

# *ASSP For Power Supply Applications*

**BIPOLAR**

# **Switching Regulator Controller (Low Voltage)**

## **MB3800**

### ■ DESCRIPTION

The MB3800 is a single-channel switching regulator control IC for low voltage applications incorporating a soft start function and short circuit detection function. The device has a low minimum operating voltage of 1.8 V and is ideal for the power supply of battery-operated electronic equipment.

### ■ FEATURES

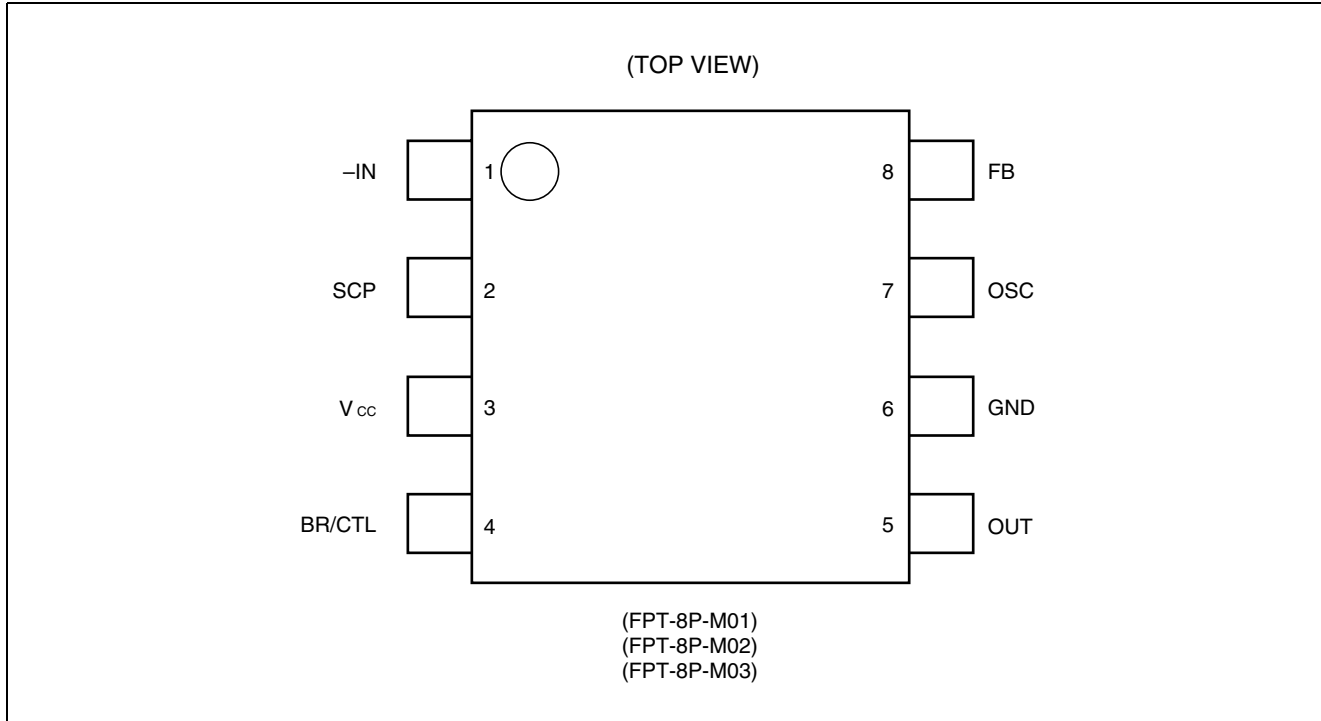
- Wide supply voltage operating range: 1.8 V to 15 V
- Low current consumption: Typically 5.5 mA in operation, 1  $\mu$ A or less in stand-by
- High speed operation is possible: Maximum 1 MHz
- The error amplifier gain is set inside the IC, so peripheral components are minimized.
- Incorporates a soft start circuit.
- Incorporates a timer-latch type short circuit detection circuit (SCP).
- Totem-pole type output with adjustable on/off current (for NPN transistors)
- Incorporates a stand-by function.
- Three types of packages (SOP-8 : 2 types, SSOP-8 : 1 type)

### ■ Application

- LCD monitor/panel
- Power supply module
- Portable apparatus      etc.

# MB3800

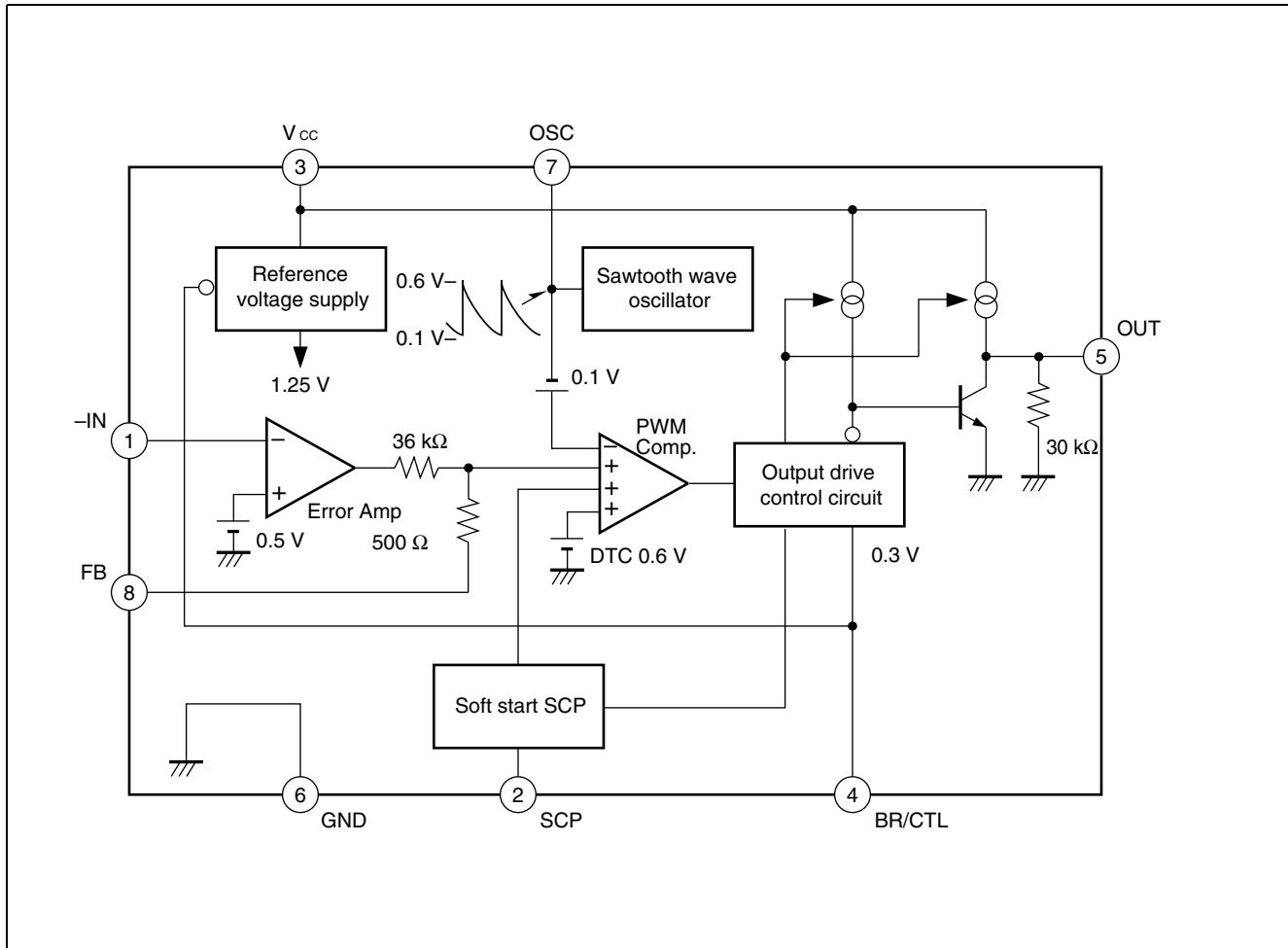
## ■ PIN ASSIGNMENT



## ■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Description
1	-IN	I	Error amplifier inverting input pin
2	SCP	—	Soft start and SCP setting capacitor connection pin
3	V <sub>cc</sub>	—	Power supply pin
4	BR/CTL	I	Output current setting and control pin
5	OUT	O	Totem-pole type output pin
6	GND	—	Ground pin
7	OSC	—	Capacitor and resistor connection pin for setting the oscillation frequency
8	FB	O	Error amplifier output pin

