FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-27208-1E

ASSP

BIPOLAR

Switching Regulator Controller
(4 Channels plus High-Precision, High-Frequency Capabilities)

MB3785A

■ DESCRIPTION

The MB3785A is a PWM-based 4-channel switching regulator controller featuring high-precision, high-frequency capabilities. All of the four channels of circuits allow their outputs to be set in three modes: step-down, step-up, and inverted. The third and fourth channels are suited for DC motor speed control.

The triangular-wave oscillation circuit accepts a ceramic resonator, in addition to the standard method of oscillation using an RC network.

■ FEATURES

- Wide range of operating power supply voltages: 4.5 V to 18 V
- Low current consumption: 6 mA [TYP] when operating10 µA or less during standby
- Built-in high-precision reference voltage generator: 2.50 V±1%
- Oscillation circuit
  - Capable of high-frequency oscillation: 100 kHz to 1 MHz
  - Also accepts a ceramic resonator.
- Wide input range of error amplifier: –0.2 V to V_{CC}–1.8 V
- Built-in timer/latch-actuated short-circuiting detection circuit

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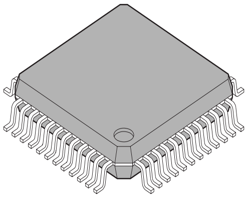
■ PACKAGE

48-pin, Plastic LQFP



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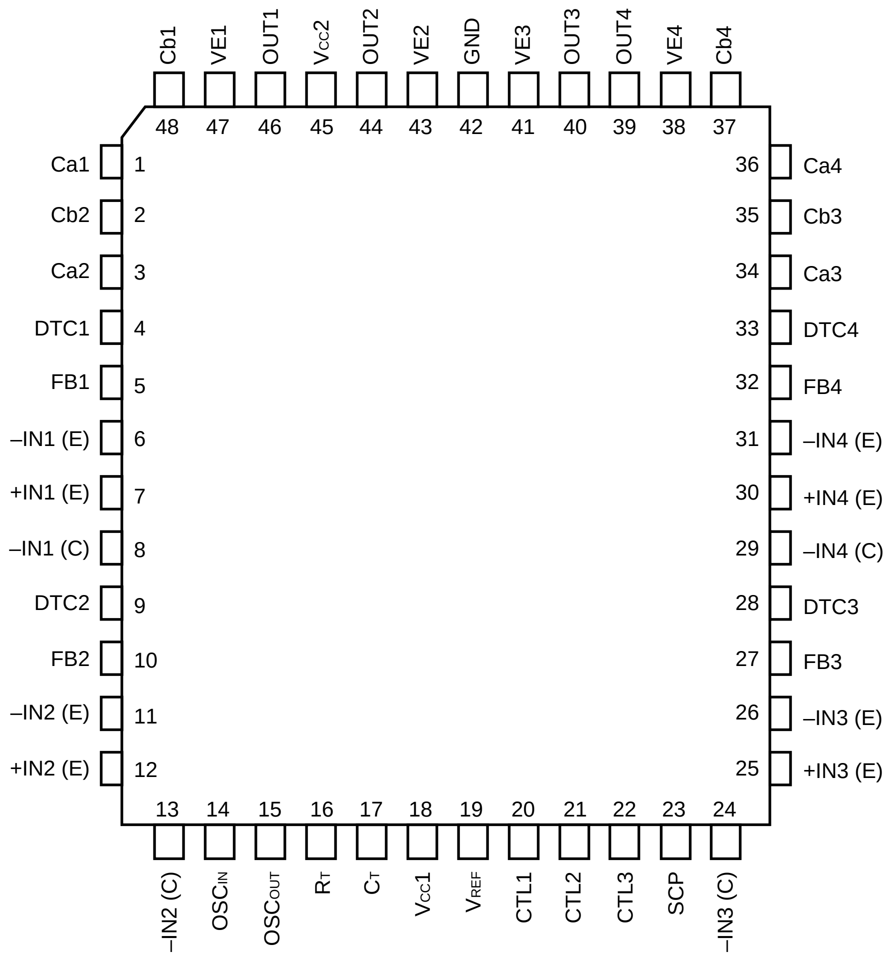
- Output circuit
  - The drive output for PNP transistors is the totem-pole type allowing the on-current and off-current values to be set independently.
- Adjustable dead time over the entire duty ratio range
- Built-in standby and output control functions
- High-density mounting possible: 48-pin LQFP package

■ PIN ASSIGNMENT

(TOP VIEW)



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Each alphabet in parentheses following the pin symbol indicates the input pin of the next circuit.
(C) denotes a comparator.
(E) denotes an error amplifier.

■ PIN DESCRIPTION

Pin No.		Symbol	I/O	Description
CH1	1	Ca1	—	CH1 output transistor OFF-current setting pin. Insert a capacitor between the Ca1 and the Cb1 pins, then set the output transistor OFF-current.
	48	Cb1	—	
	7	+IN1(E)	I	CH1 error amp non-inverted input pin.
	6	–IN1(E)	I	CH1 error amp inverted input pin.
	5	FB1	O	CH1 error amp output pin.
	8	–IN1(C)	I	CH1 comparator inverted input pin.
	4	DTC1	I	CH1 dead time control pin.
	47	VE1	I	CH1 output current setting pin.
	46	OUT1	O	CH1 totem-pole output pin.
CH2	3	Ca2	—	CH2 output transistor OFF-current setting pin. Insert a capacitor between the Ca2 and the Cb2 pins, then set the output transistor OFF-current.
	2	Cb2	—	
	12	+IN2(E)	I	CH2 error amp non-inverted input pin.
	11	–IN2(E)	I	CH2 error amp inverted input pin.
	10	FB2	O	CH2 error amp output pin.
	13	–IN2(C)	I	CH2 comparator inverted input pin.
	9	DTC2	I	CH2 dead time control pin.
	43	VE2	I	CH2 output current setting pin.
	44	OUT2	O	CH2 totem-pole output pin.
CH3	34	Ca3	—	CH3 output transistor OFF-current setting pin. Insert a capacitor between the Ca3 and the Cb3 pins, then set the output transistor OFF-current.
	35	Cb3	—	
	25	+IN3(E)	I	CH3 error amp non-inverted input pin.
	26	–IN3(E)	I	CH3 error amp inverted input pin.
	27	FB3	O	CH3 error amp output pin.
	24	–IN3(C)	I	CH3 comparator inverted input pin.
	28	DTC3	I	CH3 dead time control pin.
	41	VE3	I	CH3 output current setting pin.
	40	OUT3	O	CH3 totem-pole output pin.
CH4	36	Ca4	—	CH4 output transistor OFF-current setting pin. Insert a capacitor between the Ca4 and the Cb4 pins, then set the output transistor OFF-current.
	37	Cb4	—	
	30	+IN4(E)	I	CH4 error amp non-inverted input pin.
	31	–IN4(E)	I	CH4 error inverted input pin.
	32	FB4	O	CH4 error amp output pin.
	29	–IN4(C)	I	CH4 comparator inverted input pin.

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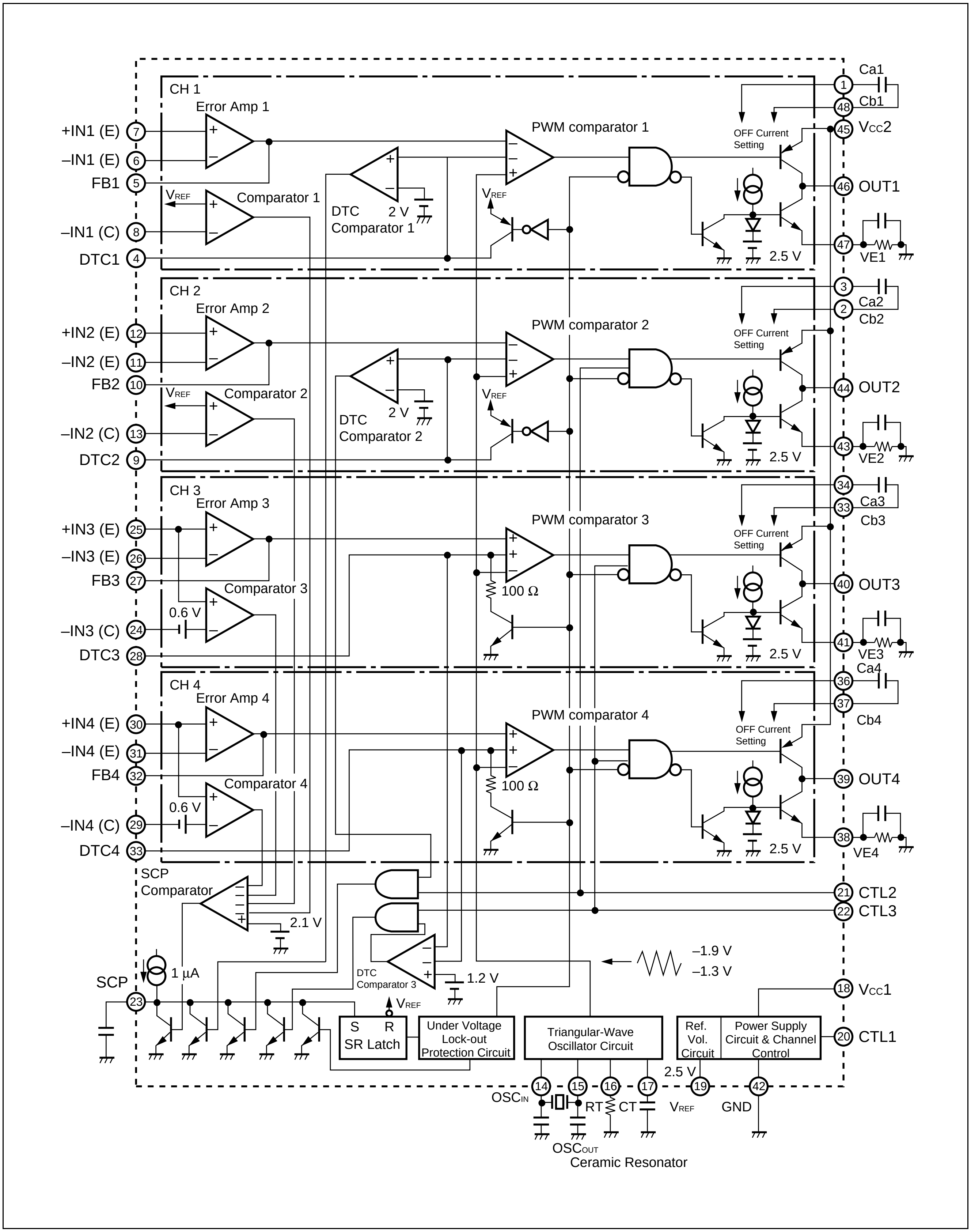
Pin No.		Symbol	I/O	Description
CH4	33	DTC4	I	CH4 dead time control pin.
	38	VE4	I	CH4 output current setting pin.
	39	OUT4	O	CH4 totem-pole output pin.
Triangular-Wave Oscillator Circuit	14	OSC_{IN}	—	This pin connects a ceramic resonator.
	15	OSC_{OUT}	—	
	16	R_T	—	This pin connects to a resistor for setting the triangular-wave frequency.
	17	C_T	—	This pin connects to a capacitor for setting the triangular-wave frequency.
Power Supply Circuit	18	$V_{CC}1$	—	Power supply pin for the reference power supply control circuit.
	45	$V_{CC}2$	—	Power supply pin for the output circuit.
	42	GND	—	GND pin.
	19	V_{REF}	O	Reference voltage output pin.
Control Circuit	23	SCP	—	This pin connects to a capacitor for the short-circuit protection circuit.
	20	CTL1	I	Power supply circuit and first-channel control pin. When this pin is High, the power supply circuit and first channel are in active state. When this pin is Low, the power supply circuit and first channel are in standby state.
	21	CTL2	I	Second-channel control pin. While the CTL1 pin is High When this pin is High, the second channel is in active state. When this pin is Low, the second channel is in the inactive state.
	22	CTL3	I	Third and fourth-channel control pin. While the CTL1 pin is High When this pin is High, the third and fourth channels are in active state. When this pin is Low, the third and fourth channels are in the inactive state.

