_{CVH}$  and charging continues.

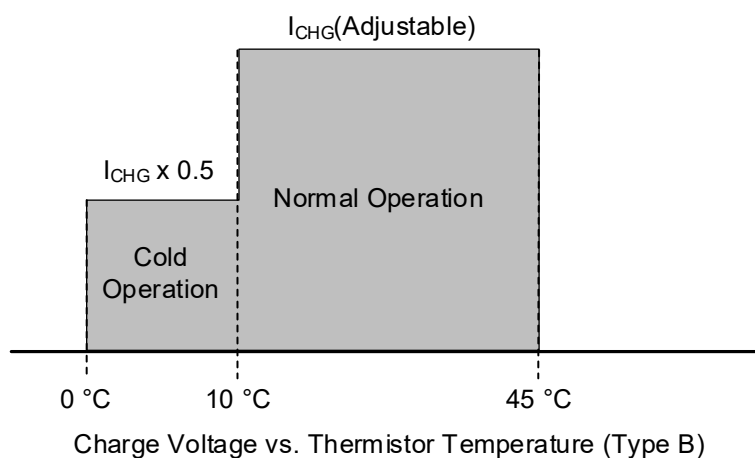
When  $60^\circ\text{C}(V_{T60}) \leq \text{Thermistor Temperature}$ , charging and timer counting are temporarily stopped.

The recharge function does not operate when charging is stopped by the temperature monitoring function.

## ■ OPERATIONAL EXPLANATION

### Li-ion battery temperature monitoring function (Continued)

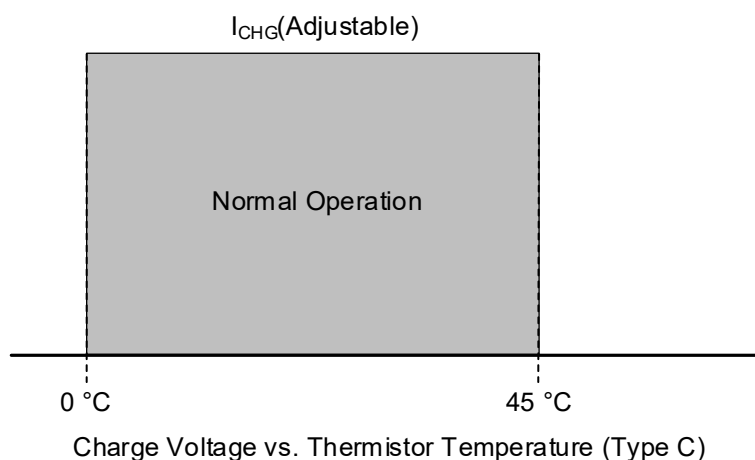
#### ■ Type B (3 temperatures monitoring, 0°C, 10°C, 45°C)



Comparing to the type A, type B does not monitor at 60°C, charging and timer counting are temporarily stopped at  $45^{\circ}\text{C} \leq \text{Thermistor Temperature}$ .

The recharge function does not operate when charging is stopped by the temperature monitoring function.

#### ■ Type C (2 temperatures monitoring, 0°C, 45°C)



Comparing to the type A, type C does not monitor at 10°C ( $V_{T10}$ ) and 60°C ( $V_{T60}$ ), when Thermistor Temperature  $\leq 0^{\circ}\text{C}$  ( $V_{T0}$ ) or Thermistor Temperature  $\geq 45^{\circ}\text{C}$  ( $V_{T45}$ ), charging and timer counting are temporarily stopped.

The recharge function does not operate when charging is stopped by the temperature monitoring function.

## ■ 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

If the  $V_{IN}$  is lower than 3.5V ( $V_{UVLOR}$ ) or the BAT voltage ( $V_{BAT}$ ) is higher than 2.888V ( $V_{BAT\_DOVP} + V_{BAT\_DOVPHYS}$ ), the device will switch to battery mode when a "L" level voltage ( $V_{WAL}$ ) is continuously applied to the wake-up for 256ms ( $t_{WUD}$ ) or longer.

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 ( $V_{UVLOB}$ ) 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  $V_{BAT} + 60\text{mV}$  ( $V_{BAT\_REVTH}$ ), 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  $V_{BAT} + 60\text{mV}$  ( $V_{BAT\_REVTH}$ ), this function is released.

#### ■ 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 ( $I_{INL} < I_{OUT}$ )
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 $T_j$ )
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,K,N

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 (Battery LED Indicator)

