

# ASSP For Power Supply Applications

## BIPOLAR

# Switching Regulator Controller (Low Voltage)

# MB3800

## ■ DESCRIPTION

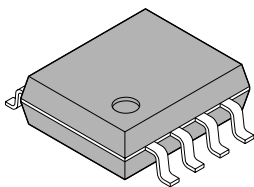
The MB3800 is a single-channel switching regulator control IC for low voltage applications incorporating a soft start function and short circuit detection function. The device has a low minimum operating voltage of 1.8 V and is ideal for the power supply of battery-operated electronic equipment.

## ■ FEATURES

- Wide supply voltage operating range: 1.8 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 or SOL-8, SSOP-8)

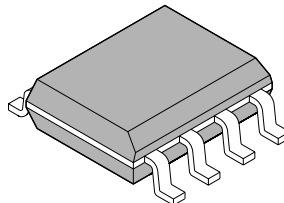
## ■ PACKAGES

8-pin Plastic SOP



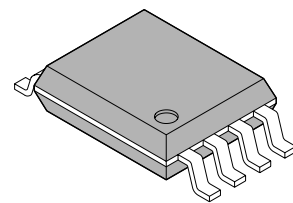
(FPT-8P-M01)

8-pin Plastic SOL



(FPT-8P-M02)

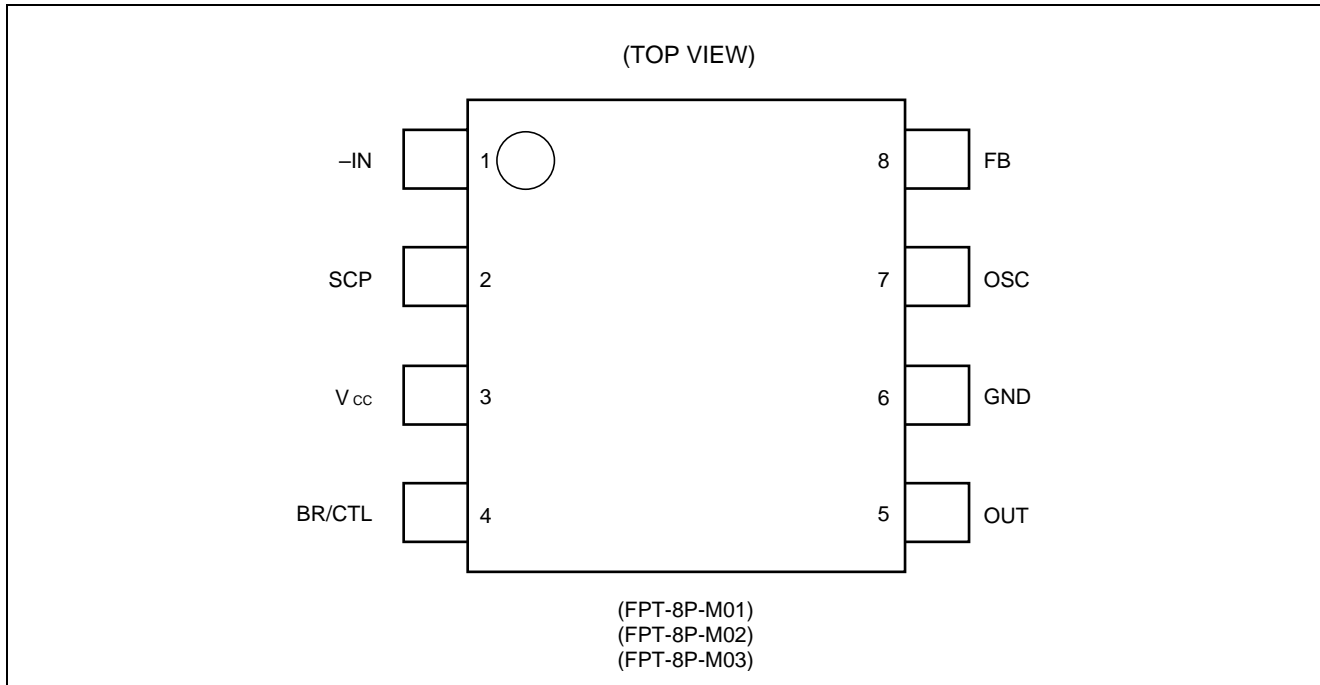
8-pin Plastic SSOP



(FPT-8P-M03)

