"FA8C00 Series" 7th-Generation PWM Power Supply Control ICs

MATSUMOTO, Shinji* YAMANE, Hiroki* MIYAGI, Kodai*

ABSTRACT

The recent electronic equipment market has increasingly seen advances in energy. This trend has increased the demand for switching power supplies for electronic equipment with high efficiency in power conversion at light loads, high voltage AC input, and compactness. Fuji Electric has thus developed the "FA8C00 Series" 7th-generation PWM power supply control ICs. Minimum output pulse width is selectable for optimal MOSFET gate drive, improving power conversion efficiency at light loads. The maximum applied voltage at the high voltage AC input terminals has increased from 650 V to 710 V. Furthermore, clamping the IC output voltage eliminates the need for an external regulator circuit, reducing the number of components.

1. Introduction

As measures to address the critical issue of global warming, efforts to reduce greenhouse gas emissions have become extremely important. The growing concern about environmental problems has increased the demand for energy saving also in switching power supplies for electronic equipment. In particular, the expansion of network use and the increase of always-on systems in recent years have created a significant need to improve power conversion efficiency at light loads.

In emerging countries, the proliferation of electronic equipment progresses along with economic developments, meanwhile, voltage fluctuations in commercial power supplies (AC power supplies) are occurring frequently due to delays in infrastructure development. This causes high voltages exceeding the input voltage range of the power supplies, leading to power supply breakdown. On the other hand, the continued demand for lower prices for electronic equipment has also increased the need to reduce the size of power supplies and the number of components.

Fuji Electric has developed the "FA8C00 Series" of 7th-generation PWM power supply control ICs, which can further improve the power conversion efficiency of power supply systems at light loads, support high AC input voltages, and reduce the number of power supply components compared with the conventional product(1).

This paper provides an overview of the FA8C00 Series and describes its features as well as the effects of its application.

2. Product Overview

Figure 1 shows the external appearance of the FA8C00 Series. The FA8C00 Series use the same SOP-8, a compact package with 8 pins, as the conventional product did. This IC has a new function that allows external components to select the optimum minimum output pulse width for gate drive of metal-oxide-semiconductor field-effect transistors (MOSFETs) to improve power conversion efficiency at light loads.

The maximum applied voltage of the input ter-

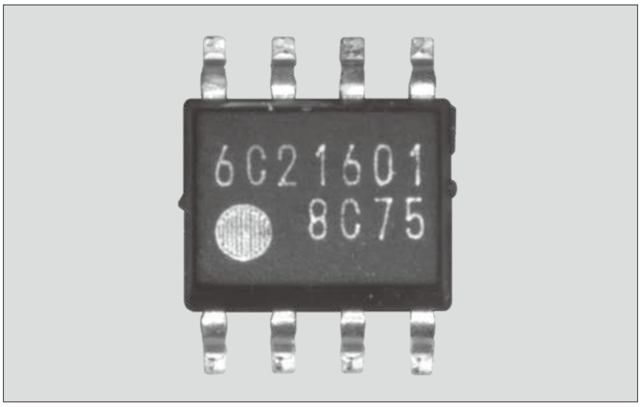

Fig.1 "FA8C00 Series" external appearance

Table 1 "FA8C00 Series" function overview

Item	Conventional products	FA8C00 Series
Minimum output pulse width selection function	Not provided	Available
Maximum applied voltage of the high AC input voltage terminal	650 V	710 V
IC output voltage clamp function	Not provided	Available (16 V)
External regulator	Required	Not required (8 components reducible)

* Semiconductors Business Group, Fuji Electric Co., Ltd.

