ASSP For Power Manegement Applications (DC/DC Converter for DSC/Camcorder)

4-ch DC/DC Converter IC
for low voltage

MB39A103

■ DESCRIPTION

The MB39A103 is a 4-channel DC/DC converter IC using pulse width modulation (PWM). This IC is ideal for up conversion, down conversion, and up/down conversion.
Achievement of low voltage start-up (1.7 V or more) enables operation from low voltage.
4ch is built in TSSOP-30P/package. Each channel can be controlled, and soft-start.
This is an ideal power supply for high-performance portable devices such as digital still cameras.
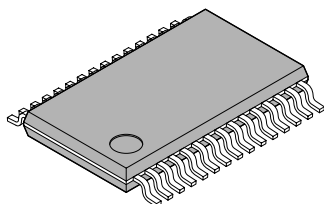This product is covered by US Patent Number 6,147,477.

■ FEATURES

- Supports for down-conversion and up/down Zeta conversion (CH1)
- Supports for up-conversion and up/down Sepic conversion (CH2 to CH4)
- Low voltage start-up (CH4): 1.7 V
- Power supply voltage range : 2.5 V to 11 V
- Reference voltage : 2.0 V $\pm$ 1 %
- Error amplifier threshold voltage : 1.24 V $\pm$ 1.5 %
- Built-in totem-pole type output for MOS FET
- Built-in soft-start circuit independent of loads
- High-frequency operation capability: 1.5 MHz (Max)
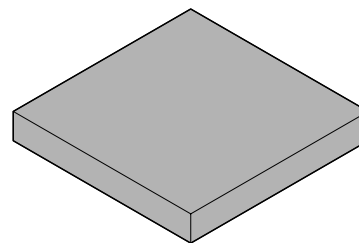- External short-circuit detection capability by −INS terminal
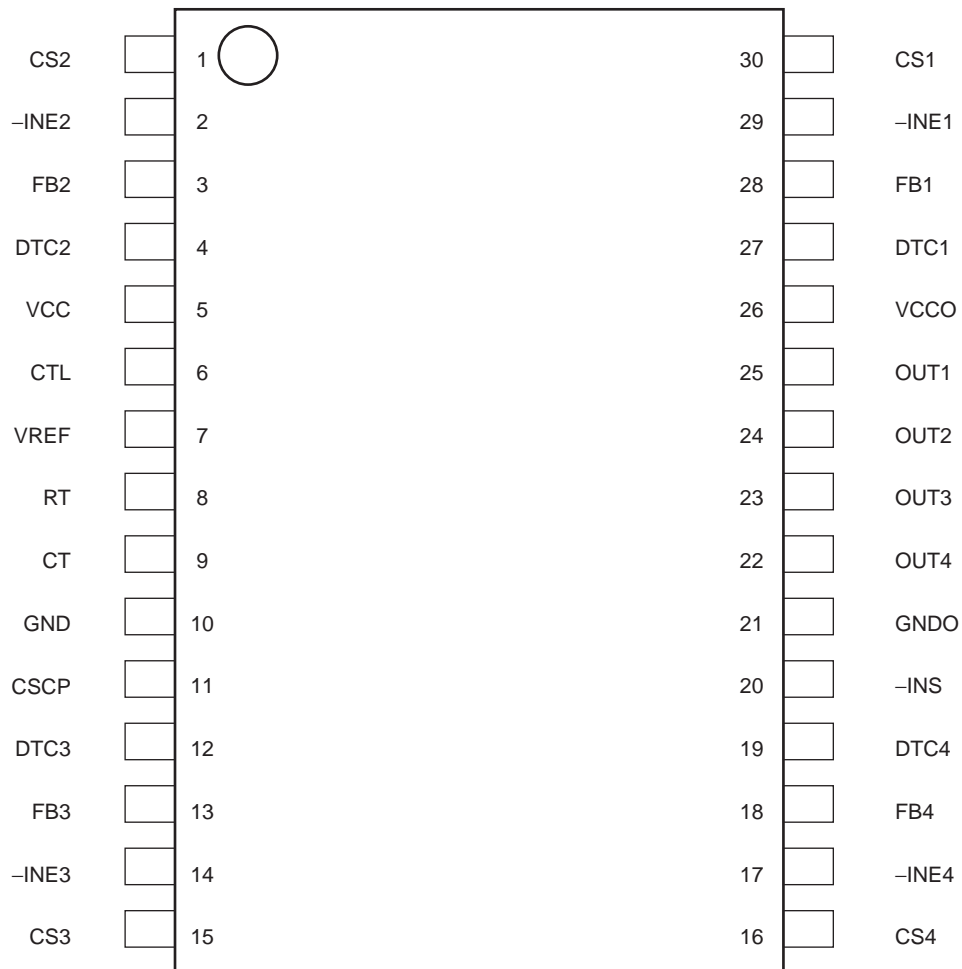
■ PACKAGES

30-pin plastic TSSOP

(FPT-30P-M04)

32-pad plastic BCC

(LCC-32P-M15)

FUJITSU

■ PIN ASSIGNMENTS

(TOP VIEW)

Left	Pin		Pin	Right
CS2	1		30	CS1
−INE2	2		29	−INE1
FB2	3		28	FB1
DTC2	4		27	DTC1
VCC	5		26	VCCO
CTL	6		25	OUT1
VREF	7		24	OUT2
RT	8		23	OUT3
CT	9		22	OUT4
GND	10		21	GNDO
CSCP	11		20	−INS
DTC3	12		19	DTC4
FB3	13		18	FB4
−INE3	14		17	−INE4
CS3	15		16	CS4

(FPT-30P-M04)

(Continued)

(Continued)

(TOP VIEW)
(Penetration diagram from surface)

Left Pin	No.	Right Pin
N.C.	1	DTC1 (25)
VCC	2	VCCO (24)
CTL	3	OUT1 (23)
VREF	4	OUT2 (22)
RT	5	OUT3 (21)
CT	6	OUT4 (20)
GND	7	GNDO (19)
CSCP	8	−INS (18)
N.C.	9	DTC4 (17)

Top pins: DTC2 (32), FB2 (31), −INE2 (30), CS2 (29), CS1 (28), −INE1 (27), FB1 (26)

Bottom pins: DTC3 (10), FB3 (11), −INE3 (12), CS3 (13), CS4 (14), −INE4 (15), FB4 (16)

(LCC-32P-M15)

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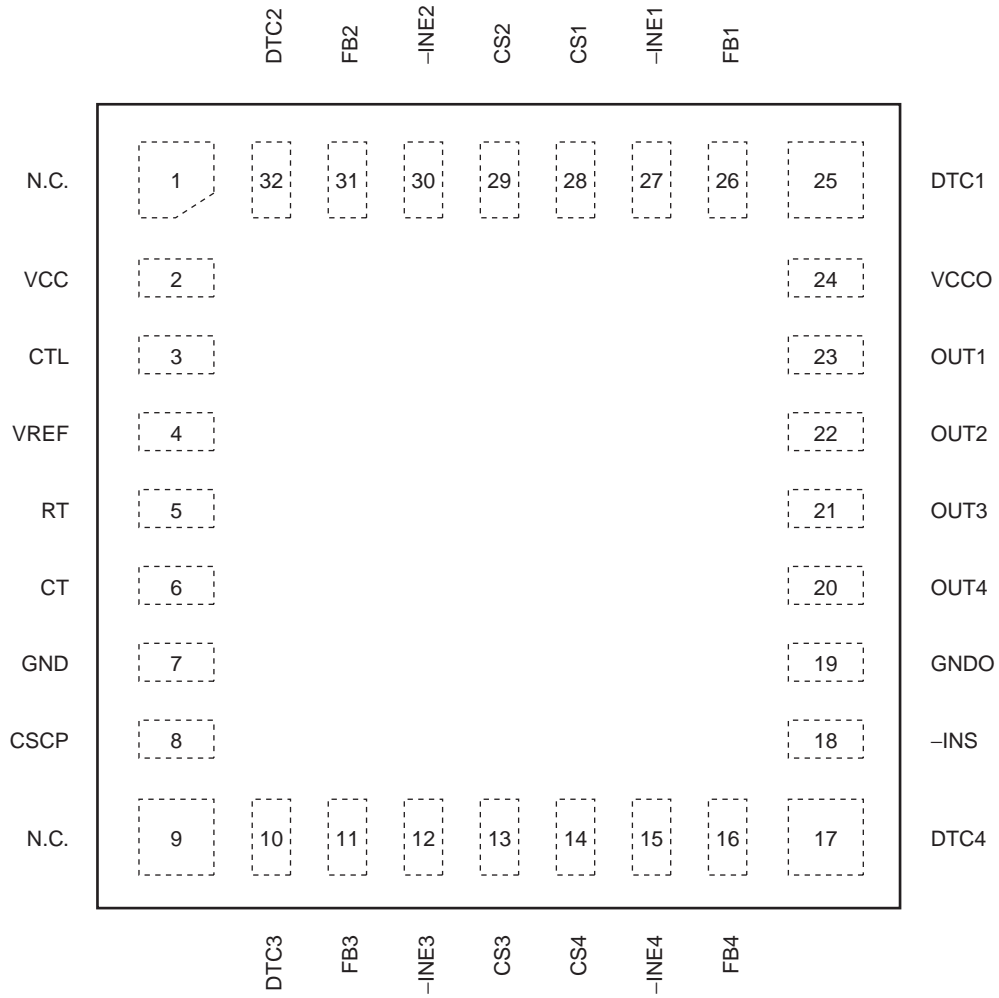
MB39A103

■ PIN DESCRIPTION

Block	Pin No. TSSOP	Pin No. BCC	Symbol	I/O	Descriptions
CH1	27	25	DTC1	I	Dead time control terminal
	28	26	FB1	O	Error amplifier output terminal
	29	27	−INE1	I	Error amplifier inverted input terminal
	30	28	CS1	—	Soft-start setting capacitor connection terminal
	25	23	OUT1	O	Totem pole type output terminal
CH2	4	32	DTC2	I	Dead time control terminal
	3	31	FB2	O	Error amplifier output terminal
	2	30	−INE2	I	Error amplifier inverted input terminal
	1	29	CS2	—	Soft-start setting capacitor connection terminal
	24	22	OUT2	O	Totem pole type output terminal
CH3	12	10	DTC3	I	Dead time control terminal
	13	11	FB3	O	Error amplifier output terminal
	14	12	−INE3	I	Error amplifier inverted input terminal
	15	13	CS3	—	Soft-start setting capacitor connection terminal
	23	21	OUT3	O	Totem pole type output terminal
CH4	19	17	DTC4	I	Dead time control terminal
	18	16	FB4	O	Error amplifier output terminal
	17	15	−INE4	I	Error amplifier inverted input terminal
	16	14	CS4	—	Soft-start setting capacitor connection terminal
	22	20	OUT4	O	Totem pole type output terminal
OSC	9	6	CT	—	Triangular wave frequency setting capacitor connection terminal
	8	5	RT	—	Triangular wave frequency setting resistor connection terminal
Control	6	3	CTL	I	Power supply control terminal
	11	8	CSCP	—	Short-circuit detection circuit capacitor connection terminal
	20	18	−INS	I	Short-circuit detection comparator inverted input terminal
Power	26	24	VCCO	—	Output block power supply terminal
	5	2	VCC	—	Power supply terminal
	7	4	VREF	O	Reference voltage output terminal
	21	19	GNDO	—	Output block ground terminal
	10	7	GND	—	Ground terminal

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■ BLOCK DIAGRAM

−INE1 (29)

Threshold voltage accuracy ±1.5%

VREF
10 μA
Error Amp1

CS1 (30)

1.24 V
L priority

L priority

PWM Comp.1

《CH1》

Drive1
Pch

(26) VCCO

(25) OUT1

Io = 130 mA at VCCO = 4 V

FB1 (28)

DTC1 (27)

−INE2 (2)

Threshold voltage accuracy ±1.5%

VREF
10 μA
Error Amp2

CS2 (1)

1.24 V
L priority

L priority

PWM Comp.2

《CH2》

Drive2
Nch

(24) OUT2

Io = 130 mA at VCCO = 4 V

FB2 (3)

DTC2 (4)

−INE3 (14)

Threshold voltage accuracy ±1.5%

VREF
10 μA
Error Amp3

CS3 (15)

1.24 V
L priority

L priority

PWM Comp.3

《CH3》

Drive3
Nch

(23) OUT3

Io = 130 mA at VCCO = 4 V

FB3 (13)

DTC3 (12)

−INE4 (17)

Threshold voltage accuracy ±1.5%

VREF
10 μA
Error Amp4

CS4 (16)

1.24 V
L priority

L priority

PWM Comp.4

《CH4》

Drive4
Nch

(22) OUT4

(21) GNDO

Io = 130 mA at VCCO = 4 V

FB4 (18)

DTC4 (19)

Short detection signal (L: at short)

VREF
100 kΩ
SCP Comp.

