

ASSP For Power Supply Applications

6-ch DC/DC Converter IC With Synchronous Rectifier

MB3825A

■ DESCRIPTION

The MB3825A is a pulse width modulation (PWM) type 6-channel DC/DC converter IC with synchronous rectification (2-channels) designed for low voltage, high efficiency operation in high precision and high frequency applications, ideal for down conversion.

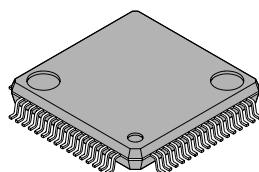
The MB3825A is an ideal device offering low power consumption, compact size and light weight for products such as self-contained camcorders and digital still cameras.

■ FEATURES

- Synchronous rectification (channels 1 and 4)
- High efficiency drive with power-on output enhanced by built-in speed-up circuit
- Wide range of operating power supply voltage : 2.5 V to 12 V
- Built-in high-precision reference voltage generator : $1.5\text{ V} \pm 1\%$
- Wide operating oscillator frequency range, high frequency capability : 50 kHz to 800 kHz
- Wide input voltage range (all channels) : 0 V to $V_{CC} - 0.9\text{ V}$
- Error amplifier output for soft start (channels 1, 2, 4) (All channels may be set for same soft start time regardless of duty factor setting.)

■ PACKAGE

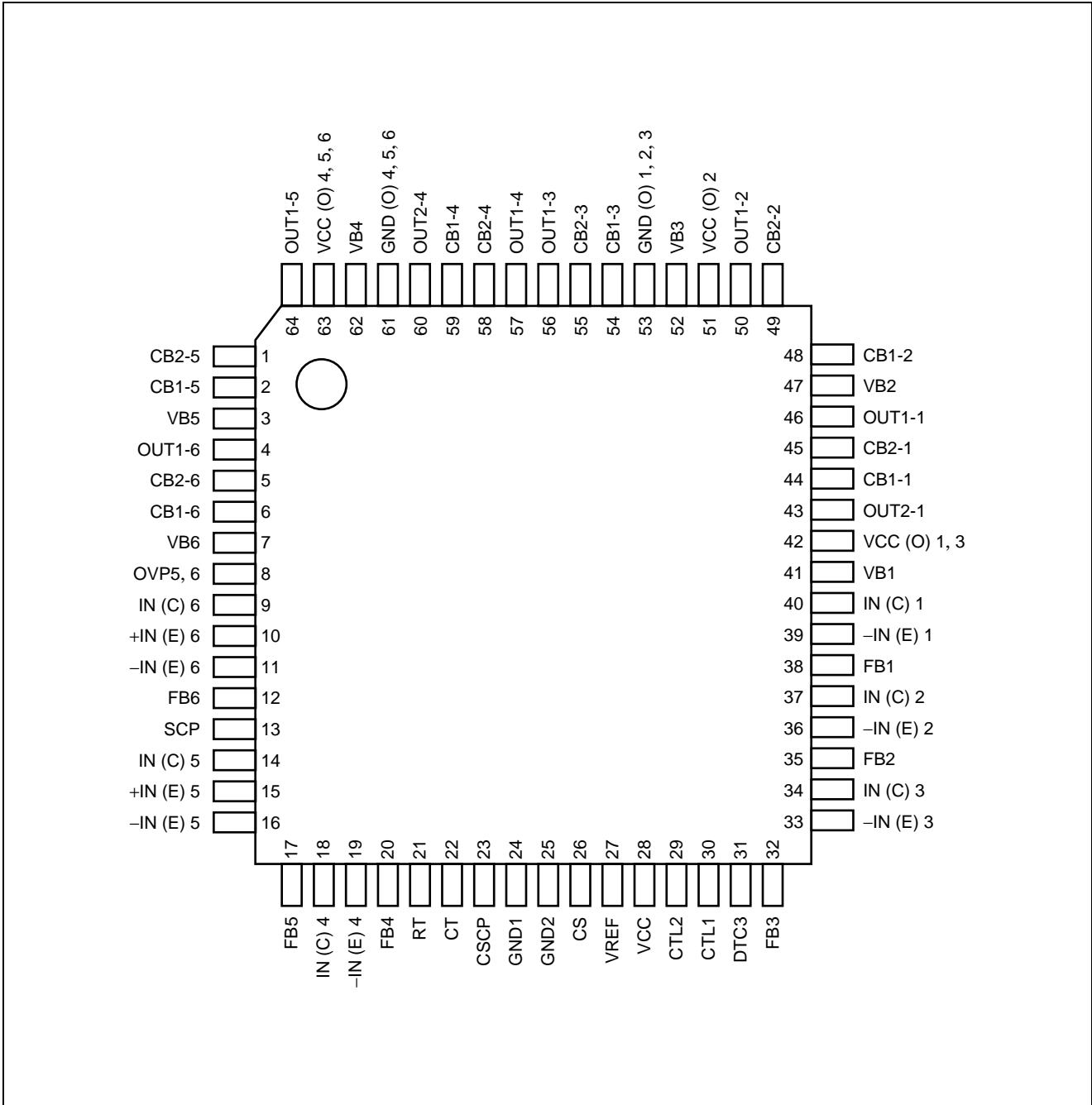
64-pin, Plastic LQFP



(FPT-64P-M03)

MB3825A

■ PIN ASSIGNMENT



■ PIN DESCRIPTION

| Pin No. | Symbol | I/O | Descriptions | |
|---------|--------|---------|--------------|--|
| CH 1 | 38 | FB1 | O | Channel 1 error amplifier output pin. |
| | 39 | -IN(E)1 | I | Channel 1 error amplifier inverted input pin. |
| | 40 | IN(C)1 | I | Channel 1 short detection comparator input pin. |
| | 46 | OUT1-1 | O | Channel 1 main side output pin. |
| | 43 | OUT2-1 | O | Channel 1 synchronous rectifier side output pin. |
| | 44 | CB1-1 | — | Channel 1 boot capacitor connection pin. |
| | 45 | CB2-1 | — | |
| | 41 | VB1 | — | Channel 1 output sink current setting pin. |
| CH 2 | 35 | FB2 | O | Channel 2 error amplifier output pin. |
| | 36 | -IN(E)2 | I | Channel 2 error amplifier inverted input pin. |
| | 37 | IN(C)2 | I | Channel 2 short detection comparator input pin. |
| | 50 | OUT1-2 | O | Channel 2 output pin. |
| | 48 | CB1-2 | — | Channel 2 boot capacitor connection pin. |
| | 49 | CB2-2 | — | |
| | 47 | VB2 | — | Channel 2 output sink current setting pin. |
| CH 3 | 32 | FB3 | O | Channel 3 error amplifier output pin. |
| | 33 | -IN(E)3 | I | Channel 3 error amplifier inverted input pin. |
| | 34 | IN(C)3 | I | Channel 3 short detection comparator input pin. |
| | 56 | OUT1-3 | O | Channel 3 output pin. |
| | 54 | CB1-3 | — | Channel 3 boot capacitor connection pin. |
| | 55 | CB2-3 | — | |
| | 52 | VB3 | — | Channel 3 output sink current setting pin. |
| | 31 | DTC3 | I | Channel 3 dead time control pin. |
| CH 4 | 20 | FB4 | O | Channel 4 error amplifier output pin. |
| | 19 | -IN(E)4 | I | Channel 4 error amplifier inverted input pin. |
| | 18 | IN(C)4 | I | Channel 4 short detection comparator input pin. |
| | 57 | OUT1-4 | O | Channel 4 main side output pin. |
| | 60 | OUT2-4 | O | Channel 4 synchronous rectifier side output pin. |
| | 59 | CB1-4 | — | Channel 4 boot capacitor connection pin. |
| | 58 | CB2-4 | — | |
| | 62 | VB4 | — | Channel 4 output sink current setting pin. |

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| Pin No. | Symbol | I/O | Descriptions | |
|------------------------------------|--------|---------|--------------|--|
| CH 5 | 17 | FB5 | O | Channel 5 error amplifier output pin. |
| | 16 | -IN(E)5 | I | Channel 5 error amplifier inverted input pin. |
| | 15 | +IN(E)5 | I | Channel 5 error amplifier non-inverted input pin. |
| | 14 | IN(C)5 | I | Channel 5 short detection comparator input pin. |
| | 64 | OUT1-5 | O | Channel 5 output pin. |
| | 2 | CB1-5 | — | Channel 5 boot capacitor connection pin. |
| | 1 | CB2-5 | — | |
| | 3 | VB5 | — | Channel 5 output sink current setting pin. |
| | 8 | OVP5,6 | I | Channel 5, 6 output maximum voltage setting pin. |
| CH 6 | 12 | FB6 | O | Channel 6 error amplifier output pin. |
| | 11 | -IN(E)6 | I | Channel 6 error amplifier inverted input pin. |
| | 10 | +IN(E)6 | I | Channel 6 error amplifier non-inverted input pin. |
| | 9 | IN(C)6 | I | Channel 6 short detection comparator input pin. |
| | 4 | OUT1-6 | O | Channel 6 output pin. |
| | 6 | CB1-6 | — | Channel 6 boot capacitor connection pin. |
| | 5 | CB2-6 | — | |
| | 7 | VB6 | — | Channel 6 output sink current setting pin. |
| | 8 | OVP5,6 | I | Channel 5, 6 output maximum voltage setting pin. |
| Triangular-Wave Oscillator Circuit | 21 | RT | — | Triangular wave frequency setting resistor connection pin. |
| | 22 | CT | — | Triangular wave frequency setting capacitor connection pin. |
| Control Circuit | 30 | CTL1 | I | Power supply control circuit. “H” level: Power supply operating mode “L” level: Standby mode |
| | 29 | CTL2 | I | Channel 3 control circuit. When CTL1 pin is “H” level “H” level: Channel 3 in operating mode “L” level: Channel 3 in OFF mode |
| | 13 | SCP | I | Short detection comparator input pin. |
| | 23 | CSCP | — | Short protection circuit capacitor connection pin. |
| | 26 | CS | — | Soft start circuit capacitor connection pin. |

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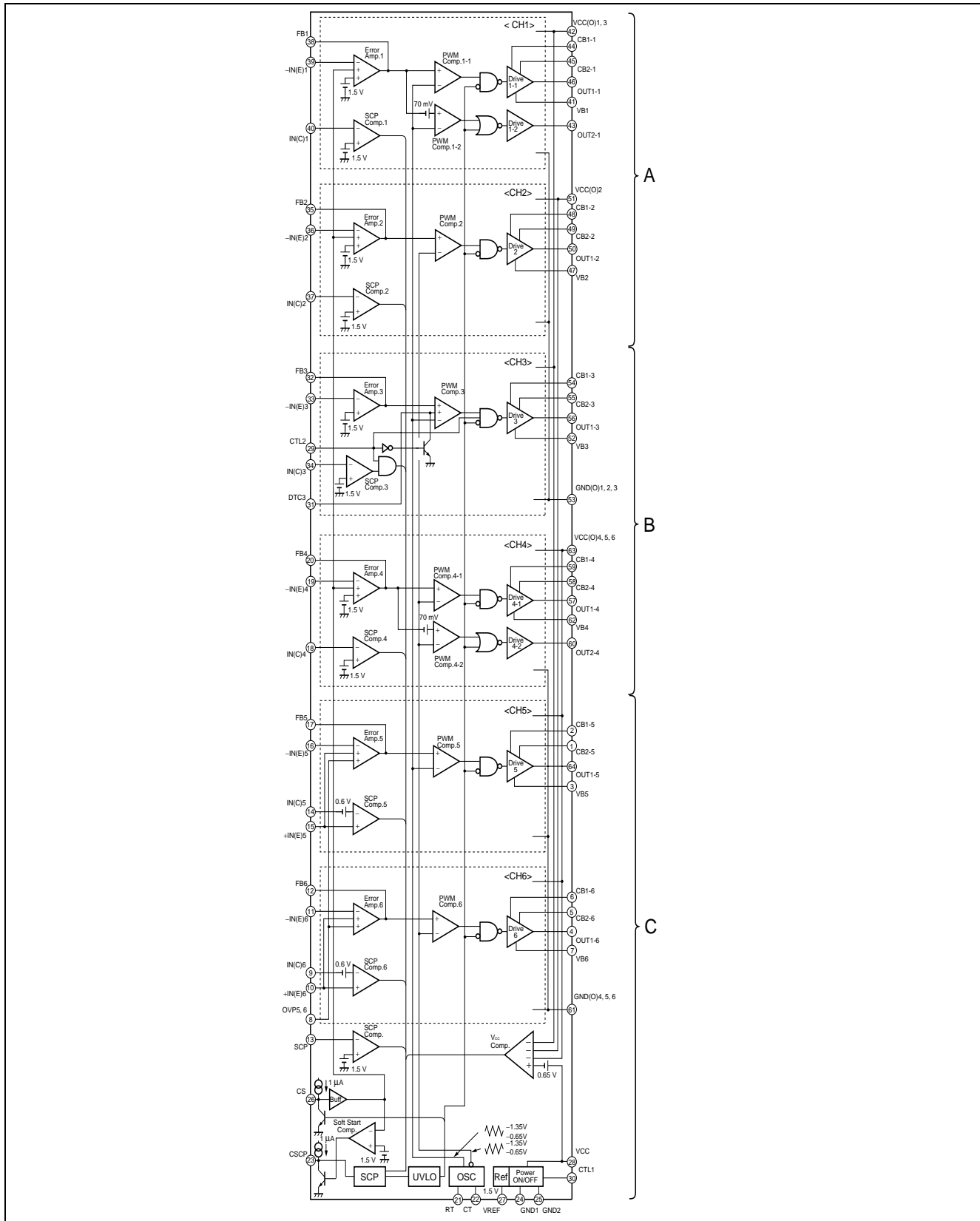
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| Pin No. | Symbol | I/O | Description | |
|-------------------------|--------|-------------|-------------|---|
| Power Supply Circuit | 28 | VCC | — | Reference voltage and control circuit power supply pin. |
| | 42 | VCC(O)1,3 | — | Output circuit power supply pin (Channel 1, 3). |
| | 51 | VCC(O)2 | — | Output circuit power supply pin (Channel 2). |
| | 63 | VCC(O)4,5,6 | — | Output circuit power supply pin (Channel 4,5,6). |
| | 27 | VREF | O | Reference voltage output pin. |
| | 24 | GND1 | — | Ground pin. |
| | 25 | GND2 | — | Ground pin. |
| | 53 | GND(O)1,2,3 | — | Output circuit ground pin (Channel 1,2,3). |
| | 61 | GND(O)4,5,6 | — | Output circuit ground pin (Channel 4,5,6). |

