“FA8A80 Series” 650-V PWM Power Supply Control ICs

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ABSTRACT

Switching power supplies for electronic devices, which are increasingly being required to save energy and reduce the number of parts usage, need to achieve high efficiency, low standby power, and reduction in the number of parts. Fuji Electric has developed the “FA8A80 Series” 650-V PWM power supply control ICs, which allows power supplies to achieve compact size and improve safety, as well as high efficiency and low stand-by power, which are inherited from the “FA8A60 Series.” The maximum applied voltage for the high-voltage input terminals has increased to 650 V from the previous withstand voltage of 500 V. Furthermore, the series has also achieved greater surge resistance. Their protection functions have the same characteristics as conventional products, facilitating to use existing design resources to promote labor savings in power supply design.

1. Introduction

In order to prevent global warming, which is posing a serious problem, there is an increasing need to save on the energy used by electronic devices themselves and reduce the parts and materials used for them. Accordingly, switching power supplies, which function as power converters of electronic devices, need to offer higher efficiency and lower standby power and have fewer parts. In developing countries, electronic devices are becoming widespread as their economies develop. Meanwhile, slow infrastructure development has caused frequent instantaneous power failures and voltage fluctuations of commercial power supplies (AC power supplies). During recovery from an instantaneous power failure, in particular, excessively high voltage generated in the AC power supply poses problems. These include damage to the power supply due to the AC power voltage exceeding the input voltage range of the power supply or high surge voltage applied. Accordingly, power supplies increasingly need to support high input voltage and ensure safety and reliability such as by having a high surge resistance.

In order to meet the needs of the switching power supply market described earlier, Fuji Electric has commercialized the “FA8A60 Series.” The series are current mode pulse width modulation (PWM) ICs in a small package (SOP-8). The products offer high efficiency and are equipped with a low stand-by power function. They are intended for controlling switching power supplies.

We have now developed the “FA8A80 Series” 650-V PWM power supply control ICs. They inherit the features of the “FA8A60 Series” and allow power supplies to come in a compact size and have improved safety.

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2. Overview of “FA8A80 Series”

Figure 1 shows the external appearance of the FA8A80 Series. The FA8A80 Series is based on the

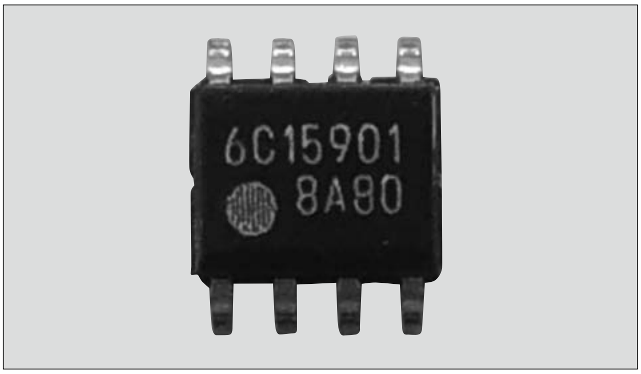

Fig.1 “FA8A80 Series” 650-V PWM power supply control IC

Table 1 Function overview of “FA8A80 Series”

Item	FA8A80 Series	Conventional product
Start-up device	Integrated	
Maximum applied voltage for high-voltage input terminal	650 V	500 V
ESD resistance of high-voltage input terminal (HBM)	±2 kV	+1 kV/ -2 kV
Maximum sink current of LAT terminal	500 μA	100 μA
External latch function	Integrated	
Function to reduce switching frequency	Integrated	
Function to set frequency reduction state	Integrated	
Function to adjust burst operation	Integrated	
Function to correct overload protection level for AC input voltage	Integrated	
Power-off mode	Integrated	
Standby power (with no load)	30 mW or less	

