

## ■ Description

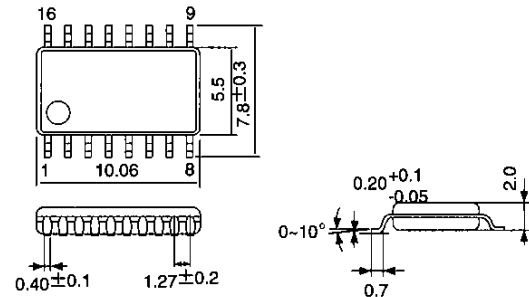
The FA5321P(M) is a current mode switching power supply control IC. In addition to basic control circuits, this IC contains protection and accessory circuits. Use this IC to develop a high performance compact switching power circuit.

## ■ Features

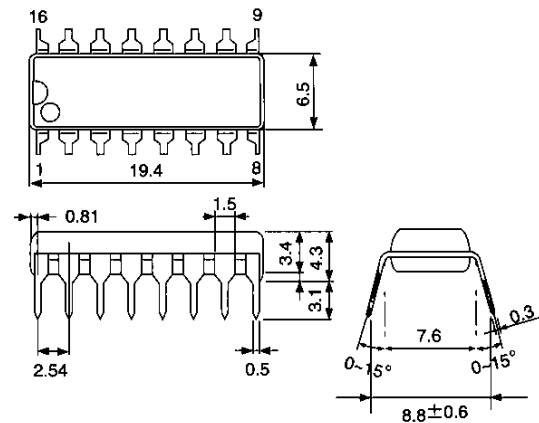
- Drive circuit for connecting a power MOSFET ( $I_o = \pm 1.5A$ )
- Overvoltage protection (latch mode)
- Intermittent operations under overload (Automatic return)
- Independent switching and stop period with external components
- Control of maximum duty cycle with an external components
- Peak current adjustment
- Soft-start
- Synchronous operation with an external signal
- Wide operating frequency range
- Low standby current (90 $\mu A$  typ.)
- 16-pin package (DIP/SOP)

## ■ Dimensions, mm

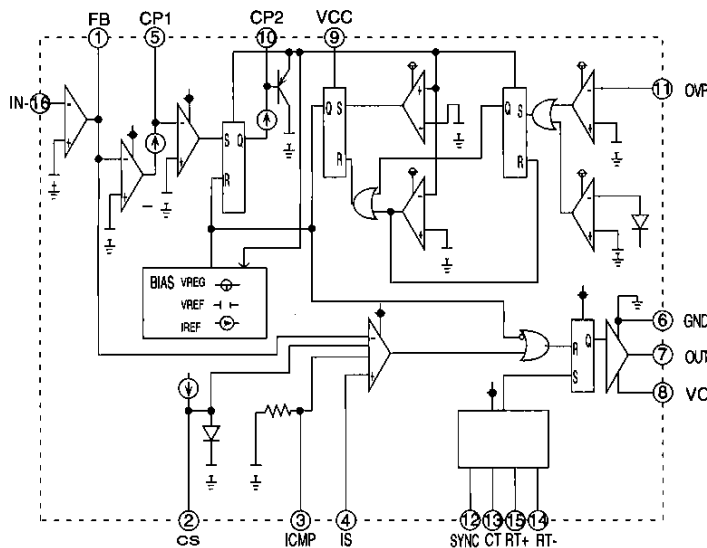
### • SOP-16



### • DIP-16



## ■ Block diagram



| Pin No. | Pin symbol | Description                        |
|---------|------------|------------------------------------|
| 1       | FB         | Error amplifier output             |
| 2       | CS         | Soft-start                         |
| 3       | ICMP       | Peak current compensation          |
| 4       | IS         | Current sense                      |
| 5       | CP1        | Interval protect (ON)              |
| 6       | GND        | Ground                             |
| 7       | OUT        | PWM output                         |
| 8       | VC         | Power supply to output circuit     |
| 9       | VCC        | Power supply                       |
| 10      | CP2        | Interval protect (OFF)             |
| 11      | OVP        | Overvoltage protection             |
| 12      | SYNC       | Oscillator synchronization input   |
| 13      | CT         | Oscillator timing capacitor        |
| 14      | RT-        | Oscillator timing resistance       |
| 15      | RT+        | Oscillator timing resistance       |
| 16      | IN-        | Inverting input to error amplifier |