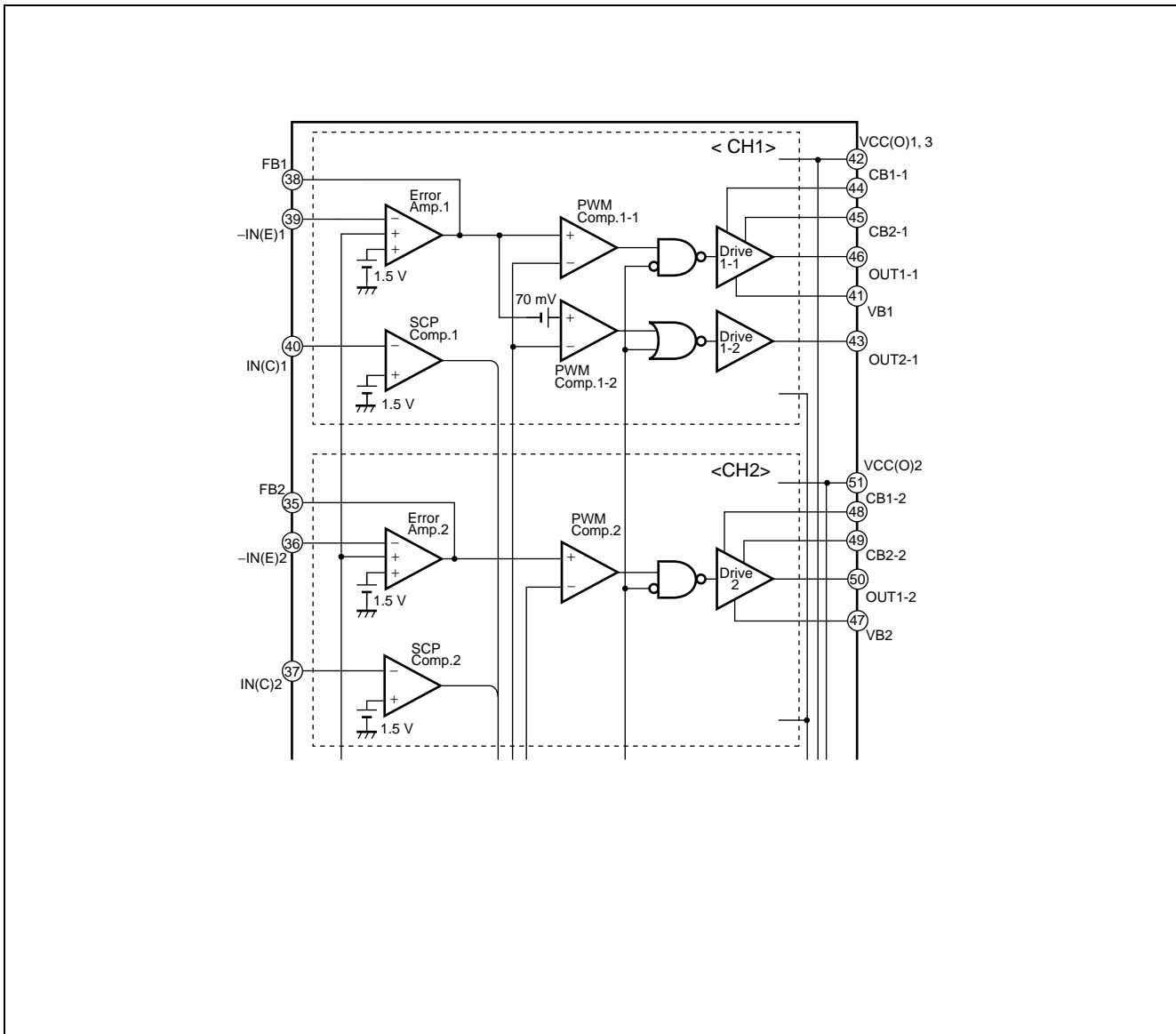
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■ BLOCK DIAGRAM

• General view

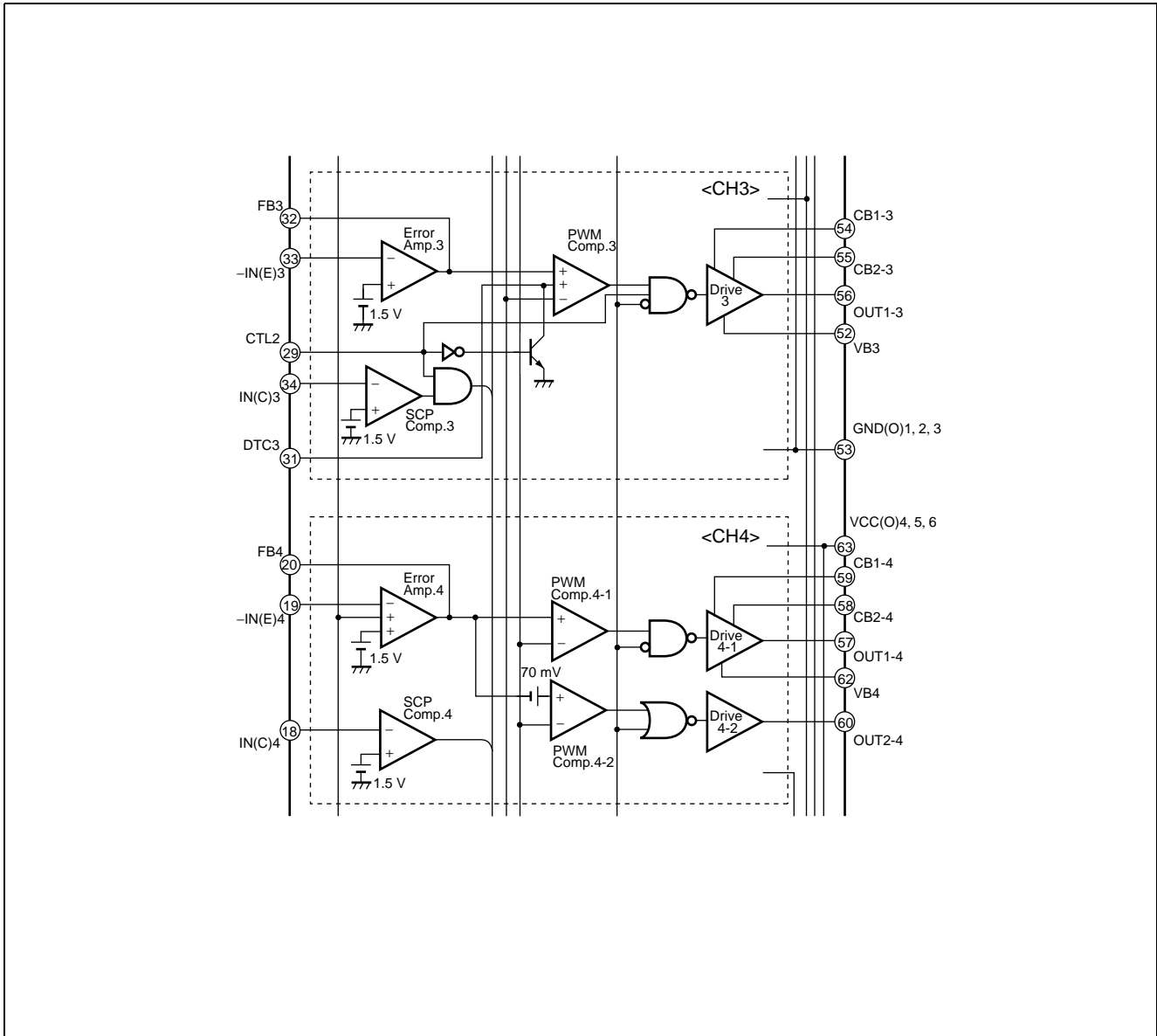


• Enlarged view of A

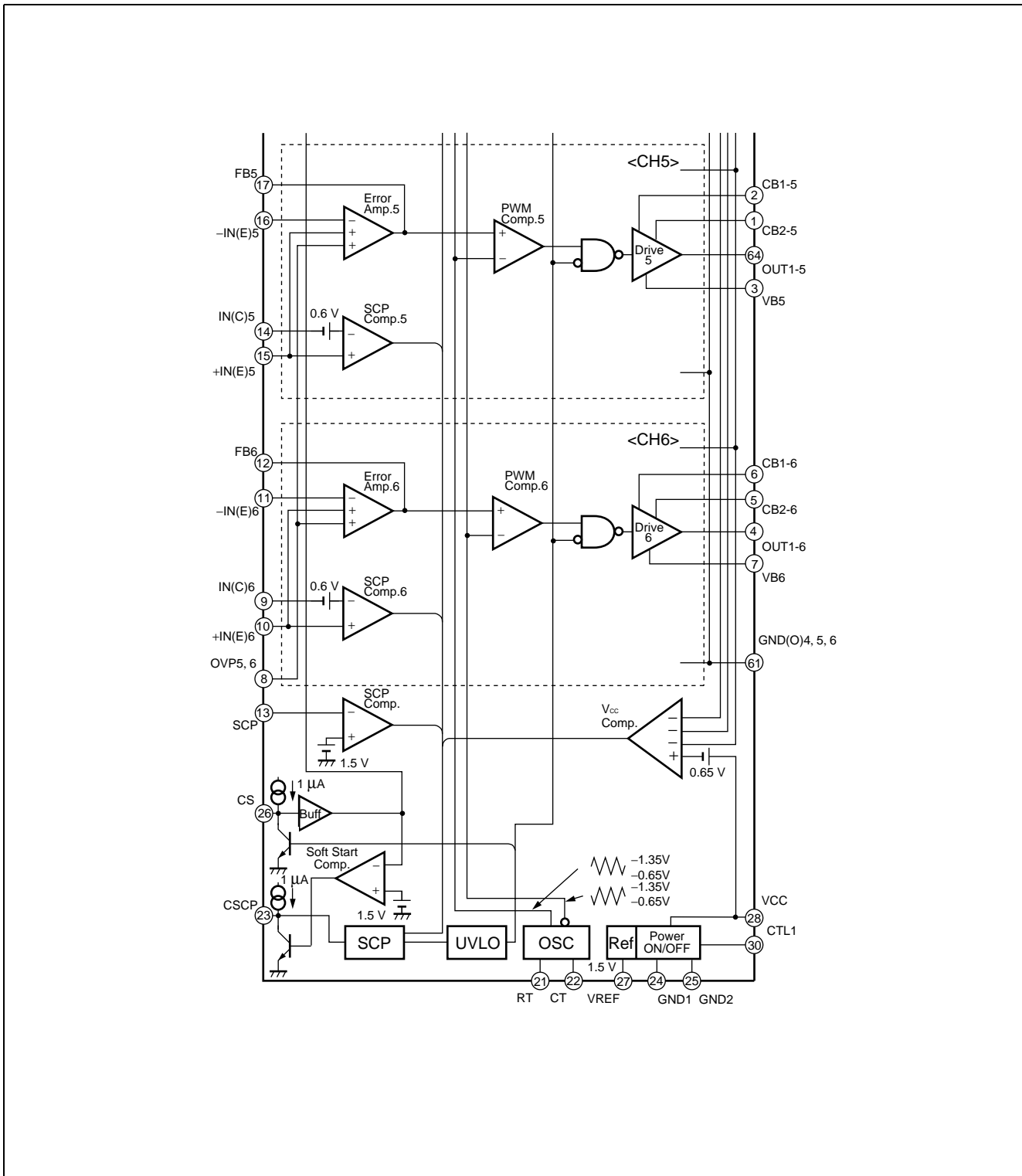


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• Enlarged view of B



• Enlarged view of C



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■ ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Conditions | Rating | | Unit |
|----------------------|-----------|------------------------------|--------|------|------------------|
| | | | Min. | Max. | |
| Power supply voltage | V_{CC} | — | — | 17 | V |
| Output current | I_o | OUT pin | — | 50 | mA |
| Output peak current | I_o | OUT pin, Duty \leq 5% | — | 200 | mA |
| Power dissipation | P_D | $T_a \leq +25^\circ\text{C}$ | — | 800* | mW |
| Storage temperature | T_{stg} | — | -55 | +125 | $^\circ\text{C}$ |

*: 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 | Conditions | Value | | | Unit |
|----------------------------------|-----------|------------------------|-------|------|----------------|------------------|
| | | | Min. | Typ. | Max. | |
| Power supply voltage | V_{CC} | — | 2.5 | 6.0 | 12 | V |
| Reference voltage output current | I_{OR} | — | -1 | — | 0 | mA |
| Input voltage | V_{IN} | -IN(E), IN(C), OVP pin | 0 | — | $V_{CC} - 0.9$ | V |
| Control input voltage | V_{CTL} | CTL pin | 0 | — | 12 | V |
| Output current | I_o | Main side OUT pin | 2 | — | 20 | mA |
| Output current setting resistor | R_B | — | 2.7 | 5.6 | 30 | $k\Omega$ |
| Oscillator frequency | f_{OSC} | — | 50 | 500 | 800 | kHz |
| Timing capacitor | C_T | — | 50 | 100 | 1500 | pF |
| Timing resistor | R_T | — | 20 | 39 | 82 | $k\Omega$ |
| Soft-start capacitor | C_S | — | — | 0.1 | 1.0 | μF |
| Short detection capacitor | C_{SCP} | — | — | 0.1 | 1.0 | μF |
| Operating ambient temperature | T_a | — | -30 | +25 | +85 | $^\circ\text{C}$ |

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

($V_{CC} = V_{CC(O)} = +6\text{ V}$, $T_a = +25^\circ\text{C}$)

| Parameter | Symbol | Pin No. | Conditions | Value | | | Unit | |
|---|--------------------------------------|----------------------------------|------------------|--|-------|-------|-------|---------------|
| | | | | Min. | Typ. | Max. | | |
| Reference voltage block | Reference voltage | V_{REF} | 27 | — | 1.485 | 1.500 | 1.515 | V |
| | Output voltage temperature stability | $\frac{\Delta V_{REF}}{V_{REF}}$ | 27 | $T_a = -30^\circ\text{C}$ to $+85^\circ\text{C}$ | — | 0.5* | — | % |
| | Input stability | Line | 27 | $V_{CC} = 2.5\text{ V}$ to 12 V | — | 2 | 10 | mV |
| | Load stability | Load | 27 | $V_{REF} = 0\text{ mA}$ to -1 mA | — | 2 | 10 | mV |
| | Short-circuit output current | I_{OS} | 27 | $V_{REF} = 2\text{ V}$ | -10 | -6 | -1 | mA |
| Under voltage lockout protection circuit block(U.V.L.O) | Threshold voltage | V_{TH} | 46 | $V_{CC} = \underline{\hspace{1cm}}$ | — | 2.1 | — | V |
| | Hysteresis width | V_H | 46 | — | — | 0.1 | — | V |
| | Reset voltage | V_{RST} | 46 | — | 1.8 | 2.0 | — | V |
| Soft-start block | Input standby voltage | V_{STB} | 26 | — | — | 50 | 100 | mV |
| | Charge current | I_{CS} | 26 | — | -1.4 | -1.0 | -0.6 | μA |
| Short circuit detection block | Threshold voltage | V_{TH} | 23 | — | 0.65 | 0.70 | 0.75 | V |
| | Input standby voltage | V_{STB} | 23 | — | — | 50 | 100 | mV |
| | Input latch voltage | V_I | 23 | — | — | 50 | 100 | mV |
| | Input source current | I_{CSCP} | 23 | — | -1.4 | -1.0 | -0.6 | μA |
| Triangular wave oscillator block | Oscillator frequency | f_{OSC} | 46,50,56,57,64,4 | $C_T = 100\text{ pF}$, $R_T = 39\text{ k}\Omega$ | 450 | 500 | 550 | kHz |
| | Frequency stability for voltage | $\Delta f/fdv$ | 46,50,56,57,64,4 | $V_{CC} = 2.5\text{ V}$ to 12 V | — | 1 | 10 | % |
| | Frequency stability for temperature | $\Delta f/fdt$ | 46,50,56,57,64,4 | $T_a = -30^\circ\text{C}$ to $+85^\circ\text{C}$ | — | 1* | — | % |

*: Standard design value.