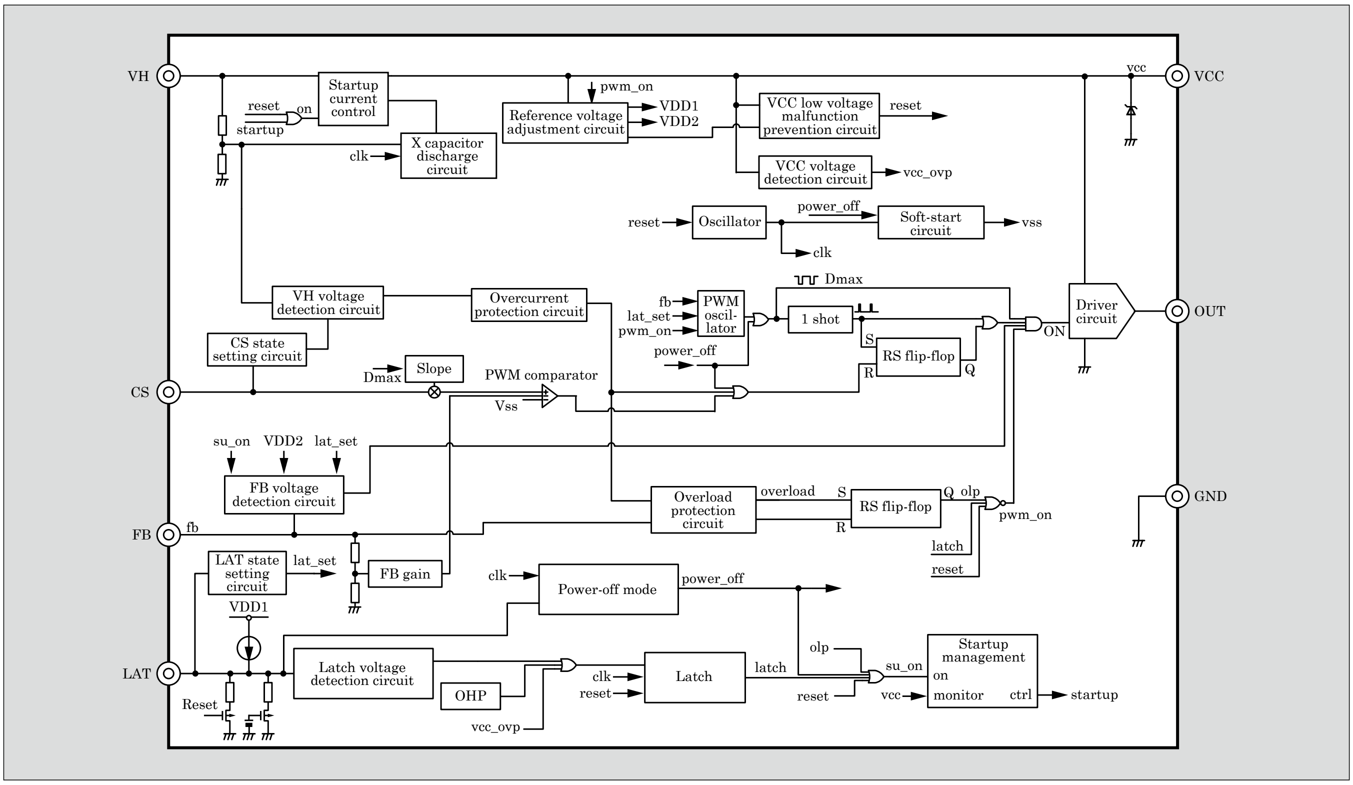

Fig.2 “FA8A80 Series” block diagram (FA8A90N)

conventional FA8A60 Series. It has increased the maximum applied voltage for the high-voltage input terminals connected to the AC power supply to 650 V from the previous 500 V. Further, it has been given greater surge resistance by improving the electrostatic discharge (ESD) resistance of the VH terminal to 2 kV.

In addition, the sink current characteristic of the fault detection signal input (LAT) terminal for stopping power supply in the event of an abnormality has been improved. This improvement eliminates the use of a Zener diode (ZD) that has to be added depending on the protection specifications of a power supply to protect the IC.

Furthermore, we have employed the same basic functions, characteristics and terminal layout as those of conventional products. This makes it possible to utilize the existing power supply design resources, leading to reduced design periods. Table 1 shows an overview of the features of the FA8A80 Series, and Fig. 2, a block diagram.

3. Features of “FA8A80 Series”

3.1 Support for high-voltage input by providing 650 V start-up device

Figure 3 shows a schematic diagram of the VH terminal and internal circuit. The VH terminal connected to the AC power supply unit has a function of supplying current when the VCC terminal voltage is low and stopping the current supply at a certain voltage or higher.

