Control ICs for DC-DC Converters

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1. Introduction

In recent years electronic home and office equipment has been made smaller in size and lighter in weight. As a result, the mass production of portable equipment has increased dramatically.

A switching mode power supply is widely used in these systems. This type of power supply helps to achieve smaller size and higher efficiency over many input/output voltage conditions.

To increase battery lifespan, it is important that the DC-DC converter, a switching mode power supply with DC input, is highly efficient.

Fuji Electric has many control integrated circuits (ICs) for DC-DC converters. This paper introduces the "FA76 series" ICs with applications for driving MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) and an ON/OFF function necessary for improved efficiency.

2. IC Applications

2.1 FA7610P/N application circuit

An example of n-channel MOSFET driving is shown in the flyback circuit of Fig. 1. The switching operation of the MOSFET is as follows.

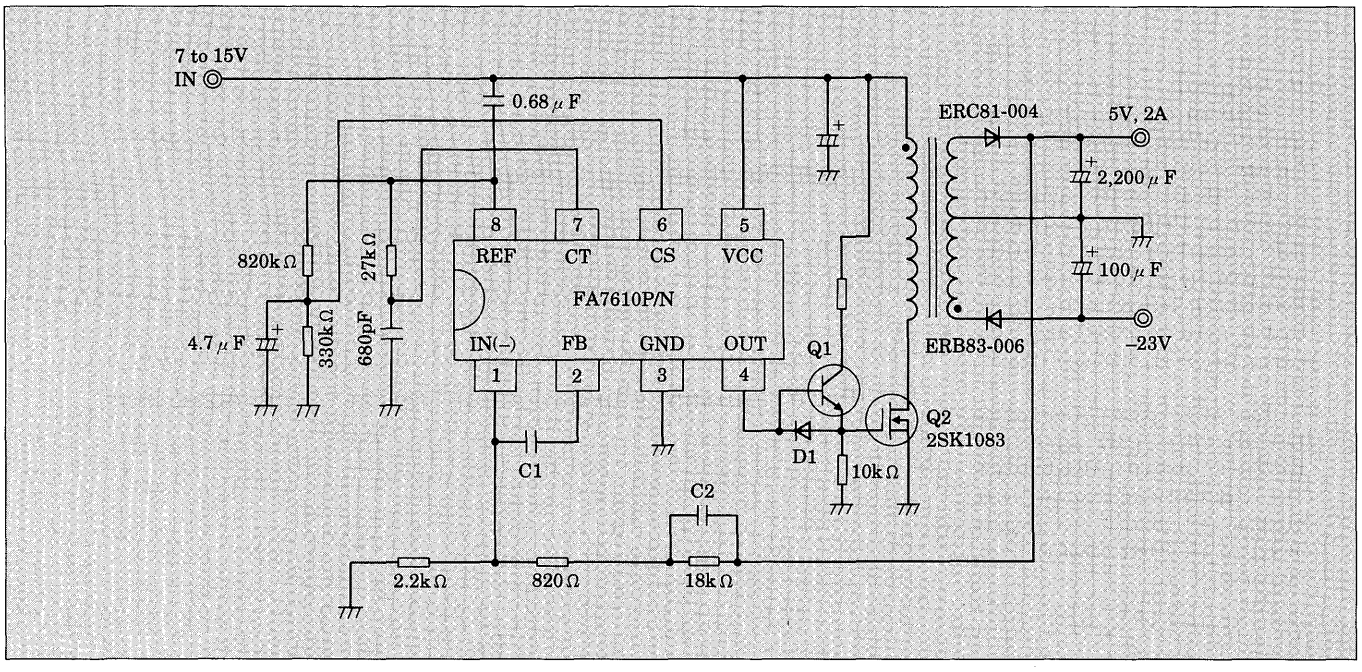
(1) turn on : By the collector current of npn transistor "Q1", the transistor amplifying the source current from the OUT pin, charges the gate capacitor of the MOSFET.

(2) turn off : By sink current to the OUT pin through diode "D1", the gate capacitor of the MOSFET is discharged.

There are two useful safety functions for this DC-DC converter : one is soft-start at startup, and the other is short protection to stop switching of the MOSFET when the DC output is overloaded or shorted.

