

# FA7622CP(E)

Bipolar IC  
For Switching Power Supply Control

## ■ Description

The FA7622CP(E) is a DC-DC converter IC that can directly drive a power MOSFET. This IC has all the necessary protection functions for a power MOSFET. It is optimum for a portable equipment power supply which uses low-voltage input to output comparably large power.

## ■ Features

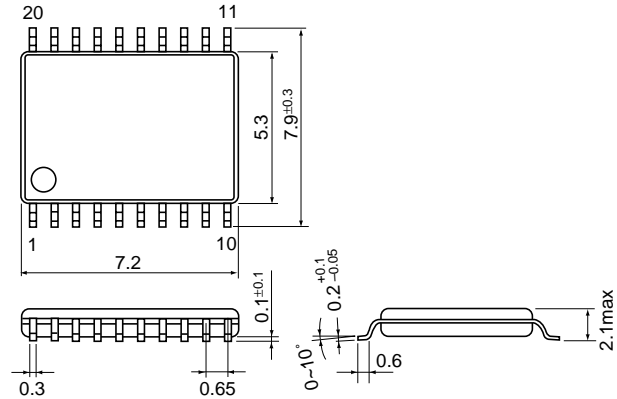
- Drive circuit for connecting a power MOSFET ( $I_o = \pm 600\text{mA}$ )
- Built-in voltage step-up circuit to drive a power MOSFET gate: A converter circuit requires only an N-channel power MOSFET.
- Dual control circuit
- Overcurrent limiting circuit
- Overload cutoff circuit with timer and latch circuit
- ON/OFF control pin
- Wide operating range: 3.6 to 28V
- High-frequency operation: up to 1MHz
- 20-pin package (DIP/SSOP)

## ■ Applications

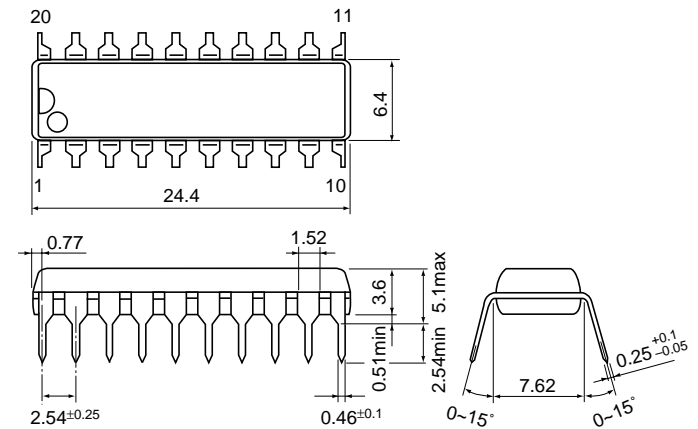
- Battery power supply for portable equipment

