DC Brushless Motor Driver Series for Cooling Fans

Two-phase Half-wave
DC Brushless Fan Motor Drivers
BD6706FV, BD6701F, BA6406F, BA6901F, BD6712AF

Pb Free ROHM Electronic Components   RoHS Directive Compliance

●Description

This is the summary of models for two-phase half-wave fan motor driver. They incorporate lock protection, automatic restart circuit and FG/AL output. Some of them have variable speed control function, 48V power supply adaptation.

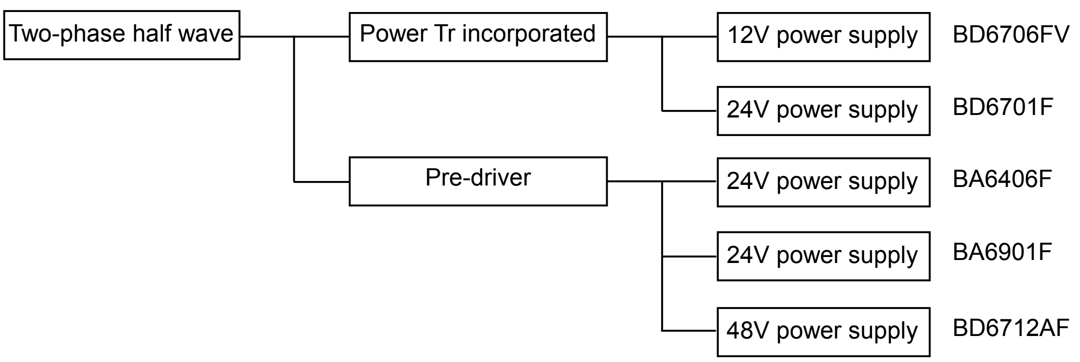
●Feature

1) Power Tr incorporated(BD6706FV、BD6701F)
2) Pre-driver(BA6406F、BA6901F、BD6712AF)
3) Variable speed control(BD6706FV、BA6901F)
4) Incorporates reverse connection protection diode(BD6701F)
5) Incorporates lock protection and automatic restart circuit
6) Rotation speed pulse signal (FG) output(BD6706FV、BD6701F、BA6901F、BD6712AF)
7) Lock alarm signal (AL) output

●Applications

For desktop PC, server, general consumer equipment, communication equipment and industrial equipment.

●Lineup



●Absolute maximum ratings

◎BD6706FV

Parameter	Symbol	Limit	Unit
Supply voltage	Vcc	15	V
Power dissipation	Pd	560＊	mW
Operating temperature range	Topr	-40～+95	℃
Storage temperature range	Tstg	-55～+150	℃
Output current	Iomax	800＊＊	mA
FG signal output current	IFG	10	mA
FG signal output voltage	VFG	15	V
AL signal output current	IAL	10	mA
AL signal output voltage	VAL	15	V
Junction temperature	Tjmax	150	℃

＊ Reduce by 4.48 mW/°C over 25°C.
(On 70.0 mm x 70.0 mm x 1.6 mm glass epoxy board)
＊＊ This value is not to exceed Pd.

◎BD6701F

Parameter	Symbol	Limit	Unit
Supply voltage	Vcc	36	V
Power dissipation	Pd	780＊	mW
Operating temperature range	Topr	-40～+100	℃
Storage temperature range	Tstg	-55～+150	℃
Output current	Iomax	800＊＊	mA
AL signal output current	IAL	10	mA
AL signal output voltage	VAL	36	V
FG signal output current	IFG	10	mA
FG signal output voltage	VFG	36	V
Junction temperature	Tjmax	150	℃

＊ Reduce by 6.24 mW/°C over 25°C.
(On 70.0 mm x 70.0 mm x 1.6 mm glass epoxy board)
＊＊ This value is not to exceed Pd.

◎BA6406F

Parameter	Symbol	Limit	Unit
Supply voltage	Vcc	30	V
Power dissipation	Pd	624＊	mW
Operating temperature	Topr	-40～+100	℃
Storage temperature	Tstg	-55～+125	℃
Output current	Iomax	70	mA
AL signal output current	IAL	8	mA
AL signal output voltage	VAL	30	V
Junction temperature	Tjmax	125	℃

＊ Reduce by 6.24 mW/°C over 25°C.
(On 70.0 mm x 70.0 mm x 1.6 mm glass epoxy board)

◎BA6901F

Parameter	Symbol	Limit	Unit
Supply voltage	Vcc	36	V
Power dissipation	Pd	625＊	mW
Operating temperature	Topr	-40～+100	℃
Storage temperature	Tstg	-55～+150	℃
Output current	Iomax	70	mA
FG signal output current	IFG	15	mA
FG signal output voltage	VFG	36	V
AL signal output current	IAL	15	mA
AL signal output voltage	VAL	36	V
Junction temperature	Tjmax	150	℃

＊ Reduce by 5.0 mW/°C over 25°C.
(On 70.0 mm x 70.0 mm x 1.6 mm glass epoxy board)

◎BD6712AF

Parameter	Symbol	Limit	Unit
Supply voltage	Pd	780＊	mW
Power dissipation	Topr	-35～+95	℃
Operating temperature range	Tstg	-55～+150	℃
Storage temperature range	Iomax	40	mA
Output current	IAL	15	mA
AL signal output current	VAL	60	V
AL signal output voltage	Tjmax	150	℃

＊ Reduce by 6.24 mW/°C over 25°C.
(On 70.0 mm x 70.0 mm x 1.6 mm glass epoxy board)

●OPERATING CONDITIONS

◎BD6706FV

Parameter	Symbol	Limit	Unit
Operating supply voltage range	Vcc	6.0～14.0	V
Hall input voltage range	VH	0～Vcc-2.2	V

◎BD6701F

Parameter	Symbol	Limit	Unit
Operating supply voltage range	Vcc	6.0～28.0	V
Hall input voltage range	VH	0～Vcc-3.0	V

◎BA6406F

Parameter	Symbol	Limit	Unit
Operating supply voltage range	Vcc	4.0～28.0	V
Hall input voltage range	VH	1.0～Vcc-0.5	V

◎BA6901F

Parameter	Symbol	Limit	Unit
Operating supply voltage range	Vcc	3.5～28.0	V
Hall input voltage range	VH	0～Vcc-2.2	V

◎BD6712AF

Parameter	Symbol	Limit	Unit
Operating supply voltage range	Vcc	3.5～Vcz	V
Operating supply current range	Icc	1～30	mA
FG output voltage range，AL output voltage range	VSI	0～48	V
Hall input voltage range	VH	0～Vcz-1.5	V

●ELECTRICAL CHARACTERISTICS

◎BD6706FV(Unless otherwise specified Ta=25℃,Vcc=12V)

Parameter	Symbol	Limit			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Circuit current	Icc	3	6	9	mA		Fig.1
Hall minimum input level	VHmin	30	-	-	mVpp		-
Output L voltage	VOL	-	0.25	0.4	V	Io=200mA	Fig.2
Output leak current	IOL	-	-	100	μA	Vo=20V	-
Output zenner voltage	VOZ	27	30	33	V	Clamp current=10mA	Fig.3
Lock detection ON time	TON	0.3	0.5	0.7	sec		Fig.4
Lock detection OFF time	TOFF	2.0	3.0	4.0	sec		Fig.5
FG output L voltage	VFGL	-	-	0.3	V	IFG=5mA	Fig.6
FG output leak current	IFGL	-	-	50	μA	VFG=14V	-
AL output L voltage	VALL	-	-	0.3	V	IAL=5mA	Fig.7
AL output leak current	IALL	-	-	50	μA	VAL=14V	-
Vreg terminal voltage	Vreg	3.3	3.7	4.1	V		Fig.8
Rref terminal voltage	VRref	0.4	0.5	0.6	V	Rref=10kΩ	Fig.9
RTH terminal voltage	VRTH	0.4	0.5	0.6	V	RTH=10kΩ	-
CR terminal voltage L level	VCRL	0.8	1.0	1.2	V		Fig.10
CR terminal voltage H level1	VCRH1	3.0	3.7	4.1	V	Rref=10kΩ RTH=10kΩ RG=100kΩ	Fig.11
CR terminal voltage H level2	VCRH2	2.1	2.6	3.1	V	Rref=10kΩ RTH=9kΩ RG=100kΩ	Fig.11

◎BD6701F(Unless otherwise specified Ta=25℃,Vcc=12V)

Parameter	Symbol	Limit			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Circuit current	Icc	3	6	9	mA		Fig.13
Hall input offset voltage	VHofs	-10	-	10	mV		-
Hall input hysteresis	Vhys	±5	±10	±15	mV		Fig.14
Output L voltage	VOL	-	0.30	0.50	V	Io=200mA	Fig.15
Output leak current	IOL	-	-	100	μA	Vo=45V	-
Output zenner voltage	VOZ	50	54	58	V	Clamp current =10mA	Fig.16
Lock detection ON time	TON	0.30	0.50	0.70	sec		Fig.17
Lock detection OFF time	TOFF	3.0	5.0	7.0	sec		Fig.18
FG output voltage L	VFGL	-	-	0.4	V	IFG=5mA	Fig.19,20
FG output leak current	IFGL	-	-	50	μA	VFG=36V	-
AL output voltage L	VALL	-	-	0.4	V	IAL=5mA	Fig.19,20
AL output leak current	IALL	-	-	50	μA	VAL=36V	-

◎BA6406F(Unless otherwise specified Ta=25℃,Vcc=12V)

Parameter	Symbol	Limit			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Circuit current	Icc	-	3.2	5.0	mA	At output OFF	Fig.22
Hall input hysteresis	Vhys	±3	-	±15	mV		Fig.23
AL output L voltage	VALL	-	-	0.5	V	IAL=5mA	Fig.24
AL current capacity	IAL	8.0	-	-	mA	VAL=2V	-
Charge current of capacitor for lock detection	ILDC	2.0	3.45	5.25	μA	VLD=1.5V	Fig.25
Discharge current of capacitor for lock detection	ILDD	0.35	0.80	1.45	μA	VLD=1.5V	Fig.25
Charge-discharge current ratio of capacitor for lock detection	rCD	3	4.5	8	-	rCD=ILDC/ILDD	-
Clamp voltage of capacitor for lock detection	VLDCL	2.2	2.6	3.0	V		Fig.26
Comparison voltage of capacitor for lock detection	VLDCP	0.4	0.6	0.8	V		Fig.26
Output H voltage	VOH	10	10.5	-	V	Io=10mA	Fig.27

◎BA6901F(Unless otherwise specified Ta=25℃,Vcc=12V)

Parameter	Symbol	Limit			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Circuit current	Icc	3.0	7.0	12.0	mA	At output OFF	Fig.28
Hall input hysteresis	Vhys	±4	±10	±20	mV		Fig.29
Charge current of capacitor for lock detection	ILDC	2.0	5.0	8.0	μA	VLD=1.5V	Fig.30
Discharge current of capacitor for lock detection	ILDD	0.2	0.5	0.8	μA	VLD=1.5V	Fig.30
Charge-discharge current ratio of capacitor for lock detection	rCD	4	10	16	-	rCD=ILDC/ILDD	-
Clamp voltage of capacitor for lock detection	VLDCL	1.60	2.40	3.20	V		Fig.31
Comparison voltage of capacitor for lock detection	VLDCP	0.25	0.60	0.95	V		Fig.31
Output H voltage	VOH	-	1.5	2.0	V	Io=-10mA Voltage between output and Vcc	Fig.32
FG output L voltage	VFGL	-	0.10	0.50	V	IFG=5mA	Fig.33
AL output L voltage	VALL	-	0.10	0.50	V	IAL,IALB=5mA	Fig.34
CL-CS offset voltage	VofsCS	75.0	92.0	99.5	mV	CL=100mV	Fig.35
Response time for current limit	TCS	-	50	150	μsec		-
PWM input voltage H	VPWMH	2.0	-	-	V	At output ON	Fig.36
PWM input voltage L	VPWML	-	-	0.8	V	At output OFF	Fig.36
Charge-discharge pulse comparison voltage	VCRCP	0.26	0.35	0.44	V		-
Charge-discharge pulse output voltage H	VTOH	0.7	1.0	1.3	V	ITO=-0.5mA Voltage between output and Vcc	-
Charge-discharge pulse output voltage L	VTOL	0.7	1.0	1.3	V	ITO=0.5mA	-

◎BD6712AF (Unless otherwise specified Ta=25℃,Vcc=5V)

Parameter	Symbol	Limit			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Internal voltage	Vcz	5.5	6.0	6.5	V	Icc=10mA	-
Circuit current1	Icc1	0.5	1.5	3.0	mA	＊	-
Circuit current2	Icc2	4	6.7	9.5	mA	＊＊	Fig.37
Hall input hysteresis voltage	Vhys	5	15	25	mV		-
Lock detection ON time	TON	0.25	0.5	1	sec		Fig.38
Lock detection OFF time	TOFF	2.5	5	10	sec		Fig.39
Output H voltage	VOH	Vcc-0.5	Vcc-0.2	Vcc	V	Io=-10mA	Fig.40,41
Output L voltage	VOL	-	0.2	0.5	V	Io=10mA	Fig.42,43
FG output L voltage	VFGL	-	0.15	0.5	V	IFG=5mA	Fig.44,45
FG output leak current	IFGL	-	0	10	μA	VFG=48V	-
AL output L voltage	VALL	-	0.15	0.5	V	IAL=5mA	Fig.44,45
AL output leak current	IALL	-	0	10	μA	VAL=48V	-

＊　H+:3V,H-:2V,Output,FG,AL terminal are open

＊＊　Hall-input is 100Hz square wave. Output is connected with 1kΩ to ground.
FG and AL are connected with 50kΩ to Vcc.