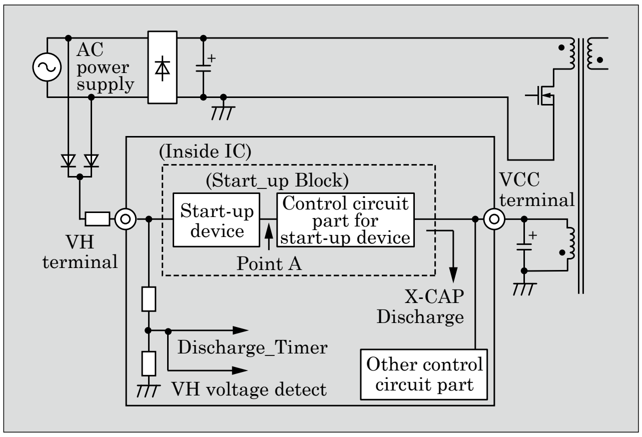

Fig.3 Schematic diagram of VH terminal and internal circuit

As shown in Fig. 4, the output voltage of the start-up device (at Point A in Fig. 3) depends on the VH terminal voltage. For that reason, with a conventional start-up device, increasing the applied voltage causes the voltage at Point A in Fig. 3 to exceed the allowable applied voltage of the start-up device control circuit to which the current is input.

Accordingly, we have improved the dependence of the start-up device on the VH voltage with the FA8A80 Series. We have achieved a characteristic in which the rated voltage of the start-up device control circuit is not exceeded even if the maximum applied voltage to the VH terminal is increased. This has permitted a high-voltage input of 650 V.

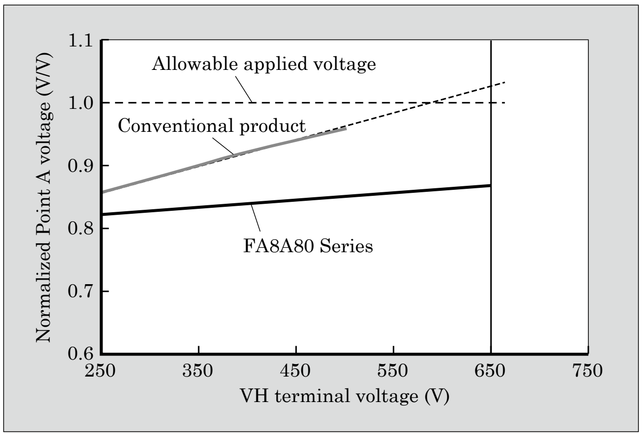

Fig.4 Relationship between VH terminal voltage and internal voltage

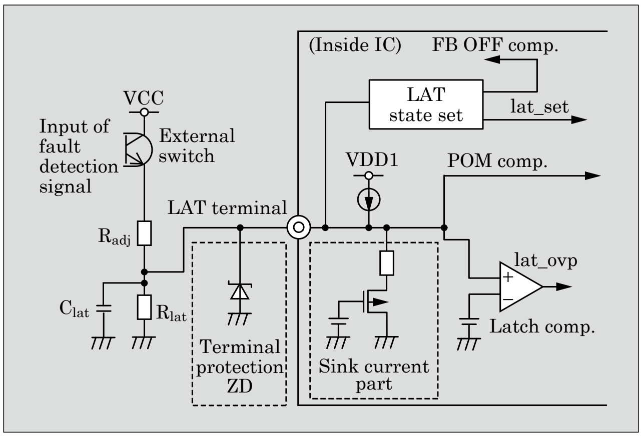

Fig.6 External circuit configuration of LAT terminal

3.2 Improved ESD withstand voltage

The human body model (HBM) ESD withstand voltage on the VH terminal of conventional products was +1 kV. With the FA8A80 Series, the breakdown resistance as well as the maximum applied voltage to the VH terminal has been increased. This has led to a guarantee voltage of ±2 kV with the HBM for all IC terminals.

3.3 Support for various power supplies by frequency reduction and burst operation

To realize high efficiency and low standby power as with conventional products, the FA8A80 Series integrates a function for improving efficiency during light- and no-load operation. This is achieved by reducing the switching frequency during light-load operation and having burst operation (intermittent operation) during no-load operation. In addition, 3 switching frequency reduction characteristics as shown in Fig. 5 are provided in order to support power supplies of various specifications. The LAT terminal is equipped with a function to set the frequency reduction state by selecting one of the 3 characteristics and a burst operation adjustment function.