−INS (20)

1 V

SCP

H: at SCP

Error Amp Power Supply
SCP Comp. Power Supply

(5) VCC

CSCP (11)

0.9 V
0.4 V

UVLO2

bias

Error Amp Reference
1.24 V

OSC

UVLO1

Accuracy ±1%

VREF

VR1
Power ON/OFF CTL

(6) CTL

H:UVLO release

2.0 V

(8) RT

(9) CT

(7) VREF

(10) GND

H : ON (Power/ ON)
L : OFF (Standby mode)
$V_{TH} = 1.4$ V

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power supply voltage	V_{CC}	VCC, VCCO terminals	—	12	V
Output current	I_O	OUT1 to OUT4 terminals	—	20	mA
Peak output current	I_{OP}	OUT1 to OUT4 terminals Duty $\leq$ 5% (t = 1/f_{osc}×Duty)	—	400	mA
Power dissipation	P_D	$T_A \leq$ +25 °C (TSSOP-30P)	—	1390*	mW
		$T_A \leq$ +25 °C (BCC-32P)	—	980*	mW
Storage temperature	T_{STG}	—	−55	+125	°C

* : The packages are mounted on the epoxy board (10 cm $\times$ 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	
Start power supply voltage	V_{CC}	VCC, VCCO terminals (CH4)	1.7	—	11	V
Power supply voltage	V_{CC}	VCC, VCCO terminal s (CH1 to CH4)	2.5	4	11	V
Reference voltage output current	I_{REF}	VREF terminal	−1	—	0	mA
Input voltage	V_{INE}	−INE1 to −INE4 terminals	0	—	V_{CC} − 0.9	V
		−INS terminal	0	—	V_{REF}	V
	V_{DTC}	DTC1 to DTC4 terminals	0	—	V_{REF}	V
Control input voltage	V_{CTL}	CTL terminal	0	—	11	V
Output current	I_O	OUT1 to OUT4 terminals	−15	—	+15	mA
Oscillation frequency	f_{OSC}	*	100	500	1500	kHz
Timing capacitor	C_T	—	39	100	560	pF
Timing resistor	R_T	—	11	24	130	kΩ
Soft-start capacitor	C_S	CS1 to CS4 terminals	—	0.1	1.0	μF
Short-circuit detection capacitor	C_{SCP}	—	—	0.1	1.0	μF
Reference voltage output capacitor	C_{REF}	—	—	0.1	1.0	μF
Operating ambient temperature	T_A	—	−30	+25	+85	°C

* : See "■ SETTING THE TRIANGULAR OSCILLATION FREQUENCY".

Note: Pin numbers referred after this part are present on TSSOP-30P PKG.

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 representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

(VCC = VCCO = 4 V, T_A = +25 °C)

Parameter		Symbol	Pin No	Conditions	Value			Unit
					Min	Typ	Max	
Reference voltage block [Ref]	Output voltage	V_{REF}	7	—	1.98	2.00	2.02	V
	Output voltage temperature stability	$\Delta V_{REF}/V_{REF}$	7	T_A = −30 °C to +85 °C	—	0.5*	—	%
	Input stability	Line	7	VCC = 2.5 V to 11 V	−10	—	+10	mV
	Load stability	Load	7	VREF = 0 mA to −1 mA	−10	—	+10	mV
Under voltage lockout protection circuit block (CH4) [UVLO1]	Threshold voltage	V_{TH}	22	VCC = ⌐	1.4	1.5	1.65	V
	Hysteresis width	V_H	22	—	0.02	0.05	0.1	V
Under voltage lockout protection circuit block (CH1 to CH3) [UVLO2]	Threshold voltage	V_{TH}	25	VCC = ⌐	1.7	1.8	1.95	V
	Hysteresis width	V_H	25	—	0.05	0.1	0.2	V
Short-circuit detection block [SCP]	Threshold voltage	V_{TH}	11	—	0.65	0.70	0.75	V
	Input source current	I_{CSCP}	11	—	−1.4	−1.0	−0.6	μA
	Reset voltage	V_{RST}	25	VREF = ⌐	1.3	1.45	1.63	V
Triangular wave oscillator block [OSC]	Oscillation frequency	f_{OSC}	22, 23, 24, 25	CT = 100 pF, RT = 24 kΩ	450	500	550	kHz
	Frequency temperature stability	$\Delta f_{OSC}/f_{OSC}$	22, 23, 24, 25	T_A = −30 °C to +85 °C	—	1*	—	%
Soft-start block [CS1 to CS4]	Charge current	I_{CS}	1, 15, 16, 30	CS1 to CS4 = 0 V	−14	−10	−6	μA
Error amplifier block [Error Amp1 to Error Amp4]	Threshold voltage	V_{TH}	3, 13, 18, 28	FB1 to FB4 = 0.65 V	1.222	1.240	1.258	V
	Input bias current	I_B	2, 14, 17, 29	−INE1 to −INE4 = 0 V	−120	−30	—	nA
	Voltage gain	A_V	3, 13, 18, 28	DC	—	100*	—	dB
	Frequency bandwidth	BW	3, 13, 18, 28	A_V = 0 dB	—	1.6*	—	MHz

* : Standard design value

(Continued)

(VCC = VCCO = 4 V, T_A = +25 °C)

Parameter		Symbol	Pin No	Conditions	Value			Unit
					Min	Typ	Max	
Error amplifier block [Error Amp1 to Error Amp4]	Output voltage	V_{OH}	3, 13, 18, 28	—	1.7	1.9	—	V
		V_{OL}	3, 13, 18, 28	—	—	40	200	mV
	Output source current	I_{SOURCE}	3, 13, 18, 28	FB1 to FB4 = 0.65 V	—	−2	−1	mA
	Output sink current	I_{SINK}	3, 13, 18, 28	FB1 to FB4 = 0.65 V	150	200	—	µA
PWM comparator block [PWM Comp.1 to PWM Comp.4]	Threshold voltage	V_{T0}	22, 23, 24, 25	Duty cycle = 0 %	0.3	0.4	—	V
		V_{T100}	22, 23, 24, 25	Duty cycle = Dtr	—	0.9	1.0	V
	Input current	I_{DTC}	4, 12, 19, 27	DTC1 to DTC4 = 0.4 V	−2.0	−0.6	—	µA
Output block [Drive1 to Drive4]	Output source current	I_{SOURCE}	22, 23, 24, 25	Duty ≤ 5 % (t = 1/fosc×Duty) OUT1 to OUT4 = 0 V	—	−130	−75	mA
	Output sink current	I_{SINK}	22, 23, 24, 25	Duty ≤ 5 % (t = 1/fosc×Duty) OUT1 to OUT4 = 4 V	75	130	—	mA
	Output ON resistor	R_{OH}	22, 23, 24, 25	OUT1 to OUT4 = −15 mA	—	18	27	Ω
		R_{OL}	22, 23, 24, 25	OUT1 to OUT4 = 15 mA	—	18	27	Ω
Short-circuit detection comparator block [SCP Comp.]	Threshold voltage	V_{TH}	25	—	0.97	1.00	1.03	V
	Input bias current	I_B	20	−INS = 0 V	−25	−20	−17	µA
Control block [CTL]	CTL input voltage	V_{IH}	6	IC Active mode	1.7	—	11	V
		V_{IL}	6	IC Standby mode	0	—	0.8	V
	Input current	I_{CTLH}	6	CTL = 3 V	5	30	60	µA
		I_{CTLL}	6	CTL = 0 V	—	—	1	µA
General	Standby current	I_{CCS}	5	CTL = 0 V	—	0	2	µA
		I_{CCSO}	26	CTL = 0 V	—	0	2	µA
	Power supply current	I_{CC}	5	CTL = 3 V	—	2.3	4.5	mA

*: Standard design value.

■ **TYPICAL CHARACTERISTICS**

Power Supply Current vs. Power Supply Voltage

$T_A = +25\ °C$
$CTL = 3\ V$

Power supply current I_{CC} (mA) vs. Power supply voltage V_{CC} (V)
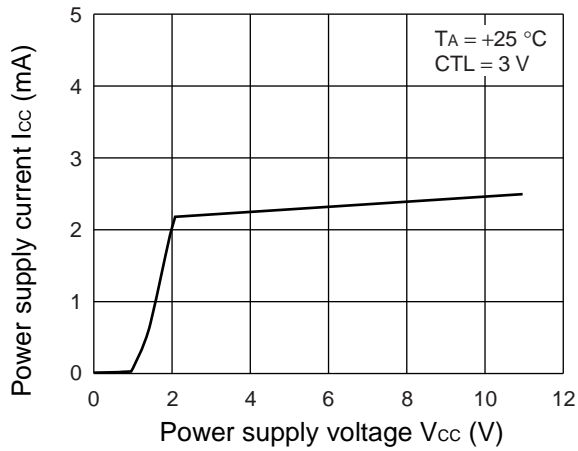
Reference Voltage vs. Power Supply Voltage

$T_A = +25\ °C$
$CTL = 3\ V$
$VREF = 0\ mA$

Reference voltage V_{REF} (V) vs. Power supply voltage V_{CC} (V)
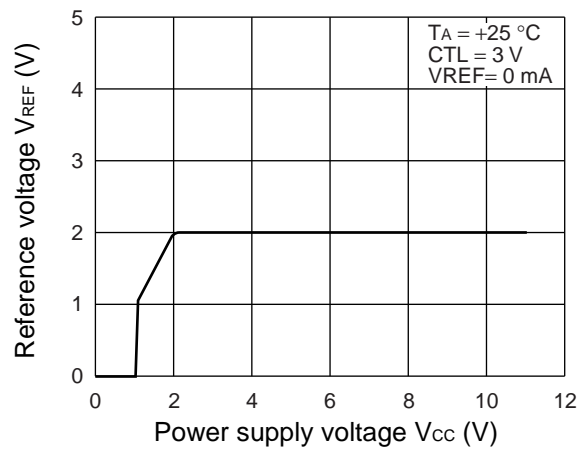
Reference Voltage vs. Operating Ambient Temperature

