

Compact, low-consumption linear charge control IC

MM3835W Series

Outline

This IC is a linear charge control IC for 1-cell lithium-ion and lithium polymer batteries, capable of high-precision charge current control from 3 to 1000 mA, making it ideal for mobile devices with low-capacity batteries. Products are available with charge control voltages corresponding to various types of batteries (4.20V, 4.35V, 4.1V). Safe charge control is possible by controlling charge voltage and charge current according to temperature in compliance with the JEITA battery temperature profile.

Application

Wearable devices and others

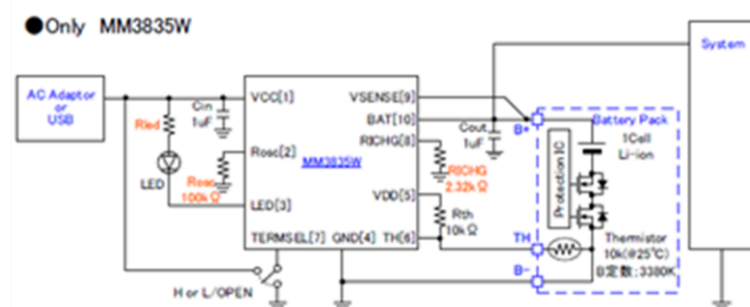
Feature

1. Low charge current control suitable for low-capacitance battery (charge current 3mA min.)
2. Multiple charge voltage (4.1V, 4.2V, 4.35V)
3. Selectable full charge current (TERMSEL pin)
4. Low BAT leak current (100nA max.)
5. Multiple battery temperature profile
6. Built-in thermal regulation function
7. Space saving package (2.7mm x 2.5mm x 0.55mm)
8. Operating temperature range $T_a = -40 \sim 85^\circ\text{C}$

Major Specification

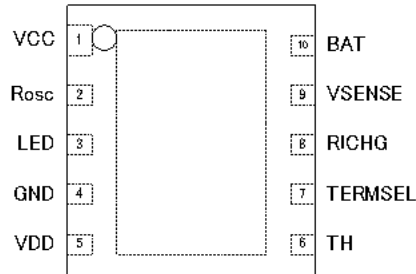
Parameter	Specification	Units
Rating voltage (VCC)	6	V
Operating voltage range (VCC)	4.0~5.8	V
Charge voltage	4.1/4.2/4.35	V
Fast charge current	3 - 1000	mA
Pre-charge current	Fast charge current $\times 0.1$	mA
Fast charge starting voltage	3.0	V
Full charge current	Fast charge current $\times 0.1 / \times 0.05$	mA
BAT leakage current (max.)	100	nA
Thermal regulation temperature	93	$^\circ\text{C}$
Charging timer	Pre:1, Fast:5	Hour

Application Circuit



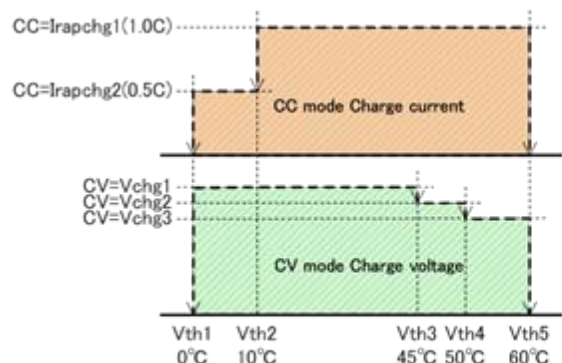
Package

SSON-10 (2.7mm x 2.5mm x 0.55mm)

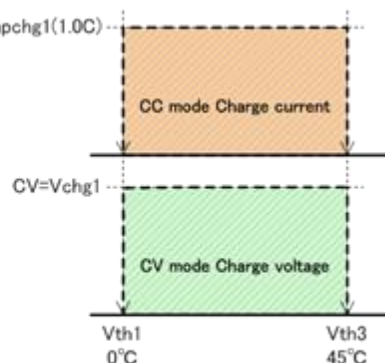


(TOP VIEW)

Battery Temperature Profile



(MM3835W01, MM3835W02, MM3835W03, MM3835W04)



(MM3835W05, MM3835W06, MM3835W07)





1. MODEL NAME

Model name		MM3835xxxRRE (xxx : see below)						
		W01	W02	W03	W04	W05	W06	W07
Charge Current Setting Range [mA]	Min.	200	3	200	3	200	200	200
	Max.	1000	200	1000	200	1000	1000	1000
BAT Regulation Voltage [V]		4.20	4.20	4.35	4.35	4.20	4.35	4.10
Battery Overvoltage Detection Voltage [V]		4.35	4.35	4.50	4.50	4.35	4.50	4.25
Recharge Detection Voltage [V]		3.97	3.97	4.12	4.12	3.97	4.12	3.88
Temperature Profile		JEITA compliance	JEITA compliance	JEITA compliance	JEITA compliance	Only Hot/Cold	Only Hot/Cold	Only Hot/Cold

Note on selection:

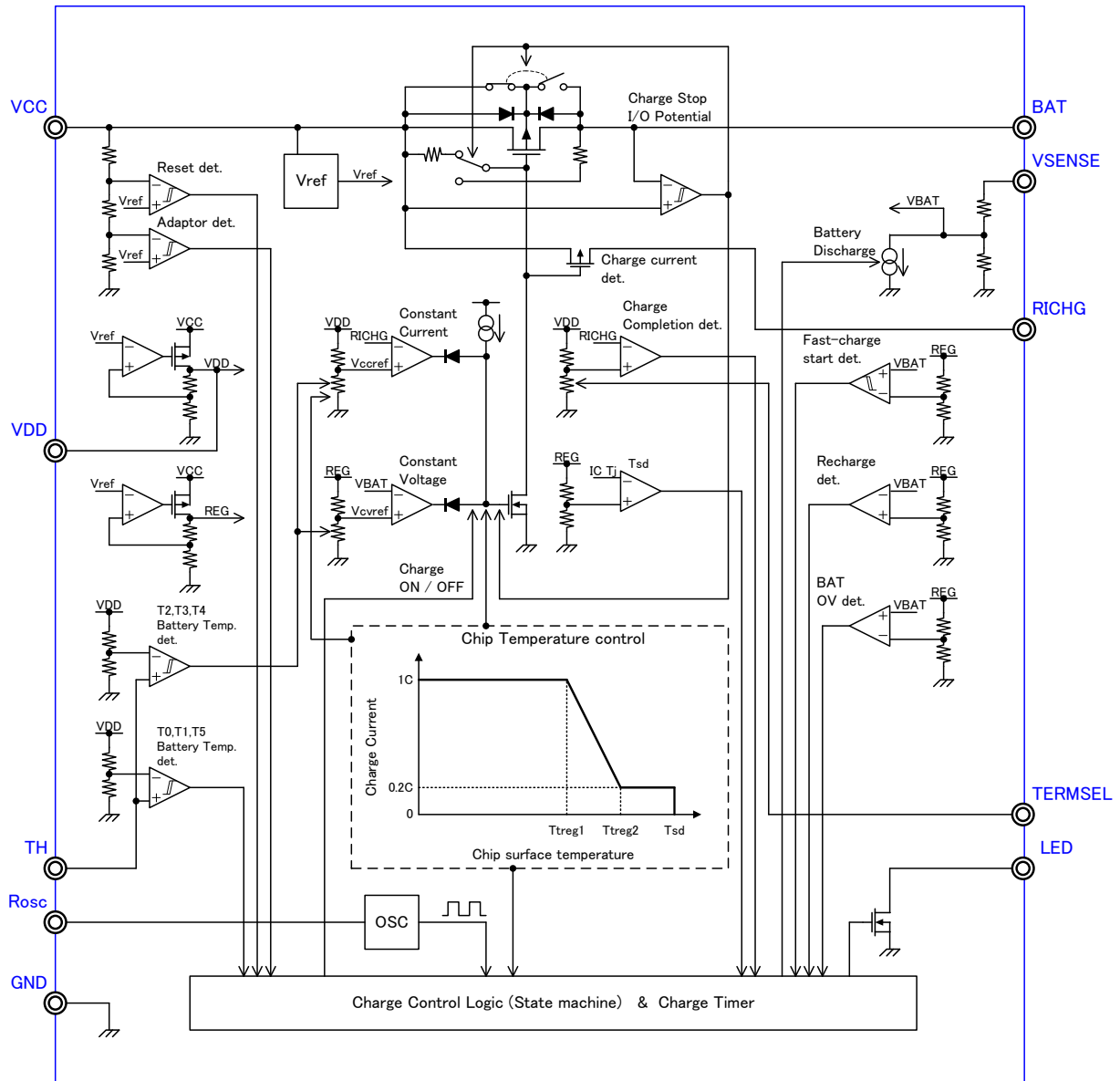
W02,W04 were prepared for wearable devices with low charging current.

Charging current of W01,W03,W05,W06 and W07 can be set up to 1500mA. But there is a case that is suppressed by the thermal regulation function. Please refer to page 7 for details.

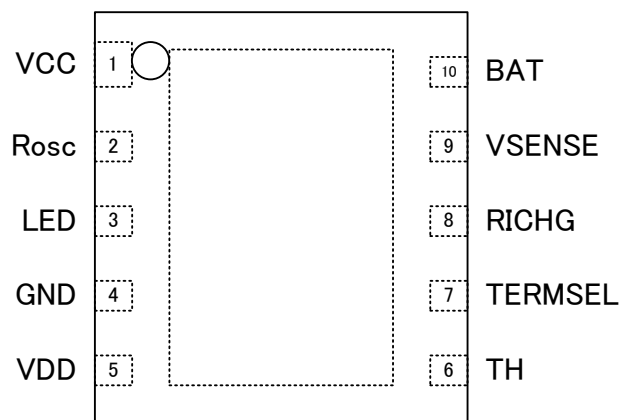
Charging current of W01,W03,W05,W06 and W07 is also can be set to 200mA or less, but if the charging current is small it is recommended more accurate W02 and W04.



