■ Description

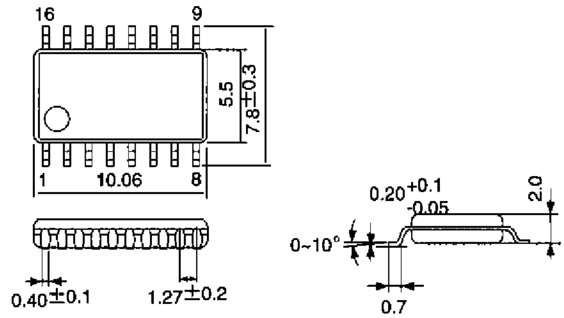
The FA5321P(M) is a current mode switching power supply control IC. In addition to basic control circuits, this IC contains protection and accessory circuits. Use this IC to develop a high performance compact switching power circuit.

■ Features

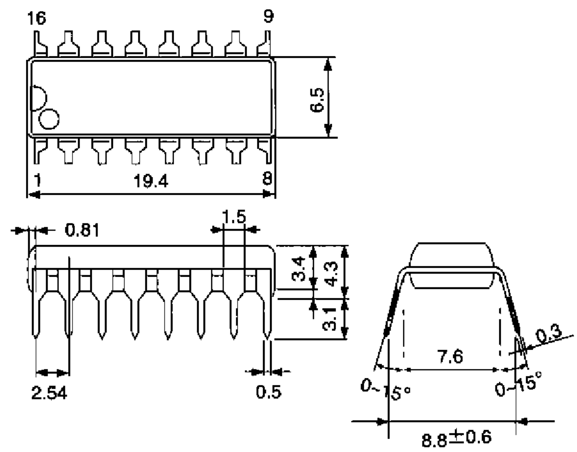
- Drive circuit for connecting a power MOSFET (Io = ±1.5A)
- Overvoltage protection (latch mode)
- Intermittent operations under overload (Automatic return)
- Independent switching and stop period with external components
- Control of maximum duty cycle with an external components
- Peak current adjustment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

■ Dimensions, mm

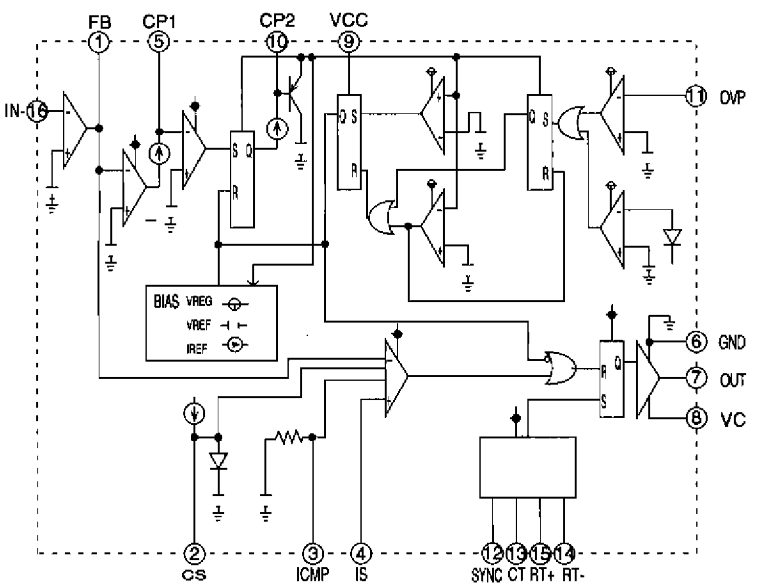
• SOP-16



• 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 resisance
15	RT+	Oscillator timing resisance
16	IN–	Inverting input to error amplifier

