DS04-27239-1E

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

3-ch DC/DC Converter IC

MB39A112

■ DESCRIPTION

The MB39A112 is a 3-channel DC/DC converter IC using pulse width modulation (PWM) , and the MB39A112 is suitable for down-conversion.

3-channel is built in TSSOP-20P package. Each channel can be controlled and soft-start.

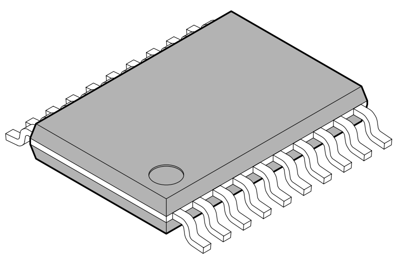
The MB39A112 contains a constant voltage bias circuit for output block, capable of implementing an efficient high-frequency DC/DC converter. It is ideal for built-in power supply such as ADSL modems.

■ REATURES

- Supports for down-conversion (CH1 to CH3)
- Power supply voltage range : 7 V to 25 V
- Error amplifier threshold voltage : 1.00 V ± 1% (CH1)
  : 1.23 V ± 1% (CH2, CH3)
- Oscillation frequency range : 250 kHz to 2.6 MHz
- Built-in soft-start circuit independent of loads
- Built-in timer-latch short-circuit protection circuit
- Built-in totem-pole type output for P-channel MOS FET devices
- Built-in constant voltage (VCCO – 5 V) bias circuit for output block

■ PACKAGE

20-pin plastic TSSOP

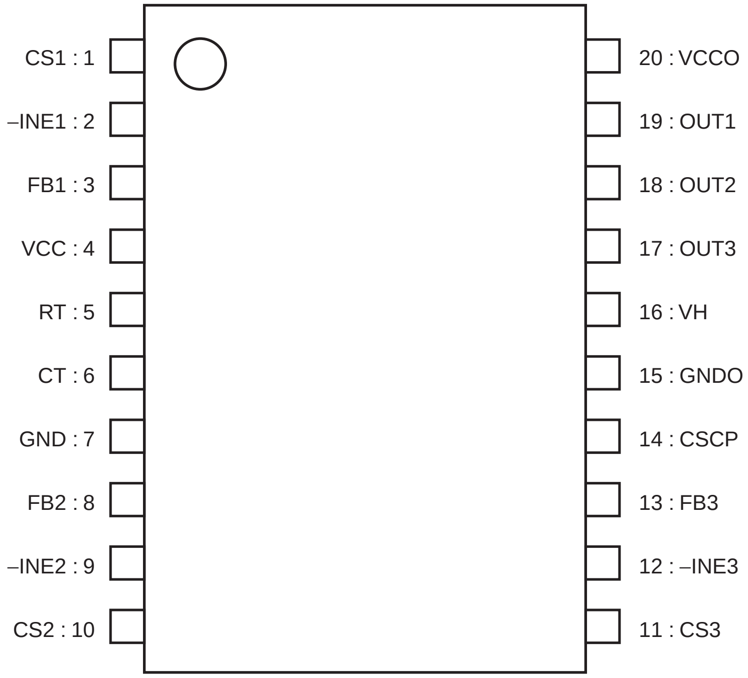


(FPT-20P-M06)

FUJITSU

■ PIN ASSIGNMENT

(TOP VIEW)

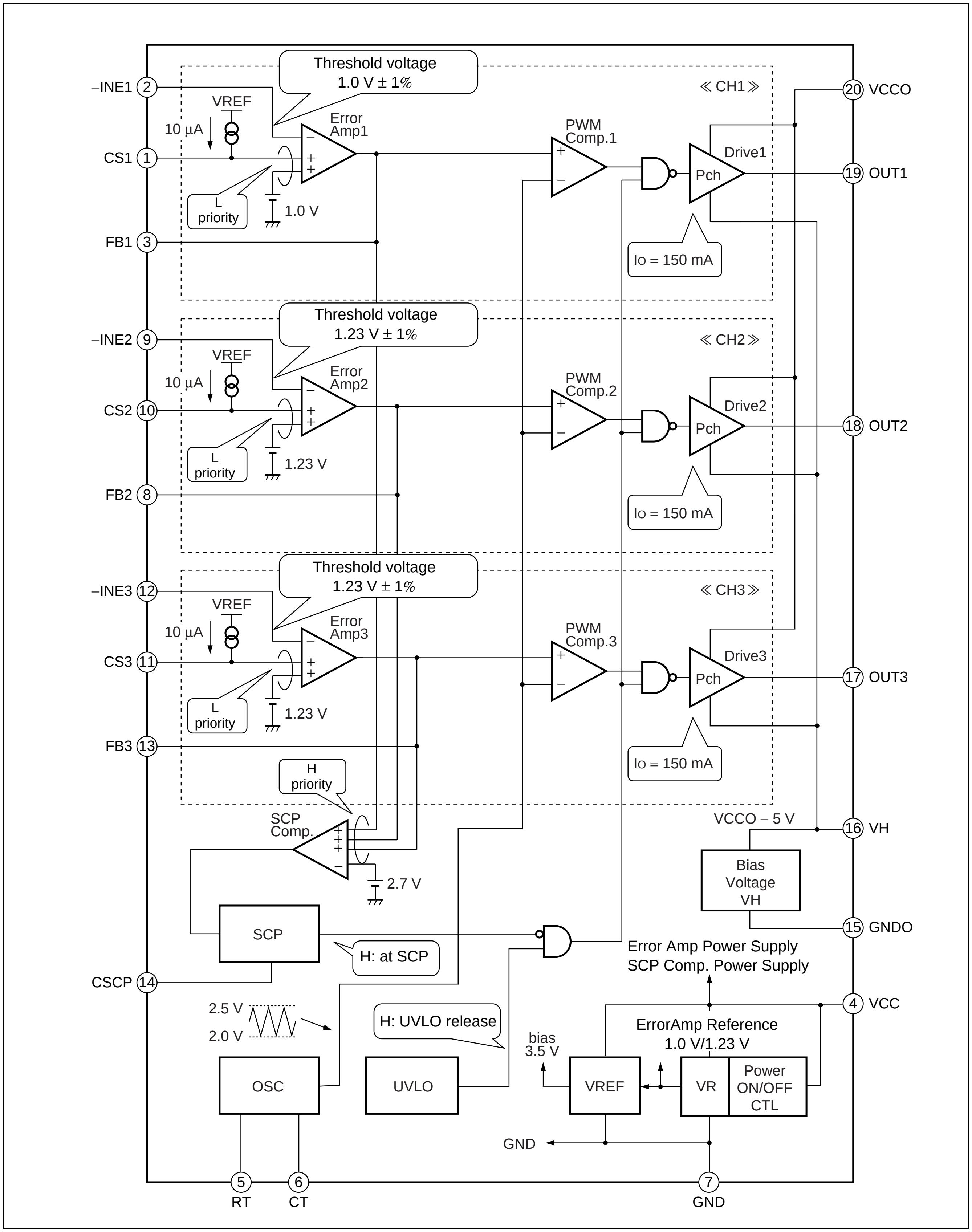


(FPT-20P-M06)

■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Descriptions
1	CS1	—	CH1 soft-start setting capacitor connection terminal.
2	– INE1	I	CH1 error amplifer inverted input terminal.
3	FB1	O	CH1 error amplifer output terminal.
4	VCC	—	Control circuit power supply terminal.
5	RT	—	Triangular-wave oscillation frequency setting resistor connection terminal.
6	CT	—	Triangular-wave oscillation frequency setting capacitor connection terminal.
7	GND	—	Ground terminal.
8	FB2	O	CH2 error amplifier output terminal.
9	– INE2	I	CH2 error amplifier inverted input terminal.
10	CS2	—	CH2 soft-start setting capacitor connection terminal.
11	CS3	—	CH3 soft-start setting capacitor connection terminal.
12	– INE3	I	CH3 error amplifier inverted input terminal.
13	FB3	O	CH3 error amplifier output terminal.
14	CSCP	—	Timer-latch short-circuit protection capacitor connection terminal.
15	GNDO	—	Ground terminal.
16	VH	O	Power supply terminal for driving output circuit. (VH = VCCO – 5 V) .
17	OUT3	O	CH3 external Pch MOS FET gate driving terminal.
18	OUT2	O	CH2 external Pch MOS FET gate driving terminal.
19	OUT1	O	CH1 external Pch MOS FET gate driving terminal.
20	VCCO	—	Power supply terminal for driving output circuit. (Connect to same potential as VCC terminal).

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Rating		Unit
			Min	Max	
Power supply voltage	V_{CC}	VCC, VCCO terminal	—	28	V
Output current	I_O	OUT1, OUT2, OUT3 terminal	—	20	mA
Peak output current	I_{OP}	Duty $\leq$ 5 % (t = 1/fosc × Duty)	—	400	mA
Power dissipation	P_D	Ta $\leq$ + 25 °C	—	1280*	mW
Storage temperature	T_{STG}	—	– 55	+ 125	°C