2. BLOCK DIAGRAM



3. PIN CONFIGURATION



(TOP VIEW)



4. PIN DESCRIPTION

PIN No.	PIN NAME	TERMINAL EXPLANATIONS
1	VCC	External power supply, charge FET input pin Connect to an AC adaptor or USB.
2	Rosc	Oscillation frequency setting resistance connection pin. $f_{osc} = 0.912V / (1.425E-10 * R_{osc})$ *This value is an estimate. The fosc value for each Rosc value is specified on Page 18.
3	LED	Charge status pin (Nch open drain output) If connected LED, turn on during charging, turn off at charge completion and blinking at charge error.
4	GND	Ground Pin
5	VDD	Reference voltage pin for battery temperature detection. *It is not recommended to be used other than as battery temperature detecting reference voltage (resistance connection) since it is also used for charge current reference voltage.
6	TH	Battery temperature detection input pin. Connect to a thermistor.
7	TERMSEL	Charge completion current select pin. L/Open: 0.1 times the fast charge current, H: 0.05 times the fast charge current. *Pull down 1MΩ in internal circuit.
8	RICHG	Charge current setting resistance connection pin. $ICHG = 674 * 1.92V / RICHG$ (W01, W03, W05, W06, W07) $ICHG = 53.9 * 1.92V / RICHG$ (W02, W04) *This value is an estimate. The Charge Current value for each RICHG value is specified on Page 17.
9	VSENSE	Battery voltage detection and constant voltage charge control pin. In order to eliminate the influence of impedance, connected as close as possible to the positive side of the battery pack.
10	BAT	Charge current output pin, charge FET output pin Connect to the positive side of the battery pack.



5. ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Storage Temperature	Tstg	-55	150	°C
Operating Temperature	Topr	-40	85	°C
VCC, Rosc, VDD, TH, TERMSEL, RICHG, VSENSE, BAT Pin Voltage	Vin	-0.3	6.0	V
BAT Pin Output Current	IBAT	-	1500	mA
LED Pin Sink Current	ILED	-	20	mA
Power Dissipation(*1)	Pd	-	1.94	W

(*1): When mounted on a 40×40×1.6mm(epoxy glass ,double-sided, copper layer 90%) PC bord.

6. RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Operating Temperature	Topr	0	45	°C
VCC Operating Voltage (*2)	Vop	4.0	5.8	V
BAT Pin Voltage (*3)	Vbop	0	4.35	V
BAT Pin Output Current (*4)	IBAT	3	1000	mA

(*2): In order to fully charge the battery, please set the voltage of VCC to following formula.

$$VCC > V_{chg} + V_{def2}$$

In addition, in order to optimize the charging time, please set the voltage of VCC to following formula.

$$VCC > V_{chg} + I_{rapchg1} * R_{on}$$

(*3): Charging of the 0V battery is possible, but in the case of protection IC in the battery pack is charging disabled state, cannot be charged.

(*4): Charging current can be set up to 1500mA. But there is a case that is suppressed by the thermal regulation function.

In the case of the large charge current, please consider the heat dissipation.



7. ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, Ta=0~45°C, VCC=5.0V)

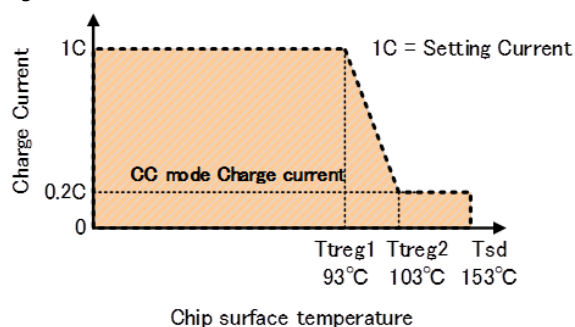
PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
POWER SUPPLY INPUT							
Supply Current	Icc	During charging stand-by		-	1.2	1.8	mA
		During fast charge Irapchg1=558mA (W01,W03,W05,W06,W07) Irapchg1=44.6mA (W02,W04)		-	2.7	4.2	mA
Battery Leakage Current 1	Ileak1	Inflow current of BAT and VSENSE pin AC adaptor is unconnected		-	10	100	nA
Battery Leakage Current 2	Ileak2	VCC=4.8V, Inflow current of BAT and VSENSE pin After Charge completion		-	-	2.0	uA
Reset Detection Voltage	Vpor	VCC=L→H		2.3	2.5	2.7	V
ADP Detection Voltage	Vadp	VCC=L→H, Charge permission voltage		3.6	3.8	4.0	V
CHARGE CONTROL							
Discharge Current 1	Idischg1	VSENSE(=BAT)=3.2V, In charge error		-	10	20	uA
Discharge Current 2	Idischg2	VSENSE(=BAT)=3.2V		100	200	300	uA
Fast-charge start voltage	Vqchgon	Detection voltage from trickle charge to fast charge		2.9	3.0	3.1	V
Fast-charge Start Hysteresis Voltage	Vqchgon hys	Detection voltage from fast charge to trickle charge		40	80	120	mV
BAT Regulation Voltage	Vchg1	Vth3<VTH≤Vth1	W05	4.17	4.2	4.23	V
			W06	4.32	4.35	4.38	V
			W07	4.07	4.10	4.13	V
	Vchg1	Vth3<VTH≤Vth1	W01,W02	4.17	4.20	4.23	V
	Vchg2	Vth4<VTH≤Vth3		4.05	4.10	4.15	V
	Vchg3	Vth5<VTH≤Vth4		4.00	4.05	4.10	V
	Vchg1	Vth3<VTH≤Vth1	W03,W04	4.32	4.35	4.38	V
	Vchg2	Vth4<VTH≤Vth3		4.20	4.25	4.30	V
	Vchg3	Vth5<VTH≤Vth4		4.15	4.20	4.25	V
Recharge Detection Voltage	Vrechg	After charge completion, VSENSE(=BAT)=H→L	W01,W02,W05	3.87	3.97	4.07	V
			W03,W04,W06	4.02	4.12	4.22	V
			W07	3.78	3.88	3.97	V
Battery Over-voltage Detection Voltage	Vov	VCC=L→H	W01,W02,W05	4.27	4.35	4.43	V
			W03,W04,W06	4.42	4.5	4.58	V
			W07	4.18	4.25	4.32	V
Charge Stop I/O Potential Difference 1	Vdef1	VCC=H→L, Charge stop voltage at VCC—BAT<Vdef1		5	30	65	mV
Charge Restart I/O Potential Difference 2	Vdef2	VCC=L→H, Charge restart voltage at VCC—BAT>Vdef2		5	45	65	mV



(Unless otherwise specified, Ta=0~45°C, VCC=5.0V)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Forced Charge Current	Istart	RICHG=2.32kΩ	W01,W03,W05,W06,W07	116	167	219	mA
			W02,W04	9.3	13.4	17.5	mA
Trickle-charge Current	Iprechg	RICHG=2.32kΩ, BAT=2.6V	W01,W03,W05,W06,W07	40	56	72	mA
			W02,W04	3.2	4.5	5.8	mA
Fast-charge Current	Irapchg1	RICHG=2.32kΩ, BAT=3.6V, Vth5<VTH≤Vth2 (1.0C)	W01,W03,W05,W06,W07	530	558	586	mA
			W02,W04	42.4	44.6	46.9	mA
	Irapchg2	RICHG=2.32kΩ, BAT=3.6V, Vth2<VTH≤Vth1 (0.5C)	W01,W03,W05,W06,W07	251	279	307	mA
			W02,W04	20.1	22.3	24.6	mA
Charge Completion Current	Ifc	RICHG=2.32kΩ, BAT>Vqchgcon, TERMSEL=L/Open	W01,W03,W05,W06,W07	40	56	72	mA
			W02,W04	3.2	4.5	5.8	mA
		RICHG=2.32kΩ, BAT>Vqchgcon, TERMSEL=H	W01,W03,W05,W06,W07	20	28	36	mA
			W02,W04	1.5	2.2	2.9	mA
Series Pass Tr On Resistance	Ron	Io=200mA	W01,W03,W05,W06,W07	-	0.38	0.60	Ω
			W02,W04	-	4.75	5.05	Ω
THERMAL REGULATION and THERMAL SHUTDOWN							
Chip Temperature Detection 1(*5)	Ttreg1	Applied to Tj (chip temperature)		83	93	103	℃
Chip Temperature Detection 2(*5)	Ttreg2	Applied to Tj (chip temperature)		-	103	-	℃
Chip Temperature Detection Difference (*5)	Tdtreg	Applied to Tj (chip temperature), Ttreg2-Ttreg1		5	10	15	℃
Thermal Shutdown Temperature (*5)	Tsd	Applied to Tj (chip temperature)		143	153	163	℃
BATTERY TEMPERATURE DETECT							
Temperature Detecting Reference Voltage	VDD	VDD pin Output Voltage		1.82	1.92	2.02	V
Temperature Detecting Reference Terminal Current (*5)	IDD	VDD pin Output Current		-	3	-	mA

(*5): The parameter is guaranteed by design.