# MB3800

## ■ PIN ASSIGNMENT

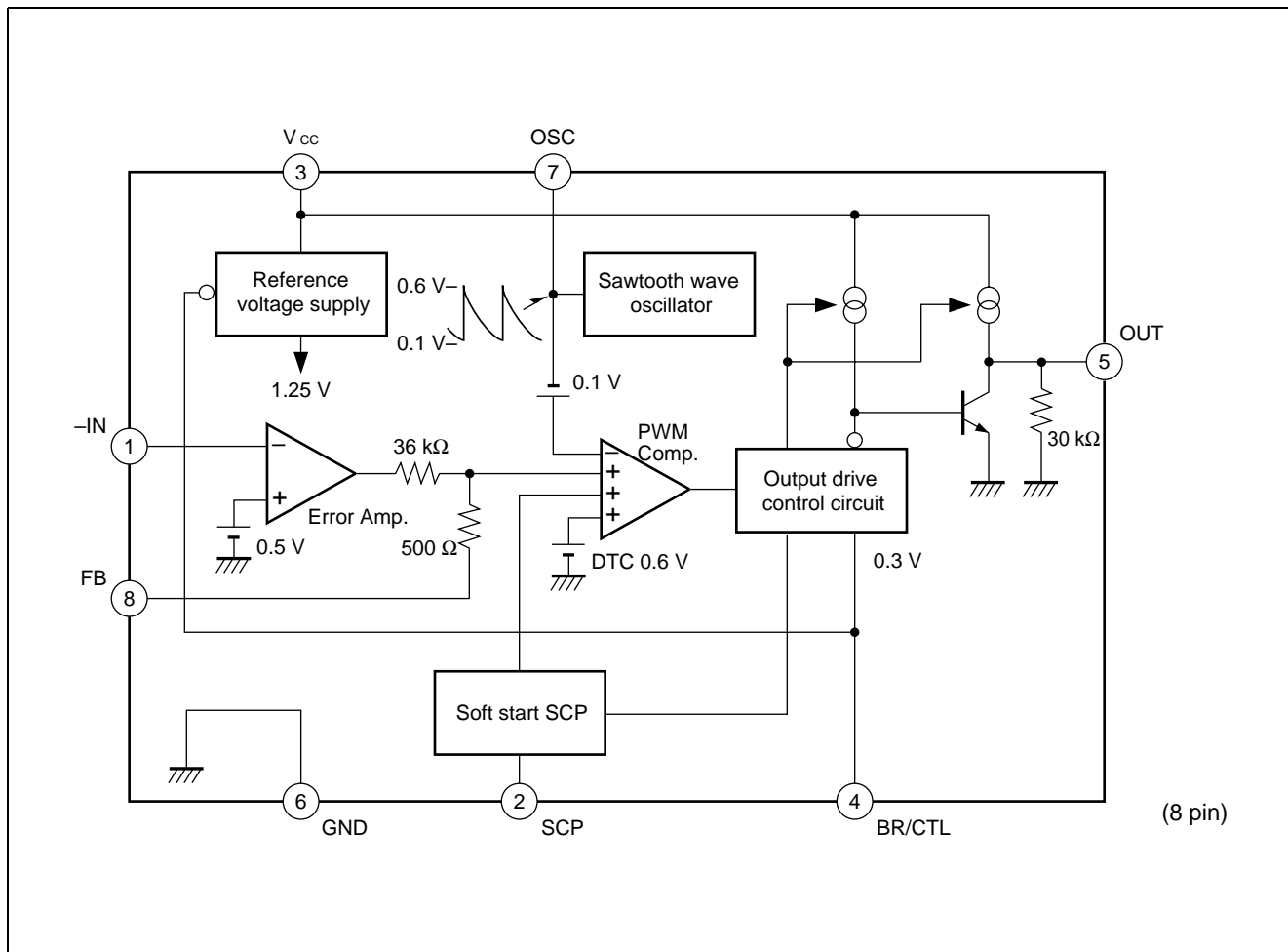


## ■ PIN DESCRIPTION

| 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       | VCC    | —   | 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  |

# MB3800

## ■ BLOCK DIAGRAM



# MB3800

## ■ ABSOLUTE MAXIMUM RATINGS

(Ta = +25°C)

| Parameter             | Symbol                      | Condition          | Rated Value |      | Unit |
|-----------------------|-----------------------------|--------------------|-------------|------|------|
|                       |                             |                    | Min.        | Max. |      |
| Power supply voltage  | V <sub>CC</sub>             | —                  | —           | 16   | V    |
| Output source current | I <sub>O</sub> <sup>+</sup> |                    | —           | −50  | mA   |
| Output sink current   | I <sub>O</sub> <sup>−</sup> |                    | —           | 50   | mA   |
| Allowable dissipation | P <sub>D</sub>              | SOP-8, Ta ≤ +25°C  | —           | 570* | mW   |
|                       |                             | SOP-8, Ta ≤ +25°C  | —           | 430* | mW   |
|                       |                             | SSOP-8, Ta ≤ +25°C | —           | 580* | mW   |
| Operating temperature | T <sub>op</sub>             | —                  | −30         | +85  | °C   |
| Storage temperature   | T <sub>stg</sub>            |                    | −55         | +125 | °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

(Ta = +25°C)

| Parameter                         | Symbol                      | Values |      |                 | Unit |
|-----------------------------------|-----------------------------|--------|------|-----------------|------|
|                                   |                             | Min.   | Typ. | Max.            |      |
| Power supply voltage              | V <sub>CC</sub>             | 1.8    | —    | 15              | V    |
| Error amplifier input voltage     | V <sub>I</sub>              | −0.2   | —    | 1.0             | V    |
| BR/CTL pin input voltage          | V <sub>BR</sub>             | −0.2   | —    | V <sub>CC</sub> | V    |
| Output source current             | I <sub>O</sub> <sup>+</sup> | −40    | —    | —               | mA   |
| Output sink current               | I <sub>O</sub> <sup>−</sup> | —      | —    | 40              | mA   |
| SCP pin capacitance               | C <sub>PE</sub>             | —      | 0.1  | —               | μF   |
| Phase compensation capacitance    | C <sub>P</sub>              | —      | 0.1  | —               | μF   |
| Output current setting resistance | R <sub>B</sub>              | 150    | 390  | 5000            | Ω    |
| Timing resistance                 | R <sub>T</sub>              | 1.0    | 3.0  | 10.0            | kΩ   |
| Timing capacitance                | C <sub>T</sub>              | 100    | 270  | 10000           | pF   |
| Oscillation frequency             | f <sub>OSC</sub>            | 10     | 500  | 1000            | kHz  |
| Operating temperature             | T <sub>OP</sub>             | −30    | +25  | +85             | °C   |

WARNING: Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges.

Always use semiconductor devices within the recommended operating conditions. 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 representative beforehand.