For a DC-DC converter with relatively low output power, this IC is capable of driving the MOSFET directly.

Fig. 1 FA7610P/N application circuit



2.2 FA7612P/N and FA7617P/N application circuits

An example of p-channel MOSFET driving is shown in the buck converter of Fig. 2. The switching operation is as follows.

(1) turn on : The MOSFET gate capacitor is charged by sink current to the OUT pin through diode "D2".

(2) turn off : The MOSFET gate capacitor is discharged by the emitter current of npn transistor "Q3".

The efficiency of this DC-DC converter is relatively high, approximately 88%.

Although the maximum duty cycle of the FA7612P/N is 100%, the FA7617P/N is a similar IC, having identical pin out, but with a maximum duty cycle which is 67%. For this reason, the FA7617P/N is suitable for applications of flyback circuits.

Both ICs have soft-start and short protection functions.

2.3 FA7611P/M and FA7615P/M application circuits

Figures 3 and 4 show examples of driving n-channel/p-channel MOSFETs for ICs with two channel output. The switching circuit of Fig. 3 is the same as that of Fig. 2, and the circuit of Fig. 4 is the same as that of Fig. 1.

A buck converter and inverting converter are shown in Fig. 3.

Figure 4 shows two boost converters, in which the switching frequency is synchronized with a outer signal (the SYNC pin input signal).