### ■ Absolute maximum ratings

| Item                      | Symbol                 | Rating            | Unit  |
|---------------------------|------------------------|-------------------|---|
| Maximum supply voltage    | VCC                    | 28                | V   |
| Maximum output current    | IOUT                   | ±1.5              | A   |
| Input voltage             | ICMP pin               | V <sub>ICMP</sub> | −0.3 to 5.3   |
|                           | IS pin                 | V <sub>IS</sub>   | −0.3 to 5.3   |
|                           | IN− pin                | V <sub>IN−</sub>  | −0.3 to 5.3   |
|                           | OVP pin                | V <sub>OVP</sub>  | −0.3 to 5.3   |
|                           | SYNC pin               | V <sub>SYNC</sub> | −0.3 to 5.3   |
| Maximum power dissipation | Ta < 25°C<br>Ta > 25°C | Pd<br>Pd          | 800 (DIP)/650 (SOP)<br>800–8.5mW/°C (DIP)<br>650–6.5mW/°C (SOP) |
| Storage temperature       | T <sub>stg</sub>       | −40 to +150       | °C  |
| Operating temperature     | T <sub>opr</sub>       | −30 to +85        | °C  |

### ■ Electrical characteristics (Ta = 25°C, fosc = 50kHz)

#### Start-up circuit

| Item              | Symbol | Test condition | Min. | Typ. | Max. | Unit |
|-------------------|--------|----------------|------|------|------|------|
| Turn-on voltage   | VCCON  |                | 14.5 | 15.5 | 17.0 | V    |
| Operating voltage | VCCOP  |                | 12.0 | –    | 27.0 | V    |
| Turn-off voltage  | VCCOF  |                | 7.0  | 7.8  | 8.5  | V    |
| Start-up current  | ICCST  | 0V to VCCON    | 40   | 90   | 160  | μA   |
| Operating current | ICCOP  | VCCOF to 27V   | 5.0  | 8.0  | 16.0 | mA   |

#### Output circuit

| Item                  | Symbol | Test condition          | Min. | Typ. | Max. | Unit |
|-----------------------|--------|-------------------------|------|------|------|------|
| Output source current | IOUTSO | VOUT pin = 2.0V         | 100  | –    | –    | mA   |
| Output sink current   | IOUTSI | VOUT pin = VCCT pin −2V | 100  | –    | –    | mA   |

#### Oscillator circuit

| Item                          | Symbol            | Test condition    | Min. | Typ. | Max. | Unit |
|-------------------------------|-------------------|-------------------|------|------|------|------|
| CT-pin voltage (peak-to-peak) | VCTPP             |                   | 1.7  | 1.9  | 2.1  | V    |
| Reference voltage             | V <sub>RT+</sub>  |                   | 0.70 | 0.85 | 1.00 | V    |
|                               | V <sub>RT−</sub>  |                   | 0.70 | 0.85 | 1.00 | V    |
| SYNC pin input voltage        | V <sub>SYNC</sub> | Threshold voltage | 1.3  | 1.5  | 1.9  | V    |

#### PWM current detection circuit

| Item          | Symbol          | Test condition | Min. | Typ. | Max. | Unit |
|---------------|-----------------|----------------|------|------|------|------|
| Input current | I <sub>IS</sub> |                | −80  | −120 | −160 | μA   |
| Input voltage | V <sub>IS</sub> |                | –    | 0.60 | –    | V    |

#### PWM current detection circuit (With no compensation bias at ICMP)

| Item             | Symbol            | Test condition | Min. | Typ. | Max. | Unit |
|------------------|-------------------|----------------|------|------|------|------|
| ICMP pin voltage | V <sub>ICMP</sub> | ICMP pin open  | 0.9  | 1.1  | 1.3  | V    |

#### Soft-start circuit

| Item           | Symbol          | Test condition | Min. | Typ. | Max. | Unit |
|----------------|-----------------|----------------|------|------|------|------|
| Charge current | I <sub>CS</sub> |                | 15   | 22   | 30   | μA   |
| Charge voltage | V <sub>CS</sub> |                | 2.7  | 3.0  | 3.3  | V    |

**Error amplifier circuit**

| Item                  | Symbol            | Test condition | Min. | Typ. | Max. | Unit |
|-----------------------|-------------------|----------------|------|------|------|------|
| Reference voltage     | V <sub>IN-</sub>  |                | 2.2  | 2.4  | 2.6  | V    |
| Input current         | I <sub>IN-</sub>  |                | -0.5 | -    | 0.5  | μA   |
| Output source current | I <sub>FBSO</sub> | FB pin = 5V    | 0.2  | -    | -    | mA   |
| Output sink current   | I <sub>FBSI</sub> | FB pin = 2V    | 0.2  | -    | -    | mA   |

