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INTEGRATED CIRCUIT FOR SWITCHING POWER SUPPLY CONTROLLER

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1. FOREWORD

Since switching regulators can produce any output voltages by step-down and step-up or inverting modes, besides their special features of small size, light weight, and high efficiency, they are widely used. Since many consumer portable equipment which have become increasingly popular recently have a power supply having multi-outputs using a battery, the switching power supply (DC-DC converter) has become indispensable. In this case, reduction of the operating voltage, lower power consumption, reduction of the number of external components, etc. is strongly demanded of the power supply control IC and meeting these demands with existing control IC was difficult.

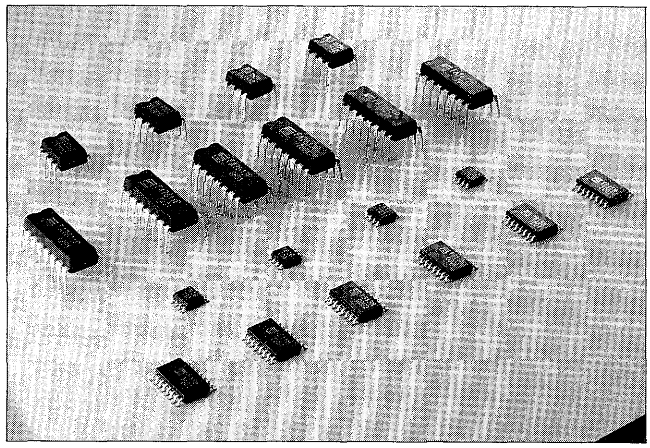
Fuji Electric has serialized the low power DC-DC converter control IC to meet this demand. These ICs are introduced here.

2. PRODUCT SERIES

Table 1 shows the devices serialized this time. The minimum operating voltage is 3.6V (4 types) and 2.5V (1 type). In the case of a dry cell, when the voltage drop by discharge is considered, the former corresponds to use of four to six cells and the latter corresponds to use of about three cells. Consideration is given to all type so that the number of external components is minimum. This has a large affect on reduction of the mounting area.

All types are available in a dual-in line package (DIP) and surface mount technology small outline package (SOP). Exterior views of the ICs are shown in *Fig. 1*.

Fig. 1 Exterior view of IC for DC-DC converter control



3. INTERNAL CIRCUIT

The five types of IC developed this time use a pulse width modulation (PWM) system which performs voltage adjustment by fixing the switching frequency and changing the on-duty cycle of the output transistor. The internal circuit configuration of this series is described below.

Table 1 IC products for DC-DC converter control

IC type	Power supply voltage range	Number of control outputs	Output configuration	Package	Applicable circuit
FA7610P/N	3.6 ~ 22V	1 channel	Totem pole	DIP-8 SOP-8	Flyback circuit, step-up circuit, inverting circuit
FA7611P/M	3.6 ~ 22V	2 channel	Totem pole Open collector	DIP-16 SOP-16	Flyback circuit, step-up circuit, step-down circuit, inverting circuit
FA7612P/N	3.6 ~ 22V	1 channel	Open collector	DIP-8 SOP-8	Step-down circuit
FA7613P/N	2.5 ~ 22V	1 channel	Open collector	DIP-16 SOP-16	Flyback circuit, step-up circuit, step-down circuit, inverting circuit
FA7615P/M	3.6 ~ 22V	2 channel	Totem pole Totem pole	DIP-16 SOP-16	Flyback circuit, step-up circuit, step-down circuit, inverting circuit

3.1 1 channel control IC

The FA7610P/N is a 1 channel control IC. Its functions and circuit configuration are basis of this series. Its internal block diagram is shown in *Fig. 2*. This IC consists of a reference voltage circuit, error amplifier, oscillator, PWM comparator, internal short circuit protector, output circuit, and undervoltage lockout circuit (inhibits output for low VCC). The following items were considered to reduce the number of external parts and the number of IC leads.

(1) The reference voltage is given internally to the non-inverting input of the error amplifier and only an inverting input terminal is provided.

