FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-27221-4E

ASSP For Power Supply Applications

With Power Mode Switching Function

2-ch DC/DC Converter IC With Synchronous Rectifier

MB3821

■ DESCRIPTION

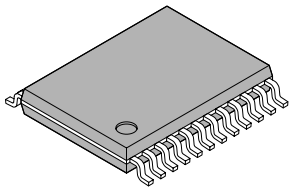
The MB3821 is a pulse width modulation (PWM) type 2-channel DC/DC converter IC with synchronous rectification designed for low voltage, high efficiency operation in high precision and high frequency applications, ideal for down conversion.
A normal/low-power mode selection is provided, ideal for an internal power supply (3.3V, 5V) in applications with substantial load current variation, such as notebook computers.
This product is covered by US Patent Number 6,147,477.

■ FEATURES

- Synchronous rectification
- High efficiency : 93 % (normal power mode, VIN = 6 V, load 1 A)
  : 84 % (low power mode, VIN = 6 V, load 20 mA)
- Built-in power mode selector circuit
- Reference voltage accuracy : 2.5V ± 2 %
- Built-in error amp input control type soft-start circuit
- Totem pole type output for N-ch MOSFET applications
- Built-in timer-latch type short protection circuit

■ PACKAGE

24-pin, Plastic SSOP



(FPT-24P-M03)

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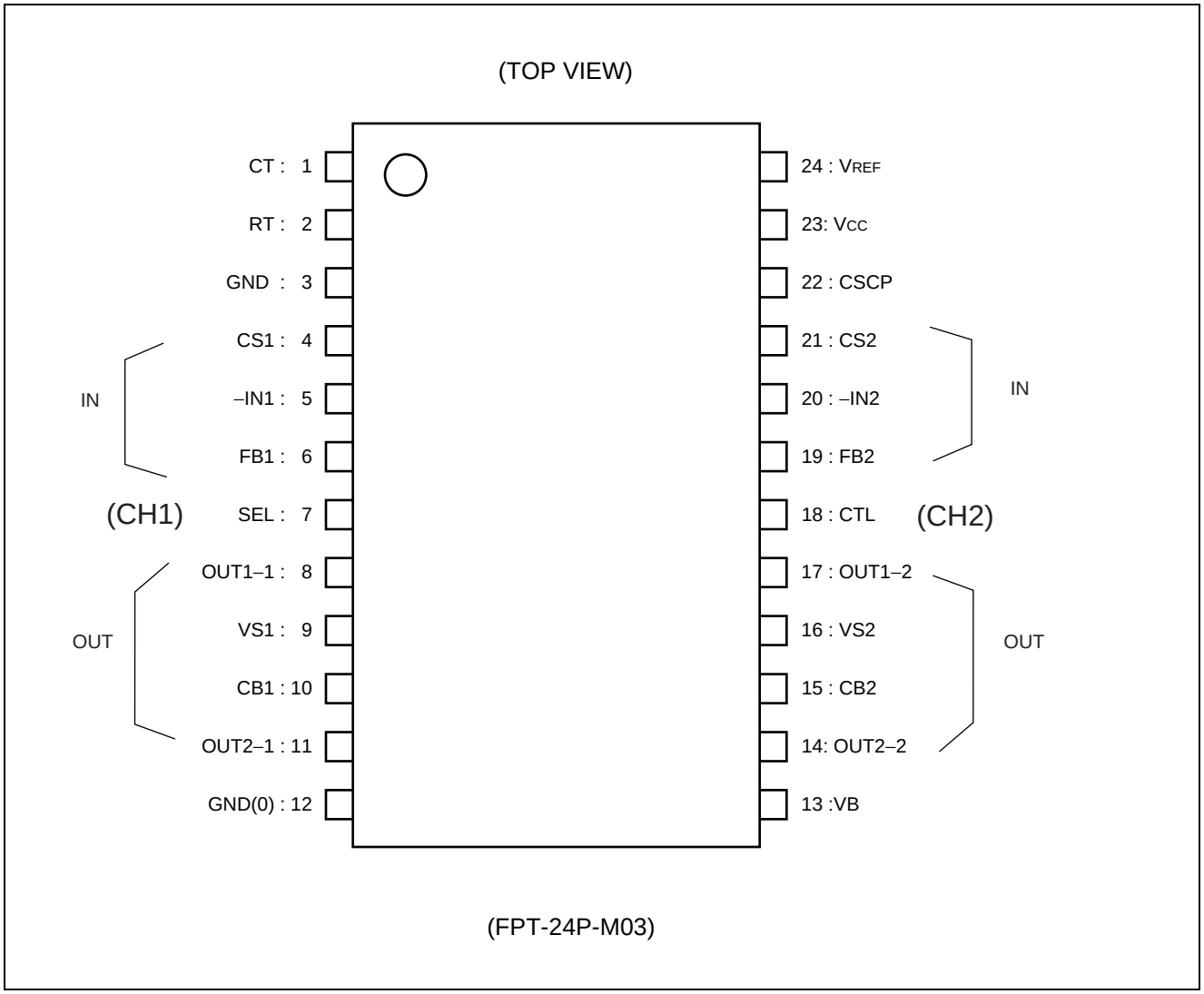
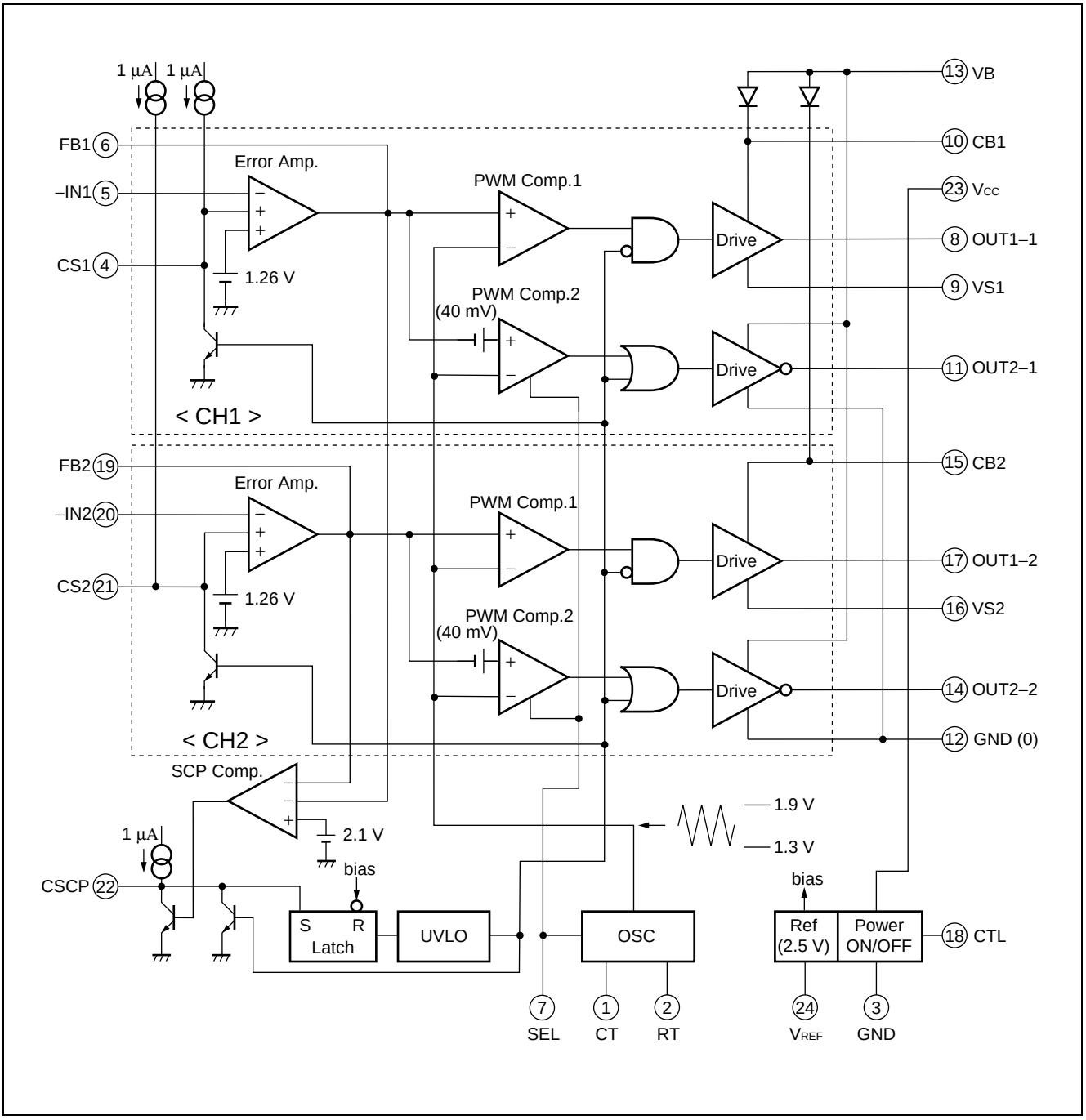
■ PIN ASSIGNMENT