## ■ BLOCK DIAGRAM



# MB3800

## ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power supply voltage	$V_{CC}$	—	—	16	V
Output source current	$I_{O+}$		—	-50	mA
Output sink current	$I_{O-}$		—	50	mA
Allowable dissipation	$P_D$	FPT-8P-M01, $T_a \leq +25^\circ\text{C}$	—	570*	mW
		FPT-8P-M02, $T_a \leq +25^\circ\text{C}$	—	430*	mW
		SSOP-8, $T_a \leq +25^\circ\text{C}$	—	580*	mW
Storage temperature	$T_{stg}$	—	-55	+125	$^\circ\text{C}$

\*: When mounted on a 10 cm square double-sided epoxy board.

**WARNING:** Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

## ■ RECOMMENDED OPERATING CONDITIONS

( $T_a = +25^\circ\text{C}$ )

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Power supply voltage	$V_{CC}$	1.8	—	15	V
Error amplifier input voltage	$V_I$	-0.2	—	+1.0	V
BR/CTL pin input voltage	$V_{BR}$	-0.2	—	$V_{CC}$	V
Output source current	$I_{O+}$	-40	—	—	mA
Output sink current	$I_{O-}$	—	—	40	mA
SCP pin capacitance	$C_{PE}$	—	0.1	—	$\mu\text{F}$
Phase compensation capacitance	$C_P$	—	0.1	—	$\mu\text{F}$
Output current setting resistance	$R_B$	150	390	5000	$\Omega$
Timing resistance	$R_T$	1.0	3.0	10.0	$\text{k}\Omega$
Timing capacitance	$C_T$	100	270	10000	pF
Oscillation frequency	$f_{osc}$	10	500	1000	kHz
Operating Ambient temperature	$T_a$	-30	+25	+85	$^\circ\text{C}$

**WARNING:** The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

## ■ ELECTRICAL CHARACTERISTICS

( $V_{CC} = +2\text{ V}$ ,  $T_a = +25^\circ\text{C}$ )

Parameter		Symbol	Condition	Value			Unit
				Min	Typ	Max	
Circuit to prevent malfunction at low input voltage (U.V.L.O.)	Reset voltage	$V_R$	—	—	—	0.9	V
	Threshold voltage	$V_{TH}$		1.1	1.3	1.5	V
Soft start	Charging current	$I_{CS}$	$V_{SCP} = 0\text{ V}$	-1.5	-1.0	-0.7	$\mu\text{A}$
	Voltage at soft start completion	$V_{IS}$	—	0.7	0.8	0.9	V
Short circuit detection (S.C.P.)	Charging current	$I_{CPC}$	$V_{SCP} = 0\text{ V}$	-1.5	-1.0	-0.7	$\mu\text{A}$
	Threshold voltage	$V_{IPC}$	—	0.7	0.8	0.9	V
Sawtooth wave oscillator (OSC)	Oscillation frequency	$f_{OCS}$	$R_T = 3.0\text{ k}\Omega$ , $C_T = 270\text{ pF}$	400	500	600	kHz
	Frequency input stability	$f_{dV}$	$V_{CC} = 2\text{ V to }15\text{ V}$	—	2	10	%
	Frequency variation with temperature	$f_{dT}$	$T_a = -30^\circ\text{C to }+85^\circ\text{C}$	—	5	—	%
Error amplifier	Input threshold voltage	$V_T$	$V_{FB} = 450\text{ mV}$	480	500	520	mV
	$V_T$ input stability	$V_{TdV}$	$V_{CC} = 2\text{ V to }15\text{ V}$	—	5	20	mV
	$V_T$ variation with temperature	$V_{TdT}$	$T_a = -30^\circ\text{C to }+85^\circ\text{C}$	—	1	—	%
	Input bias current	$I_B$	$V_{IN} = 0\text{ V}$	-1.0	-0.2	+1.0	$\mu\text{A}$
	Voltage gain	$A_V$	—	70	100	145	V/V
	Frequency bandwidth	BW	$A_V = 0\text{ dB}$	—	6	—	MHz
	Maximum output voltage range	$V_{OM+}$	—	0.78	0.87	—	V
		$V_{OM-}$		—	0.05	0.2	V
	Output source current	$I_{OM+}$	$V_{FB} = 0.45\text{ V}$	—	-40	-24	$\mu\text{A}$
Output sink current	$I_{OM-}$	24		40	—	$\mu\text{A}$	
Idle period adjustment section	Maximum duty cycle	$t_{DUTY}$	$R_T = 3.0\text{ k}\Omega$ , $C_T = 270\text{ pF}$ $V_{FB} = 0.8\text{ V}$	65	75	85	%

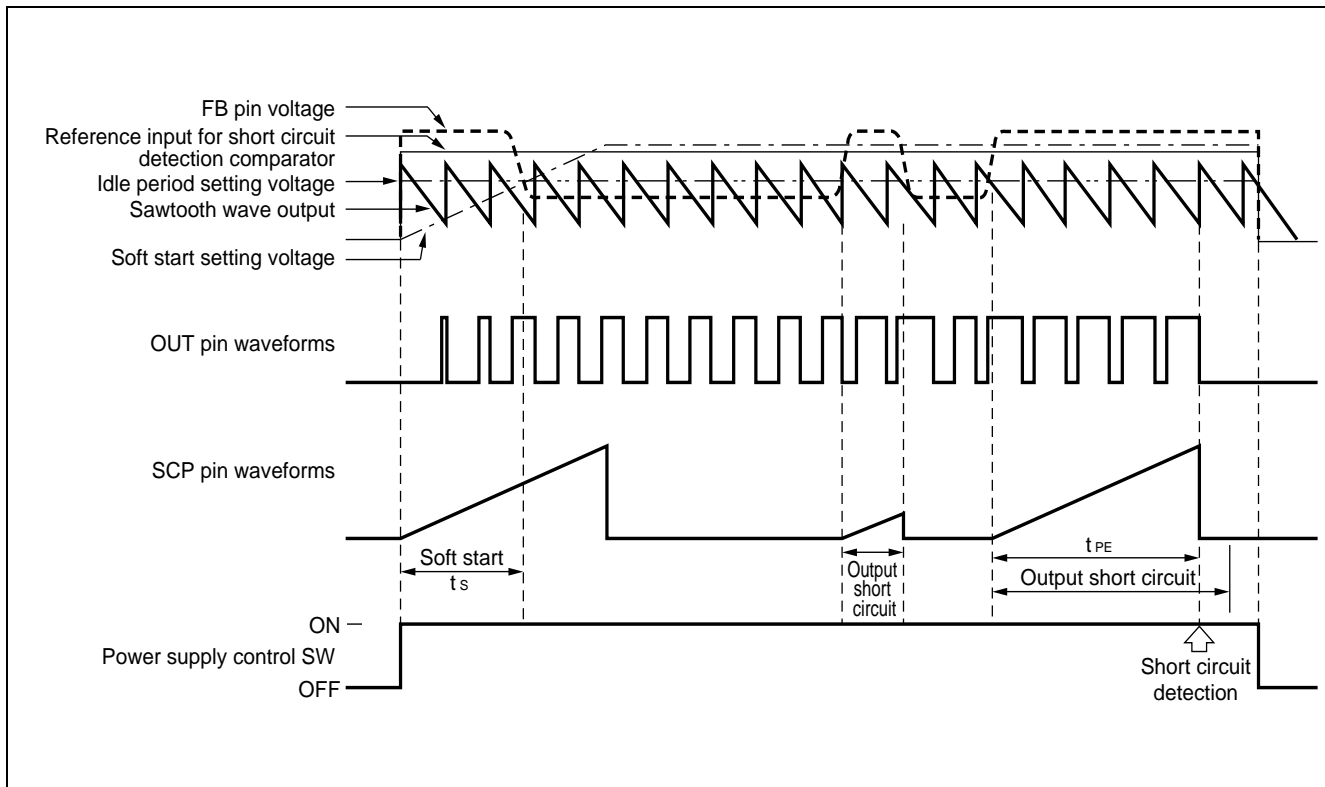
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# MB3800