* : The package is mounted on the dual-sided 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}	VCC, VCCO terminal	7	12	25	V
Input voltage	V_{IN}	– INE terminal	0	—	Vcc – 1.8	V
Output current	I_O	OUT1, OUT2, OUT3 terminal	– 15	—	15	mA
	I_{VH}	VH terminal	0	—	30	mA
Oscillation frequency	fosc	—	250	1200	2600	kHz
Timing capacitor	C_T	—	22	100	1000	pF
Timing resistor	R_T	—	4.7	10	22	kΩ
VH terminal capacitor	C_{VH}	VH terminal	—	0.1	1.0	µF
Soft-start capacitor	C_S	CS1, CS2, CS3 terminal	—	0.1	1.0	µF
Short-circuit detection capacitor	C_{SCP}	CSCP terminal	—	0.01	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 = VCCO = 12 V, Ta = + 25 °C)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min	Typ	Max	
Undervoltage Lockout Protection Circuit Block [UVLO]	Threshold voltage	V_{TH}	4	VCC = ↑	6.35	6.55	6.75	V
	Hysteresis width	V_{HYS}	4	—	—	0.15	—	V
Short-circuit Protection Circuit Block [SCP]	Threshold voltage	V_{TH}	14	—	0.67	0.72	0.77	V
	Input source current	I_{CSCP}	14	—	– 1.4	– 1.0	– 0.6	µA
	Reset voltage	V_{RST}	4	VCC = ↓	6.2	6.4	6.6	V
Triangular Wave Oscillator Block [OSC]	Oscillation frequency	fosc	17 to 19	CT = 100 pF, RT = 10 kΩ	1080	1200	1320	kHz
Soft-start Block [CS1, CS2, CS3]	Charge current	I_{CS}	1, 10, 11	—	– 14	– 10	– 6	µA
Error Amp Block (CH1) [Error Amp1]	Threshold voltage	V_{TH}	2	FB1 = 2.25 V	0.99	1.00	1.01	V
	Input bias current	I_B	2	– INE1 = 0 V	– 250	– 63	—	nA
	Voltage gain	A_V	3	DC	60	100	—	dB
	Frequency band width	B_W	3	A_V = 0dB	—	1.5*	—	MHz
	Output voltage	V_{OH}	3	—	3.2	3.4	—	V
		V_{OL}	3	—	—	40	200	mV
	Output source current	I_{SOURCE}	3	FB1 = 2.25 V	—	– 2	– 1	mA
	Output sink current	I_{SINK}	3	FB1 = 2.25 V	150	250	—	µA
Error Amp Block (CH2, CH3) [Error Amp2, Error Amp3]	Threshold voltage	V_{TH}	9, 12	FB2 = FB3 = 2.25 V	1.218	1.230	1.242	V
	Input bias current	I_B	9, 12	– INE2 = – INE3 = 0 V	– 250	– 63	—	nA
	Voltage gain	A_V	8, 13	DC	60	100	—	dB
	Frequency band width	B_W	8, 13	A_V = 0 dB	—	1.5*	—	MHz
	Output voltage	V_{OH}	8, 13	—	3.2	3.4	—	V
		V_{OL}	8, 13	—	—	40	200	mV
	Output source current	I_{SOURCE}	8, 13	FB2 = FB3 = 2.25 V	—	– 2	– 1	mA
	Output sink current	I_{SINK}	8, 13	FB2 = FB3 = 2.25 V	150	250	—	µA

* : Standard design value

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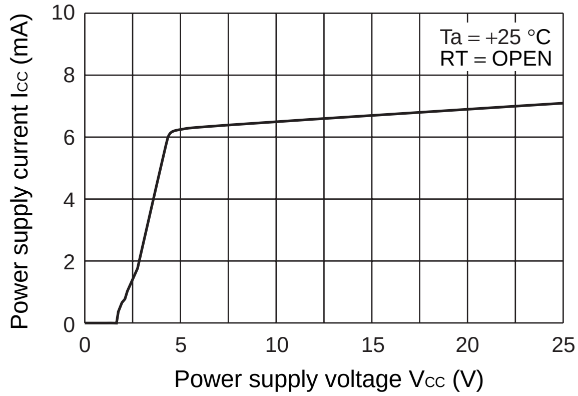
(VCC = VCCO = 12 V, Ta = + 25 °C)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min	Typ	Max	
PWM Comparator Block [PWM Comp.]	Threshold voltage	V_{T0}	17 to 19	Duty cycle = 0 %	1.9	2.0	—	V
		V_{T100}	17 to 19	Duty cycle = 100 %	—	2.5	2.6	V
Bias Voltage Block [VH]	Output voltage	V_H	16	—	V_{CCO} – 5.5	V_{CCO} – 5.0	V_{CCO} – 4.5	V
Output Block [Drive]	Output source current	I_{SOURCE}	17 to 19	Duty ≤ 5 % OUT1 = OUT2 = OUT3 = 7 V	—	– 150*	—	mA
	Output sink current	I_{SINK}	17 to 19	Duty ≤ 5 % OUT1 = OUT2 = OUT3 = 12 V	—	150*	—	mA
	Output ON resistor	R_{OH}	17 to 19	OUT1 = OUT2 = OUT3 = – 15 mA	—	13	19.5	Ω
		R_{OL}	17 to 19	OUT1 = OUT2 = OUT3 = 15 mA	—	10	15	Ω
General	Power supply current	I_{CC}	4	—	—	6	9	mA

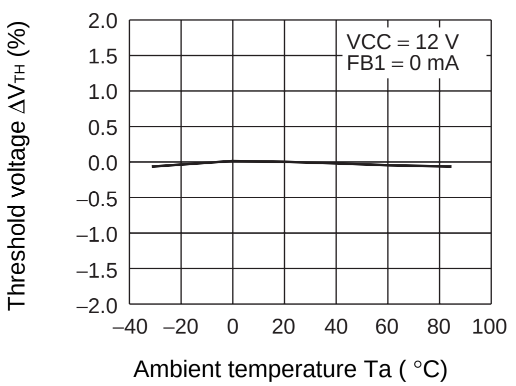
* : Standard design value

■ TYPICAL CHARCTERISTICS

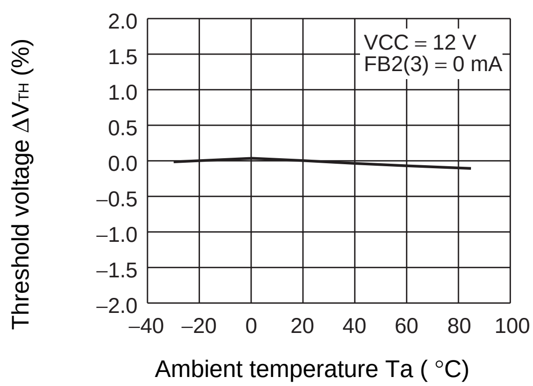
Power Supply Current vs. Power Supply Voltage



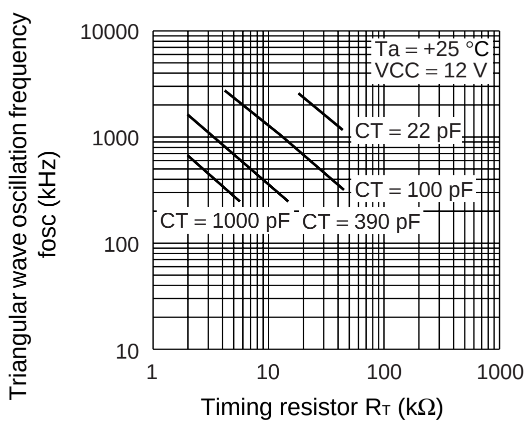
Error Amp (ERR1)
Threshold Voltage vs. Ambient Temperature



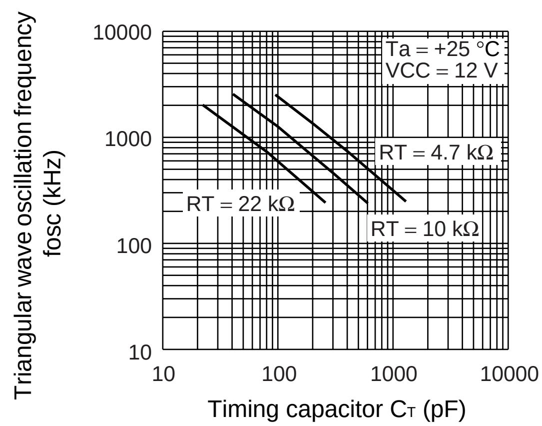
Error Amp (ERR2, ERR3)
Threshold Voltage vs. Ambient Temperature



Triangular Wave Oscillation Frequency vs.
Timing Resistor



Triangular Wave Oscillation Frequency vs.
Timing Capacitor



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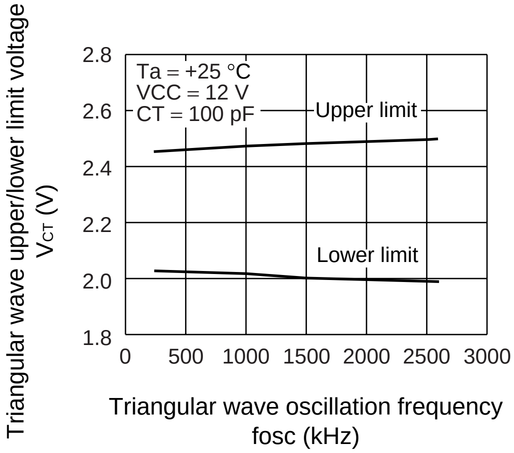
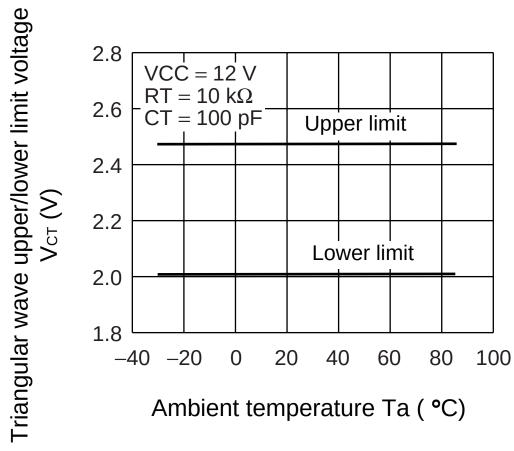
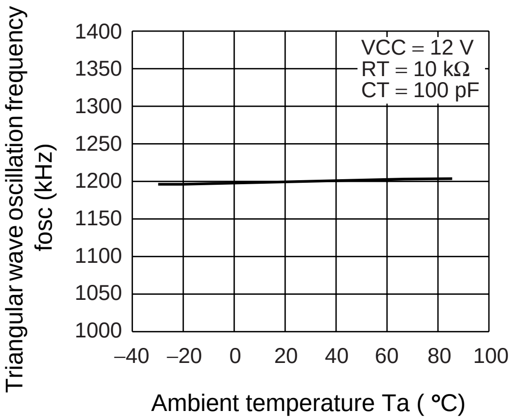
Triangular Wave Upper/Lower Limit Voltage vs. Triangular Wave Oscillation Frequency



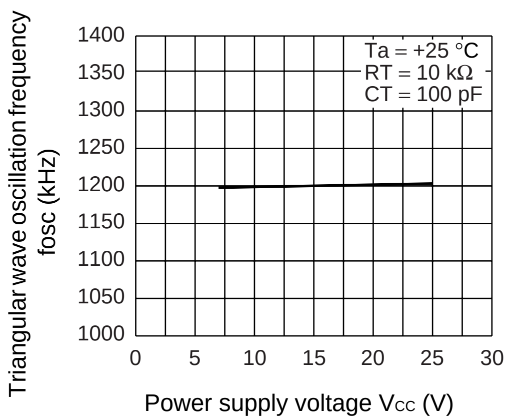
Triangular Wave Upper/Lower Limit Voltage vs. Ambient Temperature