■ BLOCK DIAGRAM



■ FUNCTIONAL DESCRIPTION

1. Switching Regulator Function

(1) Reference voltage circuit

The reference voltage circuit generates a temperature-compensated reference voltage (≅ 2.50 V) using the voltage supplied from the power supply terminal (pin 18). This voltage is used as the operating power supply for the internal circuits of the IC. The reference voltage can also be supplied to an external device from the V_{REF} terminal (pin 19).

(2) Triangular-wave oscillator circuit

By connecting a timing capacitor and a resistor to the C_T (pin 17) and the R_T (pin 16) terminals, it is possible to generate any desired triangular oscillation waveform. The oscillation can also be obtained by using a ceramic resonator connected to pins 14 and 15.

This waveform has an amplitude of 1.3 V to 1.9 V and is input to the internal PWM comparator of the IC. At the same time, it can also be supplied to an external device from the C_T terminal (pin 17).

(3) Error amplifier

This amplifier detects the output voltage of the switching regulator and outputs a PWM control signal accordingly. It has a wide common-mode input voltage range from –0.2 V to V_{CC} –1.8 V and allows easy setting from an external power supply, making the system suitable for DC motor speed control.

By connecting a feedback resistor and capacitor from the error amplifier output pin to the inverted input pin, you can form any desired loop gain, for stable phase compensation.

(4) PWM comparator

- **CH1 & CH2**

The PWM comparators in these channels are a voltage comparator with two inverted input and one non-inverted input, that is, a voltage-pulse width converter to control the output pulse on-time according to the input voltage. It turns on the output transistor when the triangular wave from the oscillator is higher than both the error amplifier output and the DTC-pin voltages.

- **CH3 & CH4**

The PWM comparators in these channels are a voltage comparator with one inverted input and two non-inverted inputs, that is, a voltage-pulse width converter to control the output pulse on-time according to the input voltage. It turns on the output transistor when the triangular wave from the oscillator is lower than both the error amplifier output and the DTC-pin voltages.

These four channels can be provided with a soft start function by using the DTC pin.

(5) Output circuit

The output circuit is comprised of a totem-pole configuration and can drive a PNP transistor (30 mA max.)

2. Channel Control Function

The MB3785A allows the four channels of power supply circuits to be controlled independently. Set the voltage levels on the CTL1 (pin 20), CTL2 (pin 21), and CTL3 (pin 22) terminals to turn the circuit of each channel “ON” or “OFF”, as listed below.

Table 1 Channel by Channel On/Off Setting Conditions.

CTL pin voltage level			On/Off state of channel			
CTL1	**CTL2**	**CTL3**	**Power supply circuit**	**First channel**	**Second channel**	**3rd and 4th channels**
H	H	H	ON		ON	ON
		L				OFF
	L	H			OFF	ON
		L				OFF
L	X		Standby state*			

* : The power supply current value during standby is 10 µA or less.

3. Protective Functions

(1) Timer/latch-actuated short-circuiting protection circuit

The SCP comparator checks the output voltage of each comparator which is used to detect the short-circuiting of output. When any of these comparators have an output voltage greater than or equal to 2.1 V, the timer circuit is activated and a protection enable capacitor externally fitted to the SCP terminal (pin 23) begins to charge.

If the comparator’s output voltage is not restored to normal voltage level by the time the capacitor voltage has risen to the base-emitter junction voltage of the transistor, i.e., V_{BE} ($\cong$ 0.65 V), the latch circuit is activated to turn off the output transistor while at the same time setting the duty (OFF) = 100 %.

When actuated, this protection circuit can be reset by turning on the power supply again.

(2) Under voltage lockout protection circuit

A transient state at power-on or a momentary drop of the power supply voltage causes the control IC to malfunction, resulting in system breakdown or deterioration. By detecting the internal reference voltage with respect to the power supply voltage, this protection circuit resets the latch circuit to turn off the output transistor and set the duty (OFF) = 100 %, while at the same time holding the SCP terminal (pin 23) at the “L”. The reset is cleared when the power supply voltage becomes greater than or equal to the threshold voltage level of this protection circuit.

■ ABSOLUTE MAXIMUM RAGINGS (See WARNING)

(Ta = +25°C)

Parameter	Symbol	Conditions	Rating	Unit
Power supply voltage	V_{CC}	—	20	V
Control input voltage	V_{ICTL}	—	20	V
Power dissipation	P_D	Ta ≤ +25°C	550*	mW
Operating ambient temperature	T_{OP}	—	–30 to 85	°C
Storage temperature	T_{stg}	—	–55 to 125	°C

* : The packages are mounted on the epoxy board (4 cm × 4 cm).

WARNING: Permanent device damage may occur if the above **Absolute Maximum Ratings** are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

■ RECOMMENDED OPERATING CONDITIONS

(Ta = +25°C)

Parameter	Symbol	Conditions	Value			Unit
			Min.	Typ.	Max.	
Power supply voltage*	V_{CC}	—	4.5	6.0	18	V
Error amp. input voltage	V_I	—	–0.2	—	V_{CC} –0.8	V
Comparator input voltage	V_I	—	–0.2	—	V_{CC}	V
Control input voltage	V_{ICTL}	—	–0.2	—	18	V
Output current	I_O	—	3.0	—	30	mA
Timing capacitance	C_T	—	68	—	1500	pF
Timing resistance	R_T	—	5.1	—	100	kΩ
Oscillation frequency	f_{OSC}	—	100	500	1000	kHz
Operating ambient temperature	T_{OP}	—	–30	25	85	°C

* : The minimum value of the recommended supply voltage is 3.6 V except when the device operates with constant output sink current.

■ ELECTRICAL CHARACTERISTICS

(V_{CC} = +6 V, Ta = +25°C)

Parameter			Symbol	Conditions	Value Min.	Value Typ.	Value Max.	Unit
Reference voltage block		Reference voltage	V_{REF}	I_{OR} = –1 mA	2.475	2.500	2.525	V
		Rate of changed in output voltage vs. Temperature	$\Delta V_{REF}/V_{REF}$	Ta = –30°C to +85°C	–2	±0.2	2	%
		Input stability	Line	V_{CC} = 3.6 V to 18 V	–10	–2	10	mV
		Load stability	Load	I_{OR} = –0.1 mA to –1 mA	–10	–3	10	mV
		Sort-circuit output current	I_{OS}	V_{REF} = 2 V	–25	–8	–3	mA
Under voltage lockout protection circuit (U.V.L.O)		Threshold voltage	V_{tH}	—	—	2.72	—	V
			V_{tL}	—	—	2.60	—	V
		Hysteresis width	V_{HYS}	—	80	120	—	mV
		Reset voltage (V_{CC})	V_R	—	1.5	1.9	—	V
Short-circuit detection comparator	1 CH/2 CH	Input threshold voltage	V_{th}	—	2.45	2.50	2.55	V
		Input bias current	I_{IB}	V_I = 0 V	–200	–100	—	nA
		Input voltage range	V_I	—	–0.2	—	V_{CC}	V
	3 CH/4 CH	Input offset voltage	V_{IO}	—	0.58	0.65	0.72	V
		Input bias current	I_{IB}	V_I = 0 V	–200	–100	—	nA
		Common mode input voltage range	V_{ICM}	—	–0.2	—	V_{CC}–1.8	V
Short circuit detection block		Threshold voltage	V_{tPC}	—	0.60	0.65	0.70	V
		Input standby voltage	V_{STB}	—	—	50	100	mV
		Input latch voltage	V_I	—	—	50	100	mV
		Input source current	I_{Ibpc}	—	–1.4	–1.0	–0.6	µA
Triangular waveform oscillator block		Oscillation frequency	f_{OSC}	C_T = 300 pF, R_T = 6.2 kΩ	450	500	550	kHz
		Frequency stability (V_{CC})	$\Delta f/f_{dv}$	V_{CC} = 3.6 V to 18 V	—	±1	—	%
		Frequency stability (Ta)	$\Delta f/f_{dT}$	Ta = –30°C to +85°C	–4	—	4	%