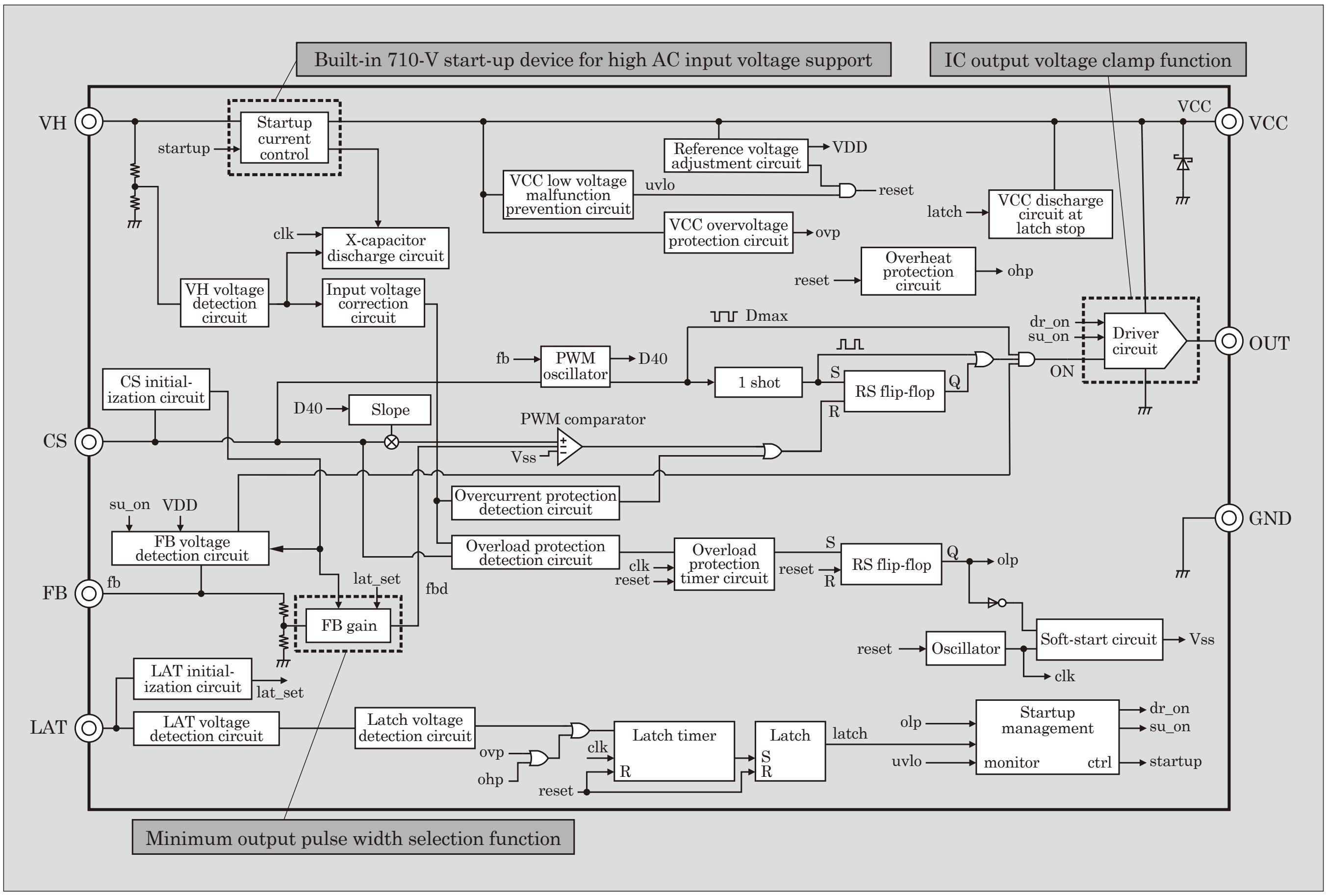

Fig.2 “FA8C00 Series” block diagram

minal connected to the AC power supply has also increased from 650 V to 710 V to prevent breakdowns caused by the application of high voltage from the AC power supply. Furthermore, to reduce the number of power supply components for this series, it uses an IC output voltage clamp function that prevents gate overvoltage breakdown of the MOSFET, eliminating the need for a conventional external regulator circuit.