Fig. 2 FA7612P/N application circuit

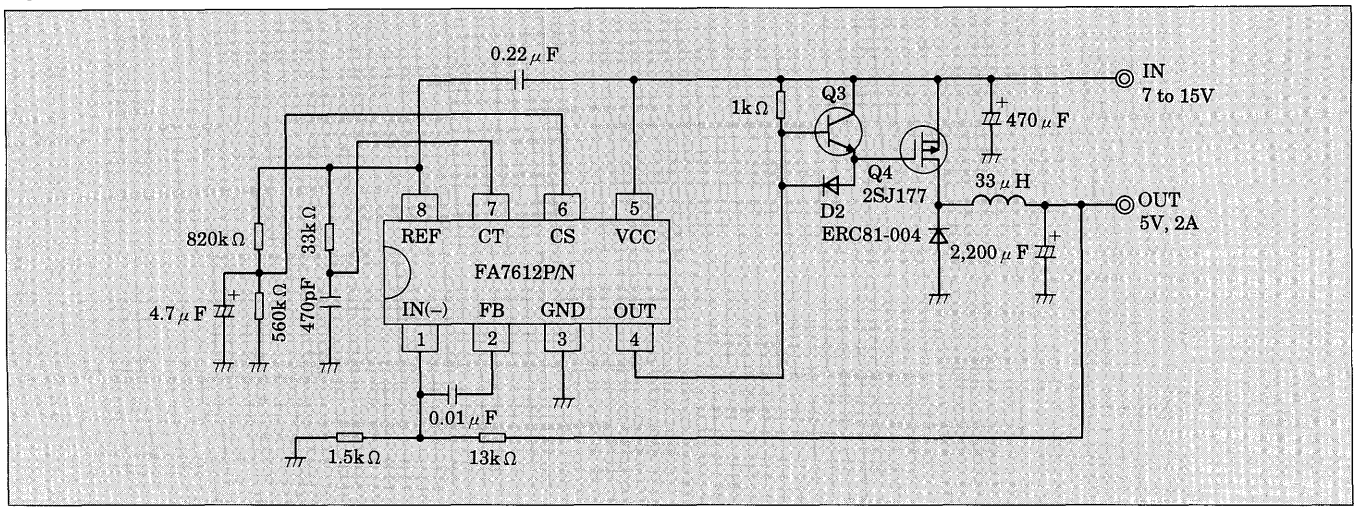