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Parameter		Symbol	Condition	Value			Unit
				Min	Typ	Max	
Output section	Output voltage	$V_{OH1}$	$R_B = 390 \Omega, I_o = -15 \text{ mA}$	1.0	1.2	—	V
		$V_{OH2}$	$R_B = 750 \Omega, V_{CC} = 1.8 \text{ V}$ $I_o = -10 \text{ mA}$	0.8	1.0	—	V
		$V_{OL1}$	$R_B = 390 \Omega, I_o = 15 \text{ mA}$	—	0.1	0.2	V
		$V_{OL2}$	$R_B = 750 \Omega, V_{CC} = 1.8 \text{ V}$ $I_o = 10 \text{ mA}$	—	0.1	0.2	V
	Output source current	$I_o^+$	$R_B = 390 \Omega, V_o = 0.9 \text{ V}$	—	-30	-20	mA
	Output sink current	$I_o^-$	$R_B = 390 \Omega, V_o = 0.3 \text{ V}$	30	60	—	mA
	Pull down resistance	$R_o$	—	20	30	40	k $\Omega$
Output current setting section/ Control section	Pin voltage	$V_{BR}$	$R_B = 390 \Omega$	0.2	0.3	0.4	V
	Input off condition	$I_{OFF}$	—	-20	—	0	$\mu\text{A}$
	Input on condition	$I_{ON}$	—	—	—	-45	$\mu\text{A}$
	Pin current range	$I_{BR}$	—	-1.8	—	-0.1	mA
Entire device	Stand-by current	$I_{CCS}$	BR/CTL pin open or $V_{CC}$	—	—	1	$\mu\text{A}$
	Average supply current	$I_{CC}$	$R_B = 390 \Omega$	—	5.5	9.3	mA

## ■ DIAGRAM



## ■ HOW TO SET THE TIME CONSTANT FOR SOFT START AND SHORT CIRCUIT DETECTION

### 1. Soft Start

At power on, the capacitor  $C_{PE}$  connected to the SCP pin (pin 2) starts charging. The PWM comparator compares the soft start setting voltage as a proportion of the voltage at the SCP pin with the sawtooth waveform. The comparison controls the ON duty of the OUT pin (pin 5), causing the soft start operation. On completion of soft start operation, the voltage at the SCP pin stays low, the soft start setting voltage stays high, and the circuit enters the output short circuit detection wait state.

Soft start time (The time until the output ON duty reaches approximately 50%)

$$t_s [s] \cong 0.35 \times C_{PE} [\mu F]$$

### 2. Short Circuit Protection

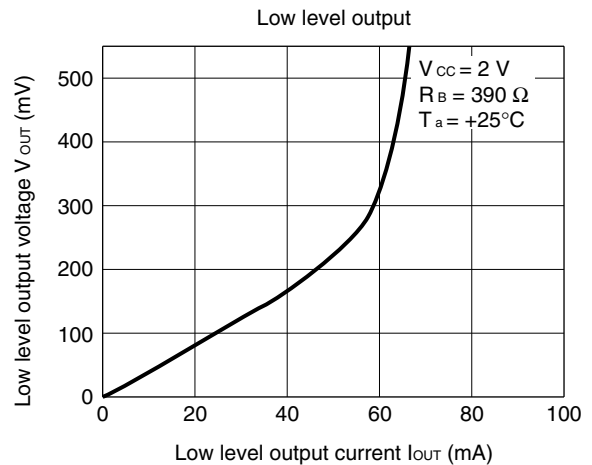
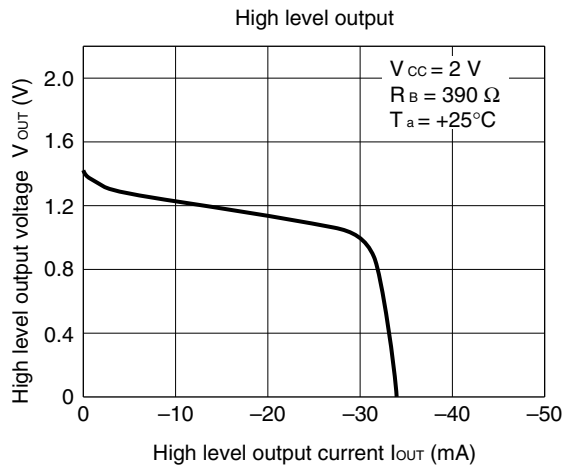
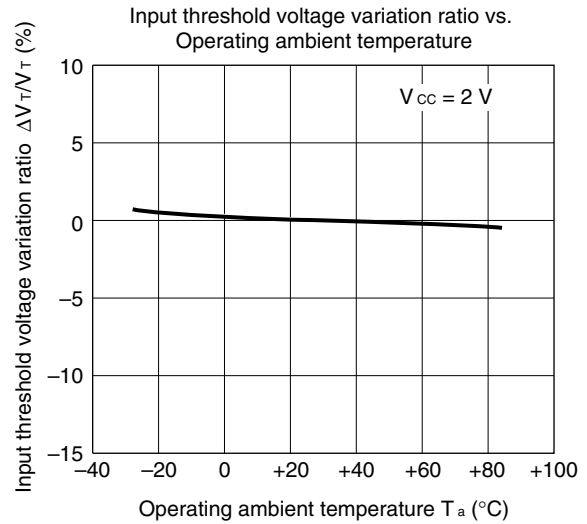
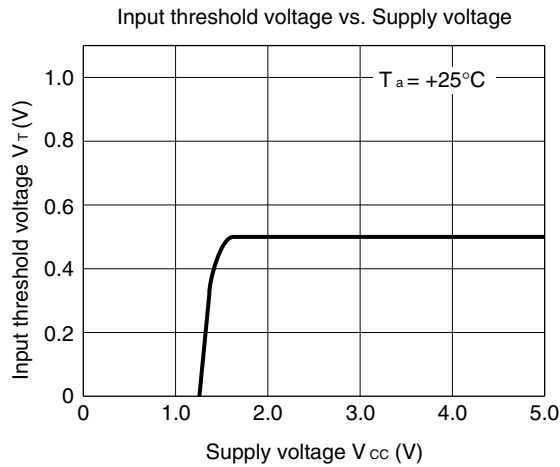
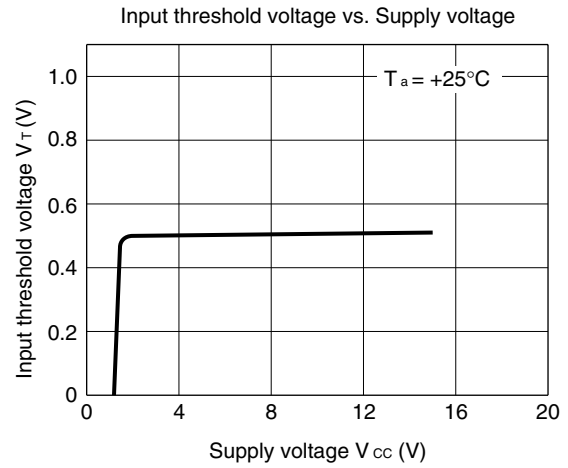
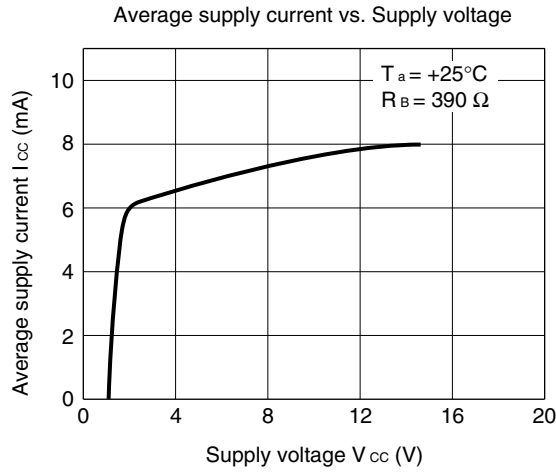
If the switching regulator output suddenly drops due to load effect, the error amplifier output (FB pin (pin 8)) is fixed at  $V_{OM}^+$  and capacitor  $C_{PE}$  starts charging. When the voltage at the SCP pin reaches approximately 0.8 V, the OUT pin (pin 5) is set low and the SCP pin (pin 2) stays low.