**Overload protection circuit**

| Item                                     | Symbol             | Test condition         | Min. | Typ. | Max. | Unit |
|--|--------------------|------------------------|------|------|------|------|
| Overvoltage detection level (Comparator) | V <sub>FBIN</sub>  |                        | 4.3  | 5.0  | 5.4  | V    |
| CP1-pin charge current                   | I <sub>CP1</sub>   | Set the detection time | 12   | 20   | 28   | μA   |
| CP1-pin voltage                          | V <sub>CP1</sub>   |                        | 4.3  | 5.0  | 5.4  | V    |
| CP2-pin voltage                          | I <sub>CP2</sub>   | Set the restart time   | 40   | 60   | 80   | μA   |
| Restart current                          | I <sub>CCRST</sub> |                        | 200  | 320  | 440  | μA   |

**Short circuit protection**

| Item                                  | Symbol            | Test condition | Min. | Typ. | Max. | Unit |
|---------------------------------------|-------------------|----------------|------|------|------|------|
| V <sub>CC</sub> voltage at protection | V <sub>CCOF</sub> |                | 7.0  | 7.8  | 8.5  | V    |

**Overvoltage protection**

| Item                                     | Symbol             | Test condition        | Min. | Typ. | Max. | Unit |
|--|--------------------|-----------------------|------|------|------|------|
| Overvoltage detection level (comparator) | V <sub>OVP</sub>   |                       | 2.25 | 2.4  | 2.55 | V    |
| Detection current                        | I <sub>OVP</sub>   |                       | 20   | 30   | 50   | μA   |
| V <sub>CC</sub> voltage at protection    | V <sub>CCFOV</sub> | Standby current ≤ 3mA | 14   | 15.5 | 17   | V    |

**Overheat protection**

| Item                                  | Symbol             | Test condition        | Min. | Typ. | Max. | Unit |
|---------------------------------------|--------------------|-----------------------|------|------|------|------|
| Shutdwn temperature                   | T <sub>THM</sub>   |                       | -    | 120  | -    | °C   |
| V <sub>CC</sub> voltage at protection | V <sub>CCFOV</sub> | Standby current ≤ 3mA | 14   | 15.5 | 17   | V    |

## ■ Explanation of circuits

### 1. Oscillator section

Figure 1 shows the oscillator circuit and Fig. 2 shows its waveforms.

The oscillation frequency and duty cycle can be set by connecting an external capacitor and resistor. The CT pin outputs a 2Vpp triangle wave. Connect the charging and discharging resistors (RTM and RTP) for the capacitor (CT) to the RT- and RT+ pins. RT+ and RT- pin voltages will be about 1V. The oscillator circuit changes the CT charging time T1 for PWM control. The OUT pin voltage remains low during the CT discharging time T2.

The duty cycle can be set in the range from 10 to 90% and the oscillation frequency in the range from 5k to 500kHz.

Charging time (Maximum ON time)

$$T_1 = \frac{CT \cdot V_{pp}}{\frac{V_{REF}}{RTP} - \frac{V_{REF}}{RTM}}$$

Discharge time (OFF time)

$$T_2 = \frac{CT \cdot V_{pp} \cdot RTM}{V_{REF}}$$

Frequency

$$f_{OSC} = \frac{V_{REF} (RTM - RTP)}{C \cdot V_{pp} \cdot RTM^2}$$

Maximum ON duty cycle

$$D = \frac{RTP}{RTM}$$

The oscillator can be synchronized with an external signal at the SYNC pin. For external synchronization, the following conditions must be satisfied:

- 1) The oscillation frequency level is higher than the free-running frequency level.
- 2) The maximum ON duty cycle is 50% or less.
- 3) The pulse width of the synchronizing signal is shorter than the ON pulse width.

Figure 3 shows the circuit waveform when a synchronizing signal is applied to the SYNC pin.

A PWM limit signal can also be applied directly from the CT pin. For this control, the RT- and RT+ pins must be open.