Fig. 3 FA7611P/M application circuit

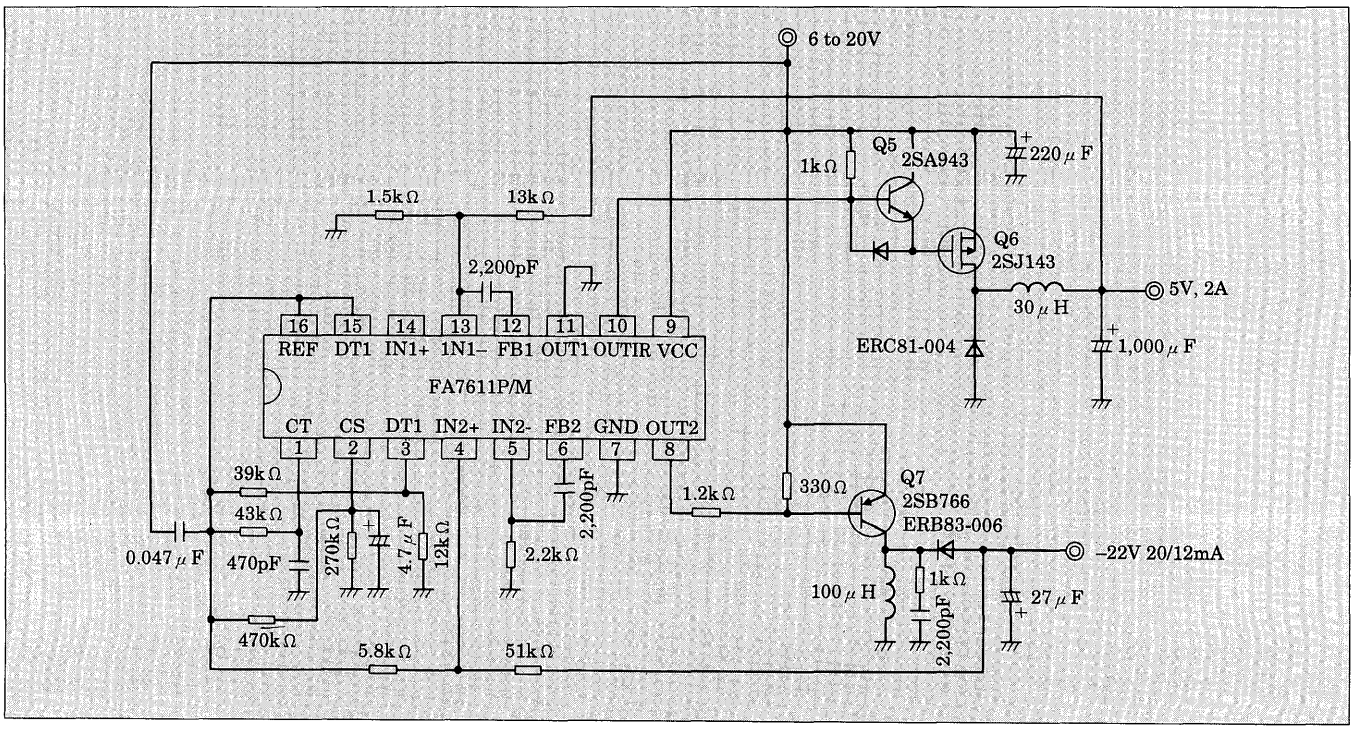


Fig. 4 FA7615P/M application circuit