Once the protection circuit operates, the circuit can be restored by resetting the power supply.

- Short circuit detection time

$$t_{PE} [s] \cong 0.8 \times C_{PE} [\mu F]$$

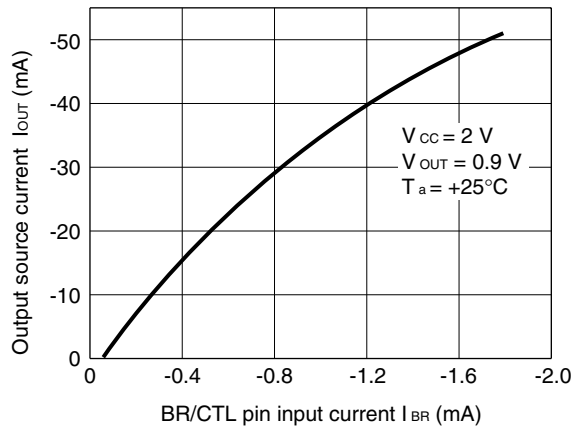
## TYPICAL CHARACTERISTICS



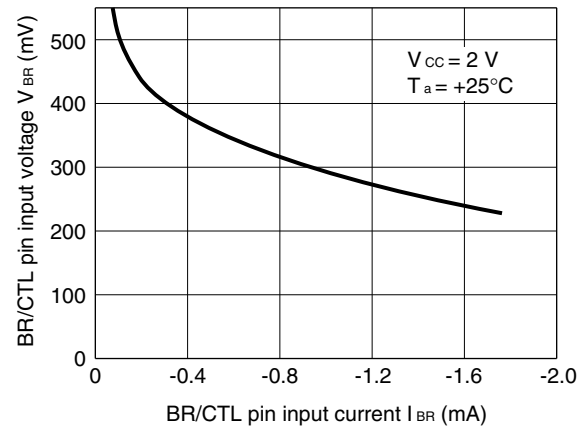
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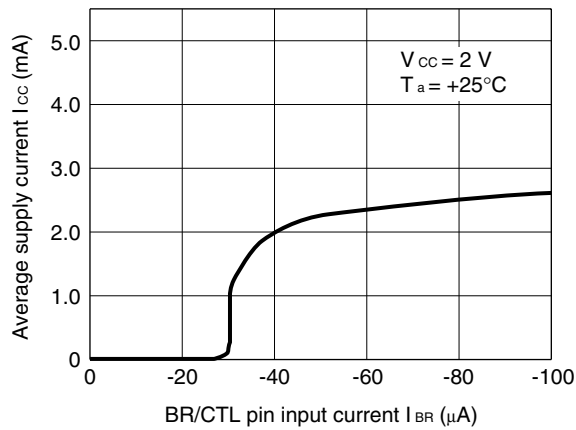
Output source current vs. BR/CTL pin input current



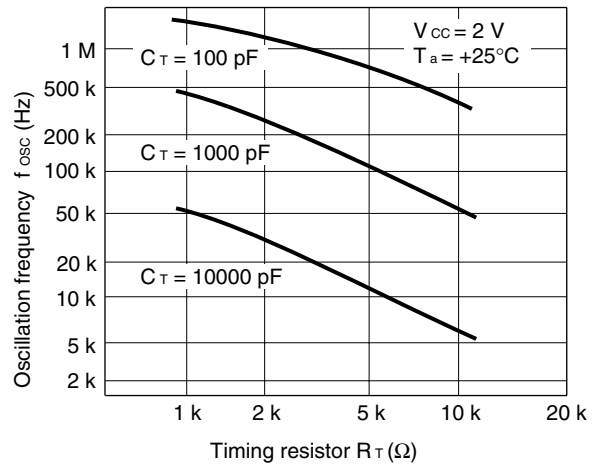
BR/CTL pin input voltage vs. BR/CTL pin input current



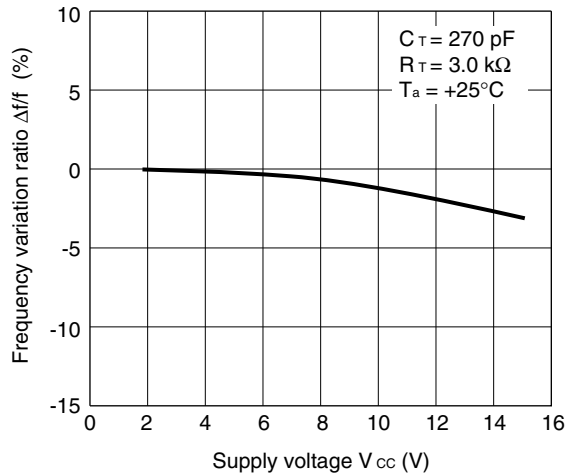
Average supply current vs. BR/CTL pin input current



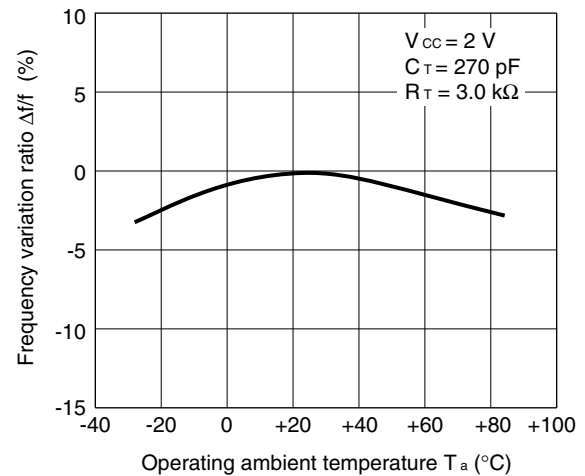
Oscillation frequency vs. Timing resistor