■ Absolute maximum ratings

Item		Symbol	Rating	Unit
Maximum supply voltage		V_{CC}	28	V
Maximum output current		I_{OUT}	±1.5	A
Input voltage	ICMP pin	V_{ICMP}	–0.3 to 5.3	V
	IS pin	V_{IS}	–0.3 to 5.3	V
	IN– pin	V_{IN-}	–0.3 to 5.3	V
	OVP pin	V_{OVP}	–0.3 to 5.3	V
	SYNC pin	V_{SYNC}	–0.3 to 5.3	V
Maximum power dissipation	Ta < 25°C Ta > 25°C	Pd Pd	800 (DIP)/650 (SOP) 800–8.5mW/°C (DIP) 650-6.5mW/°C (SOP)	mW mW
Storage temperature		T_{stg}	–40 to +150	°C
Operating temperature		T_{opr}	–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	V_{CCON}		14.5	15.5	17.0	V
Operating voltage	V_{CCOP}		12.0	–	27.0	V
Turn-off voltage	V_{CCOF}		7.0	7.8	8.5	V
Start-up current	I_{CCST}	0V to V_{CCON}	40	90	160	µA
Operating current	I_{CCOP}	V_{CCOF} to 27V	5.0	8.0	16.0	mA

Output circuit

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Output source current	I_{OUTSO}	VOUT pin = 2.0V	100	–	–	mA
Output sink current	I_{OUTSI}	VOUT pin = VCCT pin –2V	100	–	–	mA

Oscillator circuit

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
CT-pin voltage (peak-to-peak)	V_{CTPP}		1.7	1.9	2.1	V
Reference voltage	V_{RT+}		0.70	0.85	1.00	V
	V_{RT-}		0.70	0.85	1.00	V
SYNC pin input voltage	V_{SYNC}	Threshold voltage	1.3	1.5	1.9	V

PWM current detection circuit

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Input current	I_{IS}		–80	–120	–160	µA
Input voltage	V_{IS}		–	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_{ICMP}	ICMP pin open	0.9	1.1	1.3	V

Soft-start circuit

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Charge current	I_{CS}		15	22	30	µA
Charge voltage	V_{CS}		2.7	3.0	3.3	V

Error amplifier circuit

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Reference voltage	V_{IN-}		2.2	2.4	2.6	V
Input current	I_{IN-}		–0.5	–	0.5	µA
Output source current	I_{FBSO}	FB pin = 5V	0.2	–	–	mA
Output sink current	I_{FBSI}	FB pin = 2V	0.2	–	–	mA

Overload protection circuit

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

Short circuit protection

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Vcc voltage at protection	V_{CCOF}		7.0	7.8	8.5	V

Overvoltage protection

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Overvoltage detection level (comparator)	V_{OVP}		2.25	2.4	2.55	V
Detection current	I_{OVP}		20	30	50	µA
Vcc voltage at protection	V_{CCFOV}	Standby current ≤ 3MA	14	15.5	17	V

Overheat protection

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Shutdwon temperature	T_{THM}		–	120	–	°C
VCC voltage at protection	V_{CCFOV}	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.

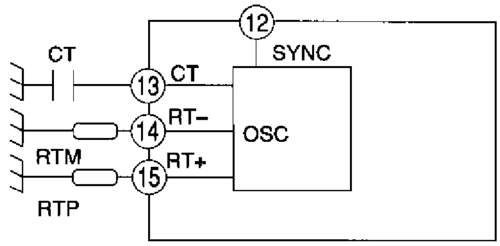


Fig. 1 Oscillator circuit

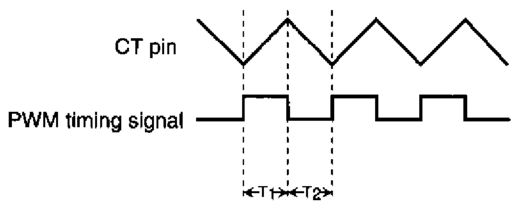


Fig. 2 Oscillation waveform

Charging time (Maximum ON time)

$$T_1 = \frac{C_T \cdot V_{pp}}{\frac{V_{IREF}}{R_{TP}} - \frac{V_{IREF}}{R_{TM}}}$$

Discharge time (OFF time)

$$T_2 = \frac{C_T \cdot V_{pp} \cdot R_{TM}}{V_{IREF}}$$

Frequency

$$f_{OSC} = \frac{V_{IREF}\,(R_{TM} - R_{TP})}{C \cdot V_{pp} \cdot R_{TM}^2}$$

Maximum ON duty cycle

$$D = \frac{R_{TP}}{R_{TM}}$$

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 opend.