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($V_{CC} = V_{CC(O)} = +6\text{ V}$, $T_a = +25^\circ\text{C}$)

| | Parameter | Symbol | Pin No | Conditions | Value | | | Unit |
|---|------------------------------------|--------------------------|--------------------|--|-------|------|---------------|---------------|
| | | | | | Min. | Typ. | Max. | |
| Error amplifier block (CH1 to CH4) | Threshold voltage | V_{TH} | 38,35, 32,20 | FB = 1.0 V | 1.45 | 1.50 | 1.55 | V |
| | V_T temperature stability | $\frac{\Delta V_T}{V_T}$ | 38,35, 32,20 | $T_a = -30^\circ\text{C}$ to $+85^\circ\text{C}$ | — | 0.5* | — | % |
| | Input bias current | I_B | 39,36, 33,19 | -IN = 0 V | -200 | -20 | — | nA |
| | Voltage gain | A_V | 38,35, 32,20 | DC | 60 | 75 | — | dB |
| | Frequency bandwidth | BW | 38,35, 32,20 | $A_V = 0\text{ dB}$ | — | 1.0* | — | MHz |
| | Maximum output voltage width | V_{OM^+} | 38,35, 32,20 | — | 1.45 | 1.55 | — | V |
| | | V_{OM^-} | 38,35, 32,20 | — | — | 20 | 200 | mV |
| | Output source current | I_{O^-} | 38,35, 32,20 | FB = 1.0 V | — | -2.0 | -0.6 | mA |
| | Output sink current | I_{O^+} | 38,35, 32,20 | FB = 1.0 V (CH1,CH4) | 60 | 120 | — | μA |
| FB = 1.0 V (CH2,CH3) | | | | 60 | 130 | — | μA | |
| Error amplifier block (CH5, CH6) | Input offset voltage | V_{IO} | 17,12 | FB = 1.0 V | -1 | 9 | 19 | mV |
| | V_T temperature stability | $\frac{\Delta V_T}{V_T}$ | 17,12 | $T_a = -30^\circ\text{C}$ to $+85^\circ\text{C}$ | — | 0.5* | — | % |
| | Input bias current | I_B | 15,10 | +IN = 0 V, +IN(E) pin | -400 | -40 | — | nA |
| | | | 16,11 | -IN = 0 V, -IN(E) pin | -200 | -20 | — | nA |
| | | | 8 | OVP = 0 V, OVP pin | -400 | -40 | — | nA |
| | Common mode input voltage range | V_{CM} | 17,12 | — | 0 | — | $V_{CC}-0.9$ | V |
| | Voltage gain | A_V | 17,12 | DC | 60 | 75 | — | dB |
| | Frequency bandwidth | BW | 17,12 | $A_V = 0\text{ dB}$ | — | 1.0* | — | MHz |
| | Maximum output voltage width | V_{OM^+} | 17,12 | — | 1.45 | 1.55 | — | V |
| | | V_{OM^-} | 17,12 | — | — | 20 | 200 | mV |
| Output source current | I_{O^-} | 17,12 | FB = 1.0 V | — | -2.0 | -0.6 | mA | |
| Output sink current | I_{O^+} | 17,12 | FB = 1.0 V | 60 | 130 | — | μA | |
| SCP Comp. block (CH1 to CH4, SCP) | Threshold voltage | V_{TH} | 46,50, 56,57 | — | 1.45 | 1.50 | 1.55 | V |
| | Input bias current | I_B | 40,37, 34,18,13 | IN(C) = SCP = 0 V | -200 | -20 | — | nA |

*: Standard design value.

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($V_{CC} = V_{CC(O)} = +6\text{ V}$, $T_a = +25^\circ\text{C}$)

| | Parameter | Symbol | Pin No. | Conditions | Value | | | Unit |
|---|---------------------------------|------------|--------------------------|---|---------------|---------------|---------------|---------------|
| | | | | | Min. | Typ. | Max. | |
| SCP Comp. block (CH5, CH6) | Input offset voltage | V_{IO} | 64,4 | — | 0.55 | 0.60 | 0.65 | V |
| | Input bias current | I_{IN^+} | 14,9 | $IN(C) = 0\text{ V}$ | -400 | -40 | — | nA |
| | Common mode input voltage range | V_{CM} | 64,4 | — | 0 | — | $V_{CC}-0.9$ | V |
| PWM Comp. block (CH1 to CH6) | Threshold voltage | V_{TO} | 46,50, 56,57, 64,4 | Duty cycle = 0 % | 0.55 | 0.65 | — | V |
| | | V_{T100} | 46,50, 56,57, 64,4 | Duty cycle = 100 % | — | 1.35 | 1.45 | V |
| Dead time control block (CH3) (DTC pin) | Input bias current | I_B | 31 | DTC = 0.4 V | -1.0 | -0.2 | — | μA |
| | Sink current at CTL2 = "L" | I_{IDTC} | 31 | DTC = 1.5 V CTL2 = 0 V | 80 | 500 | — | μA |
| | Input voltage at CTL2 = "L" | V_{IDTC} | 31 | IDTC = 40 μA CTL2 = 0 V | — | 0.2 | 0.3 | V |
| Main side output block (CH1 to CH6) (Drive-1) | Output source current | I_{O^-} | 46,50, 56,57, 64,4 | Duty cycle $\leq 5\%$ | — | -100 | — | mA |
| | Output sink current | I_{O^+} | 46,50, 56,57, 64,4 | $R_B = 5.6\text{ k}\Omega$ | 7 | 10 | 13 | mA |
| Synchronous rectifier side output block (CH1, CH4) (Drive-2) | Output source current | I_{O^-} | 43,60 | Duty cycle $\leq 5\%$, $V_O = 2\text{ V}$ | — | -70 | — | mA |
| | Output sink current | I_{O^+} | 43,60 | Duty cycle $\leq 5\%$, $V_O = 1\text{ V}$ | — | 70 | — | mA |
| | Output voltage | V_{OH} | 43,60 | — | 3.5 | 4.0 | — | V |
| | | V_{OL} | 43,60 | — | — | 0 | 0.1 | V |
| Control block | CTL input condition | V_{ON} | 27 | IC active mode | 2.1 | — | 12 | V |
| | | V_{OFF} | 27 | IC standby mode | 0 | — | 0.7 | V |
| | Input current | I_{CTL} | 30 | CTL = 5 V | — | 100 | 200 | μA |
| V_{CC} Comp. block | Threshold voltage | V_{TH} | 46,50, 56 | — | $V_{CC}-0.70$ | $V_{CC}-0.65$ | $V_{CC}-0.60$ | V |

*: Standard design value.

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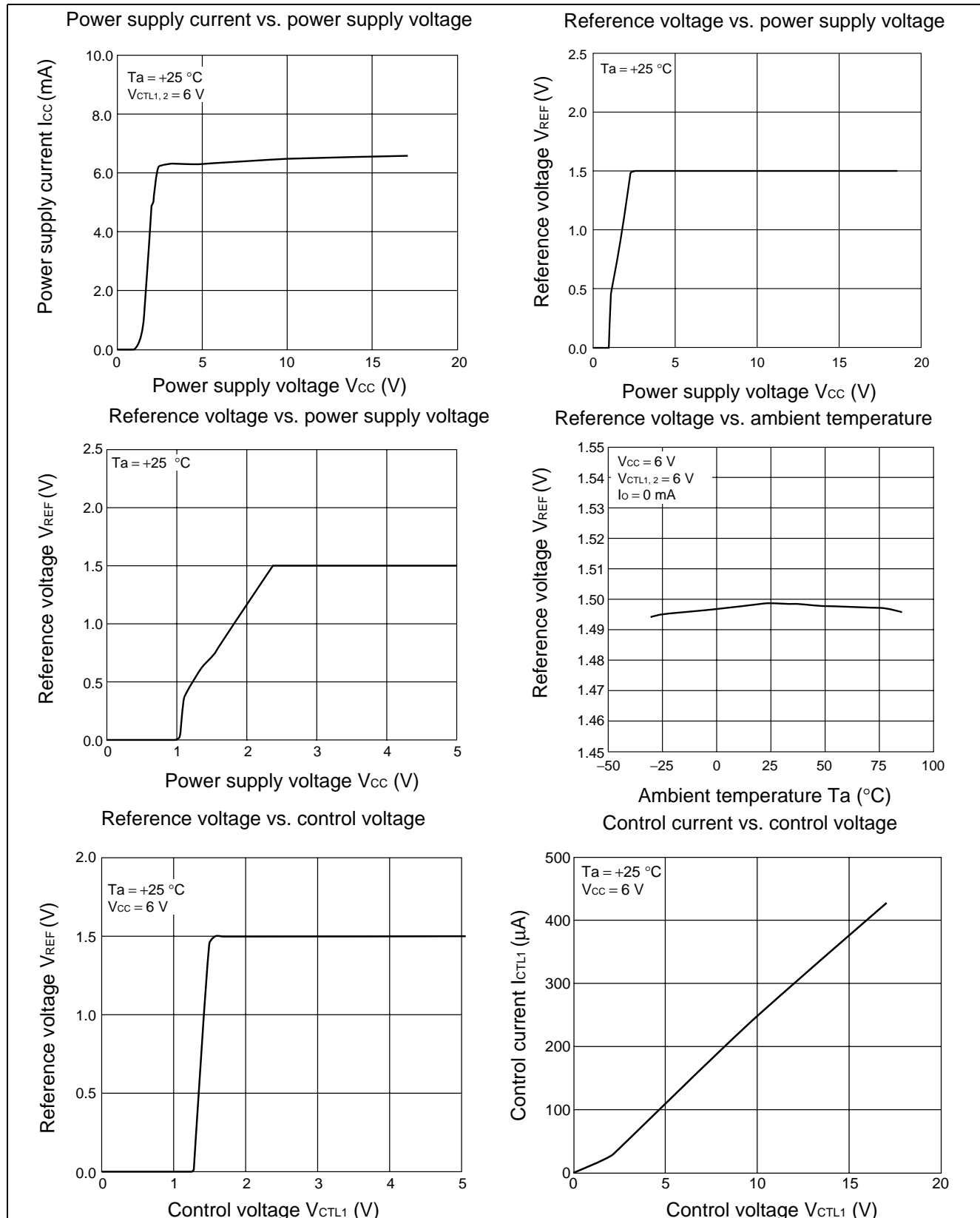
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($V_{CC} = V_{CC(O)} = +6\text{ V}$, $T_a = +25^\circ\text{C}$)

| Parameter | | Symbol | Pin No. | Conditions | Value | | | Unit |
|-----------|----------------------|--------------|-----------------|----------------------|-------|------|------|---------------|
| | | | | | Min. | Typ. | Max. | |
| General | Standby current | I_{CCS} | 28 | VCC pin, CTL = 0V | — | — | 10 | μA |
| | | $I_{CCS(O)}$ | 42,51, 63 | VCC(O) pin, CTL = 0V | — | — | 10 | μA |
| | Power supply current | I_{CC} | 28,42, 51,63 | — | — | 6.3 | 9.0 | mA |

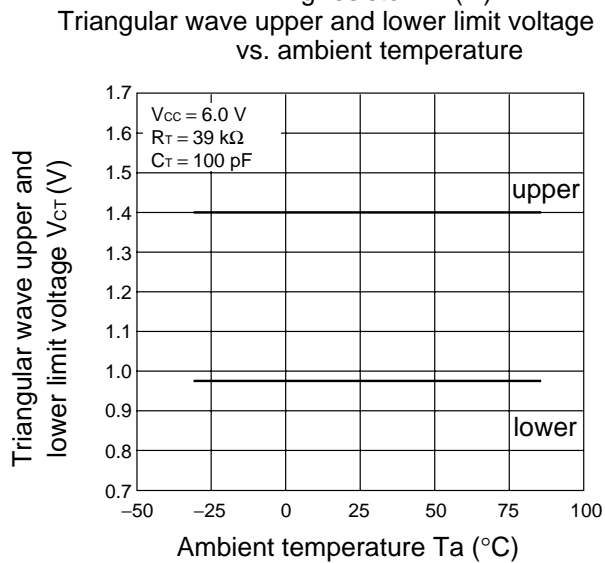
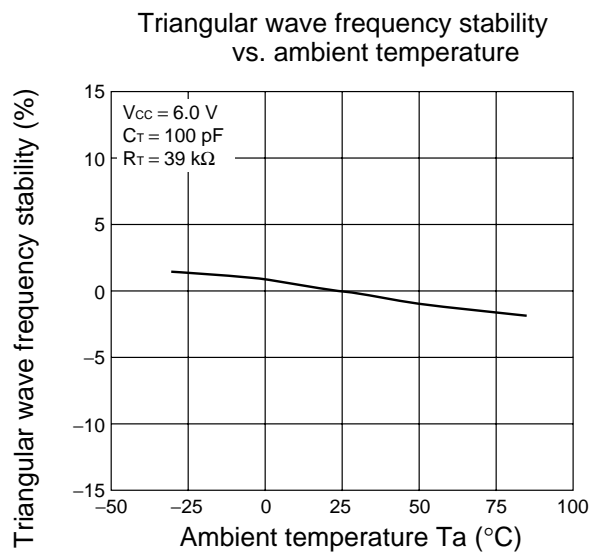
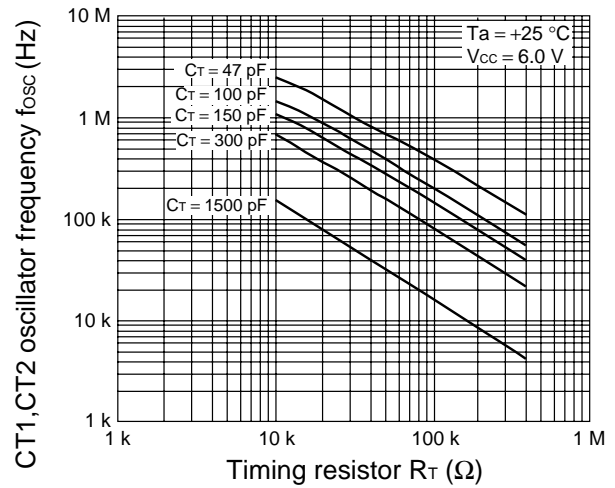
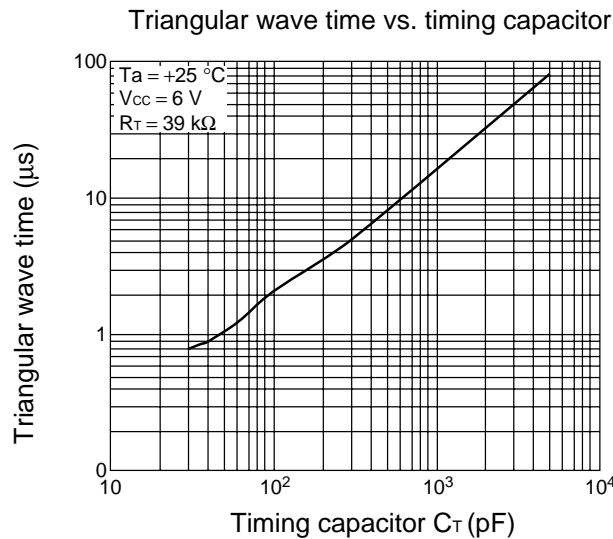
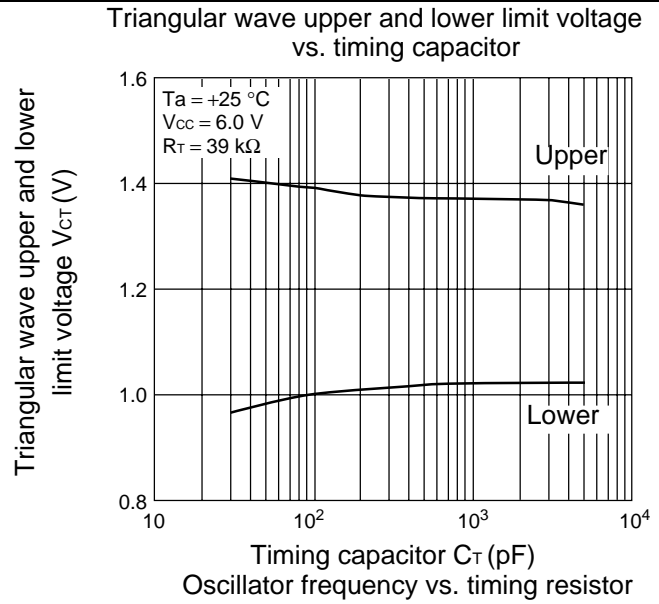
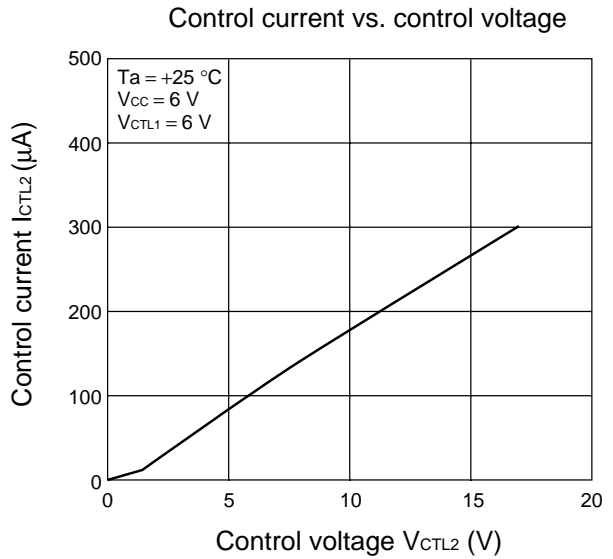
*: Standard design value.

