FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-27233-2E

ASSP For Power Supply Applications
(General Purpose DC/DC Converter)

1-ch DC/DC Converter IC
for low voltage

MB39A105

■ DESCRIPTION

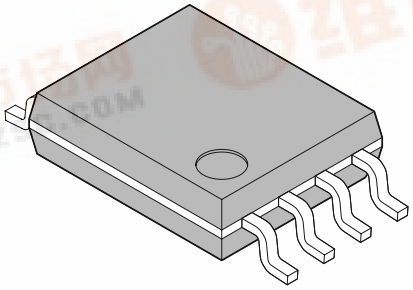
The MB39A105 is 1-channel DC/DC converter IC using pulse width modulation (PWM). This IC is ideal for up conversion.
The minimum operating voltage is low (1.8 V) , and the MB39A105 is best for built-in power supply such as LCD monitors. Also the short-circuit protection detection output function prevents input/output short on a chopper type up-converter.
This product is covered by US Patent Number 6,147,477.

■ FEATURES

- Power supply voltage range : 1.8 V to 6 V
- Reference voltage accuracy : ± 1 %
- High-frequency operation capability : 1 MHz (Max)
- Built-in standby function: 0 μA (Typ)
- Built-in timer-latch short-circuit protection circuit
- Built-in short-circuit protection detection output function
- Built-in soft-start circuit independent of loads
- Built-in totem-pole type output for Nch MOS FET
- Package : TSSOP-8P (Thickness 1.1 mm Max)

■ PACKAGE

8-pin plastic TSSOP

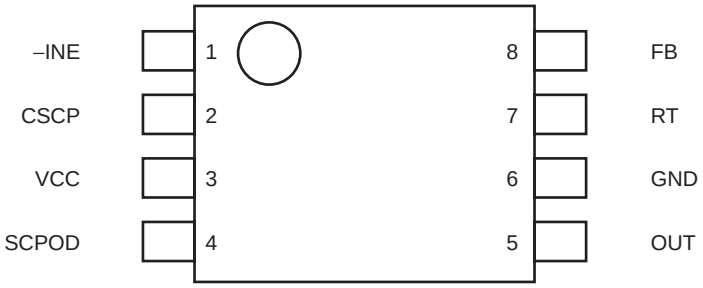


(FPT-8P-M05)

FUJITSU

■ PIN ASSIGNMENT

(TOP VIEW)

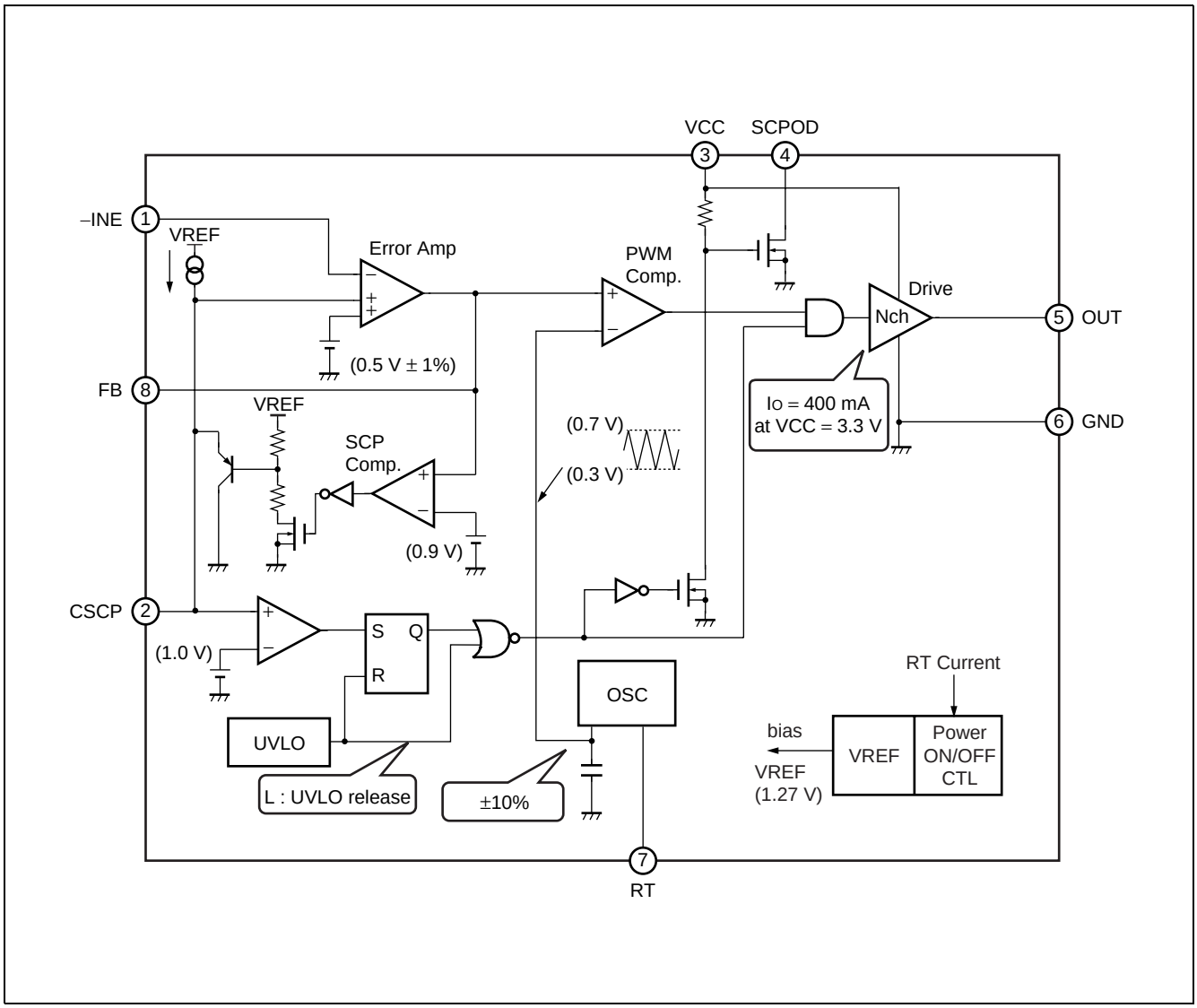


(FPT-8P-M05)

■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Descriptions
1	–INE	I	Error amplifiers (Error Amp) inverted input terminal
2	CSCP	—	Timer-latch short-circuit protection capacitor connection terminal
3	VCC	—	Power supply terminal
4	SCPOD	O	Open drain output terminal for short-circuit protection detection During timer-latch short-circuit protection operation : Output “High-Z” During normal operation : Output “L”
5	OUT	O	External Nch FET gate drive terminal
6	GND	—	Ground terminal
7	RT	—	Triangular wave oscillation frequency setting resistor connection terminal
8	FB	O	Error Amplifier (Error Amp) output terminal

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power supply voltage	V_{CC}	VCC terminal	—	7	V
Output current	I_O	OUT terminal	—	35	mA
Output peak current	I_{OP}	Duty ≤ 5% (t = 1/f_{OSC}×Duty)	—	700	mA
Power dissipation	P_D	Ta ≤ +25 °C	—	490*	mW
Storage temperature	T_{STG}	—	–55	+125	°C

* : The packages are mounted on the epoxy board (10 cm × 10 cm).

