

# Protection of Lithium Ion Batteries (one cell) Monolithic IC MM1291

## Outline

This is a protection IC for one-cell series that protects lithium ion batteries during excess charging, discharging, or overcurrent. If abnormalities occur during charging and excess voltage is applied, it has a function that turns off the external FET switch when voltage is applied to each battery beyond a specified time (overcharging detection). It also has a function that turns off the external FET switch when the voltage for each battery falls below a set voltage, to prevent excess discharge when discharging the battery (discharging detection). At that time, the IC is switched to low current consumption mode. Also, when there is a large current flow due to shorting or other reasons, there is a functions for turning off the external FET switch (overcurrent detection). These function comprise a protection circuit, with few external parts, for lithium ion batteries.

## 1-Cell Protection ICs

Package		Overcharge detection voltage	Hysteresis	Dead time	Overdischarge detection	Release voltage	Delay	Overcurrent detection			
SOP-8	VSOP-8							Overcurrent	Detec time	shot-mode	
MM1291AF	AW	4.35V	200mV	at Ctd= 0.082μF	* 2.6V 2.4V	2.9V	min. 5mS	100mV	min. 5mS	No	
	BF	4.25V	200mV		* 2.6V 2.4V	2.9V		100mV		No	
	CF	4.10V	25mV		* 2.6V 2.4V	2.9V		150mV		No	
	DF	4.35V	25mV		* 2.6V 2.4V	2.9V		100mV		No	
	EF	4.35V	27mV		* 2.6V 2.4V	2.9V		100mV		No	
	GF	4.225V	27mV		* 2.6V 2.4V	2.9V		100mV		No	
	HF	4.35V	200mV		* 2.6V 2.4V	2.9V		50mV		max. 15mS	0.45V
	JW	4.25V	270mV		2.3V	2.9V		125mV			0.45V
	KF	4.25V	200mV		2.3V	2.9V		50mV			0.9V
	MW	4.30V	270mV		2.3V	2.9V		125mV			0.45V

Note : Under open-load conditions, returns to normal mode from overcurrent mode.  
(For MM1291A to G, J, M, 5MΩ or higher; for MM1291H, K, 50MΩ or higher)

## Features

1. Current consumption (during overcharging)	$V_{CC}=4.5V$	$V_{CC}$ pin 40 $\mu A$ typ.	$V_{IN}$ pin 3 $\mu A$ typ.
2. Current consumption (normal)	$V_{CC}=3.5V$	$V_{CC}$ pin 7 $\mu A$ typ.	$V_{IN}$ pin 2 $\mu A$ typ.
3. Current consumption (during excess discharge)	$V_{CC}=1.9V$	0.7 $\mu A$ typ.	
4. Consumption current (during excess discharge)	$V_{CC}=1.0V$	0.17 $\mu A$ max.	
5. Overcharge detection voltage ( $T_a=-20^{\circ}C\sim+70^{\circ}C$ )		A 4.35V $\pm$ 50mV B 4.25V $\pm$ 50mV C 4.10V $\pm$ 50mV	
6. Overcharge detection hysteresis		A 200mV typ. B 200mV typ. C 27mV typ.	
7. Overcharge non-induction time	$C_{TD}=0.082\mu F$	1S typ.	
8. Excess discharge voltage 1	$V_{CS}=0V$	2.6V $\pm$ 0.1V	
9. Excess discharge voltage 2	$V_{CS}=0.05V$	2.4V $\pm$ 0.1V	
10.Excess discharge reset voltage		2.9V $\pm$ 0.12V	
11.Excess discharge during non-induction		10mS typ.	
12.Overcurrent detection voltage		A 100mV $\pm$ 10mV B 100mV $\pm$ 10mV C 150mV $\pm$ 15mV	
13.Reset after overcurrent detection		load release	
14.Overcurrent detection non-induction time		10mS typ.	