Table 1 is an overview of the functions of the FA8C00 Series. Figure 2 shows a block diagram of the FA8C00 Series. The FA8C00 Series has an FB gain circuit to selects the minimum output pulse width, a startup current control circuit to support high AC input voltage with a built-in 710-V start-up device, and a driver circuit to clamp IC output voltage.

3. Features

3.1 Improved efficiency at light loads

To improve power conversion efficiency, as shown in Fig. 3, the conventional product performed a burst operation that continuously repeats the starting and stopping of switching operation to reduce switching loss. Figure 4 shows the relationship between the output pulse width of the OUT terminal and the voltages of the CS and FB terminals. The output pulse width of the OUT terminal for driving MOSFETs during

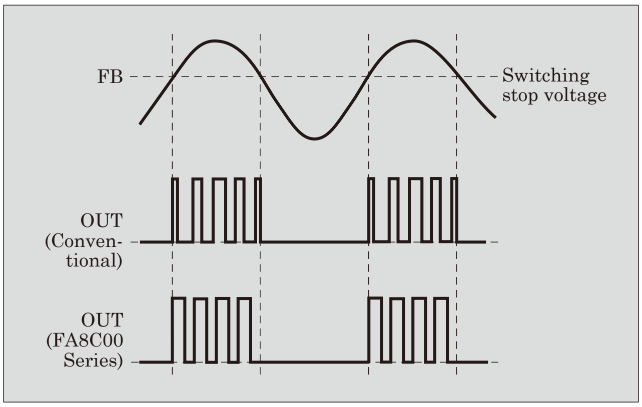

Fig.3 Burst operation

continuous switching operation is determined by the comparison result of the current sense input (CS) terminal voltage V_{cs} and the voltage V_{fbd} obtained from the feedback control signal input (FB) terminal voltage divided inside the IC. However, narrow-width pulses generated due to the low voltages at the FB terminal when the switching operation starts and stops. This reduces the amount of power sent to the output side of the power supply in a single switching operation. As a result, the number of switching operations increases to compensate for the power shortage and, in turn, expands the switching loss, thus lowering the power

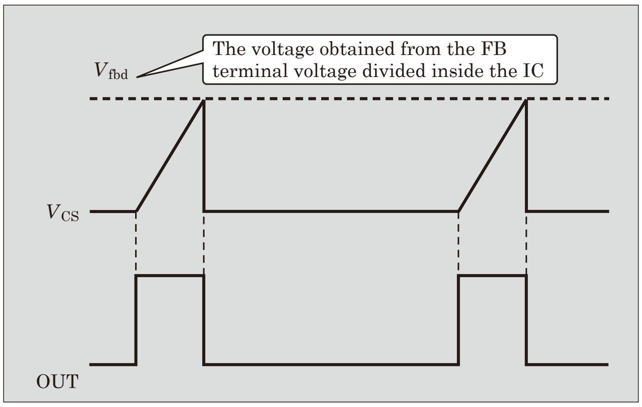

Fig.4 Relationship between the output pulse width of the OUT terminal and the voltages of the CS and FB terminals

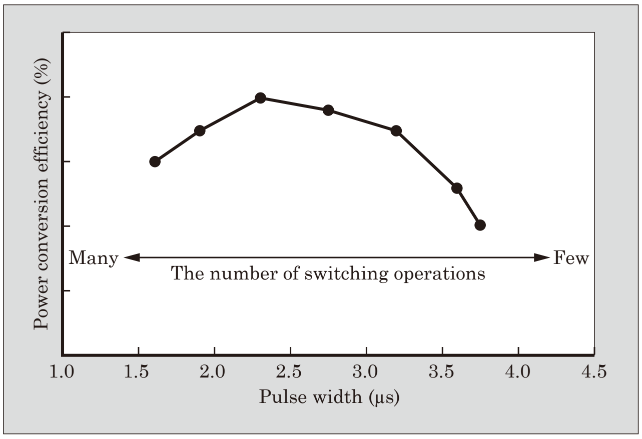

Fig.5 Power conversion efficiency variation with output pulse width

conversion efficiency at light loads. On the other hand, as shown in Fig. 5, too wide-width pulses can reduce power conversion efficiency even if the number of switching operations is small, depending on the power supply, because the conduction loss of MOSFETs and diodes increase.