## ■ Dimensions, mm

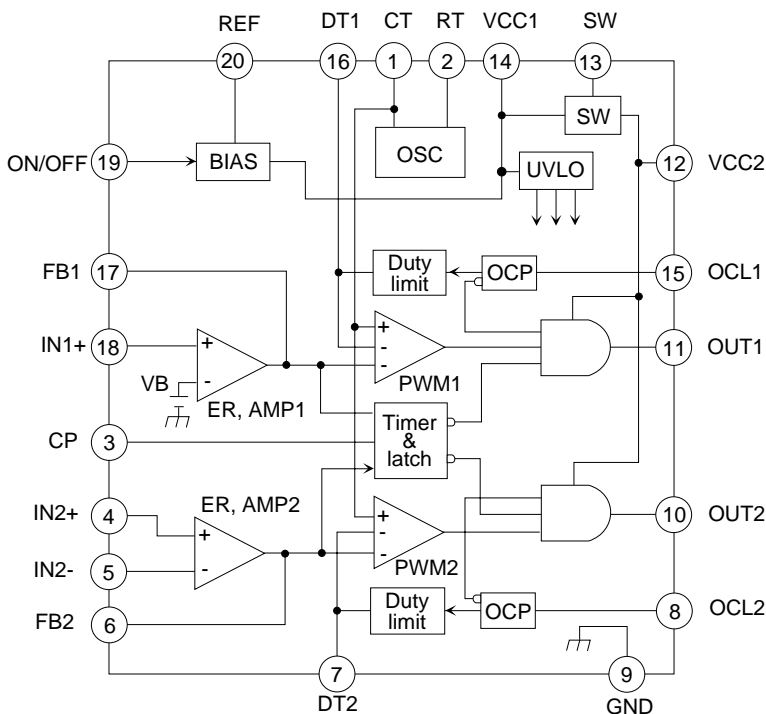
### ● SSOP-20



### ● DIP-20



## ■ Block diagram



Pin No.	Pin symbol	Description
1	CT	Oscillator timing capacitor
2	RT	Oscillator timing resistor
3	CP	Timer and latch circuit
4	IN2+	Non-inverting input to error amplifier
5	IN2-	Inverting input to error amplifier
6	FB2	Error amplifier output
7	DT2	Dead time adjustment
8	OCL2	Overcurrent limiting circuit 2
9	GND	Ground
10	OUT2	CH.2 output
11	OUT1	CH.1 output
12	VCC2	Power supply 2
13	SW	Switch for boost circuit
14	VCC1	Power supply 1
15	OCL1	Overcurrent limiting circuit 1
16	DT1	Dead time adjustment
17	FB1	Error amplifier output
18	IN1+	Non-inverting input to error amplifier
19	ON/OFF	Output ON/OFF control
20	REF	Reference voltage output

### ■ Absolute maximum ratings

Item	Symbol	Rating	Unit	
Supply voltage	Voltage boost circuit not used	V <sub>CC1</sub>	28	V
	Voltage boost circuit used	V <sub>CC1</sub>	20	V
Supply voltage	V <sub>CC2</sub>	28	V	
ON/OFF pin voltage	V <sub>ON/OFF</sub>	-0.3 to +7	V	
Out pin output current	I <sub>OUT</sub>	±600	mA	
Total power dissipation	P <sub>d</sub>	650	mW	
Junction temperature	T <sub>j</sub>	125	°C	
Operating temperature	T <sub>opr</sub>	-30 to +85	°C	
Storage temperature	T <sub>stg</sub>	-40 to +150	°C	

### ■ Recommended operating conditions

Item	Symbol	Min.	Max.	Unit	
Supply voltage	Voltage boost circuit not used	V <sub>CC1</sub>	3.6	26	V
	Voltage boost circuit used	V <sub>CC1</sub>	3.6	18	V
Feedback resistance	R <sub>NF</sub>	100		kΩ	
Timing capacitance	C <sub>T</sub>	50	2200	pF	
Timing resistance	R <sub>T</sub>	24	100	kΩ	
Oscillation frequency	f <sub>osc</sub>	50	1000	kHz	

### ■ Electrical characteristics (T<sub>a</sub> = 25°C, V<sub>CC</sub> = 6V, R<sub>T</sub> = 36kΩ, C<sub>T</sub> = 180pF)

#### Reference voltage section

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Output voltage	V <sub>REF</sub>	I <sub>OR</sub> = 1mA	2.400	2.475	2.550	V
Line regulation	LINE	V <sub>CC</sub> = 3.6 to 26V, I <sub>OR</sub> = 1mA		5	15	mV
Load regulation	LOAD	I <sub>OR</sub> = 0.1 to 1mA		2		mV
Output voltage variation due to temperature change	V <sub>TC1</sub>	T <sub>a</sub> = -30 to +25°C	-1		1	%
	V <sub>TC2</sub>	T <sub>a</sub> = +25 to +85°C	-1		1	%

#### Oscillator section

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Oscillation frequency	f <sub>osc</sub>	C <sub>T</sub> = 180pF, R <sub>T</sub> = 36kΩ	100	110	120	kHz
Frequency variation 1 (due to supply voltage change)	f <sub>dV</sub>	V <sub>CC</sub> = 3.6 to 26V		1		%
Frequency variation 2 (due to temperature change)	f <sub>dT</sub>	T <sub>a</sub> = -30 to +25°C		5		%

#### Error amplifier section (ch. 1)

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Reference voltage	V <sub>B</sub>		0.832	0.858	0.884	V
Input bias current	I <sub>B</sub>			5	100	nA
Open-loop voltage gain	A <sub>VO</sub>			40		dB
Unity-gain bandwidth	f <sub>T</sub>			1.0		MHz
Maximum output voltage	V <sub>OH</sub>	No load	1.8			V
	V <sub>OL</sub>	No load			300	mV
Output source current	I <sub>OH</sub>	V <sub>OH</sub> = 0V	30	60	90	μA