■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Descriptions
1	CT	—	Triangular wave oscillator frequency setting capacitance connection pin.
2	RT	—	Triangular wave oscillator frequency setting resistance connection pin.
3	GND	—	Ground pin.
4	CS1	—	Capacitor connection pin for Channel 1 soft-start (also channel control).
5	–IN1	I	Channel 1 error amplifier inverted input pin.
6	FB1	O	Channel 1 error amplifier output pin
7	SEL	I	Mode select pin. Set the SEL pin to “H” level to switch the IC to low power mode.
8	OUT1-1	I	Totem pole type output pin (external main side FET gate drive).
9	VS1	—	Channel 1 external main side FET source connection pin.
10	CB1	—	Channel 1 boot capacitance connection pin.
11	OUT2-1	O	Channel 1 totem pole output pin (external main side FET gate drive).
12	GND(0)	—	Ground pin for output circuit.
13	VB	—	Power supply pin for output circuit.
14	OUT2-2	O	Channel 2 totem pole output pin (external synchronous rectifier side FET gate drive).
15	CB2	—	Channel 2 boot capacitance connection pin.
16	VS2	—	Channel 2 external main side FET source connection pin.
17	OUT1-2	O	Channel 2 totem pole output pin (external main side FET gate drive).
18	CTL	I	Power supply control pin. Set CTL pin to “L” to switch the IC to standby mode.
19	FB2	O	Channel 2 error amplifier output pin.
20	–IN2	I	Channel 2 error amplifier inverted input pin.
21	CS2	—	Channel 2 soft-start capacitance connection pin(also channel control).
22	CSCP	—	Timer-latch short circuit protection capacitance connection pin.
23	V_{CC}	—	Reference power supply, control circuit power supply pin.
24	V_{REF}	O	Reference voltage output pin.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RAGINGS

Parameter	Symbol	Conditions	Rating		Unit
			Min	Max	
Power supply voltage	V_{CC}	—	—	32	V
Bias voltage	V_B	—	—	17	V
Output current	Io	—	—	50	mA
Output peak current	Io	Duty ≤ 5 %	—	500	mA
Power dissipation	P_D	Ta ≤ +25°C	—	740*	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	Conditions	Value			Unit
			Min	Typ	Max	
Power supply voltage	V_{CC}	—	4.5	16	30	V
Bias voltage	V_B	—	—	6	16	V
Reference voltage output current	I_{OR}	—	–1	—	0	mA
Input voltage	V_{IN}	-IN pin	0	—	V_{CC} – 1.8	V
		SEL, CTL pin	0	—	30	V
Output current	I_O	OUT pin	–30	—	30	mA
Output peak current	Io	Duty ≤ 5 %	–300	—	300	mA
Timing capacitance	C_T	—	150	500	15000	pF
Timing resistance	R_T	—	6.8	10	12	kΩ
Oscillator frequency	f_{OSC}	SEL = 0 V (Normal mode)	10	200	500	kHz
		SEL = 5 V (Low power mode)	1	20	50	kHz
Soft-start capacitance	C_S	—	—	0.1	1.0	µF
Short detection capacitance	C_{SCP}	—	—	0.01	1.0	µF
Boot capacitance	C_B	—	—	0.1	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

(V_{CC} = 16 V, SEL =0 V, Ta = +25°C)

Parameter		Symbol	Pin No.	Conditions		Value			Unit
						Min	Typ	Max	
Reference voltage block	Output voltage	V_{REF}	24	V_{REF} =0 mA		2.45	2.50	2.55	V
	Output voltage temperature variation	$\Delta V_{REF}/V_{REF}$	24	Ta = –30°C to +85°C		—	0.5*	—	%
	Input stability	Line	24	V_{CC} = 4.5 V to 30 V		—	—	15	mV
	Load stability	Load	24	V_{REF} = 0 mA to –1.0 mA		—	—	15	mV
	Short-circuit output current	I_{OS}	24	V_{REF} = 1 V		–60	–25	—	mA
Under voltage lockout protection circuit block(U.V.L.O.)	Threshold voltage	V_{TH}	4,21	V_{CC} = ⌐		3.2	3.5	3.8	V
	Hysteresis width	V_H	4,21	—		—	0.18	—	V
	Reset voltage	V_{RST}	4,21	—		2.4	2.8	—	V
Soft-start block	Charge current	I_{CS}	4,21	—		–1.4	–1.0	–0.6	µA
	Input standby voltage	V_{STB}	4,21	—		—	50	100	mV
Short circuit detection block	Threshold voltage	V_{TH}	4,21	—		0.63	0.68	0.73	V
	Input source current	I_{CSCP}	22	—		–1.4	–1.0	–0.6	µA
	Short detection time	t_{SCP}	22	C_{SCP} = 0.01 µF		4.5	6.8	12.2	ms
	Input standby voltage	V_{STB}	22	—		—	50	100	mV
	Input latch voltage	V_I	22	—		—	50	100	mV
Triangular wave oscillator block	Oscillator frequency	f_{OSC}	8,11, 14,17	C_T = 500pF, R_T = 10 kΩ	SEL = 0 V	180	200	220	kHz
					SEL = 5 V	16	20	24	kHz
	Mode select voltage	V_{LOW}	7	Low power mode		2.0	—	—	V
		V_{HI}	7	Normal mode		—	—	1.0	V
	Input current	I_{SEL}	7	SEL = 5 V		—	50	80	µA
	Frequency stability for voltage	$\Delta f/fdv$	8,11, 14,17	C_T = 500pF, R_T = 10 kΩ, V_{CC} = 4.5V to 30V	SEL = 0 V	—	1	10	%
					SEL = 5 V	—	1	10	%
	Frequency stability for temperature	$\Delta f/fdt$	8,11, 14,17	C_T = 500pF, R_T = 10 kΩ, Ta = –30°C to +85°C	SEL = 0 V	—	1*	—	%
					SEL = 5 V	—	1*	—	%

*: Standard design value.

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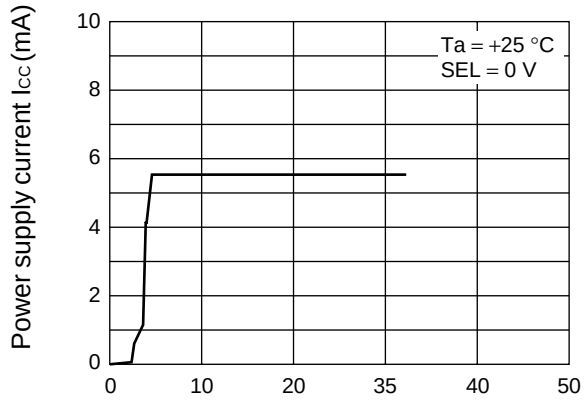
(V_{CC} = 16 V, SEL =0 V, Ta = +25°C)

Parameter		Symbol	Pin No.	Conditions		Value			Unit
						Min	Typ	Max	
Error amplifier block	Threshold voltage	V_{TH}	6,19	FB = 1.6 V		1.235	1.260	1.285	V
	V_T temperature stability	$\Delta V_T / V_T$	6,19	Ta = –30°C to +85°C		—	0.5*	—	%
	Input bias current	I_B	5,20	–IN = 0 V		–200	–50	—	nA
	Voltage gain	A_V	6,19	DC		60	100	—	dB
	Frequency bandwidth	BW	6,19	A_V = 0 dB		—	800*	—	kHz
	Output voltage	V_{OH}	6,19	—		V_{REF} – 0.3	—	—	V
		V_{OL}	6,19	—		—	0.8	1.0	V
	Output source current	I_{SOURCE}	6,19	FB = 1.6 V		—	–90	–45	µA
	Output sink current	I_{SINK}	6,19	FB = 1.6 V		1.5	6.0	—	mA
PWM Comp. block	Threshold voltage	V_{TL}	8,11 14,17	Duty cycle = 0 %		1.2	1.3	—	V
		V_{TH}		Duty cycle = Dtr		—	1.9	2.0	V
Dead time control block	Maximum duty cycle	Dtr	8,11, 14,17	C_T = 500 pF R_T = 10 kΩ	SEL = 0 V	85	90	95	%
					SEL = 5 V	89	94	99	%
Output block (Drive)	Output voltage (Main side)	V_{OH}	8,17	VS = 16 V CB = 22 V	I_O = –30 mA	CB – 1.4	CB – 1.1	—	V
		V_{OL}	8,17		I_O = 30 mA	—	VS + 1.1	VS + 1.4	V
	Output voltage (Synchronous rectifier side)	V_{OH}	11,14	I_O = –30 mA		VB – 1.4	VB – 1.1	—	V
		V_{OL}	11,14	I_O = 30 mA		—	0.1	0.5	V
	Diode voltage	V_{DIODE}	13	I_O = 10 mA		—	1.0	1.1	V
Control block	CTL input voltage	V_{IH}	18	IC active mode		2.0	—	—	V
		V_{IL}	18	IC standby mode		—	—	1.0	V
	Input current	I_{CTL}	18	CTL = 5 V		—	50	80	µA
General	Standby current	I_{CCS}	23	CTL = 0 V		—	—	10	µA
	Power supply current	I_{CC}	23	SEL = 0 V (Normal mode)		—	5.2	7.8	mA
			23	SEL = 5 V (Low power mode)		—	1.0	1.5	mA