●Truth table

◎BD6706F

H+	H-	OUT1	OUT2	FG
H	L	H (Output Tr OFF)	L (Output Tr ON)	L (Output Tr ON)
L	H	L (Output Tr ON)	H (Output Tr OFF)	H (Output Tr OFF)

◎BD6701F

H+	H-	OUT1	OUT2	FG
H	L	H (Output Tr OFF)	L (Output Tr ON)	L (Output Tr ON)
L	H	L (Output Tr ON)	H (Output Tr OFF)	H (Output Tr OFF)

◎BA6406F

H+	H-	A1	A2
H	L	H(Output Tr ON)	L (Output Tr OFF)
L	H	L (Output Tr OFF)	H (Output Tr ON)

◎BA6901F

H+	H-	PWM	A1	A2	FG
H	L	H, OPEN	H (Output Tr ON)	L (Output Tr OFF)	H (Output Tr OFF)
L	H	H, OPEN	L (Output Tr OFF)	H (Output Tr ON)	L (Output Tr ON)
H	L	L	L(Output Tr OFF)	L (Output Tr OFF)	H (Output Tr OFF)
L	H	L	L(Output Tr OFF)	L (Output Tr OFF)	L (Output Tr ON)

◎BD6712AF

H+	H-	OUT1	OUT2	FG
H	L	H	L	H (Output Tr OFF)
L	H	L	H	L (Output Tr ON)

●Reference Data

◎BD6706FV

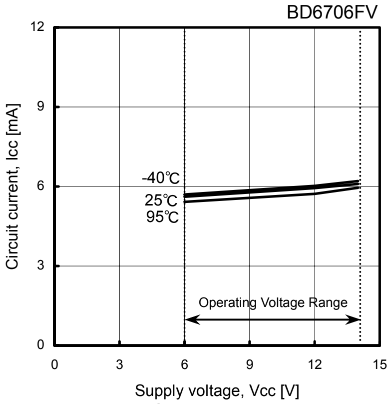


Fig.1 Circuit current

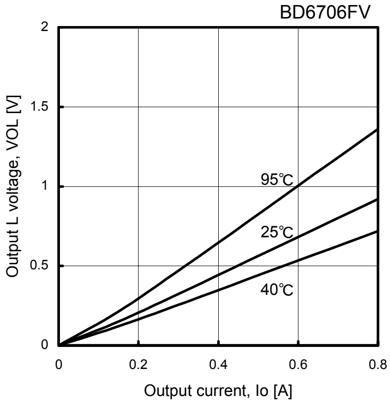


Fig.2 Output L voltage

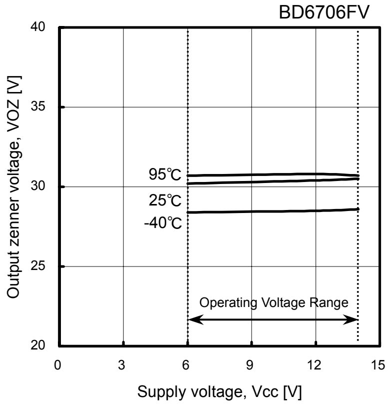


Fig.3 Output zenner voltage

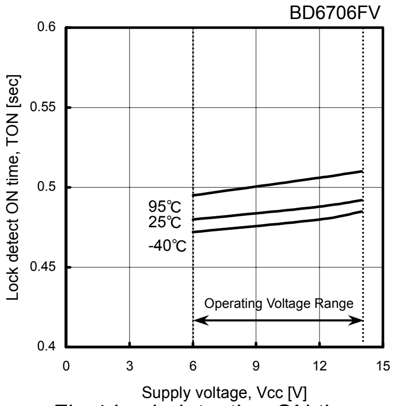


Fig.4 Lock detection ON time

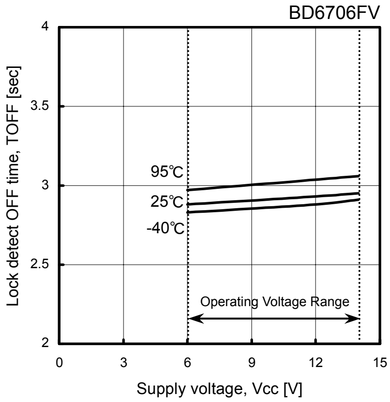


Fig.5 Lock detection OFF time

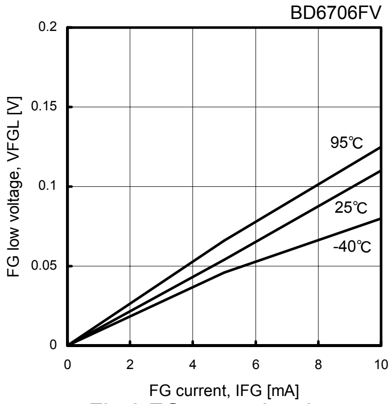


Fig.6 FG output L voltage

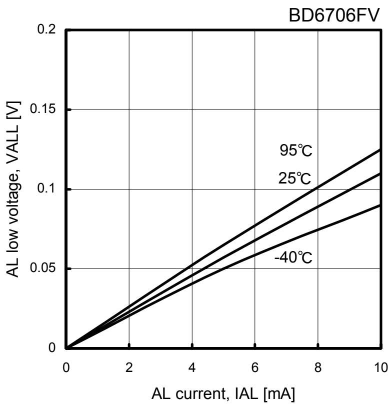


Fig.7 AL output L voltage

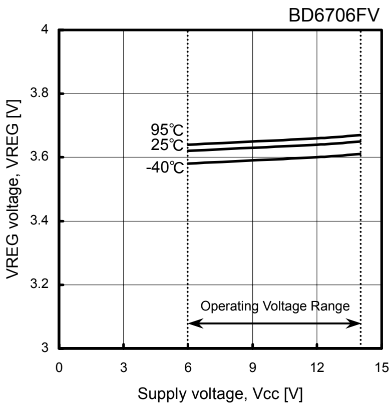


Fig.8 Vreg terminal voltage

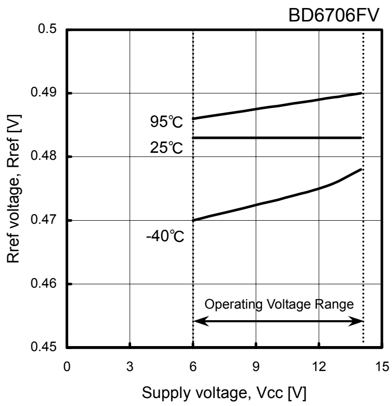


Fig.9 Rref terminal voltage

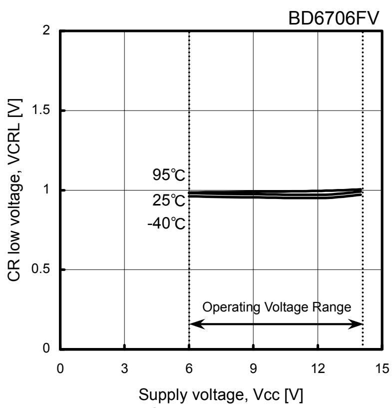


Fig.10 CR terminal L level

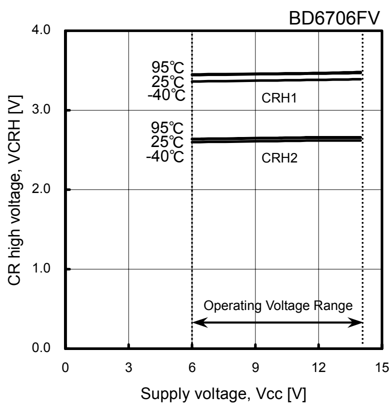


Fig.11 CR terminal H level 1, 2

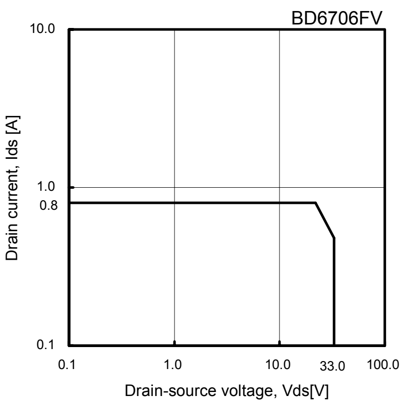


Fig.12 Output Tr ASO
(TON=100msec)

◎BD6701F

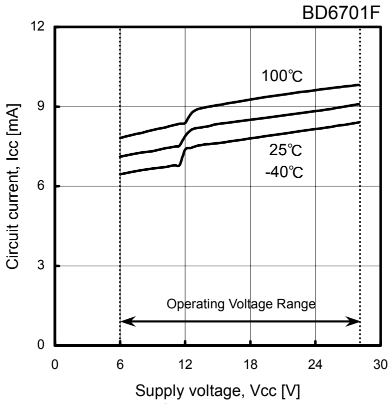


Fig.13 Circuit current

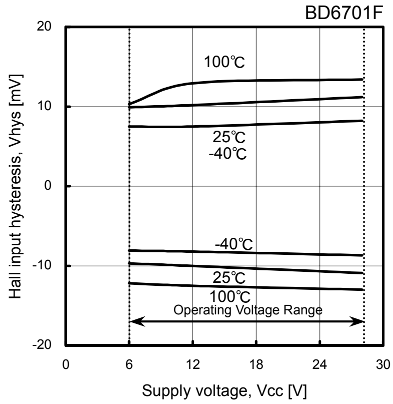


Fig.14 Hall input hysteresis

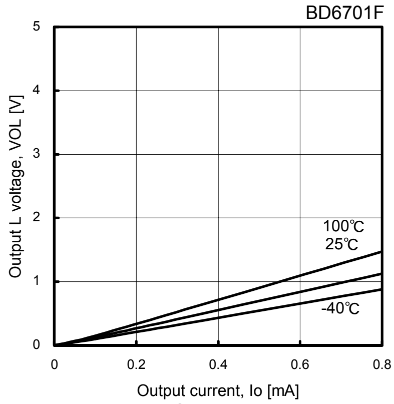


Fig.15 Output L voltage

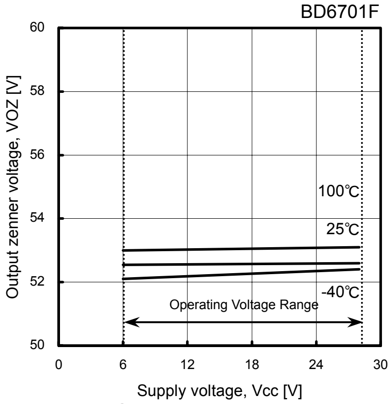


Fig.16 Output zenner voltage

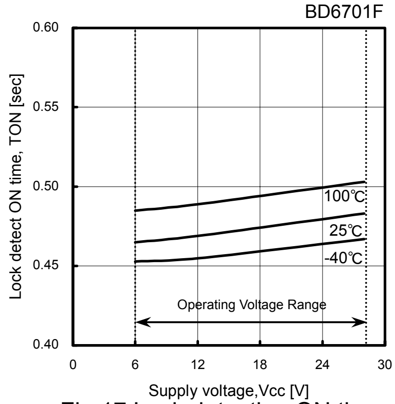


Fig.17 Lock detection ON time

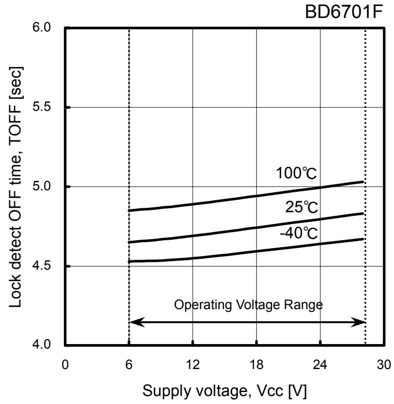


Fig.18 Lock detection OFF time

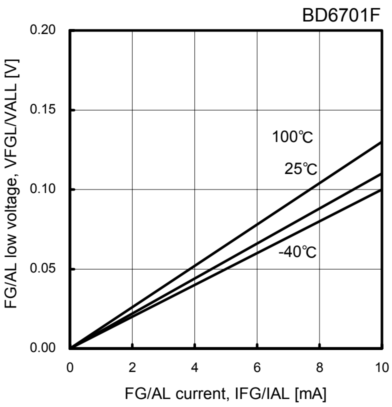


Fig.19 FG/AL output L voltage
(Temperature characteristics)