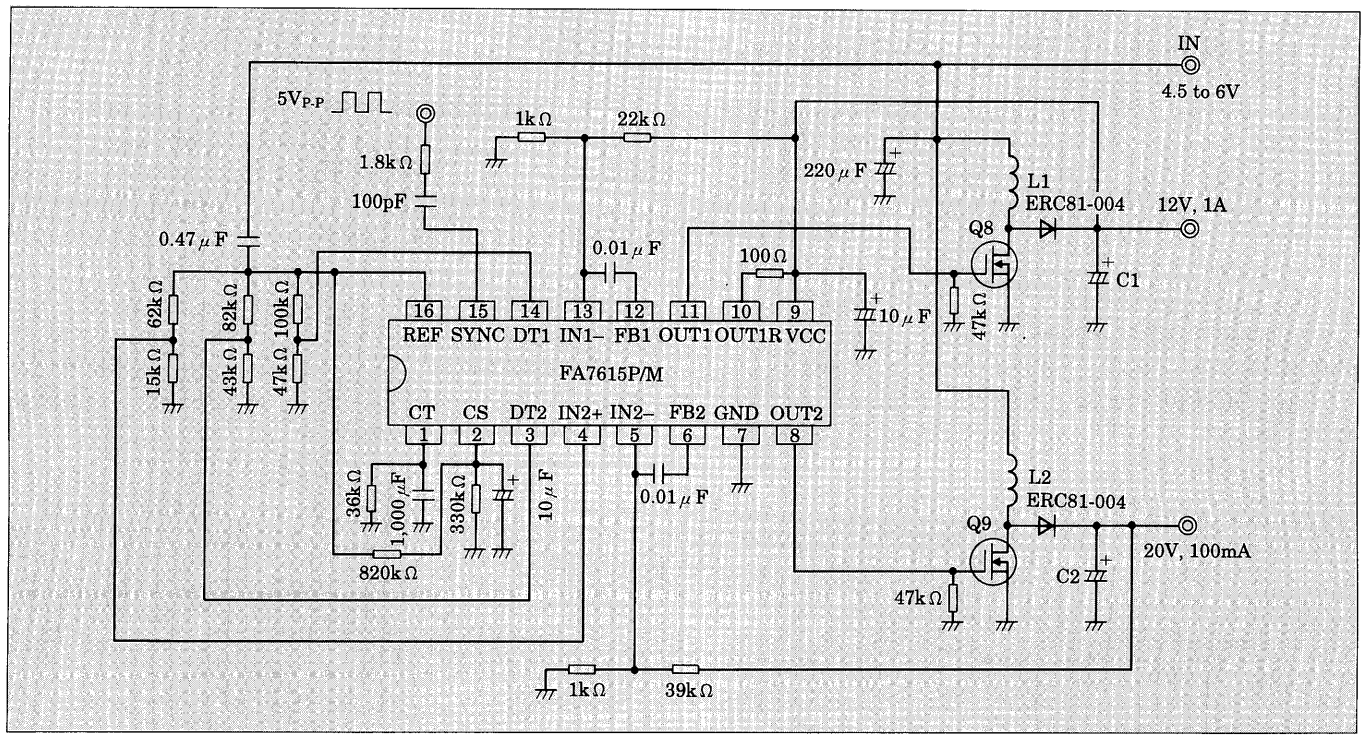
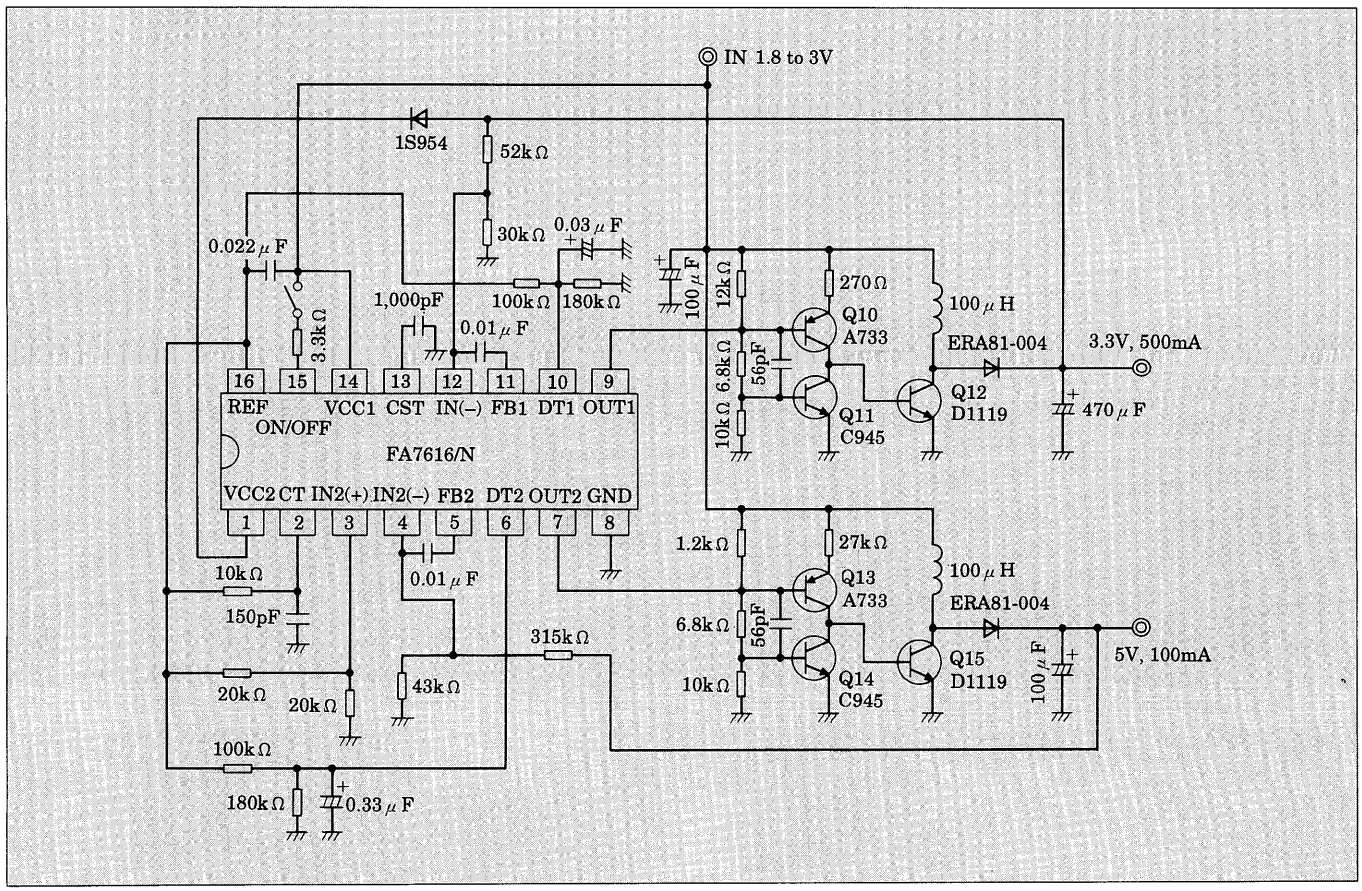