## Package

SOP-8C, SOP-8D (MM1291□F)

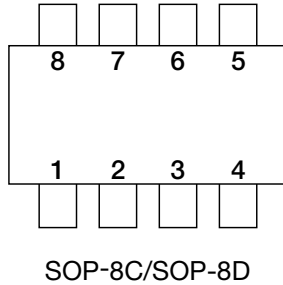
VSOP-8A (MM1291□W)

\*The box represents the rank resulting from the combination of protection functions.

## Applications

1. Cellular phones
2. PHS
3. MD
4. others

## Pin Assignment

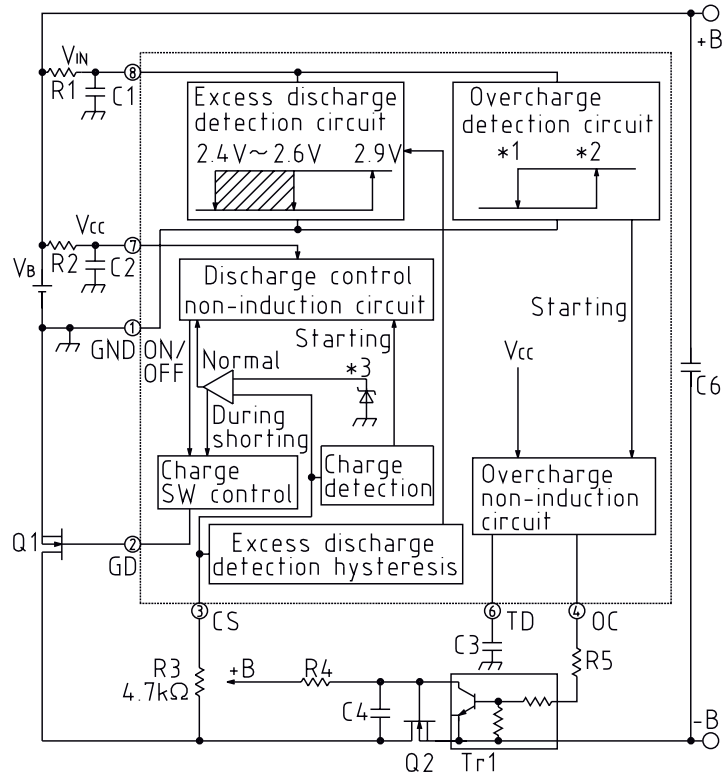


1	GND
2	GD
3	CS
4	OC
5	CE
6	TD
7	V <sub>CC</sub>
8	V <sub>IN</sub>

## Pin Description

Pin No.	NAME	I/O	Description
1	GND	Input	Negative power supply for this IC. Also acts as detection pin for the battery connected between V <sub>IN</sub> -GND.
2	GD	Output	Nch-FET gate connection pin for discharge control. Switches gate OFF when excess discharge is detected, and for current protection. Switches gate ON when excess discharge is detected in normal state.
3	CS	Input	Detection pin for voltage between CS-GND. Detects excess discharge using Nch-FET (discharge control) ON resistor and discharge current.
4	OC	Output	Control pin for Nch-FET for charge control. Switches FET off by activating an external transistor when excess charging is detected.
5	N.C		
6	TD	Input	This pin sets non-induction time for overcharge detection. It charges the capacitor connected between TD-GND with a fixed current during overcharging.
7	V <sub>CC</sub>	Input	Positive power supply pin for the IC.
8	V <sub>IN</sub>	Input	Detection pin for the battery connected between V <sub>IN</sub> -GND.