#### Error amplifier section (ch. 2)

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Input offset voltage	V <sub>IO</sub>			2	10	mV
Input bias current	I <sub>B</sub>			5	100	nA
Common-mode input voltage	V <sub>COM</sub>		0		1.0	V
Open-loop voltage gain	A <sub>VO</sub>		70			dB
Unity-gain bandwidth	f <sub>T</sub>			1.0		MHz
Maximum output voltage	V <sub>OH</sub>	No load	1.8			V
	V <sub>OL</sub>	No load			300	mV
Output source current	I <sub>OH</sub>	V <sub>OH</sub> = 0V	40	80	120	μA

**Pulse width modulation circuit section ( FB1, FB2 pin )**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Input threshold voltage	V <sub>TH0</sub>	Duty cycle = 0%		1.6	1.8	V
Input threshold voltage	V <sub>TH1</sub>	Duty cycle = 100%	0.8	1.0		V

**Dead time adjustment circuit section ( DT1, DT2 pin )**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Input threshold voltage	V <sub>TH0</sub>	Duty cycle = 0%		1.6	1.8	V
Input threshold voltage	V <sub>TH1</sub>	Duty cycle = 100%	0.8	1.0		V
Standby voltage	V <sub>STR</sub>	DT1, DT2 pin open	1.8			V

**Overcurrent limiting circuit section**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Input threshold voltage	V <sub>THOC</sub>		180	210	240	mV
Hysteresis voltage	V <sub>HYOC</sub>			40		mV
Input bias current	I <sub>OC</sub>			50	100	μA
Delay in OCL	t <sub>doc</sub>	Overdriving: 50mV		120		ns

**Timer and latch circuit section**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Latch-mode threshold voltage	V <sub>THCP</sub>		1.00	1.25	1.50	V
Input bias current	I <sub>INCP</sub>	V <sub>CP</sub> = 1.5V, V <sub>FB</sub> = 0.3V			1	μA
CP pin voltage / LOW	V <sub>SATC</sub>	I <sub>CP</sub> = 20 μA, V <sub>FB</sub> = 1.0V			300	mV

**Output ON/OFF control circuit section**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
OFF-to-ON threshold voltage	V <sub>THON</sub>				3.0	V
ON-to-OFF threshold voltage	V <sub>TH OFF</sub>		0.60			V
Input bias current	I <sub>IN</sub>	V <sub>IN</sub> = 3V		180		μA

**Undervoltage lock-out circuit section**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
OFF-to-ON threshold voltage	V <sub>CCON</sub>		2.80	3.00	3.20	V
ON-to-OFF threshold voltage	V <sub>CCOF</sub>			2.90		V
Voltage hysteresis	V <sub>HYS</sub>			0.10		V

**Output section**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Saturation voltage (H level)	V <sub>SAT+</sub>	I <sub>o</sub> = -50mA		1.50	2.00	V
Saturation voltage (L level)	V <sub>SAT-</sub>	I <sub>o</sub> = 50mA		1.70	2.20	V

**Voltage step-up circuit section**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Output voltage	V <sub>OUP</sub>	L=330μH, C=1μF, No load	10.5	12.5	14.0	V

**Overall device**

Item	Symbol	Test condition	Min.	Typ.	Max.	Unit
Stand-by supply current	I <sub>CCST</sub>	Out pin open		0.1	10	μA
Operating V <sub>CC1</sub> current	I <sub>CC1</sub>	Normal operation		3.8	5.5	mA
Operating V <sub>CC2</sub> current	I <sub>CC2</sub>	Normal operation V <sub>CC2</sub> =12V OUT1, OUT2 open Duty cycle=50%		1.5	2.2	mA

■ Description of each circuit

1. Oscillator section

This section charges and discharges an external capacitor  $C_T$ . The charge current is determined by the external resistor  $R_T$  connected to the IC. By charging and discharging the capacitor, this section provides a 1.0 to 1.6V triangle wave at the CT pin. The oscillation frequency can be set between 50kHz to 1MHz. The frequency can be calculated approximately as follows:

$$f_{osc} \text{ (kHz)} = \frac{7.1 \cdot 10^5}{R_T \text{ (k}\Omega) \cdot C_T \text{ (pF)}} \dots\dots\dots (1)$$

2. Error amplifier section

Error amplifier ①

As Fig. 3 shows, the inverting input of the error amplifier is connected to the  $V_B$  reference voltage (0.858V typ.). The non-inverting input  $IN1+$  and output  $FB1$  connect to external terminals.