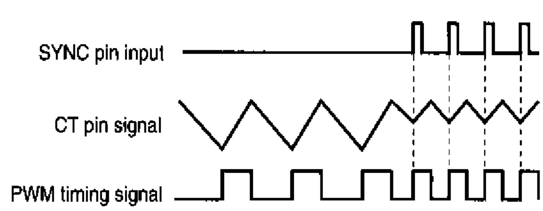


Fig. 3 Synchronizing signal and circuit waveforms

2. PWM control section (IS pin)
The PWM control section sets the output drive circuit at the rising edge of a PWM control signal and resets it with the PWM comparator. As Fig. 4 shows, the PWM comparator compares the IS pin voltage (current • resistance) with the following four signals:

1) Internal reference voltage: 0.60V
2) Soft-start signal: CS pin
3) Feedback signal: FB pin
4) Compensation input signal: ICMP pin

The comparator compares the IS pin voltage with the lowest signal among the four signals above.
If the IS pin voltage is higher than the lowest signal described above, the comparator clamps the OUT pin to ground.
Figure 5 shows the PWM control operation.

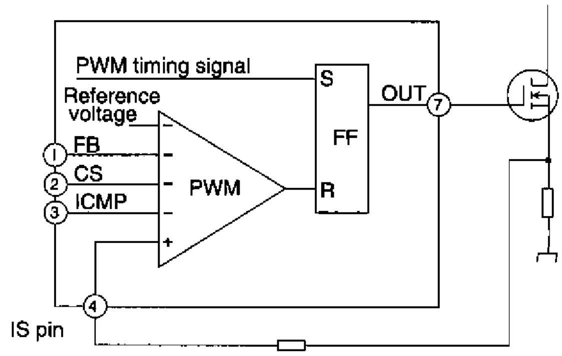


Fig. 4 PWM control circuit

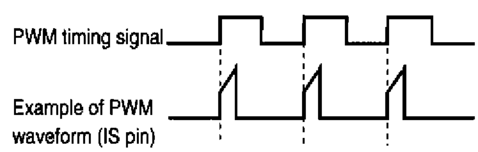


Fig. 5 PWM control

3. Feedback circuit (FB and IN- pins)
Figure 6 shows a feedback circuit using a photocoupler. Connect the IN- pin to the GND pin. This connects the FB pin, through the pull-up resistance of 4kΩ to 6.5V.
When using an error amplifier, connect the error signal to the IN- pin. The positive input line of the amplifier is internally connected to the reference voltage (2.5V). The FB pin provides the output of the amplifier. The IS pin voltage (0 to 0.6V) is controlled by the FB pin voltage (0.6 to 2.5V).

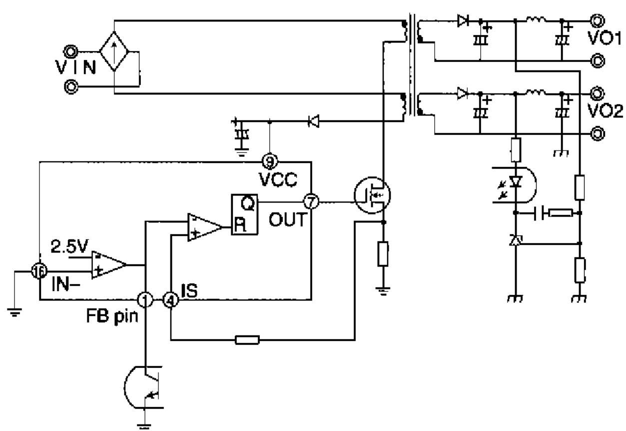


Fig. 6 Feedback circuit using a photocoupler

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 Ics 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.