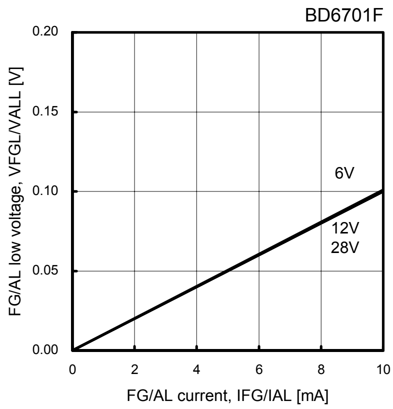


Fig.20 FG/AL output L voltage
(Voltage characteristics)

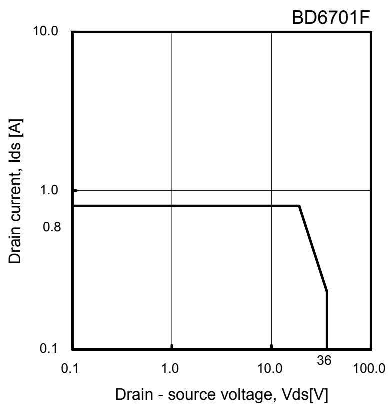


Fig.21 Output Tr ASO
(Ton=100msec)

◎BA6406F

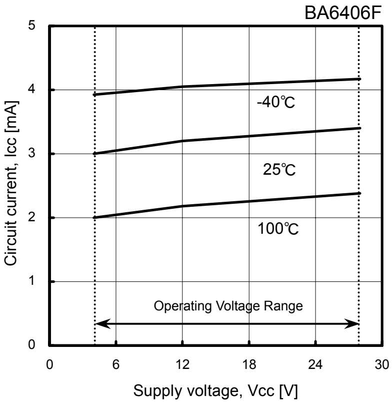


Fig.22 Circuit current

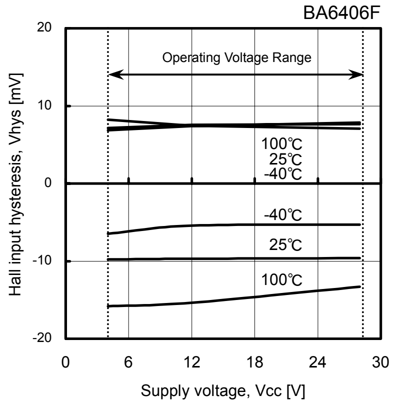


Fig.23 Hall input hysteresis

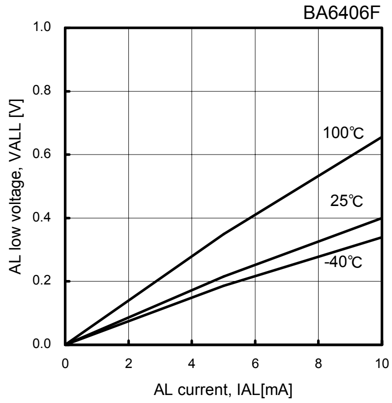


Fig.24 AL output L voltage

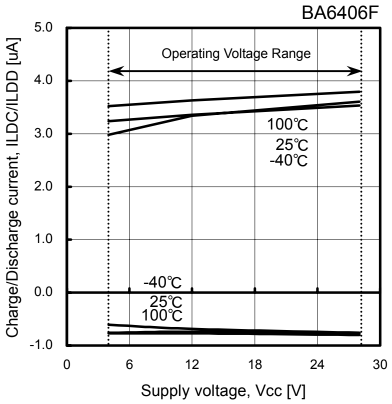


Fig.25 Charge-discharge current of capacitor for lock detection

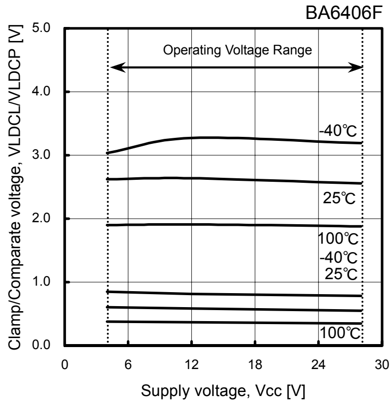


Fig.26 Clamp-comparison voltage of capacitor for lock detection

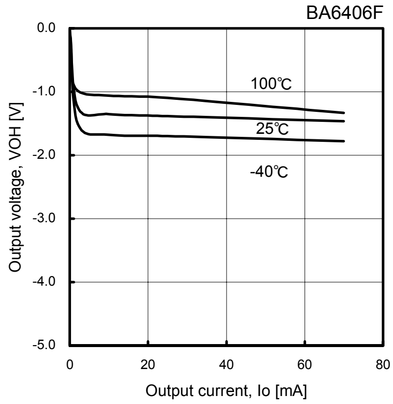


Fig.27 Output H voltage

◎BA6901F

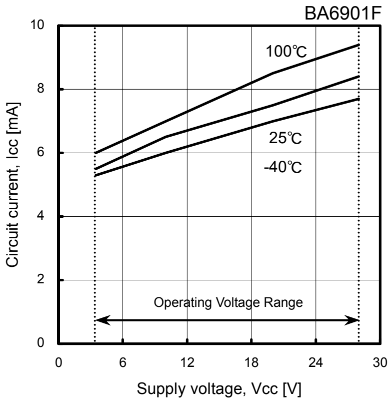


Fig.28 Circuit current

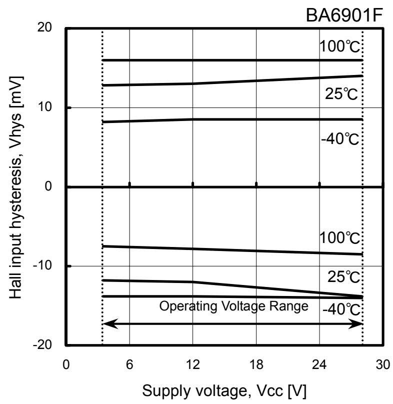


Fig.29 Hall input hysteresis

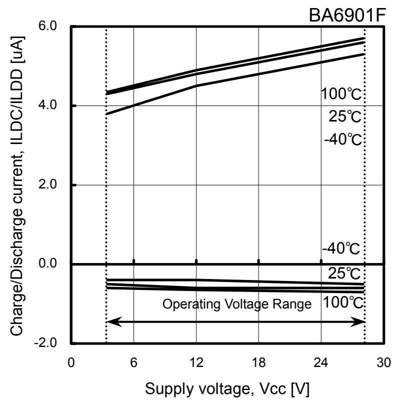


Fig.30 Charge-discharge current of capacitor for lock detection

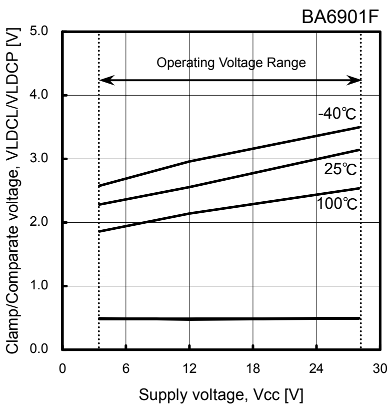


Fig.31 Clamp-comparison voltage of capacitor for lock detection

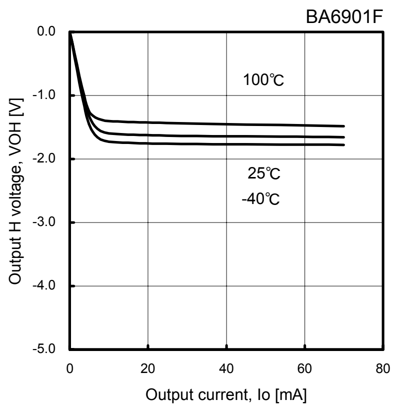


Fig.32 Output H voltage

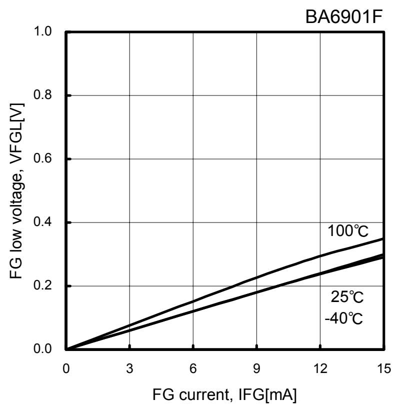


Fig.33 FG Output L voltage

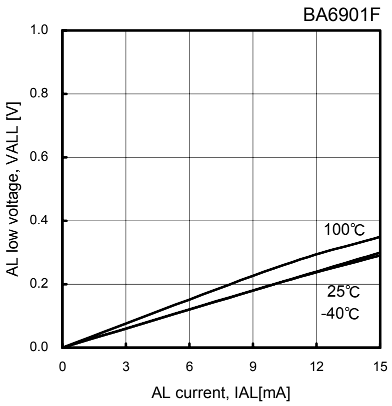


Fig.34 AL Output L voltage

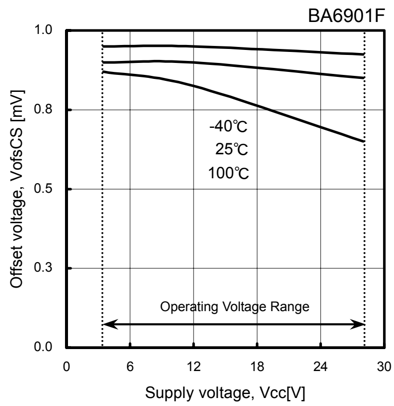


Fig.35 CS-CL offset voltage

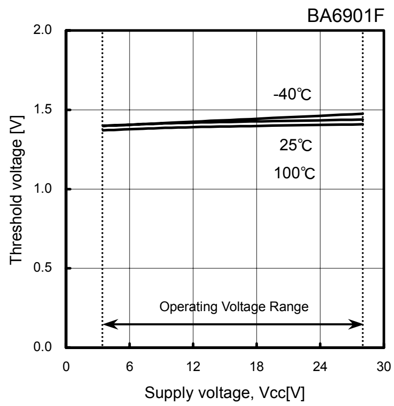


Fig.36 PWM input threshold voltage

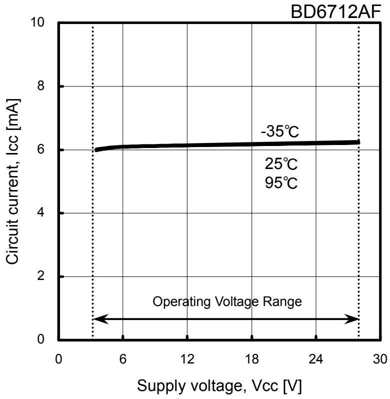


Fig.37 Circuit current

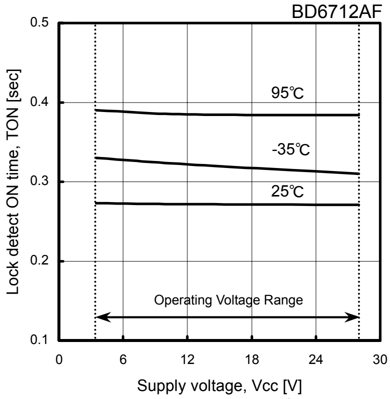


Fig.38 Lock detection ON time

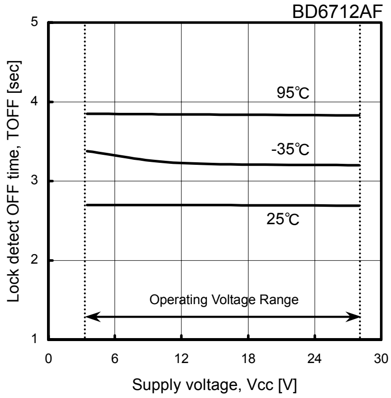


Fig.39 Lock detection OFF time

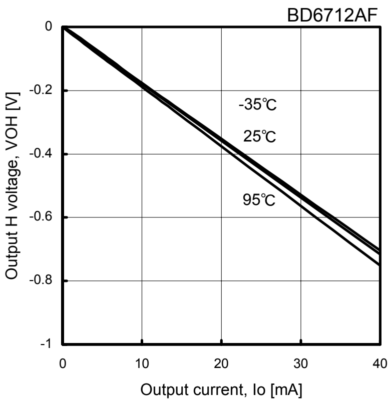


Fig.40 Output H voltage
(Temperature characteristics)

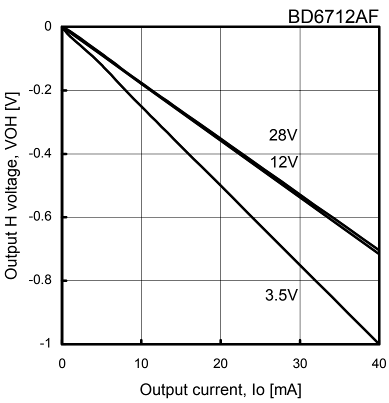


Fig.41 Output H voltage
(Voltage characteristics)