Triangular Wave Oscillation Frequency vs. Ambient Temperature



Triangular Wave Oscillation Frequency vs. Power Supply Voltage



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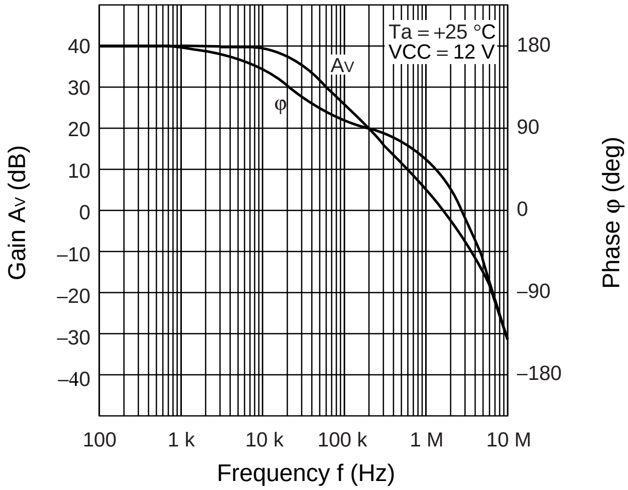
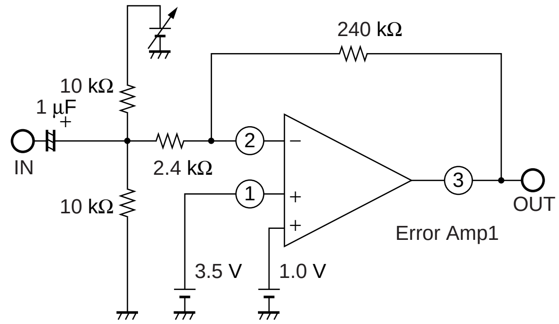
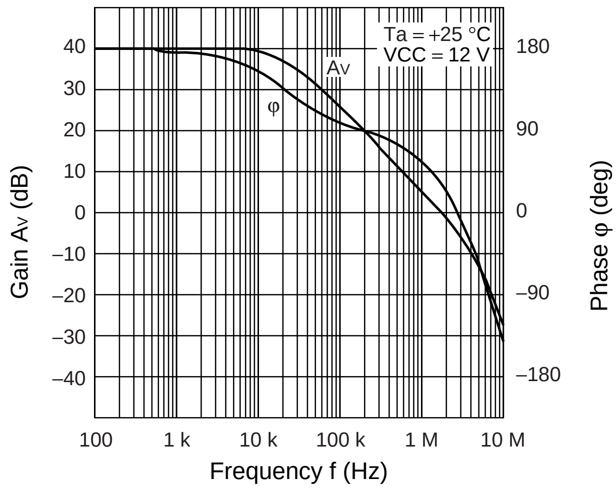
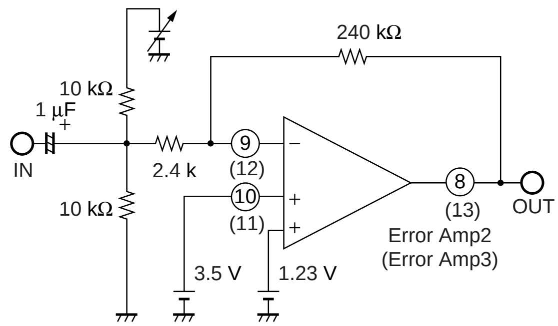
Error Amp (CH1)
Gain, Phase vs. Frequency



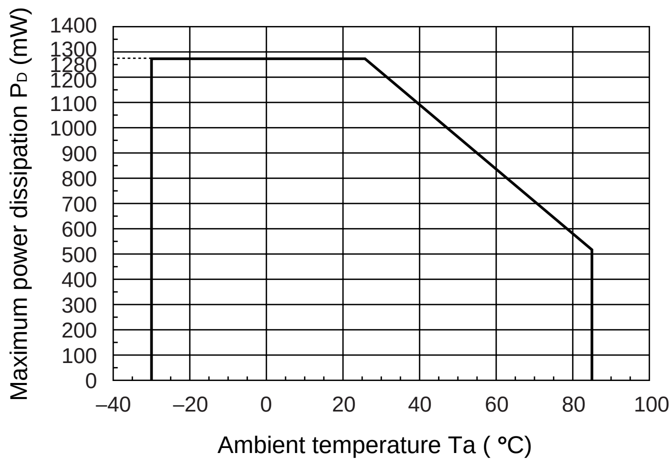


Error Amp (CH2, CH3)
Gain, Phase vs. Frequency





Maximum Power Dissipation vs. Ambient Temperature



■ FUNCTION

1. DC/DC Converter Function

(1) Triangular Wave Oscillator Block (OSC)

The triangular wave oscillator incorporates a timing capacitor and a timing resistor connected respectively to the CT terminl (pin 6) and RT terminl (pin 5) to generate triangular oscillation waveform amplitude of 2.0 V to 2.5 V. The triangular waveforms are input to the PWM comparator in the IC.

(2) Error Amplifier Block (Error Amp1, Error Amp2, Error Amp3)

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 CS1 terminl (pin 1) , CS2 terminl (pin10) and CS3 terminl (pin 11) which are 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 remain higher than the triangular wave voltage.

(4) Output Block

The output blobk is in the totem pole configulation, capable of driving an external P-channel MOS FET.

(5) Bias Voltage Block (VH)

This bias voltage circuit outputs V_{CC} – 5 V (Typ) as minimum potential of the output circuit.

2. Protective Function

(1) Timer Latch Short-circuit Protection Circuit (SCP)

Each channel has a short-circuit detection comparator (SCP Comp.) which constantly compares the error Amp. output level to the reference voltage.

While DC/DC converter load conditions are stable on all channels, the short-circuit detection comparator output remains at “L”, and the CSCP terminal is held at “L” level.

If the load condition on a channel changes rapidly due to a short-circuit of the load, causing the output voltage to drop, the output of the short-circuit detection comparator on that channel goes to “H” level. This causes the external short-circuit protection capacitor C_{SCP} connected to the CSCP terminal (pin 14) to be charged.

When the capacitor C_{SCP} is charged to the threshold voltage (VTH ≒ 0.72 V) , the latch is set and the external FET is turned off (dead time is set to 100 %) . At this point, the latch input is closed and the CSCP terminal is held at “L” level.

The latch applied by the timer-latch short-circuit protection circuit can be reset by recycling the power supply (VCC) (See “■ SETTING TIME CONSTANT FOR TIMER-LATCH SHORT-CIRCUIT PROTECTION CIRCUIT”) .

(2) Undervoltage Lockout Protection Circuit Block (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 transistor, and sets the dead time to 100% while holding the CSCP terminal (pin 14) 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) Protection Circuit Operating Function Table

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

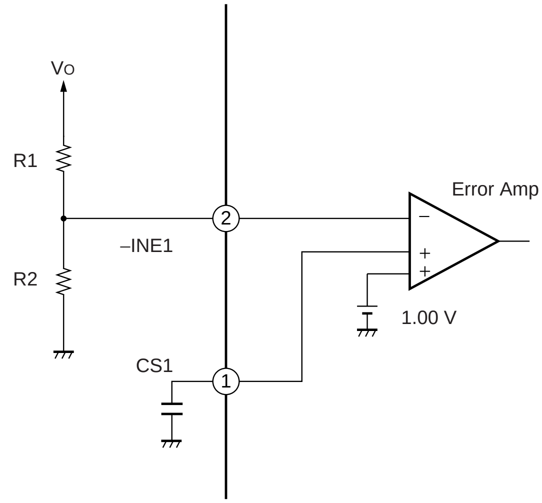
Operating circuit	CH1	CH2	CH3
	OUT1	OUT2	OUT3
Short-circuit protection circuit	H	H	H
Under-voltage lockout circuit	H	H	H

The latch can be reset as follows after the short-circuit protection circuit is actuated.

Recycling VCC resets the latch whenever the short-circuit protection circuit has been actuated.

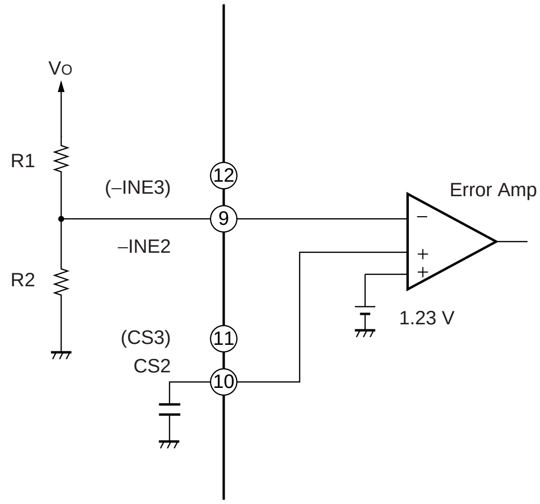
■ SETTING THE OUTPUT VOLTAGE

• **CH1**



$$V_O\ (V) = \frac{1.00}{R2}(R1 + R2)$$

• **CH2, CH3**



$$V_O\ (V) = \frac{1.23}{R2}(R1 + R2)$$

■ SETTING THE TRIANGULAR OSCILLATION FREQUENCY

The triangular oscillation frequency is determined by the timing capacitor (C_T) connected to the C_T terminal (pin 6) and the timing resistor (R_T) connected to the R_T terminal (pin 5) .

Triangular oscillation frequency : fosc

$$\text{fosc (kHz)} \fallingdotseq \frac{1200000}{C_T\ (\text{pF}) \bullet R_T\ (\text{k}\Omega)}$$

■ SETTING THE SOFT-START AND DISCHARGE TIMES

To prevent rush currents when the IC is turned on, you can set a soft-start by connecting soft-start capacitors (C_{S1}, C_{S2} and C_{S3}) to the CS1 terminal (pin 1) for channel 1, CS2 terminal (pin 10) for channel 2 and CS3 terminal (pin 11) for channel 3 respectively.

Setting each control terminal ($\overline{\text{CTLX}}$) from "H" to "L" starts charging the external soft-start capacitors (C_{S1}, C_{S2} and C_{S3}) connected to the CS1, CS2 and CS3 terminal at about 10 µA. The DC/DC converter output voltage rises in proportion to the CS terminal voltage. Also, soft-start time is obtained by the following formulas.