$VCC = 4\ V$
$CTL = 3\ V$
$VREF = 0\ mA$

Reference voltage V_{REF} (V) vs. Operating ambient temperature T_A (°C)
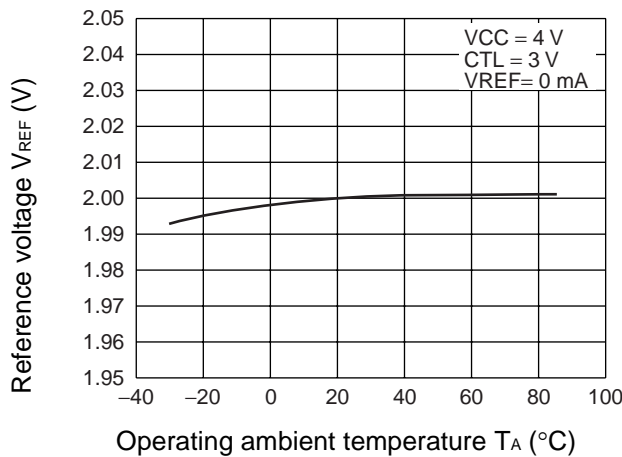
Reference Voltage vs. CTL terminal Voltage

$T_A = +25\ °C$
$VCC = 4\ V$
$VREF = 0\ mA$
$CTL = 3\ V$

Reference voltage V_{REF} (V) vs. CTL terminal voltage V_{CTL} (V)
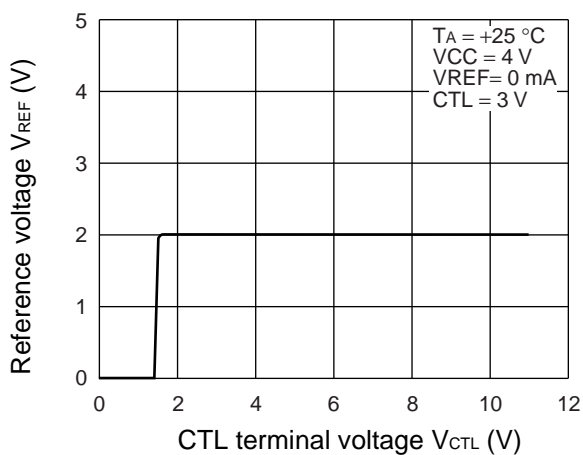
CTL terminal Current vs. CTL terminal Voltage

$T_A = +25\ °C$
$VCC = 4\ V$

CTL terminal current I_{CTL} (μA) vs. CTL terminal voltage V_{CTL} (V)

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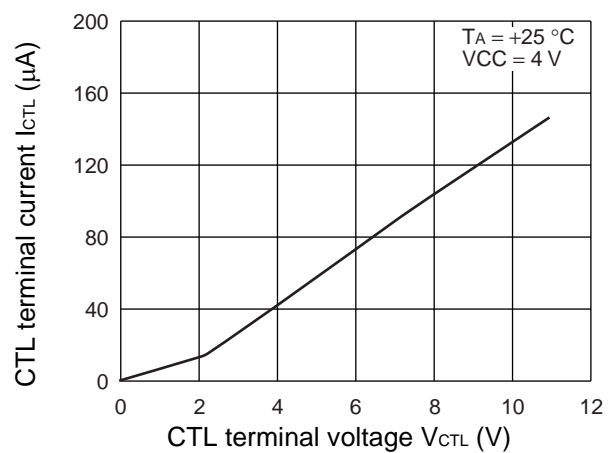
Triangular Wave Oscillation Frequency vs. Timing Resistor

Triangular wave oscillation frequency f_{OSC} (kHz)

$T_A = +25\ °C$
$VCC = 4\ V$
$CTL = 3\ V$

CT = 39 pF
CT = 100 pF
CT = 560 pF
CT = 220 pF

Timing resistor R_T (kΩ)
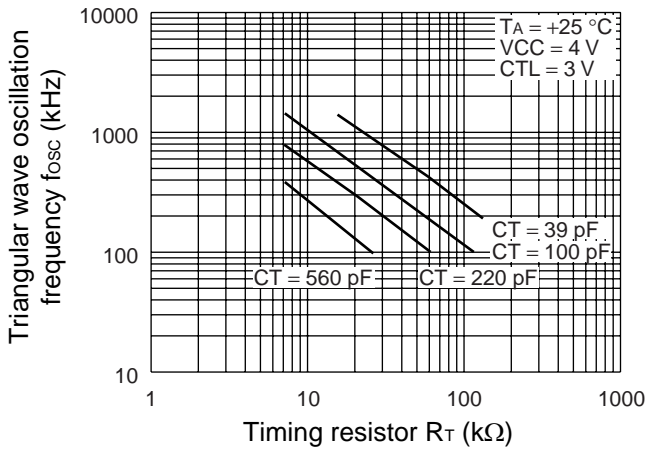
Triangular Wave Oscillation Frequency vs. Timing Capacitor

Triangular wave oscillation frequency f_{OSC} (kHz)

$T_A = +25\ °C$
$VCC = 4\ V$
$CTL = 3\ V$

RT = 11 kΩ
RT = 24 kΩ
RT = 130 kΩ
RT = 56 kΩ

Timing capacitor C_T (pF)
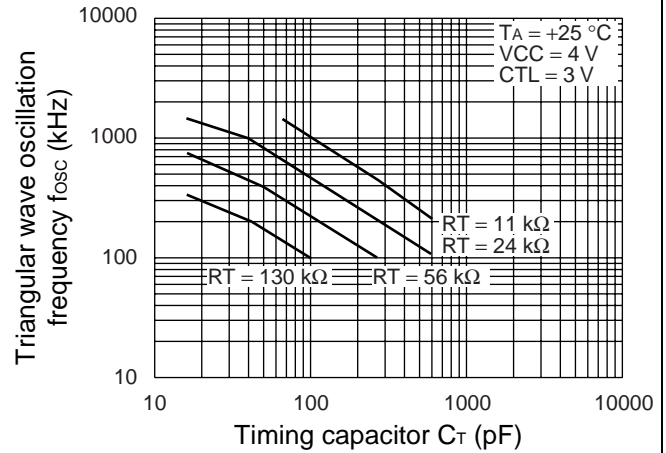
Triangular Wave Upper and Lower Limit Voltage vs. Triangular Wave Oscillation Frequency

Triangular wave upper and lower limit voltage V_{CT} (V)

$T_A = +25\ °C$
$VCC = 4\ V$
$CTL = 3\ V$
$RT = 24\ k\Omega$

Upper

Lower

Triangular wave oscillation frequency f_{OSC} (kHz)
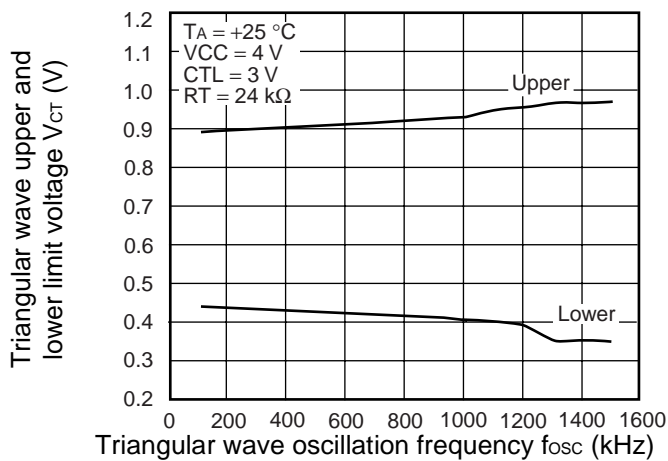
Triangular Wave Upper and Lower Limit Voltage vs. Operating Ambient Temperature

Triangular wave upper and lower limit voltage V_{CT} (V)

$VCC = 4\ V$
$CTL = 3\ V$
$RT = 24\ k\Omega$
$CT = 100\ pF$

Upper

Lower

Operating ambient temperature T_A (°C)
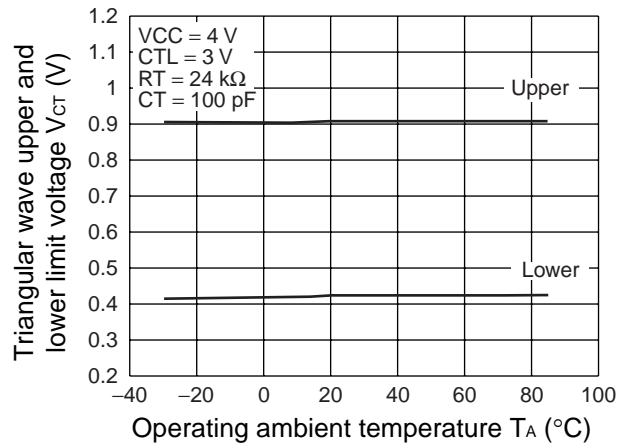
Triangular Wave Oscillation Frequency vs. Operating Ambient Temperature

Triangular wave oscillation frequency f_{OSC} (kHz)

$VCC = 4\ V$
$CTL = 3\ V$
$RT = 24\ k\Omega$
$CT = 100\ pF$

Operating ambient temperature T_A (°C)
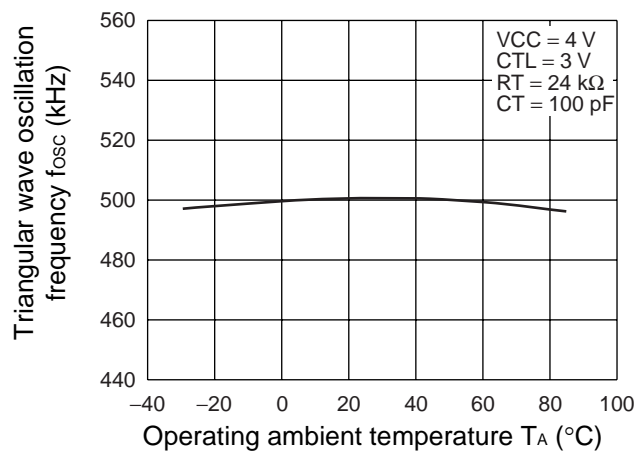
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Error Amplifier Voltage Gain, Phase vs. Frequency
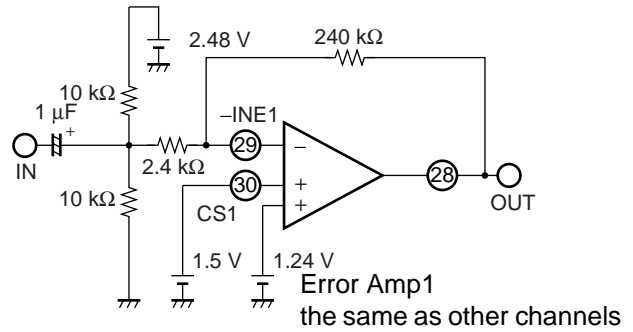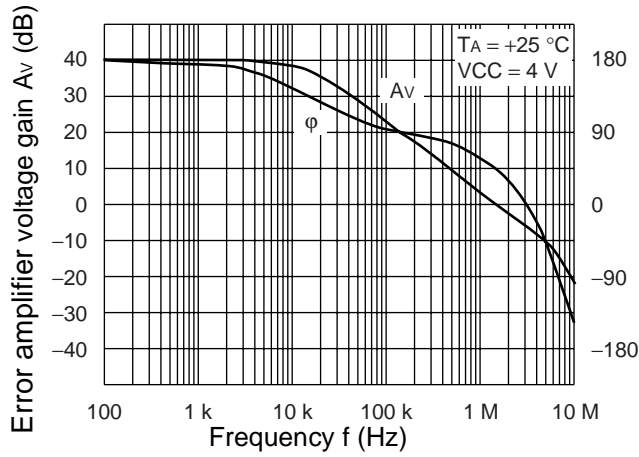
Power Dissipation vs.
Operating Ambient Temperature
(TSSOP-30P)
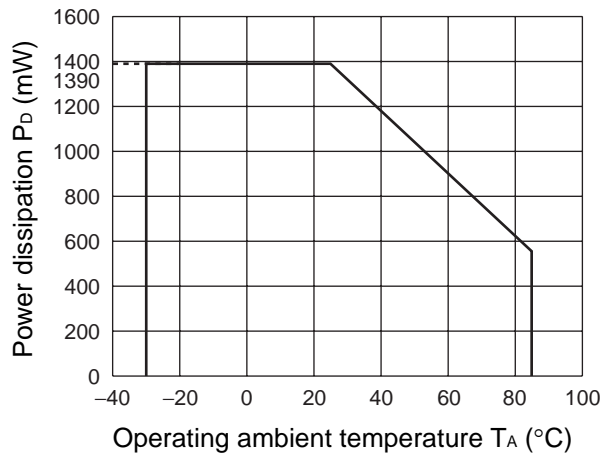
Power Dissipation vs.
Operating Ambient Temperature
(BCC-32P)
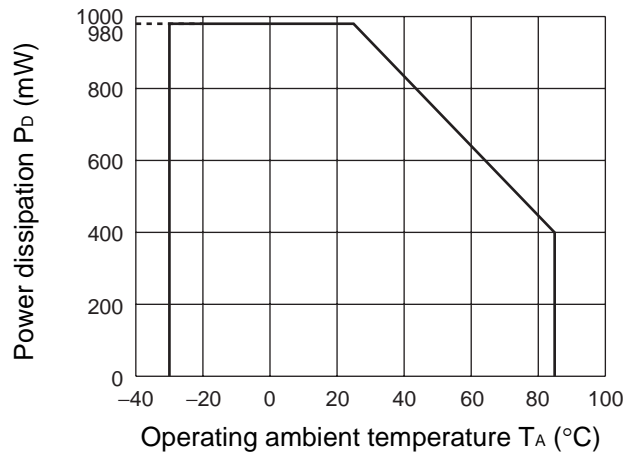
■ FUNCTIONS