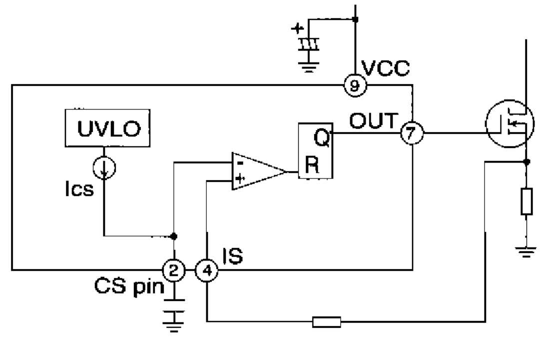


Fig. 7 Soft-start circuit

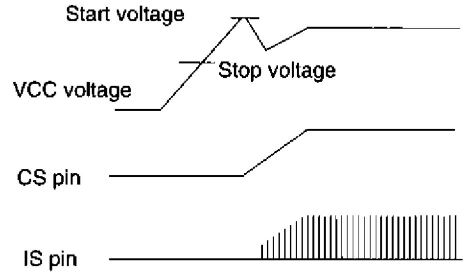


Fig. 8 Soft-start waveforms

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.

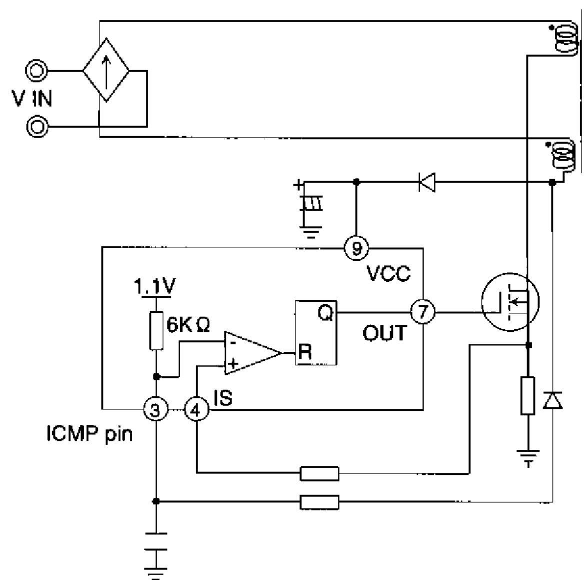


Fig. 9 Peak output current regulation circuit

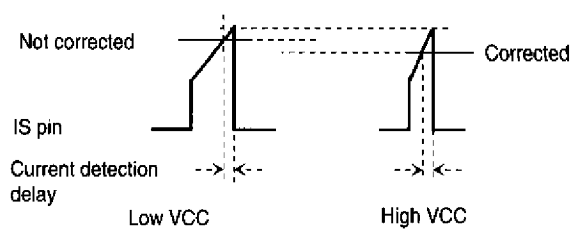


Fig. 10 Peak output current regulation

6. Undervoltage lock-out circuit (UVLO)

Figure 11 shows the UVLO operation.
This IC has a circuit to prevent an IC mulfunction at a low supply voltage. When the supply voltage rises from 0V, the UVLO circuit unlocks the other circuits at Vcc =16V. When the supply voltages goes down, the circuit locks out the other circuits at Vcc = 8V. The total current consumption of this IC is 90μA in a lock-out state.
As the VCC terminal voltage waveform shows below, the circuits are reset if Vcc drops as little as 0.3V below the lock-out voltage.

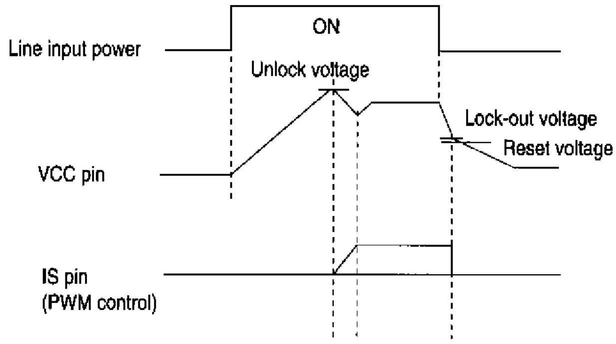


Fig. 11 UVLO operation

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 Vcc. The Vcc 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 VCC pin voltage is controlled by the CP2 pin voltage. The capacitor connected to VCC 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.