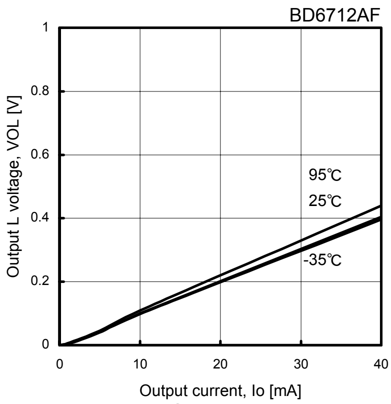


Fig.42 Output L voltage
(Temperature characteristics)

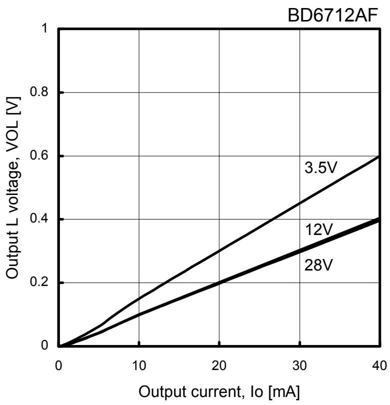


Fig.43 Output L voltage
(Voltage characteristics)

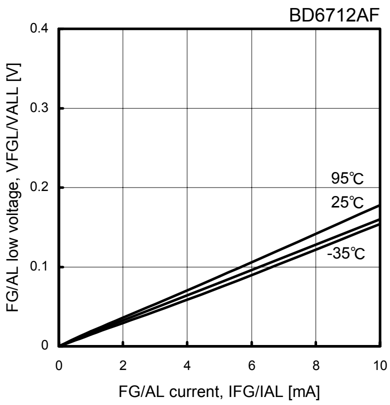


Fig.44 FG/AL output L voltage
(Temperature characteristics)

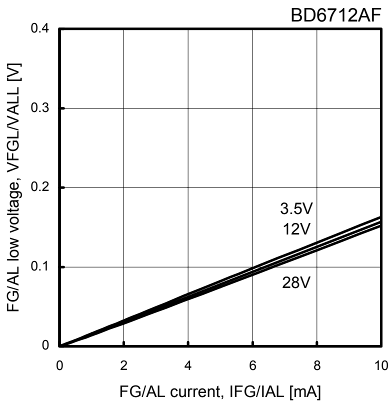
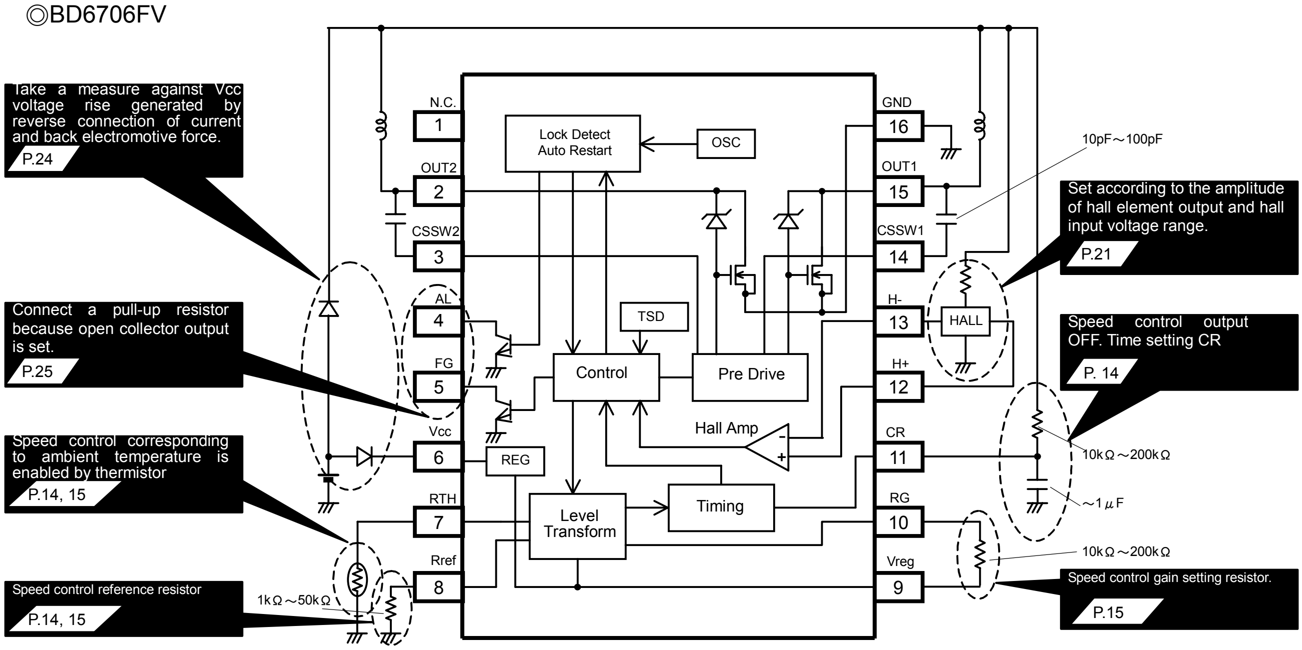


Fig.45 FG/AL output L voltage
(Voltage characteristics)

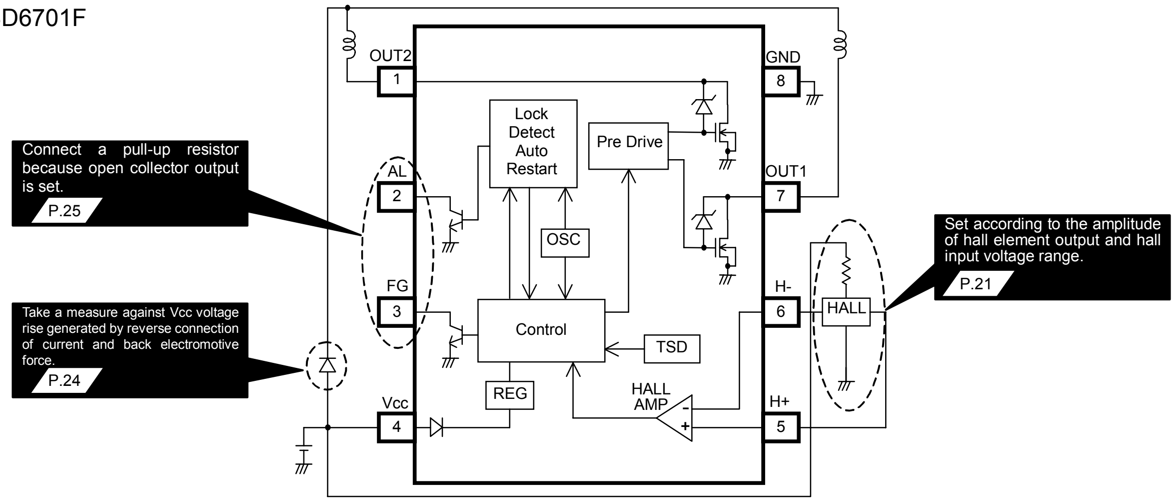
●Block diagram, application circuit, and pin assignment

◎BD6706FV



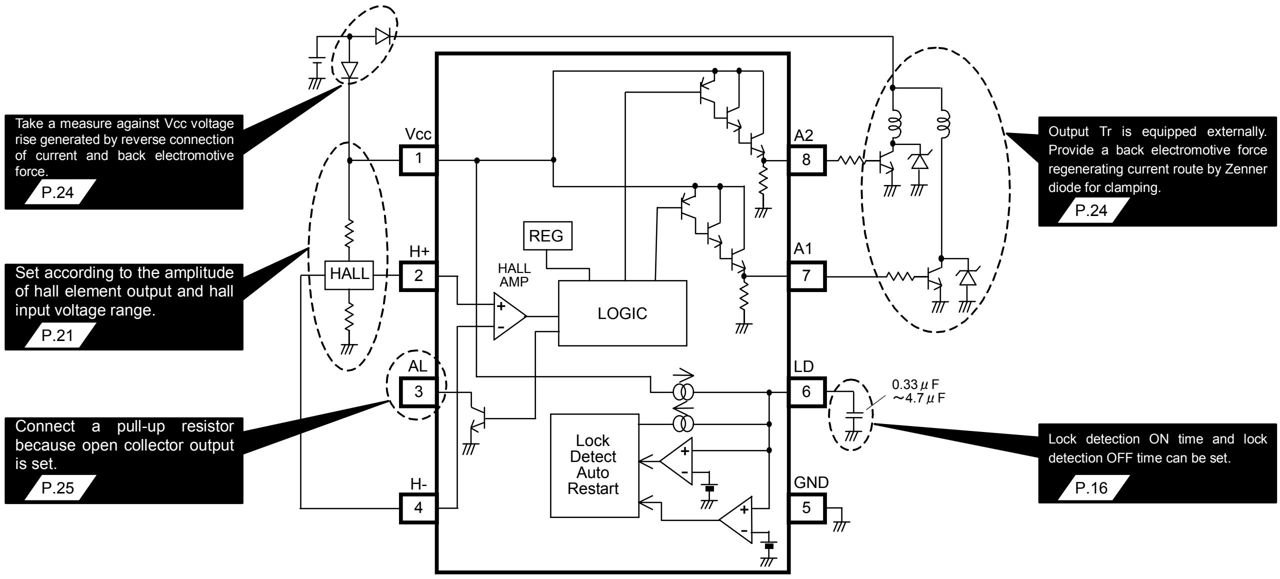
PIN No.	Terminal name	Function	PIN No.	Terminal name	Function
1	N.C.		9	Vreg	Internal power output terminal
2	OUT2	Motor output terminal 2	10	RG	Resistor connecting terminal for setting speed control gain
3	CSSW2	Capacitor connecting terminal for soft switching	11	CR	Capacitor and resistor connecting terminal for timing circuit
4	AL	Lock alarm signal output terminal	12	H+	Hall input terminal +
5	FG	Rotating speed pulse signal output terminal	13	H-	Hall input terminal -
6	Vcc	Power supply terminal	14	CSSW1	Capacitor connecting terminal for soft switching
7	RTH	Thermistor connection terminal	15	OUT1	Motor output terminal 1
8	Rref	Reference resistance connection terminal	16	GND	GND terminal

◎BD6701F



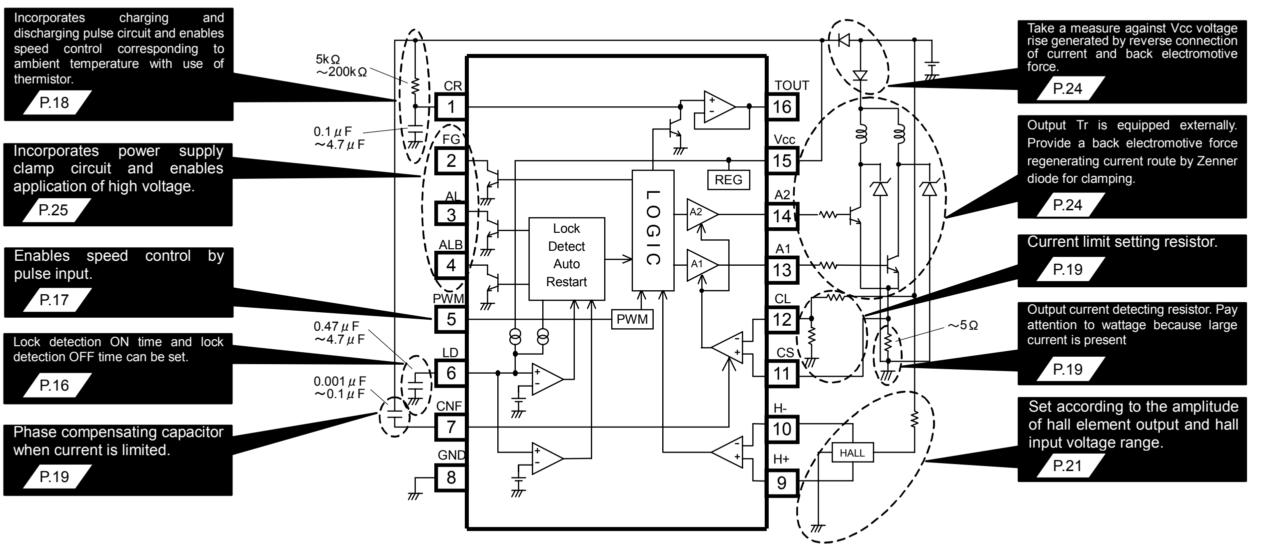
PIN No.	Terminal name	Function
1	OUT2	Motor output terminal 2
2	AL	Lock alarm signal output terminal
3	FG	Rotating speed pulse signal output terminal
4	Vcc	Power terminal
5	H+	Hall input terminal+
6	H-	Hall input terminal-
7	OUT1	Motor output terminal 1
8	GND	GND terminal