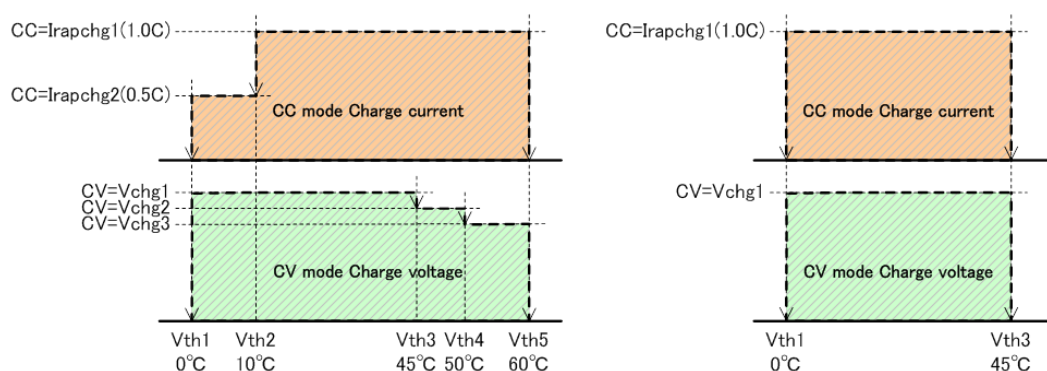
Chip temperature detection and thermal shutdown



(Unless otherwise specified, $T_a=0\sim45^{\circ}\text{C}$, $V_{CC}=5.0\text{V}$)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Battery Temperature Detection Voltage T0	Vth0	Charge stop threshold when TH pin rises(-20°C)	-	VDD* 0.8722	-	V
Battery Temperature Detection Voltage T0R(*6)	Vth0R	Charge recover threshold when TH pin falls(-17°C)	-	VDD* 0.8551	-	V
Battery Temperature Detection Voltage T1	Vth1	Charge stop threshold when TH pin rises(0°C)	VDD* 0.7142	VDD* 0.7313	VDD* 0.748	V
Battery Temperature Detection Voltage T1R(*6)	Vth1R	Charge recover threshold when TH pin falls(3°C)	-	VDD* 0.7055	-	V
Battery Temperature Detection Voltage T2	Vth2	CC=0.5C threshold when TH pin rises(10°C)	VDD* 0.6231	VDD* 0.6419	VDD* 0.6604	V
Battery Temperature Detection Voltage T2R	Vth2R	CC=1C threshold when TH pin falls(13°C)	-	VDD* 0.6137	-	V
Battery Temperature Detection Voltage T3	Vth3	CV=4.10V threshold when TH pin falls(45°C)	VDD* 0.3149	VDD* 0.3296	VDD* 0.3448	V
Battery Temperature Detection Voltage T3R	Vth3R	CV=4.20V threshold when TH pin rises(41°C)	-	VDD* 0.3604	-	V
Battery Temperature Detection Voltage T4	Vth4	CV=4.05V threshold when TH pin falls(50°C)	VDD* 0.2804	VDD* 0.2938	VDD* 0.3078	V
Battery Temperature Detection Voltage T4R	Vth4R	CV=4.1V threshold when TH pin rises(45°C)	-	VDD* 0.3296	-	V
Battery Temperature Detection Voltage T5	Vth5	Charge stop threshold when TH pin falls(60°C)	VDD* 0.2208	VDD* 0.2316	VDD* 0.2431	V
Battery Temperature Detection Voltage T5R(*6)	Vth5R	Charge recovery threshold when TH pin rises(55°C)	-	VDD* 0.2612	-	V

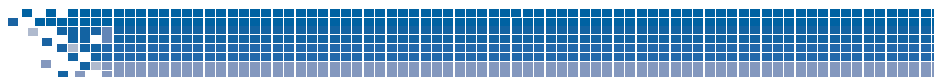
(*6): When the charge start and recharge start, to become $T1=T1R=0$ degree and $T5=T5R=60$ degree, please be careful about the noise and GND wiring.



(MM3835W01, MM3835W02, MM3835W03, MM3835W04)

(MM3835W05, MM3835W06, MM3835W07)

JEITA Battery Temperature Profile



(Unless otherwise specified, Ta=0~45°C, VCC=5.0V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
LOGIC I/O						
TERMSEL pin Low-Level Input Voltage	Vterm _L		-	-	0.5	V
TERMSEL pin High-Level Input Voltage	Vterm _H		2.0	-	-	V
TERMSEL pin Low-Level Input Current	Iterm _L	TERMSEL=0V	-	-	1	μA
TERMSEL pin High-Level Input Current	Iterm _H	TERMSEL =5.0V	-	-	10	μA
LED pin Low-Level Voltage	Vled _L	Iled=10mA	-	-	0.4	V
LED Pin Leak Current	Iled _{leak}	LED=5V	-1	-	1	μA
FREQUENCY and DETECTION DELAY TIME						
Oscillator Frequency (*5)	Fosc	Rosc=100kΩ	57.6	64.0	70.4	kHz
LED Blinking Cycle (*5)	Fled	Rosc=100kΩ, In charge error mode	0.922	1.024	1.126	s
LED Blinking Duty (*5)	Dled	Rosc=100kΩ, In charge error mode	30	50	70	%
VSENSE Pin Discharge Time (*5)	Tdischg	Rosc=100kΩ	58	64	70	ms
Reset detection time (*5)	Tpor	VCC=L→H	32	64	96	μs
Adaptor Detection Time (*5,7)	Tadp	Rosc=100kΩ, VCC=L→H	24	-	32	ms
Forced Charge Time (*5)	Tistart	Rosc=100kΩ	480	512	544	ms
Forced Charge OFF Time (*5)	Toff	Rosc=100kΩ	115	128	141	ms

(*5): The parameter is guaranteed by design.

(*7): Because the detection time for mode transition if they match 8ms x 4 times, there is the detection timing error of approximately 1 clock (8ms).



(Unless otherwise specified, Ta=0~45°C, VCC=5.0V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Battery Voltage Detection Time(*5,8)	Tcon	Rosc=100kΩ	96	-	128	ms
Fast Charge Start Voltage Detection Time (*5,8)	Tqstart	Rosc=100kΩ	96	-	128	ms
Charge Completion Current Detection Time (*5,9)	Tifc	Rosc=100kΩ	192	-	256	ms
Recharge Start Voltage Detection Time (*5,9)	Trechg	Rosc=100kΩ	192	-	256	ms
Trickle-charge Timer (*5)	Tdchg	Rosc=100kΩ	54	60	66	min
Fast-charge Timer (*5)	Tchg	Rosc=100kΩ	270	300	330	min
Battery Overvoltage Detection Time (*5,8)	Tov	Rosc=100kΩ	96	-	128	ms
Charge Stop Battery Temperature Detection Time (*5,8)	Tpro	Rosc=100kΩ Vth1、VTH=L→H or Vth5、VTH=H→L	96	-	128	ms
Charge Recovery Battery Temperature Detection Time (*5,8)	TproR	Rosc=100kΩ Vth1R、VTH=H→L or Vth5R、VTH=L→H	96	-	128	ms

(*5): The parameter is guaranteed by design.

(*8): Because the detection time for mode transition if they match 32ms x 4 times, there is the detection timing error of approximately 1 clock (32ms).

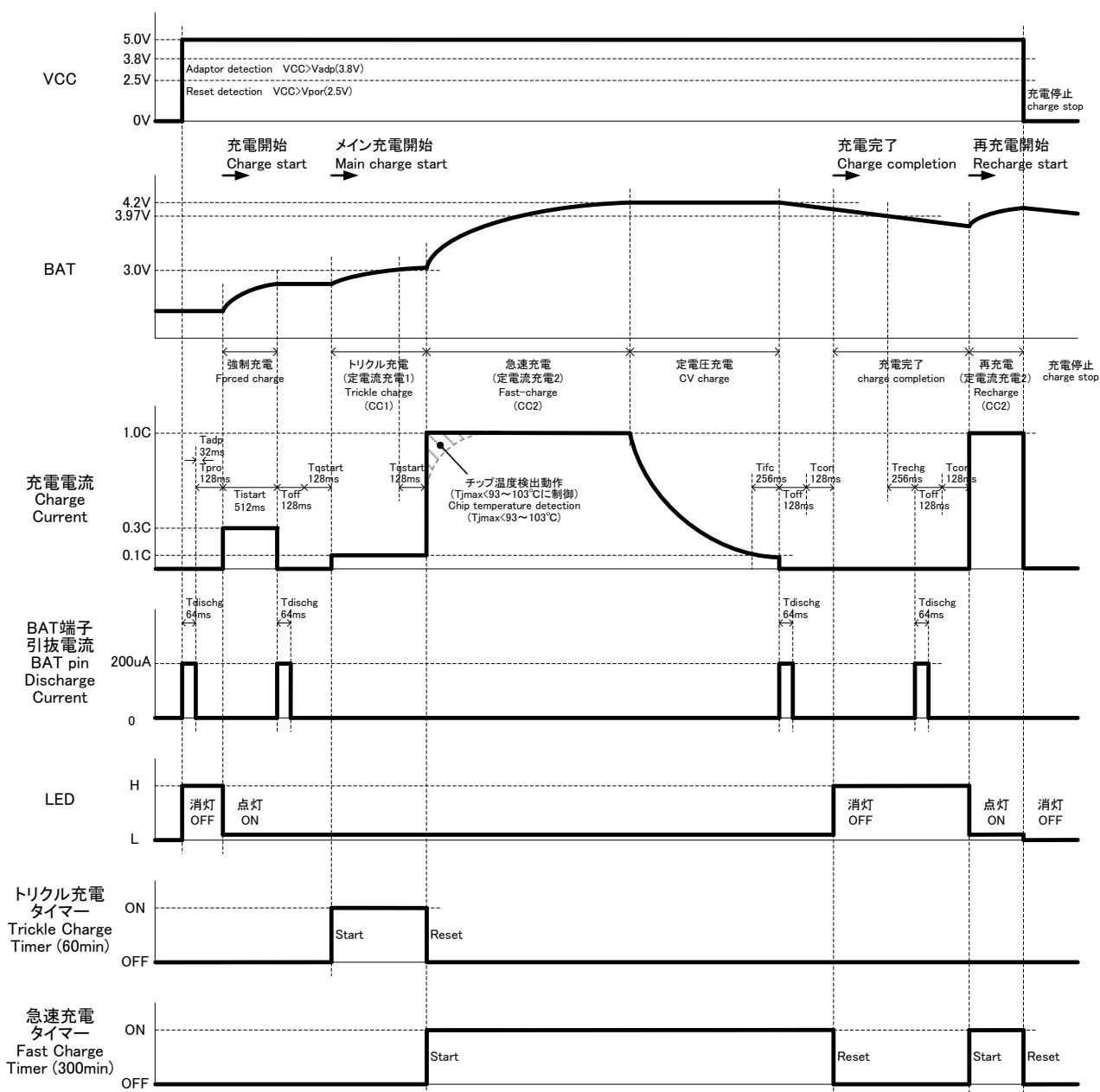
(*9): Because the detection time for mode transition if they match 64ms x 4 times, there is the detection timing error of approximately 1 clock (64ms).



8. TIMING CHART

* The characteristics of MM3835W01 as a typical.