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

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
Power supply voltage	V_{CC}	VCC terminal	1.8	—	6	V
Input voltage	V_{INE}	–INE terminal	0	—	V_{CC} – 0.9	V
SCPOD terminal output voltage	V_{SCPOD}	SCPOD terminal	0	—	6	V
SCPOD terminal output current	I_{SCPOT}	SCPOD terminal	0	—	2	mA
Output current	I_O	OUT terminal	–30	—	+30	mA
Oscillation frequency	fosc	—	100	500	1000	kHz
Timing resistor	R_T	RT terminal	3.3	7.5	33	kΩ
Short-circuit detection capacitor	C_{SCP}	CSCP terminal	—	0.22	1.0	µF
Operating ambient temperature	Ta	—	–30	+25	+85	°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

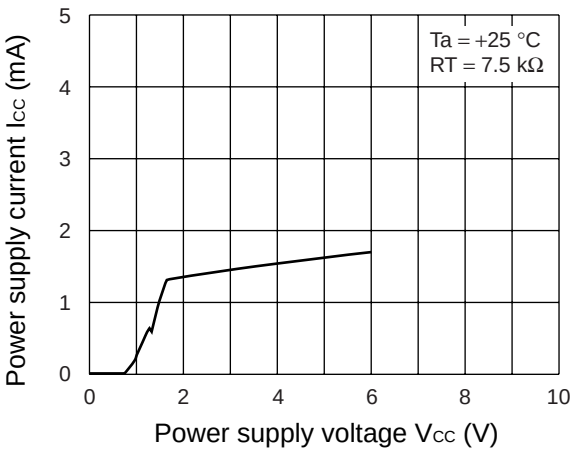
(VCC = 3.3 V, Ta = +25 °C)

Parameter		Symbol	Pin No	Conditions	Value			Unit
					Min	Typ	Max	
1. Under voltage lockout protection circuit block [UVLO]	Threshold voltage	V_{TLH}	3	VCC = ↗	1.15	1.35	1.55	V
2. Short-circuit protection block [SCP]	Threshold voltage	V_{TH}	2	—	0.95	1.00	1.05	V
	Short-circuit detection time setting difference voltage	ΔV_{CSCP}	2	—	0.15	0.20	0.25	V
	Input source current	I_{CSCP}	2	CSCP = 0.85 V	–1.76	–0.88	–0.44	µA
	Reset voltage	V_{RST}	3	VCC = ↘	1.1	1.3	1.5	V
	SCPOD terminal output leak current	I_{LEAK}	4	SCPOD = 3.3 V	—	0	1.0	µA
	SCPOD terminal output on resistor	R_{ON}	4	SCPOD = 1 mA	—	50	100	Ω
3. Triangular wave oscillator block [OSC]	Oscillation frequency	fosc	5	RT = 7.5 kΩ	450	500	550	kHz
	Frequency temperature variation	$\Delta f_{OSC}/f_{OSC}$	5	Ta = 0 °C to +85 °C	—	1*	—	%
4. Soft-start block [CS]	Charge current	I_{CS}	2	CSCP = 0 V	–16	–11	–6	µA
5. Error amplifier block [Error Amp]	Threshold voltage	V_{TH}	1	FB = 0.5 V	0.495	0.5	0.505	V
	Input bias current	I_B	1	–INE = 0 V	–120	–30	—	nA
	Voltage gain	A_V	8	DC	—	70*	—	dB
	Frequency band width	BW	8	A_V = 0 dB	—	1.1*	—	MHz
	Output voltage	V_{OH}	8	—	1.17	1.27	1.37	V
		V_{OL}	8	—	—	40	200	mV
	Output source current	I_{SOURCE}	8	FB = 0.5 V	—	–80	–50	µA
	Output sink current	I_{SINK}	8	FB = 0.5 V	100	300	—	µA
6. PWM comparator block [PWM Comp.]	Maximum duty cycle	Dtr	5	RT = 7.5 kΩ	85	90	95	%
7.Output block [Drive]	Output source current	I_{SOURCE}	5	OUT = 0 V, Duty ≤ 5% (t = 1/fosc×Duty)	—	–400*	—	mA
	Output sink current	I_{SINK}	5	OUT = 3.3 V, Duty ≤ 5% (t = 1/fosc×Duty)	—	400*	—	mA
	Output ON resistor	R_{OH}	5	OUT = –15 mA	—	4.0*	—	Ω
		R_{OL}	5	OUT = 15 mA	—	3.0	6.0	Ω
8. General block	Standby current	I_{CCS}	3	RT = OPEN	—	0	10	µA
	Power supply current	I_{CC}	3	RT = 7.5 kΩ	—	1.2	1.8	mA

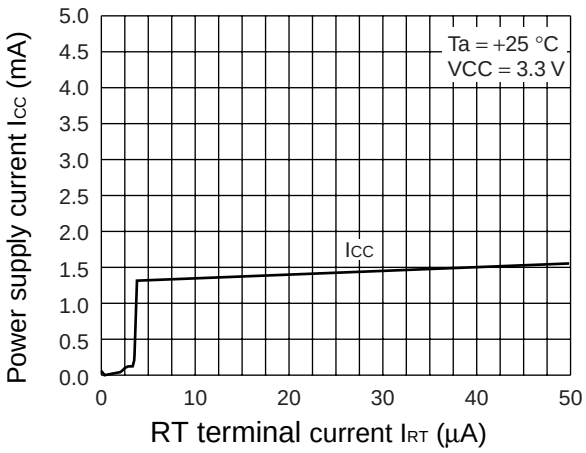
*: Standard design value.

■ TYPICAL CHARACTERISTICS

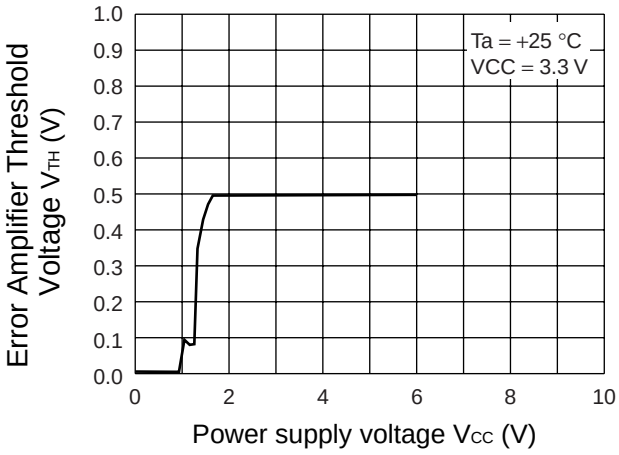
Power Supply Current vs. Power Supply Voltage



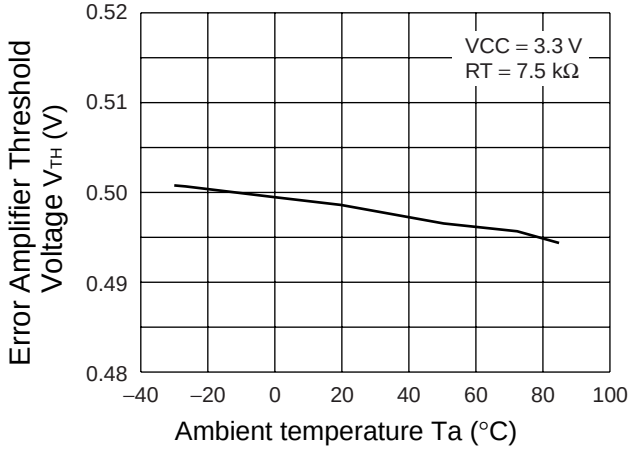
Power Supply Current vs. RT Terminal Current



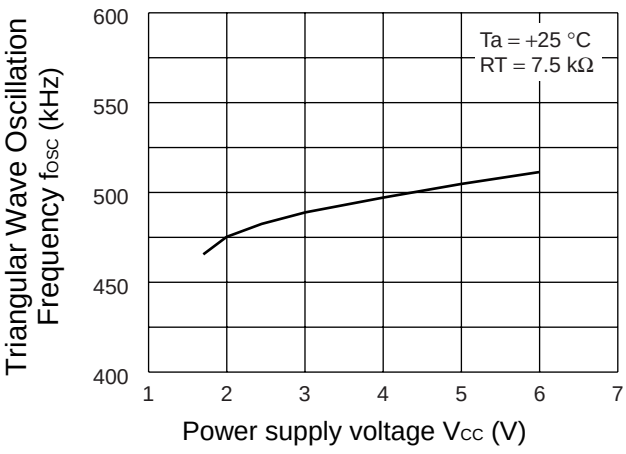
Error Amplifier Threshold Voltage vs. Power Supply Voltage