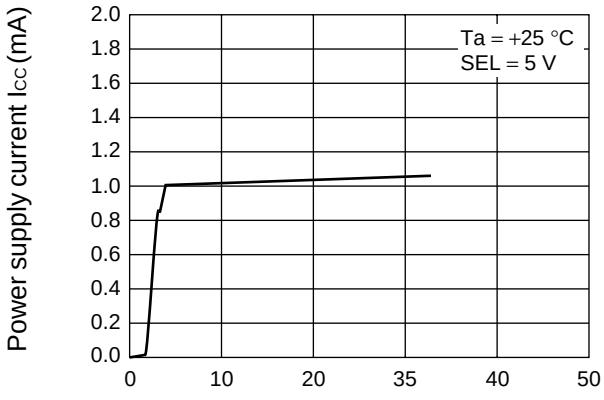
*: Standard design value.

■ TYPICAL CHARACTERISTICS

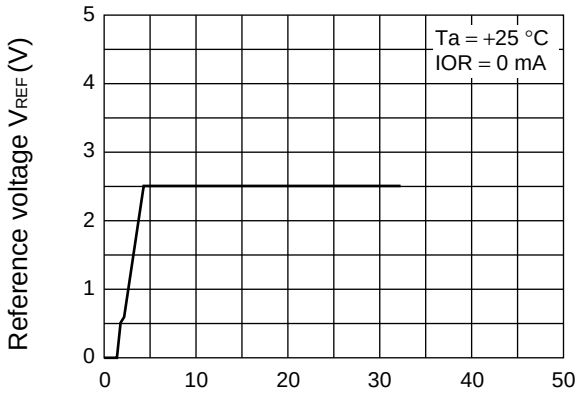
Power supply current vs. power supply voltage



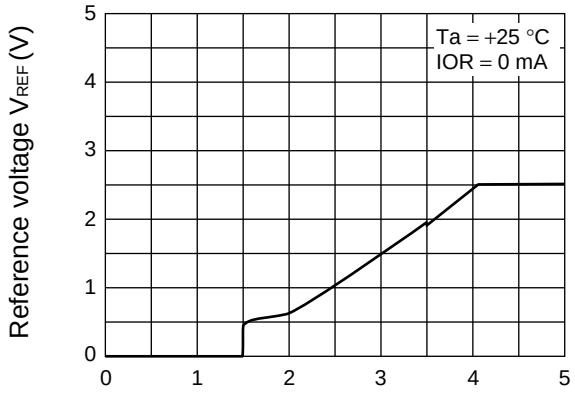
Power supply current vs. power supply voltage



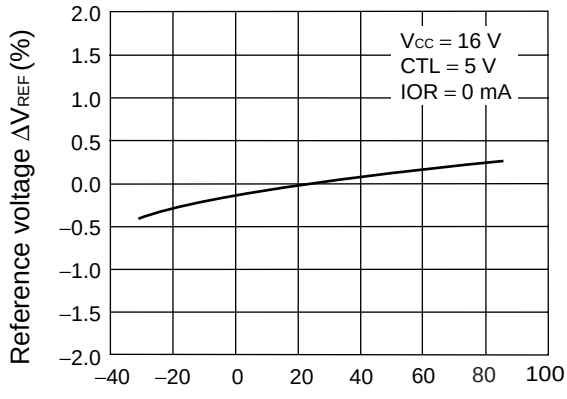
Reference voltage vs. power supply voltage



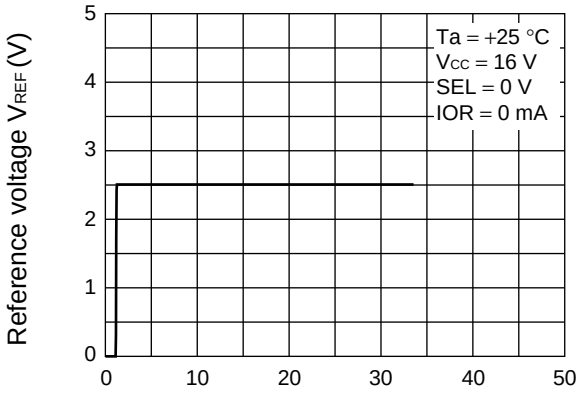
Reference voltage vs. power supply voltage



Reference voltage vs. ambient temperature



Reference voltage vs. control voltage



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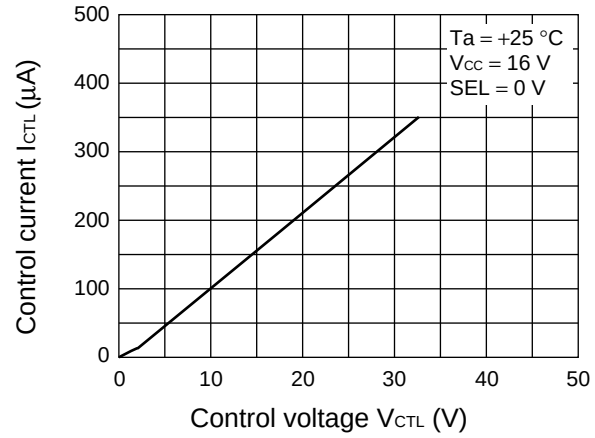
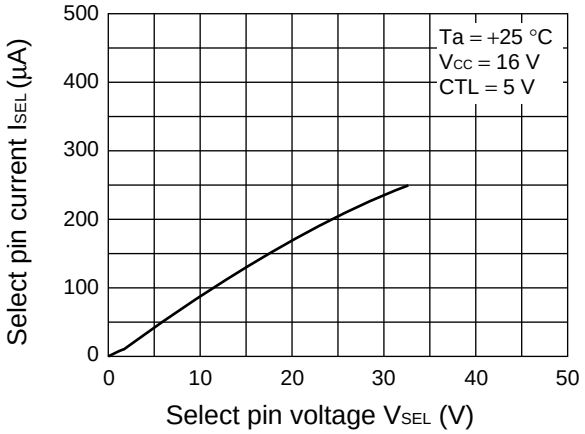
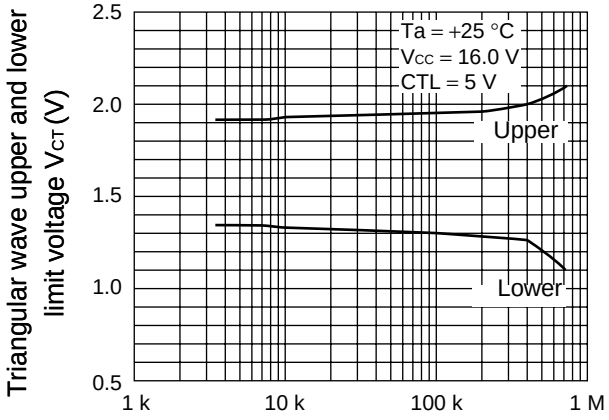
Control current vs. control voltage



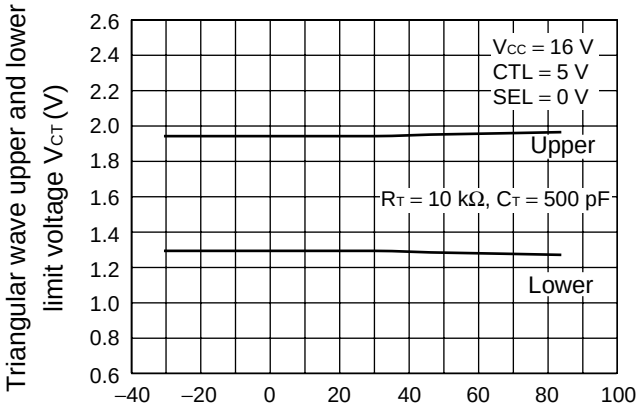
Select pin current vs. select pin voltage