STATUS	Condition	Safety Timer	LED (CSO Output)	
			Battery LED Indicator1 (Functions A,B,C,D,H)	Battery LED Indicator2 (Functions K,N)
Before Charge Start		Active	OFF (High impedance)	ON (Low impedance)
Trickle Charge		Active	ON (Low impedance)	
Main Charge		Active	ON (Low impedance)	
Charge Complete		Reset	OFF (High impedance)	
Charge Stop by temperature monitoring function	Thermistor Temperature $\leq 0^{\circ}\text{C}(V_{T0})$	Pause	OFF (High impedance)	ON (Low impedance)
	Type A (4 temperatures monitoring) : $60^{\circ}\text{C}(V_{T60}) \leq \text{Thermistor Temperature}$			
	Type B (3 temperatures monitoring) : $45^{\circ}\text{C}(V_{T45}) \leq \text{Thermistor Temperature}$			
	Type C (2 temperatures monitoring) : $45^{\circ}\text{C}(V_{T45}) \leq \text{Thermistor Temperature}$			
Charge Disable Status (Charge Enable=L, Function H, N)	Charge Stop	Pause	OFF (High impedance)	ON (Low impedance)
Charge Abnormal State	Charge Stop	Active	8Hz Oscillation	
No Battery (THIN OPEN)	Charge Stop	Reset	OFF (High impedance) <sup>†</sup>	
No Battery (THIN Connected)	Charge Complete $\leftrightarrow$ Recharge	Active	ON $\leftrightarrow$ OFF	
No Power	UVLO or Battery Reverse Current Protection	Reset	OFF (High impedance)	
Shutdown Mode		-	OFF (High impedance)	

## ■ OPERATIONAL EXPLANATION

<Charging status output CSO (Continued)>

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

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

Since the CSO of battery status indicator function 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 (Battery Status Indicator)

STATUS	Condition	Safety Timer	CSO Output	
			Battery Status Indicator1 (Functions E,F,G,J)	Battery Status Indicator2 (Functions M,P)
Before Charge Start		Active	4kHz Oscillation	2kHz Oscillation
Battery Charging less than 60%		Active	32kHz Oscillation	
Battery 60% Charging		Active	16kHz Oscillation	
Battery 90% Charging		Active	8kHz Oscillation	
Charge Complete Status		Reset	4kHz Oscillation	
Charge Stop by temperature monitoring function	Thermistor Temperature $\leq 0^{\circ}\text{C}(V_{T0})$	Pause	4kHz Oscillation	2kHz Oscillation
	Type A (4 temperatures monitoring) : $60^{\circ}\text{C}(V_{T60}) \leq \text{Thermistor Temperature}$			
	Type B (3 temperatures monitoring) : $45^{\circ}\text{C}(V_{T45}) \leq \text{Thermistor Temperature}$			
	Type C (2 temperatures monitoring) : $45^{\circ}\text{C}(V_{T45}) \leq \text{Thermistor Temperature}$			
Charge Disable Status (Charge Enable=L, Function J, P)	Charge Stop	Pause	4kHz Oscillation	2kHz Oscillation
Charge Abnormal State	Charge Stop	Active	1kHz Oscillation	
No Battery (THIN OPEN)	Charge Stop	Reset	OFF (High impedance) <sup>†</sup>	
No Battery (THIN Connected)	Charge Complete $\leftrightarrow$ Recharge	Active	ON $\leftrightarrow$ OFF	
No Power	UVLO or Battery Reverse Current Protection	Reset	OFF (High impedance)	
Shutdown Mode		-	OFF (High impedance)	

## ■ Battery Status Indicator Function : Functions E,F,G,J,M,P (Continued)

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

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

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  $V_{\text{CHG}}$ ,  $V_{\text{BAT}}$  and STATUS

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



<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 ( $V_{BAT\_LBMVT} + V_{BAT\_LBMVHYS} \leq V_{BAT}$ )	"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,K,M,N,P

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,K,M

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,K,M	Shutdown Mode	-	-	GND or High impedance
	Charge Mode / Battery Power Mode	"H"	No Change	$0.2 \times V_{BAT}$
	Charge Mode / Battery Power Mode	"L"	No Change	GND

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

The Li-ion battery connected to the BAT is charged while an "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.