## MB3800

## ■ ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +2 V, T<sub>a</sub> = +25°C)

| Parameter  |   | Symbol                       | Condition   | Value |      |      | Unit |
|--|---|------------------------------|---|-------|------|------|------|
|  |   |                              |   | Min.  | Typ. | Max. |      |
| Circuit to prevent malfunction at low input voltage (U.V.L.O.) | Reset voltage                             | V <sub>R</sub>               | —   | —     | —    | 0.9  | V    |
|  | Threshold voltage                         | V <sub>TH</sub>              |   | 1.1   | 1.3  | 1.5  | V    |
| Soft start   | Charging current                          | I <sub>CS</sub>              | V <sub>SCP</sub> = 0 V  | −1.5  | −1.0 | −0.7 | μA   |
|  | Voltage at soft start completion          | V <sub>IS</sub>              | —   | 0.7   | 0.8  | 0.9  | V    |
| Short circuit detection (S.C.P.)                               | Charging current                          | I <sub>CPC</sub>             | V <sub>SCP</sub> = 0 V  | −1.5  | −1.0 | −0.7 | μA   |
|  | Threshold voltage                         | V <sub>IPC</sub>             | —   | 0.7   | 0.8  | 0.9  | V    |
| Sawtooth wave oscillator (OSC)                                 | Oscillation frequency                     | f <sub>OC</sub>              | R <sub>T</sub> = 3.0 kΩ, C <sub>T</sub> = 270 pF                            | 400   | 500  | 600  | kHz  |
|  | Frequency input stability                 | f <sub>dV</sub>              | V <sub>CC</sub> = 2 V to 15 V   | —     | 2    | 10   | %    |
|  | Frequency variation with temperature      | f <sub>dT</sub>              | T <sub>a</sub> = −30°C to +85°C   | —     | 5    | —    | %    |
| Error amplifier  | Input threshold voltage                   | V <sub>T</sub>               | V <sub>FB</sub> = 450 mV  | 480   | 500  | 520  | mV   |
|  | V <sub>T</sub> input stability            | V <sub>TdV</sub>             | V <sub>CC</sub> = 2 V to 15 V   | —     | 5    | 20   | mV   |
|  | V <sub>T</sub> variation with temperature | V <sub>TdT</sub>             | T <sub>a</sub> = −30°C to +85°C   | —     | 1    | —    | %    |
|  | Input bias current                        | I <sub>B</sub>               | V <sub>IN</sub> = 0 V   | −1.0  | −0.2 | 1.0  | μA   |
|  | Voltage gain                              | A <sub>V</sub>               | —   | 70    | 100  | 145  | V/V  |
|  | Frequency bandwidth                       | BW                           | A <sub>V</sub> = 0 dB   | —     | 6    | —    | MHz  |
|  | Maximum output voltage range              | V <sub>OM</sub> <sup>+</sup> | —   | 0.78  | 0.87 | —    | V    |
|  |   | V <sub>OM</sub> <sup>−</sup> |   | —     | 0.05 | 0.2  | V    |
|  | Output source current                     | I <sub>OM</sub> <sup>+</sup> | V <sub>FB</sub> = 0.45 V  | —     | −40  | −24  | μA   |
|  | Output sink current                       | I <sub>OM</sub> <sup>−</sup> |   | 24    | 40   | —    | μA   |
| Idle period adjustment section                                 | Maximum duty cycle                        | t <sub>DUTY</sub>            | R <sub>T</sub> = 3.0 kΩ, C <sub>T</sub> = 270 pF<br>V <sub>FB</sub> = 0.8 V | 65    | 75   | 85   | %    |

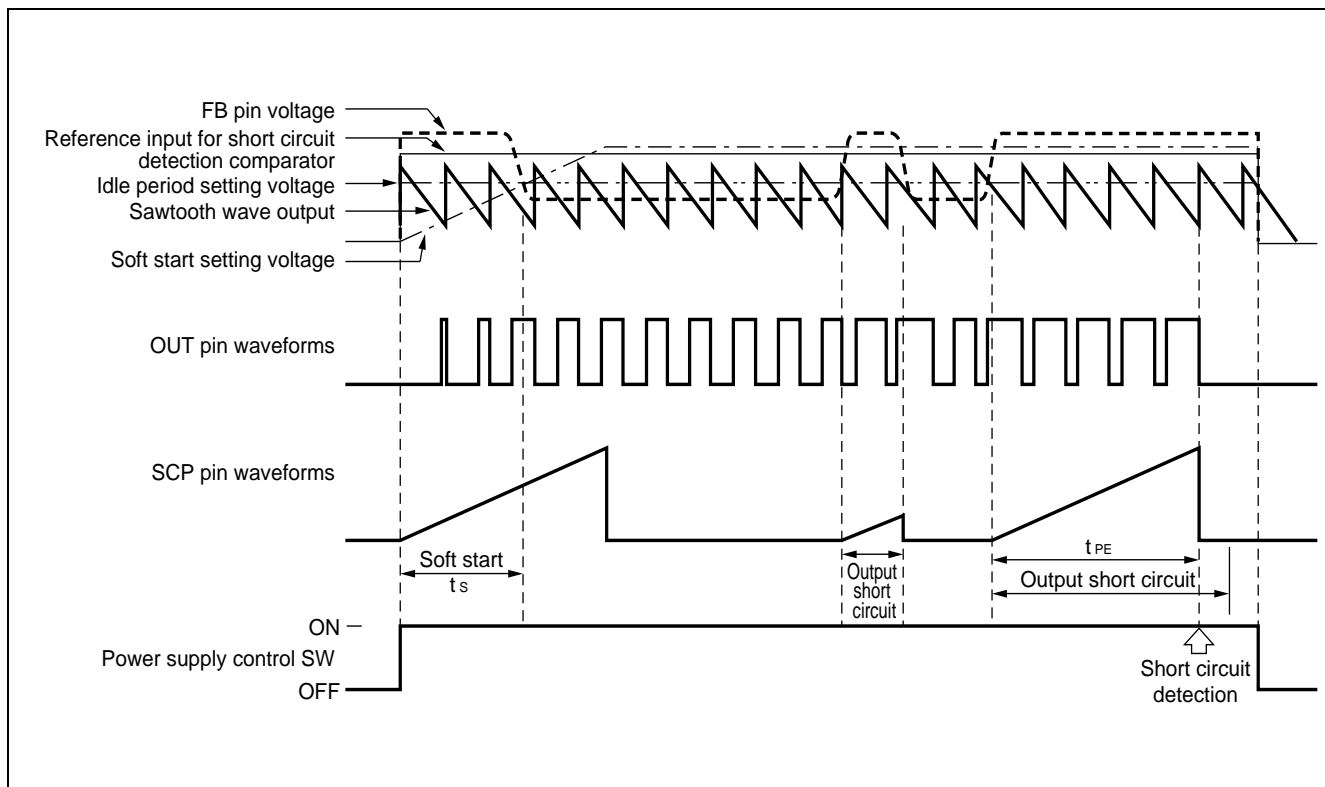
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# MB3800