Error Amplifier Threshold Voltage vs. Ambient Temperature



Triangular Wave Oscillation Frequency vs. Power supply voltage



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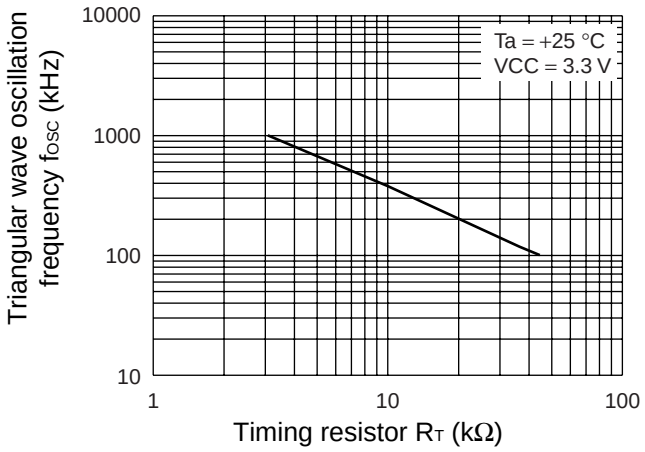
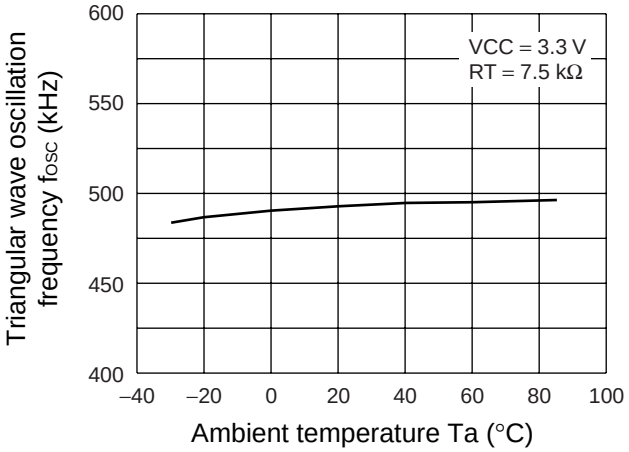
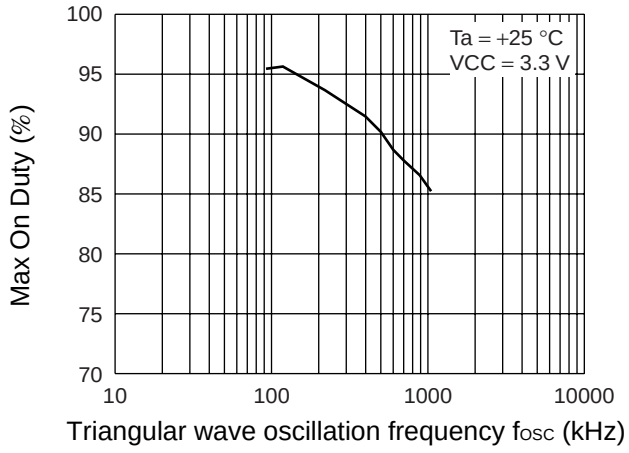
Triangular Wave Oscillation Frequency
vs. Timing Resistor



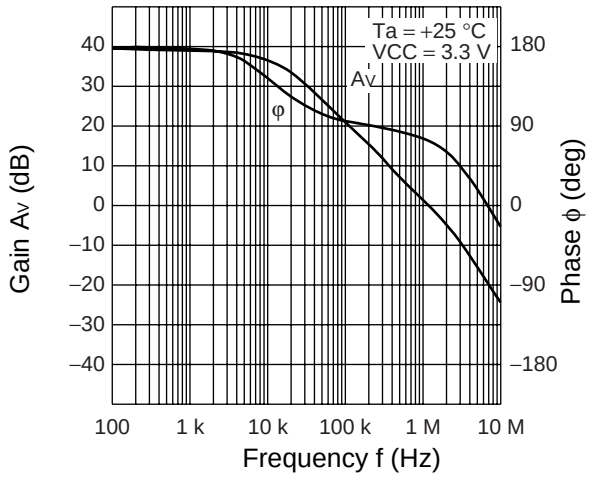
Triangular Wave Oscillation Frequency
vs. Ambient Temperature

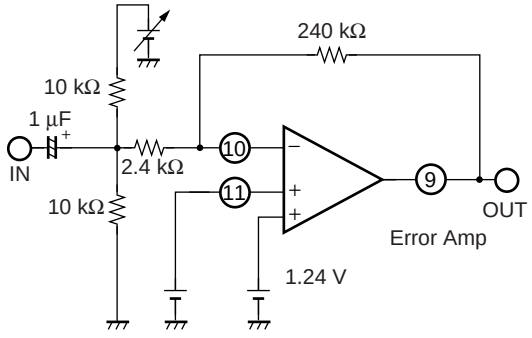


Max On Duty vs.
Triangular Wave Oscillation Frequency



Error Amplifier Gain and Phase
vs. Frequency





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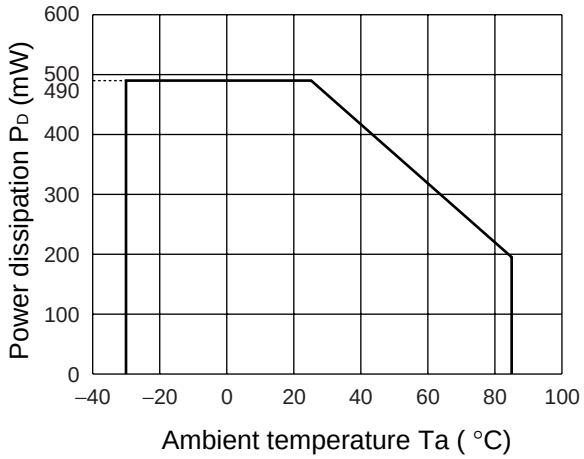
Power Dissipation vs. Ambient Temperature



■ FUNCTIONS

1. DC/DC Converter Functions

(1) Triangular-wave oscillator block (OSC)

The triangular wave oscillator incorporates a timing resistor connected to RT terminal (pin 7) to generate triangular oscillation waveform amplitude of 0.3 V to 0.7 V.
The triangular waveforms are input to the PWM comparator in the IC.

(2) Error amplifier block (Error Amp1, Error Amp2)

The error amplifier detects the DC/DC converter output voltage and outputs PWM control signals. In addition, an arbitrary loop gain can be set by connecting a feedback resistor and capacitor from the output terminal to inverted input terminal of the error amplifier, enabling stable phase compensation to the system.
Also, it is possible to prevent rush current at power supply start-up by connecting a soft-start capacitor with the CSCP terminal (pin 2) which is the non-inverted input terminal for Error Amp. The use of Error Amp for soft-start detection makes it possible for a system to operate on a fixed soft-start time that is independent of the output load on the DC/DC converter.

(3) PWM comparator block (PWM Comp.)

The PWM comparator is a voltage-to-pulse width modulator that controls the output duty depending on the input/output voltage.
The comparator keeps output transistor on while the error amplifier output voltage and the DTC voltage remain higher than the triangular wave voltage.

(4) Output block (Drive)

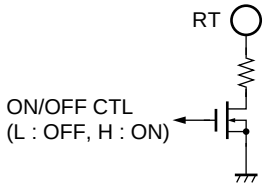
The output block is in the totem pole configuration, capable of driving an external N-channel MOS FET.

2. Power Control Function

A switch in series with a resistor connected with the RT terminal (pin 7) allows you to turn on or turn off the power.

On/off setting conditions of power supply

CTL	Power
L	OFF (standby)
H	ON (operating)



3. Protective Functions

(1) Timer-latch short-circuit protection circuit (SCP)

Short-circuit detection comparator detects the error amplifier output voltage level. If the load conditions for the DC/DC converter are stable, the short-circuit protection comparator is kept in equilibrium condition because the error amplifier is free from output variation. At this time the CSCP terminal (pin 2) is held at the soft-start end voltage (about 0.8 V) . If the DC/DC converter output voltage falls and error amplifier output is over 0.9 V, the timer circuits are actuated to start charging the external capacitor C_{SCP}.

When the capacitor voltage reaches about 1.0 V, the latch is set and the circuit is turned off the external FET and sets the dead time to 100 %. At this time, latch input is closed and the CSCP terminal is held at the “L” level. To reset the actuated protection circuit, turn off and on the power supply again and set VCC terminal voltage (pin 3) to 1.1 V (Min) or less. (See ■SETTING TIME CONSTANT FOR TIMER-LATCH SHORT-CIRCUIT PROTECTION CIRCUIT.)

(2) Under voltage lockout protection circuit (UVLO)

The transient state or a momentary decrease in supply voltage, which occurs when the power supply is turned on, may cause the IC to malfunction, resulting in breakdown or degradation of the system. To prevent such malfunctions, under voltage lockout protection circuit detects a decrease in internal reference voltage with respect to the power supply voltage, turns off the output FET, and sets the dead time to 100% while holding the CSCP terminal (pin 2) at the “L” level.