■ TYPICAL CHARACTERISTICS



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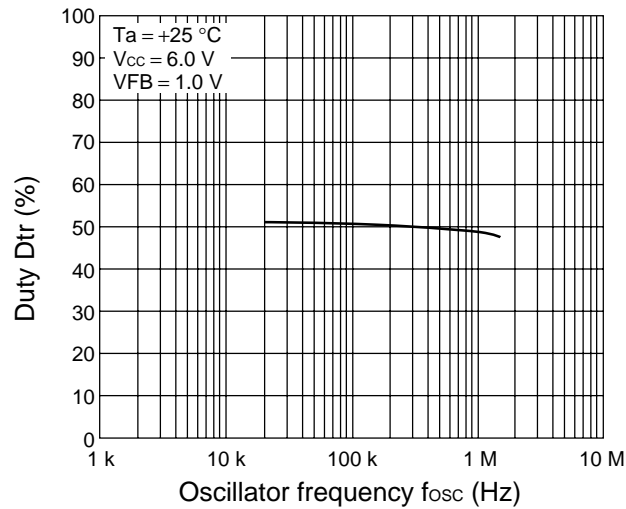
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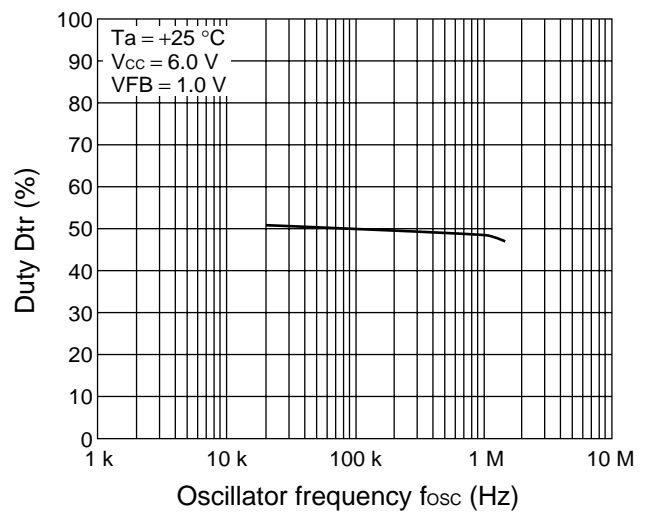
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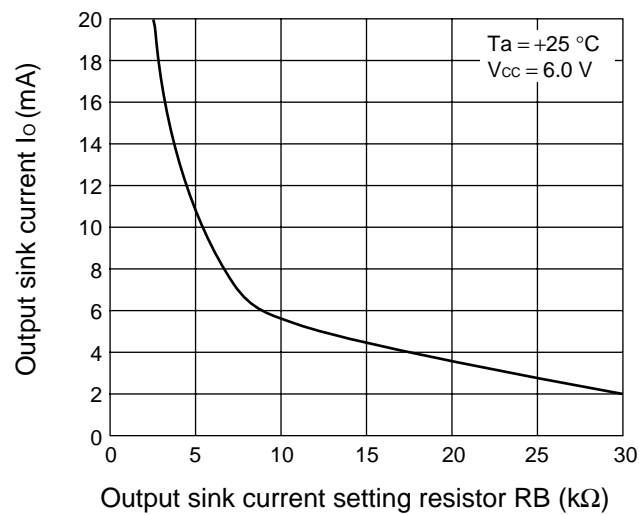
Duty vs. oscillator frequency (ch1)



Duty vs. oscillator frequency (ch4)



Output sink current vs.
output sink current setting resistor

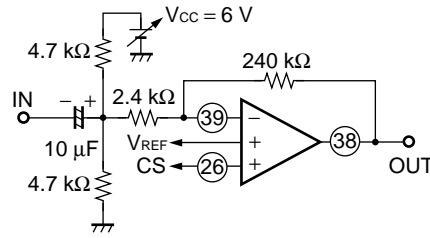
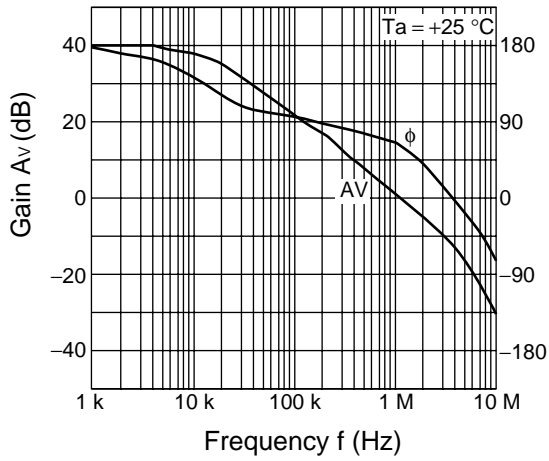


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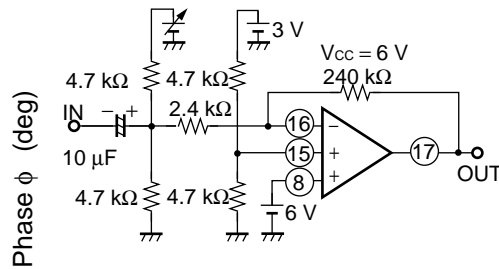
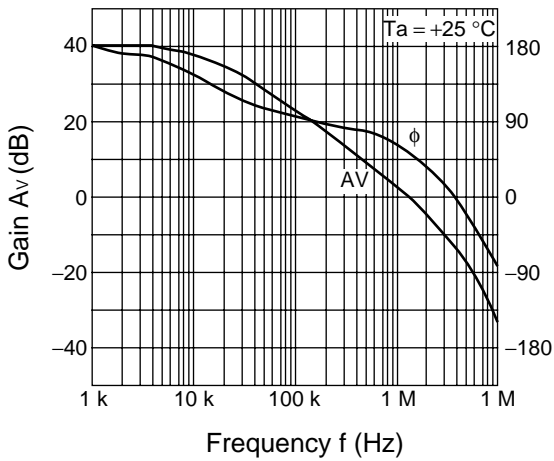
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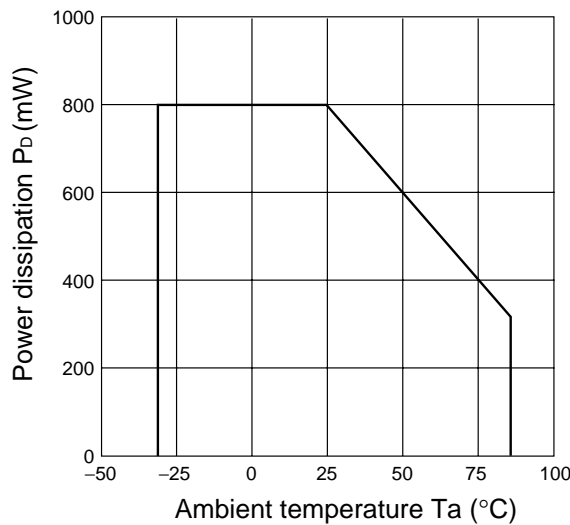
Error amplifier gain and phase vs. frequency (ch1)



Error amplifier gain and phase vs. frequency (ch5)



Power dissipation vs. ambient temperature



■ FUNCTIONAL DESCRIPTION

1. Switching Regulator Function

(1) Reference voltage circuit

The reference voltage circuit generates a temperature-compensated reference voltage ($\approx 1.500\text{ V}$) using the voltage supplied from the power supply terminal (pin 28). This voltage is used as the reference voltage for the internal circuits of the IC. The reference voltage of up to 1mA can also be supplied to an external device from the V_{REF} terminal (pin 27).

(2) Triangular-wave oscillator circuit

By connecting a timing capacitor and a resistor to the C_T (pin 22) and the R_T (pin 21) terminals, it is possible to generate any desired triangular oscillator waveform (CT : amplitude 1.0V to 1.4V, CT1 : amplitude 0.65V to 1.35V in phase with CT1, and CT2 : amplitude 0.65V to 1.35V in inverse phase with CT). The triangular wave is input to CT1, CT2 and the PWM comparator within the IC.

(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 V to $V_{CC} - 0.9\text{ V}$ on channels 5 and 6 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

The PWM comparators in these channels are a voltage comparator with one inverted input and one non-inverted input (channels 1, 2, 4, 5, 6) as well as one inverted input and two non-inverted inputs (channel 3), and voltage pulse width modifier to control output duty according to input voltage.

In the interval when the error amplifier output voltage is higher than the triangular waveform, the output transistor is turned on (channels 1, 2, 4, 5, 6).

In the interval when the error amplifier output voltage is lower than the triangular waveform, the output transistor is turned on (channel 1,4 synchronous rectifier side).

In the interval when the error amplifier output voltage and DTC3 voltage are higher than the triangular waveform, the output transistor is switched on (channel 3).

(5) Output circuit

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

Sink current (on the main side) can be set up to 20 mA depending on the resistance of the VB pin.

2. Channel Control Function

Channel on and off levels are dependent on the voltage levels of the CTL1 terminal (pin 30) and CTL 2 terminal (pin 29).

Table 1 Channel by Channel On/Off Setting Conditions.

| CTL pin voltage level | | On/Off state of channel | | | | | | |
|-----------------------|------|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| CTL1 | CTL2 | Power supply circuit | Channel 1 | Channel 2 | Channel 4 | Channel 5 | Channel 6 | Channel 3 |
| L | X | OFF (standby mode)* | | | | | | |
| H | L | ON | | | | | | OFF |
| | H | ON | | | | | | ON |

*: The power supply current in standby mode is 10 μA or less.

3. Protective Functions

(1) Timer-latch short-circuit protection circuit

The short detection comparator in each channel detects the output voltage level, and when any channel output voltage falls below the short detection voltage, or the SCP terminal (pin 13) voltage falls below the reference voltage, the timer circuit starts operating and the capacitor C_{SCP} connected to the CSCP terminal (pin 23) starts charging. When the capacitor charge reaches approximately 0.7 V, the output transistor is turned off and the idle interval becomes 100%.

When actuated, this protection circuit can be reset by turning on the power supply again. (See "METHOD OF SETTING TIME CONSTANT FOR TIMER-LATCH SHORT PROTECTION CIRCUIT".)

(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 system 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 CSCP 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.

(3) Output Supply Monitor Comparator (Vcc Comp.)

The output supply monitor comparator compares the output circuit power supply (VCC(O)1, 3, VCC(O)2, VCC(O)4, 5, 6) to the VCC level, and operates the timer-latch short protection circuit if any of the output circuit power supplies fall below $V_{cc} - 0.65V$.

METHODS OF SETTING THE OUTPUT VOLTAGE

Figure 1. CH1 to CH4

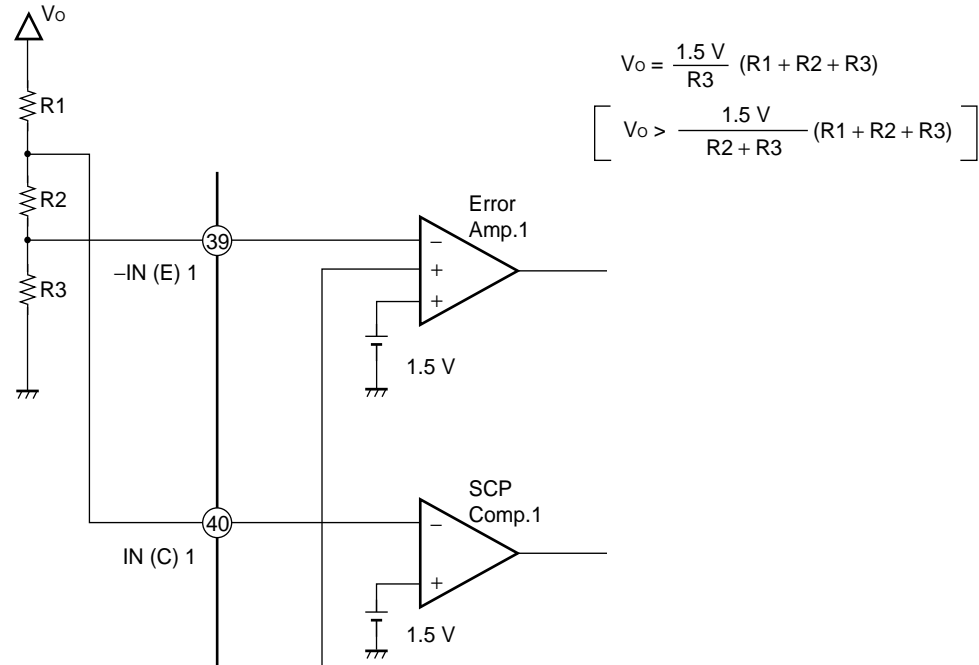
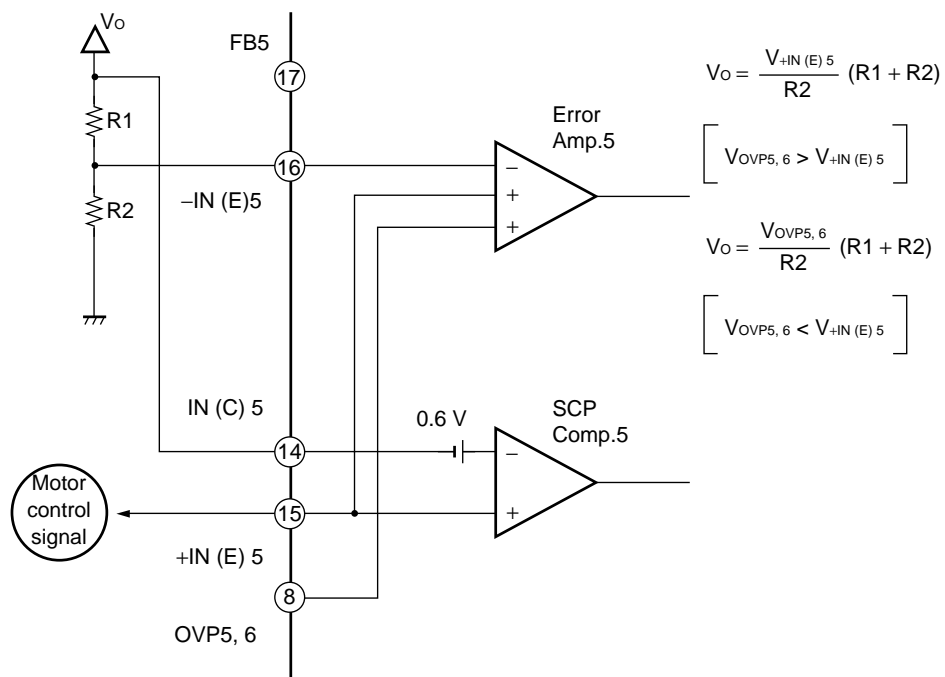