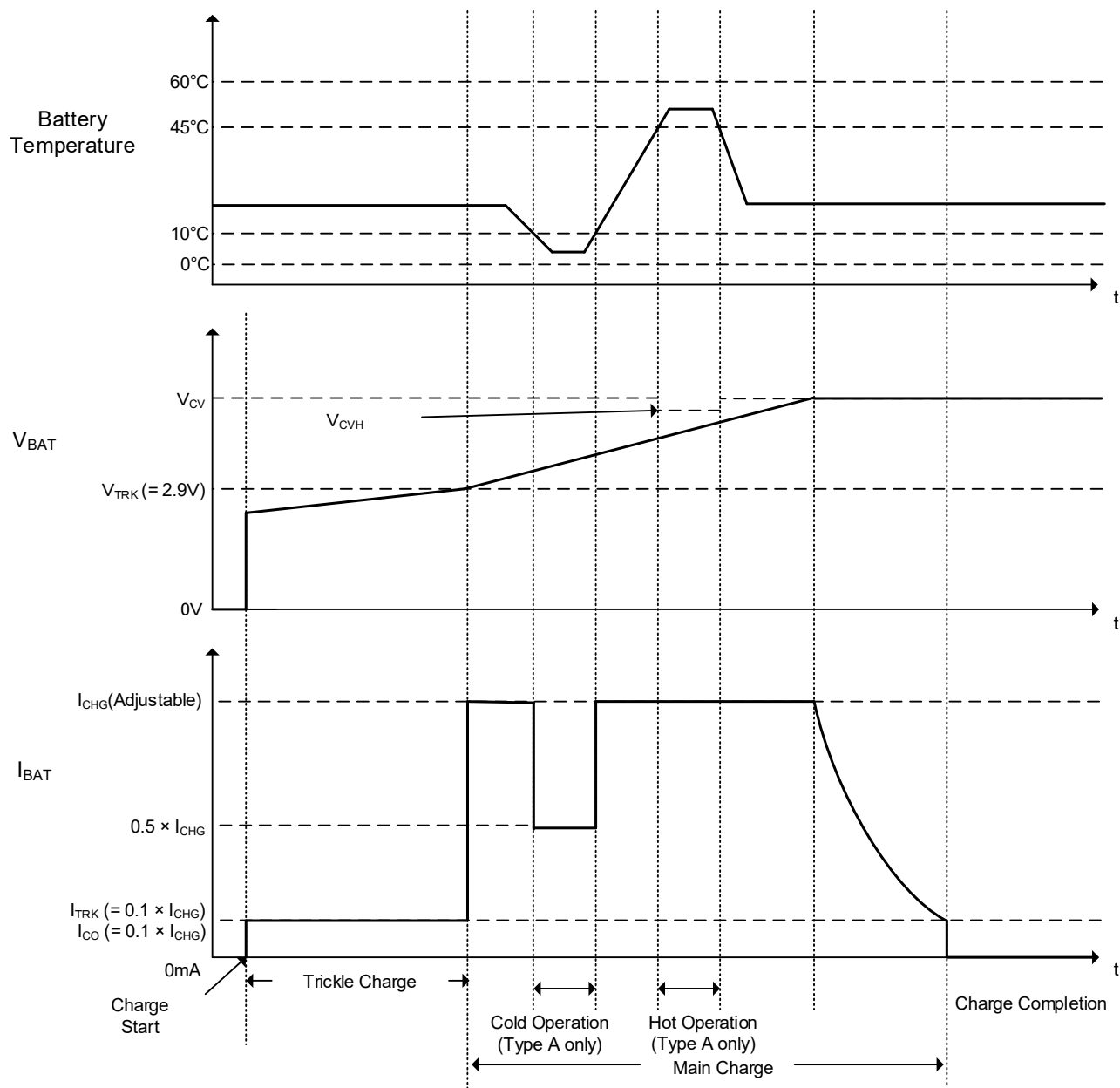
Table 8. Charge control function and charge status and BATMON output

Functions	Mode	CHG/BATmonEN	Charge State	BATMON Output
H,J,N,P	Shutdown Mode	-	-	GND or High impedance
	Charge Mode	"H"	Charge Enable	$0.2 \times V_{BAT}$
		"L"	Charge Disable (Timer pause)	GND
	Battery Power Mode	"H"	Charge Disable	$0.2 \times V_{BAT}$
		"L"		GND