Frequency variation ratio vs. Supply voltage

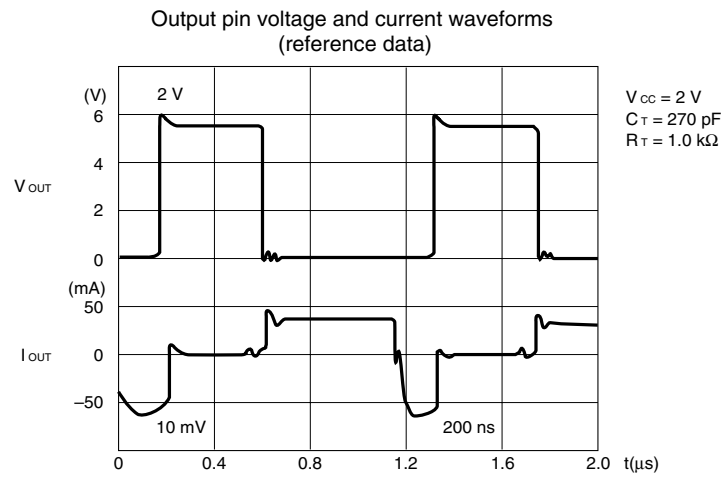
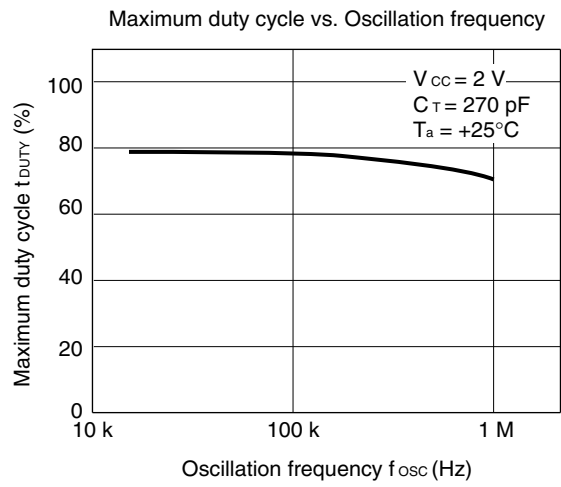


Frequency variation ratio vs. Operating ambient temperature

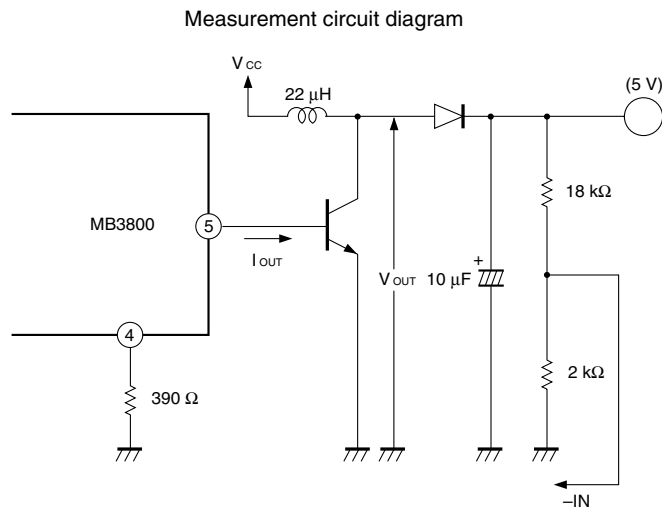


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Note: The OFF delay time of  $V_{OUT}$  depends on the characteristics of the external transistor.



## ■ FUNCTIONAL DESCRIPTION

### 1. Switching Regulator Function

#### (1) Reference voltage circuit

The reference voltage circuit generates a temperature-compensated reference voltage ( $\cong 1.25V$ ) from voltage supplied from the  $V_{CC}$  pin (pin 3). In addition to providing the reference voltage for the switching regulator, the circuit also sets the idle period.

#### (2) Sawtooth wave oscillator

The sawtooth oscillator generates a sawtooth wave (up to 1 MHz) that is stable with respect to the supply voltage and temperature. The capacitor and resistor that set the oscillation frequency are connected to the OSC pin (pin 7).

#### (3) Error amplifier (Error Amp)

The error amplifier detects the output voltage of the switching regulator and outputs the PWM control signal. The voltage gain is fixed, and connecting a phase compensation capacitor to the FB pin (pin 8) provides stable phase compensation for the system.

#### (4) PWM comparator (PWM Comp.)

The voltage comparator has one inverting and three non-inverting inputs. The comparator is a voltage/pulse width converter that controls the ON time of the output pulse depending on the input voltage. The output level is high (H) when the sawtooth wave is lower than the error amplifier output voltage, soft start setting voltage, and idle period setting voltage.

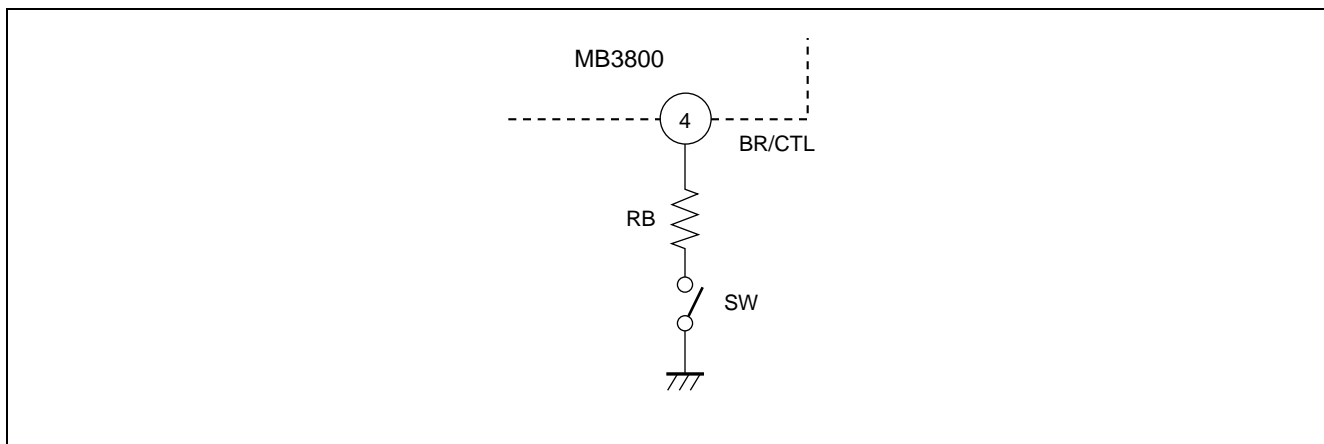
#### (5) Output circuit

The output circuit has a totem pole type configuration and can drive an external NPN transistor directly. The value of the ON/OFF current can be set by a resistor connected to the BR/CTL pin (pin 4).

### 2. Power Supply Control Function

Stand-by mode (supply current  $1 \mu A$  or less) can be set by connecting the BR/CTL pin (pin 4) to  $V_{CC}$  or by making the pin open circuit.

SW	Mode
OFF	Stand-by mode
ON	Operating mode



## 3. Other Functions

### (1) Soft start and short circuit detection

Soft start operation is set by connecting capacitor  $C_{PE}$  to the SCP pin (pin 2). Soft start prevents a current spike on start-up.

On completion of soft start operation, the SCP pin (pin 2) stays low and enters the short circuit detection wait state. When an output short circuit occurs, the error amplifier output is fixed at  $V_{OM+}$  and capacitor  $C_{PE}$  starts charging. After charging to approximately 0.8 V, the OUT pin (pin 5) is set low and the SCP pin (pin 2) stays low.