(2) The soft-start terminal and short circuit protection terminal which were provided separately in the past were made common by dividing the usage voltage range of each. (CS terminal, see *Fig. 3*) As a result, the large capacitor necessary at each terminal in the past was reduced to one. Erroneous operation of latch-mode short circuit protector caused by external noise was a problem in the past, but with this IC, the noise resistance is raised substantially by modifying the circuit configuration.

(3) The output pre-driver and current limiting resistor were built into the IC.

As a result, a control IC with 8-lead package having a higher performance than existing products was obtained.

The maximum on-duty cycle of the FA7610P/N is set to 64% (TYP) internally. The type made step-down circuit dedicated by widening this up to 100% and making the output section an open collector output is the FA7612P/N.

Fig. 2 FA7610P/N block diagram

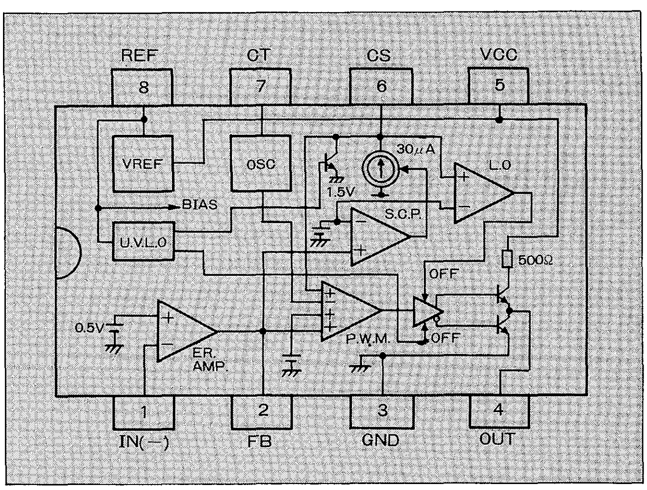
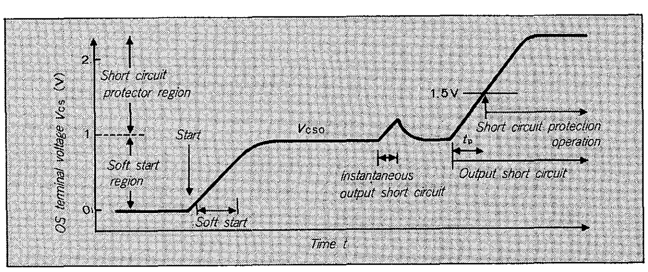


Fig. 3 CS terminal operating waveform



The FA7613P/N features a 2.5V minimum operating voltage and an ON/OFF control terminal which can turn the power supply output on and off. When the power supply output is turned off by the ON/OFF control terminal, its stand-by current is less than 10μA and the power consumption is almost zero.

3.2 2 channel control IC

Fig. 4 is an internal block diagram of the FA7611P/M 2 channel control IC. The oscillator is shared by both channels. Since switching operation is performed at the same frequency at parallel operation, the interference between channels is small. A terminal which gives a reference to the non-inverting input is provided at the CH. 1 side error amp. This terminal can also be used as the reference voltage of the CH. 2 side error amp. Both non-inverting input and inverting input terminals are provided at the CH. 2 side, negative output voltages can also be handled. DC-DC converters of various combinations can be formed. At the output section, the CH. 1 side is the totem pole type and the CH. 2 side is the open collector type. Therefore, the CH. 1 side can connect directly to an NPN type switching transistor and the CH. 2 side can connect directly to a PNP type switching transistor.

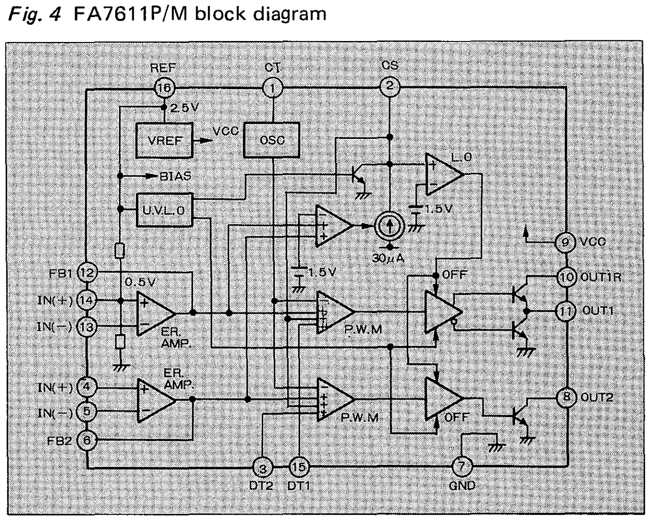
The FA7615P/M is also for 2 channel control, a terminal for external synchronization is provided at the oscillator to synchronize to another external circuit having a different oeprating frequency (other switching regulator or video curcuit in a TV set, etc.), so that abnormal operation and noise interference, etc. by interference between these circuits can be prevented.