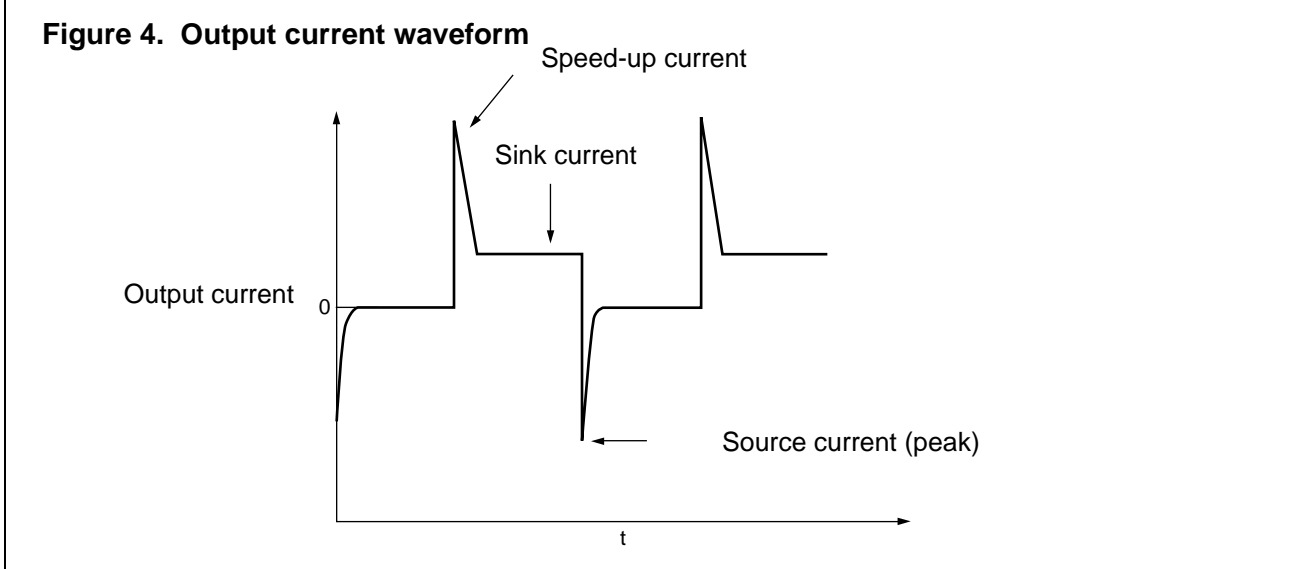
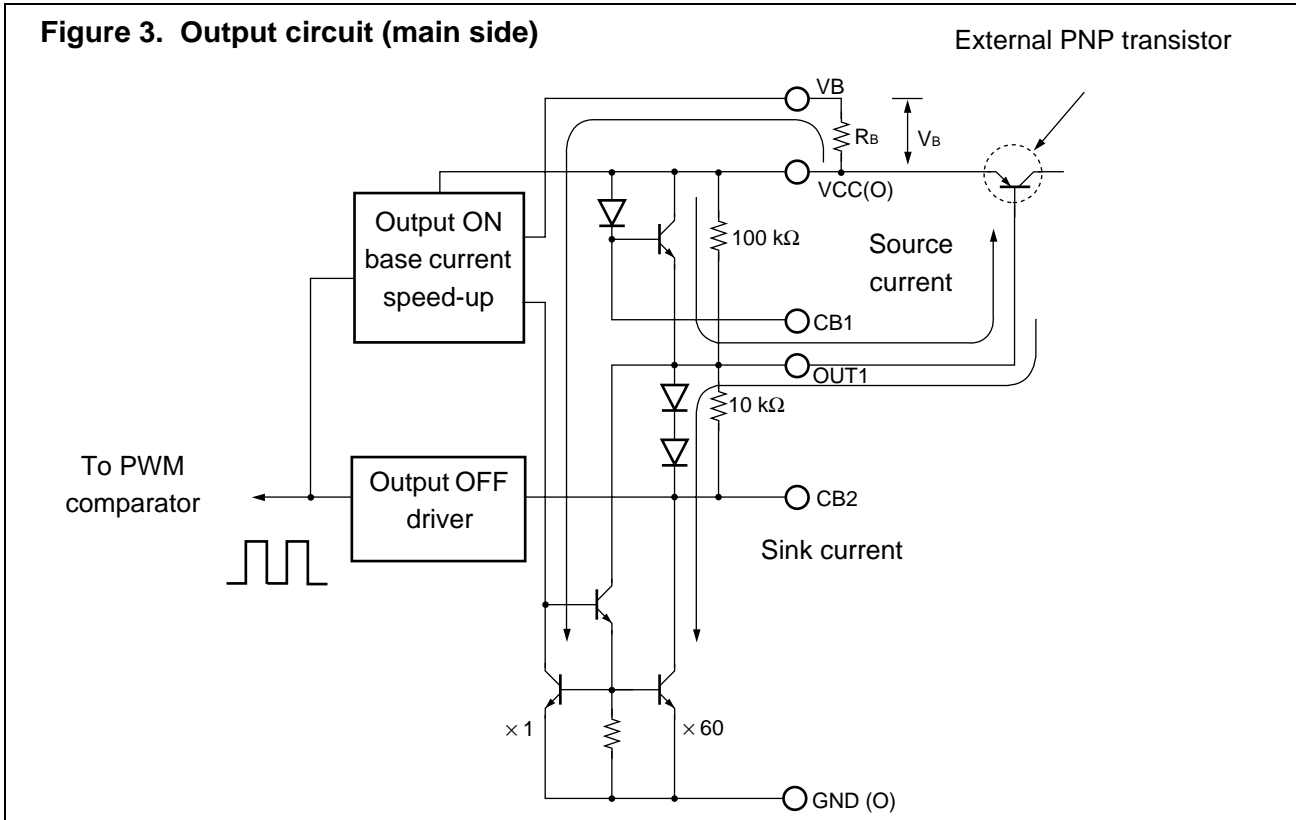
Figure 2. CH5 and CH6



■ METHOD OF SETTING THE OUTPUT CURRENT

Figure 3 shows the configuration of the output circuits, and Figure 4 illustrates how the sink current value of the output current waveform has a constant current setting. Note that the sink current is set by the following formula

- Sink current = $(V_B/R_B) \times 60 \approx 56/R_B$ [A]

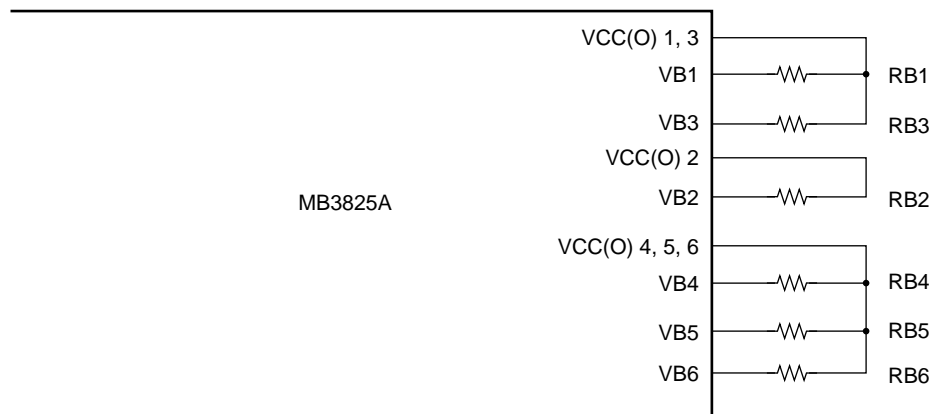


Precautions:

Output current setting resistance RB1 to RB6 should be connected to each channel as shown in Figure 5 below.

- For channel 1 and 3, connect the respective VB terminals to VCC(O) 1, 3 through the setting resistor RB.
- For channel 2, connect the VB2 terminal to VCC(O)2 through setting resistor RB2.
- For channels 4 to 6, connect the respective VB terminals to VCC(O)4, 5, 6 through setting resistor RB.

Figure 5. Output sink current setting pin connections



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

The short detection comparator (SCP comparator) in each of the channels constantly compares the error amplifier output level to the reference voltage and the SCP terminal (pin 13).

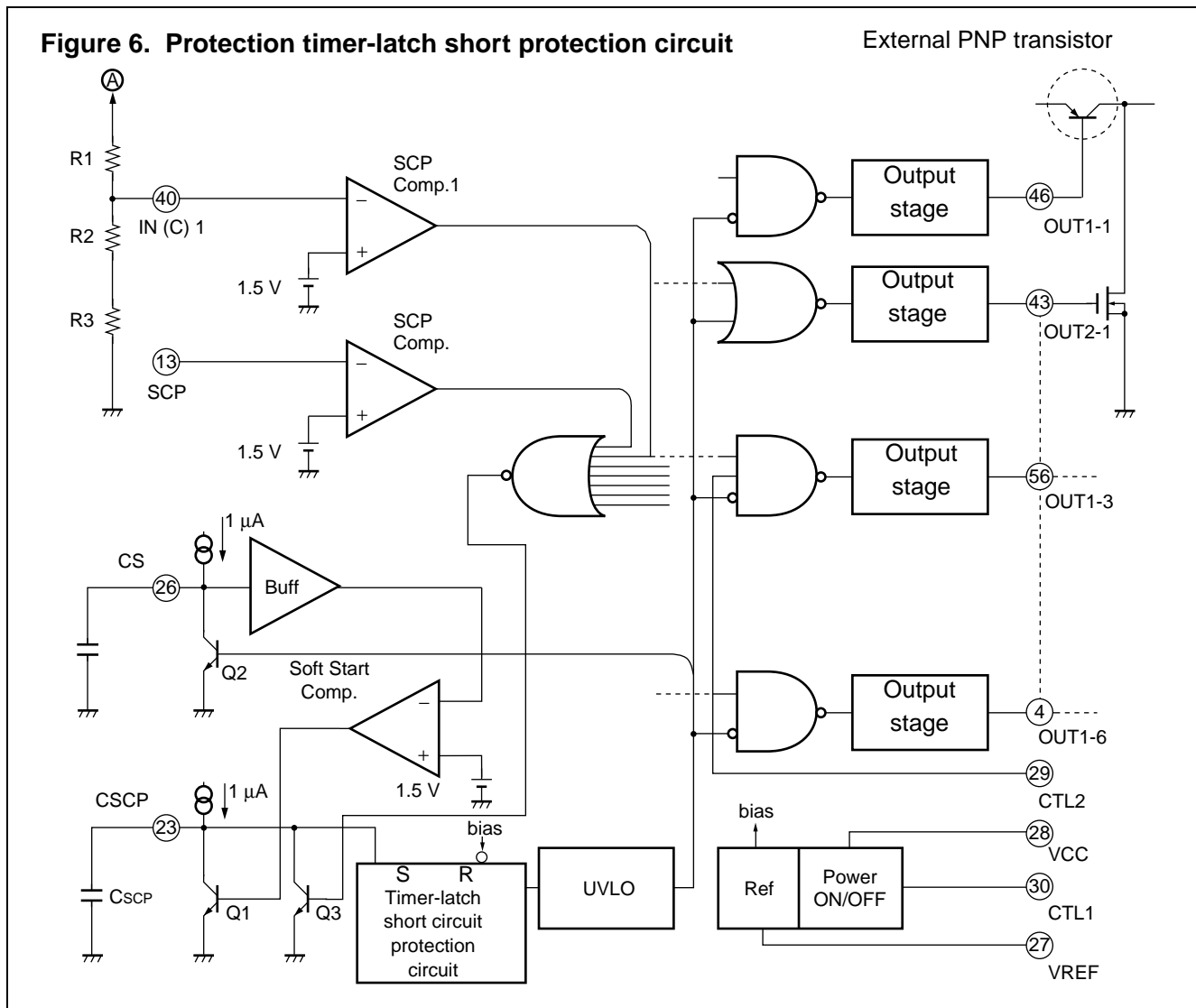
While the switching regulator load conditions are stable on all channels, or when the voltage level at the SCP terminal is higher than the reference voltage, the short detection comparator output remains at "L" level, transistor Q3 is turned on, and the CSCP terminal (pin 23) is held at input standby voltage ($V_{STB} \approx 50\text{mV}$).

If the load conditions change rapidly due to a short-circuiting of load, causing the output voltage to drop, or if the voltage at the SCP terminal falls below the reference voltage level, the output from the short detection comparator on the corresponding channel or the input at the SCP pin goes to "H" level. This causes transistor Q3 to turn off and the external short protection capacitor C_{SCP} connected to the CSCP terminal to charge at $1.0 \mu\text{A}$.

Short Detection Time (t_{PE})

$$t_{PE}(\text{sec}) \approx 0.7 \times C_{SCP} (\mu\text{F})$$

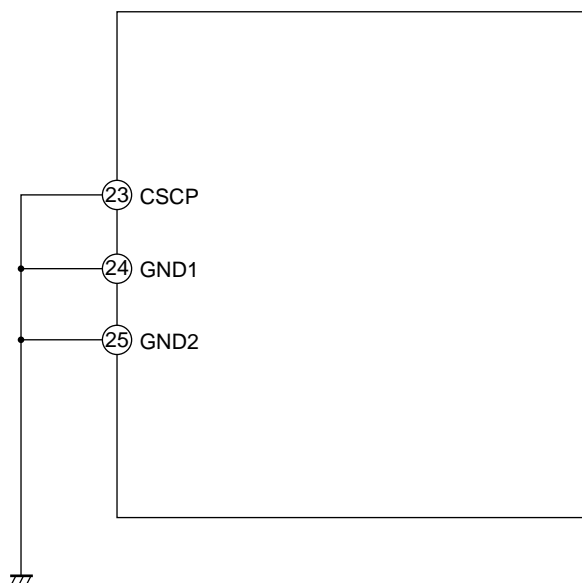
When the capacitor C_{SCP} is charged to the threshold voltage $V_{TH} \approx 0.7 \text{ V}$ the SR latch is set, and the external PNP is turned off (inactive interval is set to 100%). At this point the SR latch input is closed and the C_{SCP} pin is held at input latch voltage ($V_I \approx 50 \text{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



■ TREATMENT WITHOUT USING CSCP

When you do not use the timer-latch short protection circuit, connect the CSCP terminal (pin 23) to GND with the shortest distance.

