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IC FOR SWITCHING POWER SUPPLY CONTROLLER

Eiji Kuroda
Ichiroh Nomura
Osamu Sasaki

1. FOREWORD

Since switching power supplies features small size, light weight, and high efficiency, they are widely used as the power supply of various electronic equipment.

Up to now, Fuji Electric has mainly developed IC (FA76 Series) for low power DC-DC converter as control ICs for this field. On the other hand, in the line operation power supply field, which is the main field of application of the switching power supply, currently, transition from the bipolar transistor to the MOSFET as the main switching device is advancing with the increase of the switching frequency.

Fuji Electric developed switching power supply control IC for the original power MOSFET.

It's outline is described below.

2. OVERVIEW OF PRODUCT

The FA5304P(S)/FA5305P(S) developed this time are PWM (Pulse Width Modulation) type switching power supply control ICs which can directly drive a power MOSFET. They are unique control IC that realize multiple functions in a small 8-pin package and have a large effect in realizing a small, multiple function, low-cost power supply.

Their features are:

(1) Built-in high current output circuit that can directly drive a power MOSFET.
(2) Applicable to switching frequencies up to 600 kHz.
(3) Built-in pulse-by-pulse overcurrent limiting circuit.
(4) Built-in overload tripping function (latch mode/non-latch mode can be selected)
(5) On/off control by external signal possible.
(6) Output overvoltage tripping operation possible.
(7) Built-in error amplifier. Also applicable to tertiary winding voltage detection method.
(8) Low standby current (90 μA, standard) allows simplification of the starting circuit.
(9) 8-pin package (DIP/SOP).

This IC are shown in *Fig. 1.* The maximum ratings of the ICs are shown in *Table 1.*

3. INTERNAL CIRCUIT

The internal circuit block diagram of this IC is shown in *Fig. 2.* The internal circuits consists of a reference voltage circuit (BIAS), error amplifier, oscillator (OSC), PWM comparator, output circuit, and various protection circuits. To realize these with eight pins, circuit innovations are made. The features of this IC are described below.

Fig. 1 IC for switching power supply controller

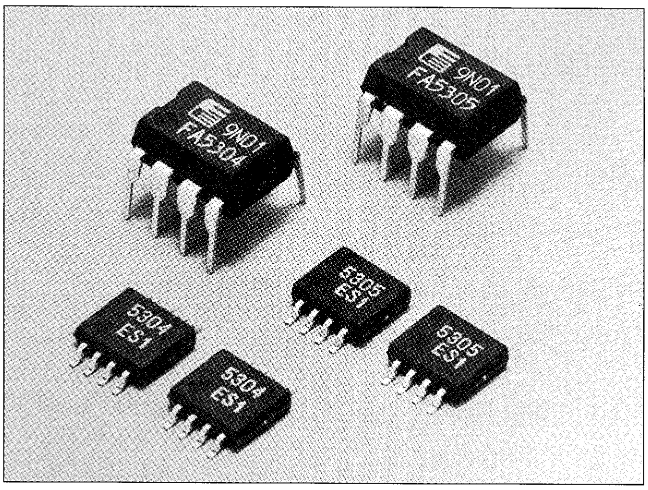


Table 1 Maximum ratings

Item	Symbol	Rating	Units
Power supply voltage	V_{CC}	30	V
Output Current	I_O	±1.5	A
Error amp input voltage	V_I	4	V
FB pin input voltage	V_{FB}	4	V
Overcurrent detection pin input voltage	V_{IS}	−0.3 ~ +4	V
CS pin input current	I_{CS}	2	mA
Overall loss (T_a = 25°C)	P_d	800 (DIP-8) 400 (SOP-8)	mW
Operating temperature range	T_{opr}	−30 ~ +85	°C
Storage temperature range	T_{stg}	−40 ~ +150	°C