The circuit restores the output transistor to normal when the supply voltage reaches the threshold voltage of the undervoltage lockout protection circuit.

(3) Short-circuit protection detection output function

Connecting the Pch MOS FET to SCPOD terminal (pin 4) turns off the Pch MOS FET when the short-circuit protection is detected or under voltage lockout protection circuit operate. This allows you to prevent the short-circuit between the input and output when the short-circuit protection is detected, thus preventing the input voltage from occurring in the output region in the standby state.

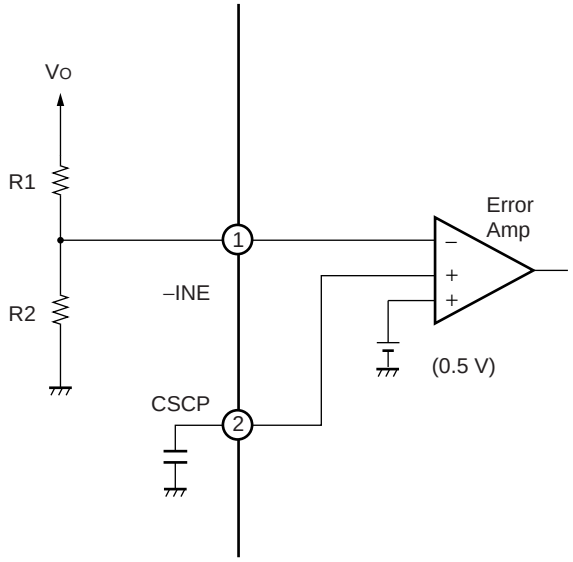
(4) Protection circuit operating function table

This table refers to output condition when protection circuit is operating.

Operating circuit	SCPOD	OUT
Short-circuit protection circuit	High-Z	L
Under voltage lockout protection circuit	High-Z	L

■ SETTING THE OUTPUT VOLTAGE

• Output Voltage Setting Circuit



$$V_O\ (V) = \frac{0.5}{R2}\ (R1 + R2)$$

■ SETTING THE TRIANGULAR OSCILLATION FREQUENCY

The triangular oscillation frequency is determined by the timing resistor (R_T) connected to the RT terminal (pin 7) .

Triangular oscillation frequency : fosc

$$fosc\ (kHz) \fallingdotseq \frac{3750}{R_T\ (k\Omega)}$$

■ SETTING THE SOFT-START TIMES

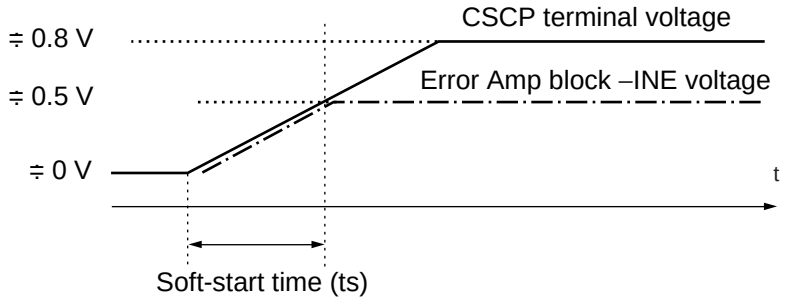
To prevent rush currents when the IC is turned on, you can set a soft-start by connecting soft-start capacitors (C_{SCP}) to the CSCP terminal (pin 2). When IC starts ($V_{CC} \geq$ UVLO threshold voltage), the external soft-start capacitors (C_{SCP}) connected to CSCP terminal are charged at 11 µA. The error amplifier output (FB (pin 8)) is determined by comparison between the lower one of the potentials at two non-inverted input terminals (0.5 V in an internal reference voltage, CSCP terminal voltages) and the inverted input terminal voltage (–INE (pin 1) voltage).

The FB terminal voltage is decided for the soft-start period by the comparison between 0.5 V in an internal reference voltage and the voltages of the CSCP terminal. The DC/DC converter output voltage rises in proportion to the CSCP terminal voltage as the soft-start capacitor connected to the CSCP terminal is charged.

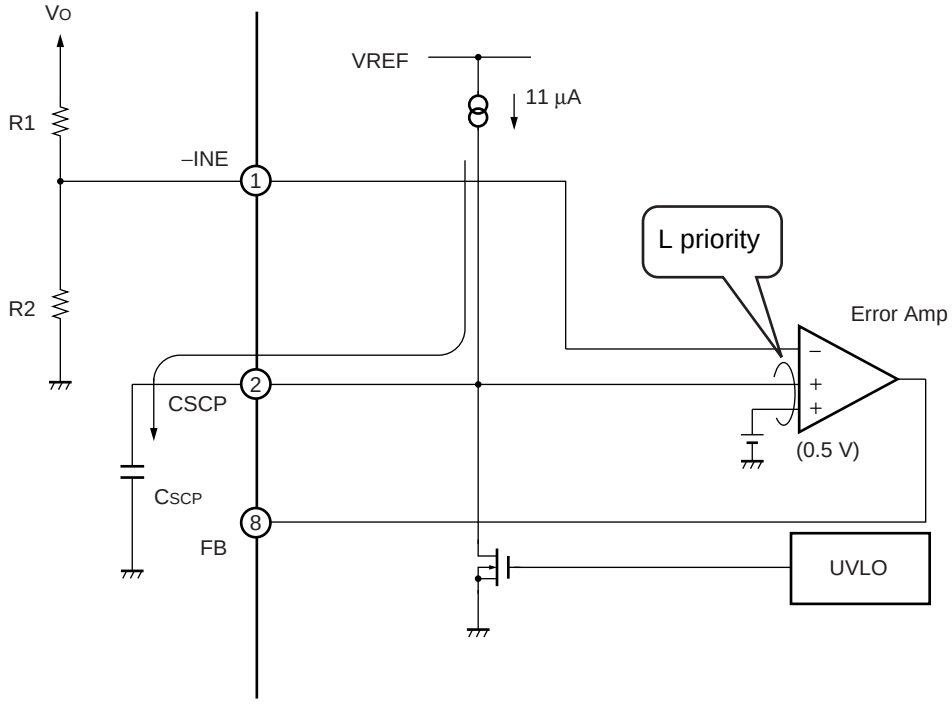
The soft-start time is obtained from the following formula:

Soft-start time: ts (time to output 100%)

ts (s) ≒ 0.045 × C_{SCP} (µF)