4. APPLICATIONS

4.1 DC-DC converter circuit

The four circuit systems generally used as low power DC-DC converters are described below.

Fig. 4 FA7611P/M block diagram



(1) Step-down circuit

This circuit converts the input voltage to a lower voltage. Its configuration is shown in *Fig. 5(a)*. The PNP type switching transistor is often used to make the ON saturation voltage low. As the on-duty cycle becomes larger, the output voltage approaches the input voltage and use at a 100% on-duty cycle is possible.

(2) Step-up circuit

This circuit is used to obtain a voltage higher than the input voltage. Its configuration is shown in *Fig. 5(b)*. When the on-duty cycle is 0%, the input and output voltages become almost equal. As the on-duty cycle becomes larger the step-up ratio becomes larger. When the step-up ratio exceeds a certain value, the output voltage drops abruptly as shown in *Fig. 6*. This is because the output impedance of the circuit rises rapidly as the on-duty cycle increases and is load-dependent. In the region at which the output decreases, the power supply control circuit falls into the positive feedback state and goes out of control. Moreover, since a large current flows in the switching transistor and the transistor may be destroyed, it is important that the maximum on-duty cycle should be set (dead-time adjustment) so that there is no flow-in at this region under all conditions. This also applies to the two circuit systems described below.

(3) Inverting circuit

This circuit provides a voltage of a polarity opposite that of the input voltage. Its configuration is shown in *Fig. 5(c)*. This circuit often uses a PNP transistor also to reduce the saturation voltage. An arbitrary output voltage can be taken according to the on-duty cycle. An on-duty cycle near 100% such as described in item (2) is prohibited.

(4) Flyback circuit

An arbitrary voltage relative to the input voltage can be obtained with this circuit, which uses a transformer. Since multiple outputs can be easily obtained, it has a wide range of applications. Its configuration is shown in *Fig. 5(d)*. In multi-output power supply applications, the following item should be considered. Only one output of some winding is stabilized directly by feedback control so the line and load regulation of the other outputs are relatively inferior. Setting of the maximum duty cycle is important with this circuit also.

Fig. 5 Basic configurations of DC-DC converter

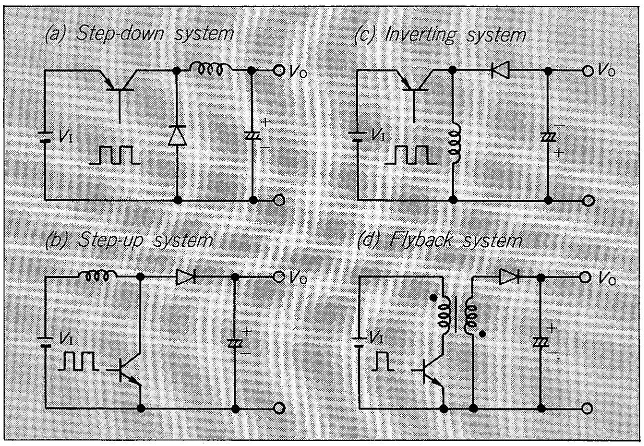
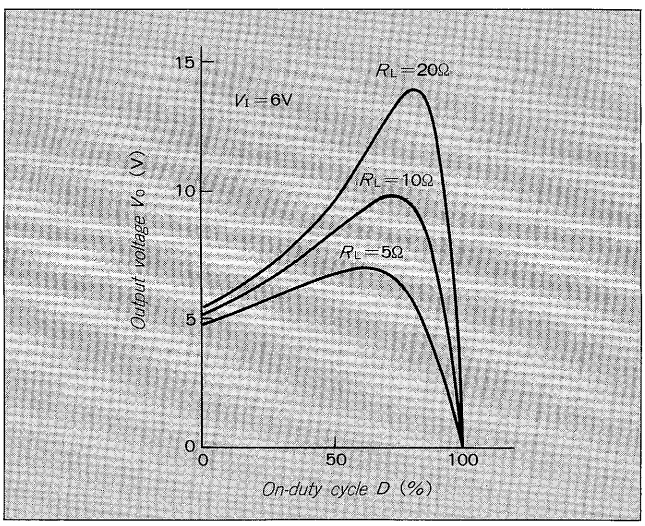