During ordinary operation, the  $IN1+$  terminal voltage is almost equal to  $V_B$ . The power-supply output  $V_{OUTA}$  can be determined as follows:

$$V_{OUTA} = \frac{R_1 + R_2}{R_2} \cdot V_B \dots\dots\dots (2)$$

The DC gain of the error amplifier is 40dB (typ.), regardless of external parts connected to the IC. Correct the phase by connecting capacitor  $C_1$  between the  $V_{OUTA}$  and  $FB1$  pins.

Error amplifier ②

• Voltage step-up or step-down chopper circuit

As Fig. 4 shows, the non-inverting input  $IN2+$ , inverting input  $IN2-$ , and output  $FB2$  of the error amplifier are connected to external terminals.

The feedback voltage  $V_{OUTB}$  to the  $IN2+$  pin can be determined as follows:

$$V_{OUTB} = \frac{(R_3 + R_4) \cdot R_6}{R_4 \cdot (R_5 + R_6)} \cdot V_{REF} \dots\dots\dots (3)$$

The DC gain  $A_v$  from the  $V_{OUTB}$  to  $FB2$  pin is 70dB (min), when  $R_7$  is not connected.

When  $R_7$  is connected, the  $A_v$  can be determined as follows:

$$A_v = \frac{R_4}{R_3 + R_4} \cdot \left( 1 + \frac{R_7 \cdot (R_5 + R_6)}{R_5 \cdot R_6} \right) \dots\dots\dots (4)$$

To correct the phase, connect the resistor  $R_8$  and capacitor  $C_2$  in series between the  $IN2-$  and  $FB2$  pins.

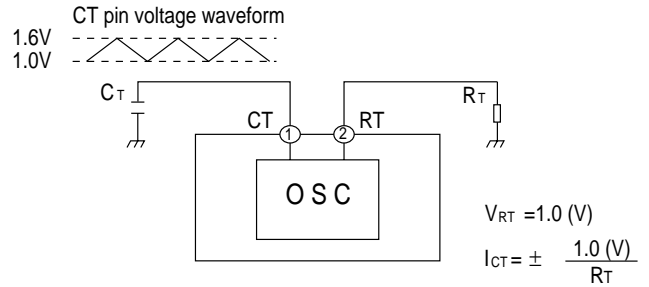


Fig. 1 Oscillator

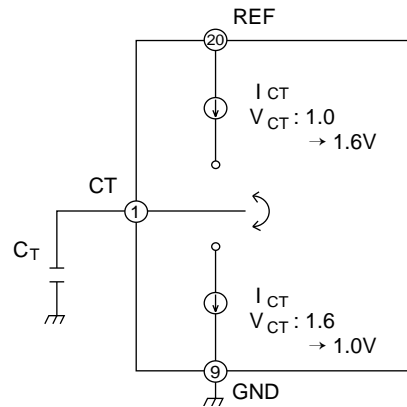


Fig. 2

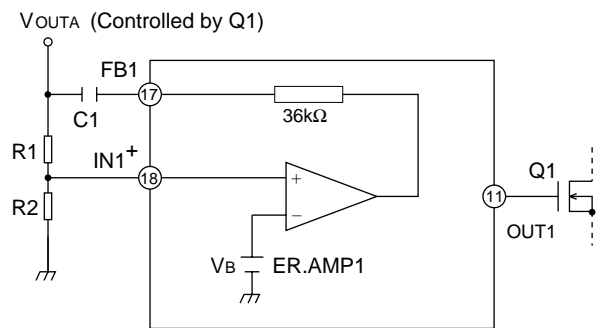


Fig. 3

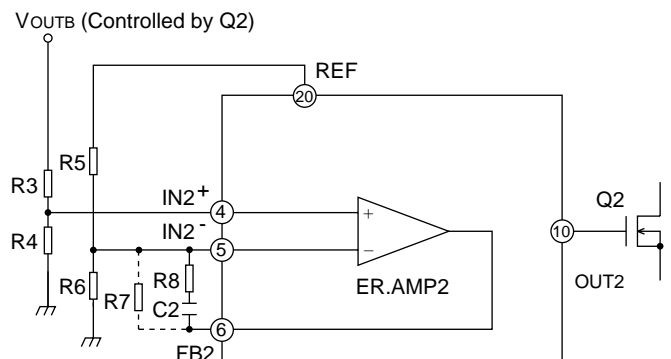


Fig. 4

• Inverting chopper circuit

According to the circuit shown in Fig. 5, the power output voltage  $V_{OUTB}$  can be determined as follows:

$$V_{OUTB} = - \frac{R_{11}}{R_{10}} \cdot V_{REF} \dots\dots\dots (5)$$

The  $A_v$  between the  $V_{OUTB}$  and  $FB2$  pins can be determined as follows:

$$A_v = \frac{-R_{11}}{R_{12}} \dots\dots\dots (6)$$

To correct the phase, connect the resistor  $R_{13}$  and capacitor  $C_3$  in series between the  $IN2-$  and  $FB2$  pins. By using this circuit, invert the output polarity of  $OUT2$  with an external transistor to drive a P-channel MOSFET (or PNP transistor).

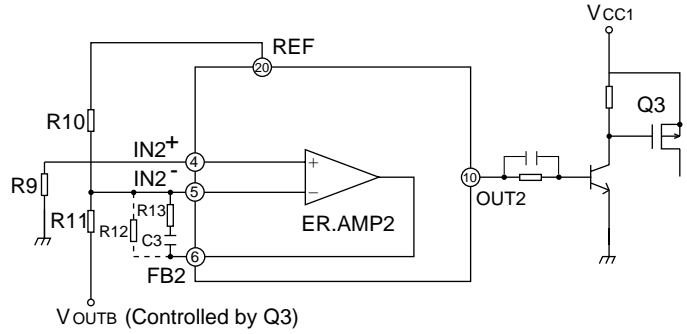


Fig. 5

3. PWM comparator section

As Fig. 6 shows, a PWM comparator has three input terminals. PWM comparator 1 determines the duty cycle of the output from the  $OUT1$  pin. This comparator compares the  $C_T$  oscillator Voltage (Pin 1) with the  $FB1$  voltage (Pin 17) or the  $DT1$  voltage (Pin 16), whichever is greater. When the highest of these voltages is lower than the  $C_T$  voltage, the PWM output is high. When it is higher than  $C_T$ , the PWM output is low.

PWM comparator 2 determines the duty cycle of the output from the  $OUT2$  pin. To determine the PWM output, this comparator compares the  $C_T$  oscillator voltage (Pin 1) with the  $FB2$  voltage (Pin 6) or the  $DT2$  voltage (Pin 7) whichever is higher.

During ordinary operation, the  $OUT1$  and  $OUT2$  pin voltages have the same polarity as the output from each comparator. When the power supply is turned on, the pulse width gradually increases. The time constant for soft-start is determined by the external resistor and capacitor across pins 16 and 7. In Figures 7 and 8, the time  $t_s$  required for the pulse width (duty-cycle) to reach about 30% after start-up can be determined as follows:

(Units:  $\mu F$  for  $C_s$  and  $k\Omega$  for  $R_s$ ,  $R_{s1}$ , and  $R_{s2}$ )

Fig.7:  
 $t_s \text{ (ms)} = 0.54C_s \cdot R_s \dots\dots\dots (7)$

Fig.8:  
 $t_s \text{ (ms)} = C_s \left( \frac{R_{s1} \cdot R_{s2}}{R_{s1} + R_{s2}} \right) \cdot \ln \left( \frac{R_{s1}}{0.417R_{s1} - 0.583 R_{s2}} \right) \dots\dots\dots (8)$

Where,  $R_{s1} / R_{s2} > 0.716$

Please connect enough large capacitance between  $REF$  and  $GND$  pins in order to prevent irregular output pulse caused by minus voltage at  $DT1$  or  $DT2$  pin when IC is shut down.

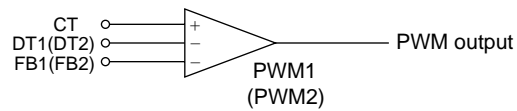
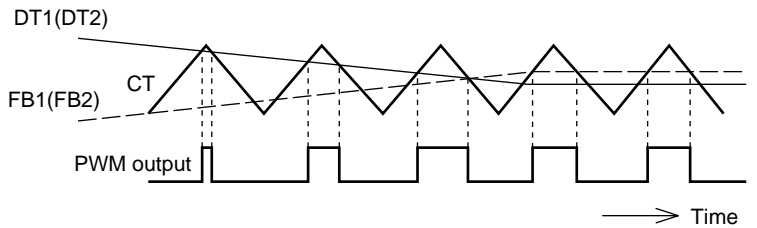