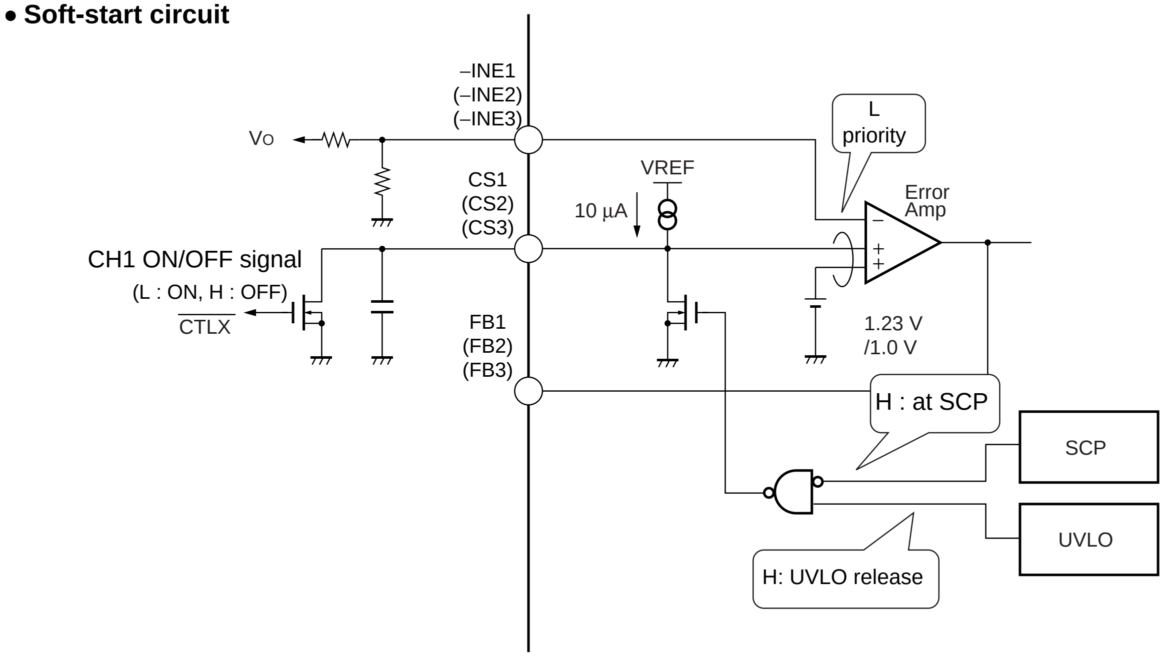
Soft-start time : ts (time to output 100%)

CH1 : $ts_1[s] \fallingdotseq 0.100 \times C_{S1}[\mu F]$

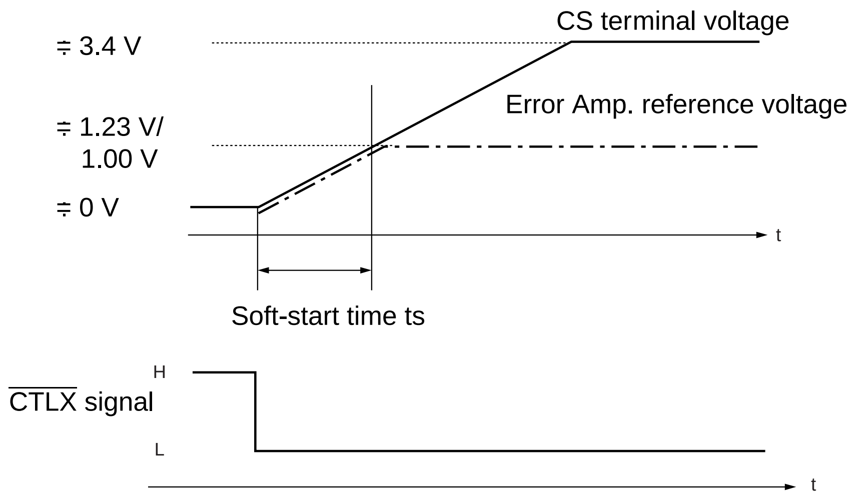
CH2 : $ts_2[s] \fallingdotseq 0.123 \times C_{S2}[\mu F]$

CH3 : $ts_3[s] \fallingdotseq 0.123 \times C_{S3}[\mu F]$

• **Soft-start circuit**



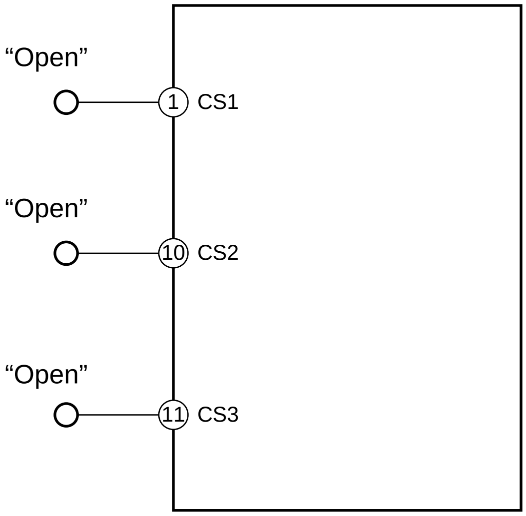
• **Soft-start operation**



■ TREATMENT WITHOUT USING CS TERMINAL

When not using the soft-start function, open the CS1 terminal (pin 1) , CS2 terminal (pin 10) and CS3 terminal (pin 11) .

• Without setting soft-start tme



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

Each channel uses the short-circuit detection comparator (SCP Comp.) to always compare the error amplifier's output level to the reference voltage.

While DC/DC converter load conditions are stable on all channels, the short-circuit detection comparator output remains at "L" level, and the CSCP terminal (pin 14) is held at "L" level.

If the load condition on a channel changes rapidly due to a short-circuit of the load, causing the output voltage to drop, the output of the short-circuit detection comparator goes to "H" level. This causes the extemal short-circuit protection capacitor C_{SCP} connected to the CSCP terminal to be charged at 1 μA.

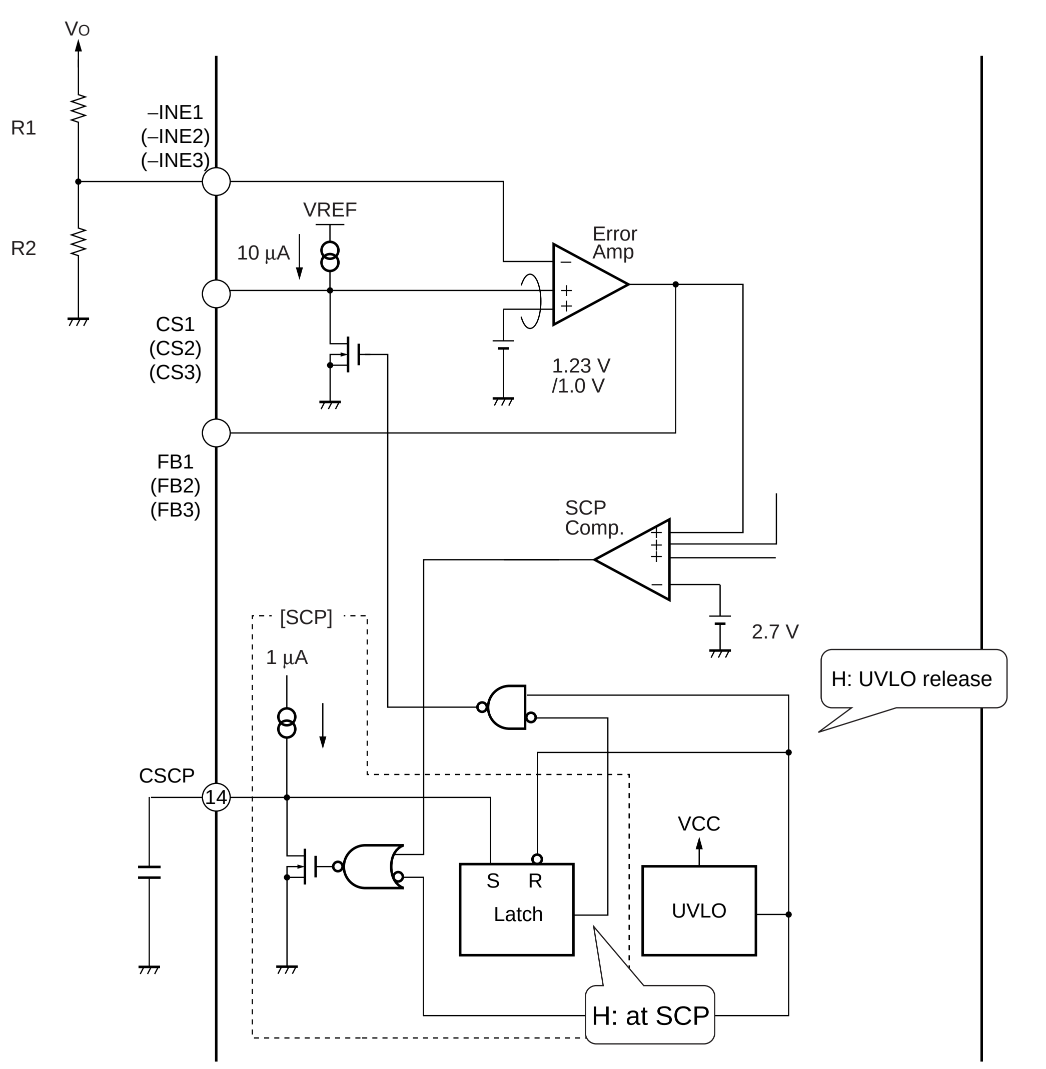
Short-circuit detection time : tcscp

$$tcscp[s] \fallingdotseq 0.72 \times C_{SCP}\ [\mu F]$$

When the capacitor C_{SCP} is charged to the threshold voltage ($V_{TH} \fallingdotseq 0.72$ 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 14) is held at "L" level.

If any of CH1 to CH3 detects a short circuit, all the channels are stopped.