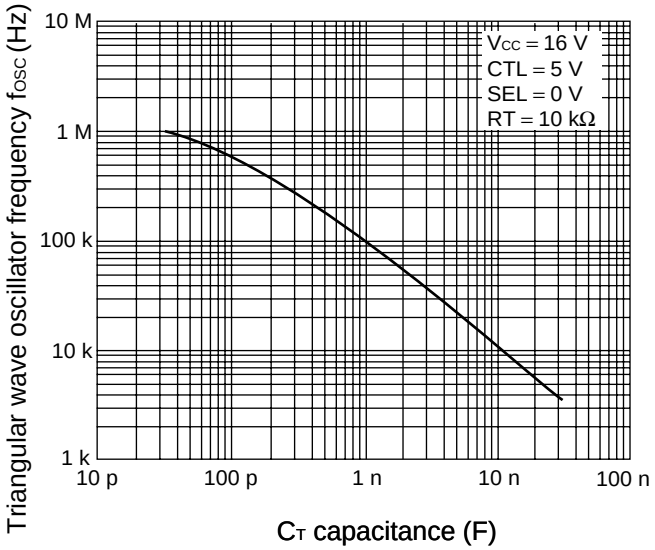
Triangular wave upper and lower limit voltage vs. triangular wave oscillator frequency



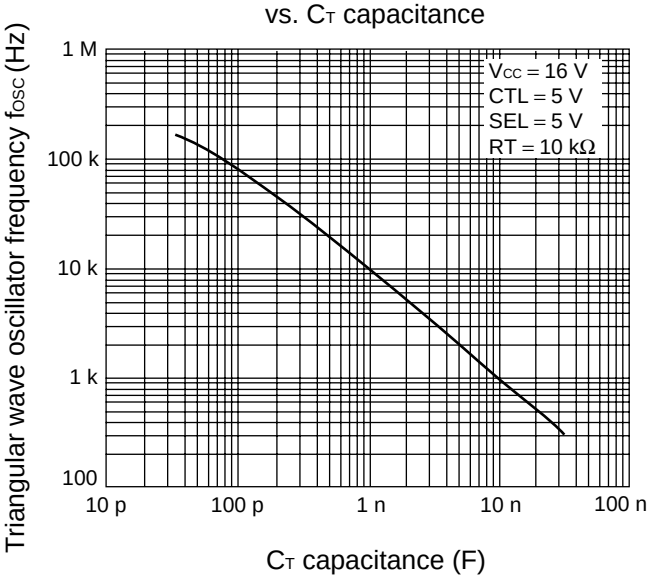
Triangular wave upper and lower limit voltage vs. ambient temperature



Triangular wave oscillator frequency vs. C_T capacitance



Triangular wave oscillator frequency vs. C_T capacitance



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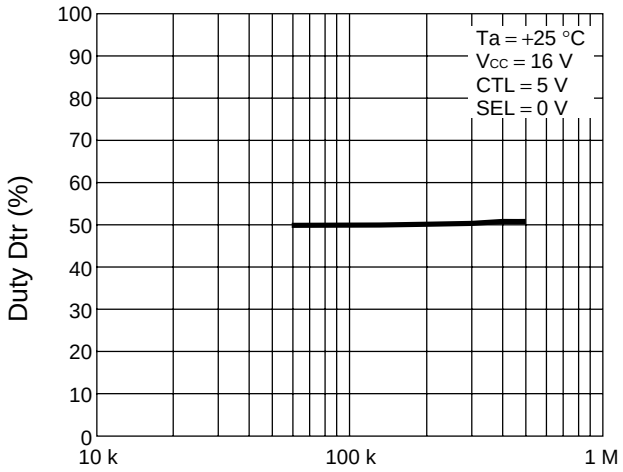
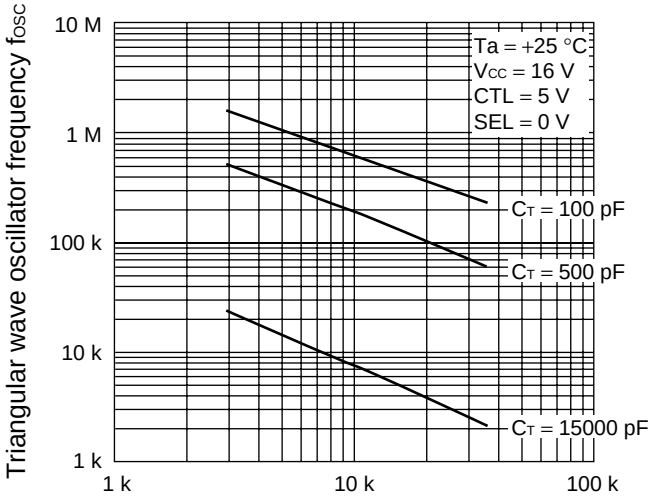
Duty vs. oscillator frequency (ch1)



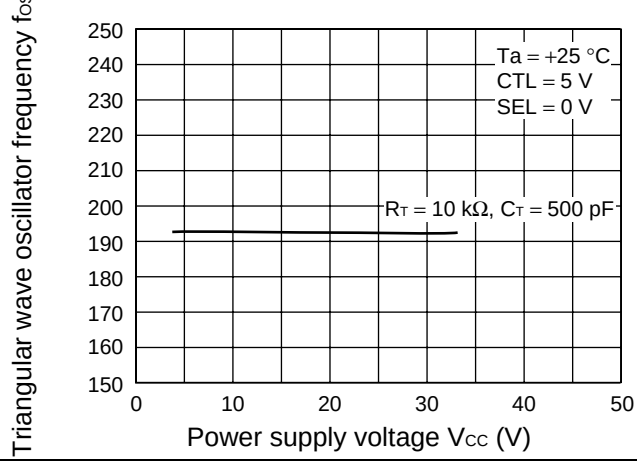
Oscillator frequency f_{OSC} (Hz)

Triangular wave oscillator frequency vs. timing resistance

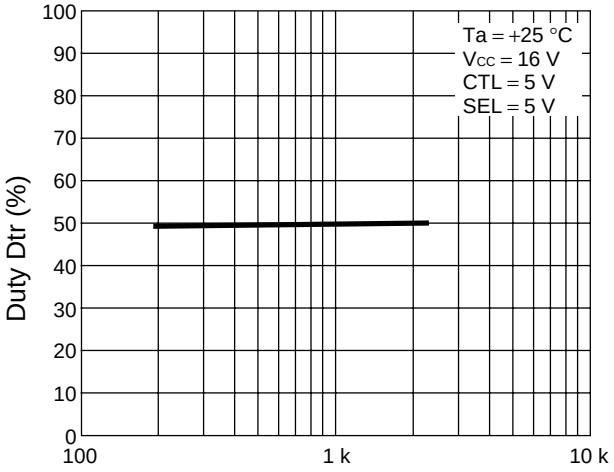


Timing resistance R_T (Ω)

Triangular wave oscillator frequency vs. power supply voltage

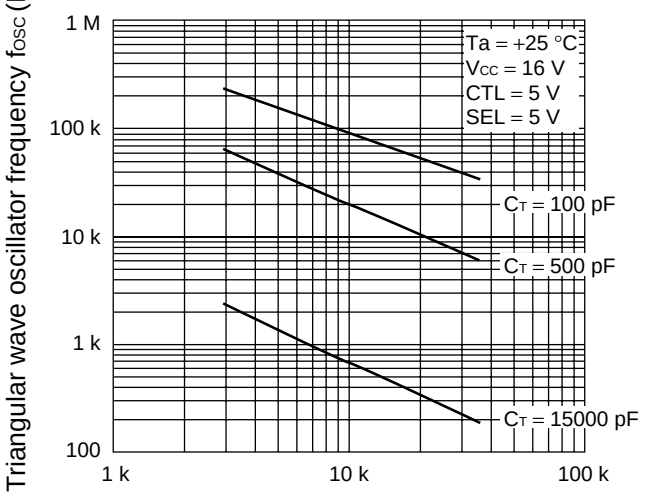


Duty vs. oscillator frequency (ch1)



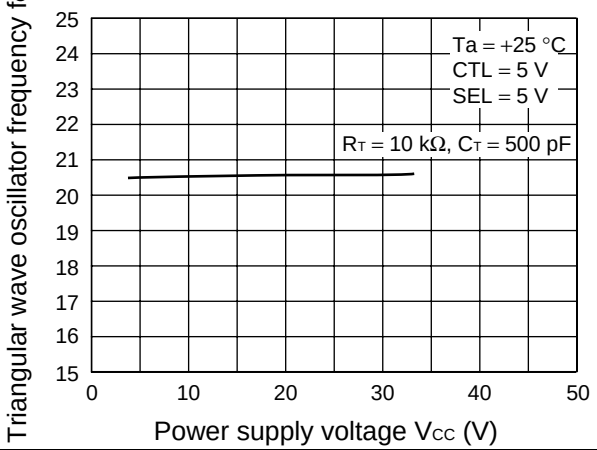
Oscillator frequency f_{OSC} (Hz)