Fig. 6

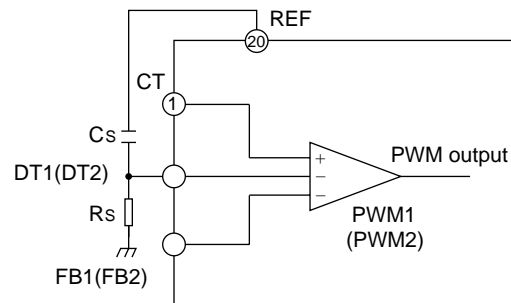


Fig. 7

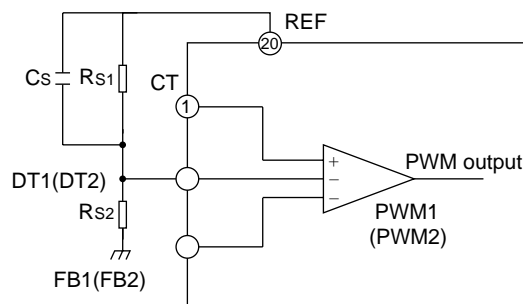


Fig. 8

**4. Timer and latch circuit for overload protection**

Figure 9 shows the timer and latch circuit for overload protection and Fig. 10 shows its timing during an overload. If the power supply output decreases due to an overload, the error amplifier output decreases. If the voltage decreases to less than 0.3V, the switch that clamps the CP pin voltage to the ground disconnects. This charges capacitor Cp from the REF pin through the resistor Rcp and the CP pin voltage increases. When the voltage reaches 1.25V, OUT1 (OUT2) voltage is clamped to ground. The N-channel MOSFET (or NPN transistor) connected to the OUT1 (or OUT2) is turned OFF and cuts off the power supply. The time tL from when the circuit is overloaded until the power supply is cut off can be determined as follows:

$$t_L \text{ (ms)} = 0.67C_P \text{ (\mu F)} \cdot R_{CP} \text{ (k}\Omega) \dots\dots\dots(9)$$

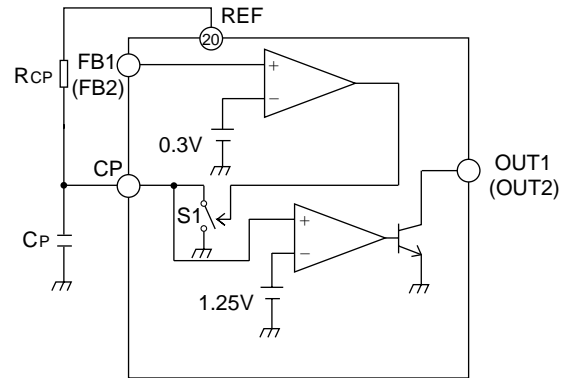


Fig. 9

**5. Overcurrent limiting circuit**

This is a pulse-by-pulse overcurrent limiting circuit which detects and limits the peak of each drain current pulse from the main switching transistor (MOSFET).

Figure 11 shows the overcurrent limiting circuit and Fig. 12 shows its timing.

This circuit detects a drain current with a voltage sampling resistor Rs. If a voltage lower than the VCC1 pin voltage by 210mV or more is input to OCL1 (OCL2), the OUT1 (OUT2) is clamped to ground. At the same time, DT1 (DT2) is raised to the reference voltage VREF. (This reduces the duty-cycle to 0%)

This circuit has hysteresis to prevent noise from causing malfunction.

The Rs voltage which is proportional to drain current is limited to 210mV (typ.) and released at 170mV (typ.).