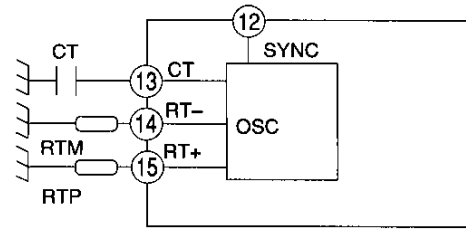


Fig. 1 Oscillator circuit

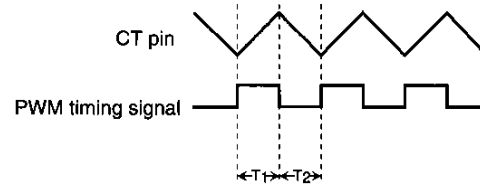


Fig. 2 Oscillation waveform

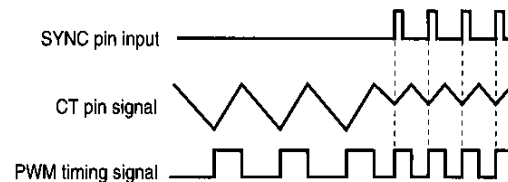


Fig. 3 Synchronizing signal and circuit waveforms



#### 4. Soft-start circuit (CS pin)

Figure 7 shows the soft-start circuit and Fig. 8 shows the soft-start waveforms.

Connect a capacitor to the CS pin to charge it to about 3.0V with the  $I_{CS}$  current. The IS pin voltage increases in proportion to the capacitor voltage. The soft-start function also acts after a restart due to overload.

When the capacitor voltage is from 0.3 to 3.0V, the IS pin voltage is controlled within the range from 0 to 0.6V.

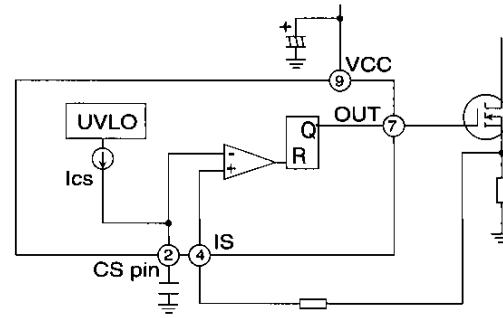


Fig. 7 Soft-start circuit

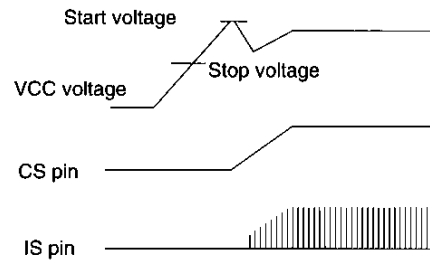


Fig. 8 Soft-start waveforms

#### 5. Peak drain current regulator (ICMP pin)

Figure 9 shows the peak drain current regulator circuit and Fig. 10 shows its operation.

This circuit regulates the peak drain current, to protect against input voltage fluctuation.

This regulation also includes a control delay after a current rise. The FB pin voltage remains stable even when the input voltage fluctuates.

ICMP pin is pulled-up through internal 6kΩ resistor from 1.1V reference voltage.

When the input voltage is from 0.4 to 1.0V, the IS pin voltage is controlled within the range from 0 to 0.6V.

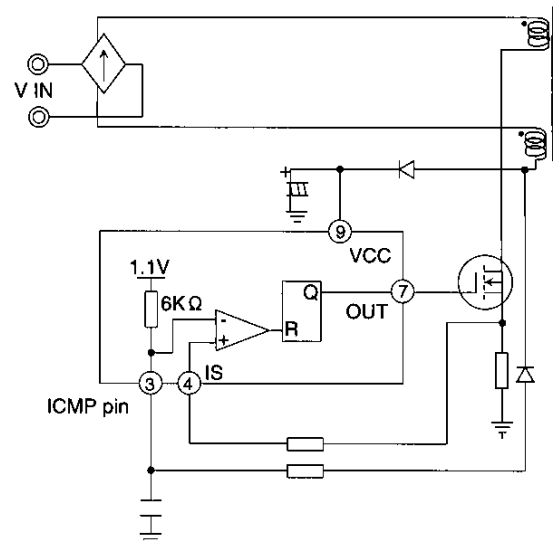


Fig. 9 Peak output current regulation circuit

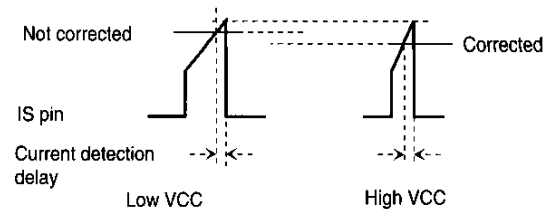


Fig. 10 Peak output current regulation

## 6. Undervoltage lock-out circuit (UVLO)

Figure 11 shows the UVLO operation.