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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             |
|  |                        | $V_{OH2}$ | $R_B = 750 \Omega$ , $V_{CC} = 1.8 \text{ V}$<br>$I_O = -10 \text{ mA}$ | 0.8   | 1.0  | —    | V             |
|  |                        | $V_{OL1}$ | $R_B = 390 \Omega$ , $I_O = 15 \text{ mA}$                              | —     | 0.1  | 0.2  | V             |
|  |                        | $V_{OL2}$ | $R_B = 750 \Omega$ , $V_{CC} = 1.8 \text{ V}$<br>$I_O = 10 \text{ mA}$  | —     | 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/<br>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 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, 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) is fixed at  $V_{OM}^+$  and capacitor  $C_{PE}$  starts charging. When the voltage at the SCP pin reaches approximately 0.8V, the output pin is set low and the SCP pin stays low.

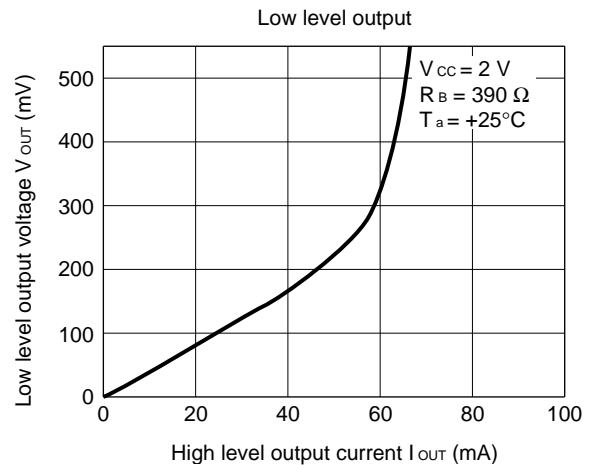
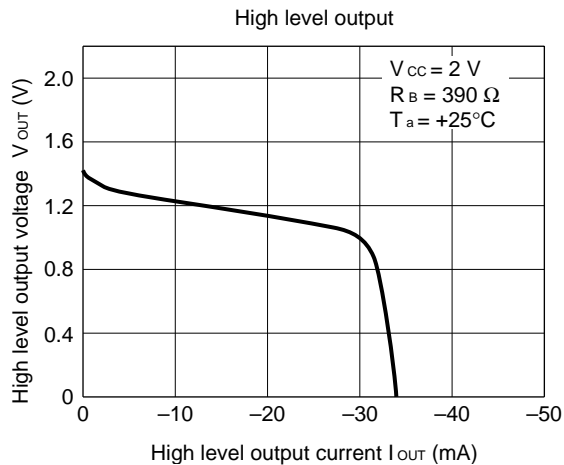
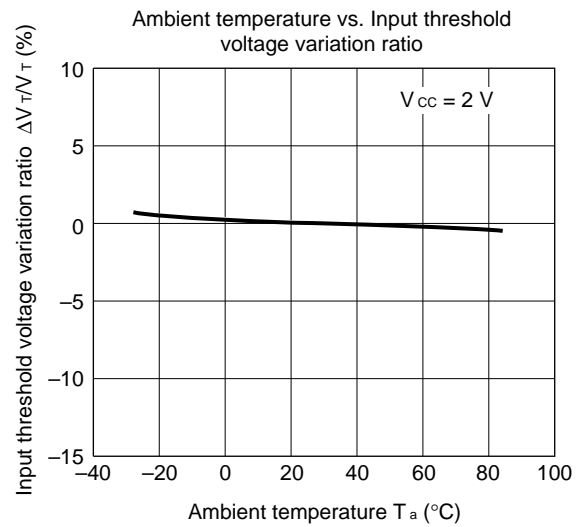
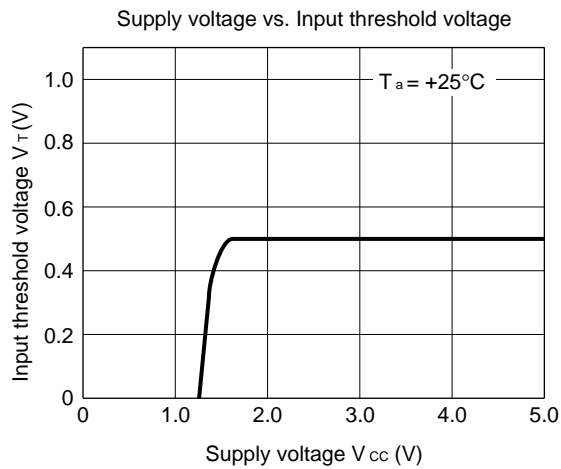
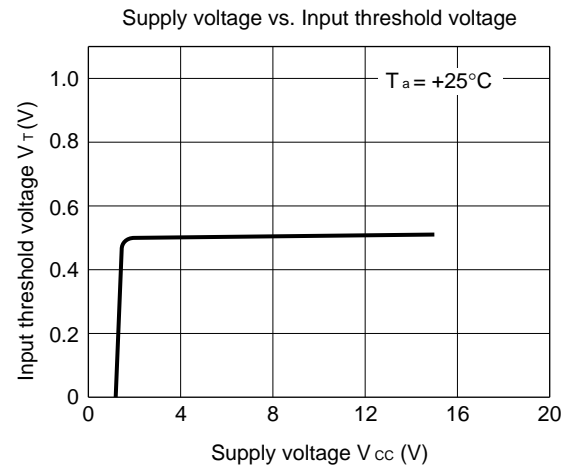
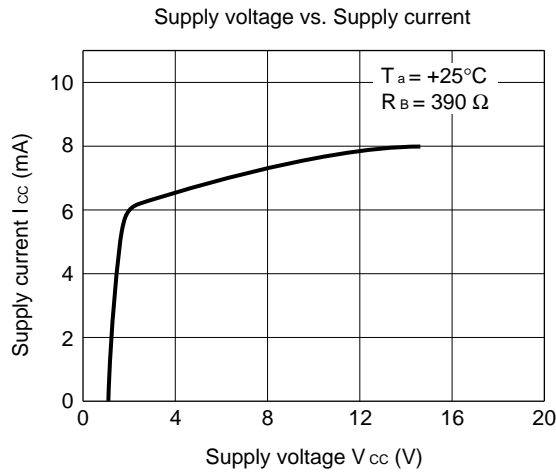
Once the protection circuit operates, the circuit can be restored by resetting the power supply.