Figure 7. Treatment when not using CSCP



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■ METHOD OF SETTING SOFT START TIME

- Channels 1, 2, 4

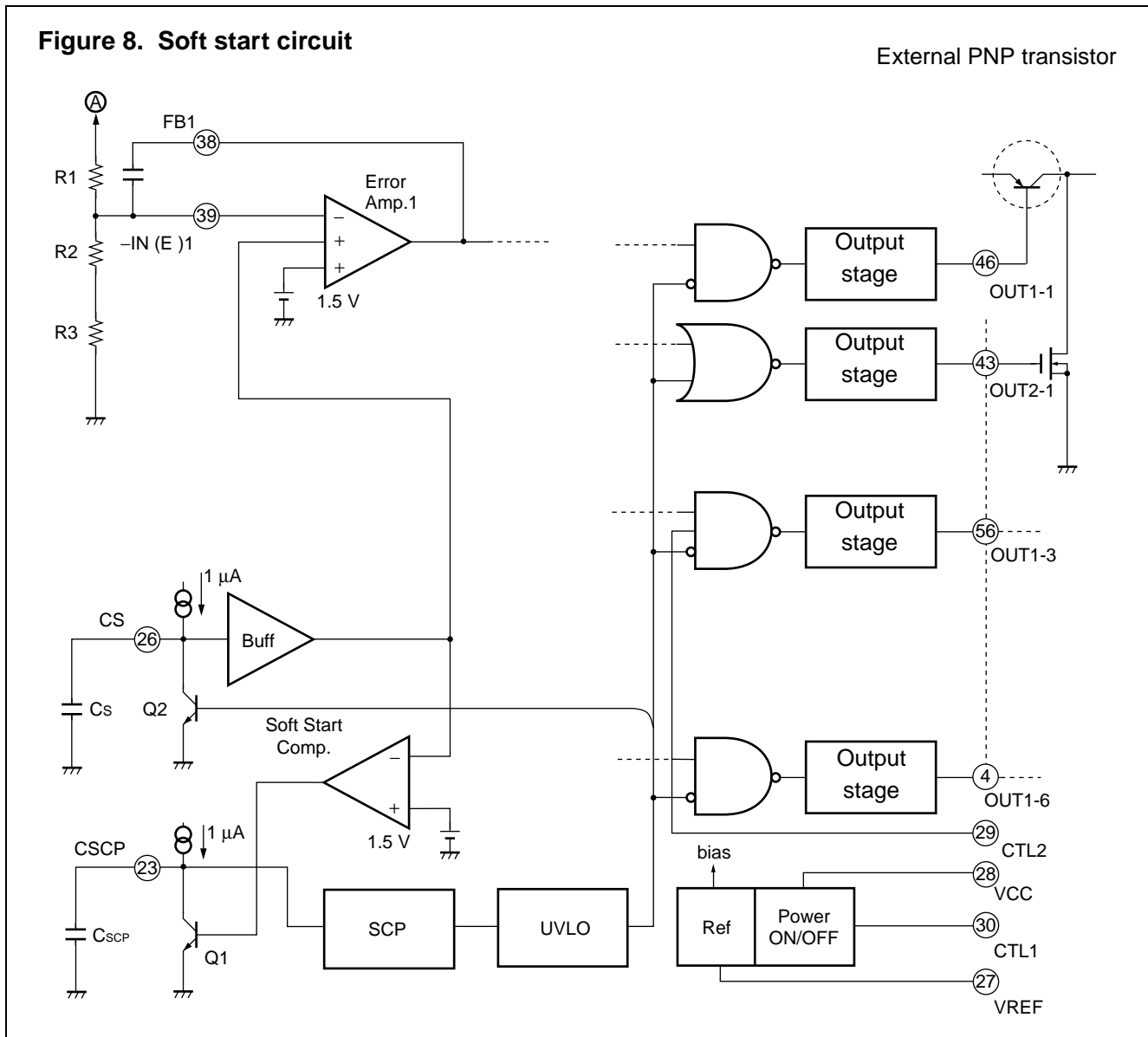
To provide a soft start by preventing current surges at power-on, soft start capacitor (Cs) can be connected to the CS terminal (pin 26).

When the IC is started (when the CTL1 terminal (pin 30) goes to "H" level, and Vcc ≥ UVLO threshold voltage), transistors Q2 switches off and the CS terminal begins charging the external soft start capacitors (Cs) at 1.0 μA. The error amplifier makes a soft start in a proportion to the output voltage to the CS terminal voltage regardless of the load current on the DC/DC converter.

Note that the soft start time can be calculated by the following formula.

Soft start time (output rise time)

$$t_s(\text{sec}) \approx 1.5 \times C_s (\mu\text{F})$$



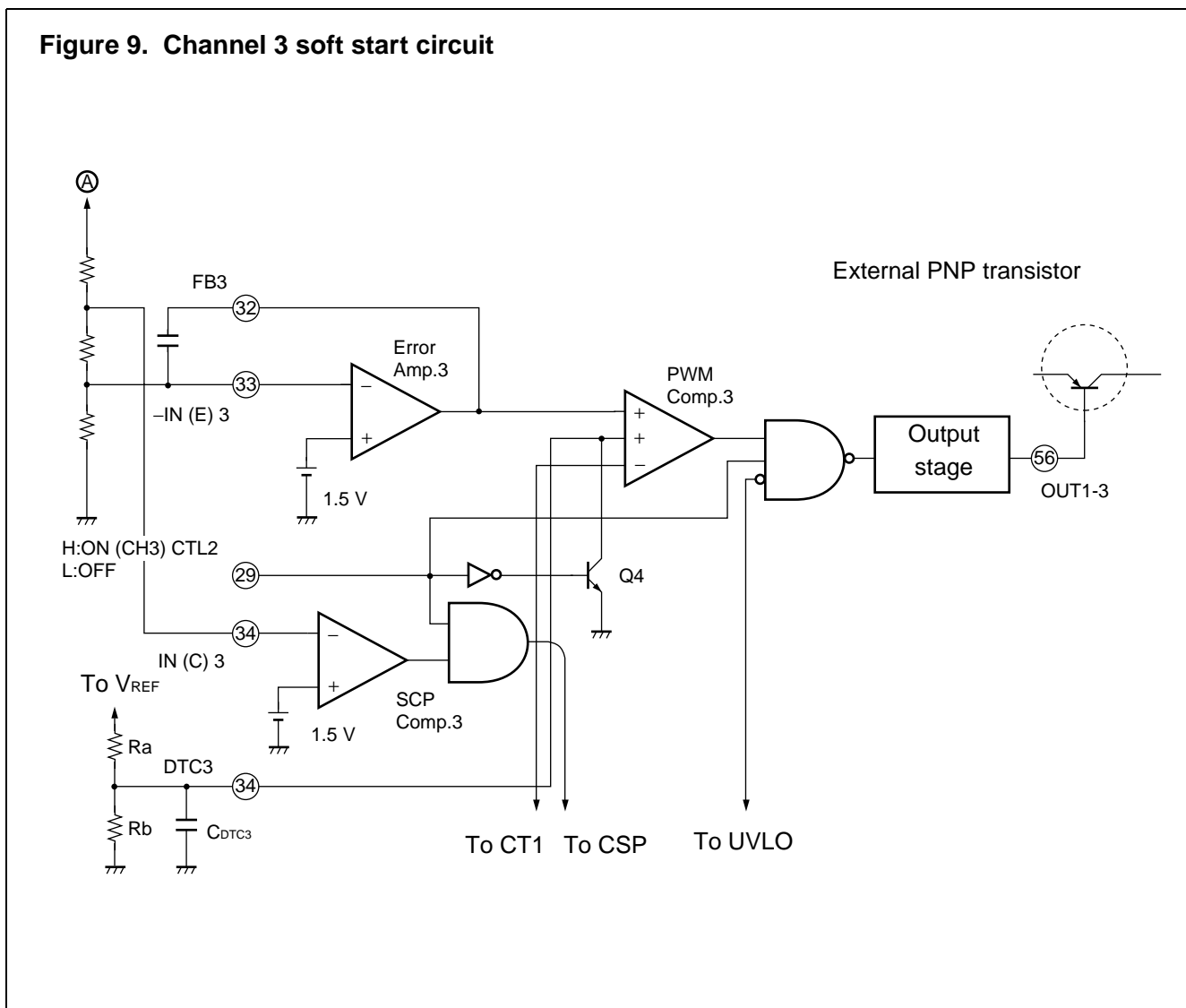
- Channel 3

The capacitor C_{DTC3} is placed between the DTC3 terminal (pin 31) and GND, so that when the CTL2 terminal (pin 29) goes from "L" to "H" level, the transistor Q4 is turned off and the output voltage is in proportion to the DTC3 terminal voltage providing the soft start operation.

As the short detection function is not turned off during soft start operation, this setting should be made under the following condition.

Channel 3 soft start circuit time < Short detection time

Figure 9. Channel 3 soft start circuit



■ PROCESSING WITHOUT USING CS PIN

If the soft start function is not used, the CS terminal (pin 26) for channels 1, 2, and 4 should be left open. For channel 3, connect the DTC3 terminal (pin 31) to the V_{REF} terminal (pin 27).

Figure 10. When no soft start time is set (1,2,4 channel)

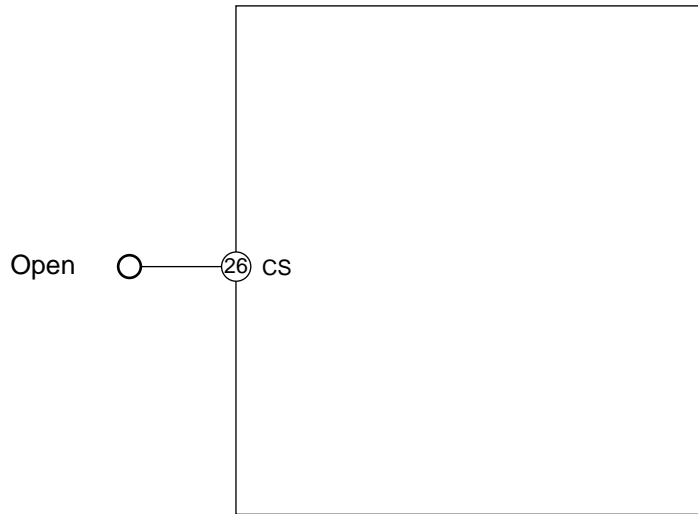
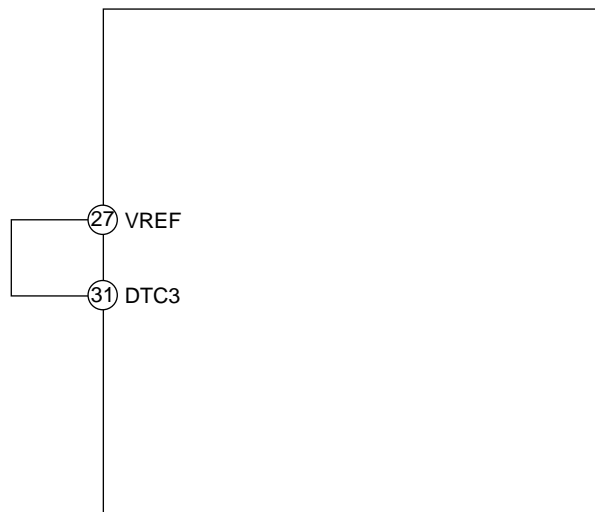


Figure 11. When no soft start time is set (3 channel)



■ METHOD OF SETTING THE DEAD TIME

When the device is set for step-up inverted output based on the flyback method, the output transistor is fixed to full-on state (ON-duty = 100 %) at power switch-on. To prevent this problem, you may determine the voltages on the DTC3 terminal (pin 31) 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 Figure.12.

When the voltage on the DTC3 terminal is lower than the triangular-wave (CT1) output voltage from the oscillator, the output transistor turns off. The dead time calculation formula assuming that triangular-wave amplitude ≈ 0.7 V and triangular-wave maximum voltage ≈ 1.35 V is given below.

$$\text{Duty (ON)}_{\text{MAX}} \approx \frac{V_{dt} - 0.65}{0.7} \times 100 [\%]$$

When you do not use this DTC3 terminal, connect then to V_{REF} terminal (pin 27) as shown Figure.13..

Figure 12. When using DTC to set dead time

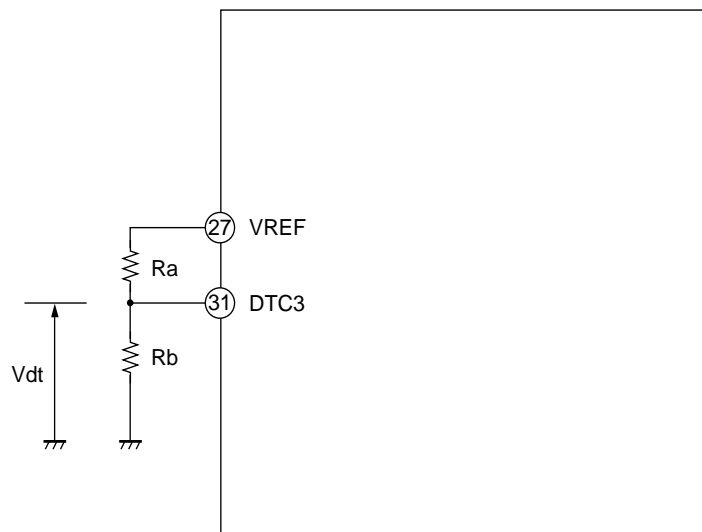
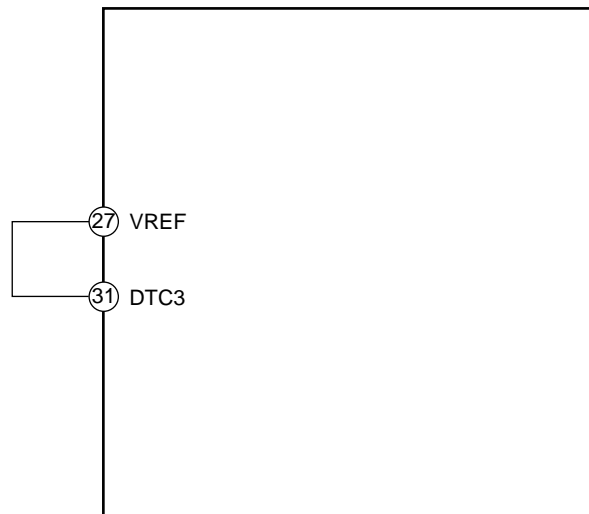


