

FA5553/5547 Series of PWM Control Power Supply ICs with Multi-functionality and Low Standby Power

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1. Introduction

In recent years, global environmental warming has come to be addressed as a worldwide problem and energy savings has become critical for all electric products. In particular, televisions, audio components, notebook computers, printers and other such peripheral devices that are often continuously plugged into an electrical outlet remain in their standby state for a longer duration of time than their actual time of usage, and therefore functions for reducing the power consumption during standby have become essential. Requests for lower standby power consumption in power supply units have also intensified year after year.

In response to these requests, Fuji Electric has already developed a series of control ICs for use in switching mode power supply units to convert commercial AC power (100 V or 240 V) to a DC power supply. Recently, Fuji Electric has developed the FA5553/5547 series of 8-pin current mode PWM (pulse width modulation) control power supply ICs which feature enhanced low standby power performance and added protection functions suitable for various products. An overview of this new product series is presented below.

2. Product Overview

Fuji Electric has developed a series of AC-DC

power supply ICs for driving externally attached power MOSFETs fabricated using a 30 V CMOS (complementary metal-oxide-semiconductor) process, and this newly developed IC series is listed in Table 1. This IC series is used as a PWM IC on the primary side in the conceptual diagram of a switching mode power supply shown in Fig. 1.

2.1 Characteristics

As indicated in Table 1 each unit type is provided

Fig.1 Conceptual diagram of switching mode power supply

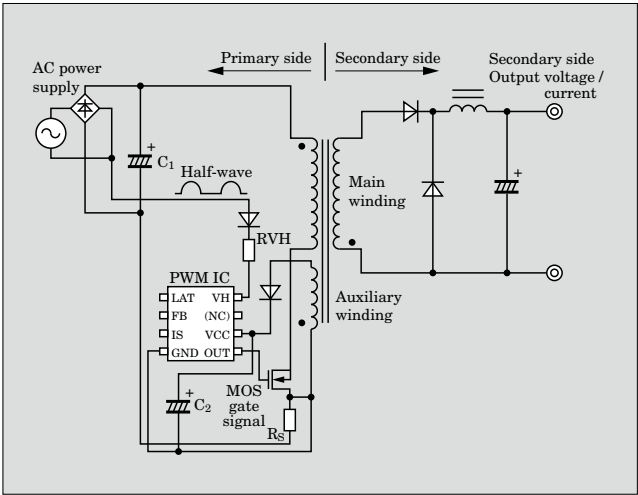


Table 1 Characteristics of PWM IC series for low standby power

Series	Model	Package	Power supply configuration	Input range	Operating frequency	Protection function				Low standby power function		
						Overload	Over-voltage	Latch by an external signal (overheat)	Brown-out	Startup circuit	Min. operating frequency during standby	Overload line compensation loss
FA5528	FA5528	SOP/DIP8	Flyback	10 to 26 V	60 kHz	Timer latch	Latch	Yes	No	Yes	1.1 kHz	< 70 mW
FA5553	FA5553	SOP/DIP8	Flyback	10 to 26 V	60 kHz	Auto-restart	Latch	Yes	No	Yes	0.35 kHz	< 5 mW
	FA5554					Timer latch						
	FA5566				100 kHz	Auto-restart						
	FA5567					Timer latch						
FA5547	FA5546	SOP/DIP8	Flyback	10 to 26 V	60 kHz	Auto-restart	Latch	Yes	Yes	Yes	0.5 kHz	< 5 mW
	FA5547					Timer latch						

□ : New product

with a built-in 500 V high voltage startup circuit as in the conventional FA5528 series and is also provided with a function to reduce the operating frequency during standby according to the load. Compared to the conventional series, the minimum operating frequency has been reduced and the loss associated with compensating for the input voltage dependency of the overload detection level (i.e. overload line compensation loss) has also been reduced for the new product series to realize even lower levels of power consumption during standby operation. Meanwhile, in terms of protection functions, a low AC input voltage protection (brown-out) function has been added to the FA5547 series. This function shares the pins used by the above-described startup circuit so that, without increasing the number of pins, a package can be realized with the same number of pins as in the past.