Triangular wave oscillator frequency vs. timing resistance



Timing resistance R_T (Ω)

Triangular wave oscillator frequency vs. power supply voltage



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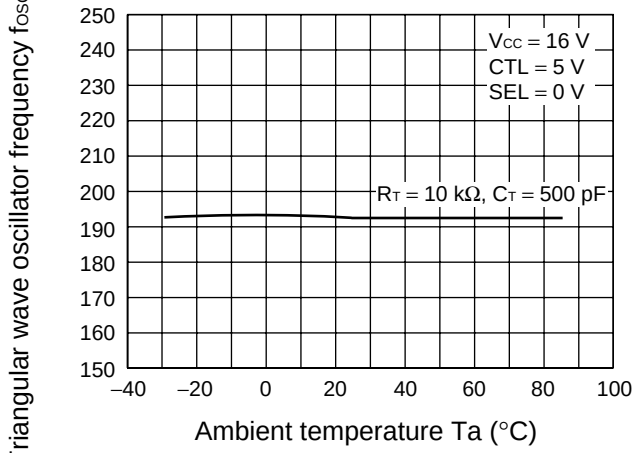
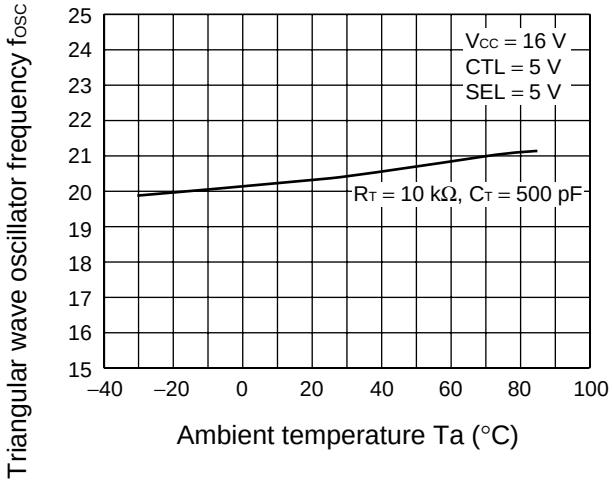
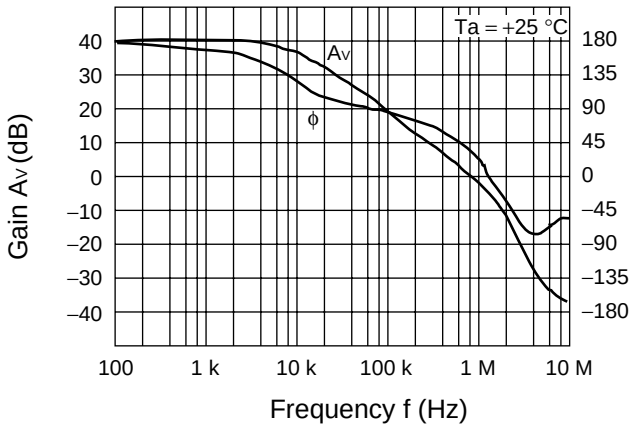
Triangular wave oscillator frequency vs. ambient temperature

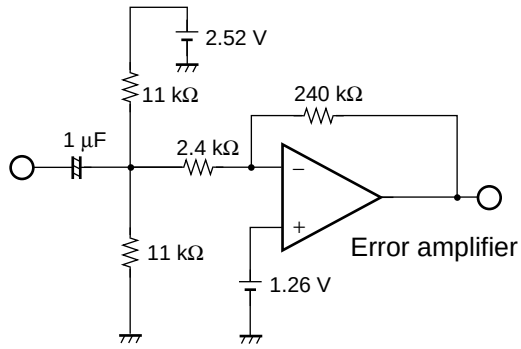


Triangular wave oscillator frequency vs. ambient temperature

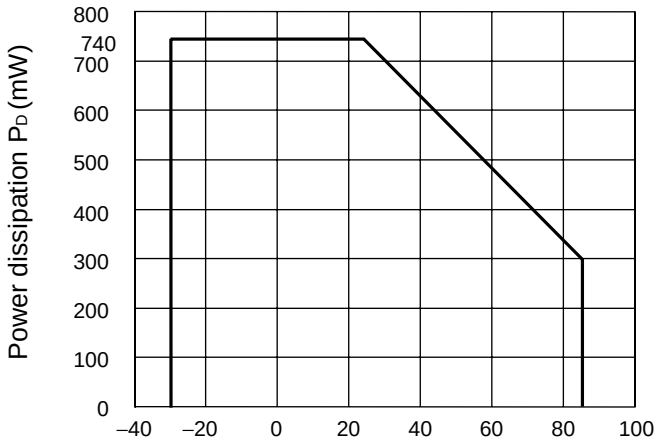


Error amplifier,gain and phase vs. frequency (ch1)





Power dissipation vs. ambient temperature



■ FUNCTIONAL DESCRIPTION

1. DC/DC Converter Function

(1) Reference voltage circuit (Ref)

The reference voltage circuit generates a temperature-compensated reference voltage (≅ 2.50 V) using the voltage supplied from the power supply terminal (pin 23). This voltage is used as the reference voltage for the internal circuits of the IC. The reference voltage can also be supplied to an external device from the V_{REF} terminal (pin 24) up to a maximum current of 1mA.

(2) Triangular-wave oscillator circuit (OSC)

By connecting a frequency setting capacitor and a resistor to the C_T (pin 1) and the R_T (pin 2) terminals, it is possible to generate any desired triangular oscillation waveform.
The triangular wave is input to the PWM comparator within the IC.

(3) Error amplifier

This amplifier detects the output voltage of the DC/DC converter and outputs a PWM control signal accordingly. The system can be provided with stable phase compensation by connecting a feedback resistor and capacitor between the FB pin and the -IN pin of the error amplifier to create the desired level of loop gain.
Also, by connecting soft-start capacitance to the CS terminal, which is the non inverted input pin for the error amplifier, it is possible to prevent current surges when the power supply is started. By using the error amplifier for soft-start detection, it is possible to operate with a fixed soft-start interval independent of the output load on the DC/DC converter.

(4) PWM comparators (PWM Comp.1, PWM Comp.2)

PWM Comp.1 and PWM Comp.2 are voltage-pulse width modulators that control the output duty according to input voltage.
PWM Comp.1 controls the pulse width on the main side output circuit, and PWM Comp.2 controls the pulse width on the synchronous rectifier side output circuit. The triangular wave generated by the triangular wave oscillator is compared to the error amplifier output voltage, and in the intervals when the error amplifier voltage is higher than the triangular wave, the main side output transistor is switched on and the synchronous rectifier side output transistor is switched off.
Also, PWM Comp.1 is set to a maximum duty cycle of approximately 90 % (normal mode).

(5) Output circuit (Drive)

The output circuits is comprised of a totem-pole configuration on both the main side and synchronous rectifier side, and can drive an external N-ch MOSFET.

(6) Mode select circuit (SEL)

The SEL terminal (pin 7) can set either channel to normal mode or low power mode.
In low power mode the triangular oscillator frequency is set to approximately 1/10 of normal mode, reducing the internal power consumption of the chip and enabling high efficiency power supply at light load levels.

(7) Power supply control circuit (CTL)

The CTL terminal (pin 18) is used for power supply on/off control (standby power consumption is 10 μA or less).

2. Protection Functions

(1) Under Voltage Lockout Circuit (UVLO)

Power-on surge states or sudden drops in supply voltage can cause a control IC to operate abnormally, leading to destruction or damage to system elements. The under voltage lockout circuit detects the internal reference voltage level from the supply voltage, and shuts off the output transistors so that the inactive interval becomes 100%, holding the CSCP terminal (pin 22) voltage at “L” level.
Operation is restored as soon as the supply voltage exceeds the under voltage lockout circuit threshold voltage.

(2) Timer-Latch Short Circuit Protection Circuit (SCP)

This circuit detects the output voltage level from the error amplifier. When the error amplifier output voltage exceeds approximately 2.1V, a timer circuit is activated and charges the external capacitor at the CSCP terminal (pin 22). If the error amplifier output does not return to normal range before the capacitor voltage reaches approximately 0.7V, a latch circuit is activated and sets both the main and synchronous rectifier side output pins to “L” level. After the short protection circuit has been activated, it is reset by simply restarting the power supply. (See “METHOD OF SETTING TIME CONSTANT FOR TIMER LATCH SHORT-CIRCUIT PROTECTION CIRCUIT”.)