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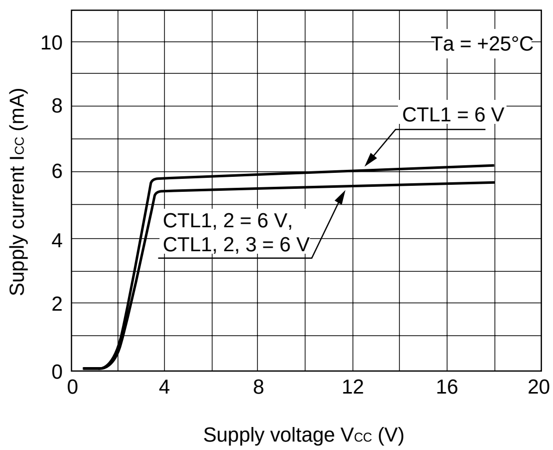
(V_{CC} = +6 V, Ta = +25°C)

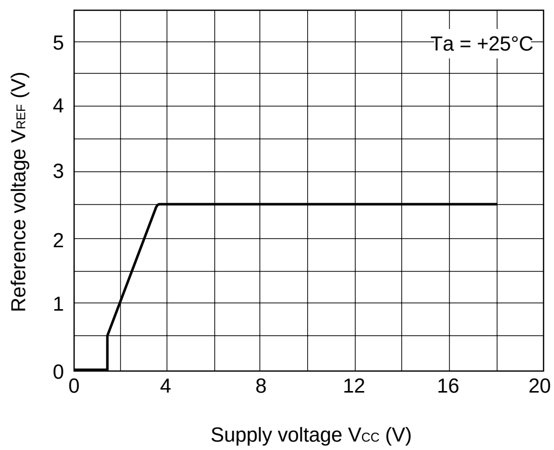
Parameter		Symbol	Conditions	Value			Unit
				Min.	Typ.	Max.	
Error amplifier	Input offset voltage	V_{IO}	V_{FB} = 1.6 V	–10	—	10	mV
	Input bias current	I_{IB}	V_{FB} = 1.6 V	–200	–100	—	nA
	Common mode input voltage range	V_{ICM}	—	–0.2	—	V_{CC}–1.8	V
	Voltage gain	A_V	—	60	100	—	dB
	Frequency bandwidth	BW	A_V = 0 dB	—	800	—	kHz
1 CH/2 CH dead time control circuit	Input threshold voltage	V_{t0}	Duty cycle = 0 %	—	1.9	2.25	V
		V_{t100}	Duty cycle = 100 %	1.05	1.3	—	V
	Input bias current	I_{Ibdt}	V_{dt} = 2.3 V	—	0.1	0.5	µA
	Latch mode source current	I_{Idt}	V_{dt} = 1.5 V	—	–500	–80	µA
	Latch input voltage	V_{Idt}	I_{dt} = –40 µA	V_{REF}–0.3	2.4	—	V
3 CH/4 CH dead time control circuit	Input threshold voltage	V_{t0}	Duty cycle = 0 %	1.05	1.3	—	V
		V_{t100}	Duty cycle = 100 %	—	1.9	2.25	V
	Input bias current	I_{Ibdt}	V_{dt} = 2.3 V	—	0.1	0.5	µA
	Latch mode source current	I_{Idt}	V_{dt} = 1.5 V	80	500	—	µA
	Latch input voltage	V_{Idt}	I_{dt} = +40 µA	—	0.2	0.3	V
Channel control block	Threshold voltage	V_{th}	—	0.7	1.4	2.1	V
	Input current	I_{IH}	V_{CTL} = 5 V	—	100	200	µA
		I_{IL}	V_{CTL} = 0 V	–10	—	10	µA
Output block	Source current	I_O	—	—	–40	—	mA
	Sink current	I_O	R_E = 82 Ω	18	30	42	mA
	Output leakage current	I_{LO}	V_O = 18 V	—	—	20	µA
General	Standby current	I_{CC0}	—	—	0	10	µA
	Supply current when output off	I_{CC}	—	—	6	8.6	mA

■ TYPICAL CHARACTERISTIC CURVES

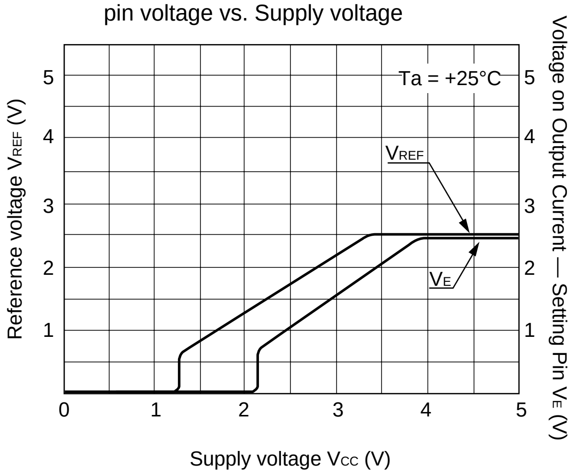
1. Supply current vs. Supply voltage



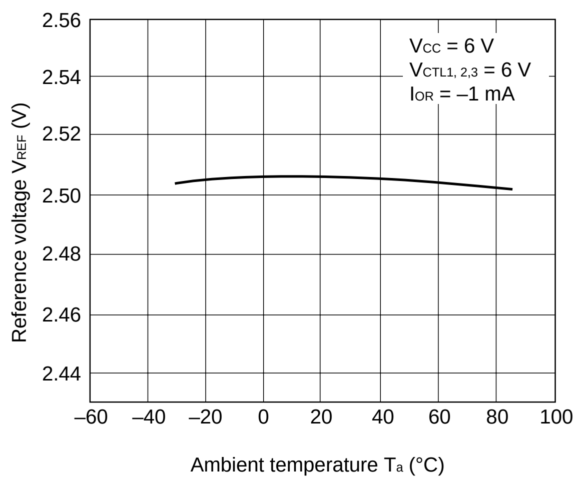
2. Reference voltage vs. Supply voltage



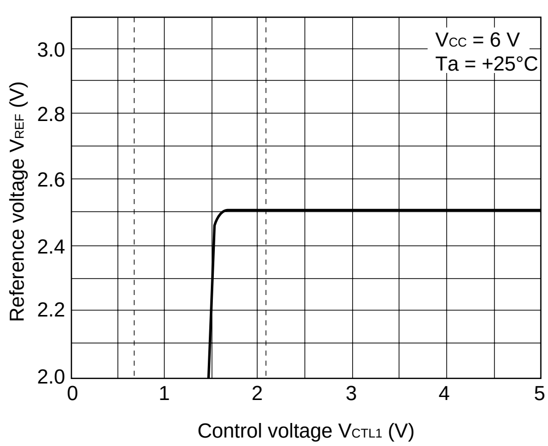
3. Reference voltage and Output current setting pin voltage vs. Supply voltage



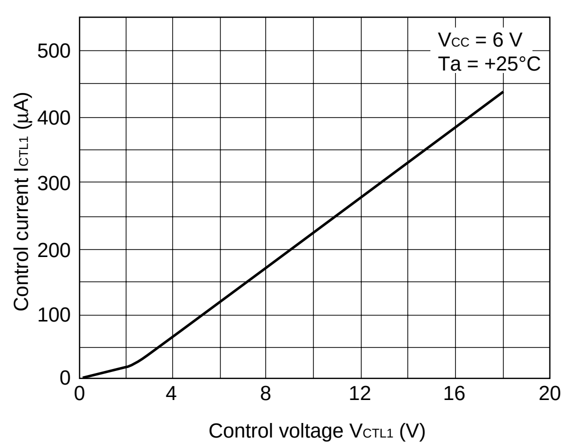
4. Reference voltage vs. Ambient temperature



5. Reference voltage vs. Control voltage



6. Control current vs. Control voltage



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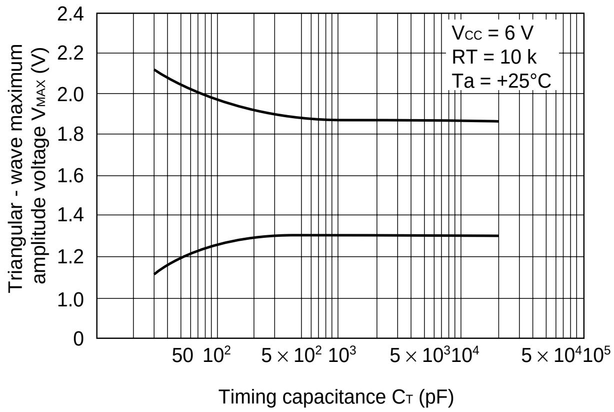
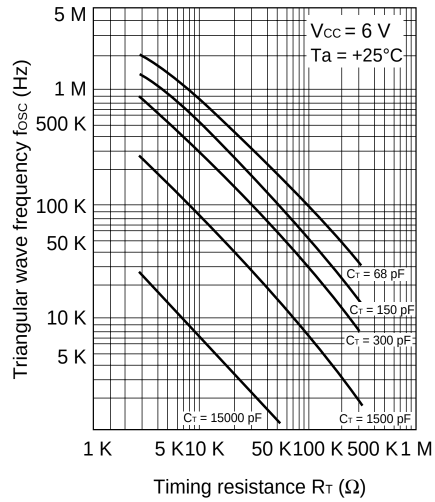
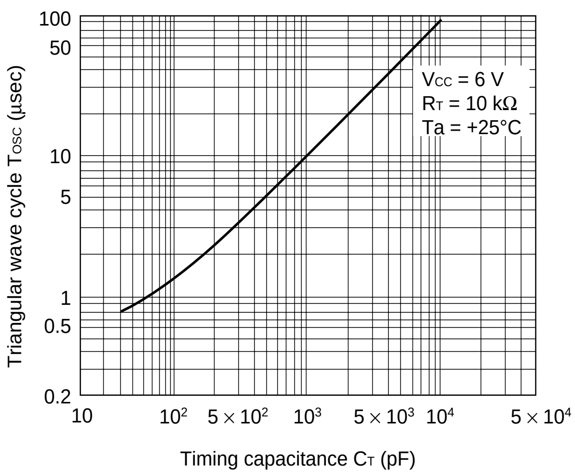
7. Triangular wave maximum amplitude voltage vs. Timing capacitance