Block Diagram

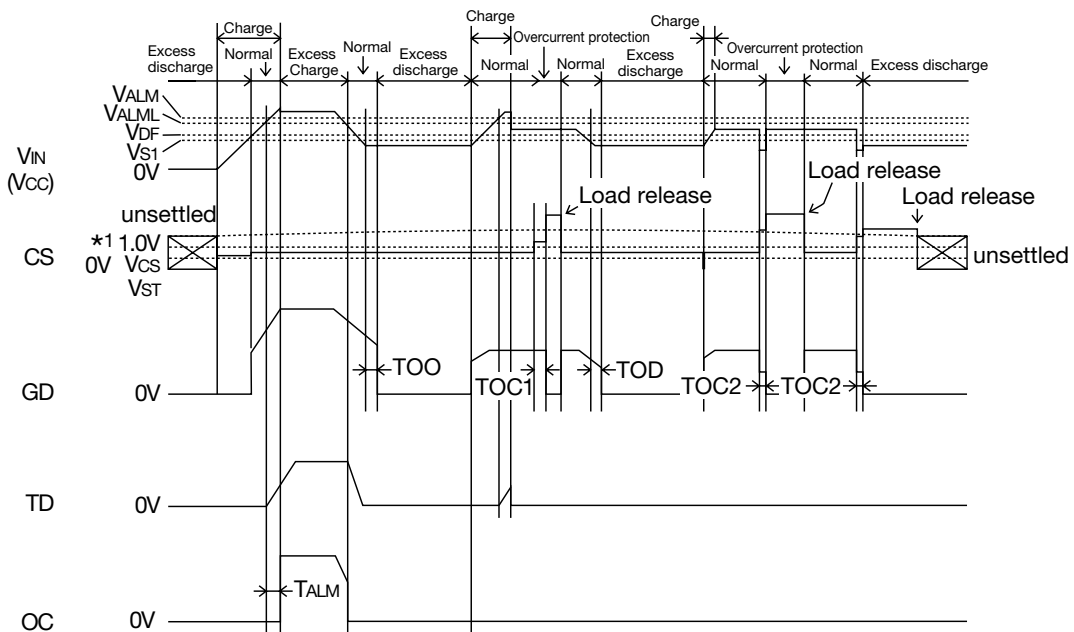


Vs indicates average values.

VALML is low due to the effect of R1 linked to the VIN pin.

*1	A : 4.150V	*2	A : 4.350V	*3	A : 0.10V
	B : 4.050V		B : 4.250V		B : 0.10V
	C : 4.073V		C : 4.100V		C : 0.15V

Timing Chart



\*1 C only

## MM1291AFBE

### Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Rating	Units
Storage temperature	T <sub>STG</sub>	-40~+125	°C
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Power supply voltage	V <sub>CC</sub>	-0.3~+18	V
V <sub>CC</sub> -OC pin voltage	V <sub>OC</sub>	-18~0	V
CS pin voltage	V <sub>CS</sub>	-0.6~V <sub>CC</sub>	V
Allowable loss	P <sub>D</sub>	300	mW

\* The CS pin will not cause abnormal operation when connected to protection resistor R<sub>CS</sub> (=4.7kΩ)