Fig. 2 Block diagram

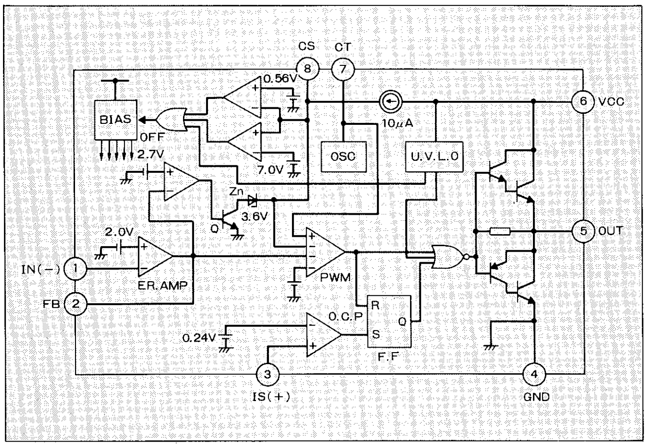
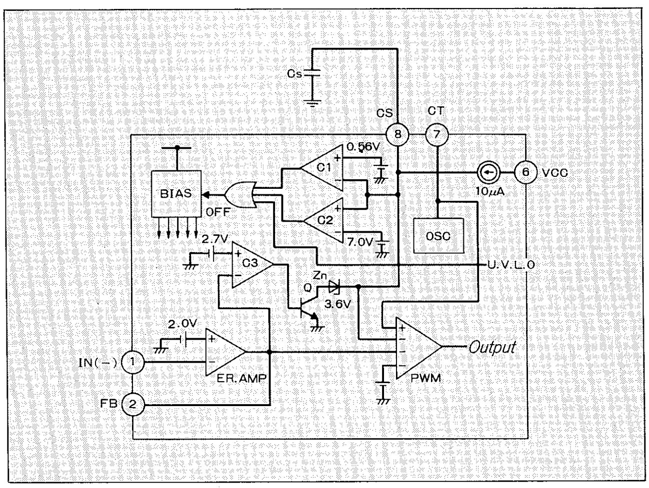


Table 2 CS pin function

Item	Contents
Soft start function	Slowly raises the output voltage at starting.
Overload tripping function	Stops the power supply when an overload is applied to the output.
Overvoltage tripping function	Stops the power supply when the output voltage rises excessively.
On/off control	Turns the power on and off by external signal.

Fig. 3 CS pin circuit



3.1 CS pin circuit

To reduce the number of pins, the four functions shown in *Table 2* are realized at the CS pin (pin 8) only. This is realized by focusing attention on the fact that the functions of *Table 2* are not necessary simultaneously and dividing the CS pin voltage region. The CS pin circuit is shown in *Fig. 3*. Since the IC supply current must be lowered at on/off control, overload and overvoltage tripping operation, the circuit is constructed to cut off the IC internal bias supply (BIAS).