Consequently, optimizing the output pulse width is effective in improving the power conversion efficiency at light loads. For this reason, the FA8C00 Series has an additional function that allows an external component to set the minimum output pulse width according to the power supply. Figure 6 shows how the minimum pulse width is configured using an external component. The specific setting method is to connect a capacitor to the external latch signal input terminal (LAT terminal) and select the V_{fbd} voltage inside the IC, which determines the minimum output pulse width, by selecting the capacitance value of the capacitor C1 from one of the three capacities. As an example, assuming that R1 = 90 kΩ and C1 = 1,000 pF are connected, this function selects High to adjust the minimum output pulse width to be widest. This function enables the optimum minimum output pulse width to be set for each power supply, thereby improving the power conversion efficiency at light loads.

	High	Middle	Low
V_{fbd}	V_{fbd_h}	V_{fbd_m}	V_{fbd_l}
R1 ≤ 90 kΩ	C1 = 1,000 pF	C1 = 4,700 pF	C1 = 15,000 pF
R1 ≥ 200 kΩ	C1 = 1,800 pF	C1 = 3,300 pF	C1 = 6,800 pF

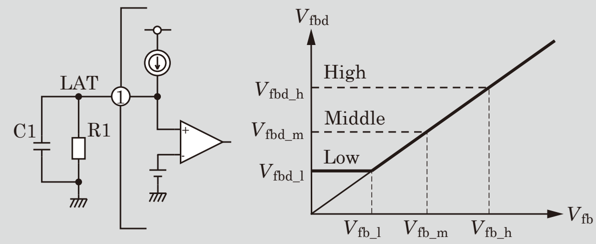

Fig.6 Selection of the minimum pulse width by an external component

3.2 Increase in maximum allowable applied voltage for AC input

The internal circuit of the high AC input voltage terminal (VH terminal), which is connected to commercial power supplies (AC power supplies) and are required to have low power consumption, has a built-in junction field-effect transistor (JFET) as a start-up device. When starting up, the IC supplies a starting current (current for charging the VCC terminal at startup) from the VH terminal to the VCC terminal, which is the power supply of the IC, and stop the current when the VCC terminal voltage exceeds a certain voltage using the starting current control circuit. If more than the rated voltage of 650 V is applied to this start-up device, breakdown may occur.

The FA8C00 Series thus uses a start-up device modified to increase the maximum voltage applied to the VH terminal to 710 V to prevent breakdown under voltage fluctuations of commercial power supplies (AC power supplies).

3.3 Built-in output voltage clamp function

The FA8C00 Series has a built-in function to clamp the IC output voltage to prevent gate overvoltage breakdown of external MOSFETs. Figure 7 shows an external circuit configuration of the OUT terminal and an IC output voltage clamp circuit, and Fig. 8 shows IC output voltage clamp operations. For the existing FA8A80 Series, the VCC terminal voltage supplied from the auxiliary winding of the power supply can exceed a VCC terminal voltage of 30 V depending on the configuration of the power supply, and the MOSFET gate drive voltage output from the IC may also exceed 30 V. The typical rated voltage of a MOSFET gate is 20 to 30 V, and to prevent MOSFET breakdown, an external regulator circuit was previously required to ensure that the VCC terminal voltage is 20 V or less.