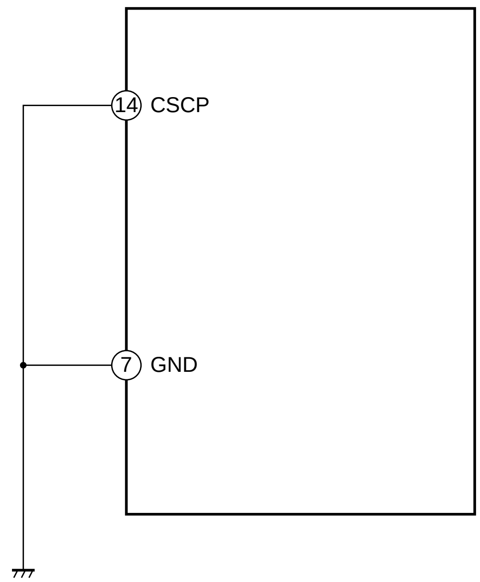
• Timer-latch short-circuit protection circuit



■ TREATMENT WITHOUT USING CSCP TERMINAL

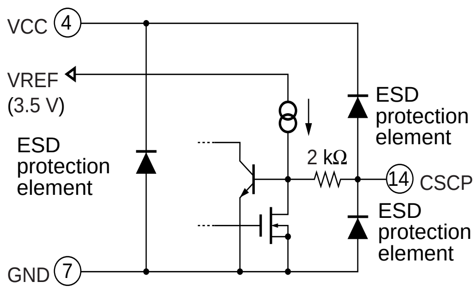
When not using the timer-latch short-circuit protection circuit, connect the CSCP terminal (pin 14) to GND with the shortest distance.

• Treatment without using CSCP terminal

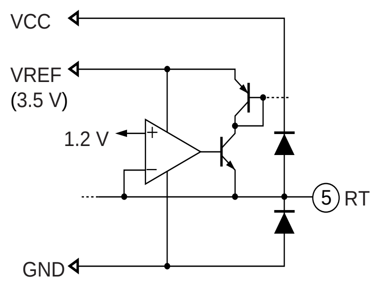


■ I/O EQUIVALENT CIRCUIT

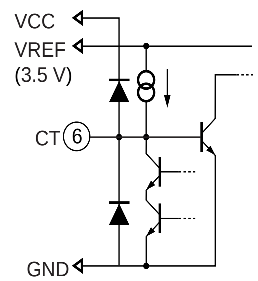
<<Short-circuit detection block>>



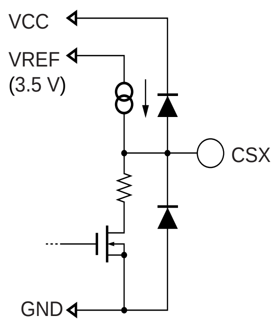
<<Triangular wave oscillator block (RT) >>



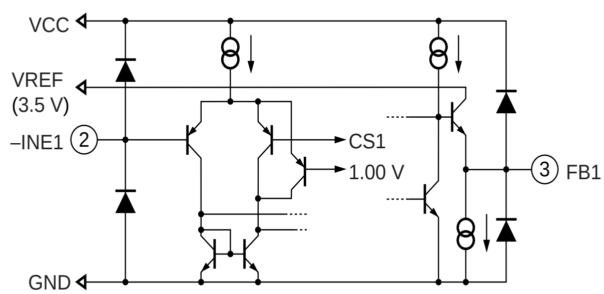
<<Triangular wave oscillator block (CT) >>



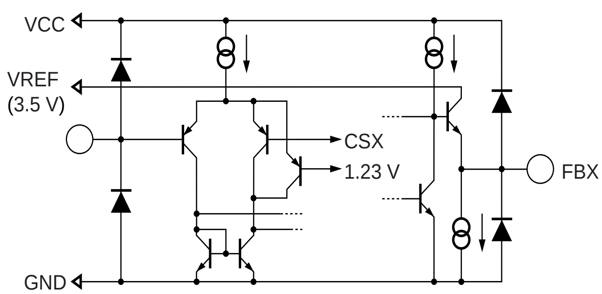
<<Soft-start block>>



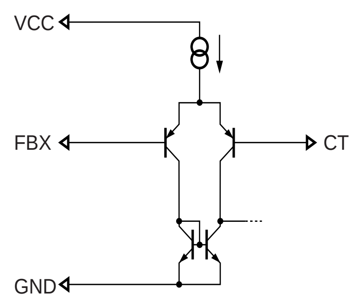
<<Error amplifier block (CH1) >>



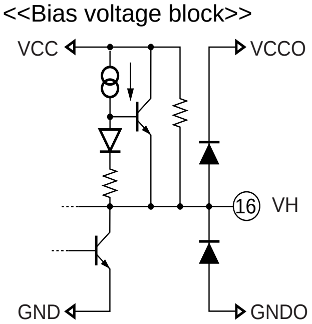
<<Error amplifier block (CH2, CH3) >>



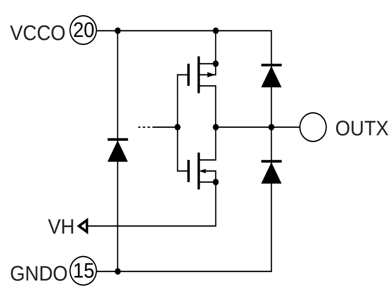
<<PWM comparator block>>



<<Bias voltage block>>

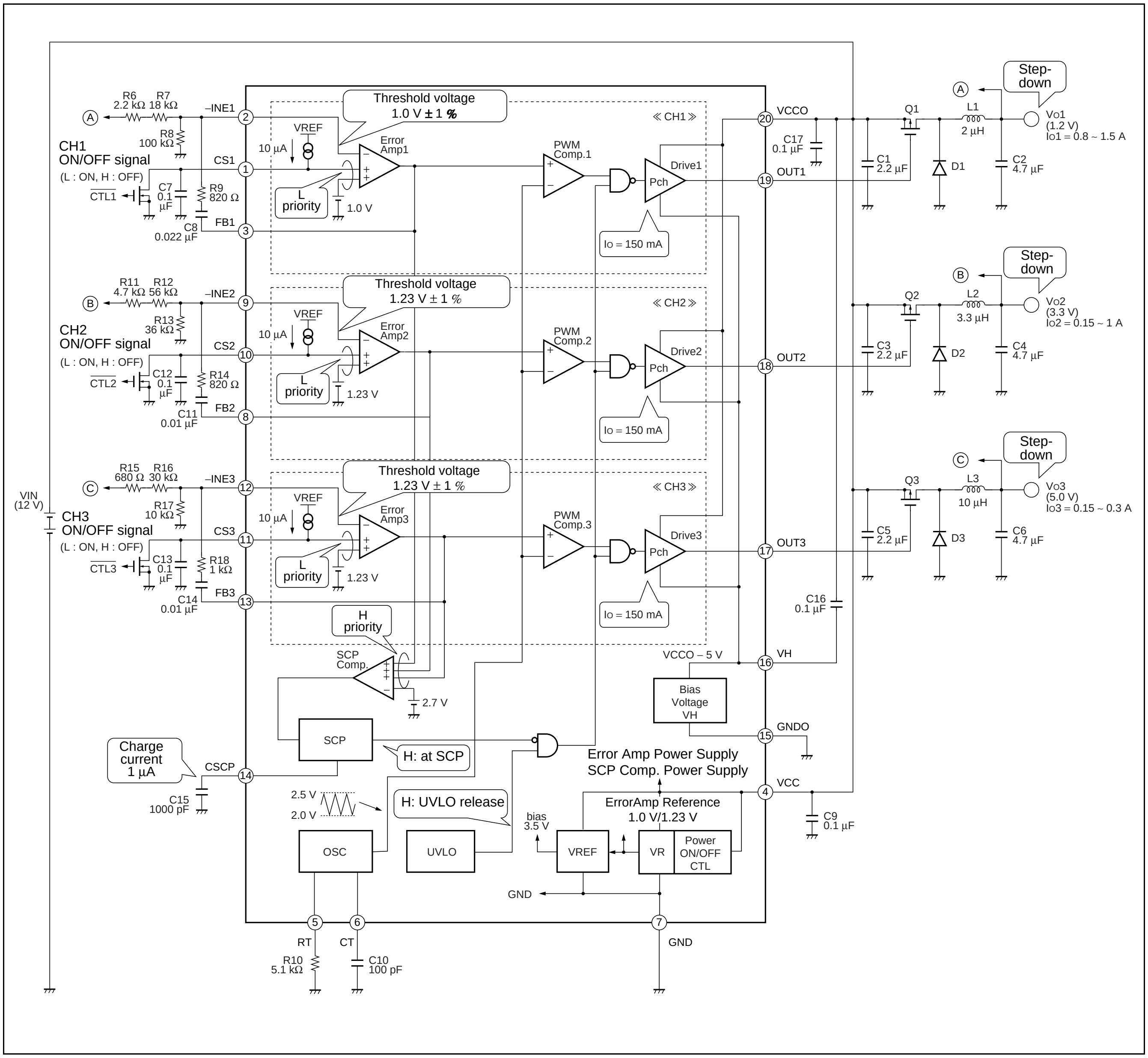


<<Output block>>



X : Each channel No.

■ APPLICATION EXAMPLE



■ PARTS LIST

COMPONENT	ITEM	SPECIFICATION		VENDOR	PARTS No.
Q1, Q2, Q3	Pch FET Pch FET	VDS = – 30 V, ID = – 2.0 A VDS = – 30 V, ID = – 1.0 A		SANYO SANYO	MCH3312 MCH3308
D1, D2 D3	Diode Diode	VF = 0.55 V (Max) , at IF = 2 A VF = 0.4 V (Max) , at IF = 0.5 A		SANYO SANYO	SBE001 SBE005
L1	Inductor	2 µH	3 A, 16 mΩ	TOKO	A916CY-2R0M
L2	Inductor	3.3 µH	2.57 A, 21.4 mΩ	TOKO	A916CY-3R3M
L3	Inductor	10 µH	1.49 A, 41.2 mΩ	TOKO	A916CY-100M
C1, C3, C5	Ceramics Condenser	2.2 µF	25 V	TDK	C3216JB1E225K
C2, C4, C6	Ceramics Condenser	4.7 µF	10 V	TDK	C3216JB1A475M
C7, C9, C12	Ceramics Condenser	0.1 µF	50 V	TDK	C1608JB1H104K
C8	Ceramics Condenser	0.022 µF	50 V	TDK	C1608JB1H223K
C10	Ceramics Condenser	100 pF	50 V	TDK	C1608CH1H101J
C11, C14	Ceramics Condenser	0.01 µF	50 V	TDK	C1608JB1H103K
C13, C16, C17	Ceramics Condenser	0.1 µF	50 V	TDK	C1608JB1H104K
C15	Ceramics Condenser	1000 pF	50 V	TDK	C1608JB1H102K
R6	Resistor	2.2 kΩ	0.5 %	ssm	RR0816P-222-D
R7	Resistor	18 kΩ	0.5 %	ssm	RR0816P-183-D
R8	Resistor	100 kΩ	0.5 %	ssm	RR0816P-104-D
R9	Resistor	820 Ω	0.5 %	ssm	RR0816P-821-D
R10	Resistor	5.1 kΩ	0.5 %	ssm	RR0816P-512-D
R11	Resistor	4.7 kΩ	0.5 %	ssm	RR0816P-472-D
R12	Resistor	56 kΩ	0.5 %	ssm	RR0816P-563-D
R13	Resistor	36 kΩ	0.5 %	ssm	RR0816P-363-D
R14	Resistor	820 Ω	0.5 %	ssm	RR0816P-821-D
R15	Resistor	680 Ω	0.5 %	ssm	RR0816P-681-D
R16	Resistor	30 kΩ	0.5 %	ssm	RR0816P-303-D
R17	Resistor	10 kΩ	0.5 %	ssm	RR0816P-103-D
R18	Resistor	1 kΩ	0.5 %	ssm	RR0816P-102-D

Note : SANYO : SANYO Electric Co., Ltd.
TOKO : TOKO Inc.
TDK : TDK Corporation
ssm : SUSUMU Co., Ltd.