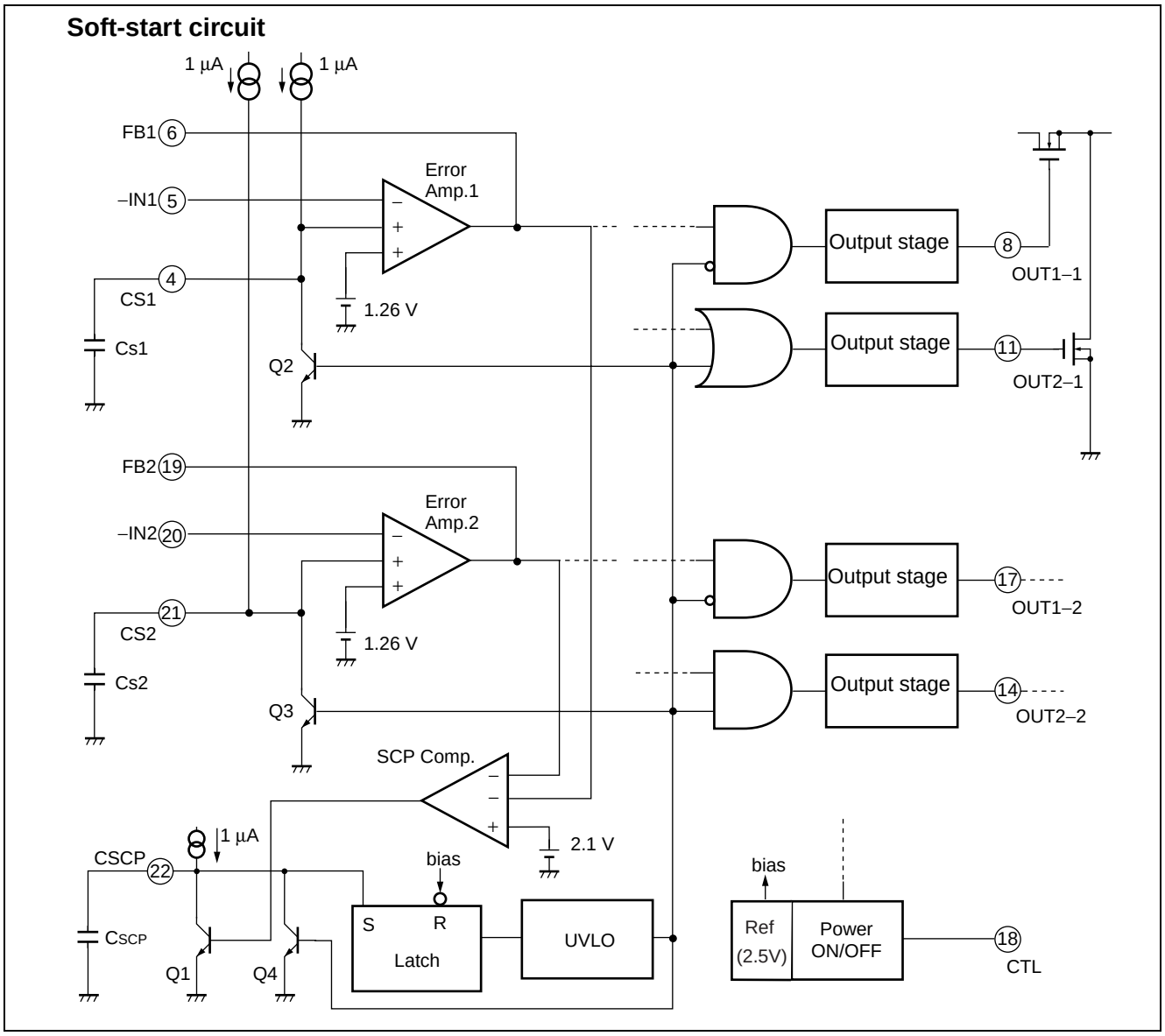
■ METHOD OF SETTING SOFT-START TIME

To provide a soft-start by preventing current surges at power-on, soft-start capacitors (Cs1, Cs2) are connected to both channels, the CS1 pin (pin 4) for CH1 and the CS2 pin (pin 21) for CH2.
When the IC is started (when the CTL pin (pin 18) goes to “H” level, and Vcc ≥ UVLO threshold voltage), transistors Q2 and Q3 switch off and the CS1 and CS2 pins begin charging the external soft-start capacitors (Cs1, Cs2) at 1 µA. The error amplifier contributes to a soft-start with the proportionate output voltage to the CS1 and CS2 pin voltage regardless of the load current on the DC/DC converter.
The soft-start time can be calculated by the following formula.

Soft-start time (time to 100% output)

$t_S(s) \fallingdotseq 1.26 \times C_S\ (\mu F)$

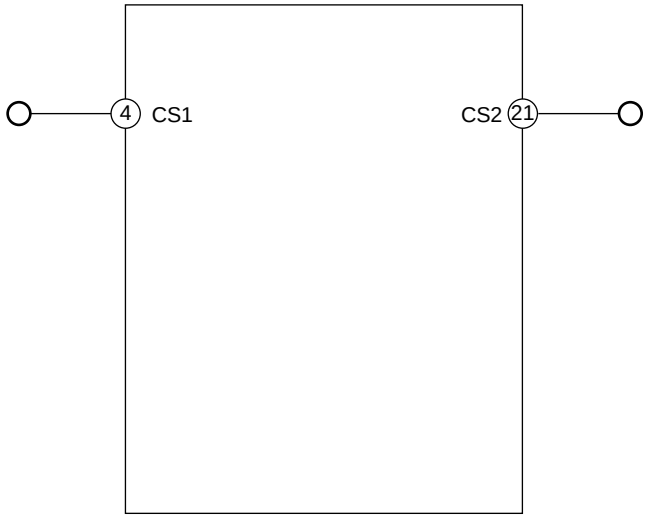
Soft-start circuit



■ TREATMENT WITHOUT USING CS TERMINAL

When you do not use the soft-start circuit, open the CS1 terminal (pin 4) and CS2 terminal (pin 21).

Treatment When Not Using SCP



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

The short detection comparator (SCP comparator) constantly compares the error amplifier output level to the reference voltage.

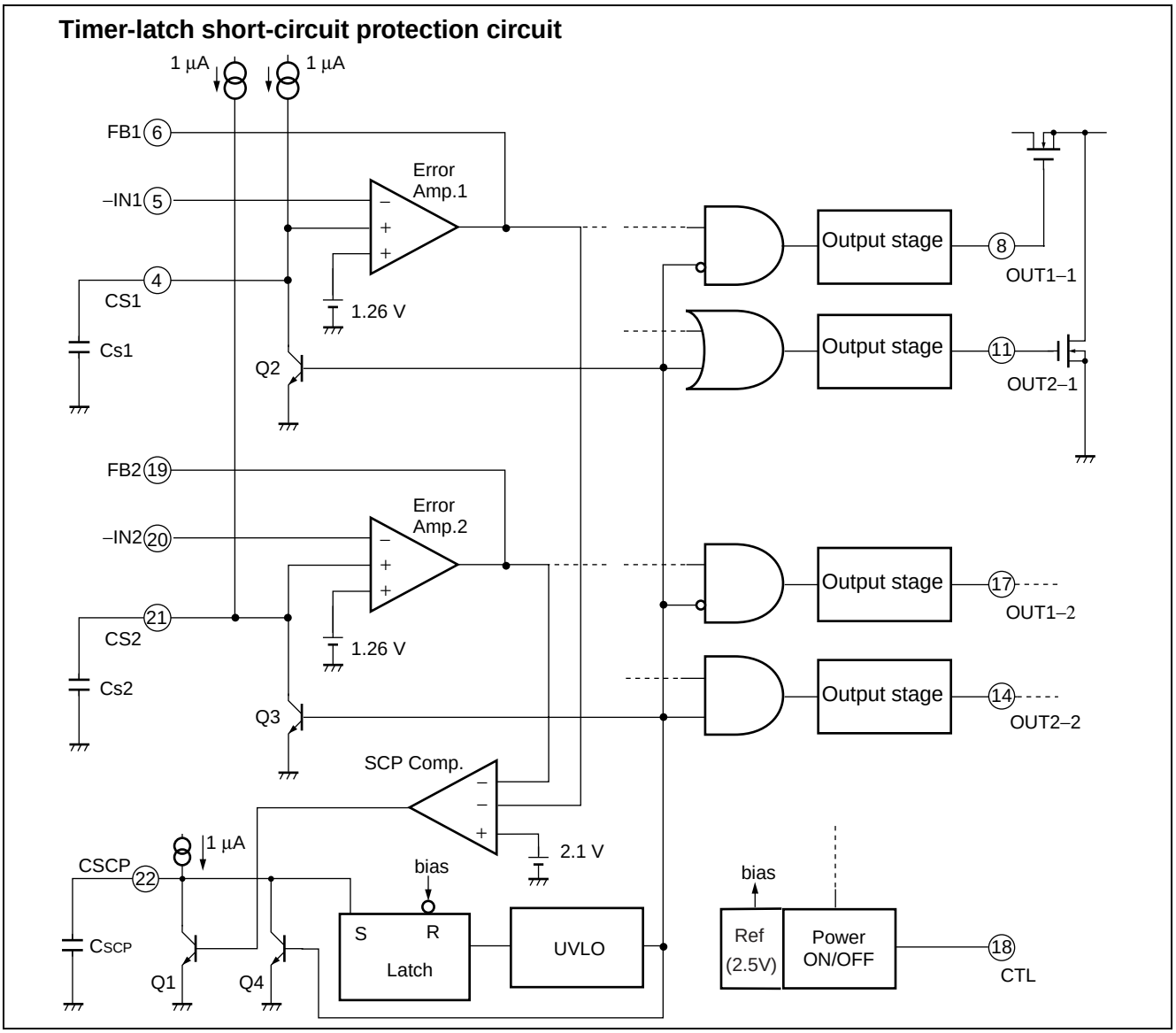
While the switching regulator load conditions are stable on all channels, the short detection comparator output remains at "H" level, transistor Q1 is on, and the CSCP terminal (pin 22) is held at input standby voltage ($V_{STB} \fallingdotseq 50$mV). If the load conditions change rapidly due to a short-circuiting of load, causing the output voltage to drop, the output from the short detection comparator goes to "L" level. This causes transistor Q1 to turn off and the external short protection capacitor C_{SCP} connected to the CSCP pin to charge at 1.0 μA.