## OPERATIONAL EXPLANATION

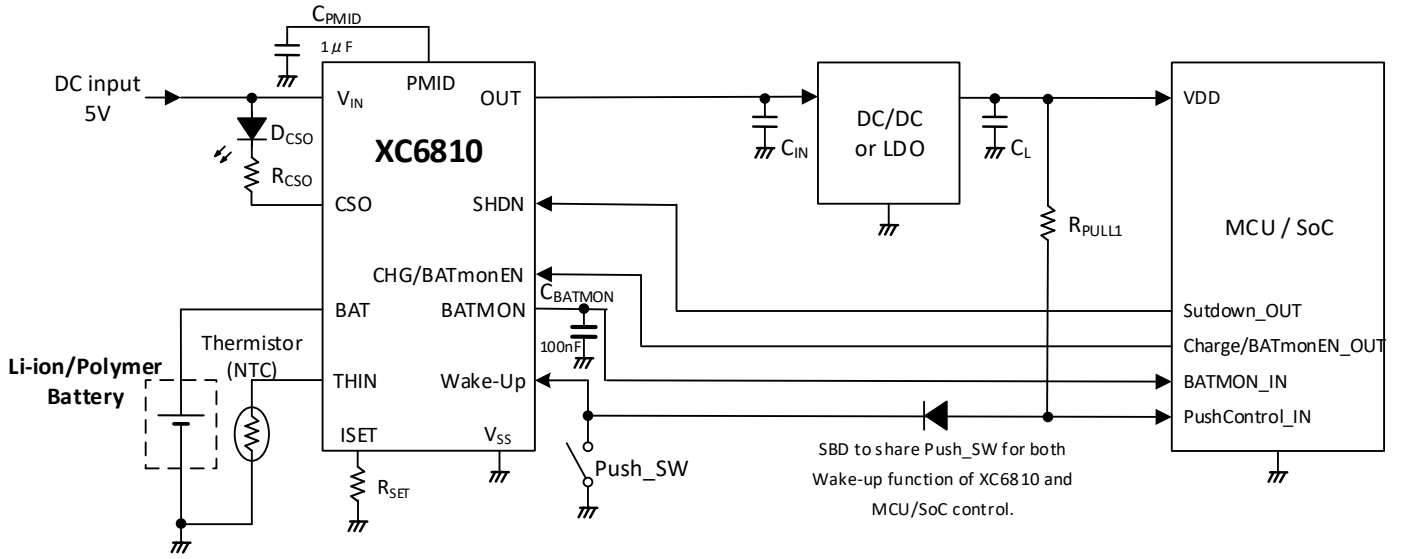
< Charge timing chart >

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

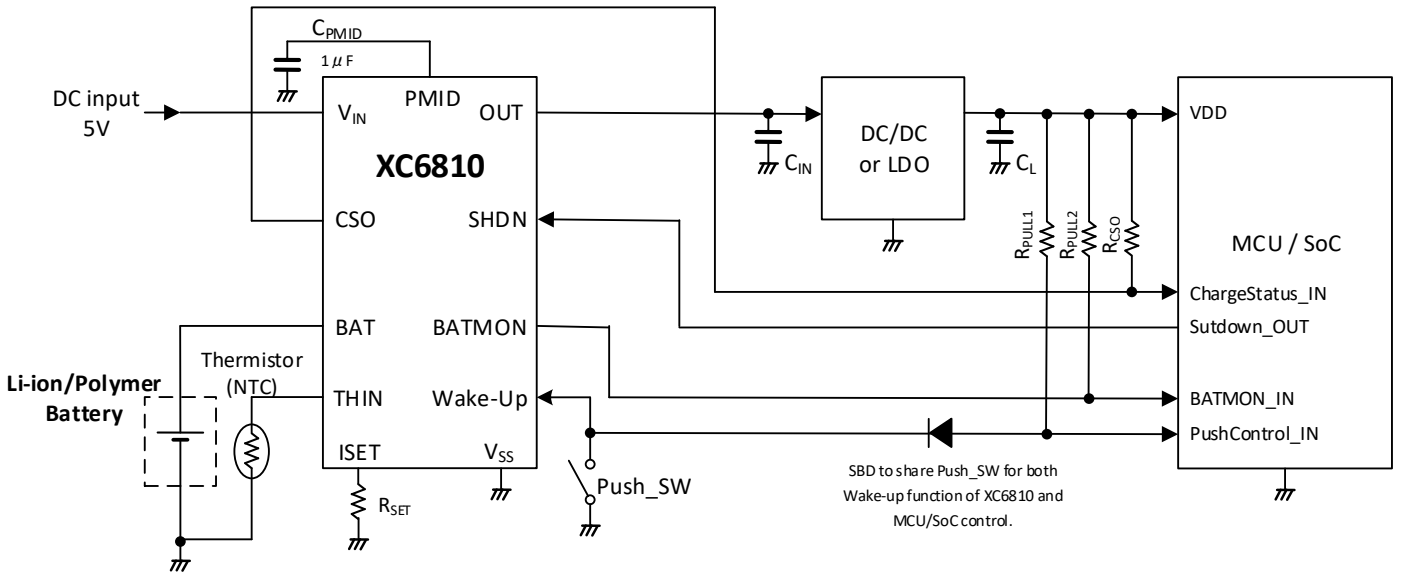


## ■ TYPICAL APPLICATION CIRCUIT

Type A,B,C / Functions H, N



Type A,B,C / Functions E



## TYPICAL APPLICATION CIRCUIT

### 【Typical Examples】

	FUNCTIONS	MANUFACTURER	PRODUCT NUMBER	Description
C <sub>PMID</sub> <sup>(*)</sup>	-	Murata	GRM033R60J105MEA2	1μF/6.3V (0.6x0.3x0.35mm)
R <sub>SET</sub>	-	-	-	1.95kΩ to 46kΩ

	FUNCTIONS	MANUFACTURER	PRODUCT NUMBER	Description
C <sub>BATMON</sub> <sup>(*)</sup>	A,C,E,F,G,H,J, K,M,N,P	Murata	GRM155R71E104KE14	100nF/25V (1.0x0.5x0.55mm)
	B,D,E	-	-	-
R <sub>PULL1</sub>	-	-	-	100kΩ
R <sub>PULL2</sub>	A,C,E,F,G,H,J, K,M,N,P	-	-	-
	B,D,E	-	-	100kΩ

	FUNCTIONS	MANUFACTURER	PRODUCT NUMBER	Description
R <sub>Cso</sub>	E,F,G,J,M,P	-	-	To MUC/SoC: 100kΩ 2-wire communication: Short
	A,B,C,D,H,K,N	-	-	10kΩ
D <sub>Cso</sub>	A,B,C,D,H,K,N	Würth 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	-	-	-