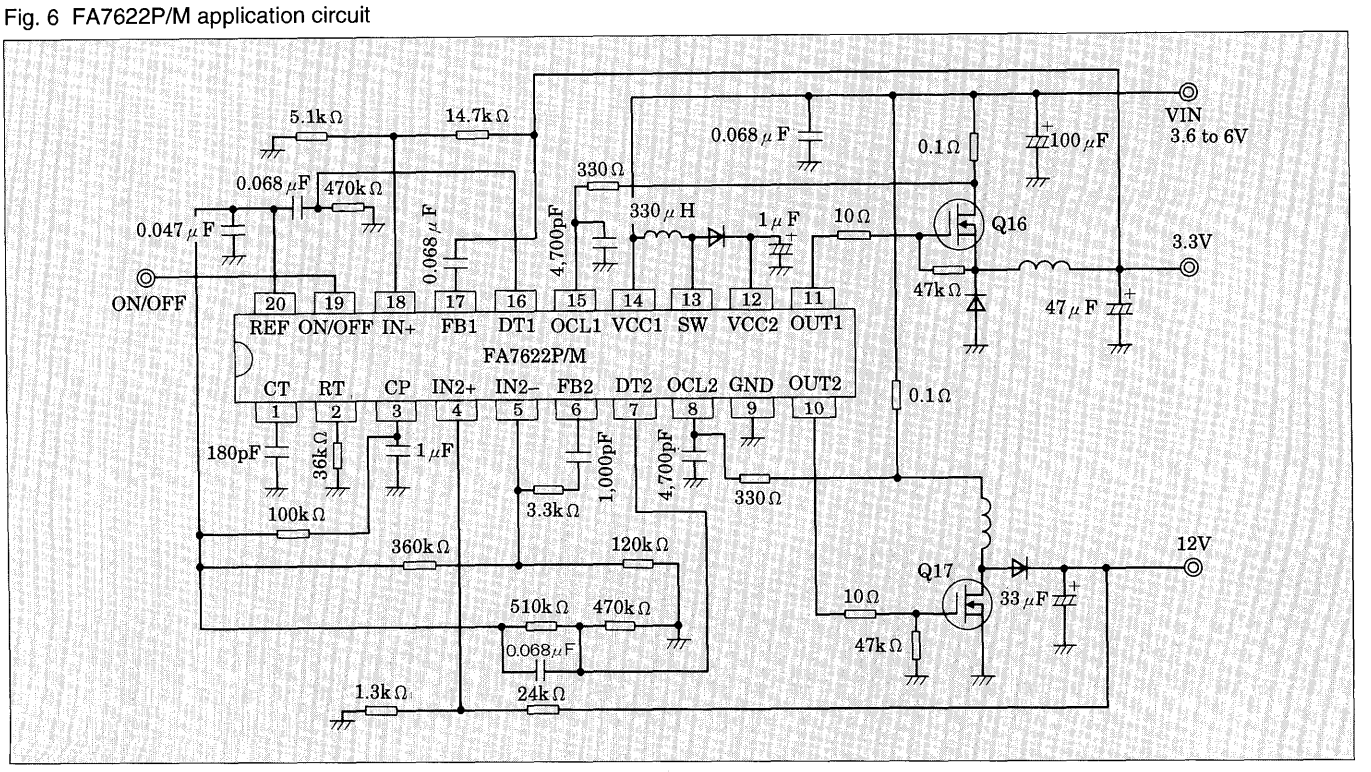
Fig. 5 FA7616P/N application circuit



These ICs have soft-start and short protection functions. Only one capacitor is connected to the CS pin for use during soft-start.

These ICs have the same function and characteristics for OUT1R pin and OUT1 pin. The output polarity of the IC at these pins is selectable.

Fig. 6 FA7622P/M application circuit



2.4 FA7616P/N and FA7613P/N application circuits

Figure 5 shows an application circuit of the FA7616P/N, which has an ON/OFF function and operates at a power supply input greater than 1.4 volts.

At start up, the power supply is applied as the IC input. Once a stable mode of DC output is reached, one DC output of the DC-DC converter is feedback as the IC input.

This circuit includes two boost converters with 3.3V or 5V output. The switching operation is achieved by pulling up the ON/OFF pin to VCC1. Standby mode, to stop the switching and reduce IC supply current to approximately 0.1μA, is achieved by opening or grounding the ON/OFF pin.

This ON/OFF function is also built into the FA7613P/N, which is suitable for buck, inverting, or flyback converters using a single switching transistor.

2.5 FA7622P/M applications

Figure 6 shows an application circuit of an IC suitable for driving two n-channel MOSFETs, using the ON/OFF function.

OUT1 and OUT2 pins have the same functions and characteristics. In this example, a buck converter is constructed at channel 1 (a control section and OUT1 pin), and a boost converter is constructed at channel 2 (a control section and OUT2 pin). Outputs of 3.3V and 12V are achieved.

MOSFETs can be driven with 600mA (maximum), to achieve low loss, high speed switching.

VCC2 pin voltage is boosted up to "VCC1 pin voltage +6.5V" by a boost converter, composed of an inductor, a diode, and a capacitor connected to SW pin or VCC2 pin and an inter switch. By applying this boosted VCC2 voltage as the bias voltage to drive the MOSFET gate electrode, it is possible to use an n-channel MOSFET for the high side switch, and to drive an n-channel MOSFET, used as the low side switch, from a supply voltage of greater than 3.6V.

If an inter boost converter is not used, SW pin should be open and VCC2 pin should be pulled up to VCC1 pin.

By grounding the ON/OFF pin, the ON/OFF function achieves standby mode in which a current of 0.1μA is supplied to the IC.

A current limiting function provides protection for the MOSFET. In Fig. 6 drain currents are converted to voltage by a 0.1Ω resistor which detects the currents. Drain currents are limited when the voltage of OCL1 pin or OCL2 reaches "VCC1-210mV".

Phase correction of the channel 1 feedback loop is possible by both the inter resistor (36kΩ) connected to FB1 pin and capacitor connected at the line between FB pin and the DC output of a power supply. This method of phase correction is unique to Fuji Electric.

3. Conclusion

Applications of MOSFET driving and the ON/OFF function of control ICs have been presented.

In the near future, development of digital ICs with ever decreasing supply voltage requirements will create a need for improved control methods and the development of power MOSFETs with built-in control ICs.

Fuji Electric will continue to develop unique ICs to meet the needs of the market place.