• Soft-Start Circuit

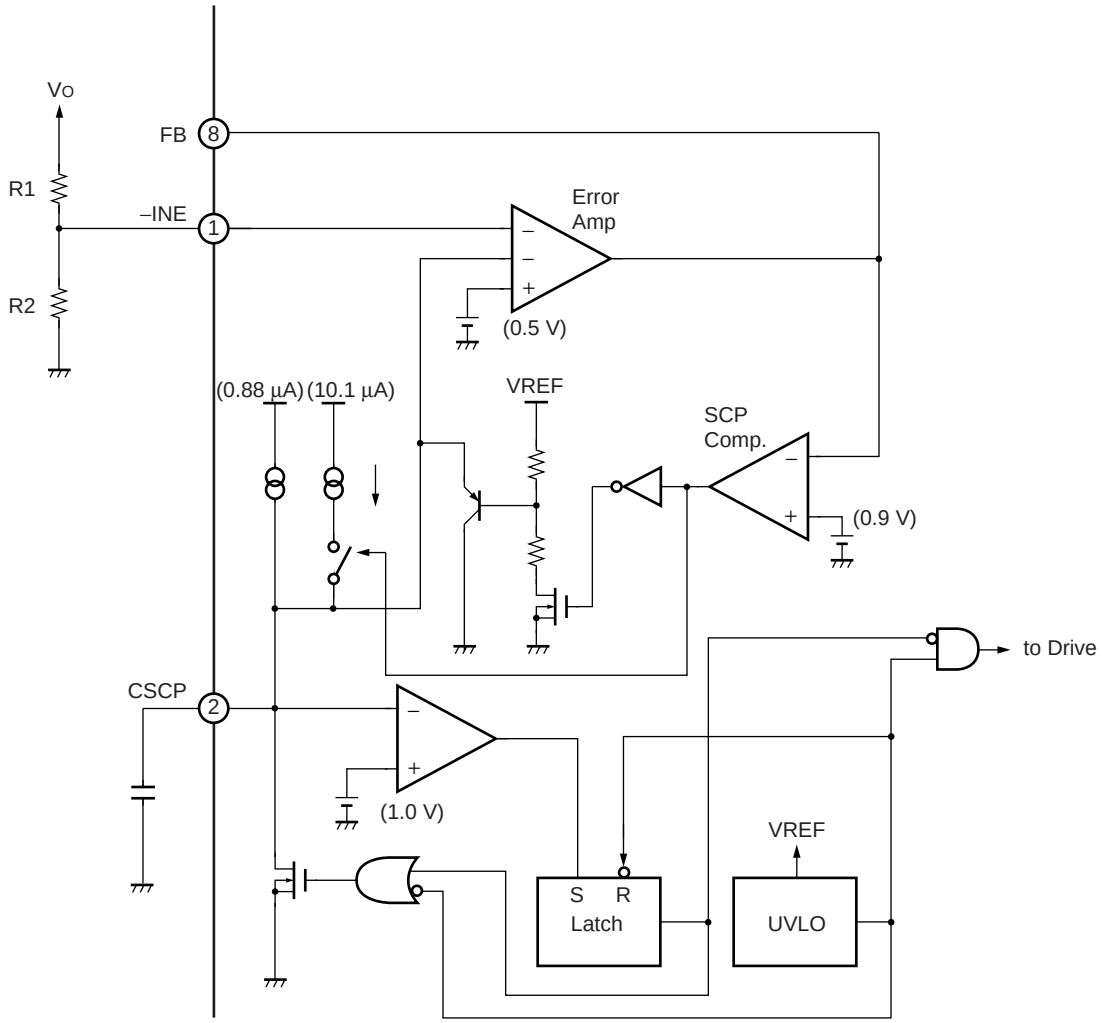


■ SETTING TIME CONSTANT FOR TIMER-LATCH SHORT-CIRCUIT PROTECTION CIRCUIT

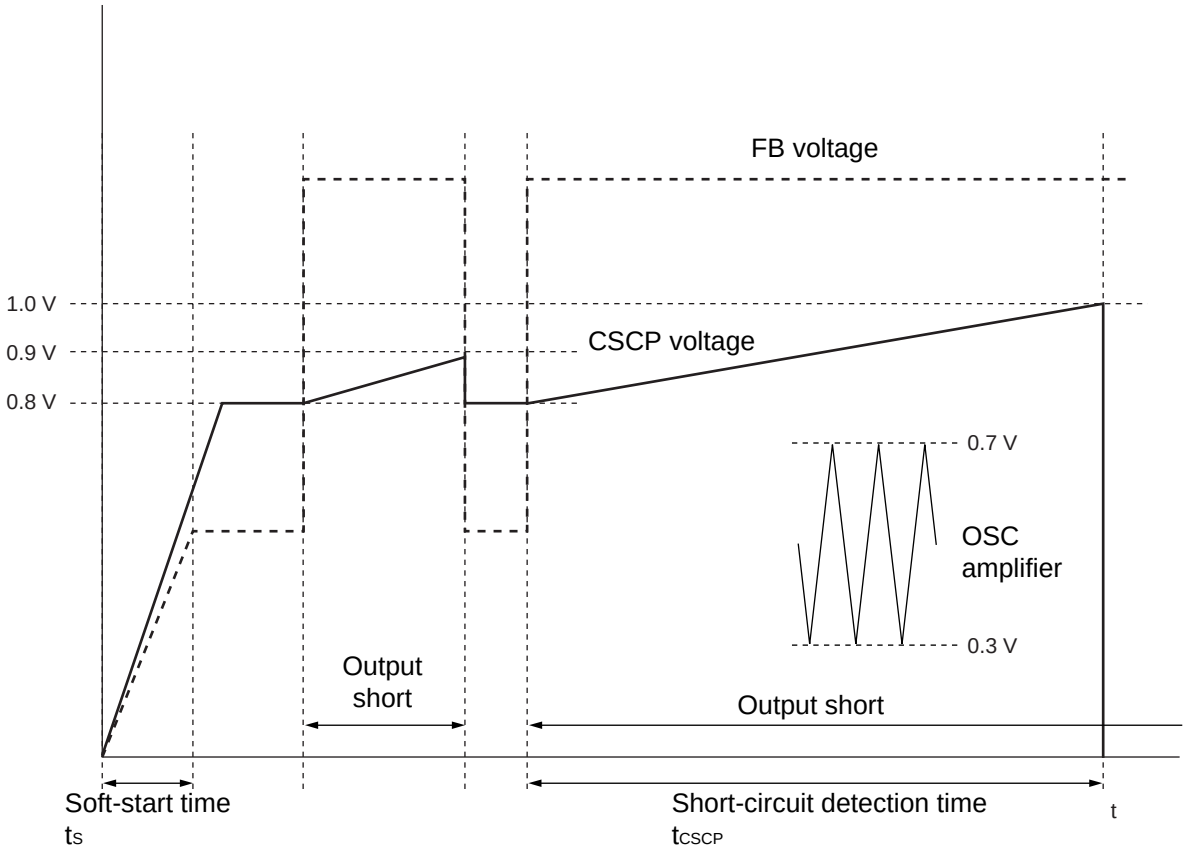
The error amplifier's output level alaways does the comparison operation with the short-circuit protection comparator (SCP Comp.) to the reference voltage.
While DC/DC converter load conditions are stable, the short-circuit detection comparator output remains stable, and the CSCP terminal (pin 2) is held at soft-start end voltage (about 0.8 V) .
If the load condition changes rapidly due to a short-circuit of the load and the DC/DC converter output voltage drops, the output of the error amplifier usually goes over 0.9 V. In that case, the capacitor C_{SCP} is charged further. When the capacitor C_{SCP} is charged to about 1.0 V, the latch is set and the external FET is turned off (dead time is set to 100%). At this time, the latch input is closed and the CSCP terminal (pin 2) is held at "L" level. When CSCP terminal becomes "L" level, SCPOD terminal Nch MOS FET becomes OFF. SCPOD terminal (pin 4) is held at "L" level and can be used as a short-circuit operating detection signal during normal operation.
To reset the actuated protection circuit, the power supply turn off and on again to lower the VCC terminal (pin 3) voltage to 1.1 V (Min) or less.
Short-circuit detection time (t_{CSCP})

t_{CSCP} (s) ≒ 0.23 × C_{SCP} (μF)

• Timer-latch short-circuit protection circuit

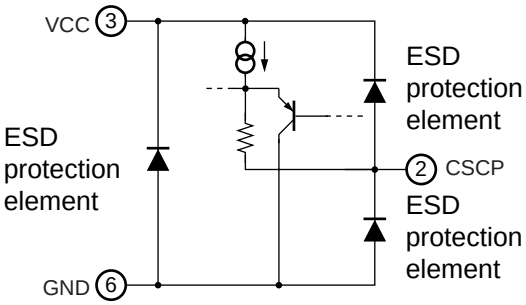


• **Soft-start and short-circuit protection circuit timing chart**

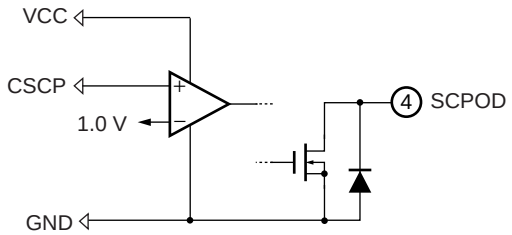


■ I/O EQUIVALENT CIRCUIT

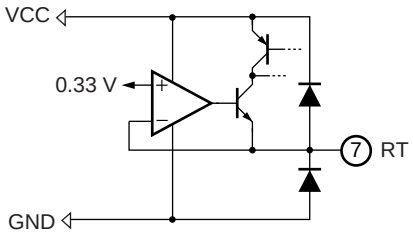
⟨⟨Soft-start block (CS) ⟩⟩



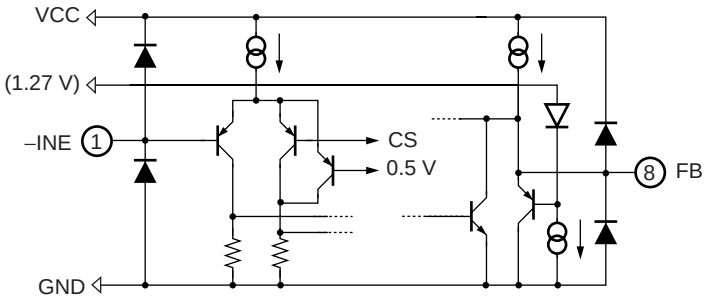
⟨⟨Short-circuit protection circuit block (SCP) ⟩⟩