■ SELECTION OF COMPONENTS

- Pch MOS FET

The Pch MOS FET for switching use should be rated for at least 20 % or more than the maximum input voltage. To minimize continuity loss, use a FET with low $R_{DS\,(ON)}$ between the drain and source. For high input voltage and high frequency operation, on-cycle switching loss will be higher so that power dissipation must be considered. In this application, the SANYO MCH3312 and MCH3308 are used. Continuity loss, on/off-cycle 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 : Pc

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

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

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

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

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

Total loss : P_T

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

Example : Using the MCH3312

- CH1

Input voltage $V_{IN} = 12$ V, output voltage $V_O = 1.2$ V, drain current $I_D = 1.5$ A, oscillation frequency $f_{OSC} = 2350$ kHz, L = 2 µH, drain-source on resistance $R_{DS(ON)} \fallingdotseq 180$ mΩ, tr $\fallingdotseq$ 2.9 ns, tf $\fallingdotseq$ 8.7 ns.

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

$$I_{D\,(Max)} = Io + \frac{V_{IN} - Vo}{2L} t_{ON}$$

$$= 1.5 + \frac{12 - 1.2}{2 \times 2.0 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.1$$

$$\fallingdotseq \underline{1.61\text{ A}}$$

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

$$I_{D\,(Min)} = Io - \frac{V_{IN} - Vo}{2L} t_{ON}$$

$$= 1.5 - \frac{12 - 1.2}{2 \times 2.0 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.1$$

$$\fallingdotseq \underline{1.39\text{ A}}$$

$$P_C = I_D^2 \times R_{DS\,(ON)} \times Duty$$
$$= 1.5^2 \times 0.18 \times 0.1$$
$$\fallingdotseq \underline{0.04\ W}$$

$$P_{S\,(ON)} = \frac{V_D \times I_D \times tr \times fosc}{6}$$
$$= \frac{12 \times 1.5 \times 2.9 \times 10^{-9} \times 2350 \times 10^3}{6}$$
$$\fallingdotseq \underline{0.02\ W}$$

$$P_{S\,(OFF)} = \frac{V_D \times I_{D\,(Max)} \times tf \times fosc}{6}$$
$$= \frac{12 \times 1.61 \times 8.7 \times 10^{-9} \times 2350 \times 10^3}{6}$$
$$\fallingdotseq \underline{0.066\ W}$$

$$P_T = Pc + P_{S\,(ON)} + P_{S\,(OFF)}$$
$$\fallingdotseq 0.04 + 0.02 + 0.066$$
$$\fallingdotseq \underline{0.126\ W}$$

The above power dissipation figures for the MCH3312 are satisfied with ample margin at 1.0 W (Ta = +25 °C) .

- CH2

Input voltage $V_{IN} = 12$ V, output voltage $V_O = 3.3$ V, drain current $I_D = 1.0$ A, oscillation frequency $f_{OSC} = 2350$ kHz, L = 3.3 µH, drain-source on resistance $R_{DS(ON)} \fallingdotseq 180$ mΩ, tr $\fallingdotseq$ 2.9 ns, tf $\fallingdotseq$ 8.7 ns.

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

$$I_{D\,(Max)} = Io + \frac{V_{IN} - Vo}{2L} t_{ON}$$
$$= 1 + \frac{12 - 3.3}{2 \times 3.3 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.275$$
$$\fallingdotseq \underline{1.15\ A}$$

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

$$I_{D\,(Min)} = Io - \frac{V_{IN} - Vo}{2L} t_{ON}$$
$$= 1 - \frac{12 - 3.3}{2 \times 3.3 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.275$$
$$\fallingdotseq \underline{0.85\ A}$$

$$P_C = I_D^2 \times R_{DS\,(ON)} \times Duty$$
$$= 1^2 \times 0.18 \times 0.275$$
$$\fallingdotseq \underline{0.0495\ W}$$

$$P_{S\,(ON)} = \frac{V_D \times I_D \times tr \times fosc}{6}$$

$$= \frac{12 \times 1 \times 2.9 \times 10^{-9} \times 2350 \times 10^3}{6}$$

$$\fallingdotseq \underline{0.0136\ W}$$

$$P_{S\,(OFF)} = \frac{V_D \times I_{D\,(Max)} \times tf \times fosc}{6}$$

$$= \frac{12 \times 1.15 \times 8.7 \times 10^{-9} \times 2350 \times 10^3}{6}$$

$$\fallingdotseq \underline{0.047\ W}$$

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

$$\fallingdotseq 0.0495 + 0.0136 + 0.047$$

$$\fallingdotseq \underline{0.11\ W}$$

The above power dissipation figures for the MCH3312 are satisfied with ample margin at 1.0 W (Ta = +25 °C) .

Example : Using the MCH3308

- CH3

Input voltage V_{IN} = 12 V, output voltage Vo = 5.0 V, drain current I_D = 0.3 A, oscillation frequency fosc = 2350 kHz, L = 10 µH, drain-source on resistance $R_{DS\,(ON)} \fallingdotseq$ 600 mΩ, tr $\fallingdotseq$ 4 ns, tf $\fallingdotseq$ 4 ns.

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

$$I_{D\,(Max)} = Io + \frac{V_{IN} - Vo}{2L}\ t_{ON}$$

$$= 0.3 + \frac{12 - 5}{2 \times 10 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.417$$

$$\fallingdotseq \underline{0.36\ (A)}$$

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

$$I_{D\,(Min)} = Io - \frac{V_{IN} - Vo}{2L}\ t_{ON}$$

$$= 0.3 - \frac{12 - 5}{2 \times 10 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.417$$

$$\fallingdotseq \underline{0.24\ (A)}$$

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

$$= 0.3^2 \times 0.6 \times 0.417$$

$$\fallingdotseq \underline{0.023\ W}$$

$$P_{S\,(ON)} = \frac{V_D \times I_D \times tr \times fosc}{6}$$

$$= \frac{12 \times 0.3 \times 4 \times 10^{-9} \times 2350 \times 10^3}{6}$$

$$\fallingdotseq \underline{0.0056\ W}$$

$$P_{S\,(OFF)} = \frac{V_D \times I_{D\,(Max)} \times tf \times fosc}{6}$$

$$= \frac{12 \times 0.36 \times 4 \times 10^{-9} \times 2350 \times 10^3}{6}$$

$$\fallingdotseq \underline{0.0068\ W}$$

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

$$\fallingdotseq 0.023 + 0.0056 + 0.0068$$

$$\fallingdotseq \underline{0.0354\ W}$$

The above power dissipation figures for the MCH3308 are satisfied with ample margin at 0.8 W (Ta = +25 °C) .

- 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.

The L value for all load current conditions is set so that the peak to peak value of the ripple current is 1/2 the load current or less.

Inductance value : L

$$L \geq \frac{2\,(V_{IN} - V_O)}{I_O}\ t_{ON}$$

Example

- CH1

$$L \geq \frac{2\,(V_{IN} - V_{O1})}{I_O}\ t_{ON}$$

$$\geq \frac{2 \times (12 - 1.2)}{1.5} \times \frac{1}{2350 \times 10^3} \times 0.1$$

$$\geq \underline{0.61\ \mu H}$$

• CH2

$$L \geq \frac{2\,(V_{IN} - Vo2)}{Io}\; t_{ON}$$

$$\geq \frac{2 \times (12 – 3.3)}{1} \times \frac{1}{2350 \times 10^3} \times 0.275$$

$$\geq \underline{2.04\ \mu H}$$

• CH3

$$L \geq \frac{2\,(V_{IN} - Vo3)}{Io}\; t_{ON}$$

$$\geq \frac{2 \times (12 - 5)}{0.3} \times \frac{1}{2350 \times 10^3} \times 0.417$$

$$\geq \underline{8.28\ \mu H}$$

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 TOKO A916CY-2R0M, A916CY-3R3M and A916CY-100M are used. At 2 µH, 3.3 µH and 10 µH, the load current value under continuous operating conditions is determined by the following formula.