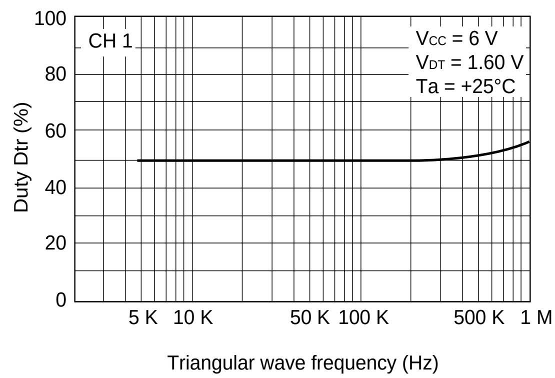
8. Triangular wave frequency vs. Timing resistance



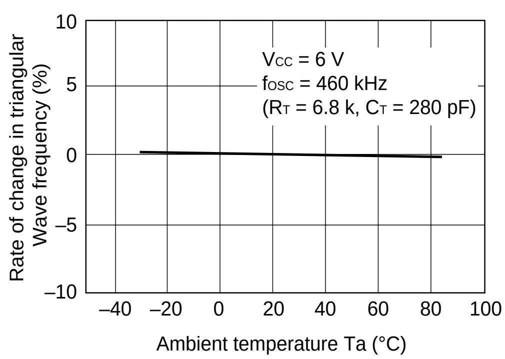
9. Triangular wave cycle vs. Timing capacitance



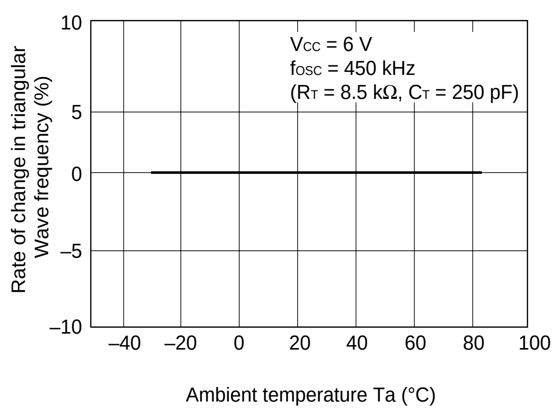
10. Duty vs. Triangular wave frequency



11. Rate of change in triangular wave frequency vs. Ambient temperature (Not using ceramic resonator)



12. Rate of change in triangular wave frequency vs. Ambient temperature (Using ceramic resonator)



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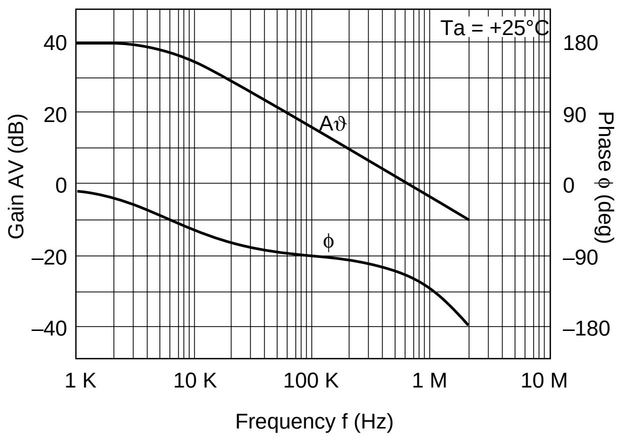
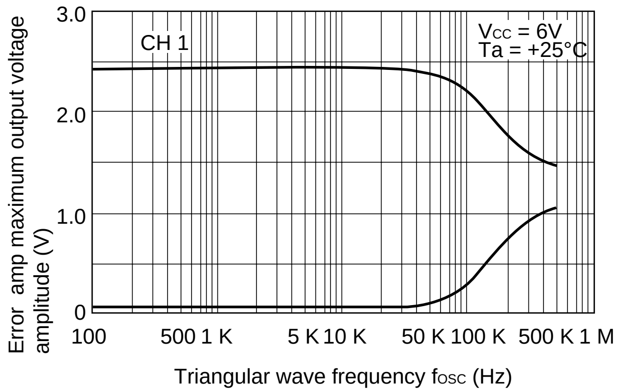
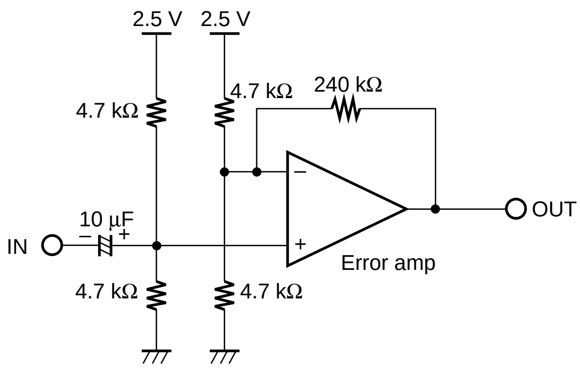
13. Gain vs. Frequency and Phase vs. Frequency



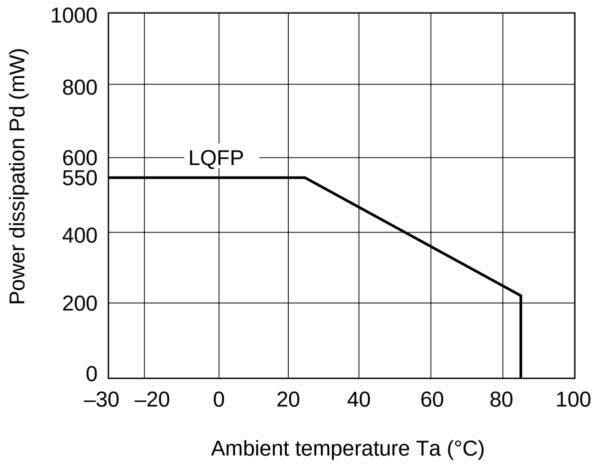
14. Error amp maximum output voltage vs. Frequency



[Measuring Circuit]

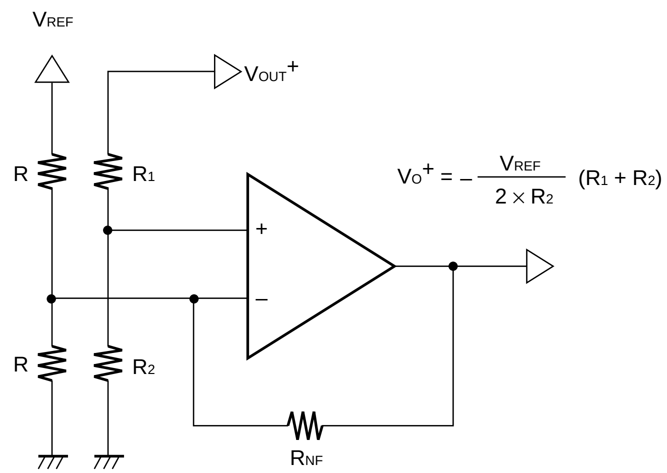


15. Power dissipation vs. Ambient temperature

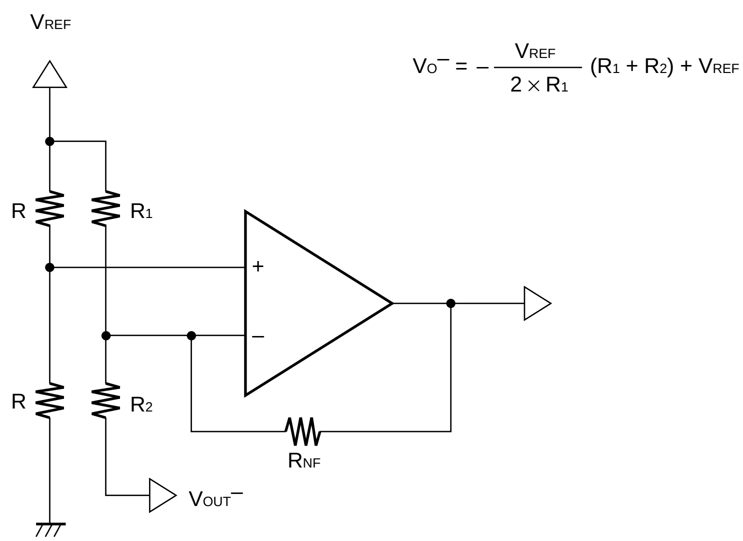


■ METHODS OF SETTING THE OUTPUT VOLTAGE

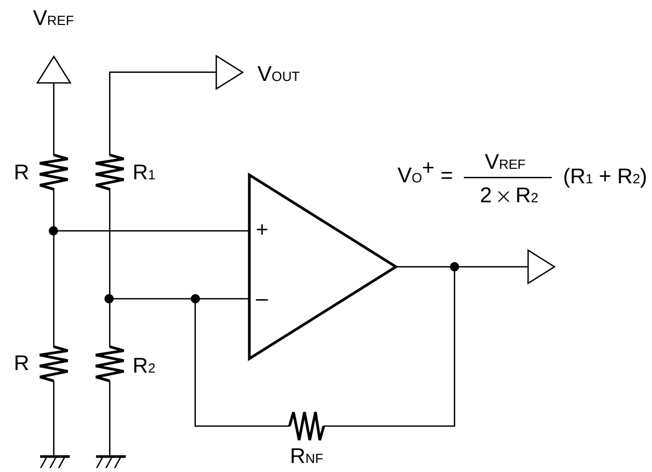
1. Method of Connecting Channels 1 and 2: When Output Voltage (V_O) is Positive