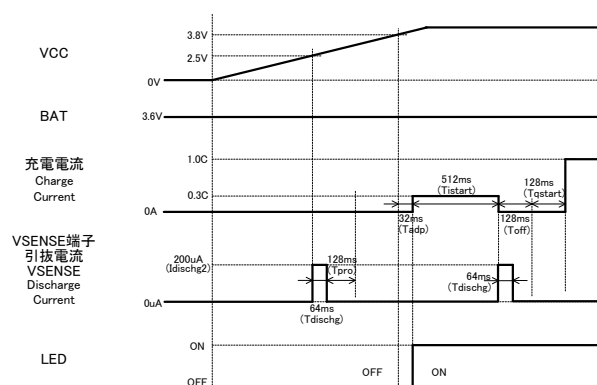
• Normal charge



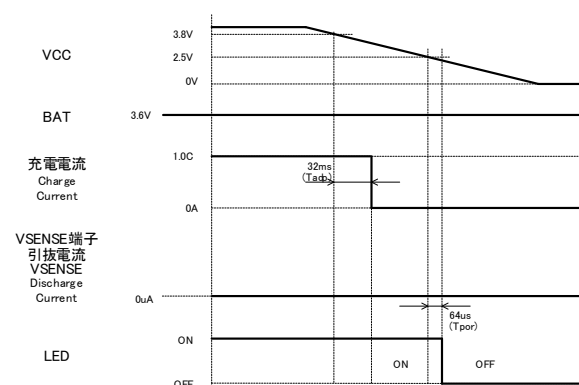


* The characteristics of MM3835W01 as a typical.

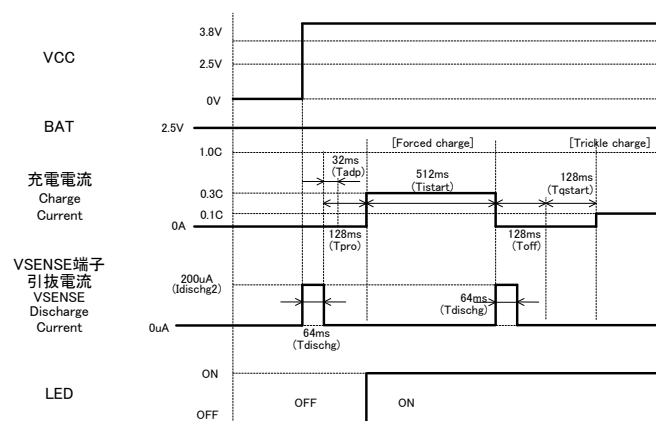
• Adapter connection



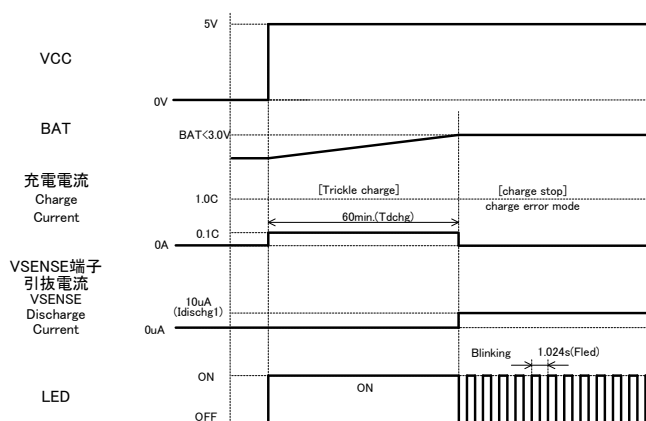
• Adaptor release



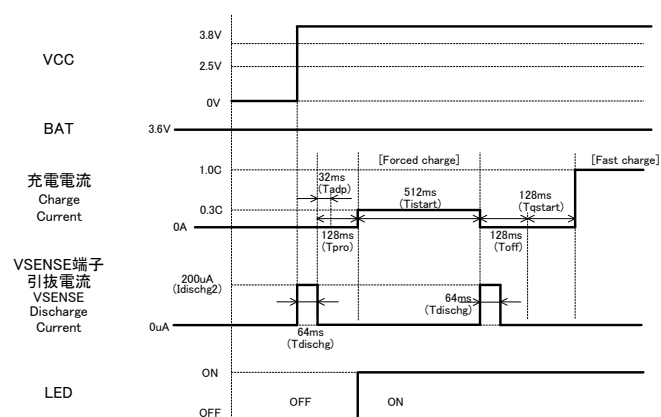
• BAT<3.0V, Charge start (trickle charge)



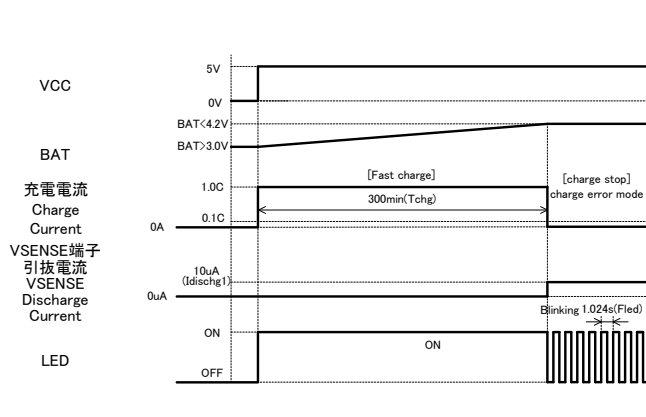
• Trickle charge timeup



• 3.0V<BAT<4.2V, Charge start (fast charge)



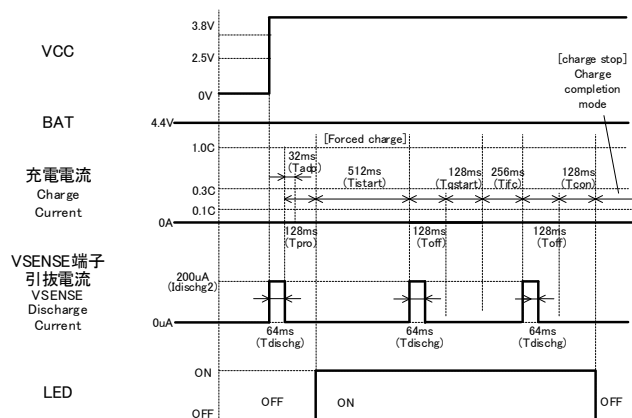
• Fast charge timeup



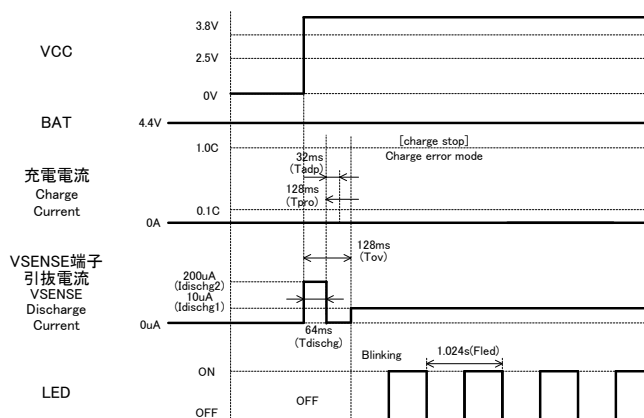


* The characteristics of MM3835W01 as a typical.

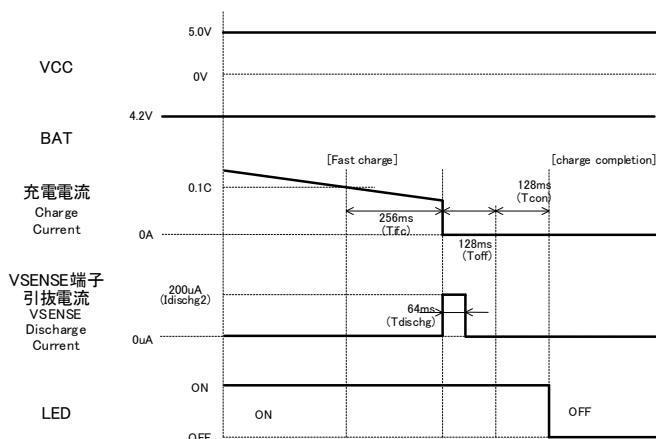
• BAT=4.2V, Charge start (Charge Completion)



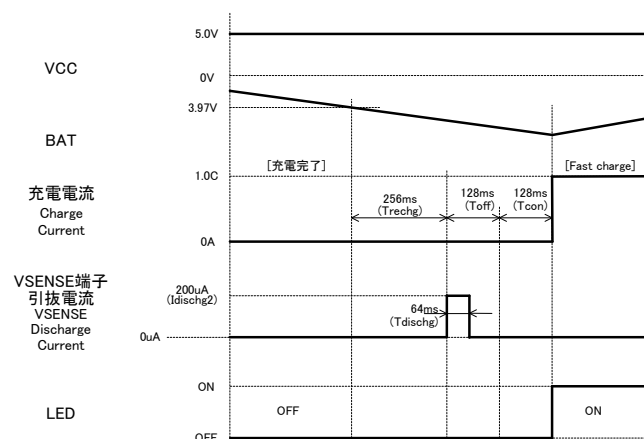
• BAT>4.35V, Charge start (battery overvoltage)



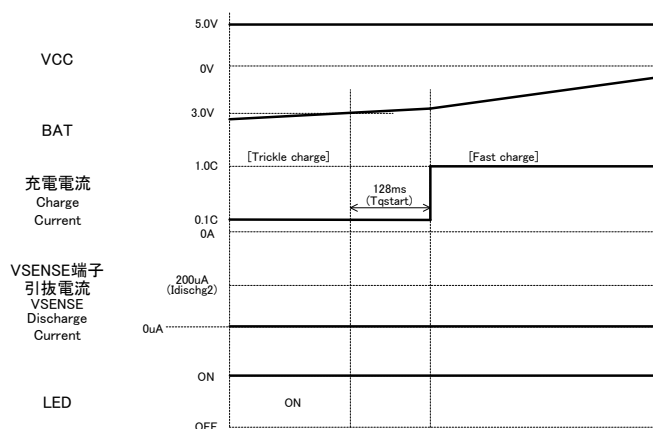
• Full charge detection



• Recharge detection



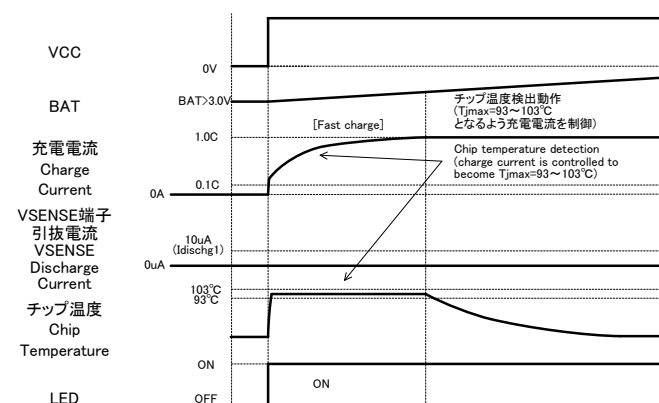
• Fast-charge start voltage detection



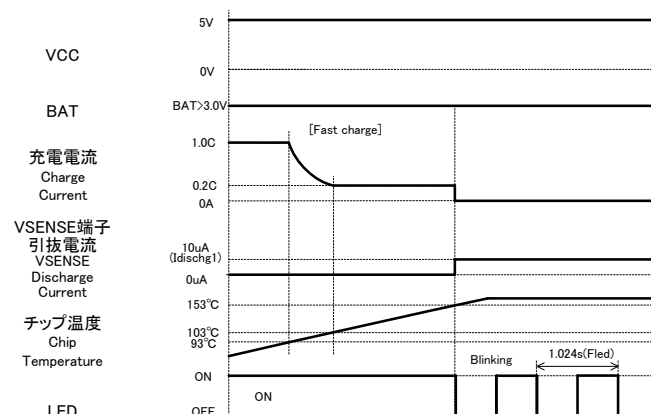


* The characteristics of MM3835W01 as a typical.