This IC has a circuit to prevent an IC malfunction at a low supply voltage. When the supply voltage rises from 0V, the UVLO circuit unlocks the other circuits at  $V_{CC} = 16V$ . When the supply voltage goes down, the circuit locks out the other circuits at  $V_{CC} = 8V$ . The total current consumption of this IC is  $90\mu A$  in a lock-out state.

As the  $V_{CC}$  terminal voltage waveform shows below, the circuits are reset if  $V_{CC}$  drops as little as 0.3V below the lock-out voltage.

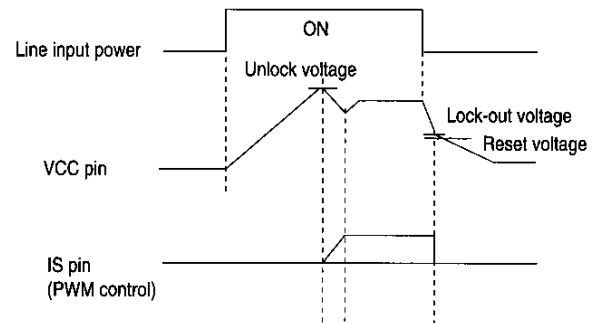


Fig. 11 UVLO operation

## 7. Overload protection circuit

Figure 12 shows the overload protection circuit and Fig. 13 shows its operation.

An overload decreases the output supply voltage of a power supply and increases the FB pin voltage. The overload protection shuts off the other circuits by detecting this change and reactivates them when the overload is removed. Connect a capacitor to the CP1 pin to determine the time from overload detection to circuit shut-off.

Connect a capacitor to the CP2 pin to determine the time to restart-up the circuits. Even when a capacitor is not connected to CP2, the start-up time is delayed because of the delay to charge the capacitor connected to  $V_{CC}$ . The  $V_{CC}$  capacitor is charged with the difference of the current flowing through the resistor for start-up and the current flowing in the protection circuit. Connect a capacitor to the CP2 pin to extend this delay.

The  $V_{CC}$  pin voltage is controlled by the CP2 pin voltage. The capacitor connected to  $V_{CC}$  pin is discharged once and charged again.

When not using the overload protection circuit, connect the CP1 pin to the GND pin. Never connect the CP2 pin directly to the GND pin.

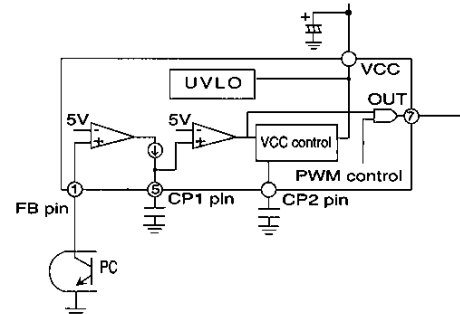


Fig. 12 Overload protection circuit

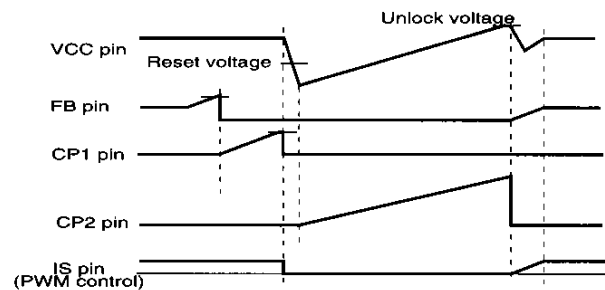


Fig. 13 Circuit waveforms during overload

## 8. Overvoltage protection and shut-down circuit (OVP)

Figure 14 shows the overvoltage and overheat protection and shut-down circuit. When a supply overvoltage is detected at the OVP pin, this circuit stops the operating bias current. To reactivate the IC, you must reset the input power. Turn the line input power off and on again to restart the IC. Fig. 15 shows how the circuit stops when an overvoltage is detected.