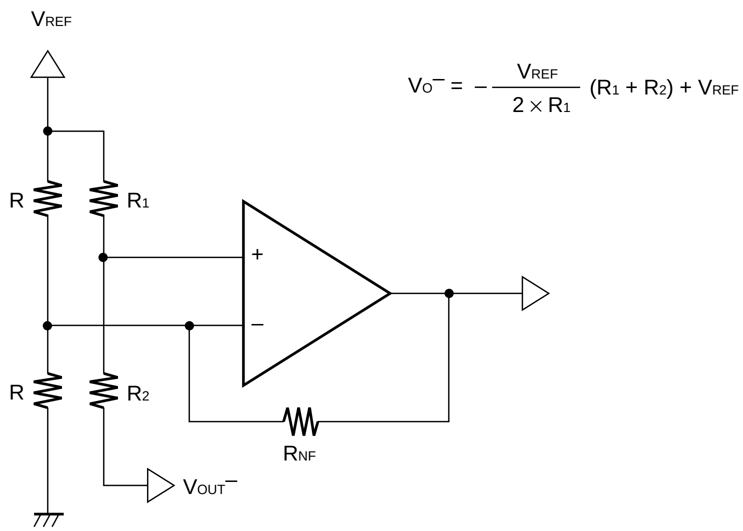
2. Method of Connecting Channels 1 and 2: When Output Voltage (V_O) is Negative



3. Method of Connecting Channels 3 and 4: When Output Voltage (V_O) is Positive



4. Method of Connecting Channels 3 and 4: When Output Voltage (V_O) is Negative



■ METHOD OF SETTING THE OUTPUT CURRENT

The output circuit is comprised of a totem-pole configuration. Its output current waveform is such that the ON-current value is set by constant current and the OFF-current value is set by a time constant as shown in Figure 2. These output currents are set using the equations below.

- ON-current = 2.5/R_E [A]
  (Voltage on output current-setting pin V_E = 2.5 V)
- OFF-current time constant = proportional to the value of C_B

Figure 1. CH1 to CH4 Output Circuit

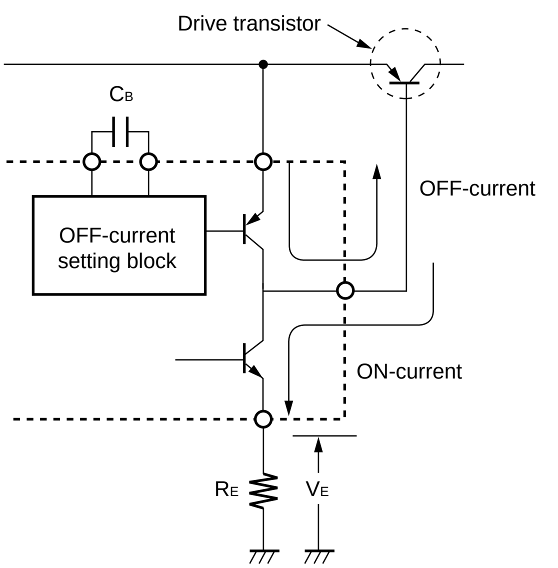


Figure 2. Output Current Waveform

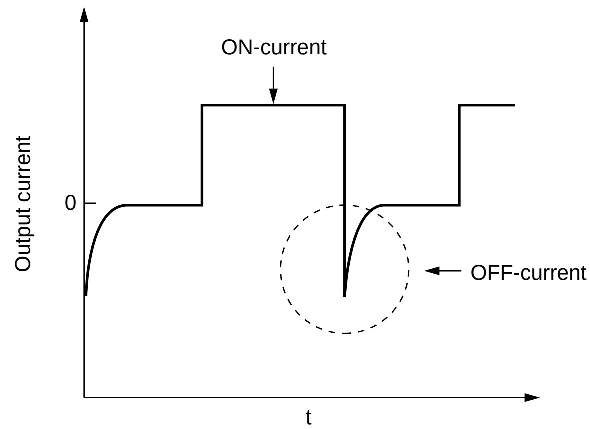


Figure 3. Voltage and Current Waveforms on Output Pin (CH1)

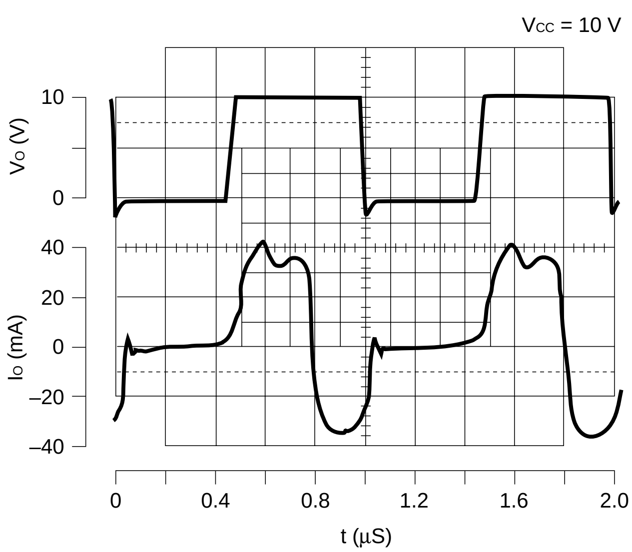
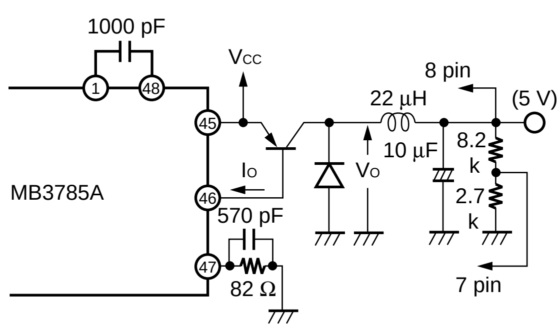


Figure 4. Measuring Circuit Diagram



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

Figure 5 schematically shows the protection latch circuit.

The outputs from the output-shorting detection comparators 1 to 4 are respectively connected to the inverted inputs of the SCP comparator. These inputs are always compared with the reference voltage of approximately 2.1 V which is fed to the non-inverted input of the SCP comparator.

While the switching regulator load conditions are stable, there are no changes in the outputs of the comparators 1 to 4 so that short-circuit protection control keeps equilibrium state. At this time, the voltage on the SCP terminal (pin 23) is held at approximately 50 mV.

When load conditions change rapidly due to a short-circuiting of load, for example, the output voltage of the comparator for the relevant channel goes “H” (2.1 V or more). Consequently, the SCP comparator outputs a “L”, causing the transistor Q_1 to turn off, and the short-circuit protection capacitor C_{PE} (externally fitted to the SCP terminal) begins to charge.

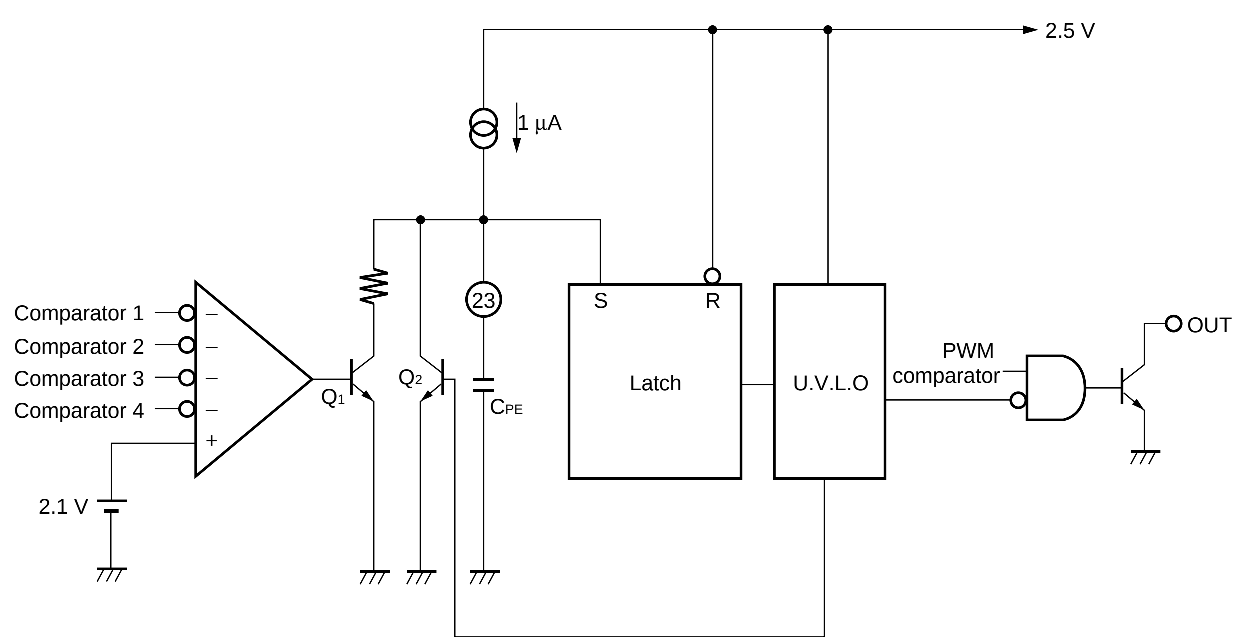
$$V_{PE} = 50\text{ mV} + t_{PE} \times 10^{-6}/C_{PE}$$

$$0.65 = 50\text{ mV} + t_{PE} \times 10^{-6}/C_{PE}$$

$$C_{PE} = t_{PE}/0.6\text{ (sec)}$$

When the external capacitor C_{PE} is charged to approximately 0.65 V, the SR latch is set and the output drive transistor is turned off. Simultaneously, the dead time is extended to 100% and the output voltage on the SCP terminal (pin 23) is held “L”. As a result, the S-R latch input is closed and C_{PE} is discharged.