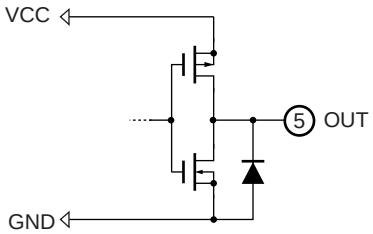
⟨⟨Triangular wave oscillator block (RT) ⟩⟩



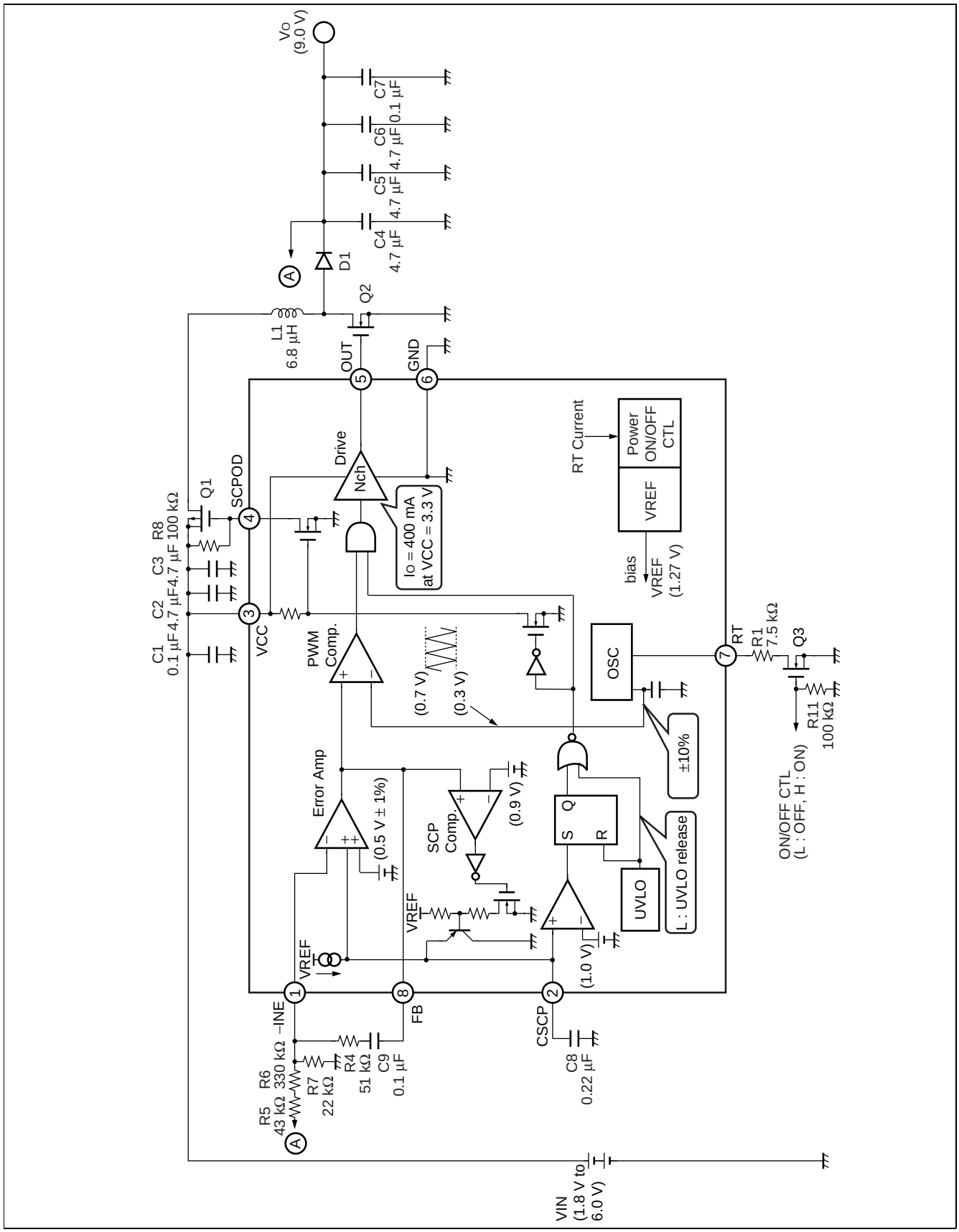
⟨⟨Error amplifier block⟩⟩



⟨⟨Output block⟩⟩



■ APPLICATION EXAMPLE



■ PARTS LIST

COMPONENT	ITEM	SPECIFICATION		VENDOR	PARTS No.
Q1	Pch FET	VDS = 20 V, ID = –2 A (Max)		SANYO	MCH3306
Q2, Q3	Nch FET	VDS = 20 V, Qg = 4.5 nC (Typ)		SANYO	MCH3405
D1	Diode	VF = 0.40 V (Max) , at IF = 1 A		SANYO	SBS004
L1	Inductor	6.8 µH	1.4 A, 144 mΩ	SUMIDA	CMD5D13-6R8
C1, C7, C9	Ceramics Condenser	0.1 µF	50 V	TDK	C1608JB1H104K
C2 to C6	NeoCapacitor	4.7 µF	10 V	NEC/TOKIN	TEPSLA21A475M8R
C8	Ceramics Condenser	0.22 µF	10 V	TDK	C1608JB1A224K
R1	Resistor	7.5 kΩ	0.5 %	ssm	RR0816P-752-D
R4	Resistor	51 kΩ	0.5 %	ssm	RR0816P-513-D
R5	Resistor	43 kΩ	0.5 %	ssm	RR0816P-433-D
R6	Resistor	330 kΩ	0.5 %	ssm	RR0816P-334-D
R7	Resistor	22 kΩ	0.5 %	ssm	RR0816P-223-D
R8, R11	Resistor	100 kΩ	0.5 %	ssm	RR0816P-104-D

Note : SANYO : SANYO Electric Co., Ltd.
SUMIDA : SUMIDA Electric Co., Ltd.
TDK : TDK Corporation
NEC/TOKIN : NEC TOKIN Corporation
ssm : SUSUMU Co., Ltd.

■ SELECTION OF COMPONENTS

• Nch MOS FET

The N-ch MOSFET for switching use should be rated for at least 20% more than the maximum output voltage. To minimize continuity loss, use a FET with low $R_{DS(ON)}$ between the drain and source. For high output voltage and high frequency operation, on/off-cycle switching loss will be higher so that power dissipation must be considered. In this application, the SANYO MCH3405 is used. Continuity loss, on/off switching loss, and total loss are determined by the following formulas. The selection must ensure that peak drain current does not exceed rated values.

Continuity loss : P_C

$$P_C = I_D{}^2 \times R_{DS(ON)} \times \text{Duty}$$

On-cycle switching loss : $P_{S\,(ON)}$

$$P_{S\,(ON)} = \frac{V_{D\,(Max)} \times I_D \times tr \times f_{OSC}}{6}$$

Off-cycle switching loss : $P_{S\,(OFF)}$

$$P_{S\,(OFF)} = \frac{V_{D\,(Max)} \times I_{D\,(Max)} \times tf \times f_{OSC}}{6}$$

Total loss : P_T

$$P_T = P_C + P_{S\,(ON)} + P_{S\,(OFF)}$$

Example: Using the SANYO MCH3405

Input voltage $V_{IN\,(Max)}$ = 2.4 V, output voltage V_O = 9 V, drain current I_D = 0.94 A, Oscillation frequency f_{OSC} = 500 kHz, L = 6.8 µH, drain-source on resistance $R_{DS\,(ON)}$ ≒ 160 mΩ, tr = 18 ns, tf = 8 ns.