Short Detection Time

$$t_{SCP}(s) \fallingdotseq 0.7 \times C_{SCP}\ (\mu F)$$

When the capacitor C_{SCP} is charged to the threshold voltage $V_{TH} \fallingdotseq 0.7$ V, the SR latch is set, and the external FET is turned off (inactive interval is set to 100%). At this point, the SR latch input is closed and the CSCP terminal is held at input latch voltage ($V_I \fallingdotseq 50$ mV).

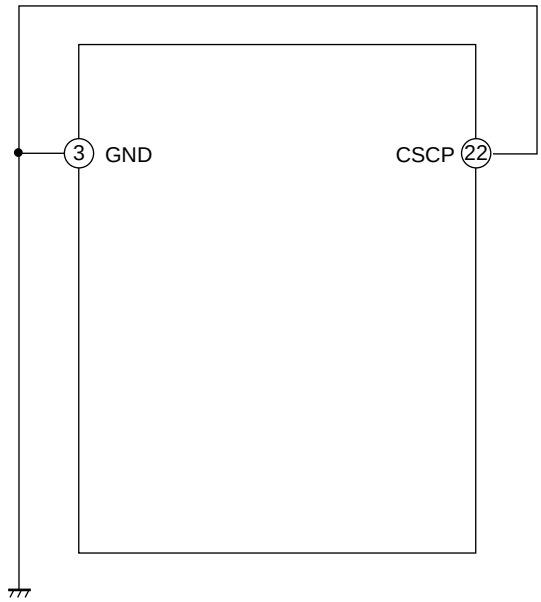
Timer-latch short-circuit protection circuit



■ TREATMENT WITHOUT USING CSCP TERMINAL

When you do not use the timer latch short-circuit protection circuit, connect the CSCP terminal (pin 22) to GND with the shortest distance.

Treatment When Not Using SCP



■ Channel Control Method

On/off controls for either channel are enabled by setting the CS pins.

Setting Conditions

CS pin setting		Channel output state	
CS1	CS2	CH1	CH2
GND	GND	OFF	OFF
GND	Open	OFF	ON
Open	GND	ON	OFF
Open	Open	ON	ON

■ METHOD OF SETTING OSCILLATOR FREQUENCY

Oscillator Frequency can be set by timing capacitor (C_T) connected to CT pin (pin 1) and timing resistor (R_T) connected to RT pin (pin 2).