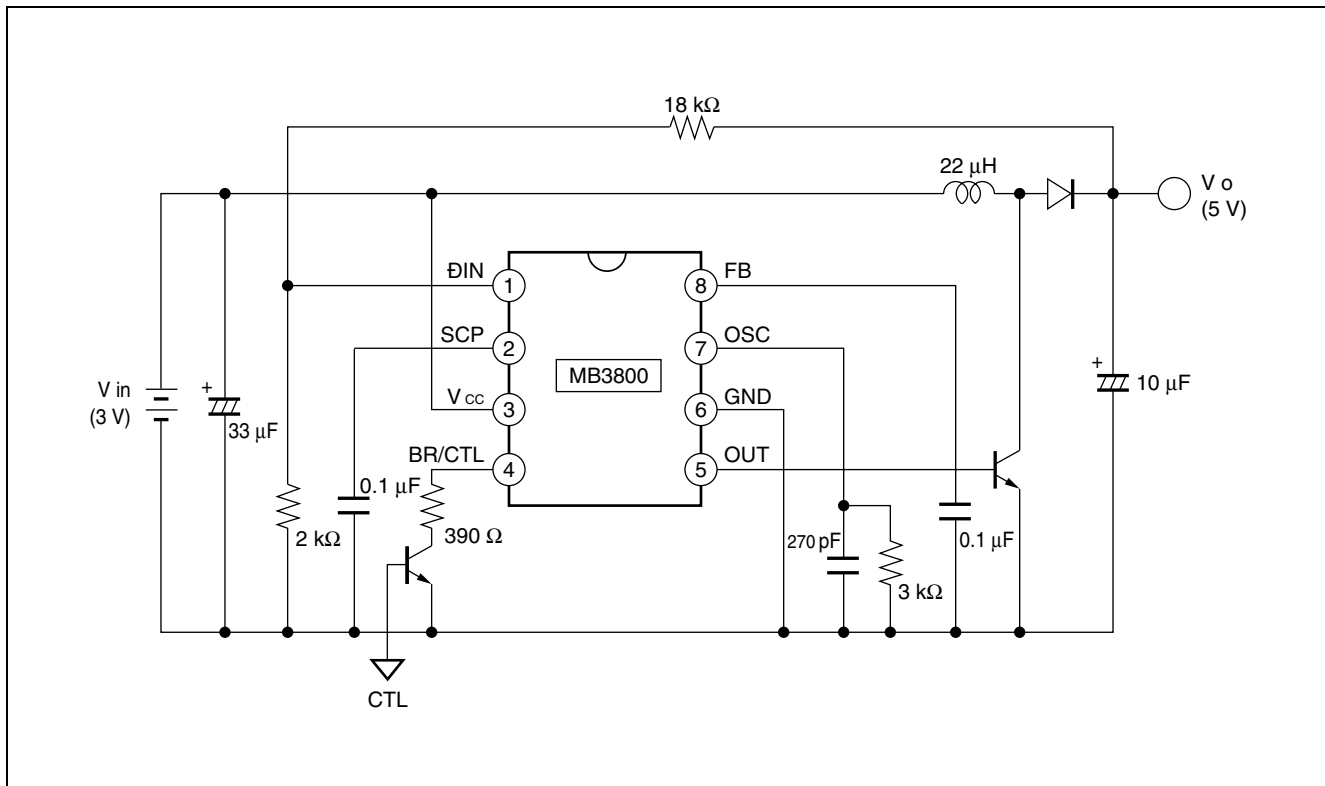
Once the protection circuit operates, the circuit can be restored by resetting the power supply. (See “**■ HOW TO SET THE TIME CONSTANT FOR SOFT START AND SHORT CIRCUIT DETECTION**”.)

### (2) Circuit to prevent malfunction at low input voltage

Transients when powering on or instantaneous glitches in the supply voltage can lead to malfunction of the control IC and cause system damage or failure. The circuit to prevent malfunction at low input voltage detects a low input voltage by comparing the supply voltage to the internal reference voltage. On detection, the circuit fixes the OUT pin (pin 5) to low.

The system recovers when the supply voltage rises back above the threshold voltage of the malfunction prevention circuit.

## ■ APPLICATION EXAMPLE



## ■ NOTES ON USE

- Take account of common impedance when designing the earth line on a printed wiring board.
- Take measures against static electricity.
  - For semiconductors, use antistatic or conductive containers.
  - When storing or carrying a printed circuit board after chip mounting, put it in a conductive bag or container.
  - The work table, tools and measuring instruments must be grounded.
  - The worker must put on a grounding device containing 250 kΩ to 1 MΩ resistors in series.
- Do not apply a negative voltage
  - Applying a negative voltage of -0.3 V or less to an LSI may generate a parasitic transistor, resulting in malfunction.

## ■ ORDERING INFORMATION

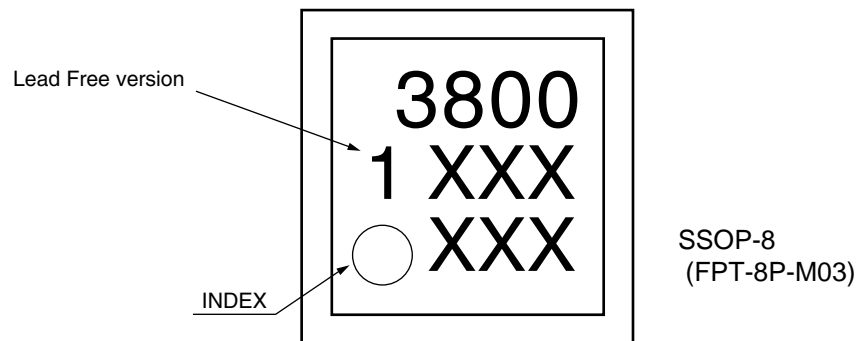
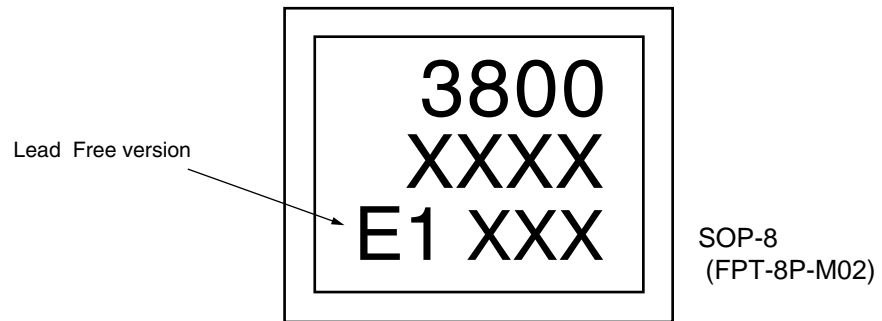
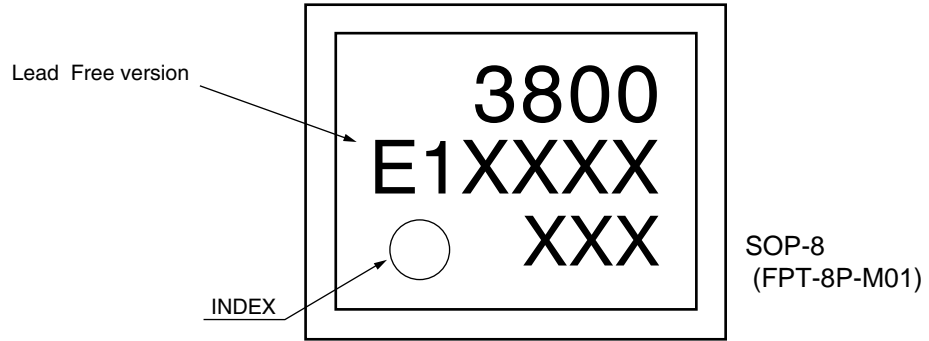
Part number	Package	Remarks
MB3800PF-□□□	8-pin Plastic SOP (FPT-8P-M01)	Conventional version
MB3800PNF-□□□	8-pin Plastic SOP (FPT-8P-M02)	Conventional version
MB3800PFV-□□□	8-pin Plastic SSOP (FPT-8P-M03)	Conventional version
MB3800PF-□□□E1	8-pin Plastic SOP (FPT-8P-M01)	Lead Free version
MB3800PNF-□□□E1	8-pin Plastic SOP (FPT-8P-M02)	Lead Free version
MB3800PFV-□□□E1	8-pin Plastic SSOP (FPT-8P-M03)	Lead Free version

## ■ RoHS Compliance Information of Lead (Pb) Free version

The LSI products of Fujitsu with "E1" are compliant with RoHS Directive , and has observed the standard of lead, cadmium, mercury, Hexavalent chromium, polybrominated biphenyls (PBB) , and polybrominated diphenyl ethers (PBDE) .

The product that conforms to this standard is added "E1" at the end of the part number.