The new FA8C00 Series incorporates a function to clamp the IC output voltage inside the IC to keep

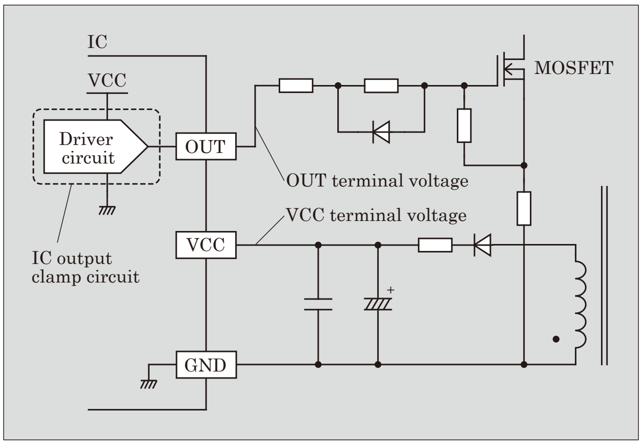

Fig.7 External circuit configuration of the OUT terminal and IC output voltage clamp circuit

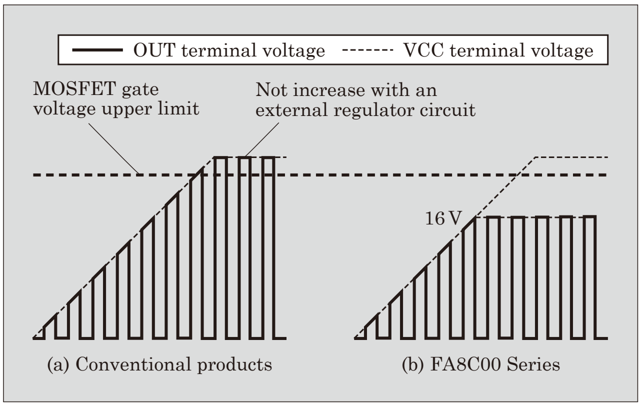

Fig.8 IC output voltage clamp operations

the gate voltage output from the IC to 16 V even if the VCC terminal voltage exceeds 30 V. This function eliminates the need for an external regulator circuit, thus reducing the number of power supply components.

4. Effects of Application to Power Circuits

4.1 Improved power conversion efficiency

Table 2 shows a comparison of power conversion efficiency with conventional product's, and Fig. 9 shows the measurement results of power conversion efficiency. In addition, Fig. 10 shows the circuit diagram of the FA8C00 Series power supply board for evaluation use, which was used for the measurement.

Table 2 Comparison of power conversion efficiency with conventional products

Products		Conventional products		FA8C00 Series	
Input voltage		115 V AC	230 V AC	115 V AC	230 V AC
Light load area power conversion efficiency	Output current 0.01 A	81.9%	78.2%	82.5%	79.7%
	Output current 0.02 A	85.7%	83.3%	86.6%	84.1%
	Output current 0.05 A	88.0%	86.8%	88.7%	87.2%
	Output current 0.1 A	89.0%	87.9%	89.5%	88.3%