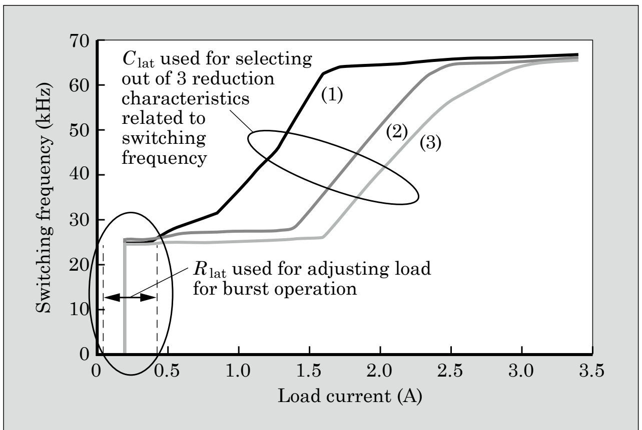

Fig.5 Change of frequency by using function to set frequency reduction state and function to adjust burst operation

Figure 6 shows an external circuit configuration of the LAT terminal. The function to set the frequency reduction state can select one of the 3 reduction characteristics by setting the capacity C_{lat} connected between the LAT terminal and GND to a specific value. For a power supply specification in the normal operating conditions with a high load, the characteristic (1) in Fig. 5 is selected. As light-load operation increases, characteristic (2) or (3) in Fig. 5 with a wider load current range for operation at a low frequency is selected to save energy.

The burst operation adjustment function is intended to adjust the load current for burst operation. It does this by setting FB OFF, the threshold voltage for stopping switching output of the FB terminal. The FB OFF voltage is determined by the value of the resistor R_{lat} connected between the LAT terminal and GND shown in Fig. 6 and the constant-current output value of the LAT terminal to set the load current value for burst operation.

By appropriately setting the load current during burst operation, the power supply specifications of the standby power and output voltage ripple can be satisfied without generating any sound. This is very important in designing power supplies. An excessively large set value for the load current for burst operation may cause the power supply output voltage ripple to exceed the specification while the standby power is decreased, or it may cause the burst frequency to increase to an audible range and generate unwanted sound. Meanwhile, an excessively small set value may cause the standby power to exceed the specification. Accordingly, the setting can be adjusted to an optimum value by, for example, selecting a small R_{lat} value that corresponds to the upper limit of the standby power specification and increasing the R_{lat} value within a range that does not cause unwanted sound.

3.4 Size reduction of power supply by improving characteristics of external latch function

The external latch function stops switching operation (to enter a latch state) by bringing the LAT terminal voltage to 2.0 V (max.) or higher, which is the external latch function threshold, using the fault detection signal generated within the power supply in the event of device fault. In this way, it ensures the power supply is safe.

For designing a power supply, the adjustment resistor R_{adj} shown in Fig. 6 is used to set the external circuit constant that achieves both the time between fault detection and protective stop of the power supply specification and the LAT terminal rating of the IC specification.

The VCC terminal, which is a power supply to the external circuit, is generally connected to the auxiliary winding of the transformer as shown in Fig. 3. The voltage may vary by about 20 V (ratio of the maximum voltage to the minimum voltage: approximately 3 times) depending on the size of the load current of the power supply. Accordingly, with an inappropriate R_{adj} value, the time taken before latch protective stop may increase when the VCC terminal voltage is low. This will result in a failure to satisfy the power supply specification, and the LAT terminal voltage after the protective stop may increase to higher than the rated voltage when the VCC terminal voltage is high. This will result in a failure to satisfy the IC specification. In cases like this, an R_{adj} value satisfying the power supply specification must be selected and a ZD for LAT terminal protection must be added between the LAT terminal and GND. This required expensive external components and board space.

To deal with this issue, the FA8A80 Series has increased the maximum current and improved the current-voltage characteristic of the sink current part of the LAT terminal shown in Fig. 6. The maximum value for the sink current valid at a voltage equal to or higher than the latch protection threshold has been increased from 100 µA to 500 µA. This has expanded the selection range available for the adjustment resistor value R_{adj} to include a resistance value one-fifth that of conventional products.

In addition, we have expanded the terminal voltage range generating a sink current by improving the current-voltage characteristic. Together with the increase in the maximum current value described above, this allows a pickup current larger than that of conventional products to be set while ensuring a margin with reference to the rated voltage of the terminal even with a greatly varying VCC terminal voltage (see Fig. 7).