The power supply protection functions and number of externally attached components are listed in Table 2. With the FA5553 series, an external latch type overheat protection function is configured by a thermistor only, enabling the number of external components to be reduced by two components compared to the conventional series. Moreover, with the FA5547 series, in addition to the abovementioned overheat protection, a current limiting function that operates in response to a pulsed load current and is required in power supply units having a load such as a motor, and a brown-out function are built into the IC, enabling the number of external components to be reduced by eight components compared to the conventional series and a reduction in cost of the power supply unit.

2.2 Low standby power consumption

(1) Startup circuit (common function)

Table 2 Power supply protection functions and number of externally attached components

(a) Power supplies that require overheat protection

Model	Protection function			No. of external components
	Overload	Over-voltage	Latch by an external signal (overheat)	
FA5528	Yes	Yes	Yes	17
FA5553 FA5554	Yes	Yes	Yes*	15

* Overheat detectoin possible with a thermistor only : New product

(b) Power supplies having diverse protection functions

Model	Protection function					No. of external components
	Overload	Current limiting	Over-voltage	Latch by an external signal (overheat)	Brown-out	
FA5528	Yes	No	Yes	Yes	No	25
FA5546 FA5547	Yes	Yes	Yes	Yes*	Yes	17

* Overheat detectoin possible with a thermistor only : New product

Figure 2 shows the method for connecting the VH pin to the half-wave rectified AC input voltage. When the power supply is turned on, the current supplied from the startup circuit to the VCC pin charges the capacitor C2 connected to the VCC pin, causing the VCC voltage to rise, the IC to be activated and the power supply to start operation. The current supplied from the VH pin to the VCC pin is largest in the state where the VCC pin voltage is 0 V, and the supplied current decreases when the VCC pin voltage increases. Moreover, a resistor is connected in series with the VH pin in order to prevent IC damage due to surge voltage on the AC line or elsewhere.

(2) Minimum operating frequency during standby (common function)

When the load is heavy, the switching frequency is fixed at the 60 kHz or 100 kHz operating frequency listed in Table 1. However, a function is provided for automatically decreasing the switching frequency when the load is light, such as during standby, so as to reduce loss. As shown in Fig. 3, when the load is light, the frequency decrease is proportional to the FB pin voltage and is nearly linear down to a minimum frequency f_{\min} (0.35 kHz).

(3) Reduction of overload line compensation loss (common function)

Fig.2 Startup circuit

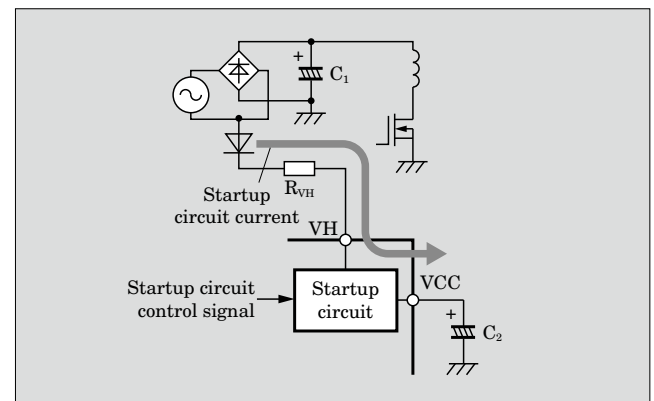
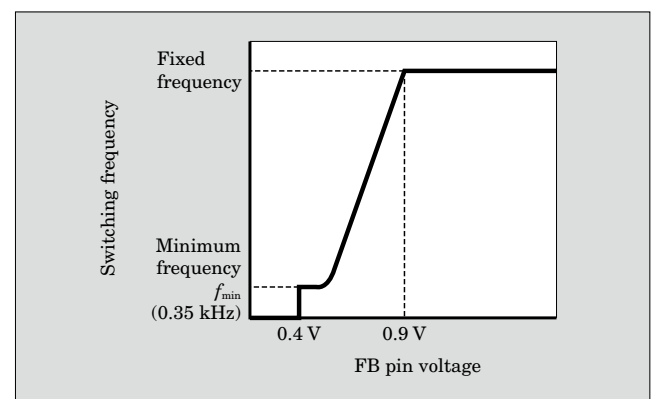


Fig.3 Relationship between switching frequency and FB pin voltage



Since the gradient of the inductance current of a transformer differs according to the input voltage, the overcurrent values associated with an overload condition will be different. Previously, as shown in Fig. 4 (b), a resistor R_4 is connected between the current detection resistor R_s and the IS pin, and a resistor R_5 is connected between the AC line (after rectification and smoothing) and the IS pin, and since a high voltage is applied to resistor R_5 , the loss of 70 mW at this portion was particularly large. Thus, with the new product series, the IS detection polarity was changed from plus detection to minus detection. As a result, as shown in Fig. 4 (a), a resistor R_9 is connected between the auxiliary winding and the IS pin, enabling a decrease in the input voltage dependency of the overload detection level and a loss at this portion of 5 mW which is 1/14th that of the conventional product series.