## MARKING FORMAT (Lead Free version)



## ■ LABELING SAMPLE (Lead free version)

The image shows a rectangular label with the following text and markings:

- Top line: MB123456P - 789 - GE1
- Second line: (3N) 1MB123456P-789-GE1 1000
- Barcode
- Third line: (3N)2 1561190005 107210
- Barcode
- Fourth line: 1,000 PCS
- Fifth line: MB123456P - 789 - GE1
- Barcode
- Sixth line: 2006/03/01 ASSEMBLED IN JAPAN
- Horizontal dashed line
- Seventh line: MB123456P - 789 - GE1
- Barcode
- Eighth line: 1561190005 1/1 0605 - Z01A 1000

Callouts and Markings:

- JEITA logo: A square box containing the letter 'G'.
- JEDEC logo: A circle containing a crossed-out 'Pb'.
- lead-free mark: Points to the JEDEC logo.
- QC PASS: Text located to the right of the second barcode.
- Lead Free version: Points to the '1/1' in the bottom line of the label.

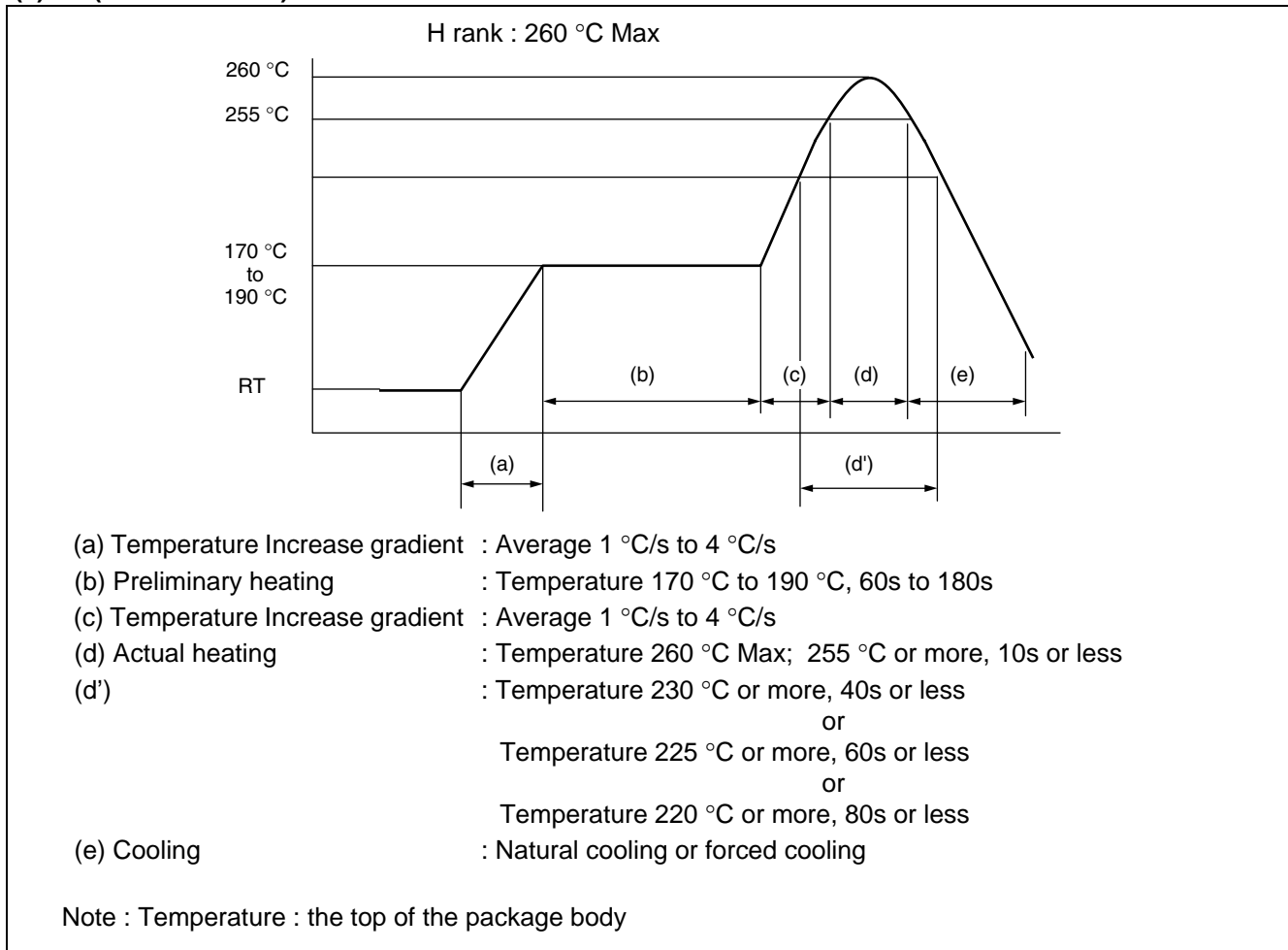
# MB3800

## ■ MB3800PF-□□□E1, MB3800PNF-□□□E1, MB3800PFV-□□□E1 RECOMMENDED CONDITIONS of MOISTURE SENSITIVITY LEVEL

Item	Condition	
Mounting Method	IR (infrared reflow) , Manual soldering (partial heating method)	
Mounting times	2 times	
Storage period	Before opening	Please use it within two years after Manufacture.
	From opening to the 2nd reflow	Less than 8 days
	When the storage period after opening was exceeded	Please processes within 8 days after baking (125 °C, 24H)
Storage conditions	5 °C to 30 °C, 70%RH or less (the lowest possible humidity)	

### [Temperature Profile for FJ Standard IR Reflow]

#### (1) IR (infrared reflow)

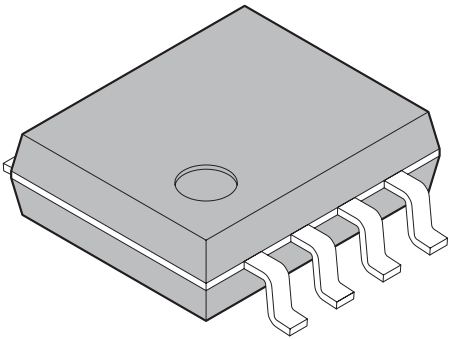


#### (2) Manual soldering (partial heating method)

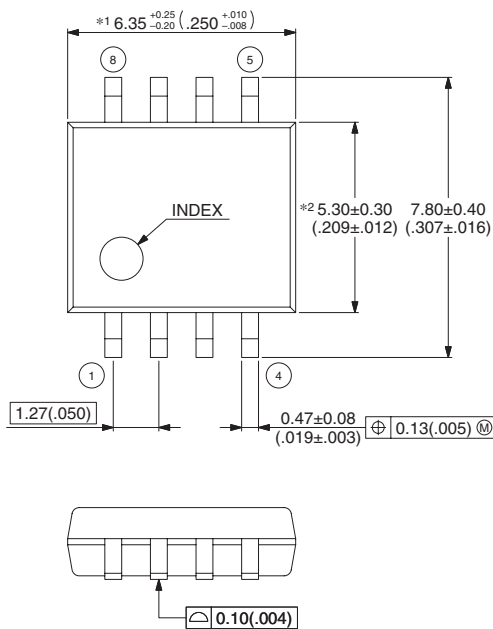
Conditions : Temperature 400 °C Max  
Times : 5 s max/pin



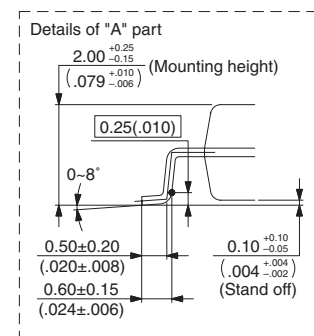
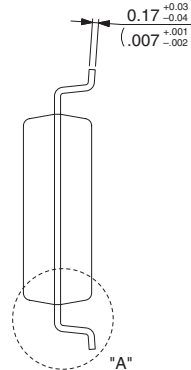
## ■ PACKAGE DIMENSIONS

<p style="text-align: center;">8-pin plastic SOP</p>  <p style="text-align: center;">(FPT-8P-M01)</p>	Lead pitch	1.27 mm
	Package width × package length	5.3 × 6.35 mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	2.25 mm MAX
	Weight	0.10 g
	Code (Reference)	P-SOP8-5.3×6.35-1.27

8-pin plastic SOP  
(FPT-8P-M01)

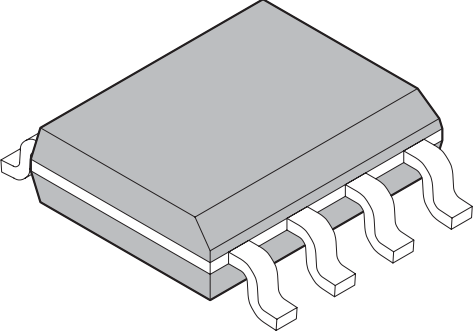


- Note 1) \*1 : These dimensions include resin protrusion.  
 Note 2) \*2 : These dimensions do not include resin protrusion.  
 Note 3) Pins width and pins thickness include plating thickness.  
 Note 4) Pins width do not include tie bar cutting remainder.