Load current value under continuous operating conditions : Io

$$Io \geq \frac{Vo}{2L}\; t_{OFF}$$

Example : Using the A916CY-2R0M

2 µH (allowable tolerance ± 20 %), rated current = 3 A

• CH1

$$Io \geq \frac{Vo1}{2L}\; t_{OFF}$$

$$\geq \frac{1.2}{2 \times 2 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times (1 - 0.1)$$

$$\geq \underline{0.11\ A}$$

Example : Using the A916CY-3R3M

3.3 µH (allowable tolerance ± 20 %) , rated current = 2.57 A

• CH2

$$Io \geq \frac{Vo2}{2L}\; t_{OFF}$$

$$\geq \frac{3.3}{2 \times 3.3 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times (1 - 0.275)$$

$$\geq \underline{0.15\ A}$$

Example : Using the A916CY-100M

10.0 µH (allowable tolerance ± 20 %) , rated current = 1.49 A

• CH3

$$Io \geq \frac{Vo3}{2L} t_{OFF}$$

$$\geq \frac{5}{2 \times 10 \times 10^{-6}} \times \frac{1}{2350 \times 10^{3}} \times (1 - 0.417)$$

$$\geq \underline{62.0\ mA}$$

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

$$I_L \geq Io + \frac{V_{IN} - Vo}{2L} t_{ON}$$

Peak-to-peak value : ΔI_L

$$\Delta I_L = \frac{V_{IN} - Vo}{L} t_{ON}$$

Example : Using the A916CY-2R0M

2.0 µH (allowable tolerance ± 20 %) , rated current = 3.0 A

• CH1

Peak value

$$I_L \geq Io + \frac{V_{IN} - Vo1}{2L} t_{ON}$$

$$\geq 1.5 + \frac{12 - 1.2}{2 \times 2.0 \times 10^{-6}} \times \frac{1}{2350 \times 10^{3}} \times 0.1$$

$$\geq \underline{1.61\ A}$$

Peak-to-peak value

$$\Delta I_L = \frac{V_{IN} - Vo1}{L} t_{ON}$$

$$= \frac{12 - 1.2}{2.0 \times 10^{-6}} \times \frac{1}{2350 \times 10^{3}} \times 0.1$$

$$\fallingdotseq \underline{0.23\ A}$$

Example : Using the A916CY-3R3M

3.3 µH (allowable tolerance ± 20 %) , rated current = 2.57 A

- CH2

Peak value

$$I_L \geq I_o + \frac{V_{IN} - V_{o2}}{2L} t_{ON}$$

$$\geq 1.0 + \frac{12 - 3.3}{2 \times 3.3 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.275$$

$$\geq \underline{1.15\ \text{A}}$$

Peak-to-peak value

$$\Delta I_L = \frac{V_{IN} - V_{o2}}{L} t_{ON}$$

$$= \frac{12 - 3.3}{3.3 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.275$$

$$\fallingdotseq \underline{0.309\ \text{A}}$$

Example : Using the A916CY-100M

10.0 µH (allowable tolerance ± 20 %) , rated current = 1.49 A

- CH3

Peak value

$$I_L \geq I_o + \frac{V_{IN} - V_{o3}}{2L} t_{ON}$$

$$\geq 0.3 + \frac{12 - 5}{2 \times 10 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.417$$

$$\geq \underline{0.36\ \text{A}}$$

Peak-to-peak value

$$\Delta I_L = \frac{V_{IN} - V_{o3}}{L} t_{ON}$$

$$= \frac{12 - 5}{10 \times 10^{-6}} \times \frac{1}{2350 \times 10^3} \times 0.417$$

$$\fallingdotseq \underline{0.124\ \text{A}}$$

- Flyback diode

The flyback diode is generally used as a Shottky barrier diode (SBD) when the reverse voltage to the diode is less than 40 V. The SBD has the characteristics of higher speed in terms of faster reverse recovery time, and lower forward voltage, and is ideal for archiving high efficiency. As long as the DC reverse voltage is sufficiently higher than the input voltage, the average current flowing through the diode is within the average output current level, and peak current is within peak surge current limits, there is no problem. In this application the SANYO SBE001, SBS005 are used. The diode average current and diode peak current can be calculated by the following formulas.

Diode mean current : I_{Di}

$$I_{Di} \geq Io \times \left(1 - \frac{Vo}{V_{IN}}\right)$$

Diode peak current : I_{Dip}

$$I_{Dip} \geq \left(Io + \frac{Vo}{2L} t_{OFF}\right)$$

Example : Using the SBE001

VR (DC reverse voltage) = 30 V, average output current = 2.0 A, peak surge current = 20 A,

VF (forward voltage) = 0.55 V, at IF = 2.0 A

- CH1

Diode mean current

$$I_{Di} \geq Io \times \left(1 - \frac{Vo1}{V_{IN}}\right)$$

$$\geq 1.5 \times (1 - 0.1)$$

$$\geq \underline{1.35\ A}$$

Diode peak current

$$I_{Dip} \geq \left(Io + \frac{Vo1}{2L} t_{OFF}\right)$$

$$\geq \underline{1.61\ A}$$

- CH2

Diode mean current

$$I_{Di} \geq Io \times \left(1 - \frac{Vo2}{V_{IN}}\right)$$

$$\geq 1.0 \times (1 - 0.275)$$

$$\geq \underline{0.725\ A}$$

Diode peak current

$$I_{Dip} \geq \left(Io + \frac{Vo2}{2L} t_{OFF}\right)$$

$$\geq \underline{1.15\ A}$$

Example : Using the SBS005

VR (DC reverse voltage) = 30 V, average output current = 1.0 A, peak surge current = 10 A,

VF (forward voltage) = 0.4 V, at IF = 0.5 A

- CH3

Diode mean current

$$I_{Di} \geq Io \times \left(1 - \frac{Vo3}{V_{IN}}\right)$$

$$\geq 0.3 \times (1 - 0.417)$$

$$\geq \underline{0.175\ A}$$

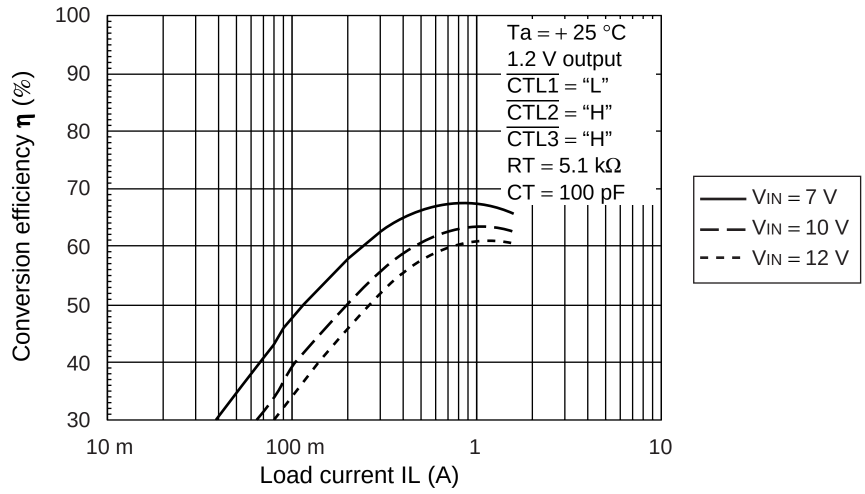
Diode peak current

$$I_{Dip} \geq \left(Io + \frac{Vo3}{2L} t_{OFF}\right)$$

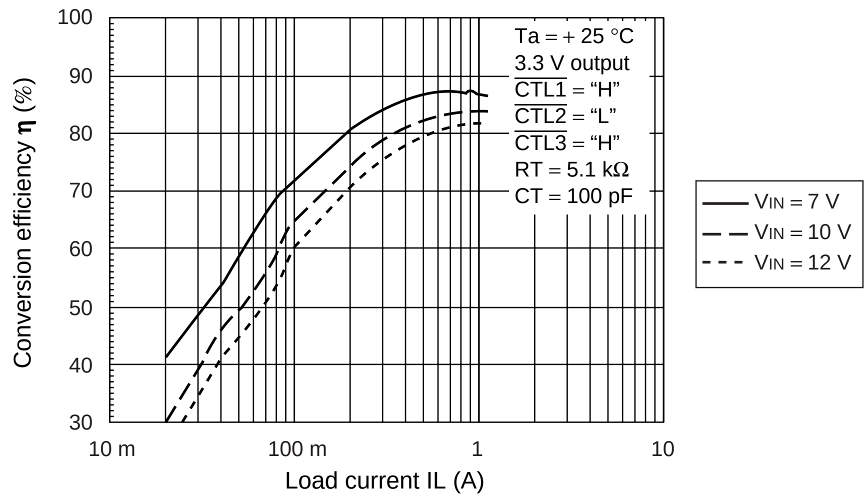
$$\geq \underline{0.36\ A}$$

■ REFERENCE DATA

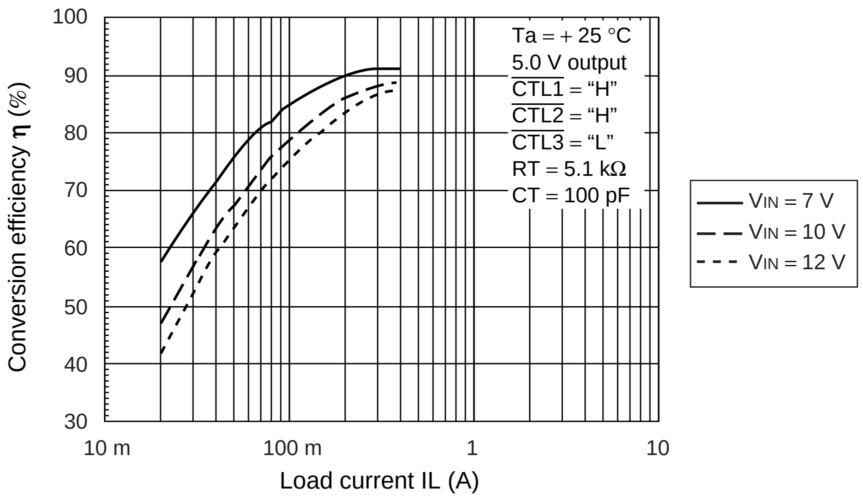
Conversion Efficiency vs. Load Current Characteristics (CH1)



Conversion Efficiency vs. Load Current Characteristics (CH2)



Conversion Efficiency vs. Load Current Characteristics (CH3)