◎BA6406F



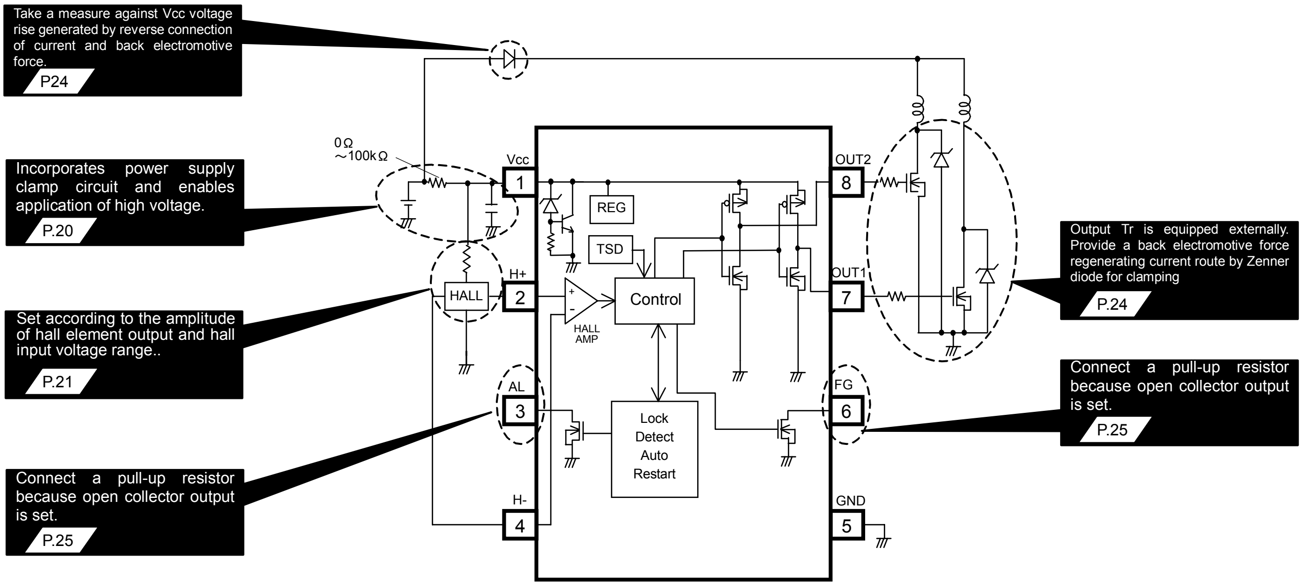
PIN No.	Terminal name	Function
1	Vcc	Power terminal
2	H+	Hall input terminal +
3	AL	Lock alarm signal output terminal
4	H-	Hall input terminal -
5	GND	GND terminal
6	LD	Lock detection and automatic restart capacitor connecting terminal
7	A1	Output terminal 1
8	A2	Output terminal 2

◎BA6901F



PIN No.	Terminal name	Function	PIN No.	Terminal name	Function
1	CR	Charging and discharging pulse circuit capacitor and resistor connecting terminal	9	H+	Hall input terminal +
2	FG	Rotating speed pulse signal output terminal	10	H-	Hall input terminal -
3	AL	Lock alarm signal output terminal	11	CS	Current detecting input terminal
4	ALB	Lock alarm signal terminal(inversion signal of AL)	12	CL	Current limiting input terminal
5	PWM	PWM input terminal(H or OPEN:Output ON, L:Output OFF)	13	A1	Output terminal 1
6	LD	Lock detection and automatic restart capacitor connecting terminal	14	A2	Output terminal 2
7	CNF	Phase compensating capacitor connecting terminal	15	Vcc	Power terminal
8	GND	GND terminal	16	TOUT	Charging and discharging pulse output terminal

◎BD6712AF



PIN No.	Terminal name	Function
1	Vcc	Power terminal
2	H+	Hall input terminal+
3	AL	Lock alarm signal output terminal
4	H-	Hall input terminal
5	GND	GND terminal
6	FG	Rotating speed pulse signal output terminal
7	OUT1	Output terminal 1
8	OUT2	Output terminal 2

●Description of operations

Function table

		BD6706FV	BD6701F	BA6406F	BA6901F	BD6712AF	Reference page
Temperature speed control		○					P.14,15
Lock protection auto restart	Incorporated counter	○	○			○	P.15
	CR timer			○	○		P.16
PWM input					○		P.17
Variable speed control					○		P.17,18
Current limit circuit					○		P.19
Supply voltage clamping circuit						○	P.20
FG output		○	○		○	○	P.25
AL output		○	○	○	○	○	P.25

1) Temperature variable speed control ＜BD6706FV＞

By connecting an external capacitor (Ccr) and resistor (Rcr) to CR terminal, the capacitor is charged and discharged according to the cycle of hall signal. Output OFF time according to charge and discharge of CR terminal is provided for reduced speed rotation. (See Fig. 46)

Output OFF time depends on CR terminal H level, which varies with the change of resistance, resulting from ambient temperature of thermistor. CR terminal H level is designed to change by comparing the current which flows in the thermistor connected to RTH terminal and reference resistor connected to Rref terminal. When the resistance of thermistor is above reference resistance, CR terminal H level reaches the maximum (3.7V:typ.), which provides the minimum rotation speed.

When the ambient temperature becomes higher and the resistance of thermistor becomes smaller than reference resistance, CR terminal H level becomes lower and output time shorter, which increases the rotation speed of motor. When CR terminal H level is below CR terminal L level (1.0V:typ.), output OFF time is lost, which provides the maximum rotation speed. Thermistor installation position (position for detecting temperature) is far from IC, and it is designed that the motor rotates at its full speed when connection wire falls off in connecting thermistor with connection wire.

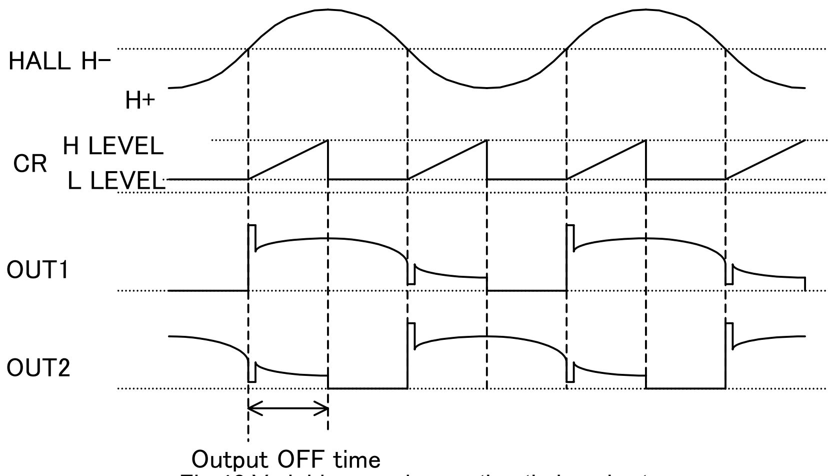


Fig.46 Variable speed operation timing chart

○Setting of external Ccr and Rcr terminal mounting

Set the value of capacitor (Ccr) and resistor (Rcr) to be connected to CR terminal depending on output OFF time required for setting the minimum rotation speed. Output OFF time (T0) can be shown by the formula below:

$$To=-Ccr \times Rcr \times \ln \frac{1-VCRH/Vcc}{1-VCRL/Vcc}$$

VCRH ：Maximum value of CR terminal H level (3.7V:typ.)

VCRL ：CR terminal L level (1.0V:typ.)

For reference, it can be calculated as follows when VCC=12.0V, Ccr=0.1 μF, and Rcr=100 kΩ.

To≒2.82msec

○Setting of rotation speed control

0.5V (typ.) is output to Rth and Rref terminal, and when resistor Rref is connected to Rref terminal and thermistor Rth to Rth terminal, then the current flowing in Rref terminal and RTH terminal (Iref, Irth) is respectively as follows:

$$Iref=0.5/Rref$$
$$Irth=0.5/Rth$$

CR terminal level changes with electric current difference between Iref and Irth.
CR terminal H level VCRH can be represented by the formula below:

$$VCRH=VREG-2\times(0.5/RTH-0.5/Rref)\times Rgain$$

Rgain：Gain setting resistor to be connected between VREG and RG terminal

Resistance of thermistor RTH is in general represented by the formula below:

$$RTH=Ro\times \exp \cdot B(1/Ta-1/To)$$

Ro：Resistance [Ω] at reference temperature T0 (normally 25ºC = 298K)
Ta：Ambient temperature [K]
B：B constant [K]

Thermistor has negative temperature characteristics against ambient temperature Ta as shown above, and has a small resistance at a higher temperature.
When Rref > Rth, the motor increases is rotating speed from the minimum rotating speed.
Taking an example where rotating speed control range is from 28 to 35ºC on a thermistor of R0 = 10kΩ and B = 4000K, resistance at each temperature of thermistor is calculated as follows by the formula of RTH:

At 28ºC：8.748kΩ
At 35ºC：6.467kΩ

In order to ensure that the rotation speed changes at 28ºC and higher, set Rref to 8.748kΩ which is the resistance of thermistor at 28ºC. Set Rgain so that CR terminal H level at 35 ºC becomes 1V to be full speed at 35 ºC. Rgain can be calculated as follows by the formula of VCRH described earlier:

Rgain=66.965kΩ

2) Lock protection and automatic restart

○Incorporated counter system ＜BD6706FV、BD6701F、BD6712AF＞

Motor rotation is detected by hall signal, and lock detection ON time (TON) and lock detection OFF time (TOFF) are set by IC internal counter. Timing chart is shown in Fig.47.

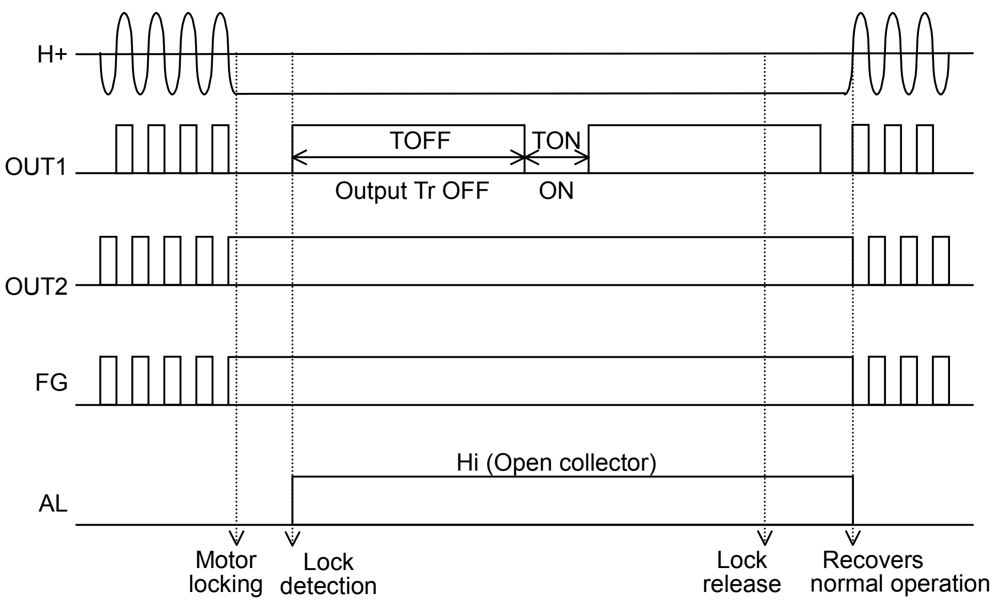


Fig.47 Lock protection (incorporated counter system) timing chart

○CR timer system <BA6406F、BA6901F>

Charging and discharging time at LD terminal depends on the capacitor equipped externally on LD terminal. Charging and discharging time is determined as follows:

$$TON(\text{charging time}) = \frac{C \times (VLDCL - VLDCP)}{ILDC}$$

$$TOFF(\text{discharging time}) = \frac{C \times (VLDCL - VLDCP)}{ILDD}$$

C	:	Capacity of capacitor equipped externally on LD terminal
VLDCL	:	LD terminal clamping voltage
VLDCP	:	LD terminal comparator voltage
ILDC	:	LD terminal charging current
ILDD	:	LD terminal discharging current

For reference, charging and discharging time when C = 1.0μF can be calculated as follows(BA6901F);

Charging time＝0.36sec(output ON)

Discharging time＝3.6sec(output OFF)

Timing chart of LD terminal is shown in Fig.48.