Oscillator frequency

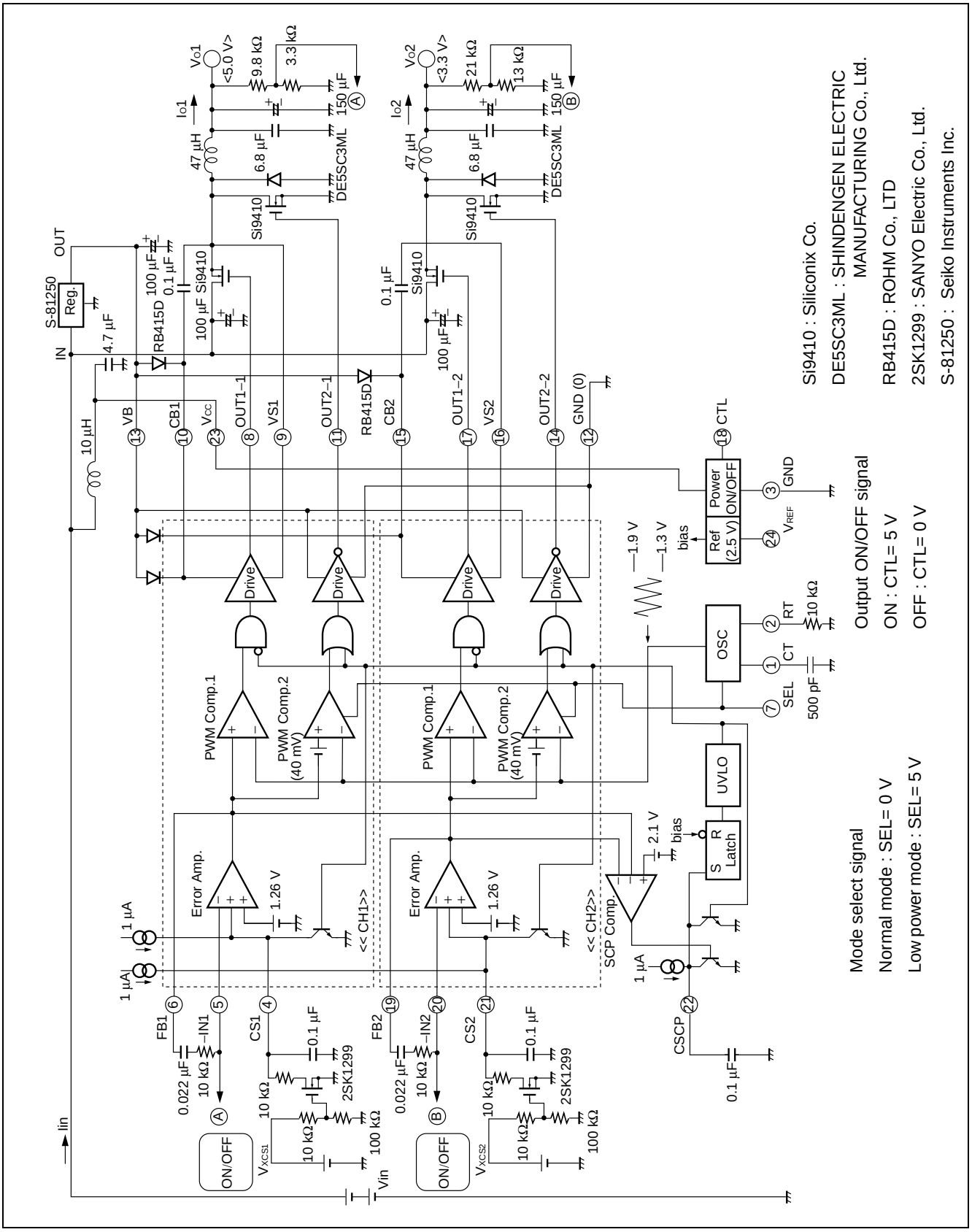
• Normal mode

$$f_{OSC}\ (kHz) \fallingdotseq \frac{1000000}{C_T(pF) \times R_T(k\Omega)}$$

• Low power mode

$$f_{OSC}\ (kHz) \fallingdotseq \frac{100000}{C_T(pF) \times R_T(k\Omega)}$$

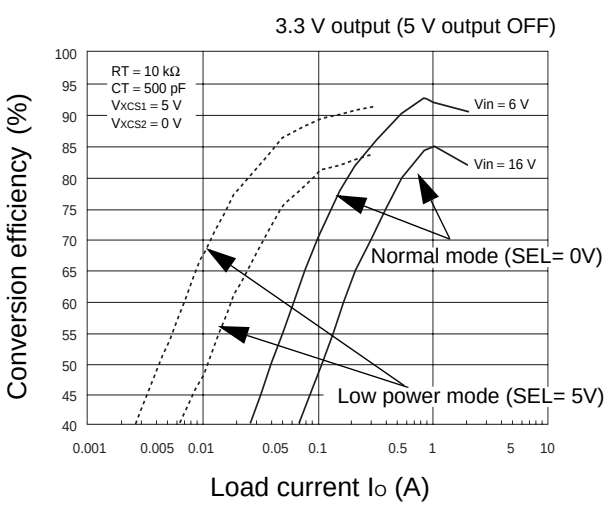
■ APPLICATION EXAMPLE



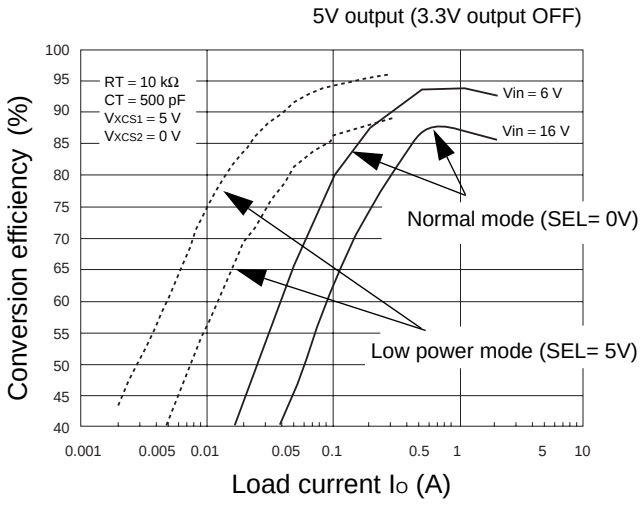
■ REFERENCE DATA

- **Load characteristic**

Conversion efficiency vs. load current

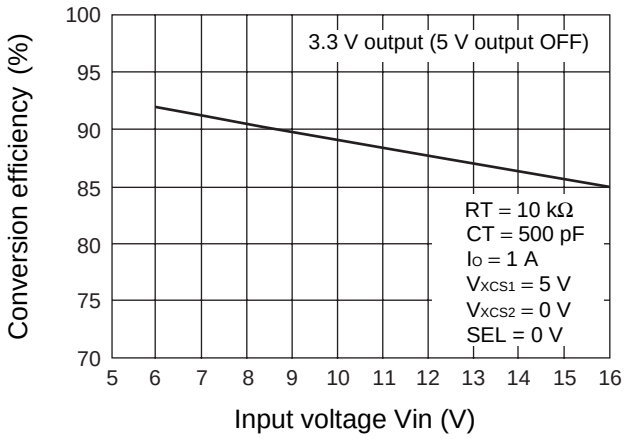


Conversion efficiency vs. load current

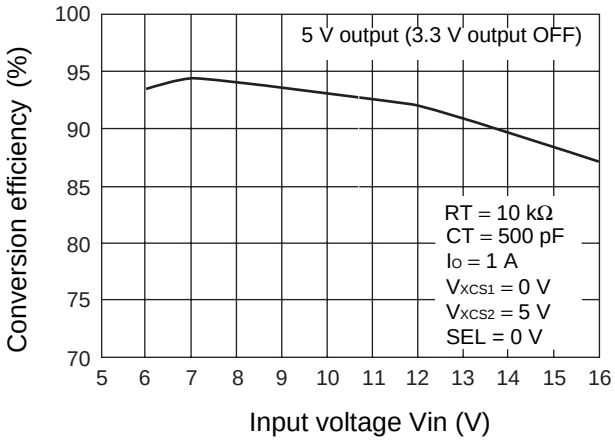


- **Normal mode**

Conversion efficiency vs. Input voltage



Conversion efficiency vs. Input voltage



(Continued)

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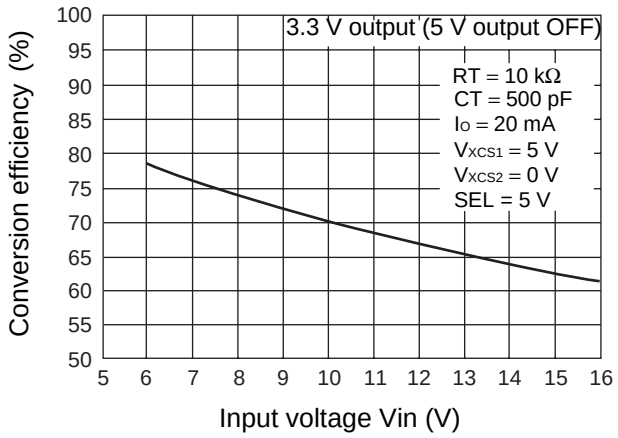
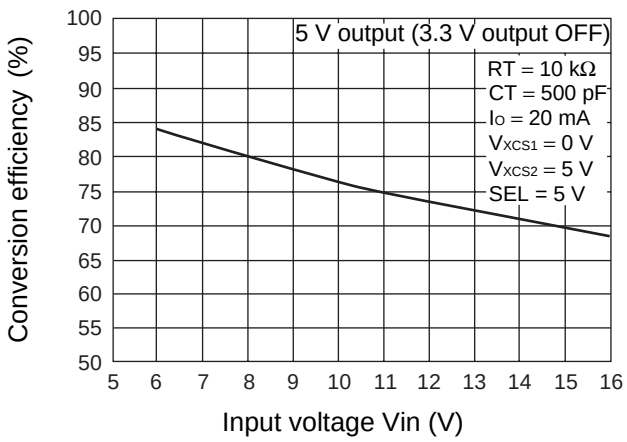
- **Low power mode**

Conversion efficiency vs. Input voltage



Conversion efficiency vs. Input voltage



■ 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.

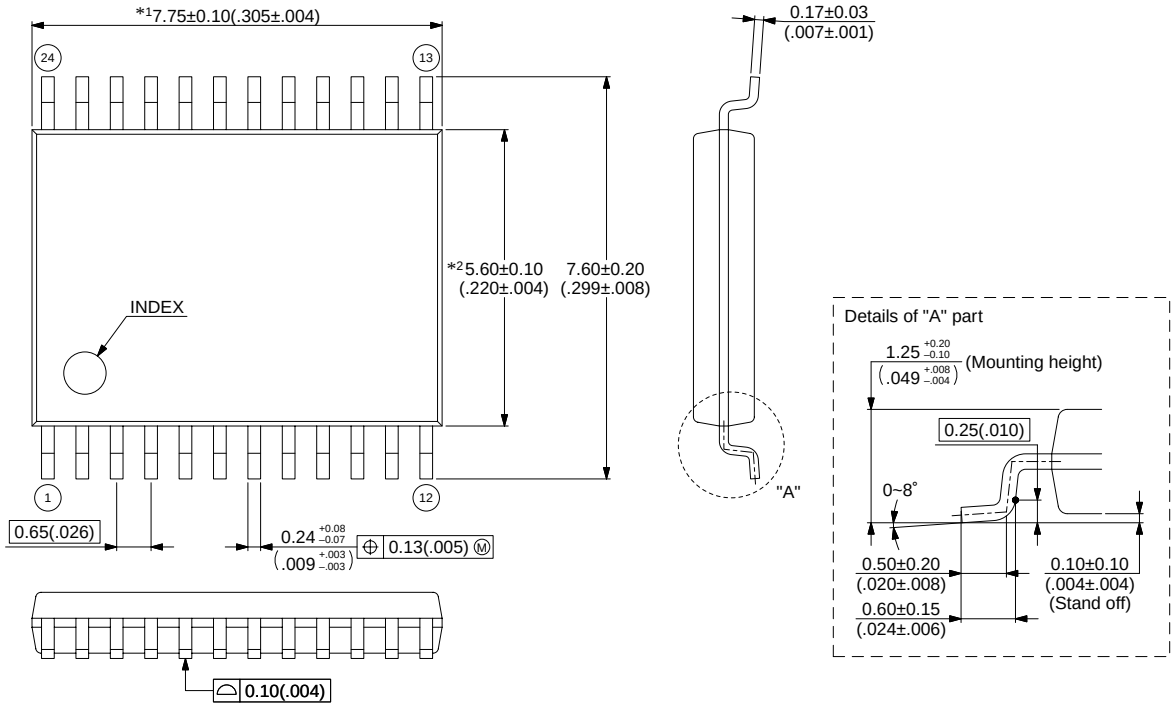
■ ORDERING INFORMATION

Part number	Package	Remarks
MB3821PFV	24-pin Plastic SSOP (FPT-24P-M03)	

■ PACKAGE DIMENSION

24-pin Plastic SSOP
(FPT-24P-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.



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

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