These characteristic improvements can do away with the need for ZD for terminal protection, leading to size and cost reduction for power supplies.

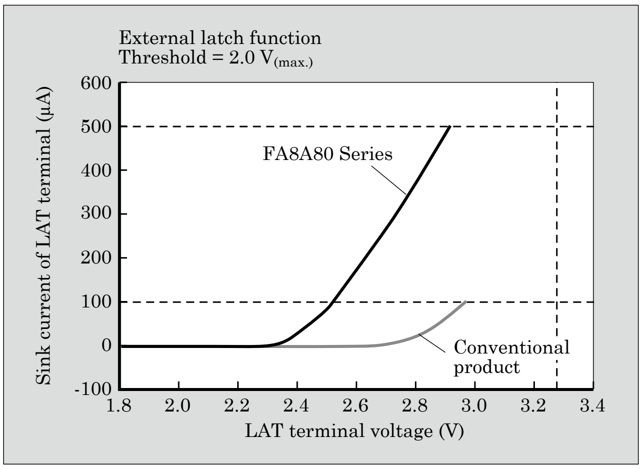

Fig.7 *I*-*V* characteristic of LAT terminal

4. Effect of Application to Power Supplies

4.1 Labor saving in power supply design

As characteristics of the start-up device and LAT

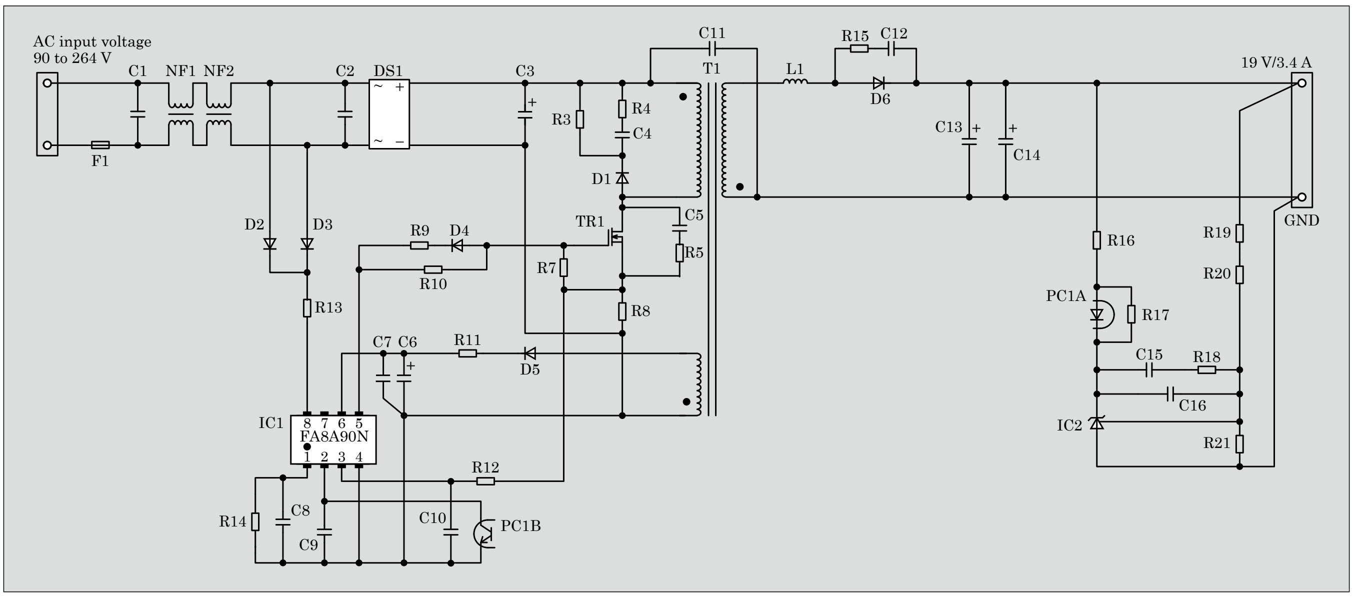

Fig.8 Circuit diagram of “FA8A80 Series” evaluation-use power supply board (19 V/3.4 A, 65 W)

terminal have been changed, we have revised the entire IC chip of conventional products. Meanwhile, we have employed the same terminal layout so that the device can be replaced with conventional products. We have designed the circuit and chip so that characteristics other than those changed are not affected.