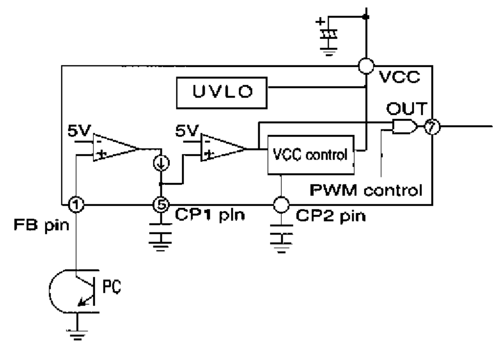


Fig. 12 Overload protection circuit

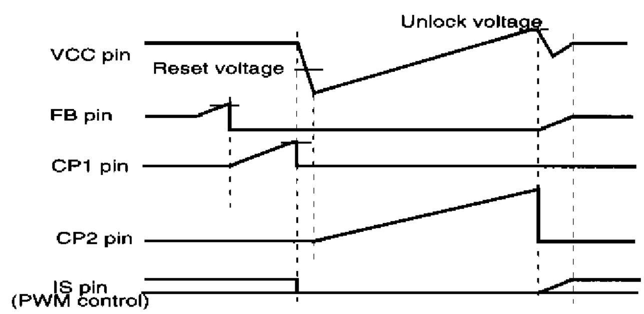


Fig. 13 Circuit waveforms during overload

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.