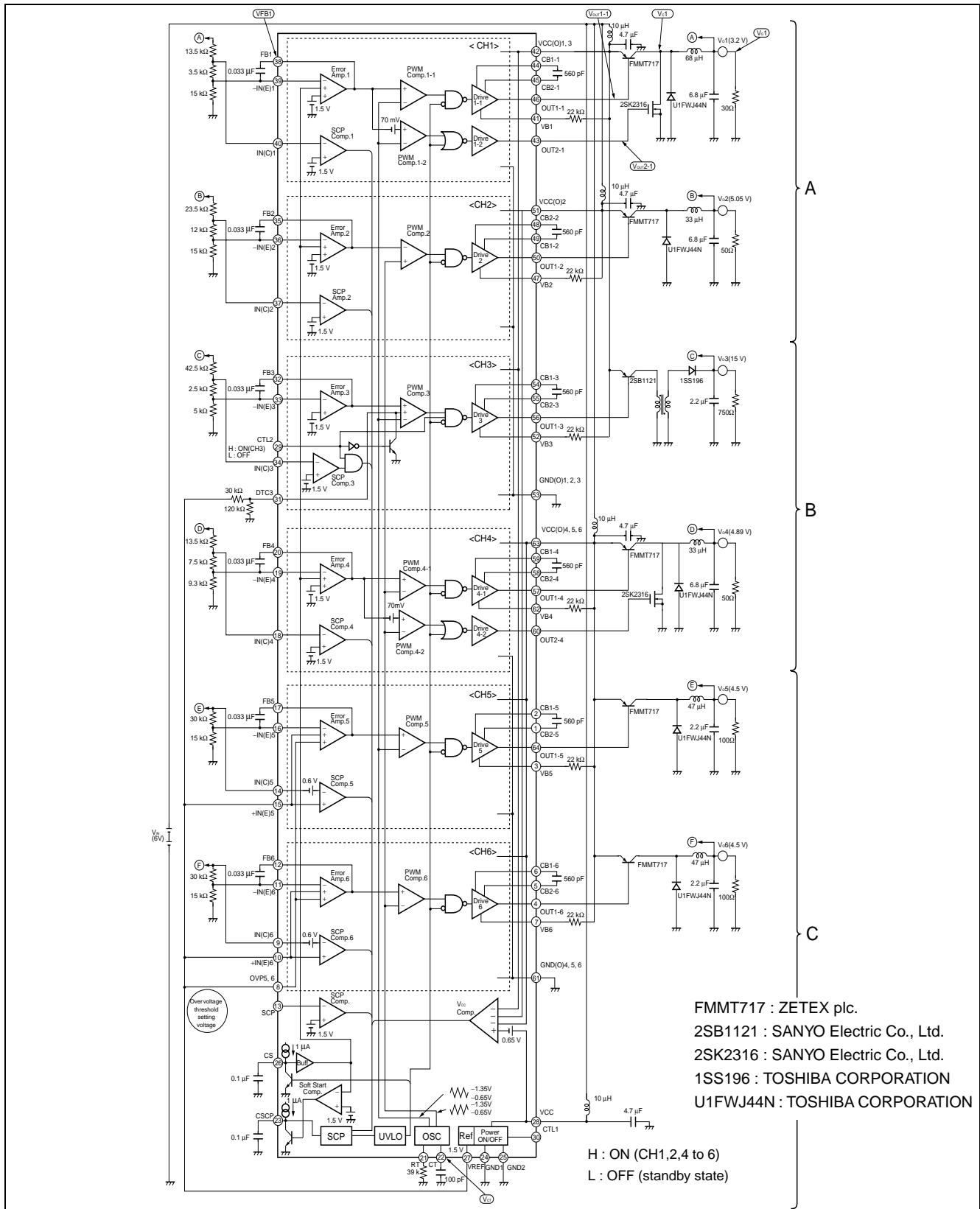
Figure 13. When not using DTC to set dead time



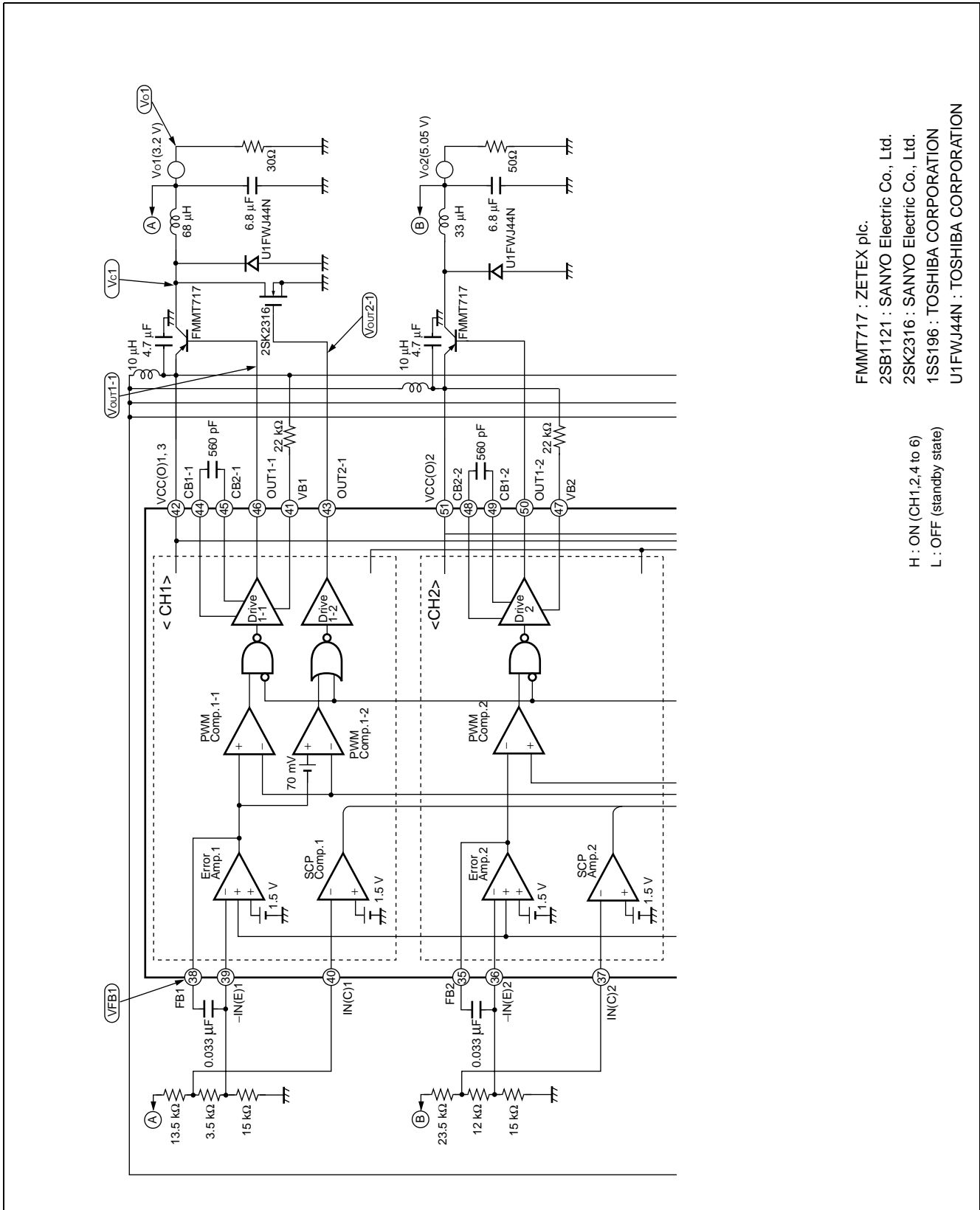
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APPLICATION EXAMPLE

General view



• Enlarged view of A

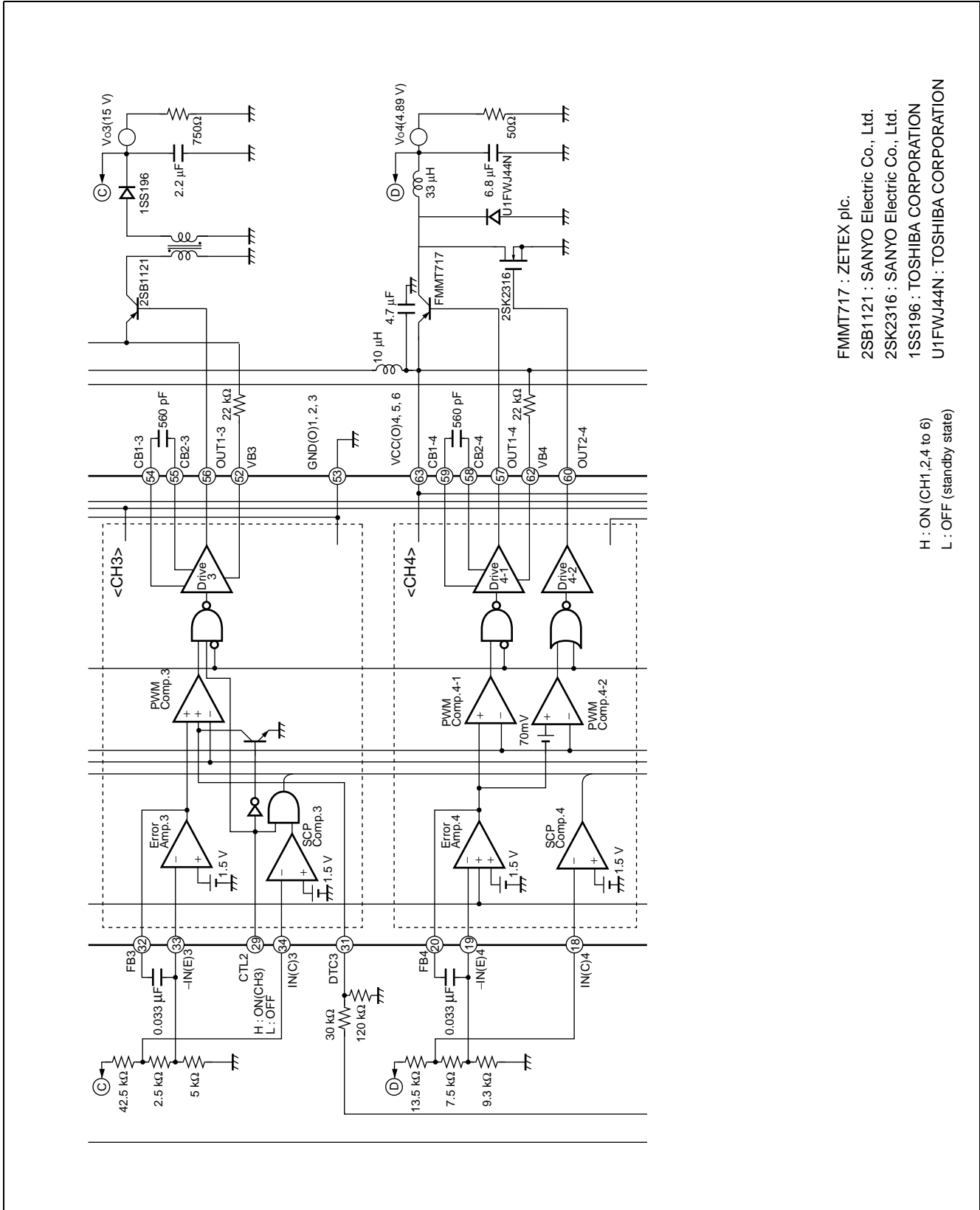


FMMT717 : ZETEX plc.
 2SB1121 : SANYO Electric Co., Ltd.
 2SK2316 : SANYO Electric Co., Ltd.
 1SS196 : TOSHIBA CORPORATION
 U1FWJ44N : TOSHIBA CORPORATION

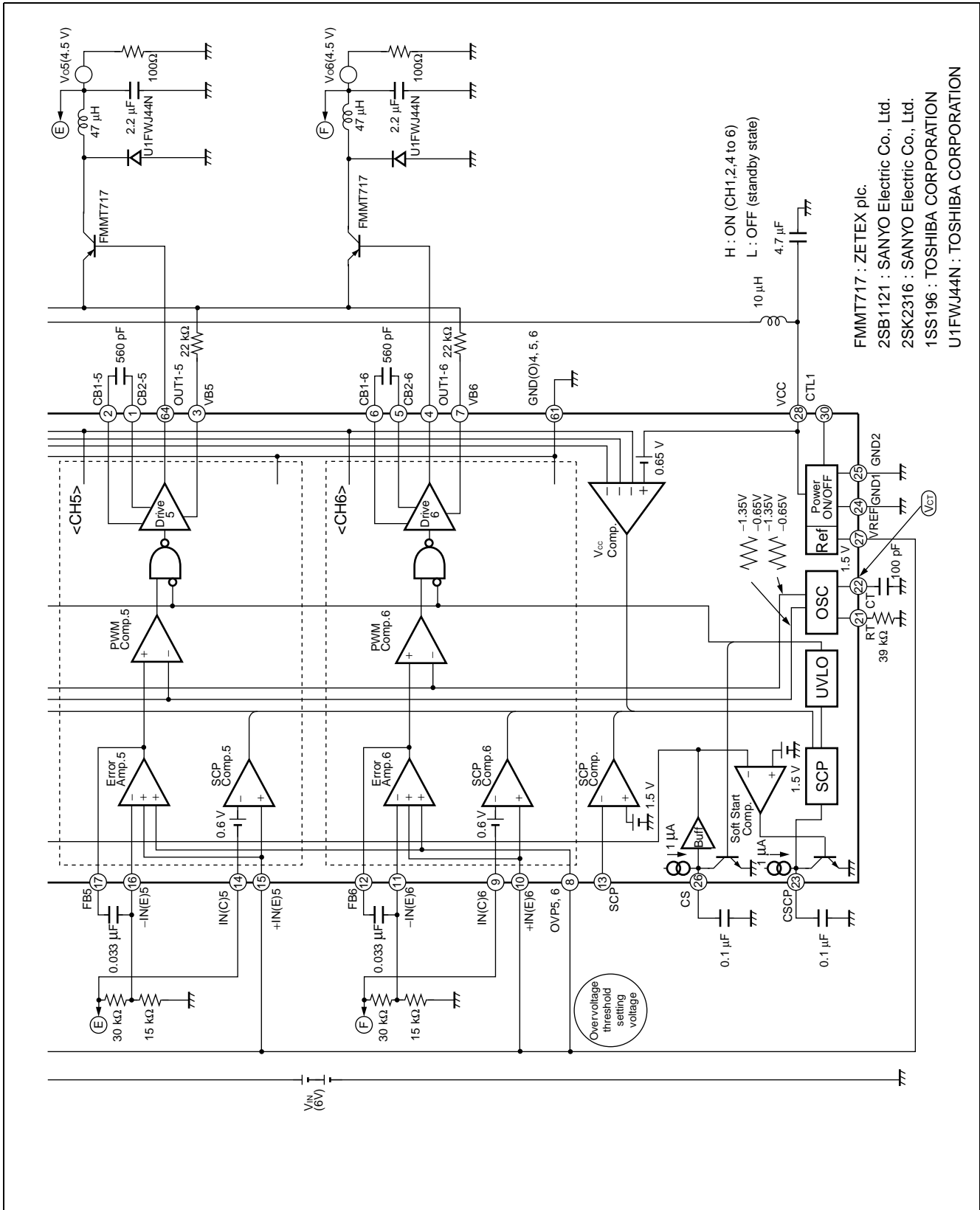
H : ON (CH1,2,4 to 6)
 L : OFF (standby state)