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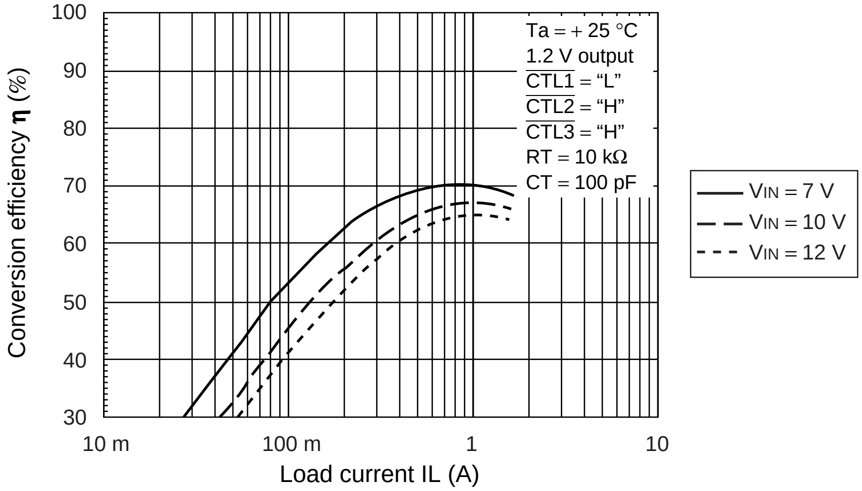
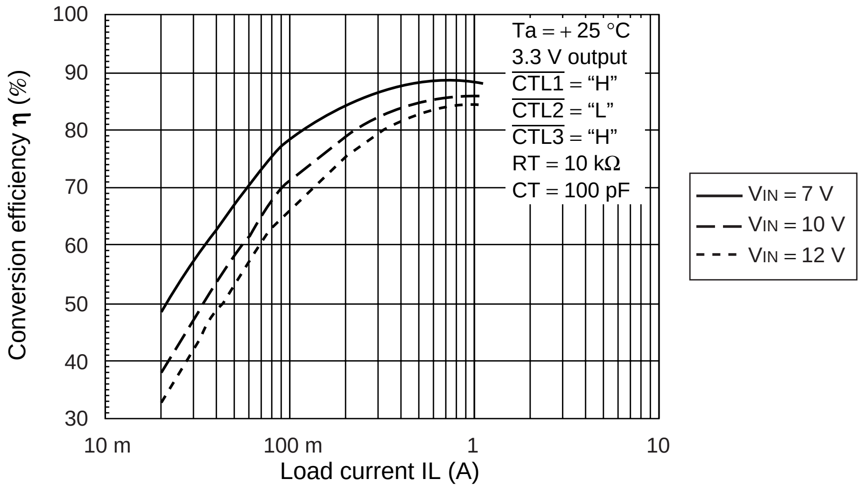
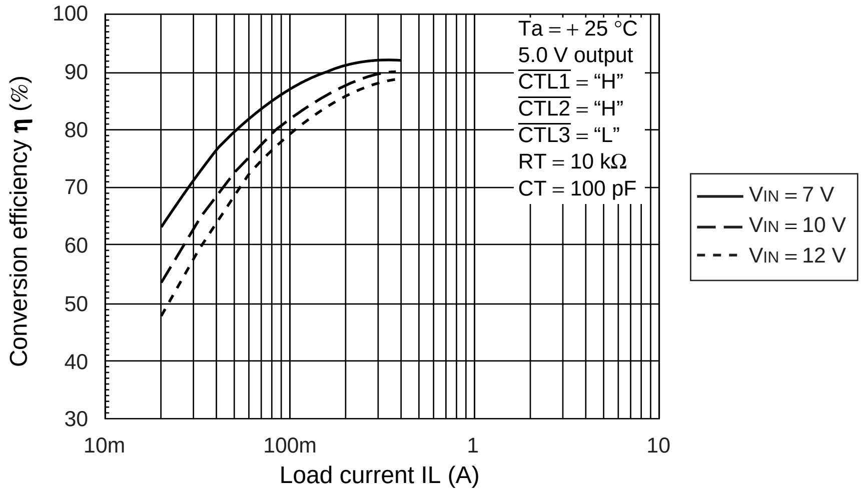
Conversion Efficiency vs. Load Current Characteristics (CH1)



Conversion Efficiency vs. Load Current Characteristics (CH2)



Conversion Efficiency vs. Load Current Characteristics (CH3)



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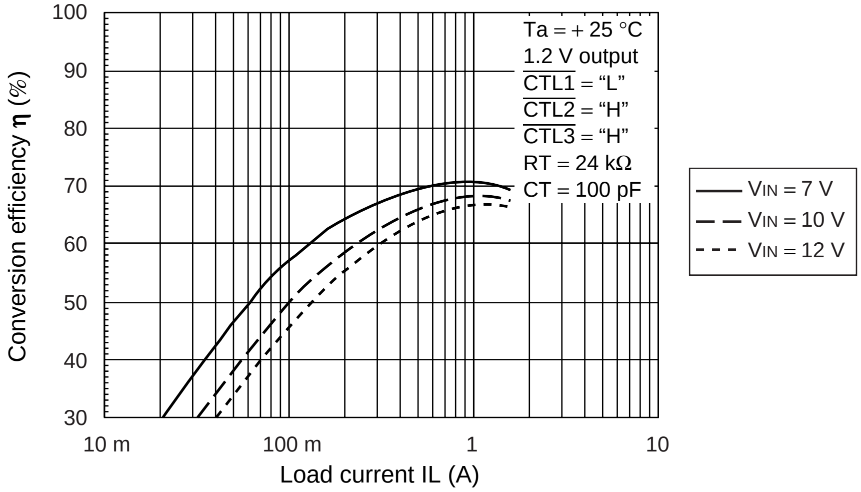
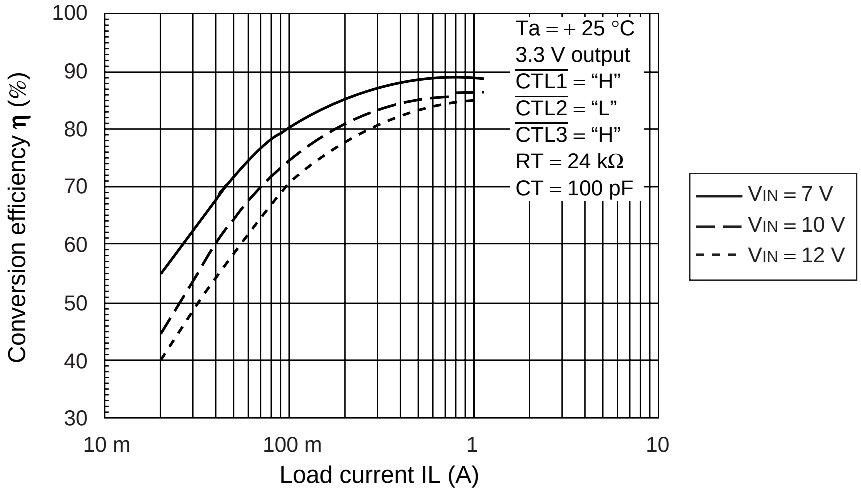
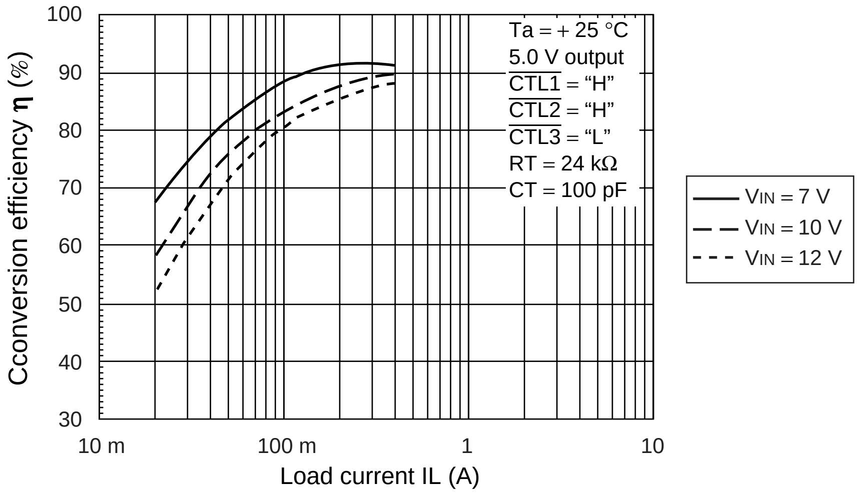
Conversion Efficiency vs. Load Current Characteristics (CH1)



Conversion Efficiency vs. Load Current Characteristics (CH2)



Cconversion Efficiency vs. Load Current Characteristics (CH3)



■ 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.

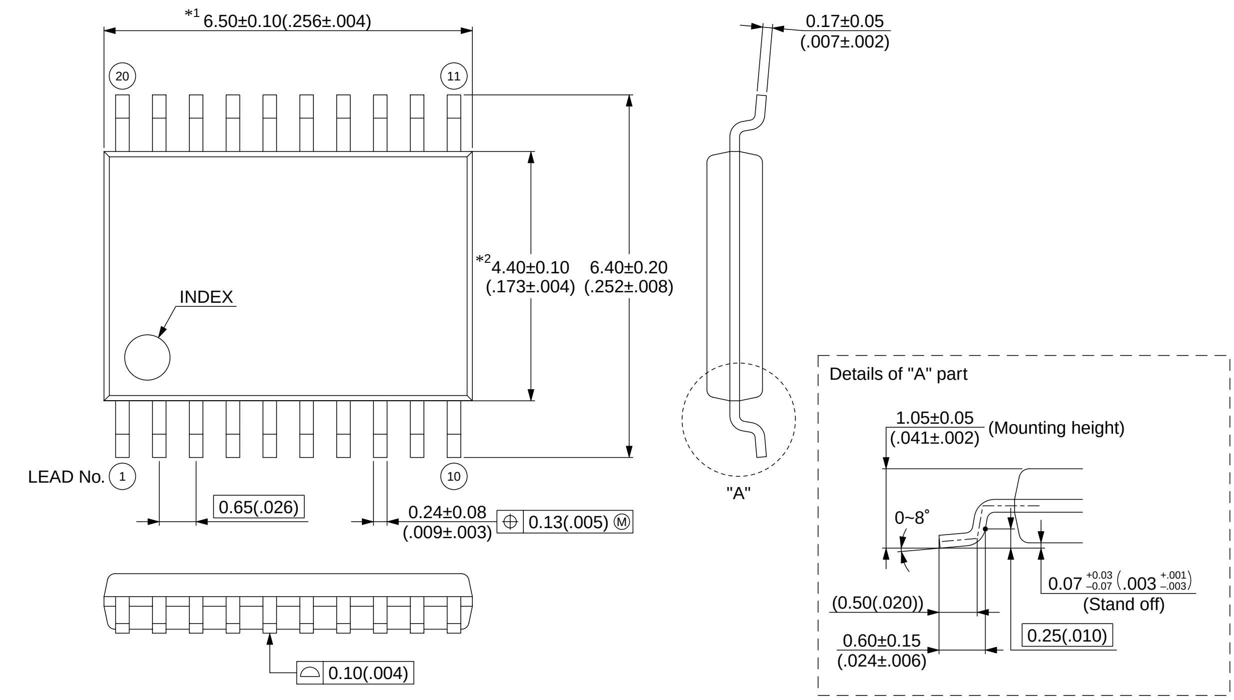
■ ORDERING INFORMATION

Part number	Package	Remarks
MB39A112PFT	20-pin plastic TSSOP (FPT-20P-M06)	

■ PACKAGE DIMENSION

20-pin plastic TSSOP
(FPT-20P-M06)

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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