Fig. 6 Normal step-up system on-duty cycle vs output voltage characteristic



4.2 Application circuit examples

Various DC-DC converter circuit can be built with a small number of external components by using this series. Typical examples are described below.

Fig. 7 shows typical application of the FA7610P/N, a multi-output flyback circuit. At starting, the stress on the switching transistor can be restrained because the output voltage is raised gradually by a soft-start function, then the rush current is suppressed. When an output circuit shorts to ground, this control IC cuts off and protects the switching transistor by detecting failure of the output voltage.

Fig. 8 shows a typical application circuit of the FA7611P/M that can control two outputs of a power supply independently. Channel 1 controls the flyback circuit and channel 2 controls the step-down circuit. This

Fig. 7 FA7610P/N application circuit example

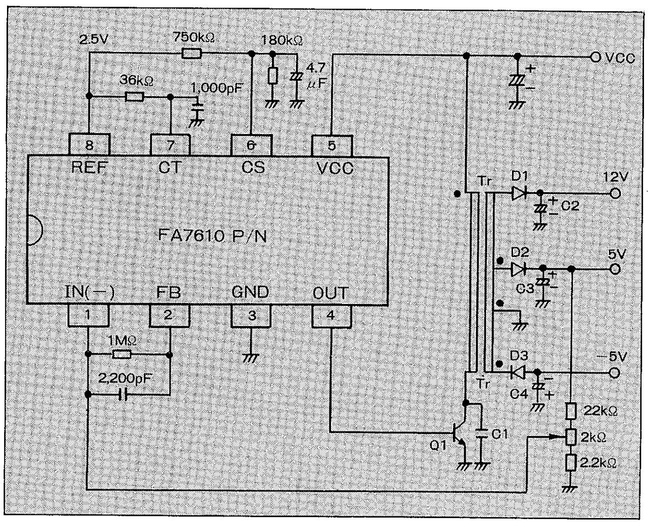
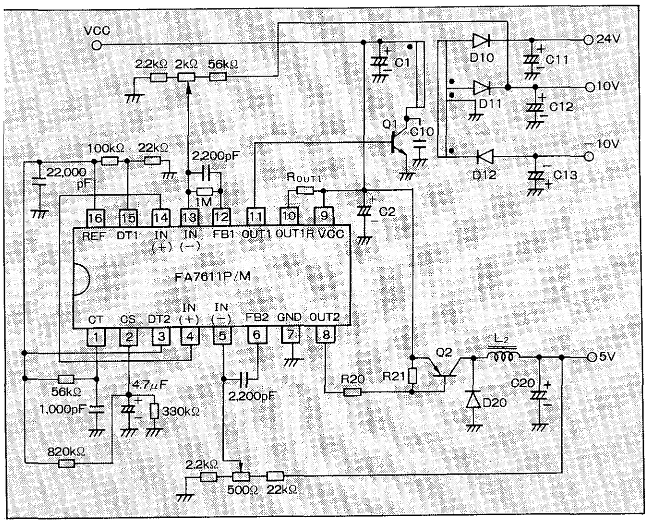


Fig. 8 FA7611P/M application circuit example



circuit also has soft-start and output short circuit protection functions. The source current of OUT1 (pin 11 can be adjusted by R_{OUT1} so that the optimum switching transistor base current is set for the output power.

We hope that many customers will chose the best control IC from this series. There are many other applications besides the examples described here.

5. CONCLUSION

Five types of control IC newly developed for low power DC-DC converters were described in this paper. High cost-performance DC-DC converts can be realized by using this series.

Lower voltage operation and lower power is expected for portable equipment power supplies in the future. Fuji Electric plans to continue to develop special products matched to these market needs.