Fig. 4 CS pin operating waveform

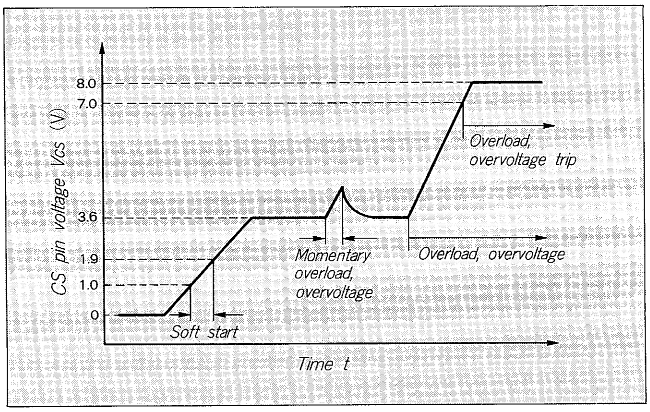


Fig. 5 Timing chart for soft start

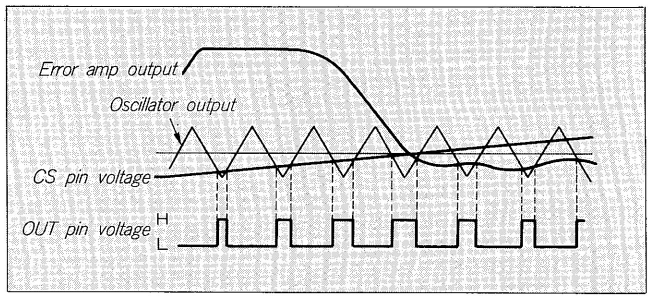
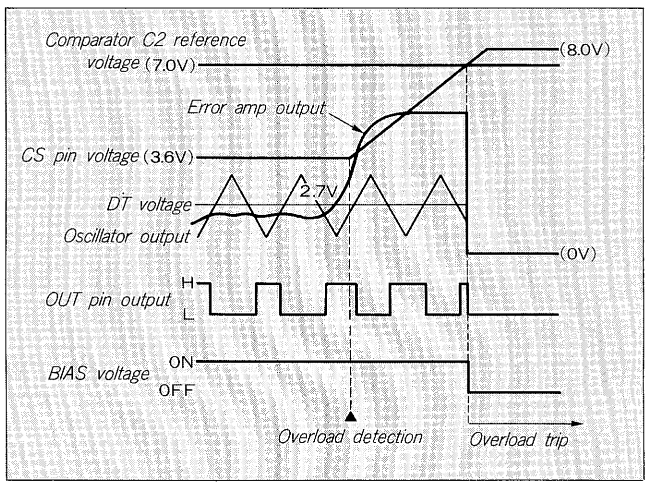


Fig. 6 Timing chart for overload tripping



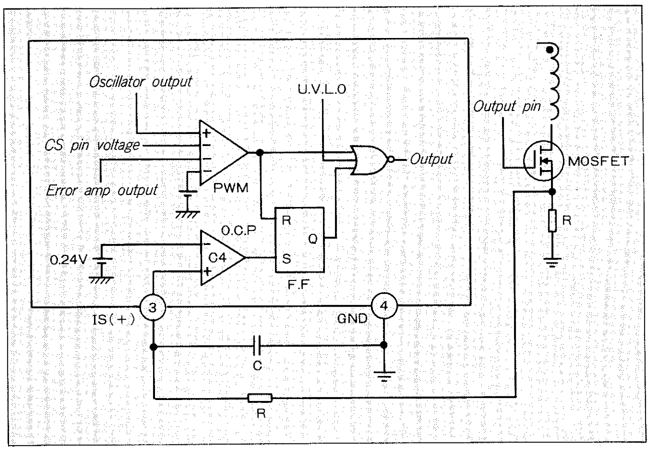
The CS pin operating waveform is shown in *Fig. 4*. At starting, the CS pin voltage is raised at the potential rise rate determined by the internal constant current supply (10 μA) and external capacitor (Cs). Soft start is applied in this process. In steady state, the CS pin voltage is fixed at 3.6 V. When an overload is generated and the power supply output voltage drops below the specified voltage, the FB pin (pin 2) voltage is forced to the + side by operation of the constant voltage feedback loop and this is detected by comparator C3 and the CS pin voltage is raised. When this voltage reaches 7 V, the internal bias supply (BIAS) is cut off and operation is stopped. On/off control and output overload tripping are performed by forcing the CS pin voltage to low level (<0.56 V) and high level (>7 V). The timing charts for soft start and overload tripping are shown in *Fig. 5* and *Fig. 6*.

3.2 Current Limiting Circuit

Current limiting of this IC uses a pulse-by-pulse method which detects and limits the peak value of the pulse shaped main current which flows in power MOSFET at each cycle. Since this method allows high-speed operation and can protect the switching devices positively, it has become the mainstream of primary side control type control IC. This circuit is shown in *Fig. 7* and the operating timing chart is shown in *Fig. 8*. Two types, FA5304/5305, are available according to the voltage polarity for current sensing.