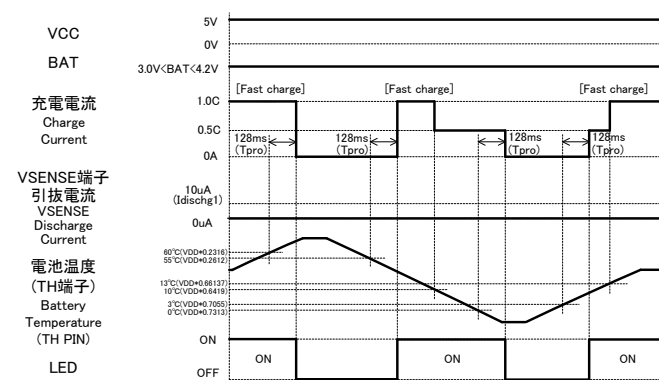
• Chip temperature detection



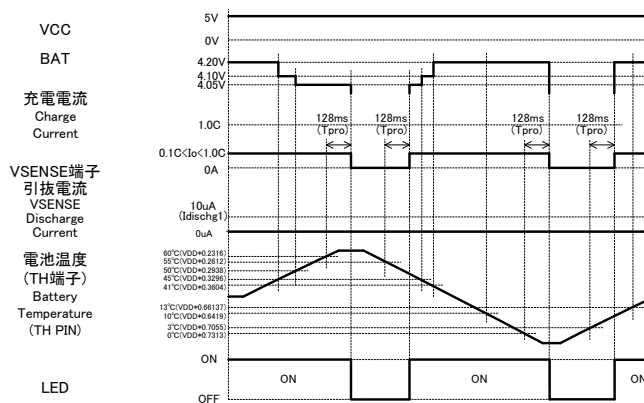
• Thermal shutdown



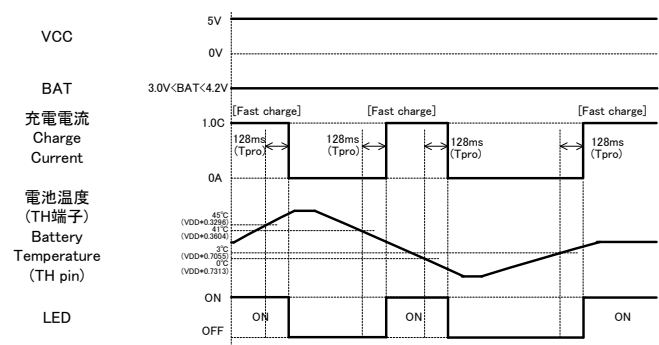
• Battery temperature detection (Constant Current Mode)



• Battery temperature detection (Constant Voltage Mode)



• Battery temperature detection (No temperature profile W05, W06, W07)



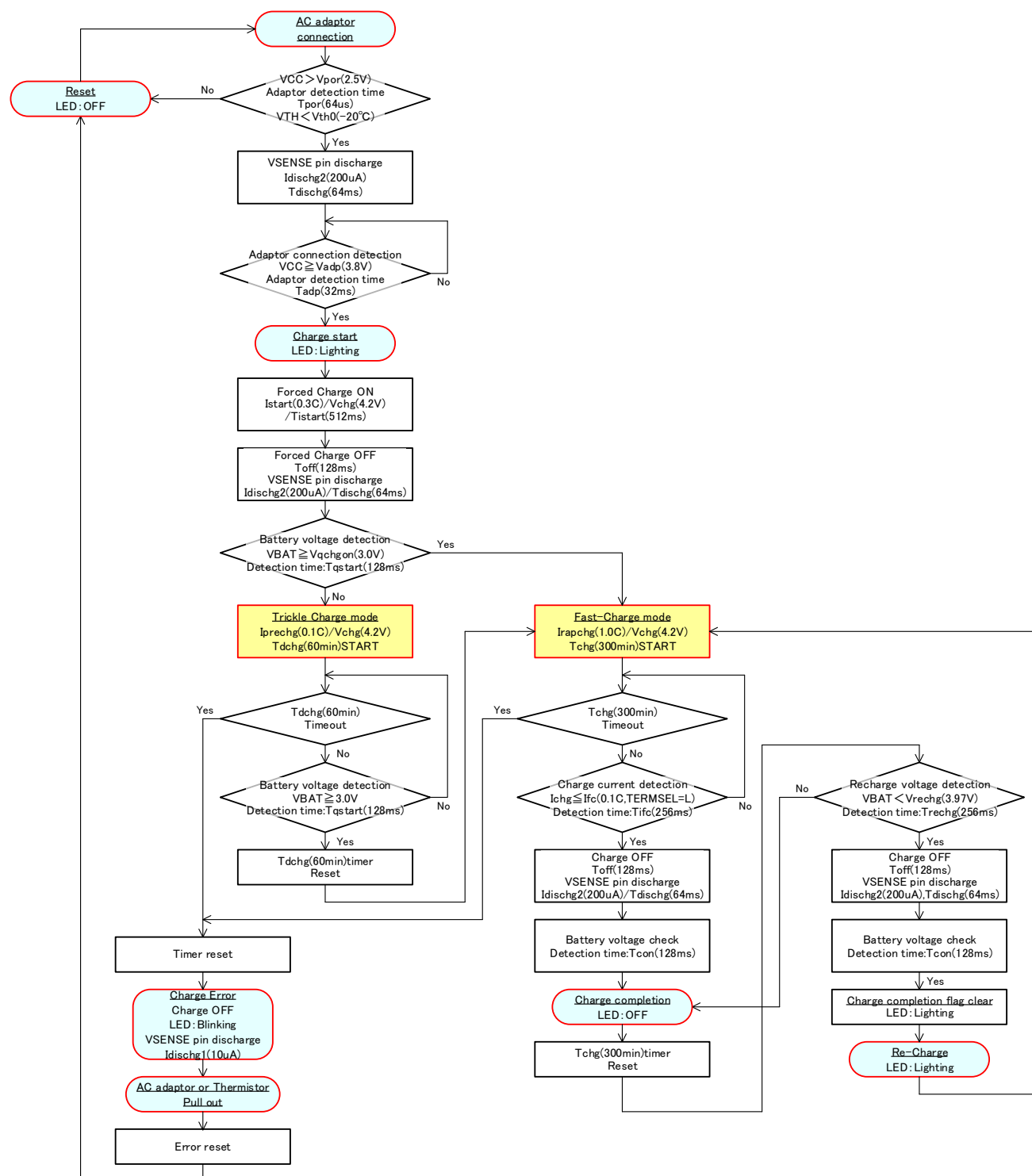


9. フローチャート / FLOW CHART

*1 All typ numeric value of MM3835W01,MM3835W02 and MM3835W05.

*2 Charge current, charge completion current and each detection time for RICHG=2.32kΩ, ROSC=100kΩ.