### Electrical Characteristics (Unless otherwise specified Ta=25°C, V<sub>CC</sub>=V<sub>IN</sub>=3.5V, V<sub>CS</sub>=0V, Measurement circuit 1, SW1 : a)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Units
1 (Normal mode) (I <sub>s1</sub> =I <sub>CC</sub> +I <sub>IN</sub> )	I <sub>CC1</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.5V		8.0	11.0	μA
Consumption current 2 (Overdischarge mode)	I <sub>OP2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =1.9V		0.7	1.0	μA
Overcharge detection voltage	V <sub>ALM</sub>	Ta=-20°C~70°C V <sub>CC</sub> =V <sub>IN</sub> =4.0V→4.5V V <sub>OC</sub> : L→H	4.300	4.350	4.400	V
Overcharge reset voltage	V <sub>ALML</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.5V 4.0V V <sub>OC</sub> : H→L	4.050	4.150	4.240	V
Overcharge hysteresis voltage	ΔV <sub>ALM</sub>	V <sub>OC</sub> -V <sub>OCR</sub>	150	200	250	mV
Excess discharge detection voltage 1	V <sub>S1</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.1V→2.0V V <sub>GD</sub> : H→L, V <sub>CS</sub> =0V	2.50	2.60	2.70	V
Excess discharge detection voltage 2	V <sub>S2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.1V→2.0V V <sub>CS</sub> =0.05V, V <sub>GD</sub> : H→L	2.30	2.40	2.50	V
Excess discharge reset voltage	V <sub>ODR</sub>	V <sub>CC</sub> =V <sub>IN</sub> =2.0V→3.1V V <sub>GD</sub> : L→H	2.78	2.90	3.02	V
Starting voltage	V <sub>ST</sub>	V <sub>CC</sub> =V <sub>IN</sub> =2.75V V <sub>CS</sub> =0V→-0.5V, V <sub>GD</sub> : L→H	-0.3	-0.1		V
Overcurrent detection voltage	V <sub>CS</sub>	V <sub>CS</sub> =0V→0.12V V <sub>GD</sub> : H→L	90	100	110	mV
Overcurrent protection release			load release (more than 5 MEG)			
Excess discharge detection non-induction time	t <sub>OD</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.0V→2.4V, *1 measurement circuit 2, SW1 : b, SW2 : a	5.0	10.0	15.0	mS
Excessive current detection during non-induction time	t <sub>OC1</sub>	V <sub>CS</sub> =0V→V <sub>CS</sub> , *1 measurement circuit 2, SW1 : a, SW2 : b	5.0	10.0	15.0	mS
Overcurrent non-induction time	t <sub>ALM</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.0V→4.5V, *1 measurement circuit 2, SW1 : b, SW2 : a C <sub>TD</sub> =0.082μF	0.5	1.0	1.5	S
Operating limit voltage *2	V <sub>OP</sub>	V <sub>CC</sub> When V <sub>GDL2</sub> > 0.4V			1.2	V
GD pin output voltage H	V <sub>GDLH</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.5V	V <sub>CC</sub> -0.3	V <sub>CC</sub> -0.1		V
GD pin output voltage L1	V <sub>GDL1</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.5V, V <sub>CS</sub> =0.5V		0.1	0.3	V
GD pin output voltage L2	V <sub>GDL2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =1.5V		0.2	0.4	V
OC pin output current	I <sub>OC</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.5V, SW1 : b			-30	μA

\*1 Refer to input waveforms.

\*2 Operation is unstable below the operating limit voltage.

## MM1291BFBE

### Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Rating	Units
Storage temperature	T <sub>STG</sub>	-40~+125	°C
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Power supply voltage	V <sub>CC</sub>	-0.3~+18	V
V <sub>CC</sub> -OC pin voltage	V <sub>OC</sub>	-18~0	V
CS pin voltage	V <sub>CS</sub>	-0.6~V <sub>CC</sub>	V
Allowable loss	P <sub>D</sub>	300	mV

\*The CS pin will not cause abnormal operation when connected to protection resistor R<sub>CS</sub> (=4.7kΩ)