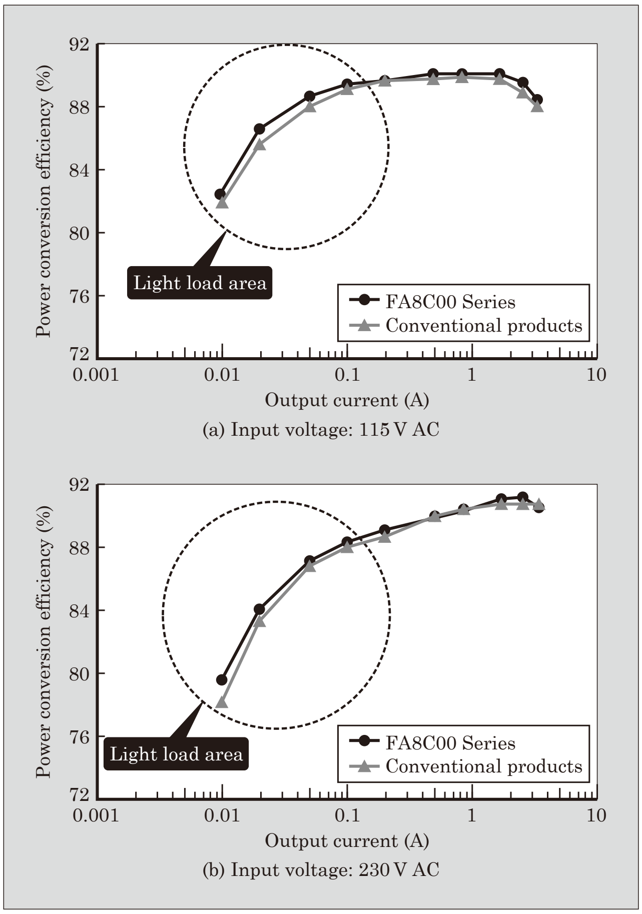

Fig.9 Power conversion efficiency measurement results

The results shows that the FA8C00 Series is more capable of improving the power conversion efficiency of light load ranges with a burst operation output current of 0.1 A or less than the conventional product. For instance, the efficiency has improved by +1.5% when the input voltage is 230 V AC and the output current is 0.01 A.

4.2 Reduction in the number of power circuit components

Figure 11 shows examples of the power supply circuits around the VCC terminal of the FA8C00 Series and the conventional product. Since the FA8C00 Series has a built-in clamp circuit in the IC as described above, even when the VCC terminal voltage is higher than the gate voltage of the MOSFET, it keeps the IC output voltage below the gate voltage of the MOSFET. This improvement eliminates the need for an external regulator circuit, which can reduce eight power supply components, contributing to a reduction in size of the power supply.