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• Enlarged view of B

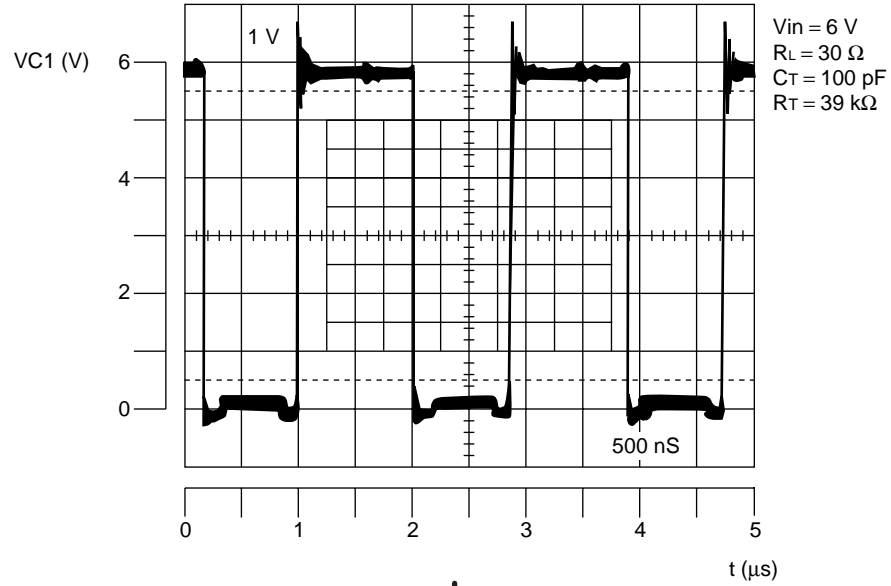


• Enlarged view of C

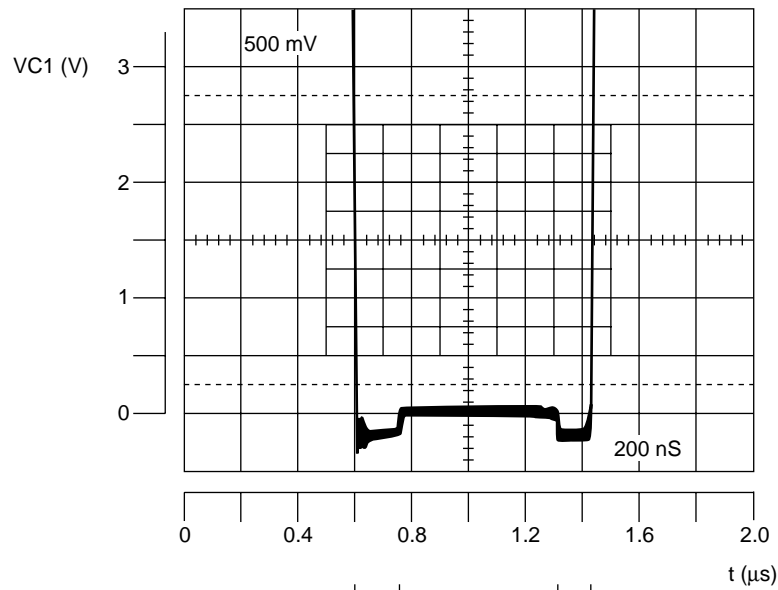


■ REFERENCE DATA

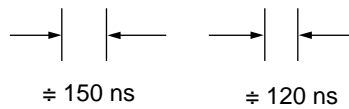
Channel 1 switching operation waveform (operation at 500 kHz)



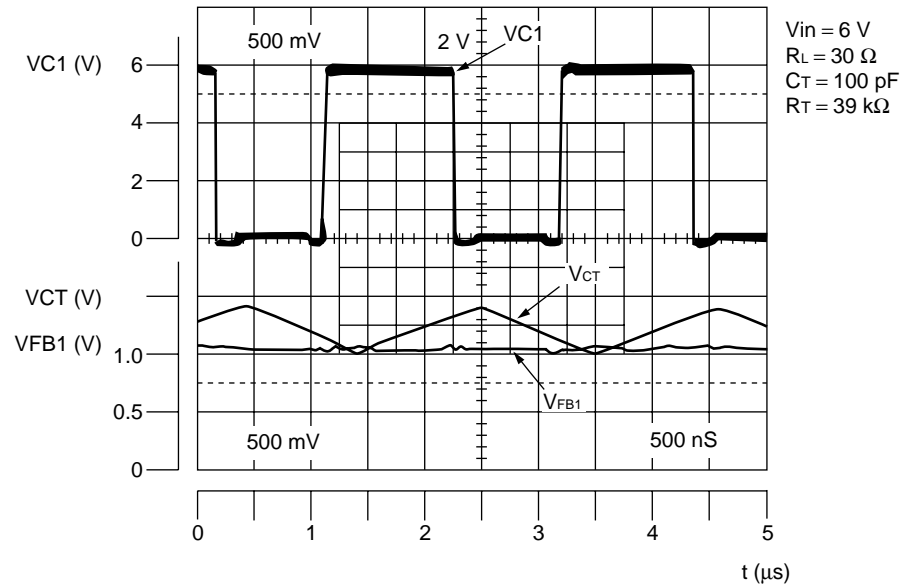
expansion



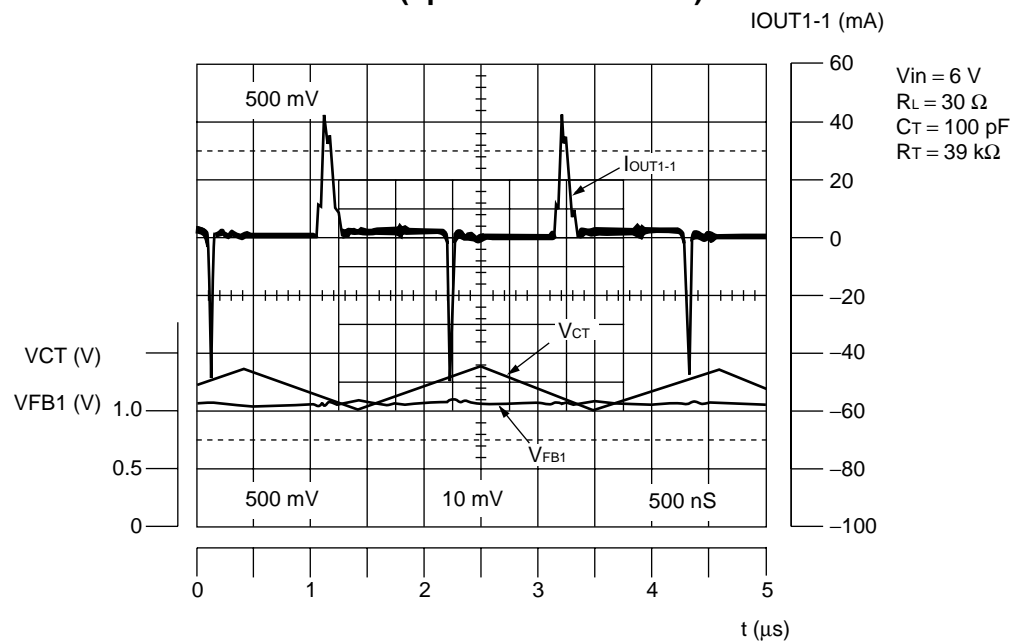
Synchronous rectifier length



Channel 1 main side output waveform (operation at 500 kHz)



Channel 1 main side base current waveform (operation at 500 kHz)



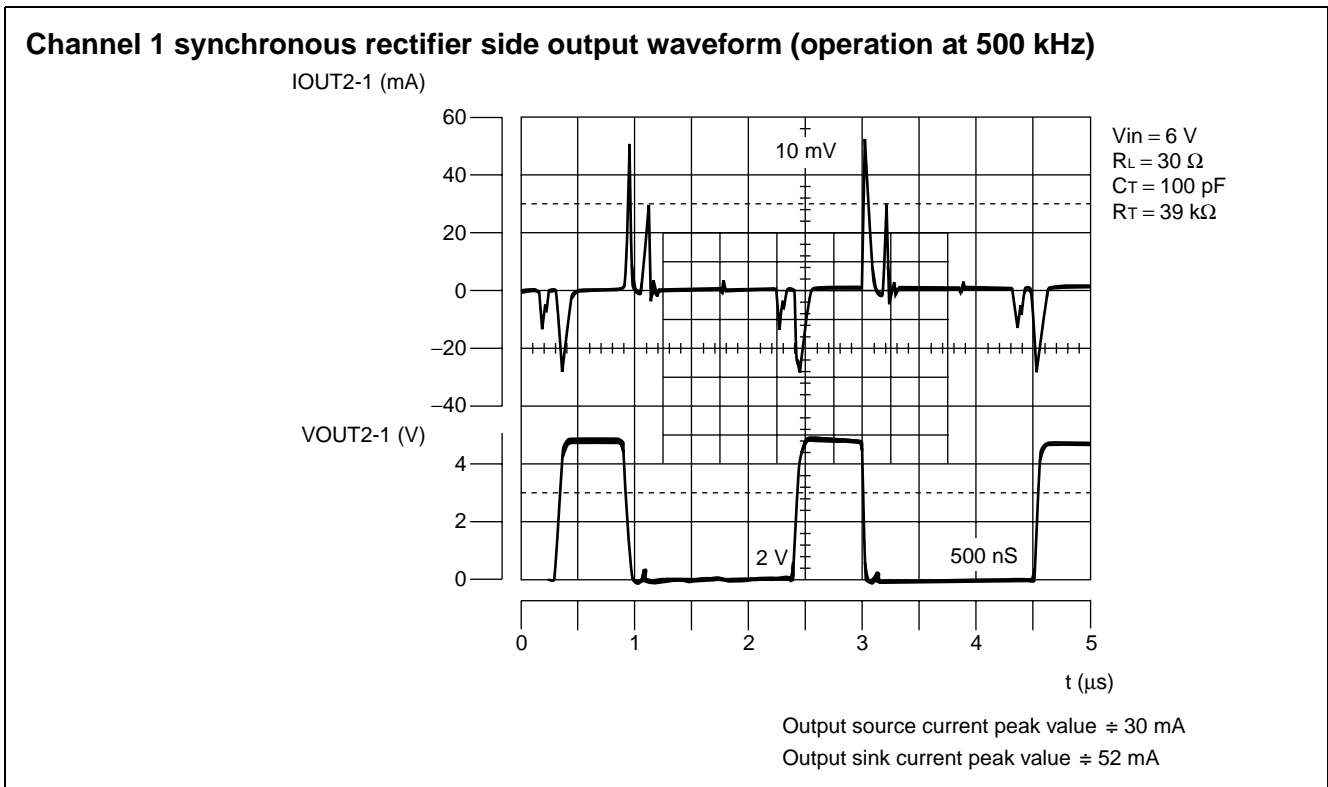
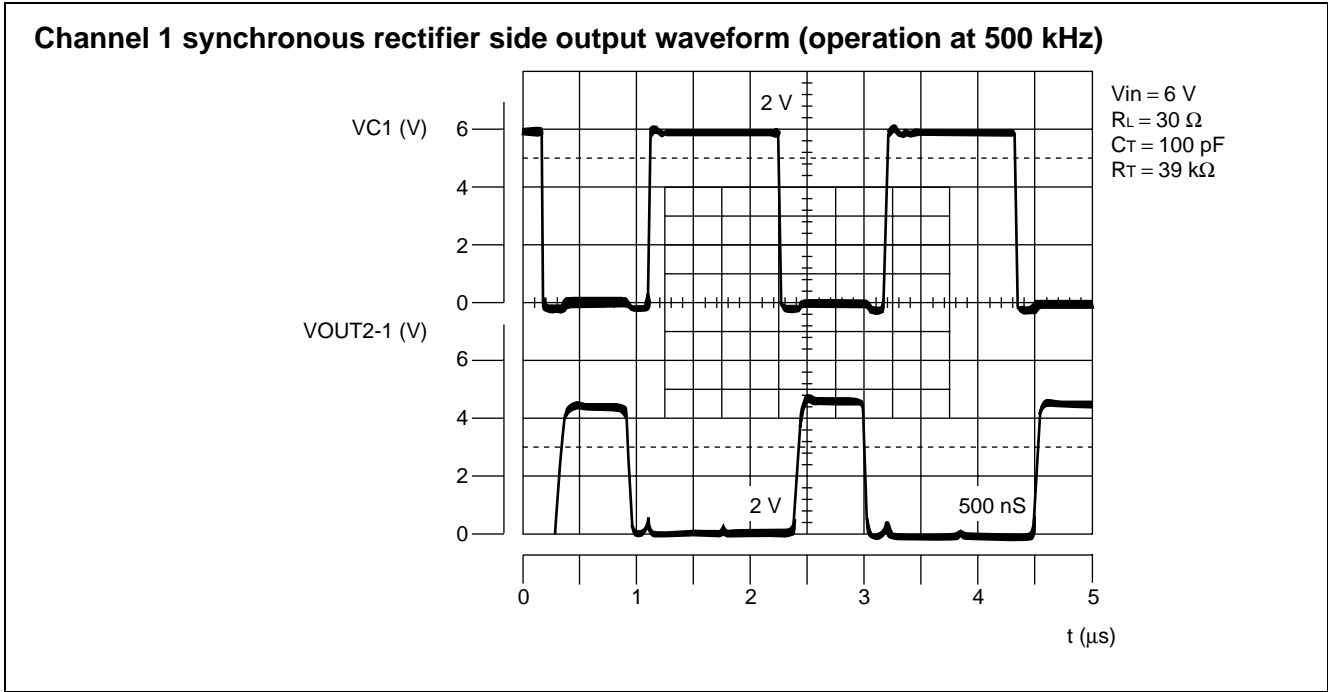
Peak current when turned ON \approx 42 mA

Peak current when turned OFF \approx 50 mA

(Continued)

MB3825A

(Continued)



■ USAGE PRECAUTIONS

1. Printed circuit board ground lines should be set up with consideration for common impedance.
2. 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 Ω to 1 M Ω placed in series between the human body and earth.

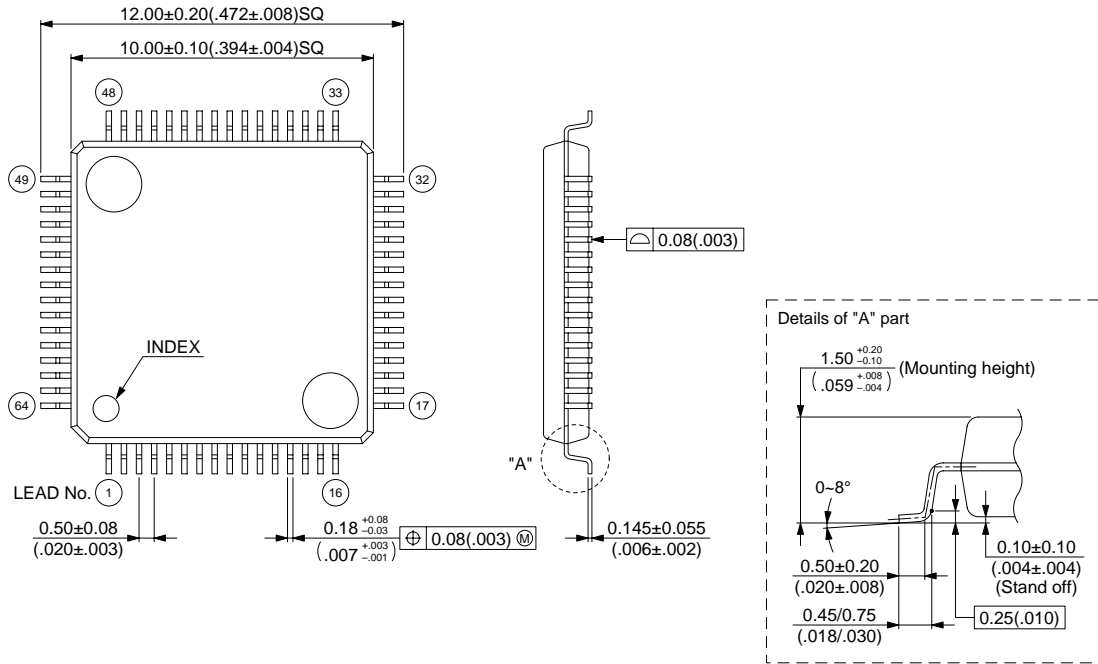
■ ORDERING INFORMATION

| Part number | Package | Remarks |
|-------------|--------------------------------------|---------|
| MB3825APFV | 64-pin plastic LQFP (FPT-64P-M03) | |

MB3825A

■ PACKAGE DIMENSION

64-pin Plastic LQFP
(FPT-64P-M03)



Dimensions in: mm (inches)

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