2.3 Protection functions

- (1) External latch type overheat protection (common function)

By connecting a thermistor TH to the LAT pin as shown in Fig. 5, the IC will enter the latch mode for LAT pin voltages of 1.05 V or less.

The protection functions of the FA5547 series only

Fig.4 Overload line compensation circuit

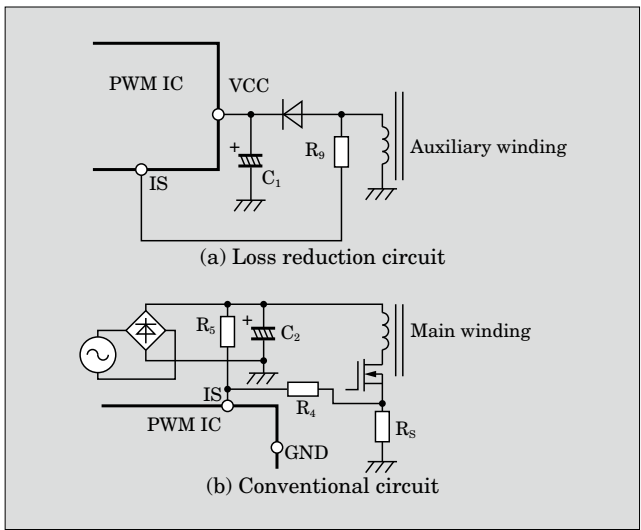
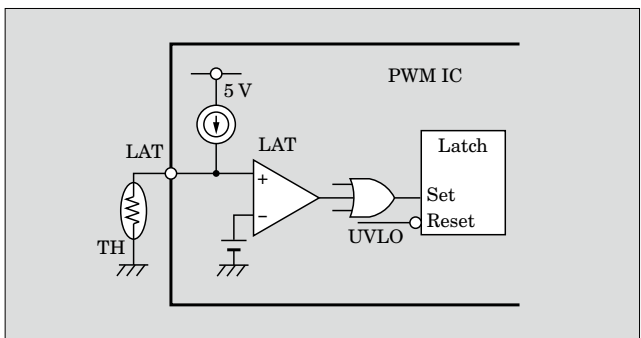


Fig.5 External latch type overheat protection circuit



are described below.

- (2) Low AC input voltage protection (brown-out)

As shown in Fig. 6, the AC input voltage is monitored at the VH pin and is input, via a startup circuit, to a comparator. Figure 7 shows conceptual diagrams of the brown-out release (brown-in) and the brown-out detection operation when using the half-wave input of the AC input voltage at the VH pin. Figure 7 (a) shows the operation during brown-in, wherein when the half-wave rectified input becomes greater than the brown-in detection voltage threshold value, the IC begins its switching operation and the secondary-side output voltage rises. Figure 7 (b) shows the operation during brown-out, wherein the IC switching operation stops 50 ms after the half-wave rectified input becomes less than the comparator's brown-out detection voltage threshold value.

- (3) Overload protection (current limiting)