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

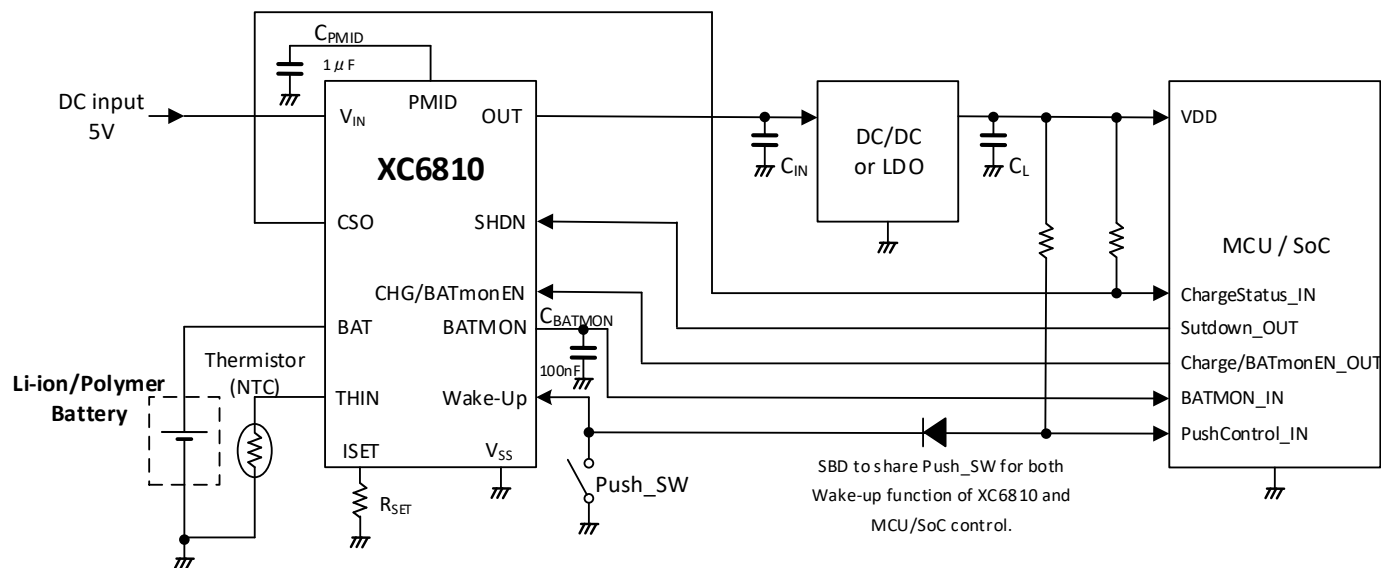
For the capacitance used for this IC, use an appropriate ceramic capacitor according to the DC bias usage conditions (ambient temperature), and make sure that the effective capacitance value is almost the same as the recommended component.

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.



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

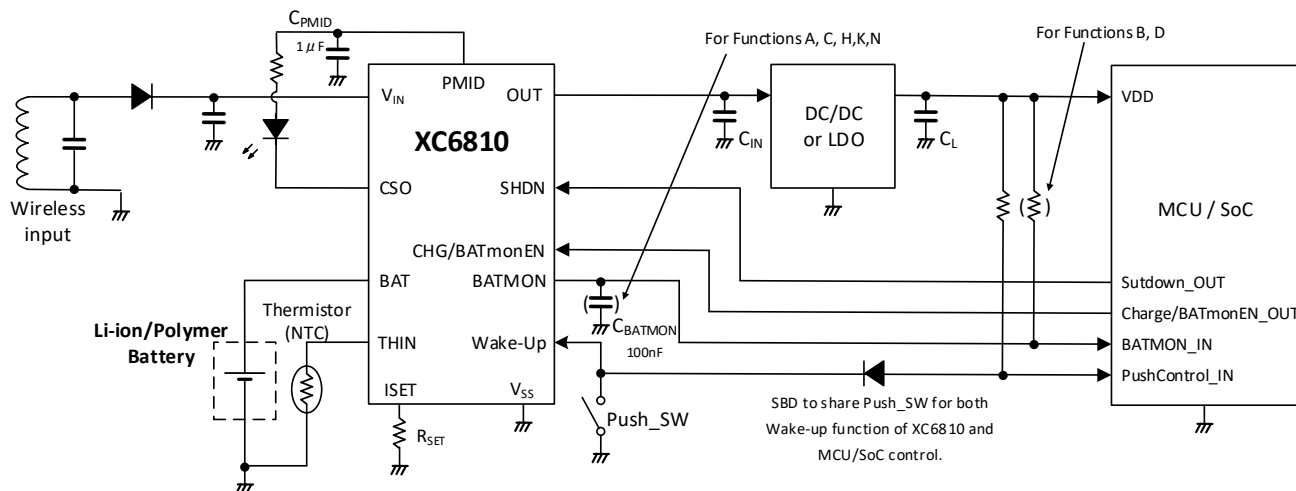
The charge level is output from CSO to MCU / SoC. Since the MCU / SoC needs to operate during charging to monitor the CSO, the operation voltage is supplied to OUT through the Current Path.



Functions	Battery Monitor Output	CSO Output	OUT		Charge Enable
			DC input Supply ( $V_{IN} \geq V_{UVLOR}$ )	DC input Open (UVLO State)	
G	0.2 x V <sub>BAT</sub>	Battery Status Indicator1	V <sub>PMID</sub>	V <sub>PMID</sub> (=V <sub>BAT</sub> )	No
J					Yes
M		Battery Status Indicator2			No
P					Yes

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

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.