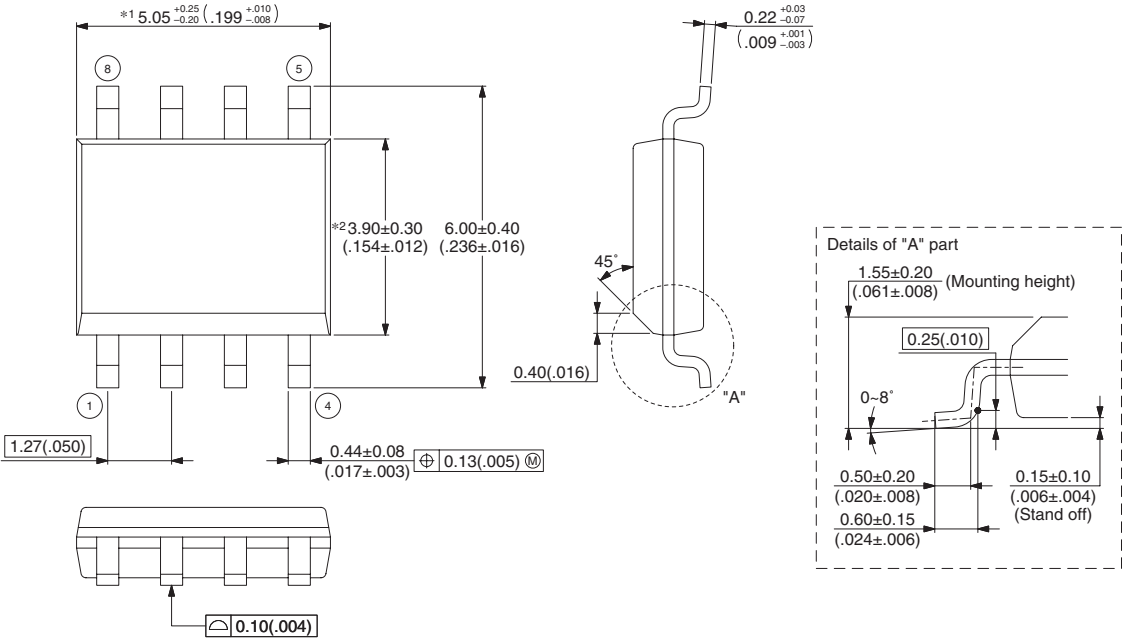


Dimensions in mm (inches).  
 Note: The values in parentheses are reference values.

# MB3800

<p style="text-align: center;">8-pin plastic SOP</p>  <p style="text-align: center;">(FPT-8P-M02)</p>	Lead pitch	1.27 mm
	Package width × package length	3.9 × 5.05 mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	1.75 mm MAX
	Weight	0.06 g

8-pin plastic SOP  
(FPT-8P-M02)



Top view dimensions:  
 \*1 5.05<sup>+0.25</sup><sub>-0.20</sub> (.199<sup>+0.10</sup><sub>-.008</sub>)  
 \*2 3.90±0.30 (.154±.012) 6.00±0.40 (.236±.016)  
 1.27(.050)  
 0.44±0.08 (.017±.003) 0.13(.005) (M)  
 0.10(.004)

Side view dimensions:  
 0.22<sup>+0.03</sup><sub>-0.07</sub> (.009<sup>+0.001</sup><sub>-.003</sub>)  
 45°  
 0.40(.016)

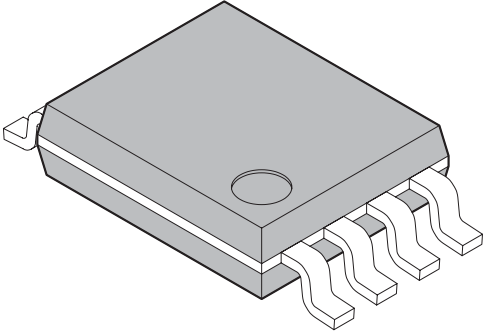
Details of "A" part:  
 1.55±0.20 (.061±.008) (Mounting height)  
 0.25(.010)  
 0-8°  
 0.50±0.20 (.020±.008)  
 0.60±0.15 (.024±.006)  
 0.15±0.10 (.006±.004) (Stand off)

Note 1) \*1 : These dimensions include resin protrusion.  
 Note 2) \*2 : These dimensions do not include resin protrusion.  
 Note 3) Pins width and pins thickness include plating thickness.  
 Note 4) Pins width do not include tie bar cutting remainder.

Dimensions in mm (inches).  
 Note: The values in parentheses are reference values.

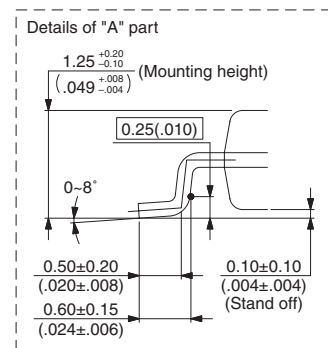
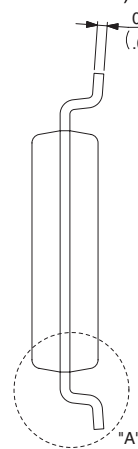
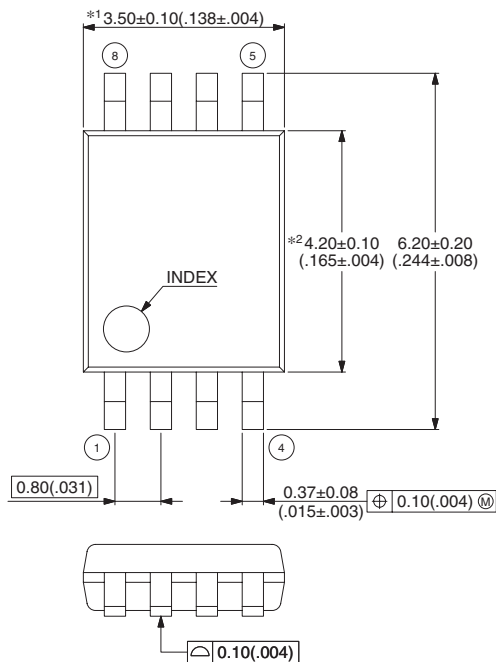
(Continued)

(Continued)

<p style="text-align: center;">8-pin plastic SSOP</p>  <p style="text-align: center;">(FPT-8P-M03)</p>	Lead pitch	0.80 mm
	Package width × package length	4.2 × 3.5 mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	1.45 mm MAX
	Weight	0.04 g
	Code (Reference)	P-SSOP8-4.2×3.5-0.80

8-pin plastic SSOP  
(FPT-8P-M03)

Note 1) \*1 : Resin protrusion. (Each side : +0.15 (.006) Max).  
 Note 2) \*2 : These dimensions do not include resin protrusion.  
 Note 3) Pins width and pins thickness include plating thickness.  
 Note 4) Pins width do not include tie bar cutting remainder.



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Dimensions in mm (inches).  
 Note: The values in parentheses are reference values.

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