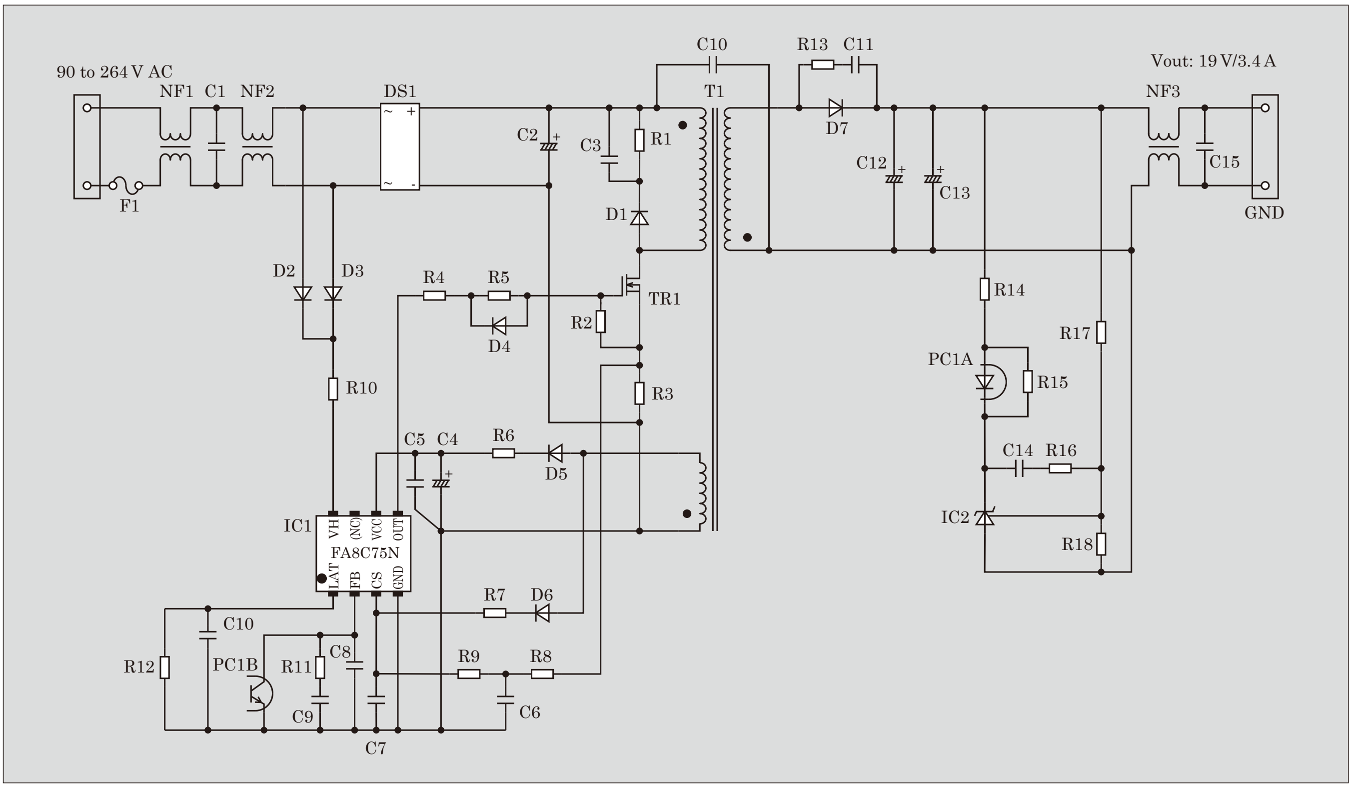

Fig.10 Circuit diagram of the power supply board for “FA8C00 Series” evaluation use (19 V/3.4 A, 65 W)

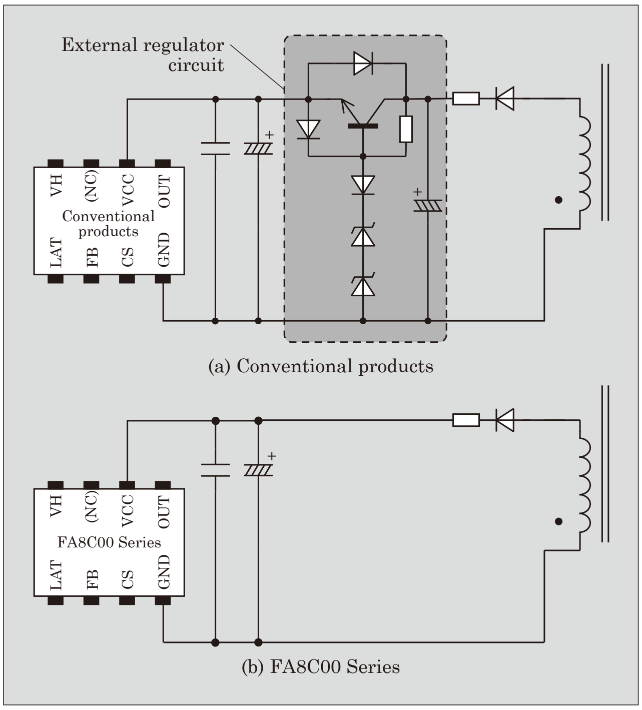

Fig 11 Examples of the power supply circuit around the VCC terminal of the “FA8C00 Series” and conventional products

5. Postscript

In this paper, we described the “FA8C00 Series” of 7th-generation PWM power supply control ICs. Current mode PWM power control ICs are required to have a variety of built-in functions to achieve a variety of power specifications.

Moving forward, Fuji Electric will continue to provide products that meet market needs of improving the power conversion efficiency at light loads and facilitating the reduction in the number of components to create compact power supplies.

References

(1) Hiasa, N. et al. “FA8A80 Series” 650-V PWM Power Supply Control ICs. FUJI ELECTRIC REVIEW. 2017, vol.63, no.4, p.237-241.