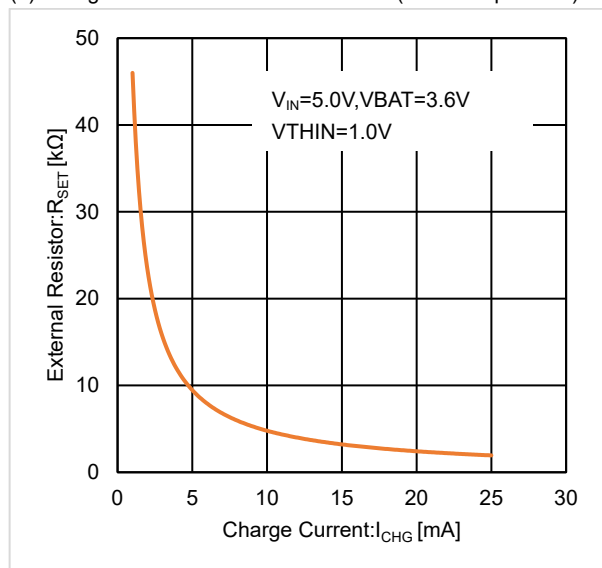
Functions	Battery Monitor Output	CSO Output	OUT		Charge Enable
			DC input Supply ( $V_{IN} \geq V_{UVLOR}$ )	DC input Open (UVLO State)	
A	0.2 x V <sub>BAT</sub>	Battery LED Indicator1	GND	V <sub>PMID</sub> (=V <sub>BAT</sub> )	No
C			V <sub>PMID</sub>		Yes
H		Battery LED Indicator2			No
K					Yes
N	Low Battery State : “L” Other State : “H”	Battery LED Indicator1	GND		No
B			V <sub>PMID</sub>		
D					

## ■ NOTES ON USE

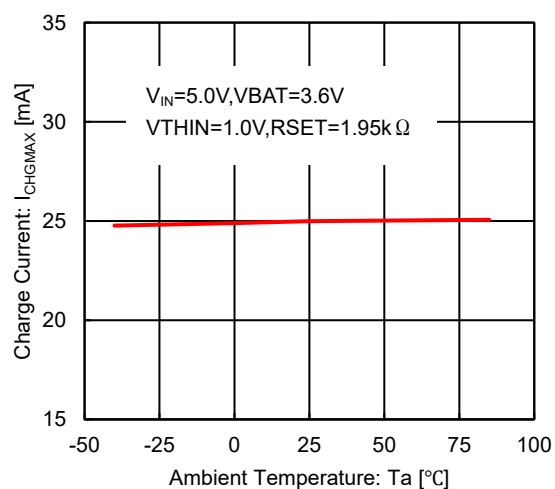
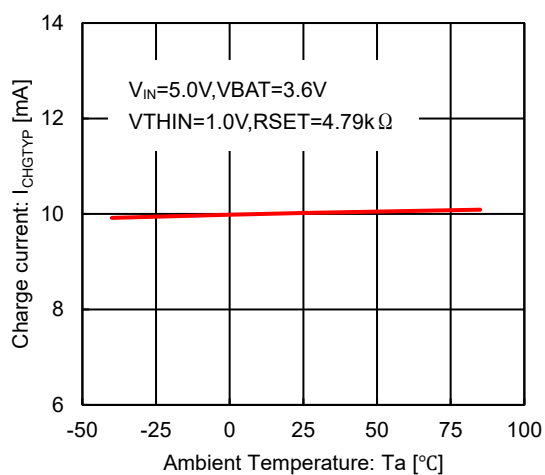
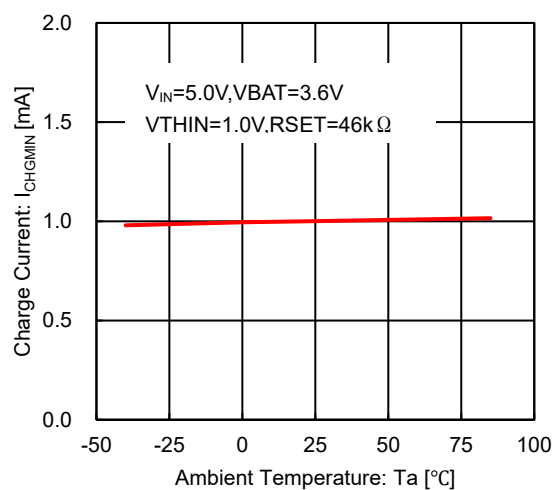
1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded. Also, if use the conditions outside the recommended operating range, the IC may not operate normally or may cause deterioration.
2. Where wiring impedance is high,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