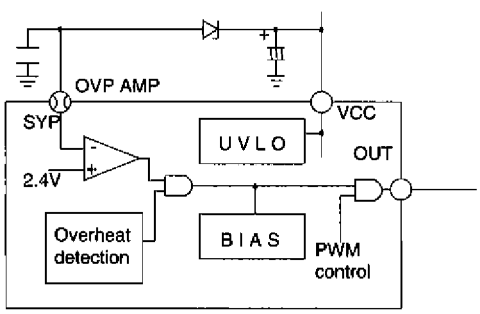


Fig. 14 Overvoltage and overheat protection and shut-down circuit

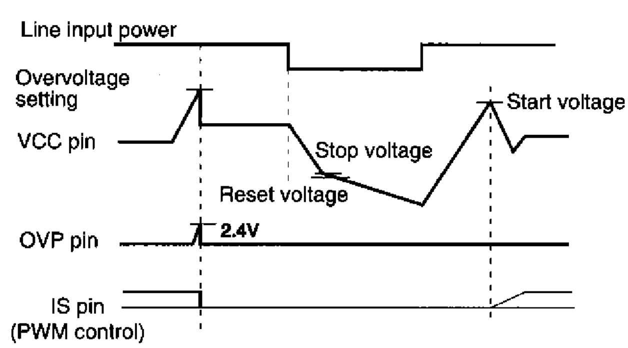


Fig. 15 Overvoltage protection and shut-down

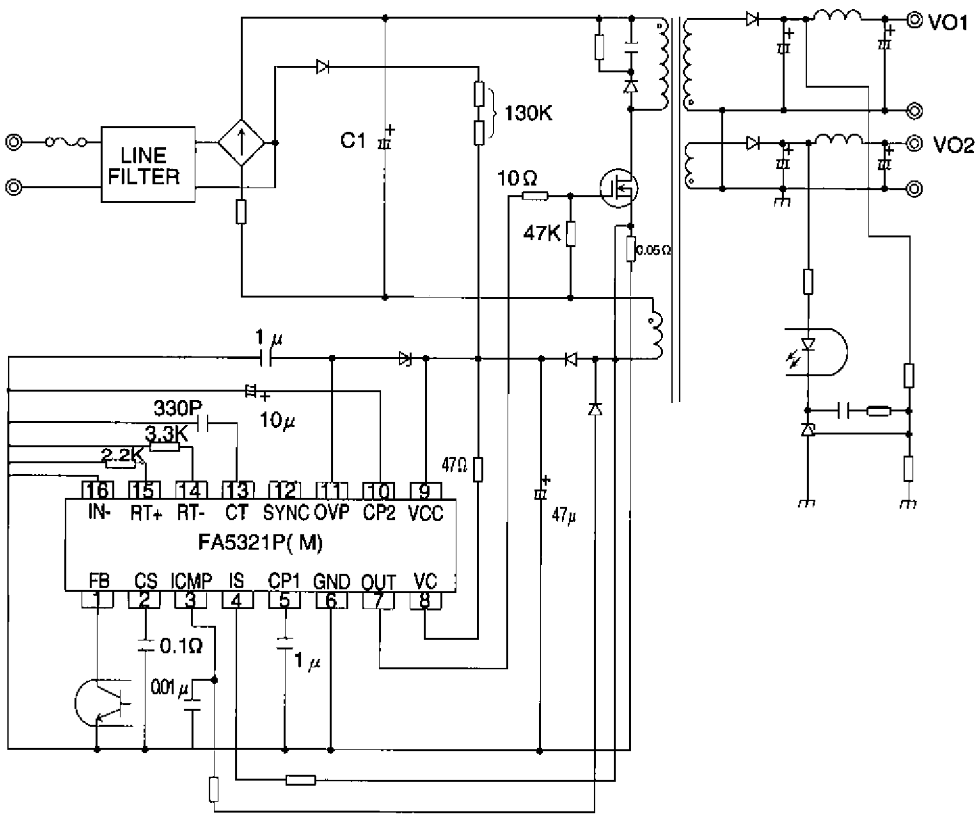
9. Short-circuit protection
The IC shuts down in the following cases:

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.

CAUTION

1. This Data Book contains the product specifications, characteristics, data, materials, and structures as of July 1995. The contents are subject to change without notice for specification changes or other reasons. When using a product listed in this Data Book, be sure to obtain the latest specifications.

2. All applications described in this Data Book exemplify the use of Fuji's products for your reference only. No right or license, either express or implied, under any patent, copyright, trade secret or other intellectual property right owned by Fuji Electric Co., Ltd. is (or shall be deemed) granted. Fuji makes no representation or warranty, whether express or implied, relating to the infringement or alleged infringement of other's intellectual property rights which may arise from the use of the applications described herein.

3. Although Fuji Electric is enhancing product quality and reliability, a small percentage of semiconductor products may become faulty. When using Fuji Electric semiconductor products in your equipment, you are requested to take adequate safety measures to prevent the equipment from causing a physical injury, fire, or other problem if any of the products become faulty. It is recommended to make your design fail-safe, flame retardant, and free of malfunction.

4. The products introduced in this Data Book are intended for use in the following electronic and electrical equipment which has normal reliability requirements.
   - Computers
   - OA equipment
   - Communications equipment (terminal devices)
   - Measurement equipment
   - Machine tools
   - Audiovisual equipment
   - Electrical home appliances
   - Personal equipment
   - Industrial robots etc.

5. If you need to use a product in this Data Book for equipment requiring higher reliability than normal, such as for the equipment listed below, it is imperative to contact Fuji Electric to obtain prior approval. When using these products for such equipment, take adequate measures such as a backup system to prevent the equipment from malfunctioning even if a Fuji's product incorporated in the equipment becomes faulty.
   - Transportation equipment (mounted on cars and ships)
   - Trunk communications equipment
   - Traffic-signal control equipment
   - Gas leakage detectors with an auto-shut-off feature
   - Emergency equipment for responding to disasters and anti-burglary devices
   - Safety devices

6. Do not use products in this Data Book for the equipment requiring strict reliability such as (without limitation)
   - Space equipment
   - Aeronautic equipment
   - Atomic control equipment
   - Submarine repeater equipment
   - Medical equipment

8. If you have any question about any portion in this Data Book, ask Fuji Electric or its sales agents before using the product. Neither Fuji nor its agents shall be liable for any injury caused by any use of the products not in accordance with instructions set forth herein.