Functions to protect against pulsed load current as

Fig.6 Brown-out detection circuit

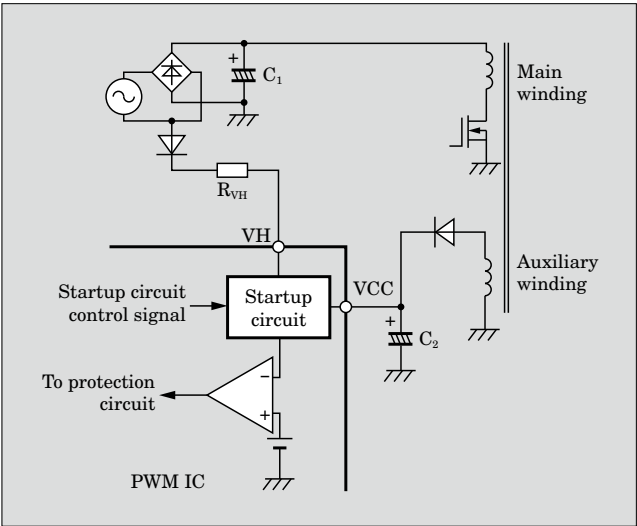


Fig.7 Conceptual diagram of brown-in and brown-out

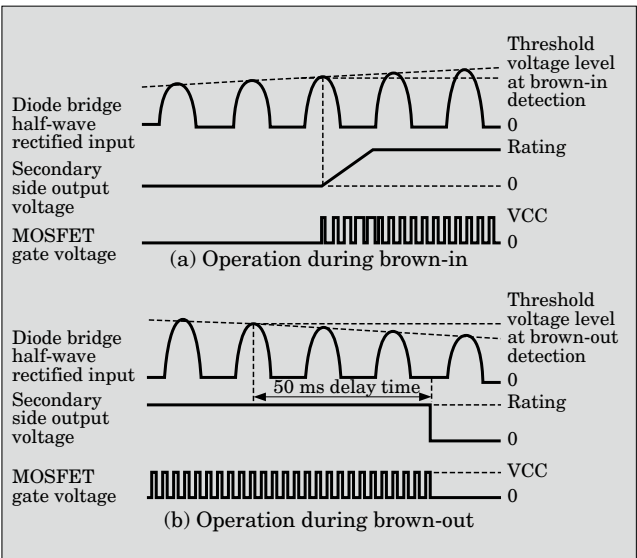
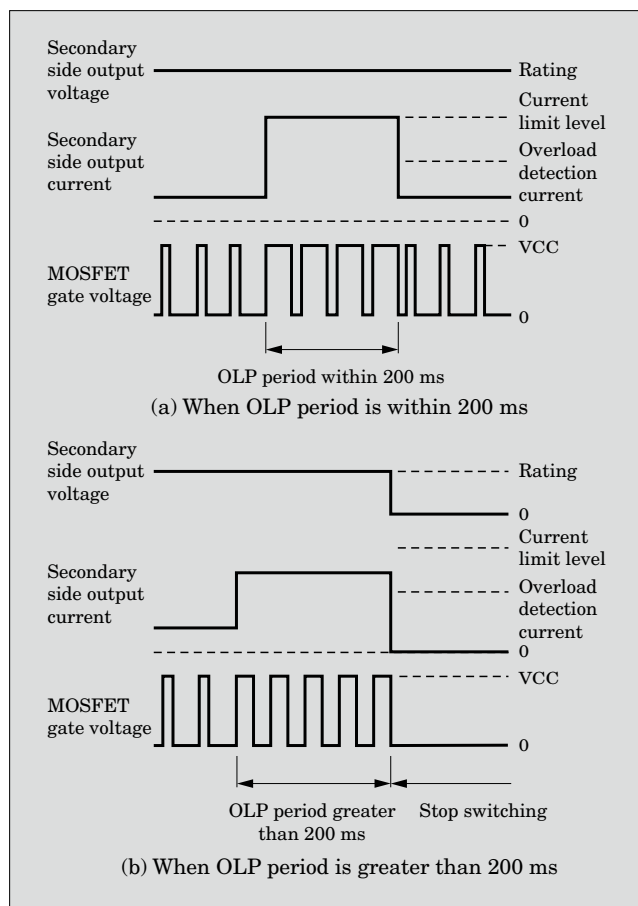


Fig.8 Conceptual diagram of overcurrent operation in response to pulsed load current



well as overload protection are required in some power supplies used for ink jet printers and other such motor loads. Figure 8 shows conceptual diagrams of the overcurrent operation in response to pulsed load current. Figure 8 (a) shows the case in which when the overload period is not more than 200 ms, even if the secondary-side output current is larger than the overload detection current level, the IC will continue switching and the secondary-side output voltage will be maintained until reaching the current limiting level. At loads above the current limiting level, the primary-side switching current is limited pulse-by-pulse, and the secondary-side output voltage decreases. However, as in Fig. 8 (b), if the load period is 200 ms or greater, the IC is latched and stopped and the switching operation is also stopped.