Drain current (Max) : $I_{D\,(Max)}$

$$I_{D\,(Max)} = \frac{V_O \times I_O}{V_{IN(Min)}} + \frac{V_{IN(Min)}}{2L} \text{ton} \qquad \text{ton} = \frac{V_O - V_{IN(Min)}}{V_O} t$$

$$= \frac{9 \times 0.25}{2.4} + \frac{2.4 \times (9-2.4)}{2 \times 6.8 \times 10^{-6} \times 9} \times \frac{1}{500 \times 10^3}$$

$$\fallingdotseq \underline{1.20\ (A)}$$

Drain current (Min) : $I_{D\,(Min)}$

$$I_{D\,(Min)} = \frac{V_O \times I_O}{V_{IN(Min)}} - \frac{V_{IN(Min)}}{2L} \text{ton}$$

$$= \frac{9 \times 0.25}{2.4} - \frac{2.4 \times (9-2.4)}{2 \times 6.8 \times 10^{-6} \times 9} \times \frac{1}{500 \times 10^3}$$

$$\fallingdotseq \underline{0.68\ (A)}$$

$$P_C = I_D{}^2 \times R_{DS\,(ON)} \times \text{Duty}$$
$$= 0.94^2 \times 0.16 \times \frac{9-2.4}{9}$$
$$\fallingdotseq \underline{0.104\ \text{W}}$$

$$P_{S\,(ON)} = \frac{V_{D\,(Max)} \times I_D \times tr \times f_{OSC}}{6}$$
$$= \frac{9 \times 0.94 \times 18 \times 10^{-9} \times 500 \times 10^3}{6}$$
$$\fallingdotseq \underline{0.013\ \text{W}}$$

$$P_{S\,(OFF)} = \frac{V_{D\,(Max)} \times I_{D\,(Max)} \times tf \times f_{OSC}}{6}$$
$$= \frac{9 \times 1.20 \times 8 \times 10^{-9} \times 500 \times 10^3}{6}$$
$$\fallingdotseq \underline{0.007\ \text{W}}$$

$$P_T = P_C + P_{S\,(ON)} + P_{S\,(OFF)}$$
$$\fallingdotseq 0.104 + 0.013 + 0.007$$
$$\fallingdotseq \underline{0.124\ \text{W}}$$

The above power dissipation figures for the MCH3405 is satisfied with ample margin at 0.8 W.

• Inductors

In selecting inductors, it is of course essential not to apply more current than the rated capacity of the inductor, but also to note that the lower limit for ripple current is a critical point that if reached will cause discontinuous operation and a considerable drop in efficiency. This can be prevented by choosing a higher inductance value, which will enable continuous operation under light loads. Note that if the inductance value is too high, however, direct current resistance (DCR) is increased and this will also reduce efficiency. The inductance must be set at the point where efficiency is greatest.
Note also that the DC superimposition characteristics become worse as the load current value approaches the rated current value of the inductor, so that the inductance value is reduced and ripple current increases, causing loss of efficiency. The selection of rated current value and inductance value will vary depending on where the point of peak efficiency lies with respect to load current.
Inductance values are determined by the following formulas.

Inductance value : L

$$L \geq \frac{V_{IN}^2}{2 I_O V_O} \text{ton}$$

Example:

$$L \geq \frac{V_{IN\,(Max)}{}^2}{2I_OV_O} ton$$

$$\geq \frac{4^2}{2 \times 0.25 \times 9} \times \frac{9-4}{9} \times \frac{1}{500 \times 10^3}$$

$$\geq \underline{3.95\ \mu H}$$

Inductance values derived from the above formulas are values that provide sufficient margin for continuous operation at maximum load current, but at which continuous operation is not possible at light loads. It is therefore necessary to determine the load level at which continuous operation becomes possible. In this application, the Sumida CMD5D13-6R8 is used. At 6.8 µH, the load current value under continuous operating conditions is determined by the following formula.

Load current value under continuous operating conditions : I_O

$$I_O \geq \frac{V_{IN\,(Max)}{}^2}{2LV_O} ton$$

$$\geq \frac{4^2}{2 \times 6.8 \times 10^{-6} \times 9} \times \frac{9-4}{9} \times \frac{1}{500 \times 10^3}$$

$$\geq \underline{145.2\ mA}$$

To determine whether the current through the inductor is within rated values, it is necessary to determine the peak value of the ripple current as well as the peak-to-peak values of the ripple current that affect the output ripple voltage. The peak value and peak-to-peak value of the ripple current can be determined by the following formulas.

Peak value : I_L

$$I_L \geq \frac{V_O \times I_O}{V_{IN}} + \frac{V_{IN}}{2L} ton \qquad ton = \frac{V_O - V_{IN}}{V_O} t$$

Peak-to-peak value : ΔI_L

$$\Delta I_L = \frac{V_{IN}}{L} ton$$

Example: Using the CMD5D13-6R8

6.8 µH (allowable tolerance ±20%) , rated current = 1.4 A

Peak value:

$$I_L \geq \frac{V_O \times I_O}{V_{IN}} + \frac{V_{IN}}{2L} ton \qquad ton = \frac{V_O - V_{IN}}{V_O} t$$

$$\geq \frac{9 \times 0.25}{2.4} + \frac{2.4 \times (9 - 2.4)}{2 \times 6.8 \times 10^{-6} \times 9} \times \frac{1}{500 \times 10^3}$$

$$\geq \underline{1.20\ A}$$

Peak-to-peak value:

$$\Delta I_L = \frac{V_{IN\,(Min)}}{L} ton$$

$$= \frac{4 \times (9 - 4)}{6.8 \times 10^{-6} \times 9} \times \frac{1}{500 \times 10^3}$$

$$\fallingdotseq \underline{0.654\ A}$$

• Flyback diode

The flyback diode is generally used as a Shottky barrier diode (SBD) when the reverse voltage to the diode is less than 40V. The SBD has the characteristics of higher speed in terms of faster reverse recovery time, and lower forward voltage, and is ideal for achieving high efficiency. As long as the DC reverse voltage is sufficiently higher than the output voltage, the average current flowing through the diode is within the mean output current level, and peak current is within peak surge current limits, there is no problem. In this application the SANYO SBS004 is used. The diode mean current and diode peak current can be calculated by the following formulas.

Diode mean current : I_{Di}

$$I_{Di} \geq I_O \times \left(1 - \frac{V_O - V_{IN\,(Min)}}{V_O}\right)$$

Diode peak current : I_{Dip}

$$I_{Dip} \geq \frac{V_O \times I_O}{V_{IN\,(Min)}} + \frac{V_{IN\,(Min)}}{2L} ton$$

Example: Using the SANYO SBS004

VR (DC reverse voltage) = 15 V, mean output current = 1.0 A, peak surge current = 10 A,
VF (forward voltage) = 0.40 V, IF = 1.0 A

$$I_{Di} \geq I_O \times \left(1 - \frac{V_O - V_{IN\,(Min)}}{V_O}\right)$$

$$\geq 0.25 \times (1 - 0.733)$$

$$\geq \underline{66.8\ mA}$$

$$I_{Dip} \geq \frac{V_O \times I_O}{V_{IN\,(Min)}} + \frac{V_{IN\,(Min)}}{2L} ton$$

$$\geq \underline{1.20\ A}$$

• Smoothing Capacitor

The smoothing capacitor is an indispensable element for reducing ripple voltage in output. In selecting a smoothing capacitor it is essential to consider equivalent series resistance (ESR) and allowable ripple current. Higher ESR means higher ripple voltage, so that to reduce ripple voltage it is necessary to select a capacitor with low ESR. However, the use of a capacitor with low ESR can have substantial effects on loop phase characteristics, and therefore requires attention to system stability. Care should also be taken to use a capacity with sufficient margin for allowable ripple current. This application uses the TEPSLA21A475M8R (NEC/TOKIN) . The ESR, capacitance value, and ripple current can be calculated from the following formulas.