1. DC/DC Converter Functions

(1) Reference voltage block (Ref)

The reference voltage circuit generates a temperature-compensated reference voltage (2.0 V Typ) from the voltage supplied from the VCC terminal (pin 5). The voltage is used as the reference voltage for the IC's internal circuitry.
The reference voltage can supply a load current of up to 1 mA to an external device through the VREF terminal (pin 7).

(2) Triangular-wave oscillator block (OSC)

The triangular wave oscillator incorporates a timing capacitor and a timing resistor connected respectively to the CT terminal (pin 9) and RT terminal (pin 8) to generate triangular oscillation waveform amplitude of 0.4 V to 0.9 V.
The triangular waveforms are input to the PWM comparator in the IC.

(3) Error amplifier block (Error Amp1 to Error Amp4)

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 terminal (pin 30) to CS4 terminal (pin 16) 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.

(4) PWM comparator block (PWM Comp.1 to PWM Comp.4)

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

(5) Output block (Drive1 to Drive4)

The output block is in the totem pole type, capable of driving an external P-channel MOS FET (channel 1), and N-channel MOS FET (channels 2 to 4).

2. Channel Control Function

The main or each channel is turned on and off depending on the voltage levels at the CTL terminal (pin 6), CS1 terminal (pin 30), CS2 terminal (pin 1), CS3 terminal (pin 15), and CS4 terminal (pin 16).

Channel On/Off Setting Conditions

CTL	CS1	CS2	CS3	CS4	Power	CH1	CH2	CH3	CH4
L	—*	—*	—*	—*	OFF	OFF	OFF	OFF	OFF
H	GND	GND	GND	GND	ON	OFF	OFF	OFF	OFF
H	High-Z	GND	GND	GND	ON	ON	OFF	OFF	OFF
H	GND	High-Z	GND	GND	ON	OFF	ON	OFF	OFF
H	GND	GND	High-Z	GND	ON	OFF	OFF	ON	OFF
H	GND	GND	GND	High-Z	ON	OFF	OFF	OFF	ON
H	High-Z	High-Z	High-Z	High-Z	ON	ON	ON	ON	ON

*: Undefined

3. Protective Functions

(1) Timer-latch short-circuit protection circuit (SCP, SCP Comp.)

The short-circuit detection comparator detects the Error Amp output voltage level of each channel, and if any channel output voltage of Error Amp reaches the short-circuit detection voltage, the timer circuits are actuated to start charging the external capacitor C_{SCP} connected to the CSCP terminal (pin 11).
When the capacitor (C_{SCP}) voltage reaches about 0.7 V, the circuit is turned off the output transistor and sets the dead time to 100 %.
In addition, the short-circuit detection from external input is capable by using −INS terminal (pin 20) on short-circuit detection comparator (SCP Comp.) .
To release the actuated protection circuit, either the power supply turn off and on again or set the CTL terminal (pin 6) to the "L" level to lower the VREF terminal (pin 7) voltage to 1.3 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 transistor, and sets the dead time to 100% while holding the CSCP terminal (pin 11) 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.
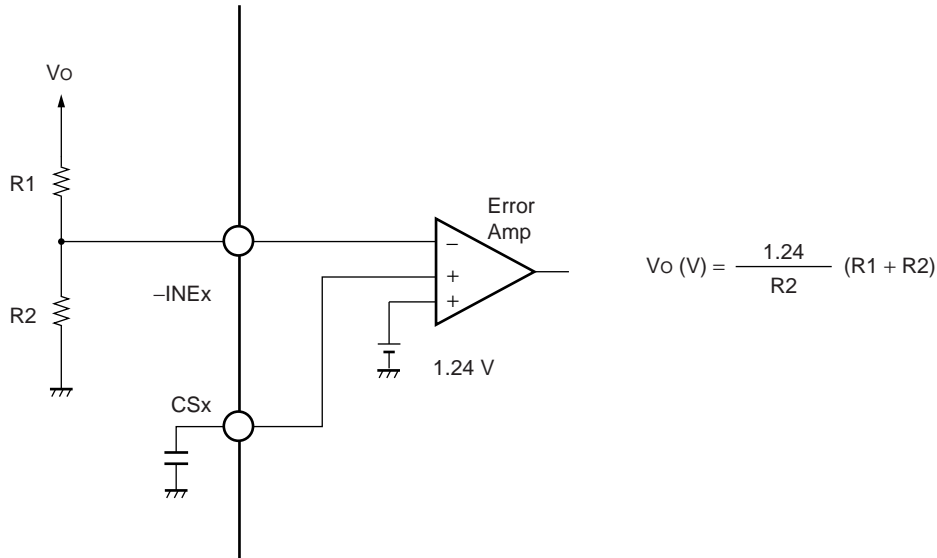
■ PROTECTION CIRCUIT OPERATING FUNCTION TABLE

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

Operating circuit	OUT1	OUT2	OUT3	OUT4
Short-circuit protection circuit	H	L	L	L
Under voltage lockout protection circuit	H	L	L	L

■ SETTING THE OUTPUT VOLTAGE

• **CH1 to CH4**

V$_O$

R1

R2

−INEx

CSx

Error
Amp

−

+

+

1.24 V

$$V_O (V) = \frac{1.24}{R2} (R1 + R2)$$

x: Each channel No.

■ SETTING THE TRIANGULAR OSCILLATION FREQUENCY

The triangular oscillation frequency is determined by the timing capacitor (C$_T$) connected to the CT terminal
(pin 9), and the timing resistor (R$_T$) connected to the RT terminal (pin 8).
Moreover, it shifts more greatly than the calculated values according to the constant of timing resistor (R$_T$) when
the triangular wave oscillation frequency exceeds 1 MHz. Therefore, set it referring to "Triangular Wave Oscillation
Frequency vs. Timing Resistor" and "Triangular Wave Oscillation Frequency vs. Timing Capacitor" in "■   TYP-
ICAL CHARACTERISTICS".

Triangular oscillation frequency : f$_{OSC}$

$$f_{OSC} \text{ (kHz)} \doteqdot \frac{1200000}{C_T \text{ (pF)} \cdot R_T \text{ (k}\Omega)}$$

■ SETTING THE SOFT-START TIME

To prevent rush currents when the IC is turned on, you can set a soft-start by connecting soft-start capacitors (C_{S1} to C_{S4}) to the CS1 terminal (pin 30) to the CS4 terminal (pin 16), respectively.

Setting each $\overline{CTLx}$ from "H" to "L" switches to charge the external soft-start capacitors (C_{S1} to C_{S4}) connected to the CS1 terminal (pin 30) to CS4 terminal (pin 16) at 10 μA.

The error amplifier output (FB1 to FB4) is determined by comparison between the lower one of the potentials at two non-inverted input terminals (1.24 V, CS terminal voltages) and the inverted input terminal voltage (−INE1 to −INE4).

The FB terminal voltage during the soft-start period (CS terminal voltage < 1.24 V) is therefore determined by comparison between the −INE terminal and CS terminal voltages. The DC/DC converter output voltage rises in proportion to the CS terminal voltage as the soft-start capacitor connected to the CS terminal is charged.

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

Soft-start time: ts (time to output 100%)
ts (s) $\doteqdot$ 0.124 × C_{SX} (μF)