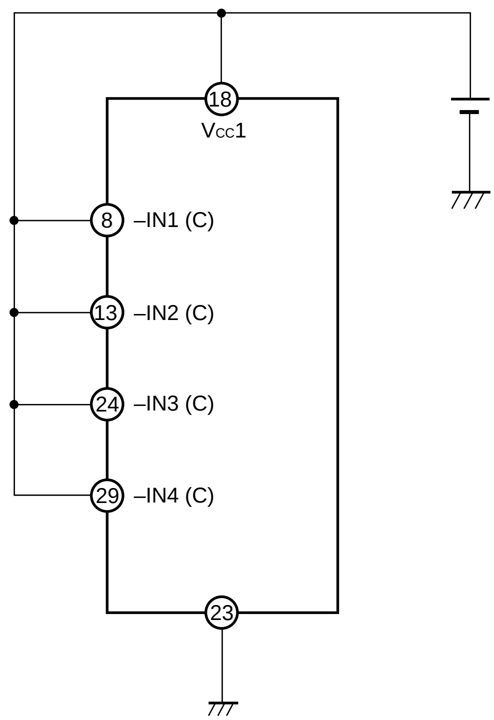
Figure 5. Protection Latch Circuit



■ TREATMENT WHEN NOT USING SCP

When you do not use the timer/latch-actuated short-circuiting protection circuit, connect the SCP terminal (pin 23) to GND with the shortest distance possible. Also, connect the comparator's input terminal for each channel to the V_{CC1} terminal (pin 18).

Figure 6. Treatment When Not Using SCP

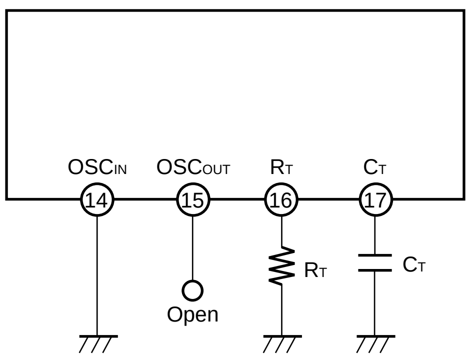


■ METHOD OF SETTING THE TRIANGULAR-WAVE OSCILLATOR CIRCUIT

1. When Not Using Ceramic Resonator

Connect the OSC_{IN} terminal (pin 14) to GND and leave the OSC_{OUT} terminal (pin 15) open. This makes it possible to set the oscillation frequency with only C_T and R_T.

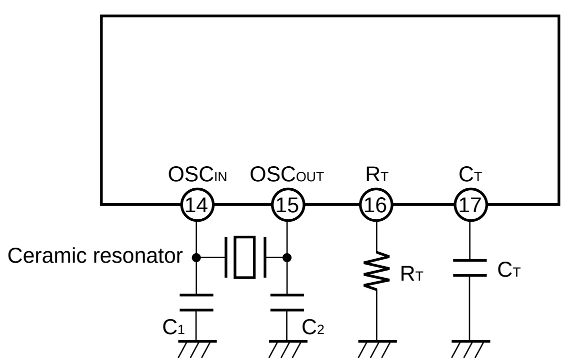
Figure 7. When Not Using Ceramic Resonator



2. When Using Ceramic Resonator

By connecting a ceramic resonator between OSC_{IN} and OSC_{OUT} as shown below, you can set the oscillation frequency. In this case, too, C_T and R_T are required. Determine the values of C_T and R_T so that the oscillation frequency of this RC network is about 5-10% lower than that of the ceramic resonator.

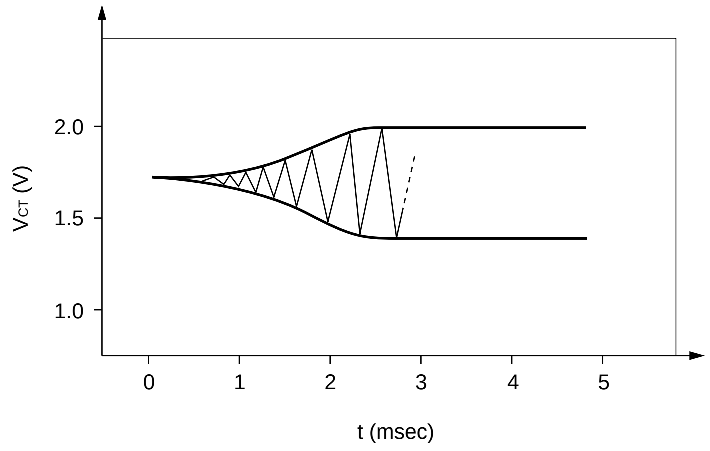
Figure 8. When Using Ceramic Resonator



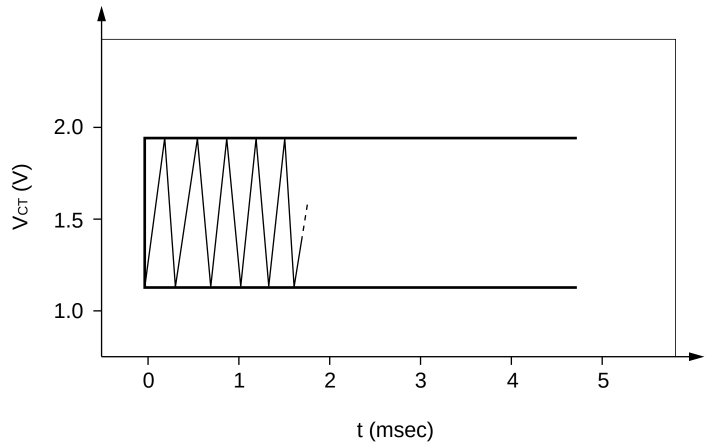
<Precautions>

When the oscillation rise time at power switch-on is compared between a ceramic and a crystal resonator, it is known that the crystal resonator is about 10 to 100 times slower to rise than the ceramic resonator. Therefore, when a crystal resonator is used, system operation as a switching regulator at power switch-on becomes unstable. To avoid this problem, it is recommended that you use a ceramic oscillator because it has a short rise time and, hence, ensures stable operation.

- **Crystal Resonator Turn-on Characteristic**



- **Ceramic Resonator Turn-on Characteristic**



■ METHOD OF SETTING THE DEAD TIME AND SOFT START

1. Dead Time

When the device is set for step-up inverted output based on the flyback method, the output transistor is fixed to a full-on state (ON-duty = 100 %) at power switch-on. To prevent this problem, you may determine the voltages on the DTC terminals (pins 4, 9, 28, and 33) from the V_{REF} voltage so you can easily set the output transistor's dead time (maximum ON-duty) independently for each channel as shown below.

(1) CH1 and CH2 Channels

When the voltage on the DTC terminals (pins 4 and 9) is higher than the triangular-wave output voltage from the oscillator, the output transistor turns off. The dead time calculation formula assuming that triangular-wave amplitude ≅ 0.6 V and triangular-wave minimum voltage ≅ 1.3 V is given below.

$$\text{Duty (OFF)} = \frac{V_{dt} - 1.3}{0.6} \times 100\ [\%],\ V_{dt} = \frac{R_2}{R_1 + R_2} \times V_{REF}$$

When you do not use these DTC terminals, connect them to GND.

Figure 9. When Using DTC to Set Dead Time

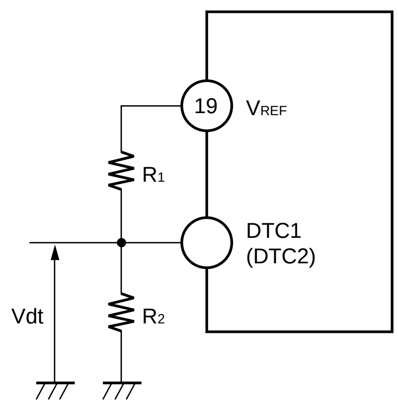
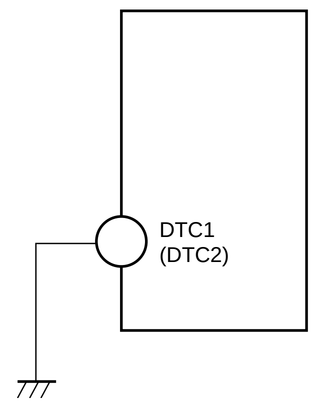


Figure 10. When Not Using DTC



(2) CH3 and CH4 Channels

When the voltage on the DTC terminals (pins 28 and 33) is lower than the triangular-wave output voltage from the oscillator, the output transistor turns off. The dead time calculation formula assuming that traingular-wave amplitude ≅ 0.6 V and triangular-wave maximum voltage ≅ 1.9 V is given below.

$$\text{Duty (OFF)} \cong \frac{1.9 - V_{dt}}{0.6} \times 100\ [\%],\ V_{dt} = \frac{R_2}{R_1 + R_2} \times V_{REF}$$

When you do not use these DTC terminals, connect them to V_{REF}.

Figure 11. When Using DTC to Set Dead Time

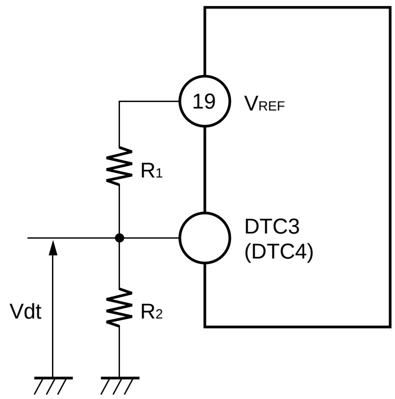
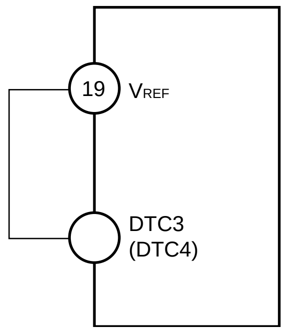


Figure 12. When Not Using DTC



<Precautions>

When you use a ceramic resonator, pay attention when setting the dead time because the triangular-wave amplitude is determined by the values of C_T and R_T.