● Main flow chart

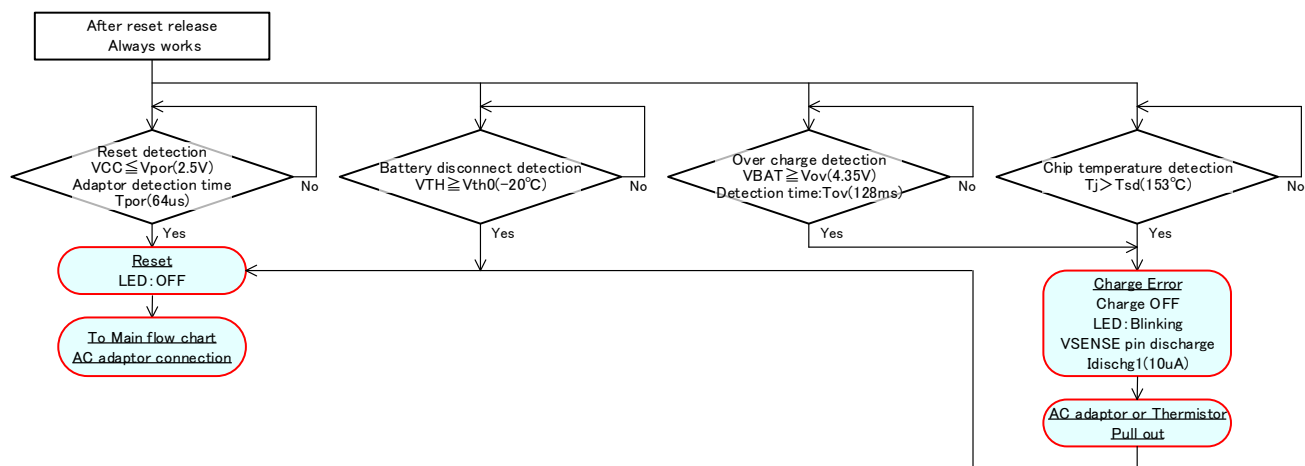




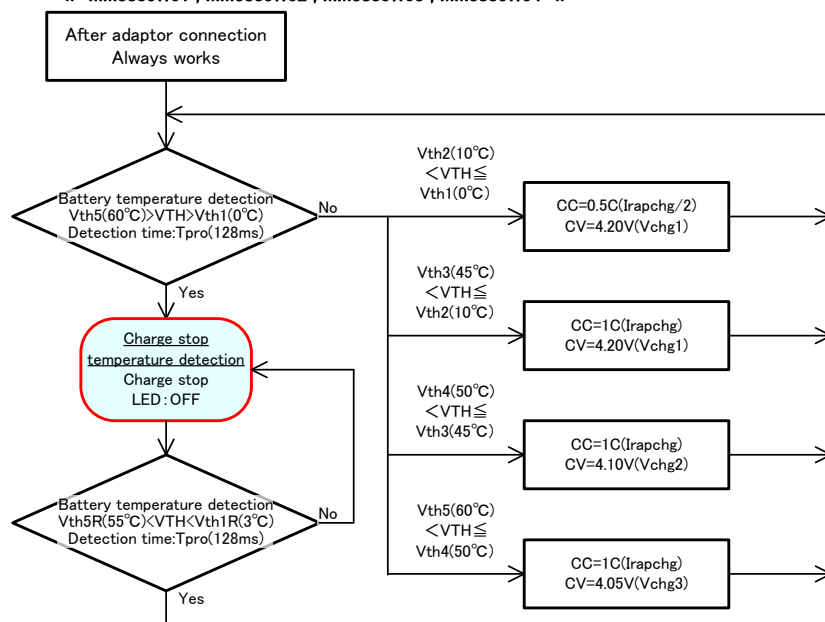
*1 All typ numeric value of MM3835W01,MM3835W02 and MM3835W05.

*2 Charge current, charge completion current and each detection time for RICHG=2.32kΩ, ROSC=100kΩ.

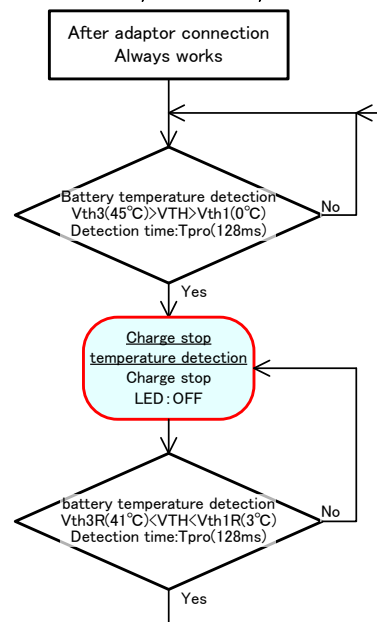
• Protection function (Always detected)



◀ MM3835W01 , MM3835W02 , MM3835W03 , MM3835W04 ▶

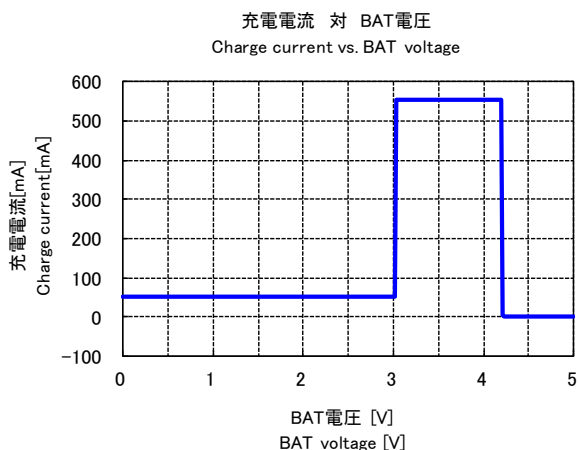


◀ MM3835W05 , MM3835W06 , MM3835W07 ▶

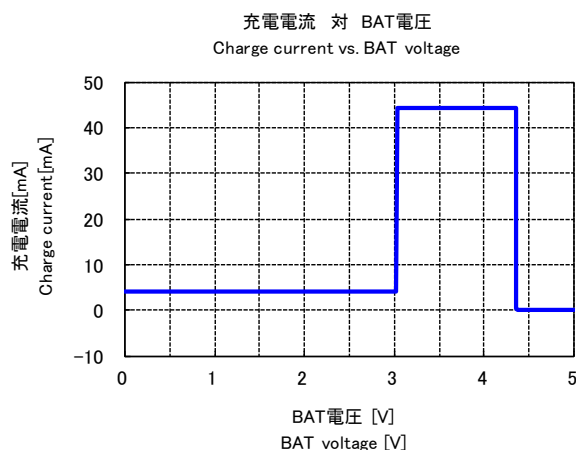


10. TYPICAL PERFORMANCE CHARACTERISTICS

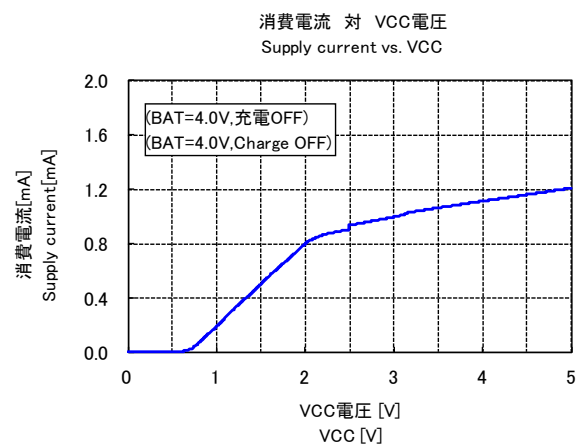
(Unless otherwise specified, VCC=5.0V, RICHG=2.32k Ω , ROSC=100k Ω , TERMSEL=0V, Ta=25°C)



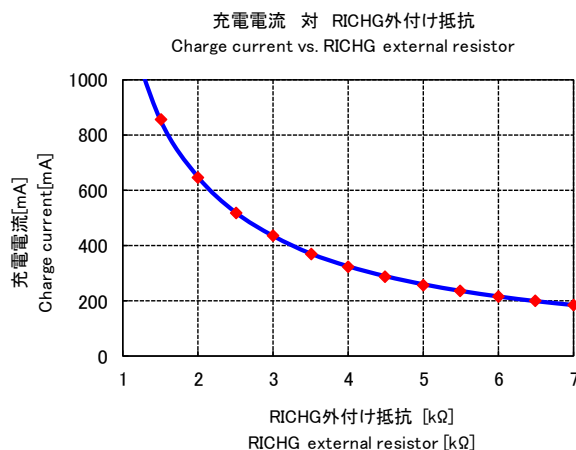
MM3835W01



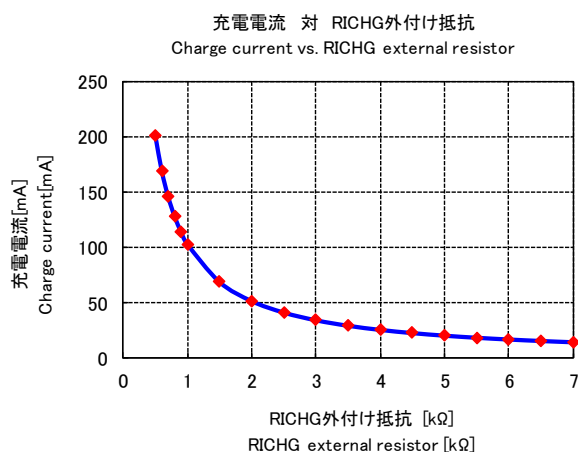
MM3835W04



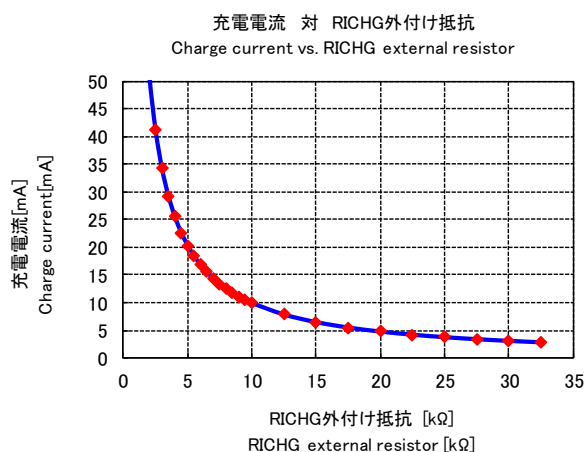
All ranks



MM3835W01



MM3835W04(50mA~200mA)

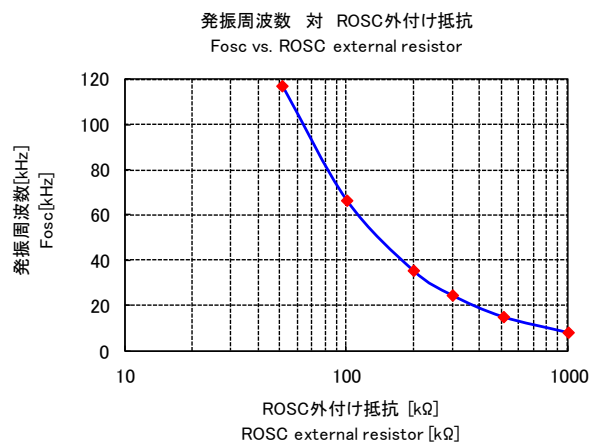


MM3835W04(3mA~50mA)

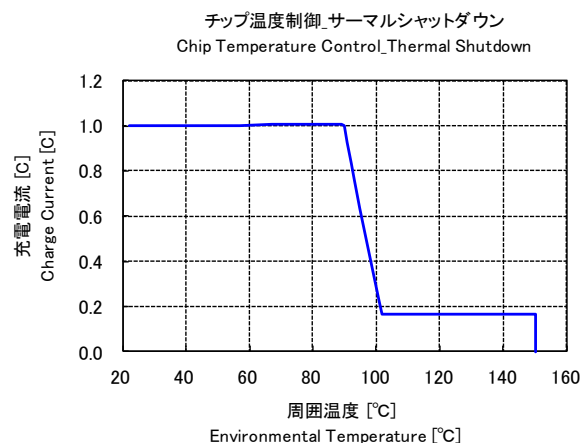
*: These are typical characteristics.