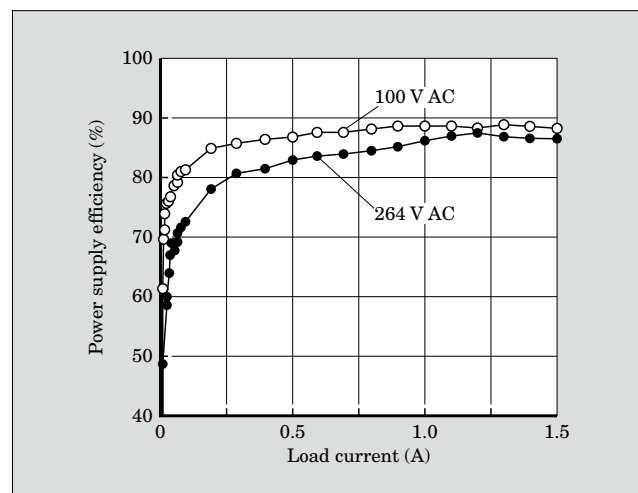
3. Application to Power Supply Circuit

Characteristics of a switching mode power supply that uses the FA5553 are described below.

3.1 Power supply efficiency characteristics

Main specifications of the power supply are listed below.

Fig.9 Relationship between load current and power supply efficiency



- (1) Input voltage: 90 to 264 V AC, 50/60 Hz
- (2) Output: 19 V DC, 0 to 3.42 A (65 W)
- (3) IC used: FA5553 (60 kHz operating frequency)

Figure 9 shows the relationship between load current and power supply efficiency for input voltages of 100 V and 264 V AC, and a load current of 1.5 A or less. A high efficiency of at least 80% is reached when the input voltage is 100 V AC and the load current is 80 mA or more and when the input voltage is 264 V AC and the load current is 0.3 A or more. In particular, there is only a small decrease in efficiency in regions where the load current is low. Figure 10 shows the circuit diagram of this power supply.

3.2 Operating frequency characteristics

Figure 11 shows the relationship between load current and operating frequency for input voltages of 100 V and 264 V AC. In the load current range from 0 to 0.9 A, the operating frequency decreases linearly, and the IC's light load frequency decreasing function, shown in Fig. 3, operates in this range. This function enables a high power supply efficiency to be maintained even in the light load region with the power supply efficiency shown in Fig. 9.

3.3 Standby power characteristics

Figure 12 shows the relationship between input voltage and input power (standby power) during unloaded output operation. In the input voltage range of 90 to 240 V AC, the input power is small as 0.1 W. These characteristics are made possible by embedding a startup circuit into the IC, decreasing the operating frequency during light load operation, and decreasing the overload line compensation loss.

As described above, use of the newly developed FA5553 series and the FA5547 series enable higher efficiency due to lower standby power and various types of required protection functions to be realized with a

A line graph showing the relationship between Operating frequency (kHz) on the y-axis and Load current (A) on the x-axis. The y-axis ranges from 0 to 70 kHz with major grid lines every 10 units. The x-axis ranges from 0 to 1.5 A with major grid lines every 0.5 units. Two data series are plotted: one for 264 V AC (represented by solid black circles) and one for 100 V AC (represented by open circles). Both series show a non-linear increase in frequency with load current, eventually reaching a saturation point. The 264 V AC series is consistently higher than the 100 V AC series.

Load current (A)	Operating frequency (kHz) at 264 V AC	Operating frequency (kHz) at 100 V AC
0.0	0	0
0.05	12	8
0.1	14	10
0.15	23	18
0.2	32	25
0.3	40	31
0.4	48	37
0.5	54	44
0.6	59	49
0.7	60	55
0.8	60	59
0.9	60	60
1.0	60	60
1.1	60	60
1.2	60	60
1.3	60	60
1.4	60	60
1.5	60	60

Input voltage (V_{AC})	Input power (W)
90	0.070
100	0.068
110	0.072
120	0.070
130	0.070
140	0.070
150	0.072
160	0.078
170	0.082
180	0.085
190	0.088
200	0.085
210	0.088
220	0.090
230	0.095
240	0.100
250	0.108
260	0.112

4. Postscript

functions to be configured with a small number of components has been described. In this field, requests for lower power consumption are expected to intensify in the future, and Fuji Electric intends to continue to enhance functionality and reduce the number of components to develop easy-to-use products.



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