2. Soft Start

To prevent inrush current at power switch-on, the device can be set for soft start by using the DTC terminals (pins 4, 9, 28, and 33). The diagrams below show how to set.

Figure 13. Setting Soft Start for CH1 and CH2

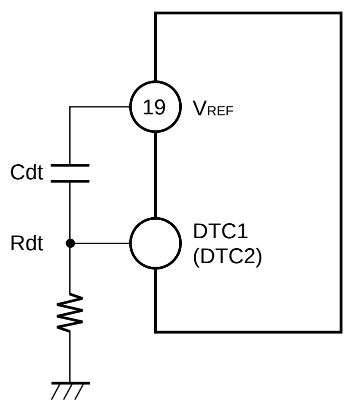
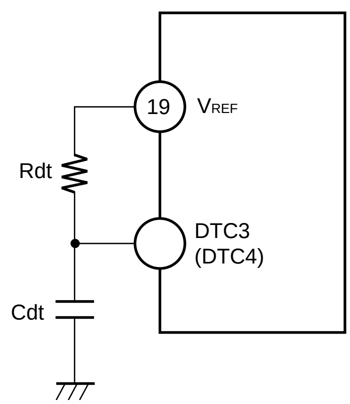


Figure 14. Setting Soft Start for CH3 and CH4



It is also possible to set soft start simultaneously with the dead time by configuring the DTC terminals as shown below.

Figure 15. Setting Dead Time and Soft Start for CH1 and CH2

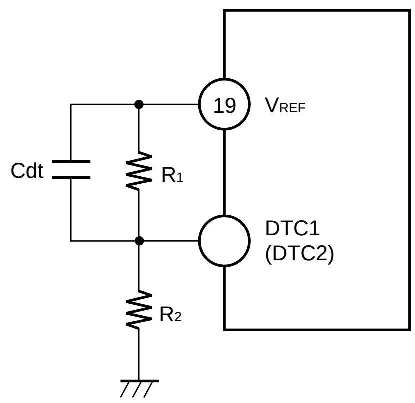
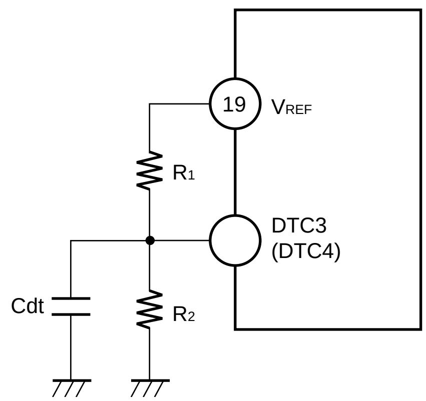


Figure 16. Setting Dead Time and Soft Start for CH3 and CH4



■ EQUIVALENT SERIES RESISTOR AND STABILITY OF SMOOTHING CAPACITOR

The equivalent series resistance (ESR) of a smoothing capacitor in a DC/DC converter greatly affects the phase characteristics of the loop depending on its value.

System stability is improved by ESR because it causes the phase to lead that of the ideal capacitor in high-frequency regions. (See Figures 17 and 19.) Conversely, if a low-ESR smoothing capacitor is used, system stability deteriorates. Therefore, use of a low-ESR semiconductor electrolytic capacitors (OS – CON) or tantalum capacitors calls for careful attention.

Figure 17. Basic Circuit of Stepdown DC/DC Converter

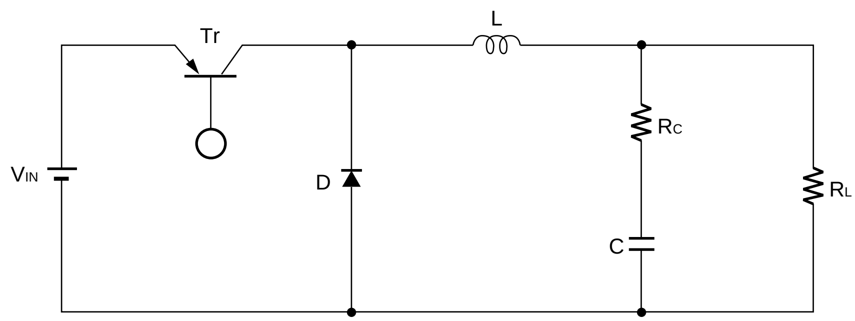


Figure 18. Gain-Frequency Characteristic

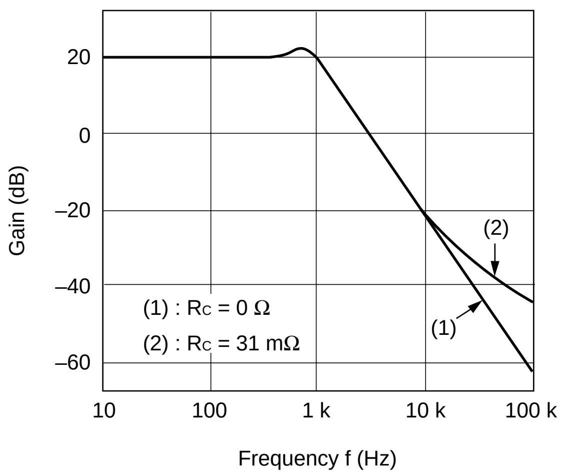
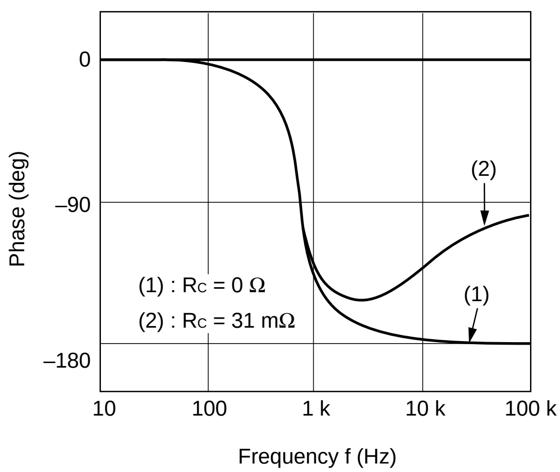


Figure 19. Phase-Frequency Characteristic



(Reference Data)

The phase margin is halved by changing the smoothing capacitor from an aluminum electrolytic capacitor (R_C = 1.0 Ω) to a small-ESR semiconductor electrolytic capacitor (OS – CON; R_C = 0.2 Ω). (See Figure 21 and 22.)

Figure 20. DC/DC Converter AV-ϕ Characteristic Measuring Circuit

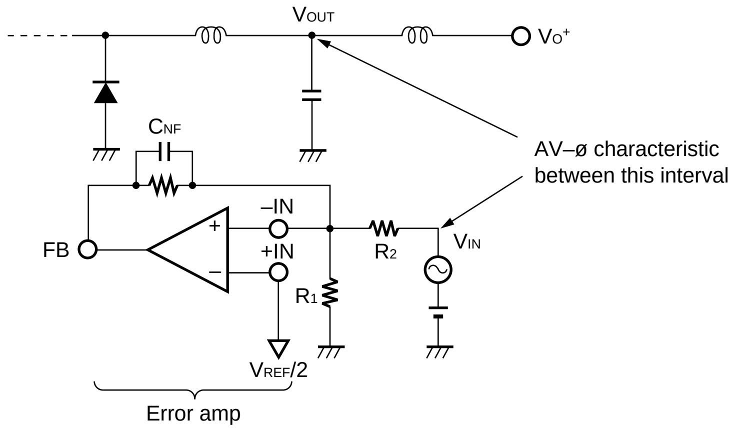


Figure 21. Gain-Frequency Characteristic

Gain - frequency and phase frequency characteristics of Al electrolytic capacitor (DC/DC converter +5 V output)