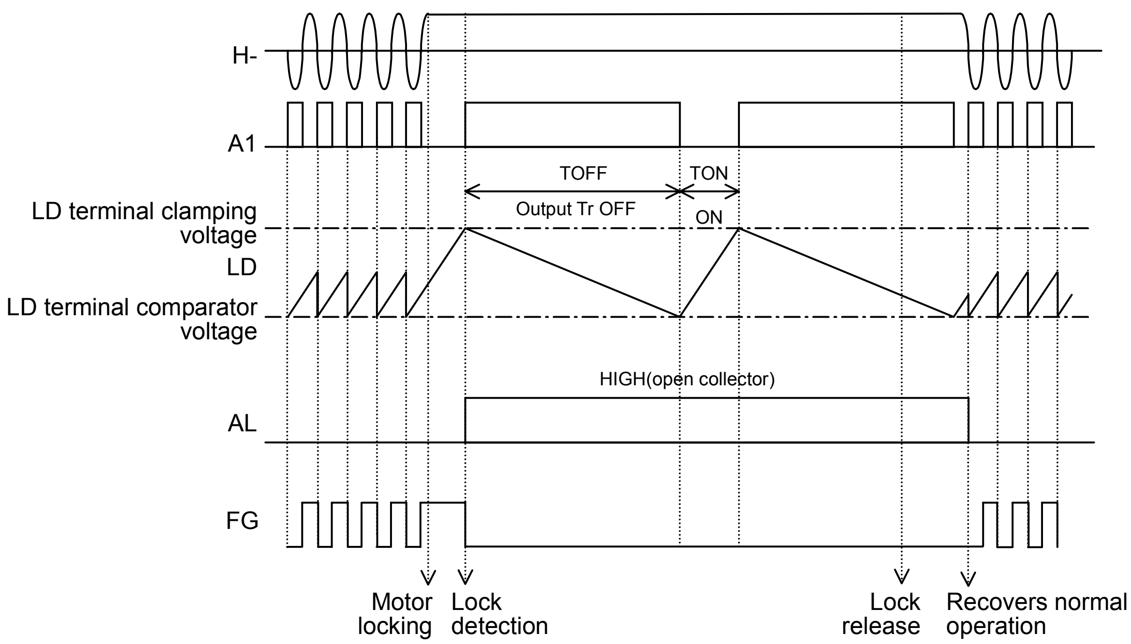


Fig.48 Lock protection (CR timer system) timing chart

When the motor is locked with hall input terminal (H-) in Lo status, FG logic is reversed.

AL might be high for few hundred ms in turning on. (BA6406F)

3) PWM terminal ＜BA6901F＞

The signal input to PWM terminal is below L (0.8V or less), output (A1 and A2) turns off. And when it is above H (2.0V or more), output turns on. PWM terminal is pulled up by resistor (30kΩ:typ.) inside IC. When it is open, the output is in operating mode.

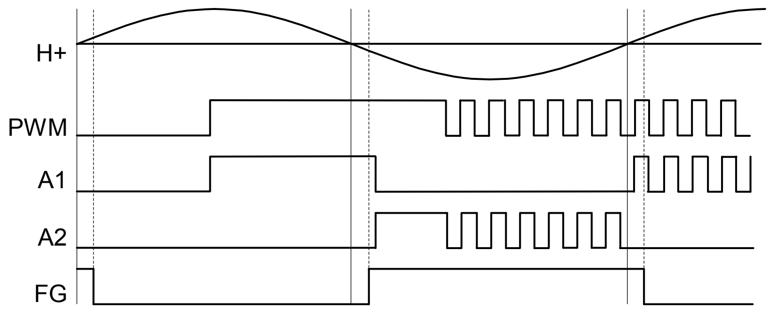


Fig.49 Timing chart in PWM control

4) Charging and discharging pulse circuit compatible with temperature variable speed control ＜BA6901F＞

When an external capacitor and resistor are connected to CR terminal, saw wave is generated by charging and discharging of capacitor corresponding to the cycle of hall signal. Saw wave of CR terminal changes with the external capacitor and resistor. Waveform of CR terminal is output to TOUT by buffer amplifier.

CR terminal is variable from VCRCP (0.35V:typ., see the electric characteristics) to Vcc. When CR voltage is above Vcc-VTOH (1V:typ., see the electric characteristics), CR terminal signal is not output to TOUT terminal as shown in Fig.50.

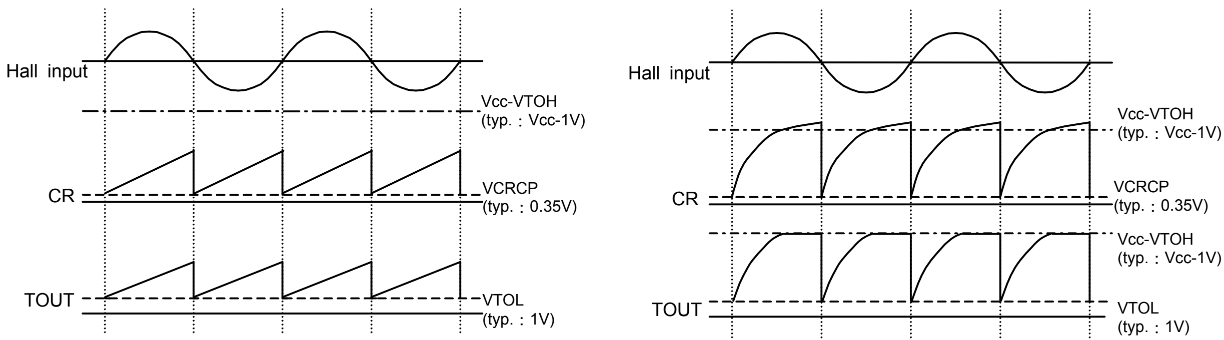


Fig.50 CR terminal and TOUT terminal timing chart

5) Variable speed control application <BA6901F>

This is an example of the application which makes the fan motor rotating speed variable corresponding to ambient temperature with thermistor by use of charging and discharging pulse circuit and PWM input.

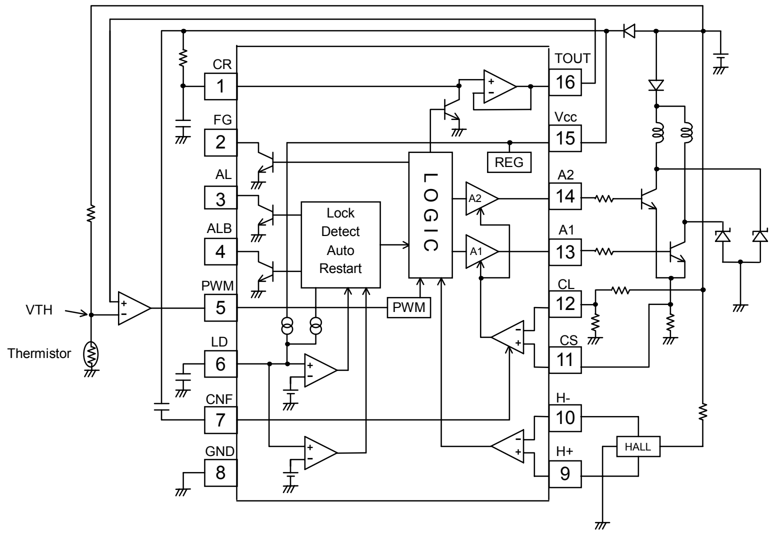


Fig. 51 Example of temperature variable speed application

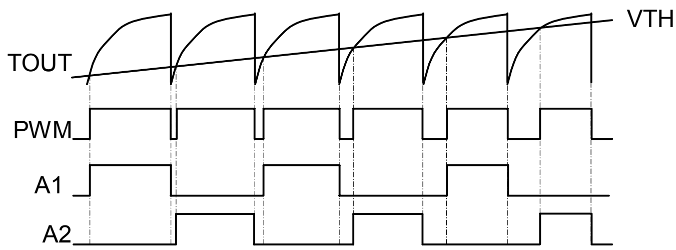


Fig. 52 Temperature variable speed timing chart

When the temperature becomes the lower and the thermistor terminal voltage the higher, PWM pulse becomes the shorter and speed is reduced as shown in Fig. 52.

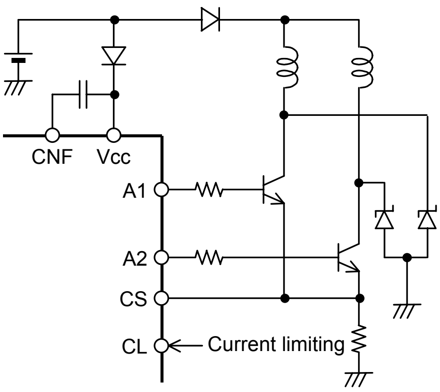
6) Current limiting circuit ＜BA6901F＞

Output current limitation can be set by the voltage (VCL) input to CL terminal. Connect a resistor (RNF) for detecting output current between the emitter of external output transistor and GND, and input the voltage generated by resistor to CS terminal, thereby detecting the output current. The output current is limited so that CL terminal and CS terminal has the same potential. There is an offset between CL terminal and CS terminal. Current limiting value can be calculated by the formula below:

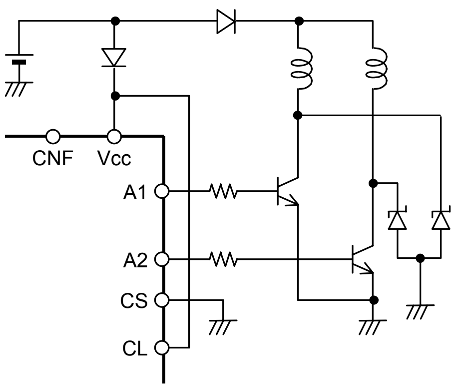
$$\text{Current limiting value} = \frac{VCL - VofsCS}{RNF}$$

VofsCS = CL-CS offset

When limiting the output current, capacitor for phase compensation must be connected between CNF terminal and Vcc terminal. When the output current is not to be limited, fix CL terminal voltage to High level (Vcc) and CS terminal to Low level (GND).



(a) When current limiting is applied



(b) When current limiting is not applied

Fig.53 External circuit of output

7) Power supply voltage clamping circuit <BD6712AF>

When the external supply voltage exceeds supply clamping voltage Vcz (see the electric characteristics), supply clamping turns on. Adjust the capacity of bypass capacitor (C2) so that the transient peak voltage does not exceed the maximum of supply clamping voltage at IC power supply terminal (Vcc).

When you use the external supply voltage above supply clamping voltage, insert the limiting resistor (R1) between the external supply and IC supply terminal. Set the limiting resistor (R1) so that Icc does not exceed the operation power supply amperage.

Example of calculation for BD6712AF is shown below:

External supply voltage	: VS	Supply clamping voltage	: Vcz=6V(typ.)
Supply current limiting resistor	: R1	Hall current limiting resistor	: R2
Circuit crrent	: Icc	Hall element current	: IH
Supply terminal voltage	: Vcc	Hall element resistance	: RH

Then,

$$R1 = \frac{VS - Vcc}{Icc + IH} \quad \cdots ①$$

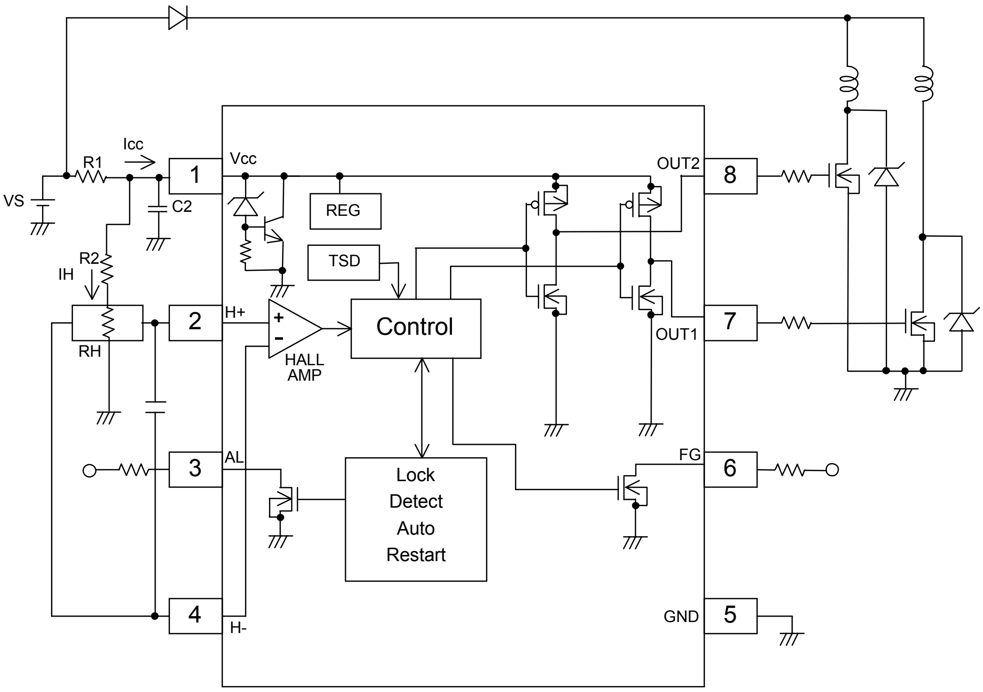


Fig.54 Example of supply voltage clamping application circuit

Assuming R2 = 2kΩ and RH = 0.5kΩ, IH is calculated as follows:

$$IH = \frac{Vcc}{R2 + RH} \quad \cdots ②$$

$$= 6V / (2k\Omega + 0.5k\Omega)$$

$$= 2.4mA$$

Icc has minimum 4mA and maximum 30mA, therefore the minimum and maximum value of R1 is calculated as follows by the formula ①:

VS	R1 Min. value	R1 Max. value
5V	0Ω	0kΩ
24V	550Ω	2.8kΩ
48V	1.3kΩ	6.6kΩ

8) Hall input setting

Hall input voltage range is shown in operating conditions.