- Short circuit detection time

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

# MB3800

## ■ TYPICAL CHARACTERISTICS



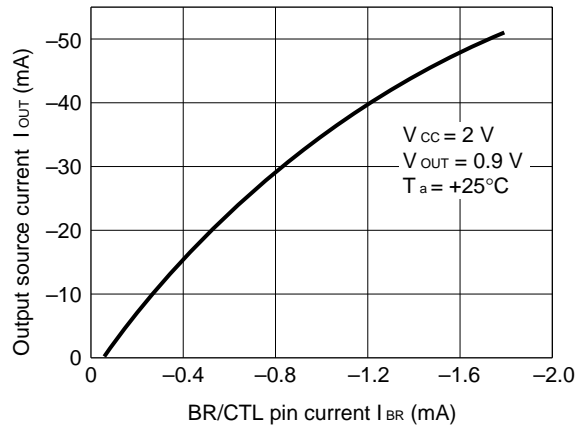
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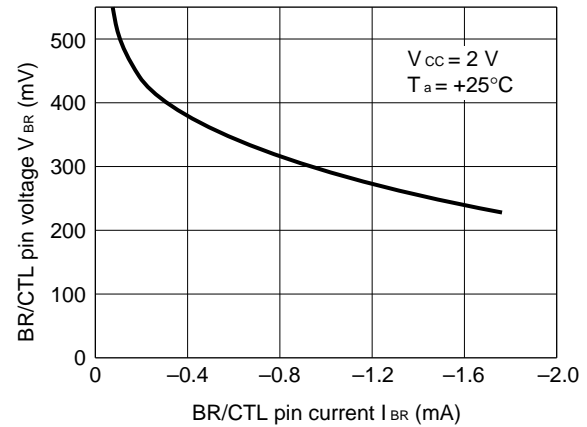
## MB3800

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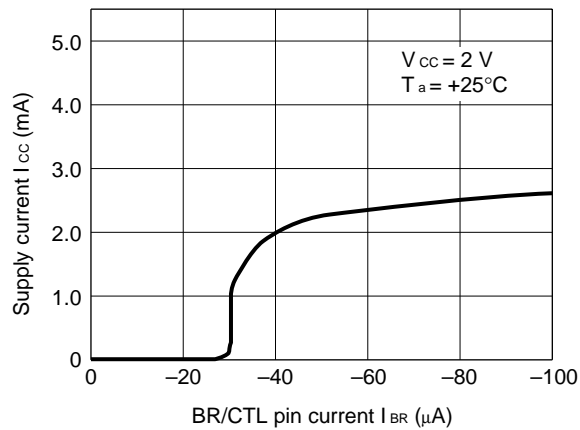
BR/CTL pin current vs. Output source current



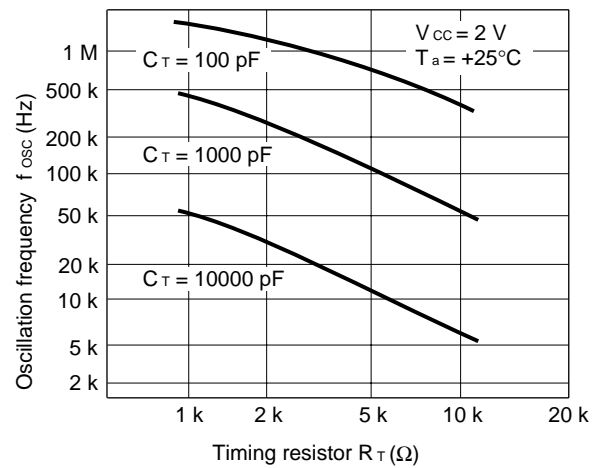
BR/CTL pin current vs. BR/CTL pin voltage



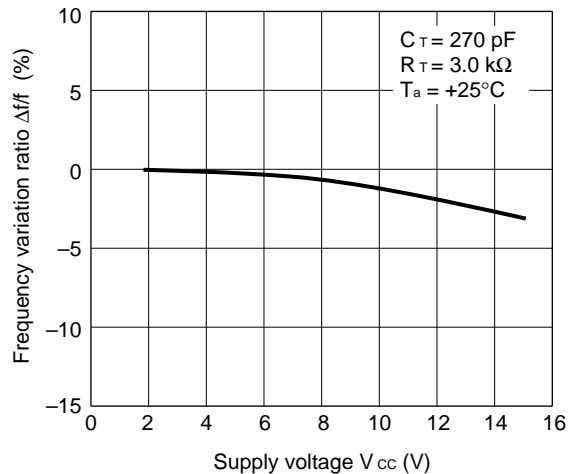
BR/CTL pin current vs. Supply current



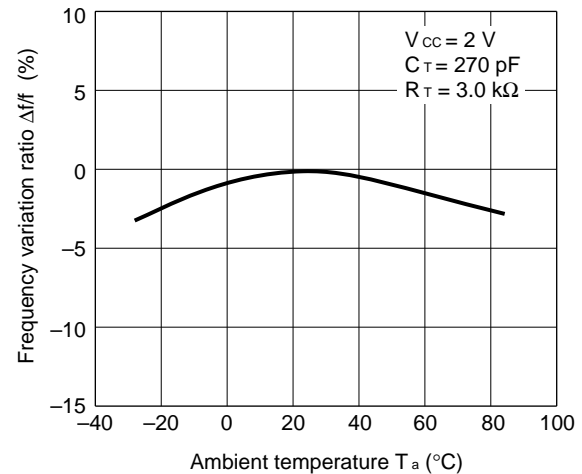
Timing resistor vs. Oscillation frequency