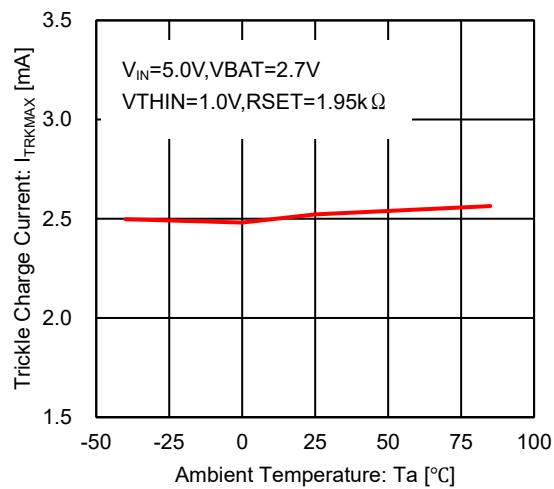
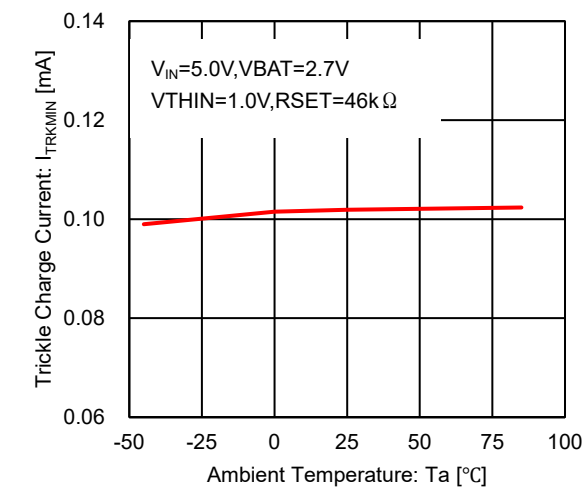
(2) Charge Current vs. Ambient Temperature (Normal Operation)



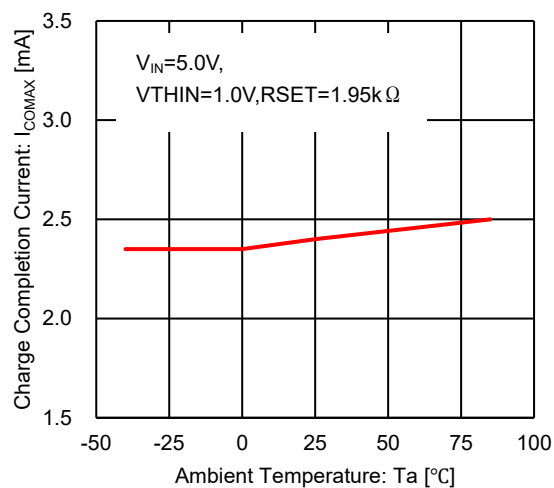
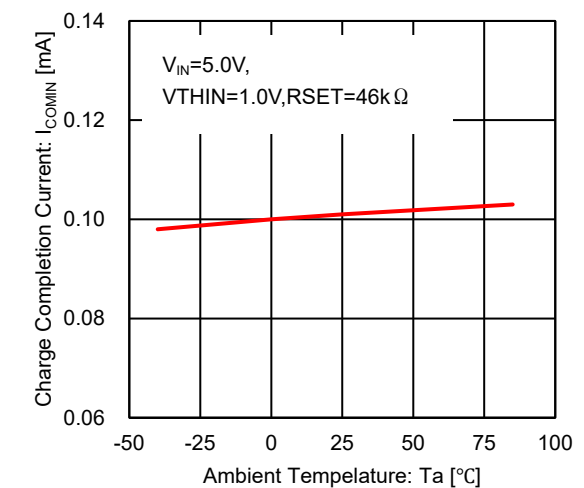


■ TYPICAL PERFORMANCE CHARACTERISTICS

(3) Trickle Charge Current vs. Ambient Temperature

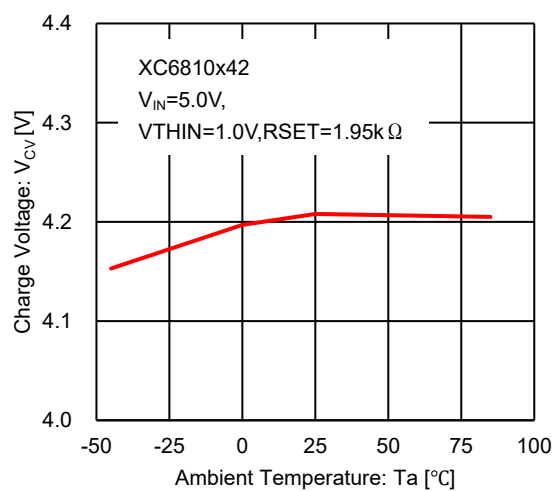
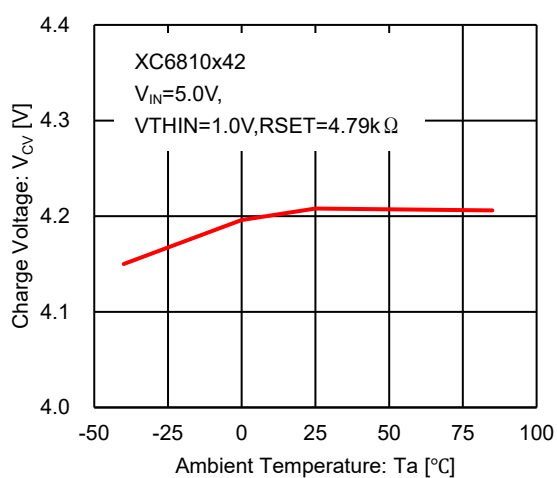
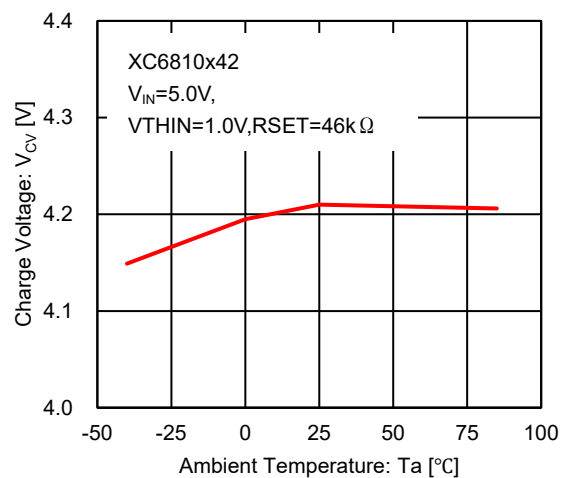