• **Soft-Start Circuit**

x: Each channel No.
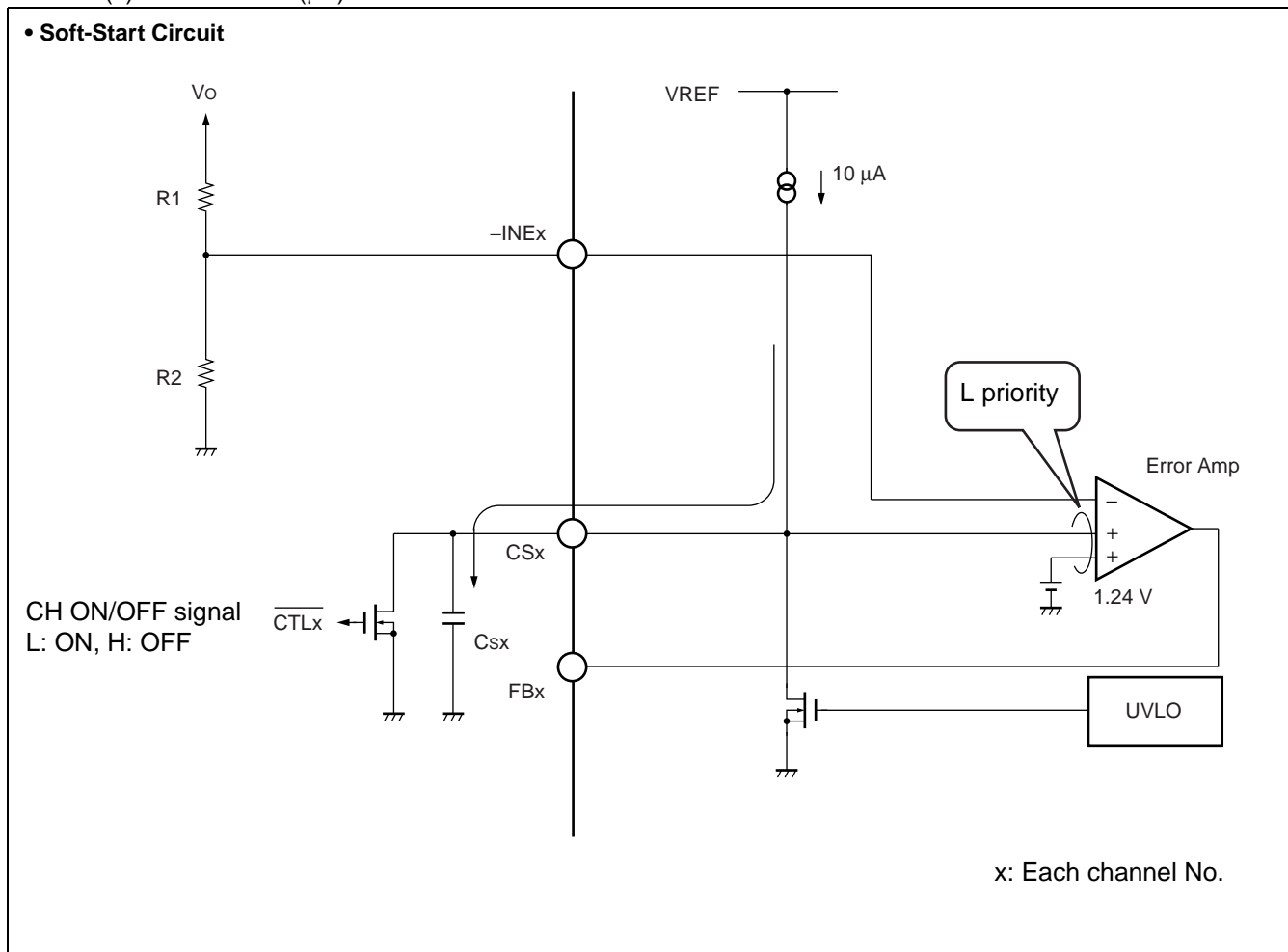
■ **TREATMENT WITHOUT USING CS TERMINAL**

When not using the soft-start function, open the CS1 terminal (pin 30), the CS2 terminal (pin 1), the CS3 terminal (pin 15), the CS4 terminal (pin 16).

• **Without Setting Soft-Start Time**

"OPEN"　　　　　　　　　　　　　　　　"OPEN"

◯──── ①　CS2　　　　　　CS1　㉚ ────◯

"OPEN"　　　　　　　　　　　　　"OPEN"

◯──── ⑮　CS3　　　　　　CS4　⑯ ────◯
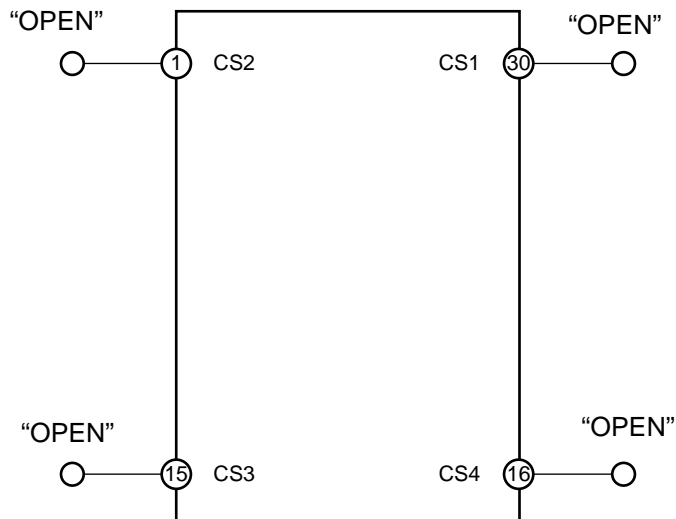
■ SETTING TIME CONSTANT FOR TIMER-LATCH SHORT-CIRCUIT PROTECTION CIRCUIT

Each channel uses the short-circuit detection comparator (SCP) 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 11) 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 11) to be charged at 1 μA.

Short-circuit detection time : t_{SCP}

t_{SCP} (s) ≑ $0.70 \times C_{SCP}$ (μF)

When the capacitor C_{SCP} is charged to the threshold voltage (V_{TH} ≑ 0.70 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 11) is held at "L" level.

In addition, the short-circuit detection from external input is capable by using −INS terminal (pin 20) on the short-circuit detection comparator (SCP Comp.). The short-circuit detection operation starts when −INS terminal voltage is less than threshold voltage (V_{TH} ≑ 1 V).

When the power supply is turn off and on again or VREF terminal (pin 7) voltage is less than 1.3 V (Min) by setting CTL terminal (pin 6) to "L" level, the latch is released.

• Timer-latch short-circuit protection circuit
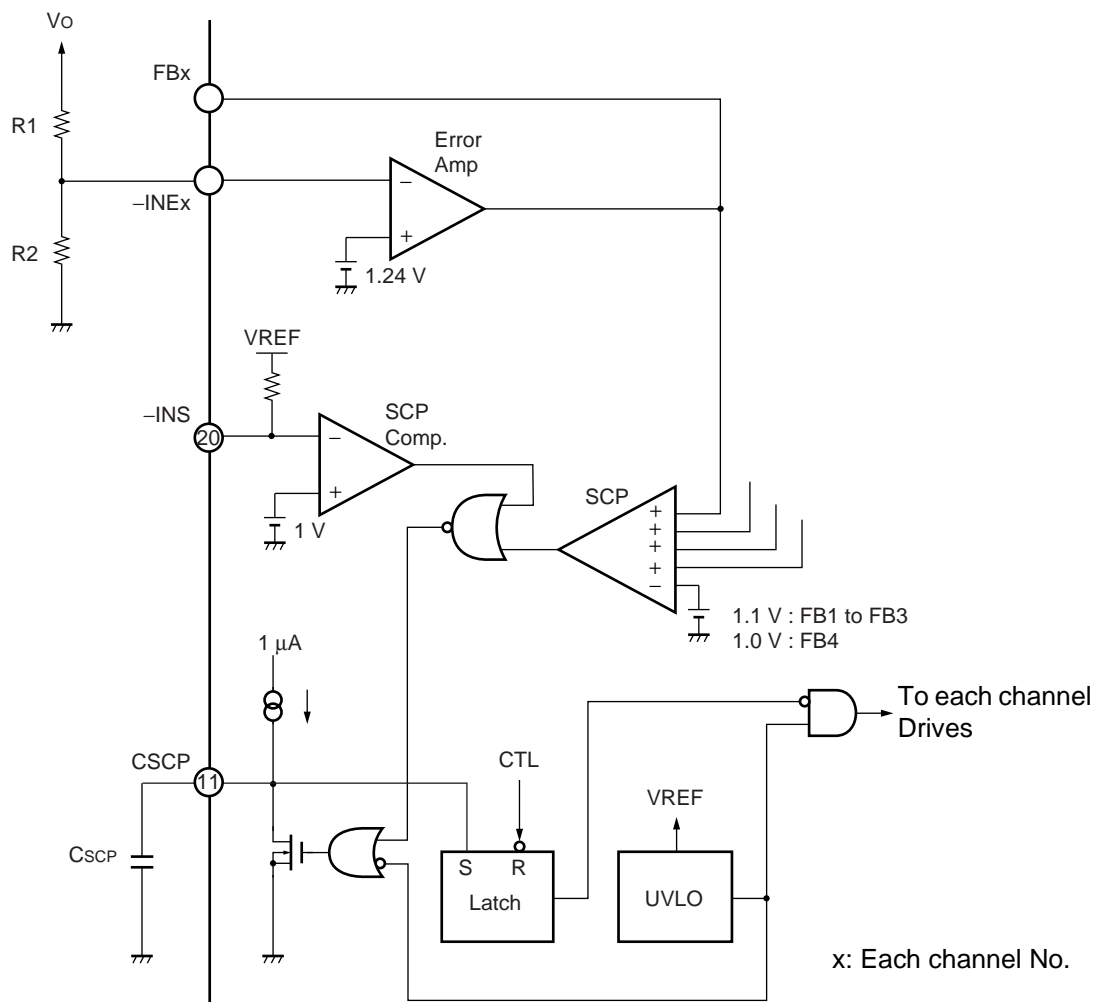
Note : When using self-power supply configuration in which the output from the CH4 DC/DC converter is connected to the VCC, note that short-circuit detection is not possible in the CH4 DC/DC converter output.

■ **TREATMENT WITHOUT USING CSCP TERMINAL**

When not using the timer-latch short-circuit protection circuit, connect the CSCP terminal (pin 11) to GND (pin 10) with the shortest distance.

• **Treatment without using CSCP terminal**

⑩　GND

⑪　CSCP
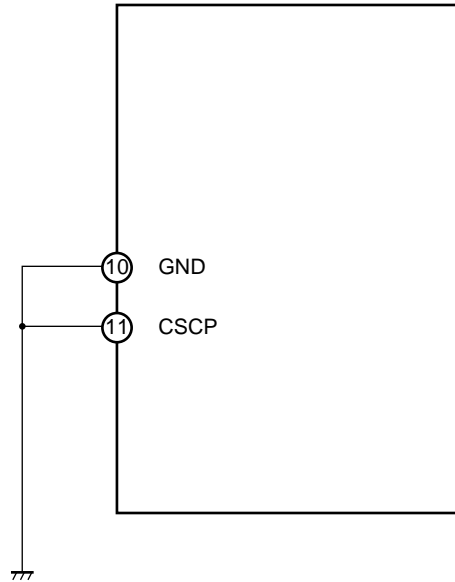
■ SETTING THE DEAD TIME

When the device is set for step-up or inverted output based on the step-up or step-up/down Zeta conversion, step-up/down Sepic conversion or flyback conversion, the FB terminal voltage may reach and exceed the triangular wave voltage due to load fluctuation. If this is the case, the output transistor is fixed to a full-ON state (ON duty = 100 %). To prevent this, set the maximum duty of the output transistor. To set it, set the voltage at the DTC terminal by applying a resistive voltage divider to the VREF voltage as shown below.