Supply voltage vs. Frequency variation ratio



Ambient temperature vs. Frequency variation ratio

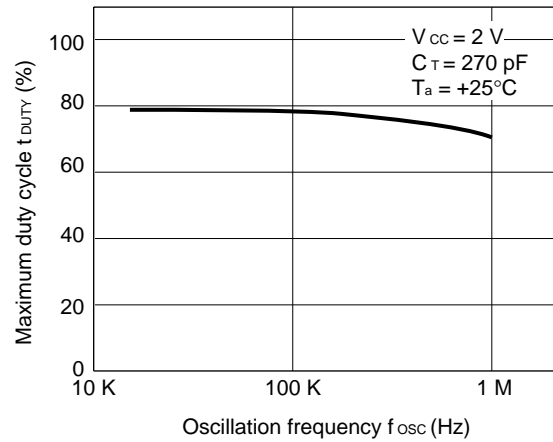


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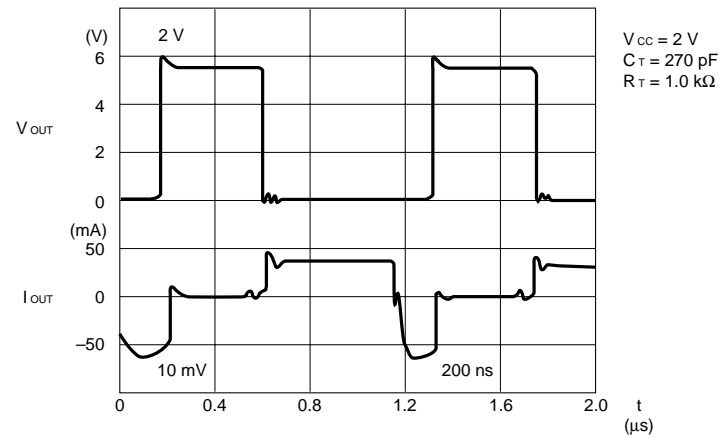
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Oscillation frequency vs. Maximum duty cycle

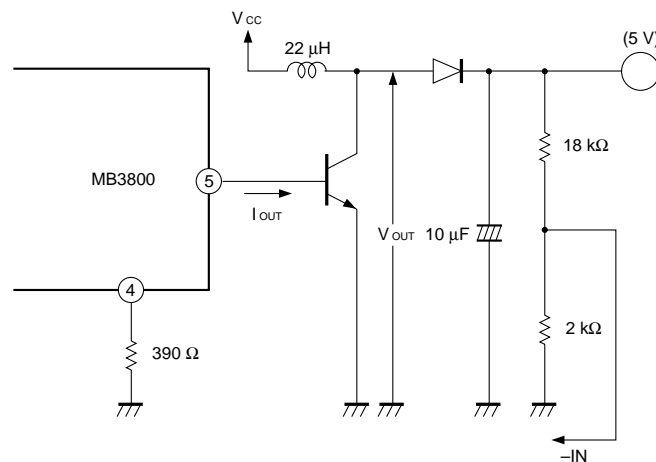


Output pin voltage and current waveforms (reference data)



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

Measurement circuit diagram



# MB3800

## ■ FUNCTIONAL DESCRIPTION

### 1. Switching Regulator Function

#### (1) Reference voltage circuit

The reference voltage circuit generates a temperature-compensated reference voltage ( $\cong 1.25\text{V}$ ) from voltage supplied from the power supply 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.

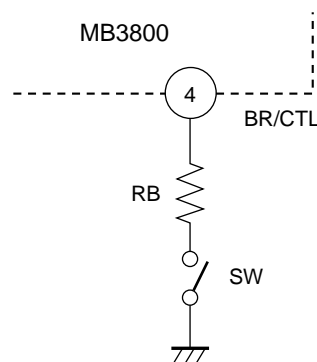
#### (5) Output circuit

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  $1\text{ }\mu\text{A}$  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 |



# MB3800

## 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 output pin (pin 5) is set low and the SCP pin (pin 2) stays low.