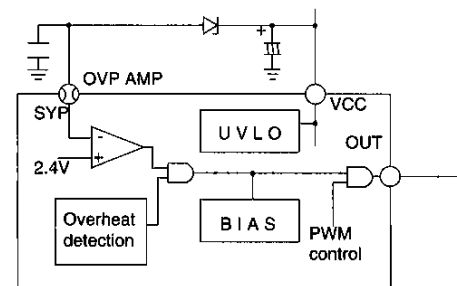


Fig. 14 Overvoltage and overheat protection and shut-down circuit

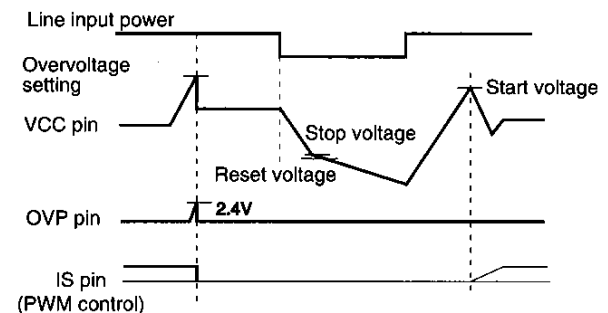


Fig. 15 Overvoltage protection and shut-down

## 9. Short-circuit protection

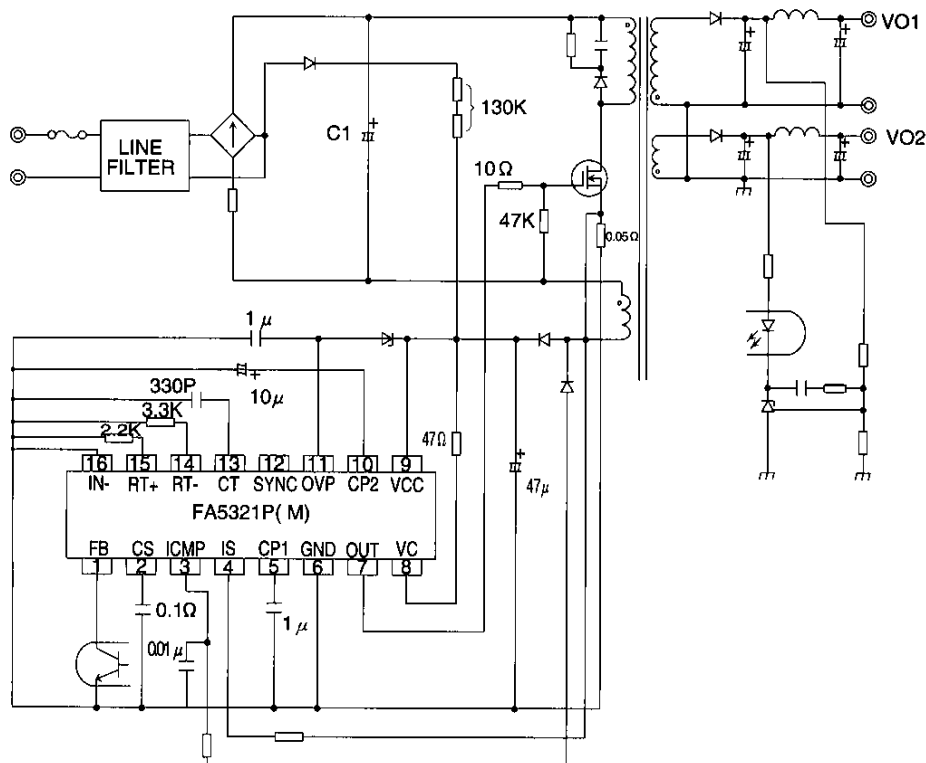
The IC shuts down in the following cases:

- 1) When the power supply is started up at a heavy load or a load short-circuit and it is not able to supply indispensable power to the IC from the auxiliary transformer.
  - 2) When the power supply is operating steadily and a heavy load disables the auxiliary transformer, which supplies power to the IC. (The power to the IC becomes insufficient within the time set with the capacitor at the CP1 pin.)
- If either of the above conditions occur, the VCC pin voltage goes below the threshold and the IC shuts down. To restart the IC, turn the line input power off and on again.

## 10. Overheat protection and shut-down circuit

The operating bias current is removed if the IC junction temperature reaches 125°C. To restart the circuit, turn the line input power off, and find and remove the cause. Then, turn the power on again.

## ■ Application circuit



Parts tolerances characteristics are not defined in the circuit design sample shown above. When designing an actual circuit for a product, you must determine parts tolerances and characteristics for safe and economical operation.



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