When the DTC terminal voltage is higher than the triangular wave voltage, the output transistor is turned on. The maximum duty calculation formula assuming that triangular wave amplitude ≒ 0.5 V and triangular wave lower voltage ≒ 0.4 V is given below.
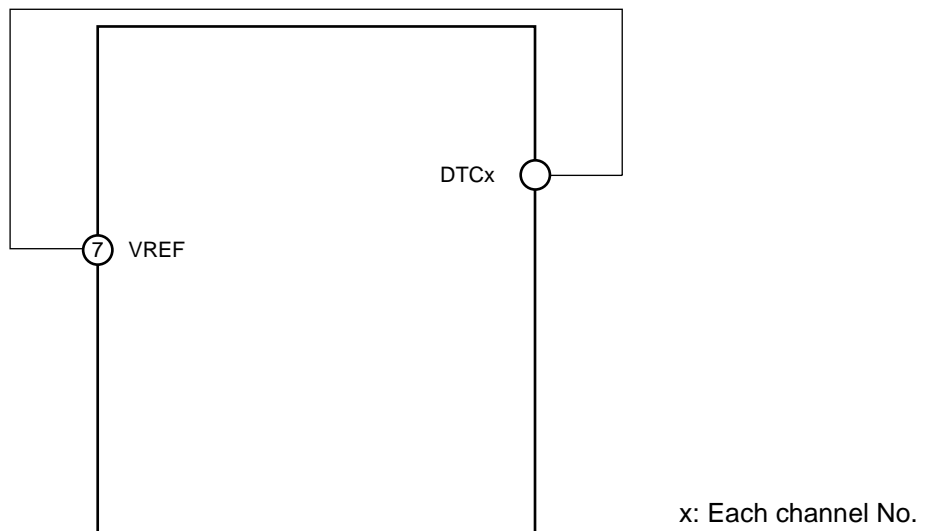
$$\text{DUTY (ON) Max} \fallingdotseq \frac{\text{Vdt} - 0.4 \text{ V}}{0.5 \text{ V}} \times 100 \text{ (\%)} \text{ , Vdt (V)} = \frac{\text{Rb}}{\text{Ra} + \text{Rb}} \times \text{VREF}$$

When the DTC terminal is not used, connect it directly to the VREF terminal (pin 7) as shown below (when no dead time is set).
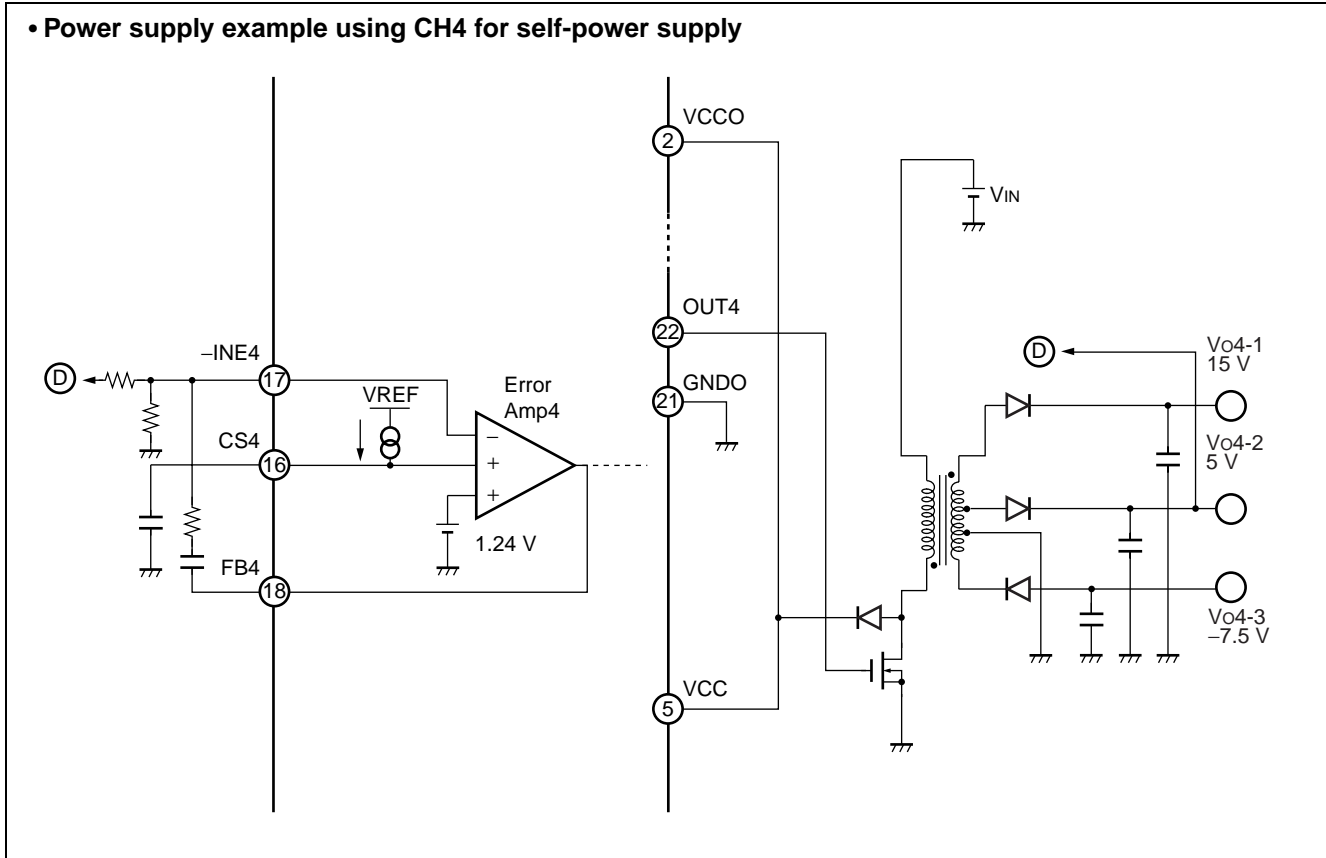

• When using DTC to set dead time

x: Each channel No.

• When no dead time is set

x: Each channel No.
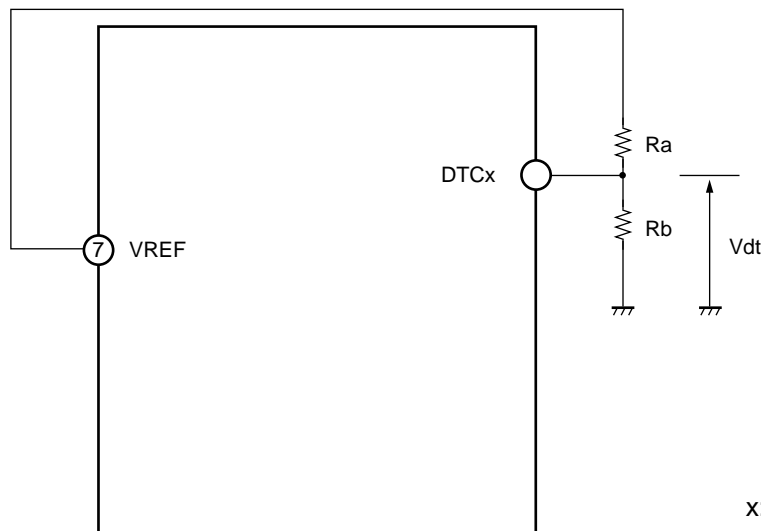
■ POWERR SUPPLY EXAMPLE USING CH4 FOR SELF-POWER SUPPLY

The MB39A103 can be started with the low input voltage ($V_{IN} \geq 1.7$ V) if the CH4 is used as a self-power supply. An example of supply the power using the transformer is shown below.

• **Power supply example using CH4 for self-power supply**

Setting shown in the "■ APPLICATION EXAMPLE" is as follows:
• Number of windings for VCC and VCCO is set to the value equivalent to $V_{IN} + 2.5$ V.

CH1 to CH3 are operational on VCC ≥ 2.5 V; in order for the CH1 to CH3 to operate on $V_{IN} \geq 1.7$ V, the number of windings should be set equivalent to $V_{IN} + 0.8$ V or more for VCC and VCCO.

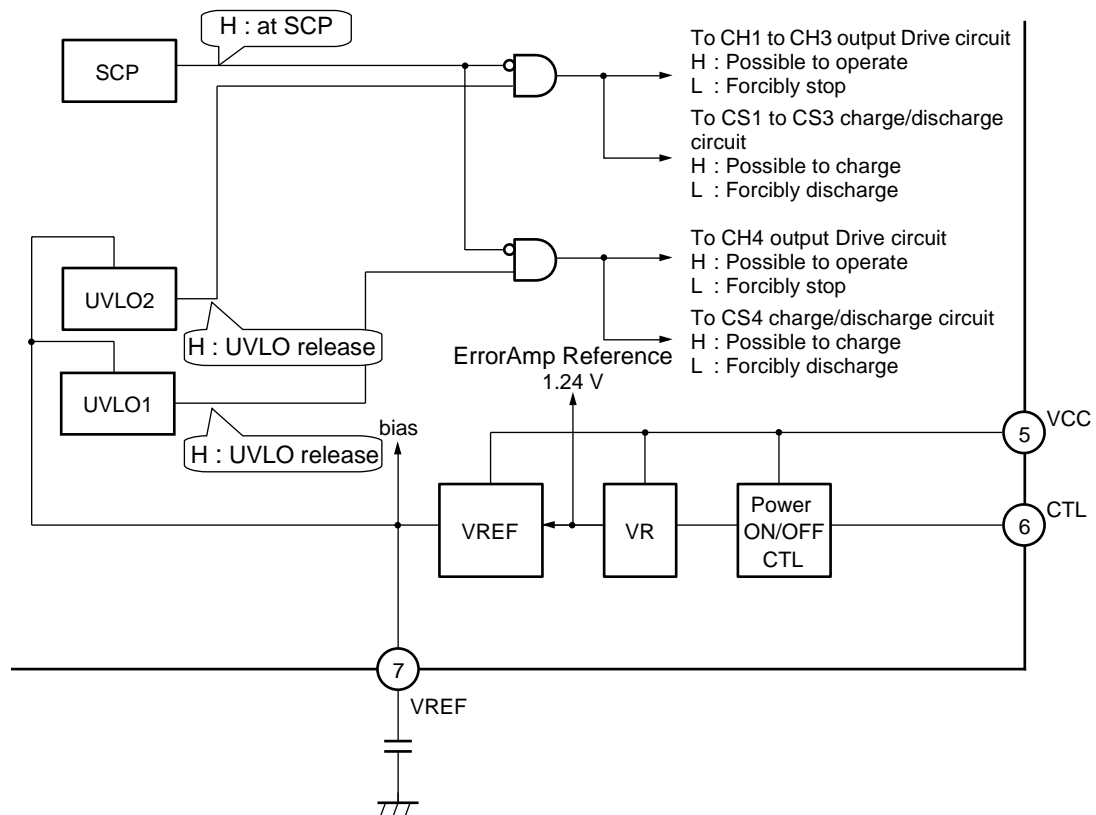## ■ OPERATION EXPLANATION WHEN CTL TURNING ON AND OFF

When CTL is turned on, internal reference voltage VR and VREF generate. When VREF exceeds each threshold voltage (VTH1, VTH2) of UVLO1 and UVLO2 (under voltage lockout protection circuit), UVLO1 and UVLO2 are released, and the operation of output Drive circuit of each channel becomes possible.