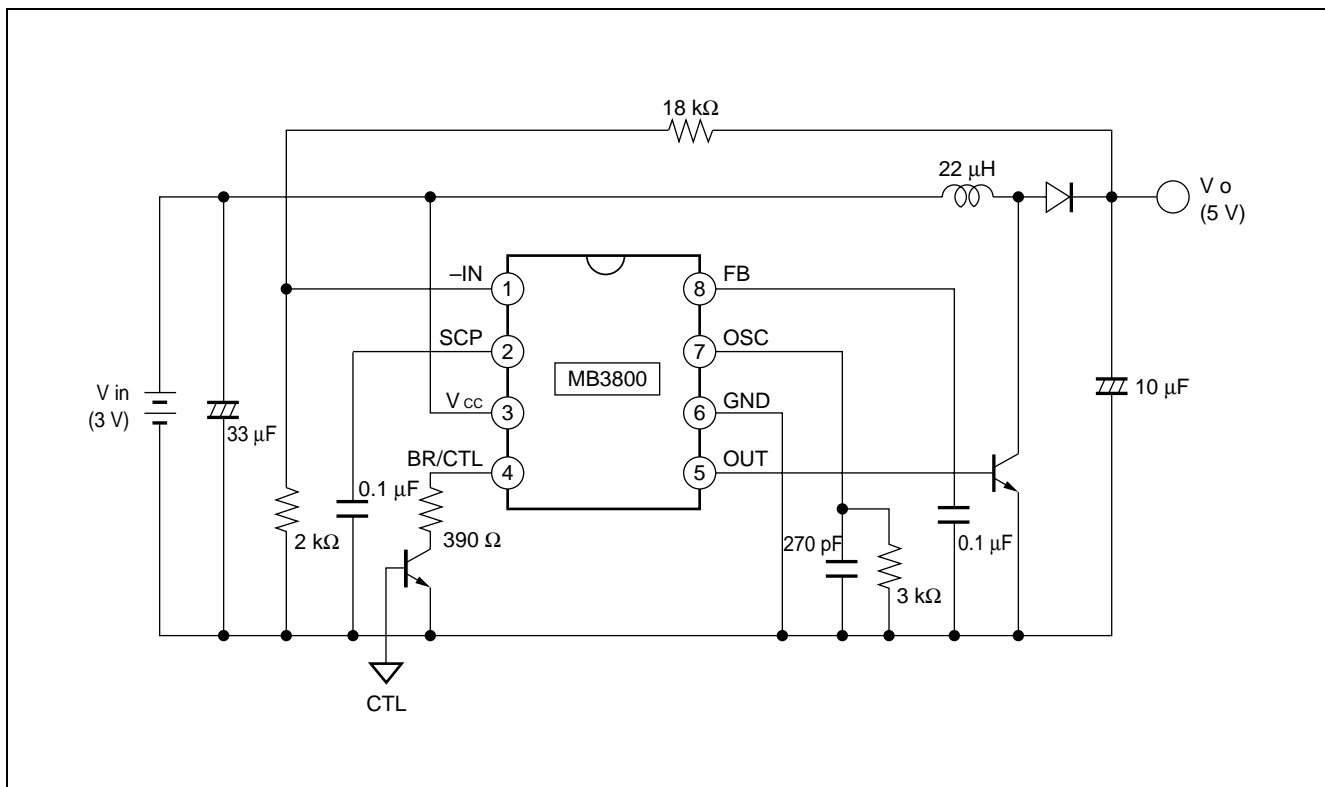
Once the protection circuit operates, the circuit can be restored by resetting the power supply. (See “**■ HOW TO SET THE TIME CONSTANT FOR SOFT START AND SHORT CIRCUIT DETECTION**”.)

### (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 output pin to low.

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

## ■ APPLICATION EXAMPLE



## ■ USAGE PRECAUTIONS

### 1. Do not apply an input voltage greater than the maximum rating.

Do not input voltages greater than the maximum rating as this can cause damage to the LSI.

### 2. Use in accordance with the recommended operating conditions.

The electrical characteristics of the LSI are not guaranteed if the input voltage is greater than the maximum. Also, LSI operation is unstable if the input voltage is less than the minimum. Therefore, always use in accordance with the recommended operating conditions.

### 3. Use a wide ground line on the printed circuit board.

As the LSI uses a high frequency and therefore can generate high frequency noise, make the ground line as wide as possible.

### 4. Take anti-static precautions.

- Use a holder for inserting the semiconductor which is anti-static or conductive.
- After mounting the device on a printed circuit board, store or transport the board in a conductive bag or container.
- Earth work benches, tools, and measuring equipment.
- Ensure that maintenance personnel have a resistance of 250 k $\Omega$  to 1 M $\Omega$  in series between their body and earth.

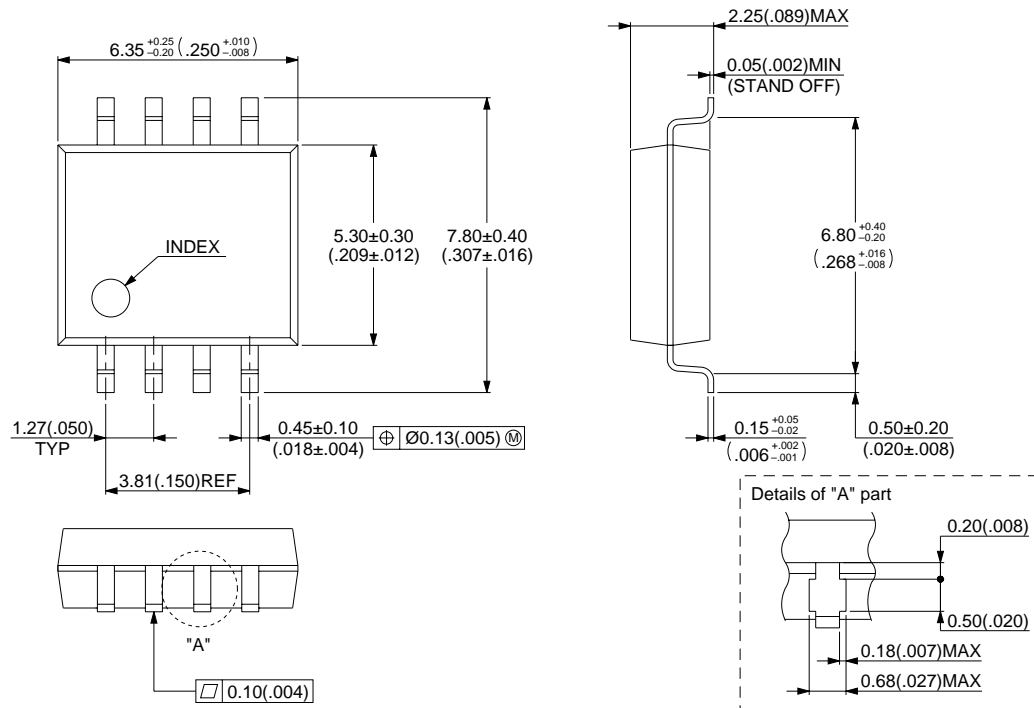
# MB3800

## ■ ORDERING INFORMATION

| Part number | Package                            | Remarks |
|-------------|------------------------------------|---------|
| MB3800PF    | 8-pin Plastic SOP<br>(FPT-8P-M01)  |         |
| MB3800PNF   | 8-pin Plastic SOL<br>(FPT-8P-M02)  |         |
| MB3800PFV   | 8-pin Plastic SSOP<br>(FPT-8P-M03) |         |