### Electrical Characteristics (Unless otherwise specified Ta=25°C, V<sub>CC</sub>=V<sub>IN</sub>=3.5V, V<sub>CS</sub>=0V, Measurement circuit 1, SW1 : a)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Units
1 (Normal mode) (I <sub>s1</sub> =I <sub>CC</sub> +I <sub>IN</sub> )	I <sub>CC1</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.5V		10.0	14.0	μA
Consumption current 2 (Overdischarge mode)	I <sub>OP2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =1.9V		0.7	1.0	μA
Overcharge detection voltage	V <sub>ALM</sub>	Ta=-20°C~70°C V <sub>CC</sub> =V <sub>IN</sub> =3.9V→4.4V V <sub>OC</sub> : L→H	4.200	4.250	4.300	V
Overcharge reset voltage	V <sub>ALML</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.4V→3.9V V <sub>OC</sub> : H→L	3.950	4.050	4.150	V
Overcharge hysteresis voltage	V <sub>OCH</sub>	V <sub>OC</sub> -V <sub>OCR</sub>	150	200	250	mV
Excess discharge detection voltage 1	V <sub>S1</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.1V→2.0V V <sub>GD</sub> : H→L V <sub>CS</sub> =0V	2.50	2.60	2.70	V
Excess discharge detection voltage 2	V <sub>S2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.1V→2.0V V <sub>CS</sub> =0.05V, V <sub>GD</sub> : H→L	2.30	2.40	2.50	V
Excess discharge reset voltage	V <sub>DF</sub>	V <sub>CC</sub> =V <sub>IN</sub> =2.0V→3.1V V <sub>GD</sub> : L→H	2.78	2.90	3.02	V
Starting voltage	V <sub>ST</sub>	V <sub>CC</sub> =V <sub>IN</sub> =2.75V V <sub>CS</sub> : 0V→-0.5V, V <sub>GD</sub> : L→H	-0.3	-0.1		V
Overcurrent detection voltage	V <sub>CS</sub>	V <sub>CS</sub> =0V→0.12V V <sub>GD</sub> : H→L	90	100	110	mV
Overcurrent protection release			load release (more than 5 MEG)			
Excess discharge detection non-induction time	t <sub>OD</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.0V→2.4V, *1 measurement circuit 2, SW1 : b, SW2 : a	5.0	10.0	15.0	mS
Excessive current detection during non-induction time	t <sub>OC1</sub>	V <sub>CS</sub> =0V→V <sub>CS</sub> , *1 measurement circuit 2, SW1 : a, SW2 : b	5.0	10.0	15.0	mS
Overcurrent non-induction time	t <sub>ALM</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.0V→4.5V, *1 measurement circuit 2, SW1 : b, SW2 : a C <sub>TD</sub> =0.082μF	0.5	1.0	1.5	S
Operating limit voltage *2	V <sub>OP</sub>	V <sub>CC</sub> When V <sub>GDL2</sub> > 0.4V			1.2	V
GD pin output voltage H	V <sub>GDLH</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.5V	V <sub>CC</sub> -0.3	V <sub>CC</sub> -0.1		V
GD pin output voltage L1	V <sub>GDL1</sub>	V <sub>CS</sub> > 1.0V		0.1	0.3	V
GD pin output voltage L2	V <sub>GDL2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.5V, V <sub>CS</sub> =0.5V		0.2	0.4	V
OC pin output current	I <sub>OC</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.5V, SW1 : b			-30	μA

\*1 Refer to input waveforms.

\*2 Operation is unstable below the operating limit voltage.

## MM1291CFBE

### Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Rating	Units
Storage temperature	T <sub>STG</sub>	-40~+125	°C
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Power supply voltage	V <sub>CC</sub>	-0.3~+18	V
V <sub>CC</sub> -OC pin voltage	V <sub>OC</sub>	-18~0	V
CS pin voltage	V <sub>CS</sub>	-0.6~V <sub>CC</sub>	V
Allowable loss	P <sub>D</sub>	300	mV

\* The CS pin will not cause abnormal operation when connected to protection resistor R<sub>CS</sub> (=4.7k Ω)