When CTL is off, VR and VREF fall. When VREF decreases and UVLO1 and UVLO2 fall below each reset voltage (VRST1, VRST2), UVLO operates and output Drive circuit of each channel is forcibly done the operation stop, and makes the output off state.
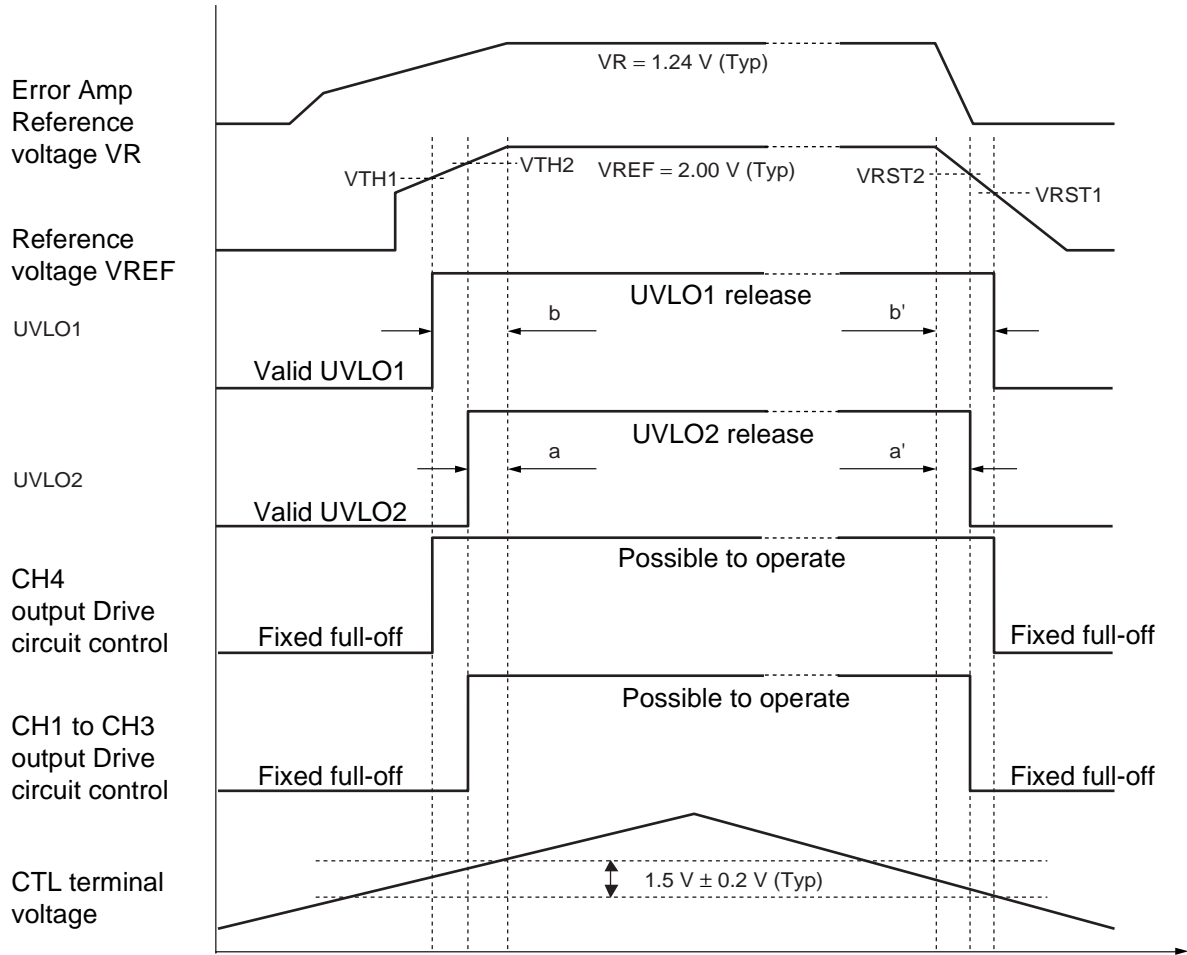
For the period to reach to 2.0 V by VREF voltage after UVLO1 and UVLO2 are released by turning on CTL (refer to a and b in "• Timing Chart") and the period when VREF decreases from 2.0 V after turning off CTL until UVLO1 and UVLO2 operate (refer to a' and b' in "• Timing Chart"), VREF which is the reference voltage does not reach 2.0 V. Therefore, the bias voltage and the bias current in IC do not reach a prescribed value, and the speed of response for IC has decreased.

Note : For this reason, when the input sudden change and the load sudden change occur in this period, IC cannot respond immediately and the output might overshoot.
Therefore, impress the voltage to CTL terminal by which the VREF terminal voltage never stays in the above-mentioned period.
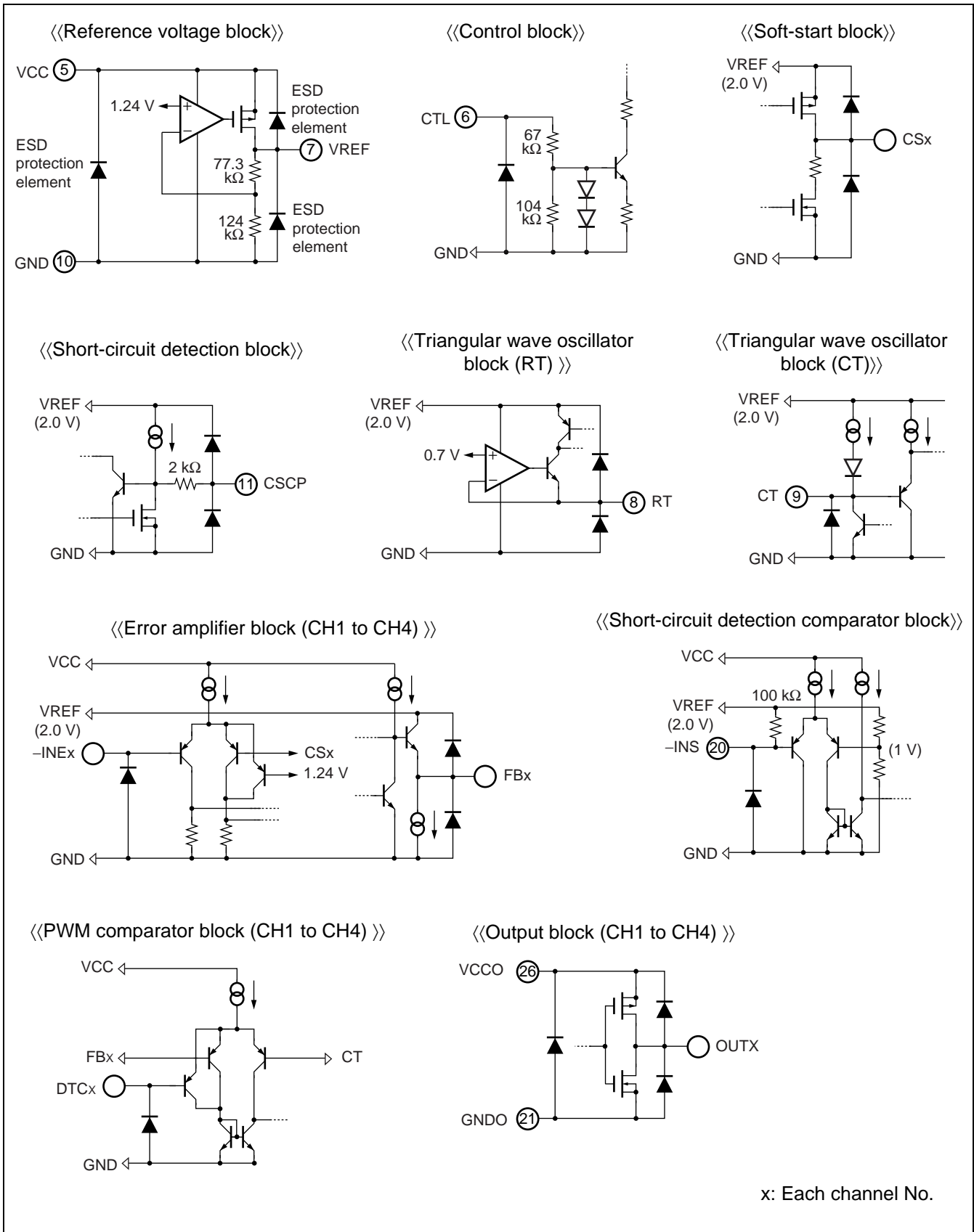

• CTL Block Equivalent Circuit

MB39A103

• **Timing Chart**

Error Amp
Reference
voltage VR

VR = 1.24 V (Typ)

Reference
voltage VREF

VTH1   VTH2   VREF = 2.00 V (Typ)   VRST2   VRST1

UVLO1

UVLO1 release

b   b'

Valid UVLO1

UVLO2

UVLO2 release

a   a'

Valid UVLO2

CH4
output Drive
circuit control

Possible to operate

Fixed full-off   Fixed full-off

CH1 to CH3
output Drive
circuit control

Possible to operate

Fixed full-off   Fixed full-off

CTL terminal
voltage

1.5 V ± 0.2 V (Typ)

22

■ I/O EQUIVALENT CIRCUIT

⟨⟨Reference voltage block⟩⟩

⟨⟨Control block⟩⟩

⟨⟨Soft-start block⟩⟩

⟨⟨Short-circuit detection block⟩⟩

⟨⟨Triangular wave oscillator block (RT) ⟩⟩

⟨⟨Triangular wave oscillator block (CT)⟩⟩

⟨⟨Error amplifier block (CH1 to CH4) ⟩⟩

⟨⟨Short-circuit detection comparator block⟩⟩

⟨⟨PWM comparator block (CH1 to CH4) ⟩⟩

⟨⟨Output block (CH1 to CH4) ⟩⟩

x: Each channel No.

■ APPLICATION EXAMPLE

R13 R14
3.3 kΩ 12 kΩ −INE1
R15 15 kΩ
CS1
C20 0.1 μF
R16 1 kΩ
C21 0.1 μF
FB1

《CH1》

R17 18 kΩ
R18 13 kΩ DTC1
R19 R20 −INE2
3 kΩ 22 kΩ 15 kΩ
CS2
C22 0.1 μF
R21
R22 1 kΩ
C23 0.1 μF
FB2

《CH2》

R23 18 kΩ
R24 13 kΩ DTC2
R25 R26 −INE3
2.4 kΩ 43 kΩ 15 kΩ
R27 CS3
C24 0.1 μF
R28 2 kΩ
C25 0.047 μF
FB3

《CH3》

R29 33 kΩ
R30 20 kΩ DTC3
R31 R32 −INE4
2.4 kΩ 43 kΩ 15 kΩ
R33 CS4
C26 0.1 μF
R34 2 kΩ
C27 0.047 μF
FB4

《CH4》

R35 33 kΩ
R36 20 kΩ DTC4
−INS

V_IN (1.7 V to 5 V)

Charging current
CSCP
C28 0.01 μF

RT
R37 24 kΩ
CT
C29 100 pF
fosc accuracy ±10%
VREF
C30 0.1 μF
GND

Pins: 29, 30, 28, 27, 2, 1, 3, 4, 14, 15, 13, 12, 17, 16, 18, 19, 20, 11, 8, 9, 7, 10

VCCO 26
C1 0.1 μF
OUT1 25
R4 150 Ω
C3 4700 pF
C4 1 μF
Q1 Vc1
V_B1
L1 22 μH
L2 15 μH
C5 4.7 μF
D1
C6 10 μF
Vo1 2.5 V, 250 mA
A

OUT2 24
R12 300 Ω
C16 4700 pF
C17 1 μF
V_B2
Q5
L3 10 μH Vc2
C18 4.7 μF
D7
L4 15 μH
C19 10 μF
Vo2 3.3 V, 500 mA
B

OUT3 23
C13 1 μF
T1
Q4
D5
D6
C14 2.2 μF
C15 2.2 μF
Vo3-1 15 V, 10 mA
Vo3-2 5 V, 50 mA
C

OUT4 22
GNDO 21
C8 1 μF
T2
D2
D3
D4
C9 2.2 μF
C10 2.2 μF
C11 2.2 μF
Vo4-1 15 V, 10 mA
Vo4-2 5 V, 50 mA
Vo4-3 −7.5 V, −5 mA
D