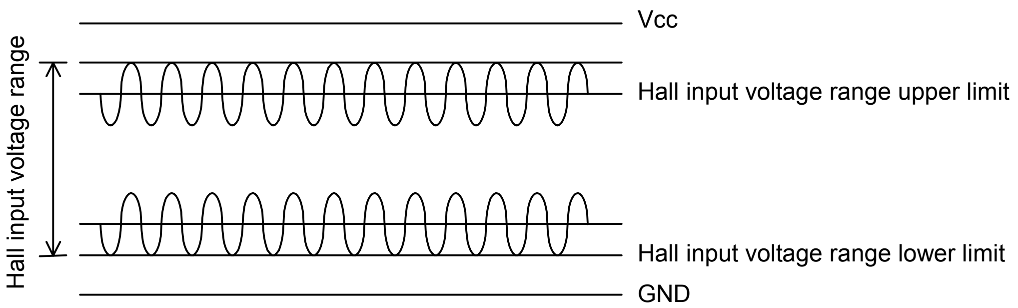


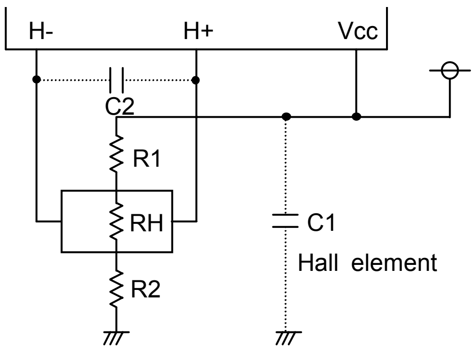
Fig.55 Hall input voltage range

Adjust the hall element bias resistor R1 and R2 in Fig.56 so that the input voltage at hall amplifier is input in "hall input voltage range" including the amplitude of signal.

For a model having hall input voltage range lower limit 0V,R2 = 0Ω is acceptable.

○Reduction of noise of hall signal

Hall element may be affected by Vcc noise or the like depending on the wiring pattern of board. In this case, place a capacitor like C1 in Fig.56. In addition, when wiring from the hall element output to IC hall input is long, noise may be loaded on wiring. In this case, place a capacitor like C2 in Fig.56.



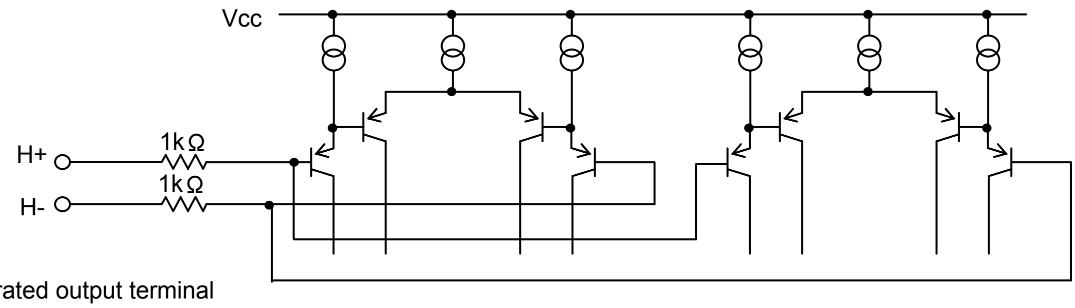
Hall bias current ＝ Vcc / (R1+R2+RH)

Fig.56 Application near of hall signal

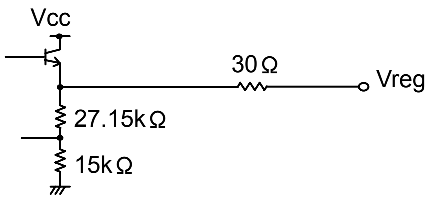
●Equivalent circuit

◎BD6706FV

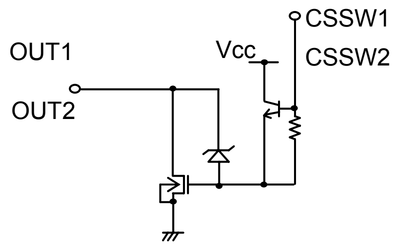
) Hall input terminal



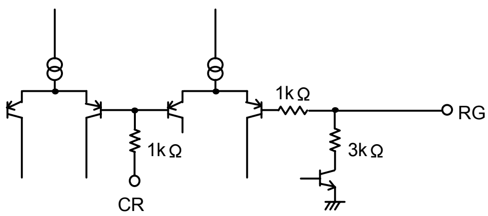
2) Regurated output terminal



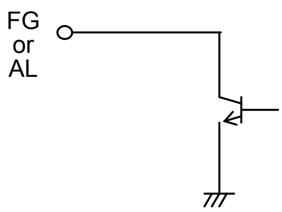
3) Motor output terminal



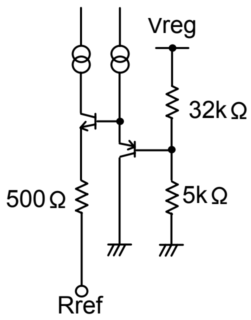
4) Connection terminal of resistor to determine speed control gain



5) FG output terminal or AL output terminal

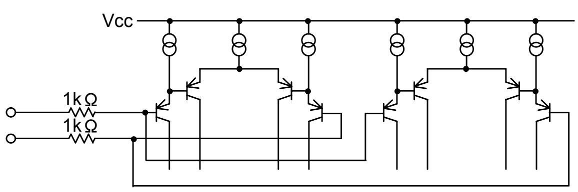


6) Connection terminal of reference register

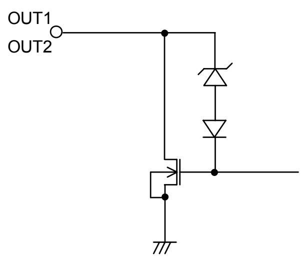


◎BD6701F

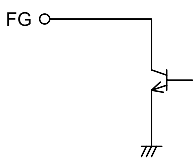
1) Hall input terminal



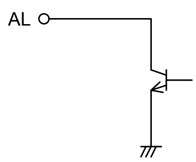
2) Output terminal



3 FG output terminal

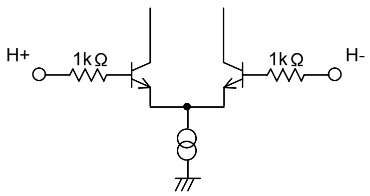


4) AL output terminal

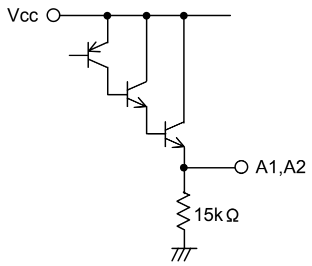


◎BA6406F

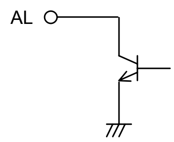
1) Hall input terminal



2) Output terminal

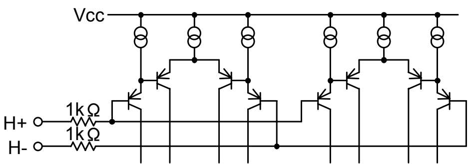


3)AL signal output terminal

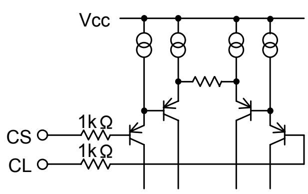


◎BA6901F

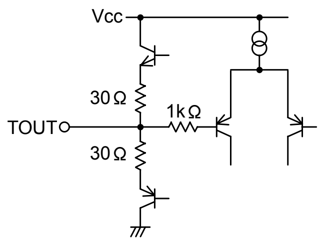
1) Hall input terminal



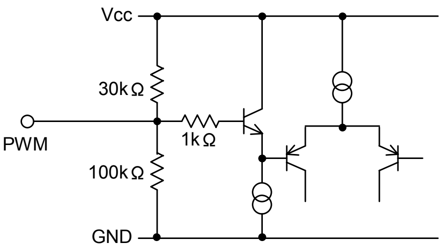
2) Current limiting input terminal
Output current detecting terminal



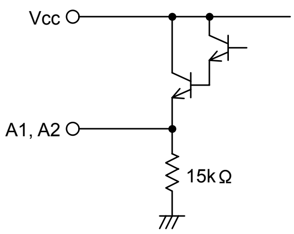
3) Charge-discharge pulse output terminal



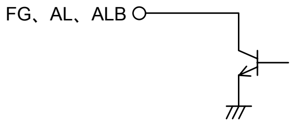
4) PWM input terminal



5) Output terminal

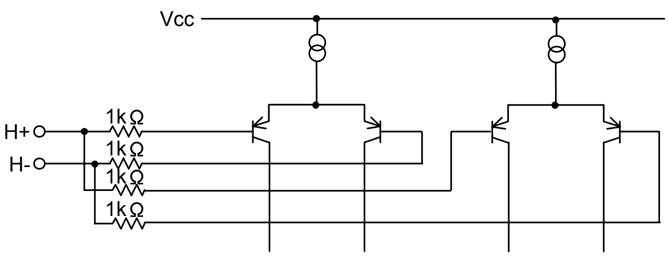


6) Signal output terminal

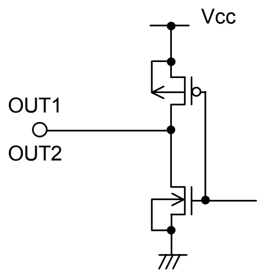


◎BD6712AF

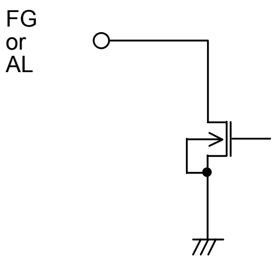
1) Hall input terminal



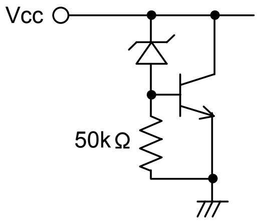
2) Output terminal



3) FG output terminal or AL output terminal



4) Power supply terminal



●Safety measure

1) Reverse connection protection diode

Reverse connection of power results in IC destruction as shown in Fig 57. When reverse connection is possible, reverse connection protection diode must be added between power supply and Vcc.

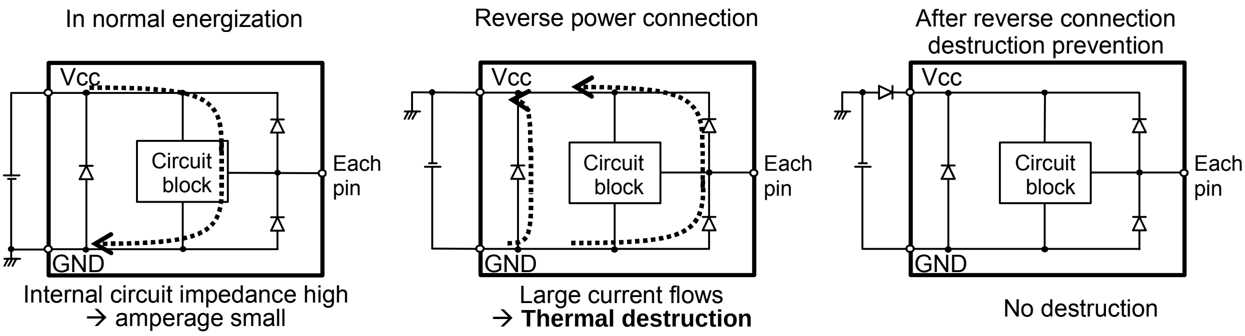


Fig.57 Current flow when power is connected reversely

＊As for BD6701F, this diode is built-in in the IC, so a protection diode between power supply -Vcc terminal is unnecessary.

2) About measures of voltage rise by back electromotive force

The voltage of output terminal rises by back electromotive force. The diode D1 of Fig.58 is necessary to divide a power supply line of motor with small signal line, so that the voltage of the output does not affect a power supply line.

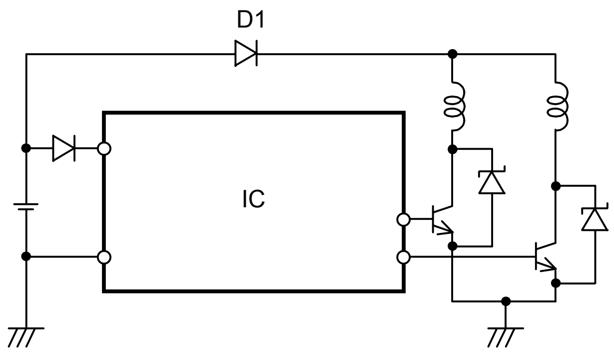


Fig.58 Separation of a power supply line

The models that incorporate power Tr (BD6706FV, BD6701F) have the circuit, which clamps the output voltage so that back electromotive force does not exceed the maximum rating voltage of output Tr.