4. APPLICATION

Fig. 7 Overcurrent limiting circuit



4.1 Power MOSFET starting

Fig. 8 Timing chart at overcurrent limiting

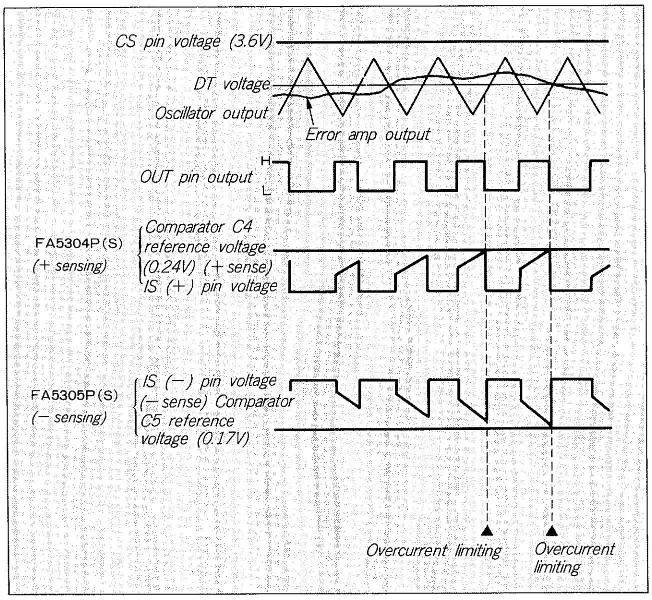


Fig. 9 Power MOSFET drive

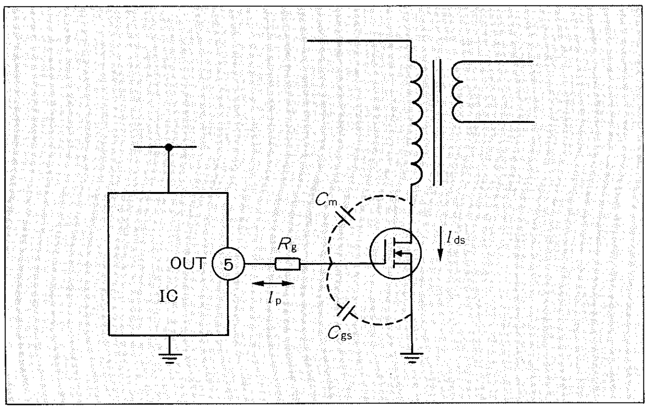


Fig. 10 Application circuit example

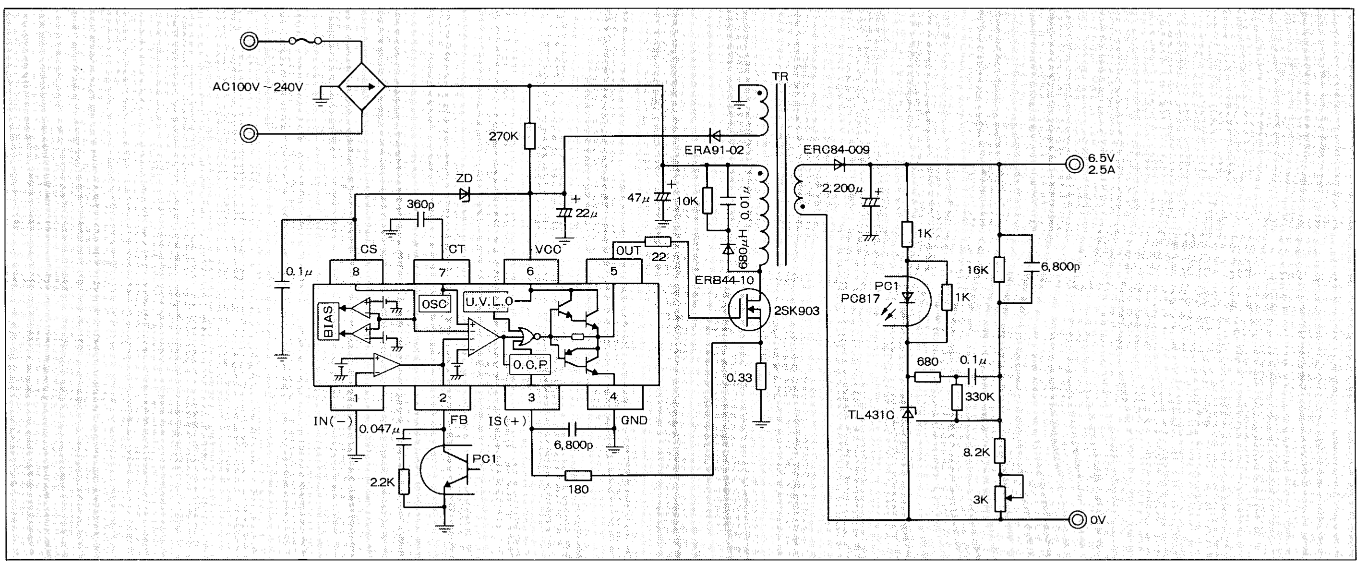


Fig. 11 MOSFET switching waveforms

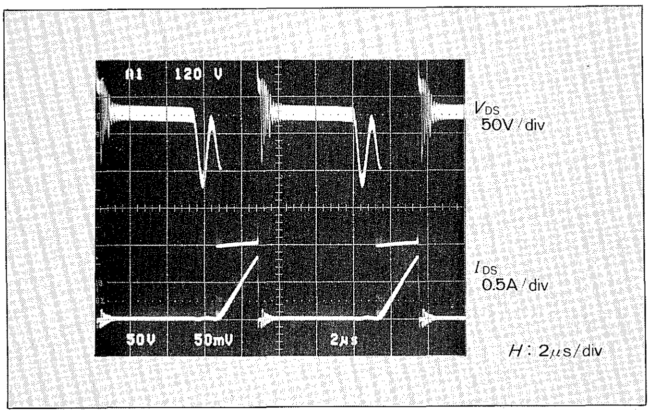
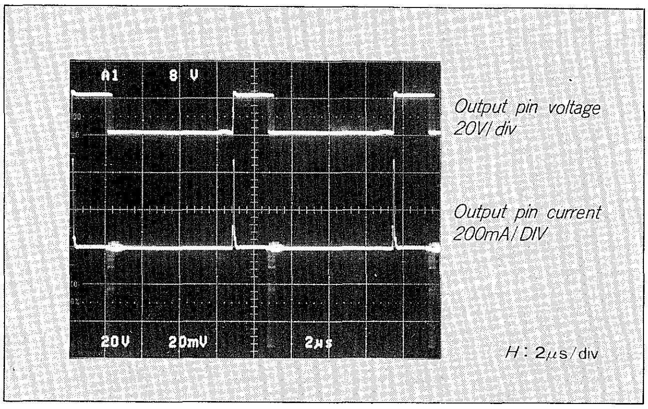


Fig. 12 IC output waveforms



The gate of the MOSFET, which is the load of IC, is a capacitive load. To drive this at high-speed, peak-shape current must flow in the gate. When this current resembles a square wave, the current peak value I_p and switching t_{sw} have the following relation:

$$I_p = Q_g / t_{sw} \quad \cdots\cdots\cdots\cdots (1)$$

Where Q_g is the gate charge of the MOSFET which is driven and is a type inherent value. The output current capacity of this IC is 1.5 A. The switching time can be adjusted by setting I_p within this range with R_g shown in *Fig. 9*. The power P_D required to drive the gate is given by Eq. (2).

$$P_D = f \cdot Q_g \cdot V_{GS} \quad \cdots\cdots\cdots\cdots (2)$$

Where, f : switching frequency

V_{GS}: gate applied voltage

Since this power is consumed entirely in the IC output circuit and R_g, it must be suppressed to within the maximum allowable loss of the IC.

4.2 Application circuit example

An example of a circuit using this IC is shown in *Fig. 10*. This circuit is a flyback converter with the various protection function previously mentioned.

Overvoltage tripping uses the proportional relationship between the power supply output voltage and back-up winding voltage. When an overvoltage is generated, the CS pin (pin 8) is pulled up by zener diode ZD and the power supply is stopped. The power MOSFET switching waveforms are shown in *Fig. 11* and the output voltage and current waveforms are shown in *Fig. 12*.

A multiple function power supply can be build with very few external parts by using this IC such as the application example shown here. Application over a wide field is expected by taking advantage of this feature.

5. CONCLUSION

The product developed as control IC for the line operation power supply field was described. This IC is a product with special features as an IC for power MOSFET. Completion of Fuji Electric switching power supply devices, in addition to diodes and MOSFET, is performed.

Regarding this field, technology is expected to advance and the market is also expected to expand noticeably. Fuji Electric plans to promote development of product with special features in this field.