VCC 5
C32 2.2 μF
C2 0.1 μF
D8
Q2
6 CTL

H : ON (Power ON)
L : OFF (Standby mode)
V_TH = 1.4 V

■ PARTS LIST

COMPONENT	ITEM	SPECIFICATION		VENDOR	PARTS No.
Q1,	PNP Tr	VCEO = −12 V, IC = −3 A		SANYO	CPH3106
Q2, Q4	Nch FET	VDS = 20 V, ID = 1.8 A		SANYO	MCH3405
Q5	NPN Tr	VCEO = 15 V, IC = 3 A		SANYO	CPH3206
D1, D7, D8	Diode	VF = 0.4 V (Max) , at IF = 1 A		SANYO	SBS004
D2 to D6	Diode	VF = 0.55 V (Max) , at IF = 0.5 A		SANYO	SB05-05CP
L1	Inductor	22 μH	0.63 A, 160 mΩ	TDK	RLF5018T-220MR63
L2	Inductor	15 μH	0.76 A, 120 mΩ	TDK	RLF5018T-150MR76
L3	Inductor	10 μH	0.94 A, 67 mΩ	TDK	RLF5018T-100MR94
L4	Inductor	15 μH	0.76 A, 120 mΩ	TDK	RLF5018T-150MR76
T1, T2	Transformer	—	—	SUMIDA	CLQ52 5388-T095
C1, C2, C30	Ceramics Condenser	0.1 μF	50 V	TDK	C1608JB1H104K
C3, C16	Ceramics Condenser	4700 pF	50 V	TDK	C1608JB1H472K
C4, C8, C13	Ceramics Condenser	1 μF	25 V	TDK	C3216JB1E105K
C5, C18	Ceramics Condenser	4.7 μF	10 V	TDK	C3216JB1A475M
C6, C19	Ceramics Condenser	10 μF	6.3 V	TDK	C3216JB0J106K
C9 to C11	Ceramics Condenser	2.2 μF	16 V	TDK	C3216JB1C225K
C13, C17	Ceramics Condenser	1 μF	25 V	TDK	C3216JB1E105K
C14, C15	Ceramics Condenser	2.2 μF	16 V	TDK	C3216JB1C225K
C20 to C24, C26	Ceramics Condenser	0.1 μF	50 V	TDK	C1608JB1H104K
C25, C27	Ceramics Condenser	0.047 μF	50 V	TDK	C1608JB1H473K
C28	Ceramics Condenser	0.01 μF	50 V	TDK	C1608JB1H103K
C29	Ceramics Condenser	100 pF	50 V	TDK	C1608CH1H101J
R4	Resistor	150 Ω	0.5%	ssm	RR0816P-151-D
R12	Resistor	300 Ω	0.5%	ssm	RR0816P-301-D
R13	Resistor	3.3 kΩ	0.5%	ssm	RR0816P-332-D
R14	Resistor	12 kΩ	0.5%	ssm	RR0816P-123-D
R15, R21, R27	Resistor	15 kΩ	0.5%	ssm	RR0816P-153-D
R16, R22	Resistor	1 kΩ	0.5%	ssm	RR0816P-102-D
R17	Resistor	18 kΩ	0.5%	ssm	RR0816P-183-D
R18	Resistor	13 kΩ	0.5%	ssm	RR0816P-133-D
R19	Resistor	3 kΩ	0.5%	ssm	RR0816P-302-D
R20	Resistor	22 kΩ	0.5%	ssm	RR0816P-223-D
R23	Resistor	18 kΩ	0.5%	ssm	RR0816P-183-D
R24	Resistor	13 kΩ	0.5%	ssm	RR0816P-133-D
R25, R31	Resistor	2.4 kΩ	0.5%	ssm	RR0816P-242-D
R26	Resistor	43 kΩ	0.5%	ssm	RR0816P-433-D
R28, R34	Resistor	2 kΩ	0.5%	ssm	RR0816P-202-D
R29, R35	Resistor	33 kΩ	0.5%	ssm	RR0816P-333-D
R30, R36	Resistor	20 kΩ	0.5%	ssm	RR0816P-203-D
R32	Resistor	43 kΩ	0.5%	ssm	RR0816P-433-D
R33	Resistor	15 kΩ	0.5%	ssm	RR0816P-153-D
R37	Resistor	24 kΩ	0.5%	ssm	RR0816P-243-D

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

■ REFERENCE DATA

TOTAL Efficiency vs. Input Voltage

T_A = +25 °C
V_{O1} = 2.5 V, 250 mA
V_{O2} = 3.3 V, 500 mA
V_{O3-1} = 15 V, 10 mA
V_{O3-2} = 5 V, 50 mA
V_{O4-1} = 15 V, 10 mA
V_{O4-2} = 5 V, 50 mA
V_{O4-3} = −7.5 V, −5 mA
f_{OSC} = 500 kHz

TOTAL efficiency η (%)

Input voltage V_{IN} (V)

Each CH Efficiency vs. Input Voltage

T_A = +25 °C

Each CH efficiency η (%)

CH1

CH3
CH4

CH2

Note: Only concerned CH and CH4 (self-power
supply) are ON.
Include external SW Tr operating current
CH4 includes IC current consumption.

Input voltage V_{IN} (V)

(Continued)

26

Conversion Efficiency vs. Load Current (CH1)

Conversion Efficiency vs. Load Current (CH2)

Conversion Efficiency vs. Load Current (CH3, CH4)

(Continued)

(Continued)

Switching Wave Form (CH1)

Switching Wave Form (CH2)

■ 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
MB39A103PFT	30-pin plastic TSSOP (FPT-30P-M04)	
MB39A103PV3	32-pad plastic BCC (LCC-32P-M15)	

■ PACKAGE DIMENSIONS

30-pin plastic TSSOP
(FPT-30P-M04)

7.80±0.10(.307±.004)

INDEX

4.40 $^{+0.20}_{-0.10}$ 6.40±0.10
(.173 $^{+.008}_{-.004}$) (.252±.004)

0.50(.020)

0.20±0.03
(.008±.001)

0.10(.004)

7.00(.276)

0.3865(.0152)

0.90±0.05
(.035±.002)

0.3865(.0152)

"A"

0.127±0.03
(.005±.001)

Details of "A" part

0~8°

1.10(.043)
MAX

0.60±0.10
(.024±.004)

0.25(.010)

0.10±0.05
(.004±.002)
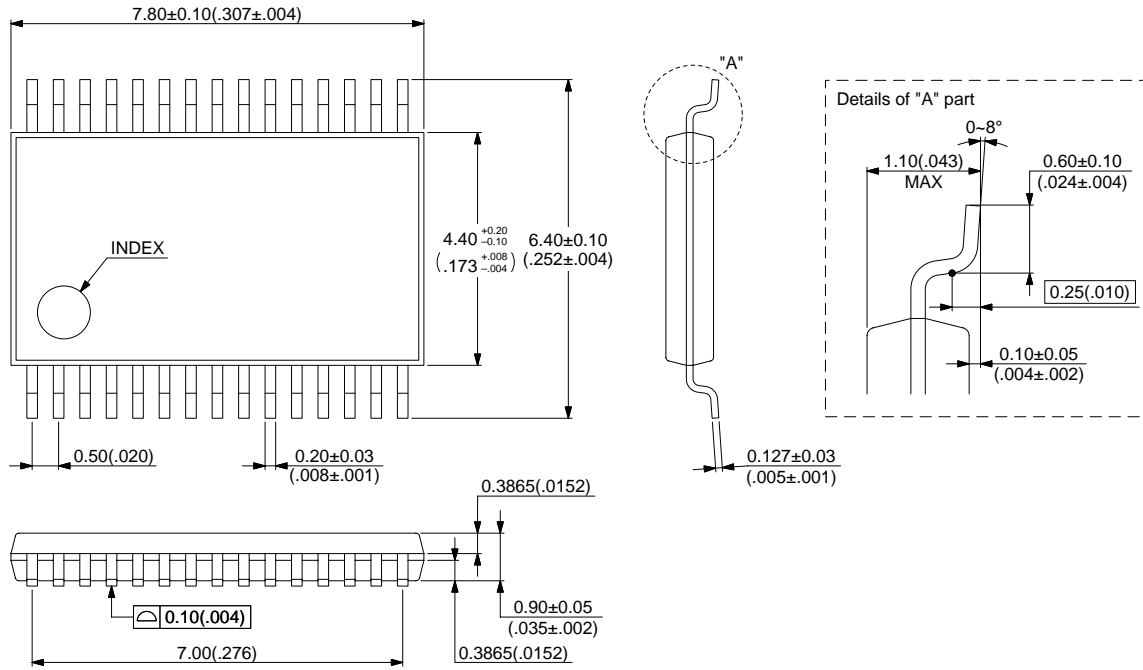
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Dimensions in mm (inches)
Note: The values in parentheses are reference values.

(Continued)

MB39A103

32-pad plastic BCC
(LCC-32P-M15)

5.00±0.10(.197±.004)

5.00±0.10
(.197±.004)

INDEX AREA

25   17

1   9

0.05(.002)

0.80(.031)MAX
(Mount height)

0.075±0.025
(.003±.001)
(Stand off)

4.25(.167)TYP
0.50(.020)TYP
0.50±0.10
(.020±.004)

17   25

4.25(.167)
TYP   0.50(.020)
TYP
0.50±0.10
(.020±.004)

3.00(.118)
REF

"C"   "A"   "B"

9   3.00(.118)REF   1

Details of "A" part

0.14(.006)
MIN   0.55±0.06
(.022±.002)

0.30±0.06
(.012±.002)

Details of "B" part

C0.2(.008)   0.55±0.06
(.022±.002)

0.55±0.06
(.022±.002)

Details of "C" part

0.55±0.06
(.022±.002)

0.55±0.06
(.022±.002)
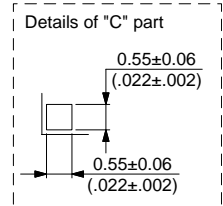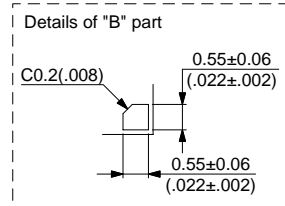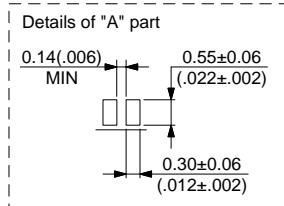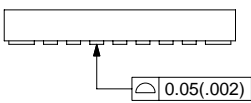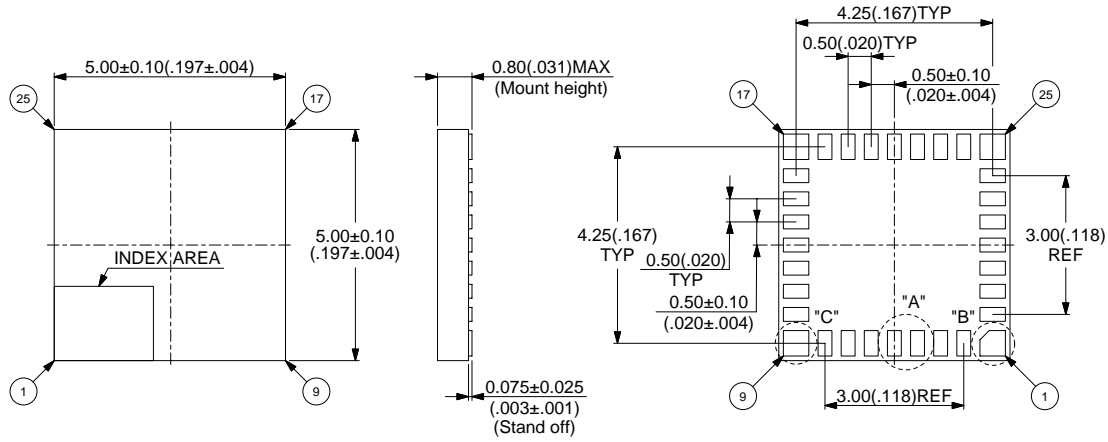
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Dimensions in mm (inches)
Note: The values in parentheses are reference values.

MEMO

MEMO

MEMO

FUJITSU MICROELECTRONICS LIMITED

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Edited   Strategic Business Development Dept.