(Unless otherwise specified, VCC=5.0V, RICHG=2.32k Ω , ROSC=100k Ω , TERMSEL=0V, Ta=25°C)



All ranks



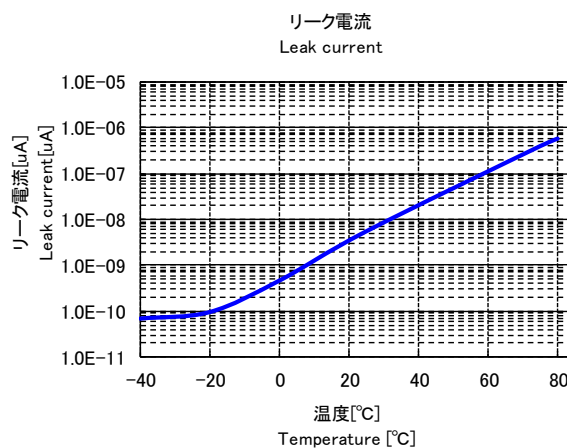
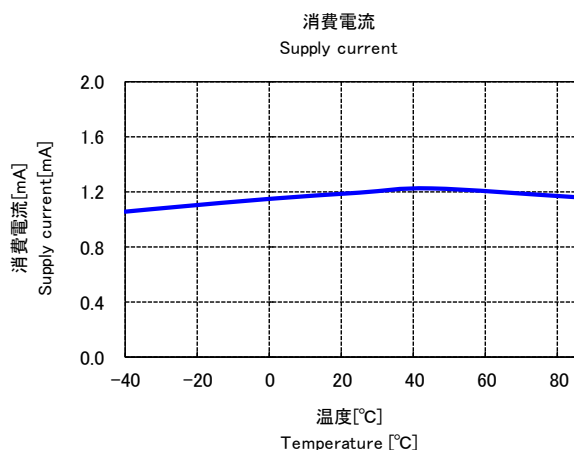
All ranks

*: These are typical characteristics.

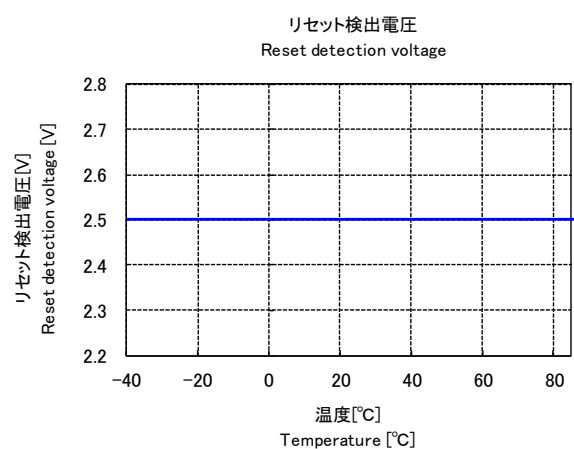


• Temperature Dependency

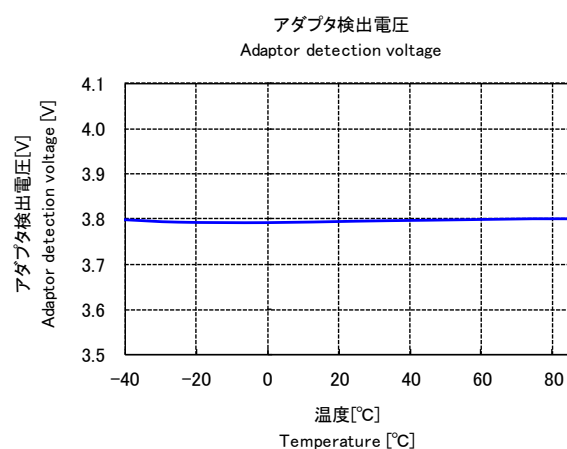
(Unless otherwise specified, VCC=5.0V, RICHG=2.32k Ω , ROSC=100k Ω , TERMSEL=0V, Ta=25°C)



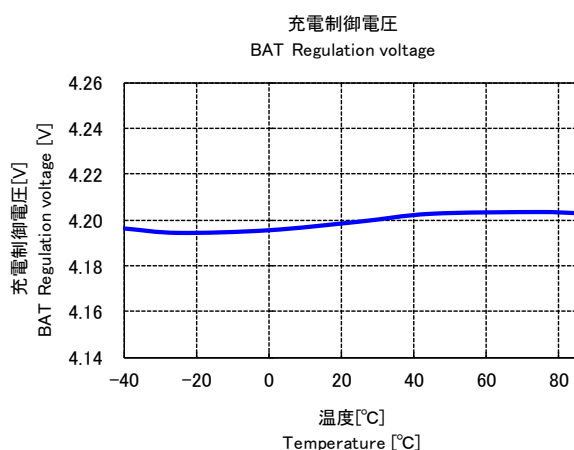
All ranks



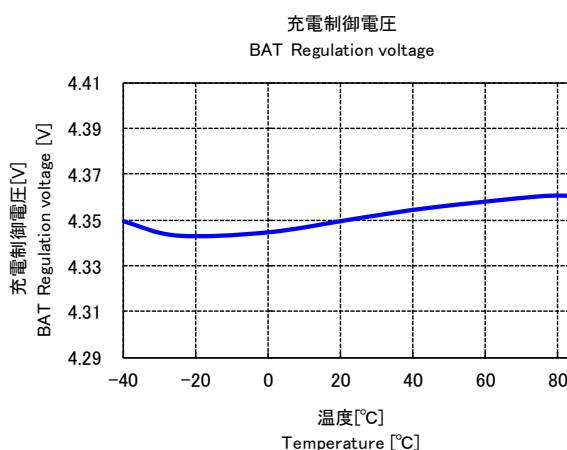
All ranks



All ranks



All ranks



MM3835W01

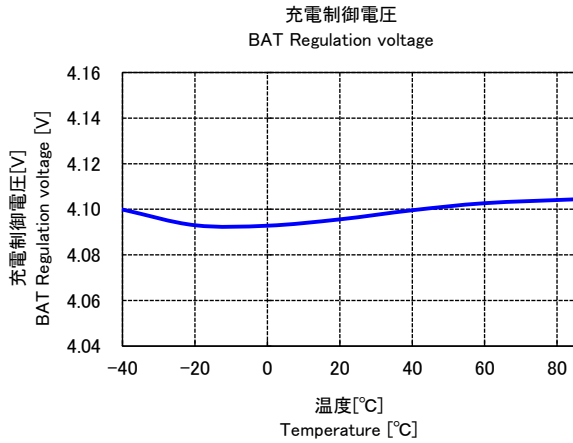
MM3835W04

*: These are typical characteristics.

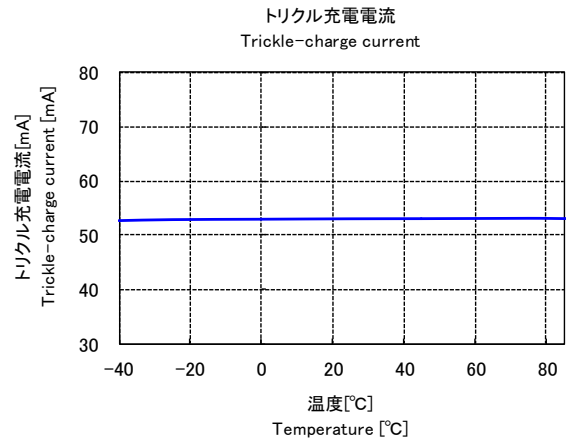


• Temperature Dependency

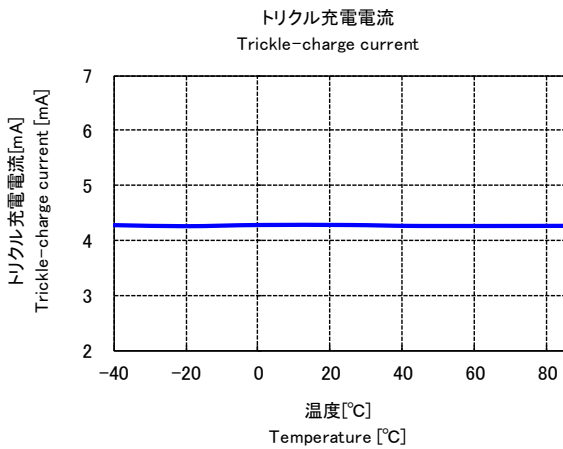
(Unless otherwise specified, VCC=5.0V, RICHG=2.32k Ω , ROSC=100k Ω , TERMSEL=0V, Ta=25°C)