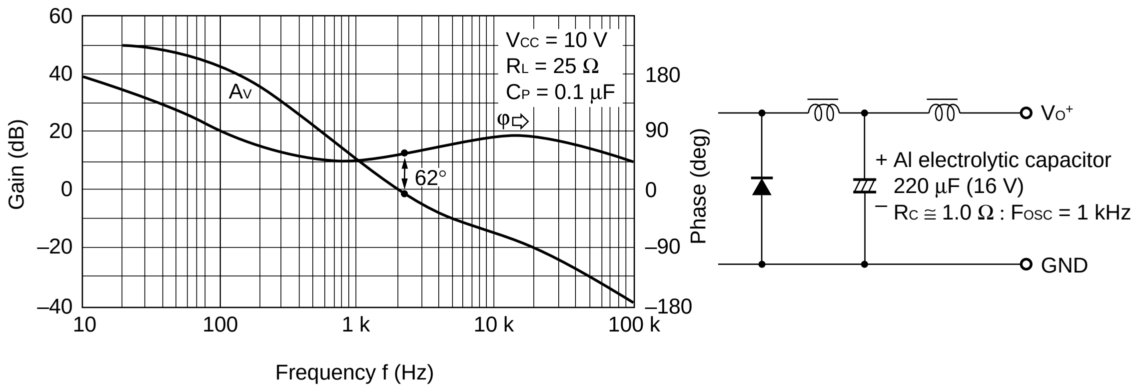
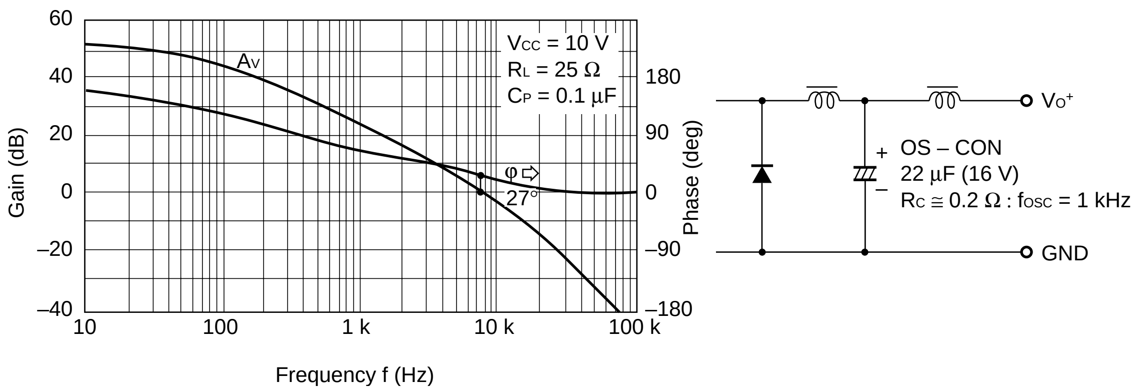
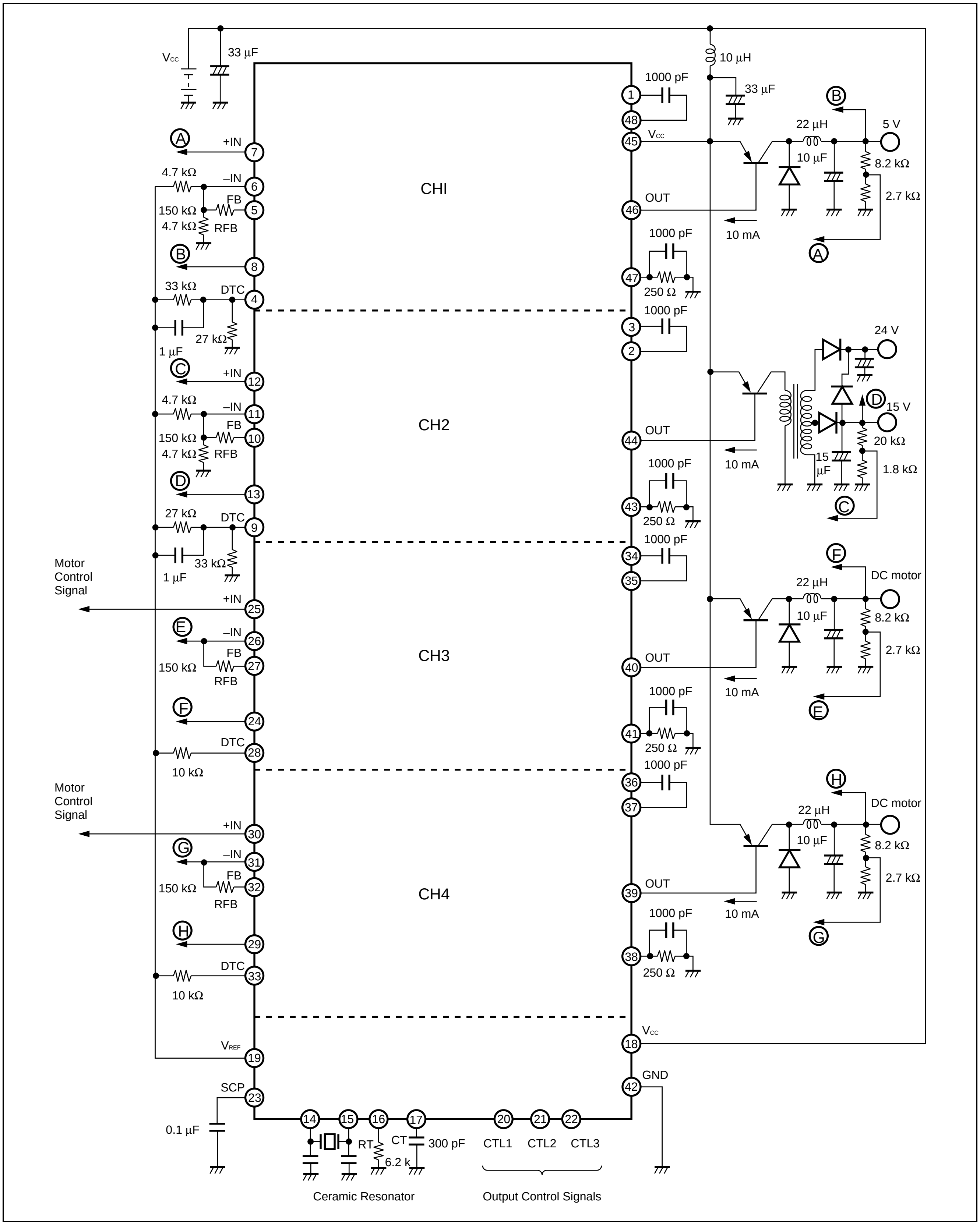


Figure 22. Phase-Frequency Characteristic

Gain - frequency and phase frequency characteristics of OS – CON (DC/DC converter +5 V output)



■ EXAMPLE OF APPLICATION CIRCUIT



■ PRECAUTIONS ON USING THE DEVICE

1. Do not input voltages greater than the maximum rating.

Inputting voltages greater than the maximum rating may damage the device.

2. Always use the device under recommended operating conditions.

If a voltage greater than the maximum value is input to the device, its electrical characteristics may not be guaranteed. Similarly, inputting a voltage below the minimum value may cause device operation to become unstable.

3. For grounding the printed circuit board, use as wide ground lines as possible to prevent high-frequency noise.

Because the device uses high frequencies, it tends to generate high-frequency noise.

4. Take the following measures for protection against static charge:

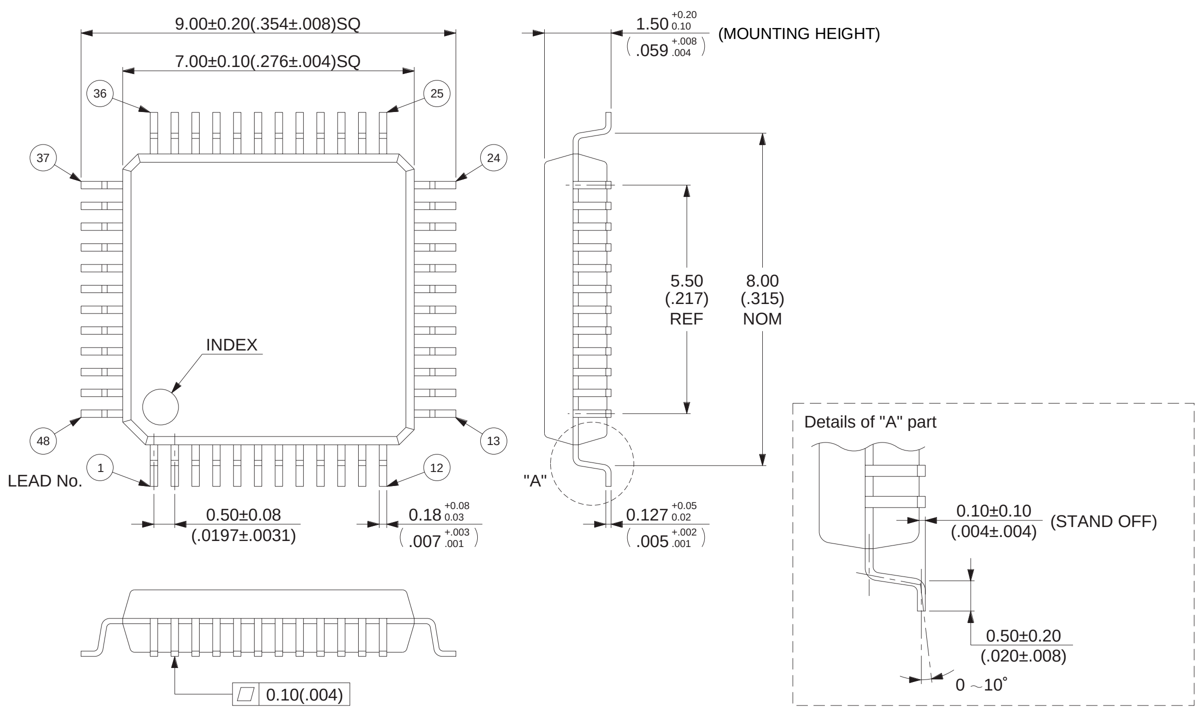
- For containing semiconductor devices, use an antistatic or conductive container.
- When storing or transporting device-mounted circuit boards, use a conductive bag or container.
- Ground the workbenches, tools, and measuring equipment to earth.
- Make sure that operators wear wrist straps or other appropriate fittings grounded to earth via a resistance of 250 k to 1 M ohms placed in series between the human body and earth.

■ ORDERING INFORMATION

Part number	Package	Remarks
MB3785APFV	48-pin plastic LQFP (FPT-48P-M05)	

■ PACKAGE DIMENSION

48-pin Plastic LQFP
(FPT-48P-M05)



Dimensions in: mm (inches)

FUJITSU LIMITED

For further information please contact:

Japan
FUJITSU LIMITED
Corporate Global Business Support Division
Electronic Devices
KAWASAKI PLANT, 4-1-1, Kamikodanaka
Nakahara-ku, Kawasaki-shi
Kanagawa 211-8588, Japan
Tel: (044) 754-3763
Fax: (044) 754-3329

http://www.fujitsu.co.jp/

North and South America
FUJITSU MICROELECTRONICS, INC.
Semiconductor Division
3545 North First Street
San Jose, CA 95134-1804, USA
Tel: (408) 922-9000
Fax: (408) 922-9179

Customer Response Center
Mon. - Fri.: 7 am - 5 pm (PST)
Tel: (800) 866-8608
Fax: (408) 922-9179

http://www.fujitsumicro.com/

Europe
FUJITSU MIKROELEKTRONIK GmbH
Am Siebenstein 6-10
D-63303 Dreieich-Buchschlag
Germany
Tel: (06103) 690-0
Fax: (06103) 690-122

http://www.fujitsu-ede.com/

Asia Pacific
FUJITSU MICROELECTRONICS ASIA PTE LTD
#05-08, 151 Lorong Chuan
New Tech Park
Singapore 556741
Tel: (65) 281-0770
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