### Electrical Characteristics (Unless otherwise specified Ta=25 °C, V<sub>CC</sub>=V<sub>IN</sub>=3.5V, V<sub>CS</sub>=0V, Measurement circuit 1, SW1 : a)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Units
Current consumption 1 (V <sub>CC</sub> pin)	I <sub>CC1</sub>	V <sub>CC</sub> =4.5V		40	60	μA
Current consumption 2 (V <sub>CC</sub> pin)	I <sub>CC2</sub>	V <sub>CC</sub> =3.5V		8.0	11.0	μA
Current consumption 1 (V <sub>IN</sub> pin)	I <sub>IN1</sub>	V <sub>IN</sub> =4.5V		3.0	5.0	μA
Current consumption 2 (V <sub>IN</sub> pin)	I <sub>IN2</sub>	V <sub>IN</sub> =3.5V		2.0	3.0	μA
Current consumption 3 (V <sub>CC</sub> , V <sub>IN</sub> pins)	I <sub>OP3</sub>	V <sub>CC</sub> =V <sub>IN</sub> =1.9V		0.7	1.0	μA
Current consumption 4 (V <sub>CC</sub> , V <sub>IN</sub> pins)	I <sub>OP4</sub>	V <sub>CC</sub> =V <sub>IN</sub> =1.0V			0.17	μA
Overcharge detection voltage	V <sub>ALM</sub>	Ta=-20°C~70°C V <sub>CC</sub> =V <sub>IN</sub> =4.0V→4.2V V <sub>CC</sub> : L→H	4.050	4.100	4.150	V
Overcharge reset voltage	V <sub>ALML</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.2V→4.0V V <sub>OC</sub> : H→L	4.018	4.075	4.128	V
Overcharge hysteresis voltage	ΔV <sub>ALM</sub>	V <sub>ALM</sub> -V <sub>ALML</sub>	18	25	32	mV
Excess discharge detection voltage 1	V <sub>S1</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.1V→2.0V V <sub>GD</sub> : H→L	2.50	2.60	2.70	V
Excess discharge detection voltage 2	V <sub>S2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.1V→2.0V V <sub>CS</sub> =0.05V, V <sub>GD</sub> : H→L	2.30	2.40	2.50	V
Excess discharge reset voltage	V <sub>DF</sub>	V <sub>CC</sub> =V <sub>IN</sub> =2.0V→3.1V V <sub>GD</sub> : L→H	2.78	2.90	3.02	V
Starting voltage	V <sub>ST</sub>	V <sub>CC</sub> =V <sub>IN</sub> =2.75V V <sub>CS</sub> =0V→-0.5V, V <sub>GD</sub> : L→H	-0.3	-0.1		V
Overcurrent detection voltage	V <sub>CS</sub>	V <sub>CS</sub> =0V→0.17V V <sub>GD</sub> : H→L	135	150	165	mV
Overcurrent protection release			load release (more than 5 MEG)			
Excess discharge detection non-induction time	t <sub>OD</sub>	V <sub>CC</sub> =V <sub>IN</sub> =3.0V→2.4V, *1 measurement circuit 2, SW1 : b, SW2 : a	5.0	10.0	15.0	mS
Excessive current detection during non-induction time	t <sub>OC1</sub>	V <sub>CS</sub> =0V→V <sub>CS</sub> , *1 measurement circuit 2, SW1 : a, SW2 : b	5.0	10.0	15.0	mS
Overcurrent detection delay	t <sub>OC2</sub>	V <sub>CS</sub> =0V→1.0V, *1 measurement circuit 2, SW1 : b, SW2 : a			100	μS
Overcurrent non-induction time	t <sub>ALM</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.0V→4.5V, *1 measurement circuit 2, SW1 : b, SW2 : a C <sub>TD</sub> =0.082μF	0.5	1.0	1.5	S
Operating limit voltage *2	V <sub>OP</sub>	V <sub>CC</sub> When V <sub>GDL2</sub> > 0.4V			1.2	V
GD pin output voltage H	V <sub>GDLH</sub>		V <sub>CC</sub> -0.3	V <sub>CC</sub> -0.1		V
GD pin output voltage L1	V <sub>GDL1</sub>	V <sub>CS</sub> > 1.0V		0.1	0.3	V
GD pin output voltage L2	V <sub>GDL2</sub>	V <sub>CC</sub> =V <sub>IN</sub> =1.5V		0.2	0.4	V
OC pin output current	I <sub>OC</sub>	V <sub>CC</sub> =V <sub>IN</sub> =4.5V, SW1 : b			-30	μA

\*1 Refer to input waveforms.

\*2 Operation is unstable below the operating limit voltage.