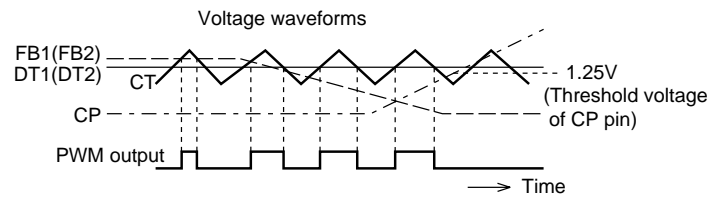


Fig. 10

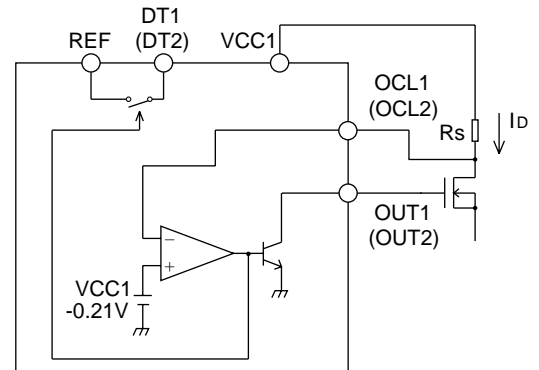


Fig. 11

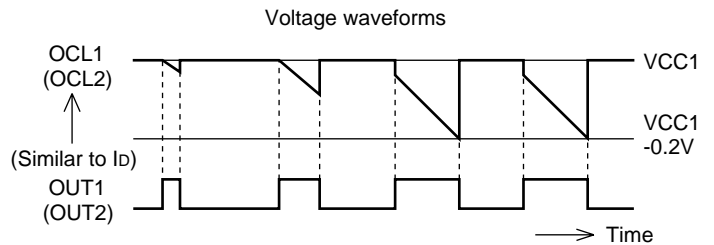


Fig. 12

**6. IC ON/OFF control circuit**

This control circuit turns the entire IC ON or OFF by an external signal using an ON/OFF control pin to limit the IC's current consumption to 10 $\mu$ A or less.

Figure 13 shows the IC ON/OFF control circuit and Fig. 14 shows its timing.

To turn the IC OFF, this circuit clamps OUT1 (OUT2) to ground when the ON/OFF pin voltage is controlled to less than 0.60V. The internal bias current is cut off to turn off the switching transistor.

To turn the IC ON, raise the ON/OFF pin voltage immediately to 3.0V or more to charge the soft-start capacitor gradually.

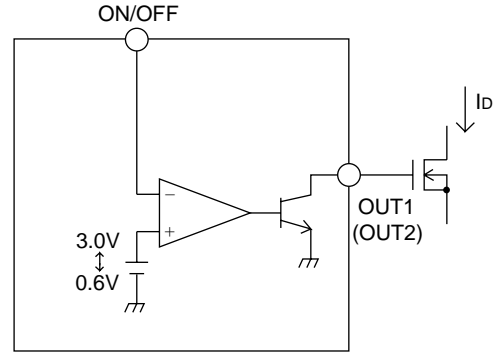


Fig. 13

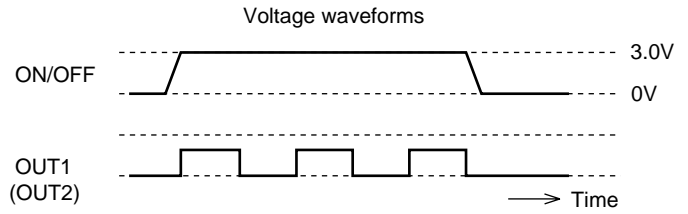


Fig. 14 Control of output

**7. Voltage boost circuit**

By using the circuit shown in Fig. 15, this IC generates a voltage 6.5V (typ.) higher than the VCC1 input voltage at the VCC2 pin. This circuit allows the IC to drive MOSFET gates directly. With this circuit, the IC can drive a low-level side N-channel MOSFET at 3.6 to 18V as VCC1 (not possible with conventional ICs). In addition, an N-channel MOSFET can be used on the high-level side of a buck chopper. In Fig. 15, the inductor (L) is about 100 $\mu$ H or more and the capacitor (Cup) should be greater than about 0.1 $\mu$ F.

If voltage boost is not necessary, connect the VCC1 and VCC2 pins directly, and SW pin must be opened.

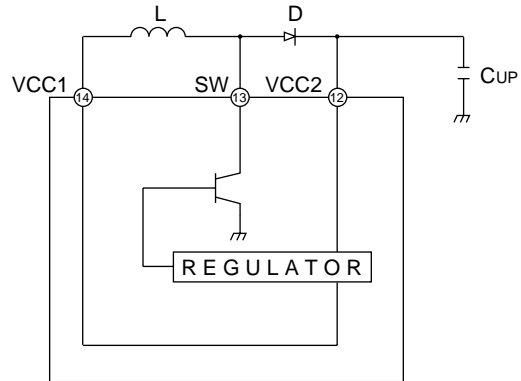


Fig. 15

**8. Undervoltage lock-out circuit**

This circuit prevents a malfunction at a low supply voltage.