## ■ PACKAGE DIMENSIONS

## 8-pin Plastic SOP (FPT-8P-M01)



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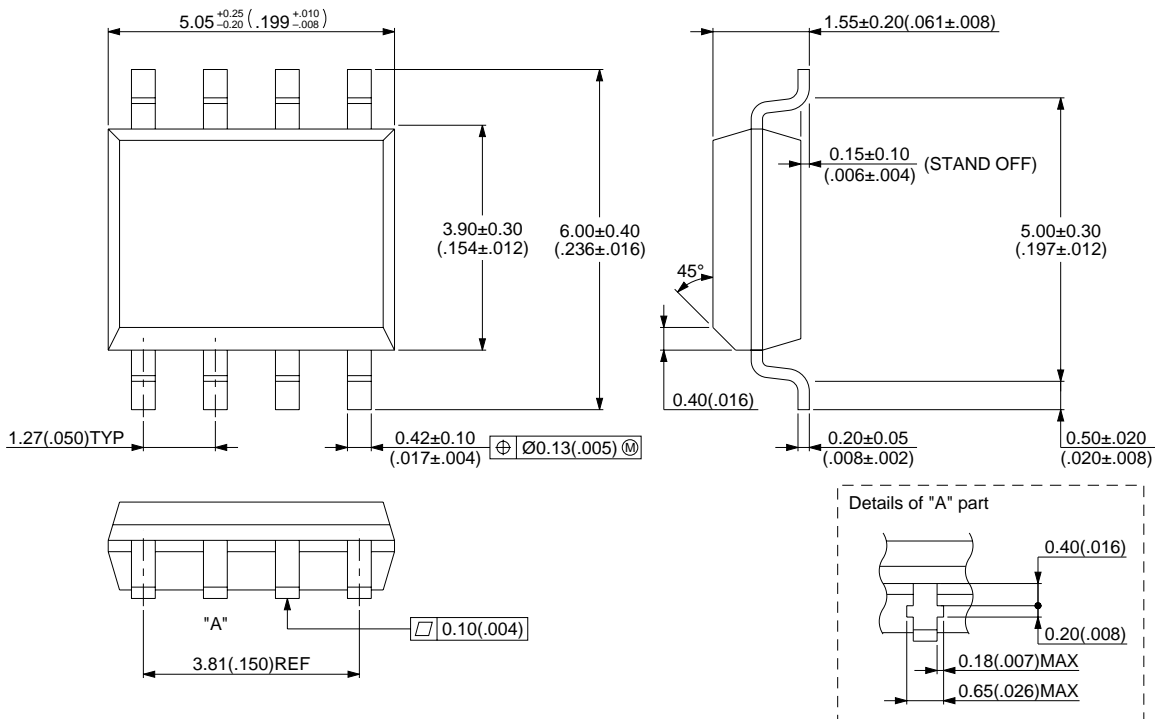
Dimensions in mm (inches).

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# MB3800

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## 8-pin Plastic SOL (FPT-8P-M02)



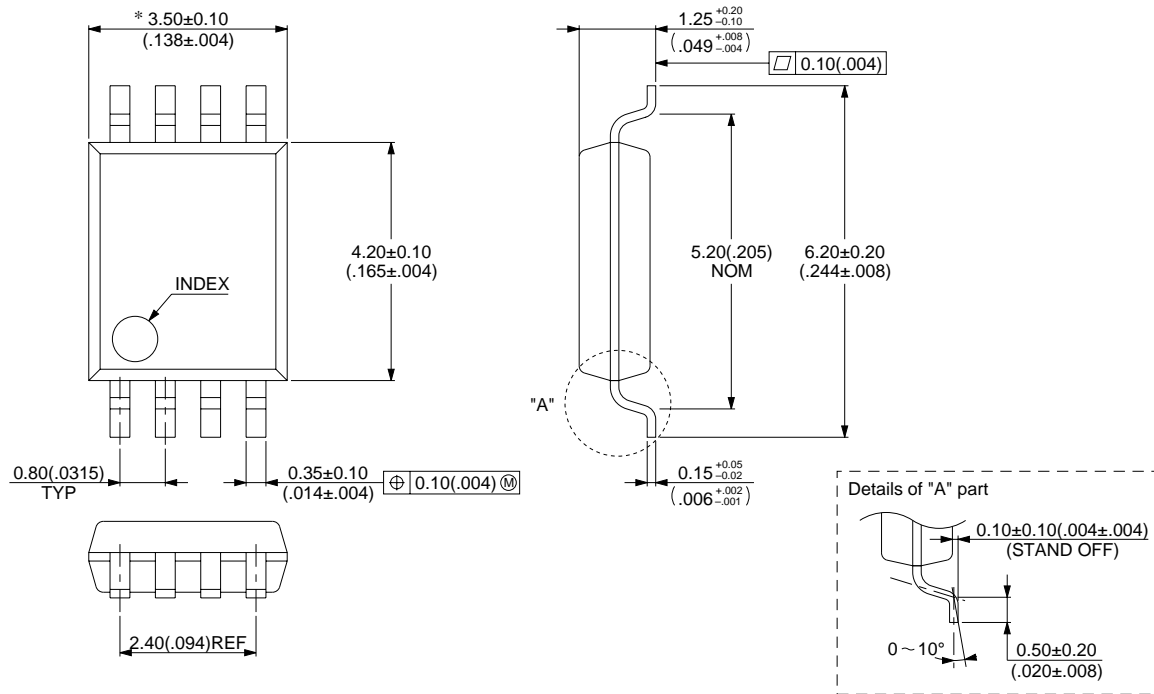
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Dimensions in mm (inches).



## MB3800

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

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Dimensions in mm (inches).

# MB3800

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Any semiconductor devices have inherently a certain rate of failure. You must protect against injury, damage or loss from such failures by incorporating safety design measures into your facility and equipment such as redundancy, fire protection, and prevention of over-current levels and other abnormal operating conditions.

If any products described in this document represent goods or technologies subject to certain restrictions on export under the Foreign Exchange and Foreign Trade Control Law of Japan, the prior authorization by Japanese government should be required for export of those products from Japan.