(4) Charge Completion Current vs. Ambient Temperature



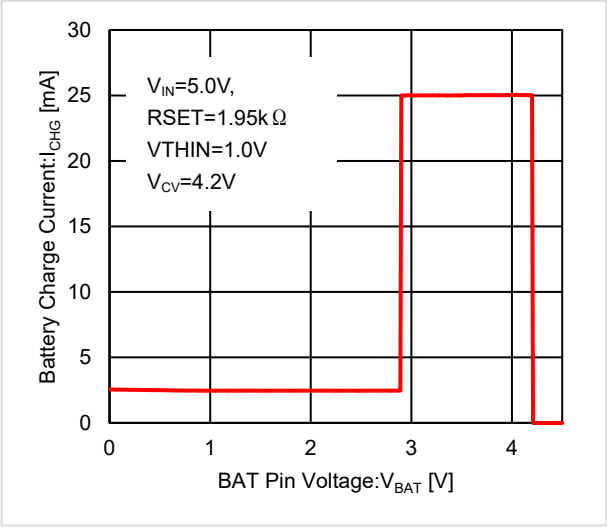
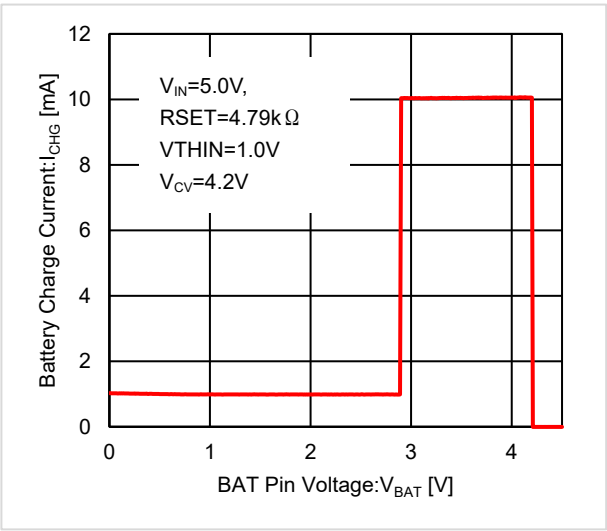
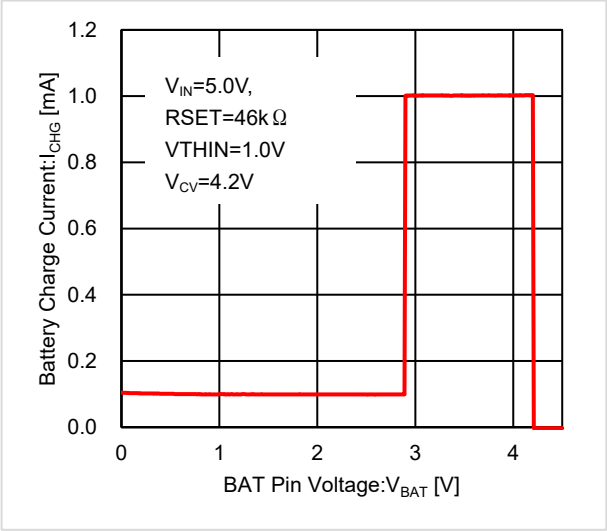
## TYPICAL PERFORMANCE CHARACTERISTICS

(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](http://www.torexsemi.com/technical-support/packages)

PACKAGE	OUTLINE / LAND PATTERN	THERMAL CHARACTERISTICS
WLP-12-01	<a href="#">WLP-12-01 PKG</a>	<a href="#">WLP-12-01 Power Dissipation</a>

## 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

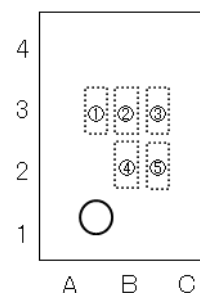
③ represents Functions.

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
K	XC6810***K0R-G
M	XC6810***M0R-G
N	XC6810***N0R-G
P	XC6810***P0R-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.)

WLP-12-01



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.
9. All rights reserved. No part of this datasheet may be copied or reproduced unless agreed by Torex Semiconductor Ltd in writing in advance.

TOREX SEMICONDUCTOR LTD.