When the supply voltage VCC1 rises and reaches 3.0V, this circuit is activated. When VCC1 drops below 2.9V, this circuit clamps OUT1 (OUT2) to ground. The CP pin voltage is reset to low by means of cutting off a power supply input.

**9. Output circuit**

As Fig. 17 shows, OUT1 and OUT2 with a totempole structure can drive a MOSFET.

Since both the maximum output source and sink currents are 600mA, a MOSFET can be switched at high speed.

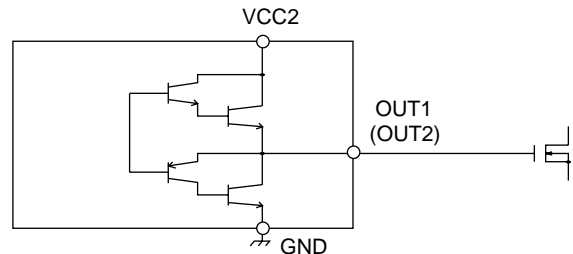
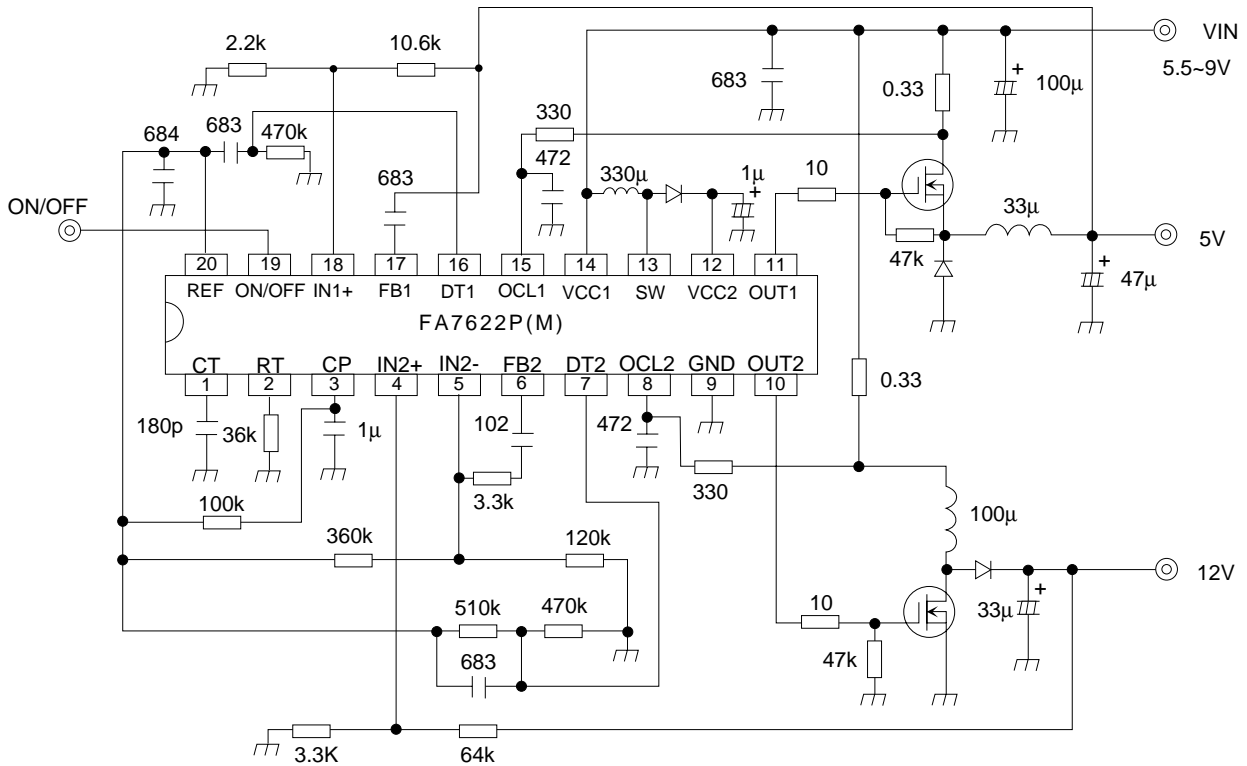


Fig. 16

## ■ Application circuit



Parts tolerances characteristics are not defined in the circuit design sample shown above. When designing an actual circuit for a product, you must determine parts tolerances and characteristics for safe and economical operation.