Equivalent Series Resistance : ESR

$$ESR \leq \frac{\Delta V_O}{\Delta I_L} - \frac{1}{2\pi f C_L}$$

Capacitance value : C_L

$$C_L \geq \frac{\Delta I_L}{2\pi f (\Delta V_O - \Delta I_L \times ESR)}$$

Ripple current : ΔIC_L

$$\Delta IC_L \geq \frac{V_{IN}}{L} ton$$

Example: Using the TEPSLA21A475M8R (Three piecies are parallel.)
Rated voltage = 10 V, ESR = 500 mΩ, maximum allowable ripple current = 1 A_{p-p}

Equivalent series resistance

$$ESR \leq \frac{\Delta V_O}{\Delta I_L} - \frac{1}{2\pi f C_L}$$

$$\leq \frac{0.18}{0.654} - \frac{1}{2\pi \times 500 \times 10^3 \times 14.1 \times 10^{-6}}$$

$$\leq \underline{252.7\ m\Omega}$$

Capacitance value : C_L

$$C_L \geq \frac{\Delta I_L}{2\pi f (\Delta V_O - \Delta I_L \times ESR)}$$

$$\geq \frac{0.39}{2\pi \times 500 \times 10^3 \times (0.18 - 0.654 \times 0.167)}$$

$$\geq \underline{2.94\ \mu F}$$

Ripple current : ΔIC_L

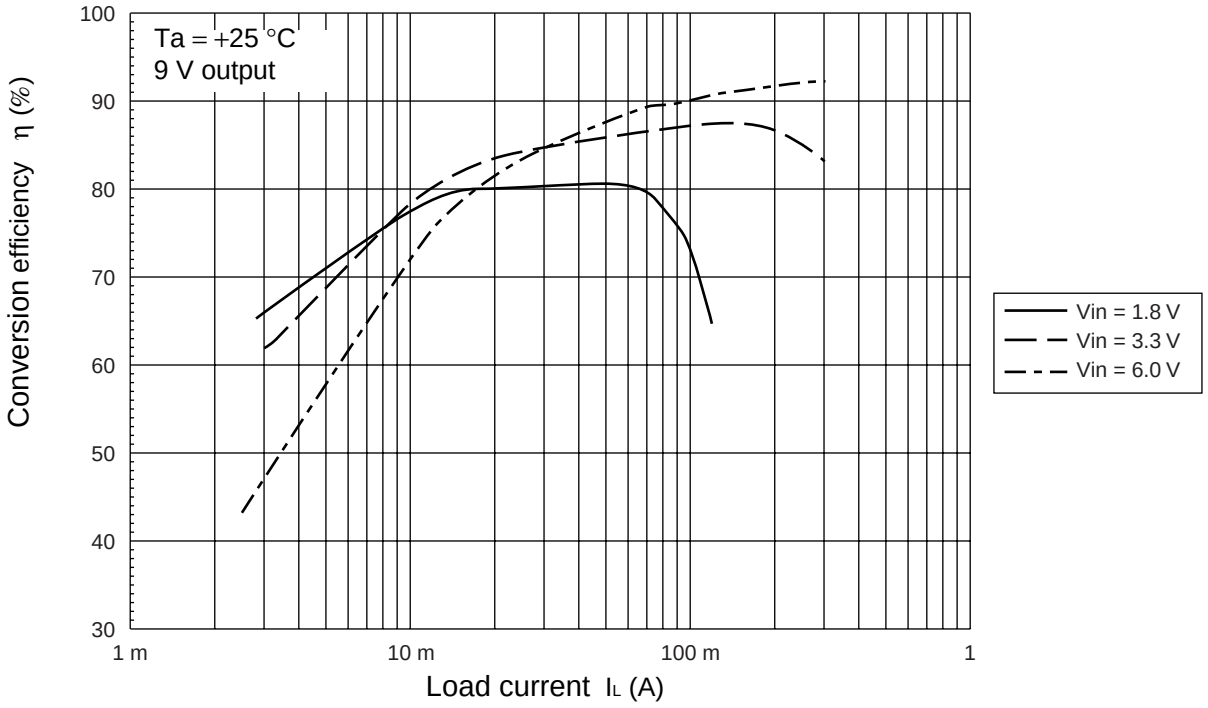
$$\Delta IC_L \geq \frac{V_{IN}}{L} ton$$

$$\geq \frac{4 \times (9 - 4)}{6.8 \times 10^{-6} \times 9} \times \frac{1}{500 \times 10^3}$$

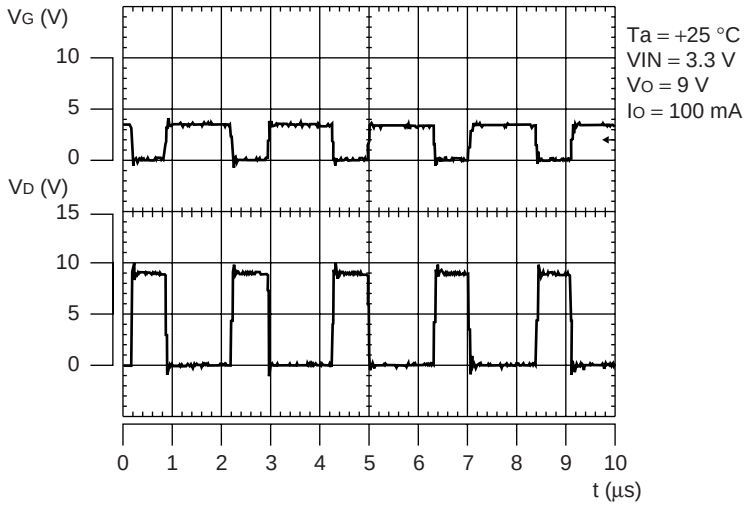
$$\geq \underline{0.654\ A_{p-p}}$$

■ REFERENCE DATA

Conversion Efficiency vs. Load current



Switching Wave Form



■ USAGE PRECAUTION

- **Printed circuit board ground lines should be set up with consideration for common impedance.**

- **Take appropriate static electricity measures.**
  - Containers for semiconductor materials should have anti-static protection or be made of conductive material.
  - After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
  - Work platforms, tools, and instruments should be properly grounded.
  - Working personnel should be grounded with resistance of 250 kΩ to 1 MΩ between body and ground.

- **Do not apply negative voltages.**

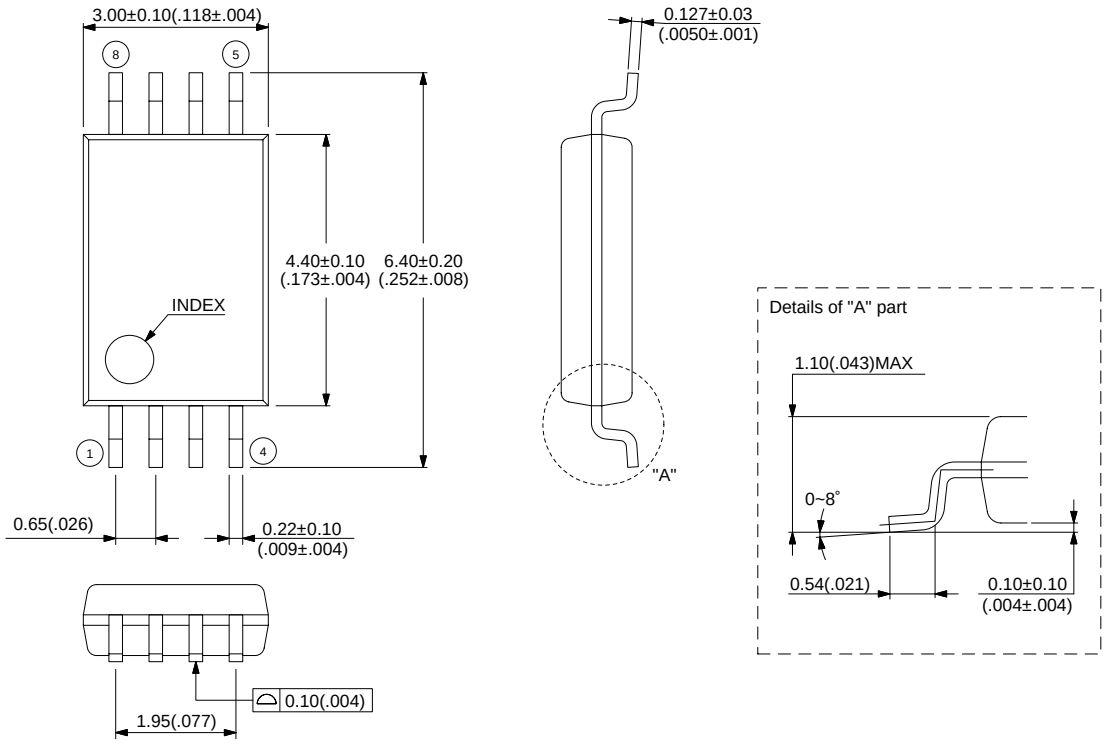
  The use of negative voltages below –0.3 V may create parasitic transistors on LSI lines, which can cause abnormal operation.

■ ORDERING INFORMATION

Part number	Package	Remarks
MB39A105PFT	8-pin plastic TSSOP (FPT-8P-M05)	

■ PACKAGE DIMENSION

8-pin plastic TSSOP
(FPT-8P-M05)



Dimensions in mm (inches)

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