We have used the evaluation-use power supply board as shown in Fig. 8 for comparative evaluation. We have confirmed there is a power supply performance equivalent to that of conventional products with the maximum efficiency at approximately 89% as shown in Fig. 9. We have also confirmed that the average efficiency among 4 load factors is 86% or higher with reference to the rated output current as shown in Table 2. The standby power during no-load operation shown in Fig. 10 is less than 30 mW. This characteristic has been confirmed to be equivalent to that of conventional products.

Based on these, it is simple to replace the device with conventional products and the labor for power supply design can be saved by utilizing the existing power supply design resources.

Figure 11 shows the line-up of the FA8A80 Series.

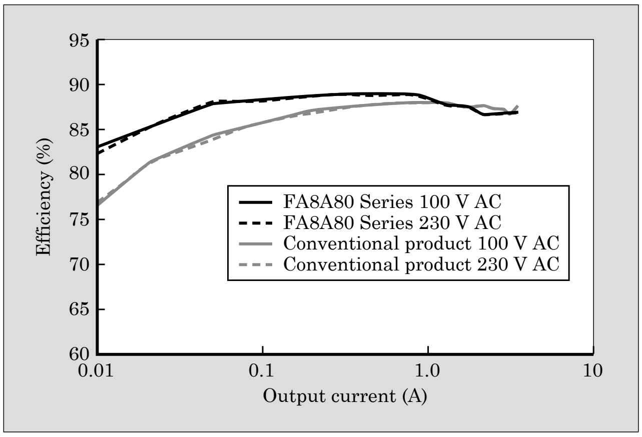

Fig.9 Power conversion efficiency

Table 2 Average efficiency of “FA8A80 Series”

Input voltage		100 V AC	230 V AC
Average efficiency (%)		87.50	87.51
Efficiency by load factor (%)	25%	88.76	88.01
	50%	87.59	87.44
	75%	86.69	86.97
	100%	86.95	87.63

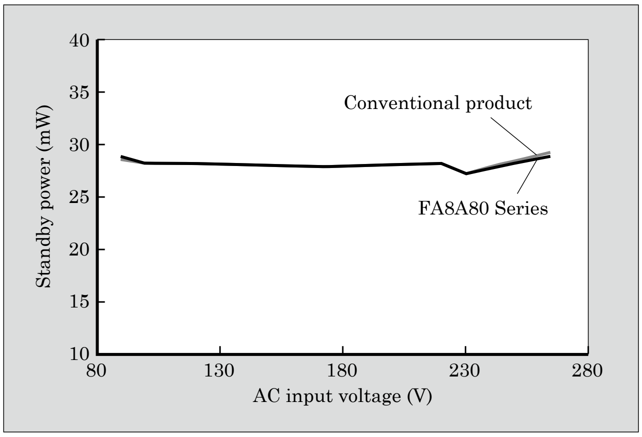

Fig.10 Standby power during no-load operation

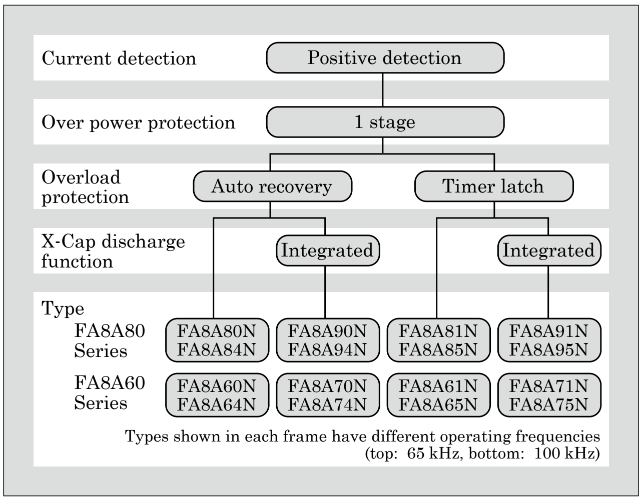

Fig.11 Product line-up of “FA8A80 Series”

Compatibility with conventional products is maintained by providing the same combinations of functions and operating frequencies.

5. Postscript

This paper has described the “FA8A80 Series” 650-V PWM power supply control IC. Current mode PWM control ICs increasingly need to have a greater input voltage range and improved safety while needing to integrate many functions for supporting various power supply specifications. In the future, we intend to continue to offer products that meet market needs.

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