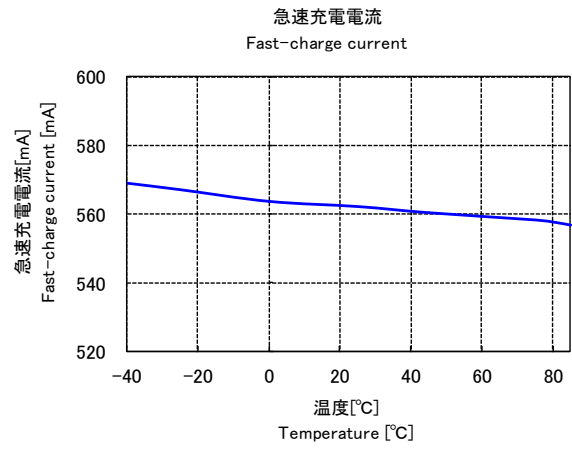
MM3835W07



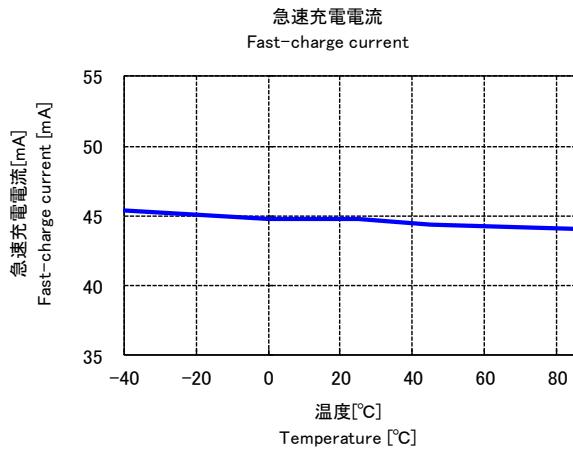
MM3835W01



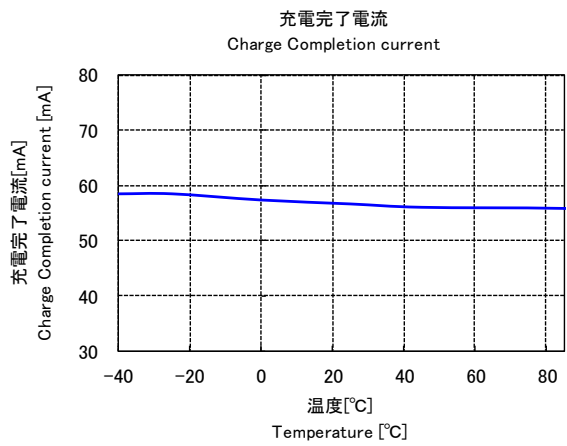
MM3835W04



MM3835W01



MM3835W04



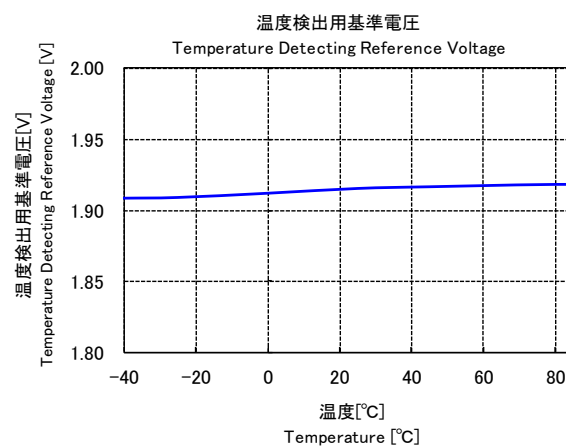
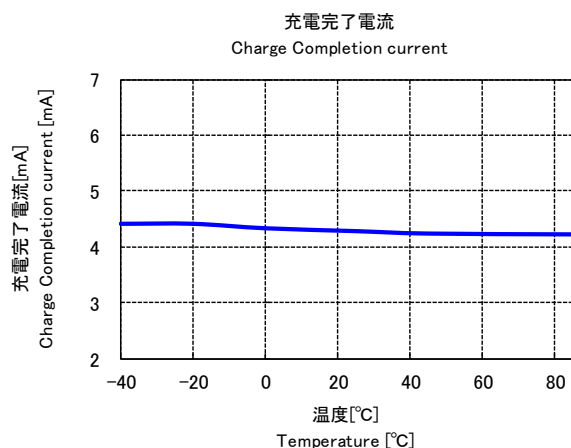
MM3835W01

*: These are typical characteristics.

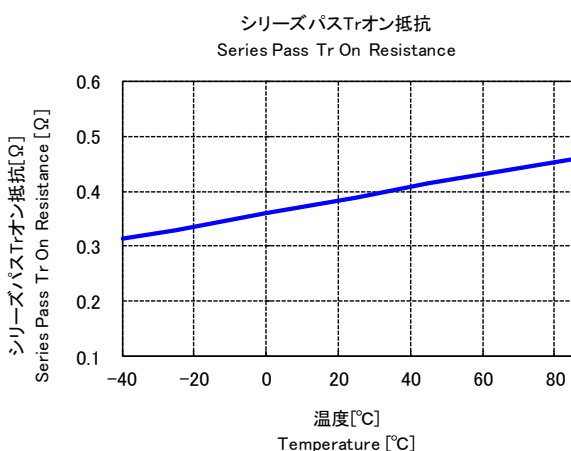


• Temperature Dependency

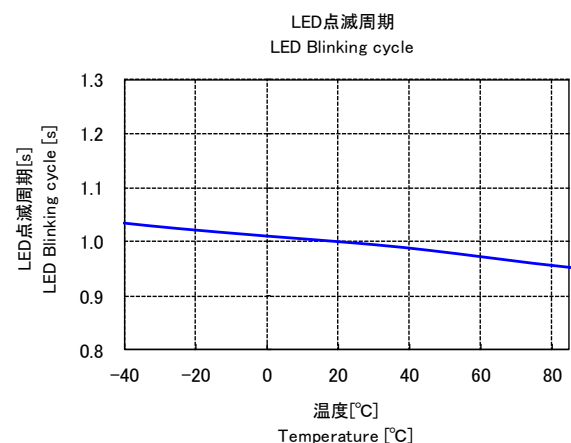
(Unless otherwise specified, VCC=5.0V, RICHG=2.32k Ω , ROSC=100k Ω , TERMSEL=0V, Ta=25 $^{\circ}$ C)



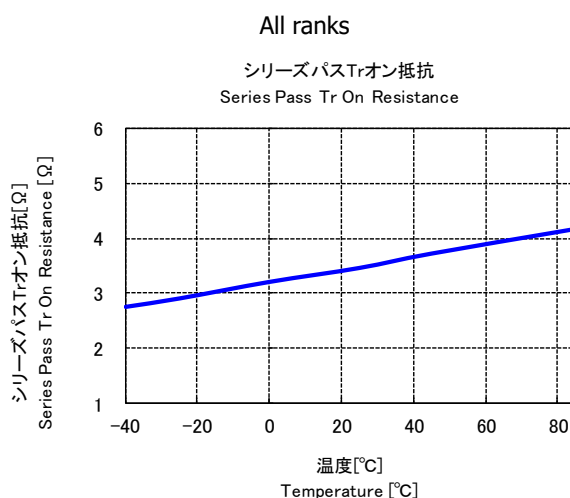
MM3835W04



MM3835W01



All ranks

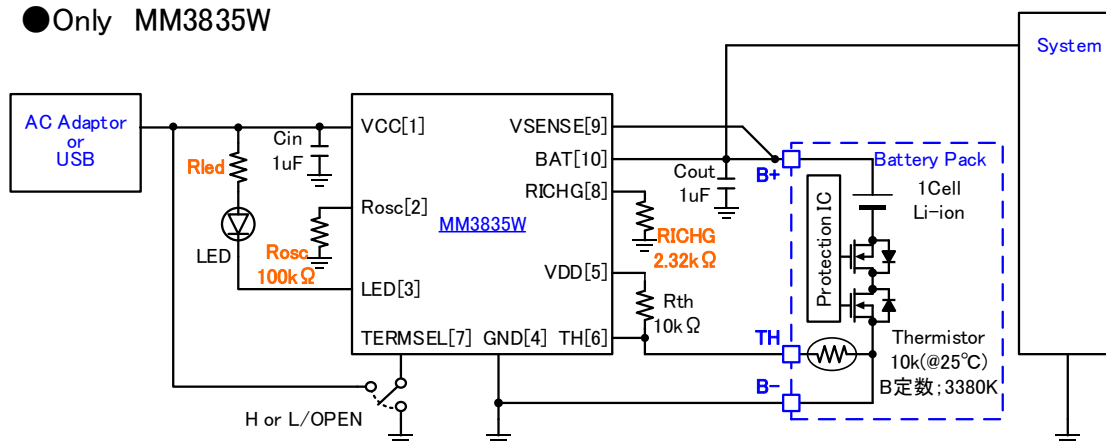


MM3835W04

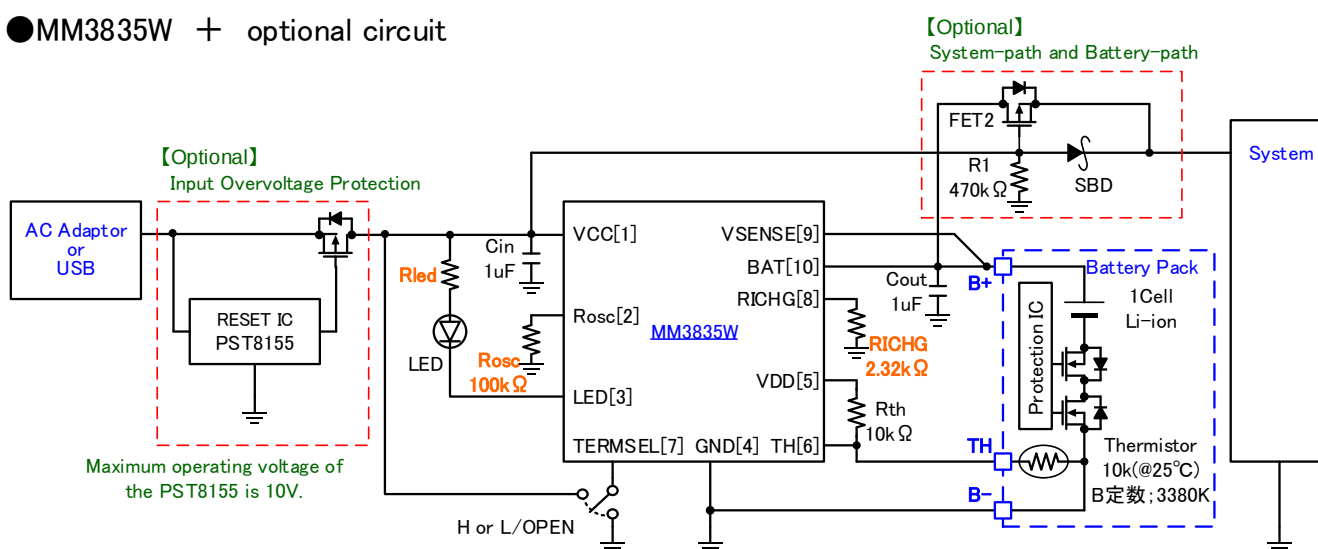
*: These are typical characteristics.

11. TYPICAL APPLICATION CIRCUIT

●Only MM3835W



●MM3835W + optional circuit



- RICHG** : 設定充電電流により変更して下さい。
Please change the setting charge current.
- Rosc** : 設定発振周波数により変更して下さい。
Please change the setting oscillator frequency.
- Rled** : 設定輝度により変更して下さい。
Please change the setting brightness.

- ・We shall not be liable for any trouble or damage caused by using this circuit. Please use on enough your evaluation.
- ・In the event a problem which may affect industrial property or any other rights of us or a third party is encountered during the use of information described in these circuit, Mitsumi Electric Co., Ltd. shall not be liable for any such problem, nor grant