3) FG, AL output

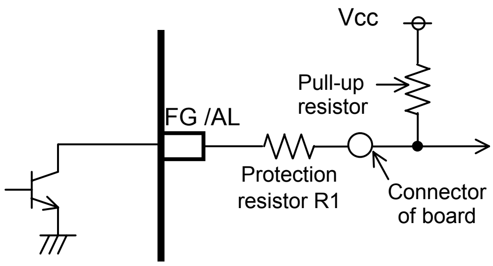


Fig.59 Protection of FG and AL terminal

FG and AL output is an open collector and requires pull-up resistor.
The IC can be protected by adding resistor R1. An excess of absolute maximum rating, when FG or AL output terminal is directly connected to power supply, could damage the IC.

4) Problem of GND line PWM switching
Do not perform PWM switching of GND line because GND terminal potential cannot be kept to a minimum.

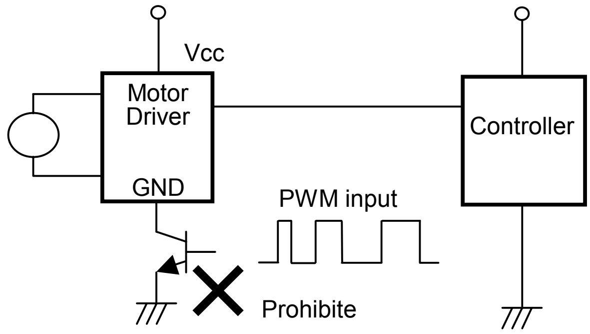


Fig.60 GND Line PWM switching prohibited

● Calculation of power consumption by IC

Power consumption of this IC is approximately calculated as follows:

Pc=Pc1+Pc2+Pc3

- Pc1：Power consumption by circuit current
  Pc1=Vcc×Icc
- Pc2：Power consumption on output stage
  Pc2=VOL×Io
  VOL is the L voltage of output terminal 1 and 2.
  Io is the current flowing to output terminal 1 and 2.
- Pc3：Power consumption at FG and AL
  Pc3=VFG×IFG＋VAL×IAL
  VFG is L voltage of FG output.
  VAL is L voltage of AL output.
  IFG and IAL are the current of FG and AL.

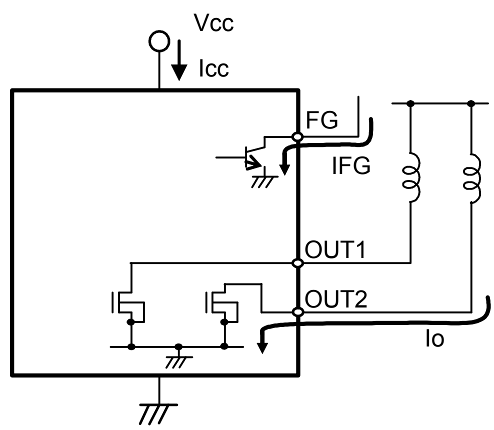


Fig.61 Calculation of power consumption by IC

Power consumption by IC greatly changes with use condition of IC such as power supply voltage and output current.
Consider thermal design so that the maximum power dissipation on IC package is not exceeded.

●Thermal derating curve

Power dissipation (total loss) indicates the power that can be consumed by IC at Ta = 25ºC (normal temperature). IC is heated when it consumes power, and the temperature of IC chip becomes higher than ambient temperature. The temperature that can be accepted by IC chip depends on circuit configuration, manufacturing process, etc, and consumable power is limited. Power dissipation is determined by the temperature allowed in IC chip (maximum junction temperature) and thermal resistance of package (heat dissipation capability). The maximum junction temperature is in general equal to the maximum value in the storage temperature range.

Heat generated by consumed power of IC is radiated from the mold resin or lead frame of package. The parameter which indicates this heat dissipation capability (hardness of heat release) is called heat resistance, represented by the symbol θja [℃/W]. The temperature of IC inside the package can be estimated by this heat resistance. Fig.62 shows the model of heat resistance of the package.

Heat resistance θja, ambient temperature Ta, junction temperature Tj, and power consumption P can be calculated by the equation below:

$$\theta ja = (Tj - Ta) / P \quad [℃/W]$$

Thermal derating curve indicates power that can be consumed by IC with reference to ambient temperature. Power that can be consumed by IC begins to attenuate at certain ambient temperature. This gradient is determined by thermal resistance θja.

Thermal resistance θja depends on chip size, power consumption, package ambient temperature, packaging condition, wind velocity, etc., even when the same package is used. Thermal derating curve indicates a reference value measured at a specified condition. Fig.63 shows a thermal derating curve (Value when mounting FR4 glass epoxy board 70 [mm] x 70 [mm] x 1.6 [mm] (copper foil area below 3 [%]))

$$\theta ja = (Tj-Ta) / P \quad [℃/W]$$

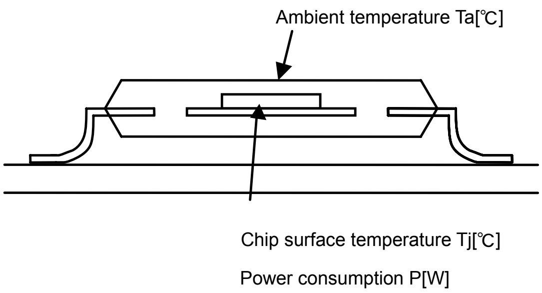
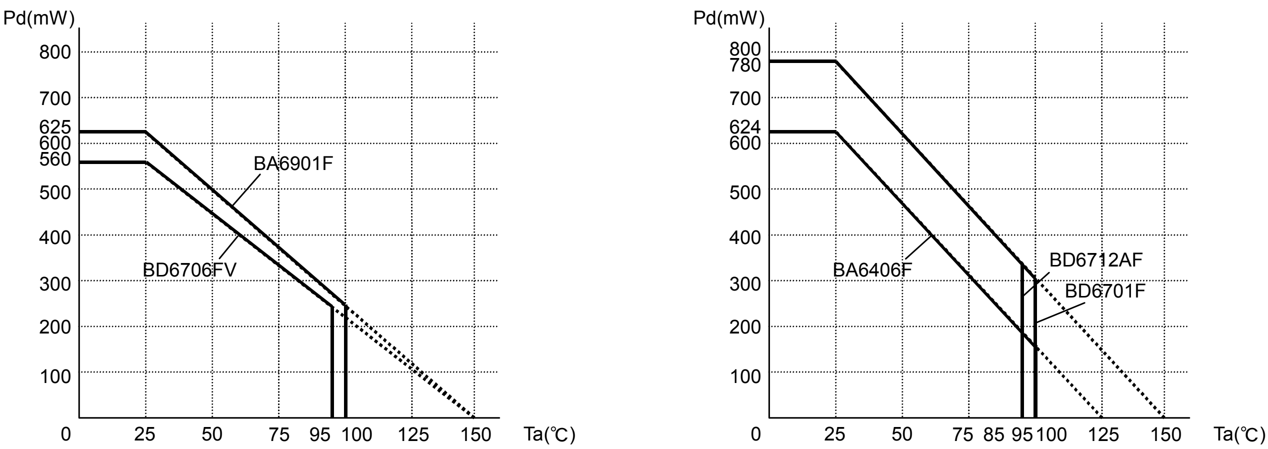


Fig.62 Thermal resistance



＊ Reduce by 4.48 mW/°C over 25°C.＜BD6706FV＞
Reduce by 6.24 mW/°C over 25°C.＜BD6701F, BA6406F, BD6712AF＞
Reduce by 5.0 mW/°C over 25°C.＜BA6901F＞
(70.0mm×70.0mm×1.6mm glass epoxy board)

Fig.63 Thermal derating curve

●Cautions on use

1) Absolute maximum ratings
An excess in the absolute maximum rations, such as supply voltage, temperature range of operating conditions, etc., can break down the devices, thus making impossible to identify breaking mode, such as a short circuit or an open circuit. If any over rated values will expect to exceed the absolute maximum ratings, consider adding circuit protection devices, such as fuses.

2) Connecting the power supply connector backward
Connecting of the power supply in reverse polarity can damage IC. Take precautions when connecting the power supply lines. An external direction diode can be added.

3) Power supply line
Back electromotive force causes regenerated current to power supply line, therefore take a measure such as placing a capacitor between power supply and GND for routing regenerated current. And fully ensure that the capacitor characteristics have no problem before determine a capacitor value. (when applying electrolytic capacitors, capacitance characteristic values are reduced at low temperatures)

4) GND potential
The potential of GND pin must be minimum potential in all operating conditions. Also ensure that all terminals except GND terminal do not fall below GND voltage including transient characteristics. However, it is possible that the motor output terminal may deflect below GND because of influence by back electromotive force of motor. Malfunction may possibly occur depending on use condition, environment, and property of individual motor. Please make fully confirmation that no problem is found on operation of IC.

5) Thermal design
Use a thermal design that allows for a sufficient margin in light of the power dissipation(Pd) in actual operating conditions.

6) Inter-pin shorts and mounting errors
Use caution when positioning the IC for mounting on printed circuit boards. The IC may be damaged if there is any connection error or if pins are shorted together.

7) Actions in strong electromagnetic field
Use caution when using the IC in the presence of a strong electromagnetic field as doing so may cause the IC to malfunction.

8) ASO
When using the IC, set the output transistor so that it does not exceed absolute maximum rations or ASO.

9) Thermal shut down circuit(＊1)
The IC incorporates a built-in thermal shutdown circuit (TSD circuit). Operation temperature is 175℃(typ.) and has a hysteresis width of 25℃(typ.). When IC chip temperature rises and TSD circuit works, the output terminal becomes an open state. TSD circuit is designed only to shut the IC off to prevent thermal runaway. It is not designed to protect the IC or guarantee its operation. Do not continue to use the IC after operation this circuit or use the IC in an environment where the operation of this circuit is assumed. (＊1:BA6406F does not incorporate TSD circuit.)

10) Testing on application boards
When testing the IC on an application board, connecting a capacitor to a pin with low impedance subjects the IC to stress. Always discharge capacitors after each process or step. Always turn the IC's power supply off before connecting it to or removing it from a jig or fixture during the inspection process. Ground the IC during assembly steps as an antistatic measure. Use similar precaution when transporting or storing the IC.

11) GND wiring pattern
When using both small signal and large current GND patterns, it is recommended to isolate the two ground patterns, placing a single ground point at the ground potential of application so that the pattern wiring resistance and voltage variations caused by large currents do not cause variations in the small signal ground voltage. Be careful not to change the GND wiring pattern of any external components, either.

12) Capacitor between output and GND
When a large capacitor is connected between output and GND, if Vcc is shorted with 0V or GND for some cause, it is possible that the current charged in the capacitor may flow into the output resulting in destruction. Keep the capacitor between output and GND below 100uF.

13) IC terminal input
When Vcc voltage is not applied to IC, do not apply voltage to each input terminal. When voltage above Vcc or below GND is applied to the input terminal, parasitic element is actuated due to the structure of IC. Operation of parasitic element causes mutual interference between circuits, resulting in malfunction as well as destruction in the last. Do not use in a manner where parasitic element is actuated.

14) In use
We are sure that the example of application circuit is preferable, but please check the character further more in application to a part which requires high precision. In using the unit with external circuit constant changed, consider the variation of externally equipped parts and our IC including not only static character but also transient character and allow sufficient margin in determining.

●Ordering part number

・Please order by ordering part number. ・Please confirm the combination of each items. ・Please write the letter close to left when column is blank.

B	D	6	7	0	6	F	V	−	E	2

Part Number

- **BD6706**
- **BD6701**
- **BA6406**
- **BA6901**
- **BD6712A**

Package Type

- **FV : SSOP-B16**
- **F : SOP8, SOP16**

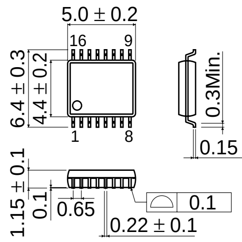
Package specification

E2 Emboss tape read Pi 1 opposite draw- out side

●Physical dimension

SSOP-B16

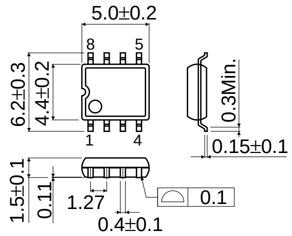
〈Dimension〉



(Unit:mm)

SOP8

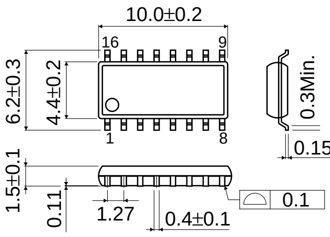
〈Dimension〉



(Unit:mm)

SOP16

〈Dimension〉

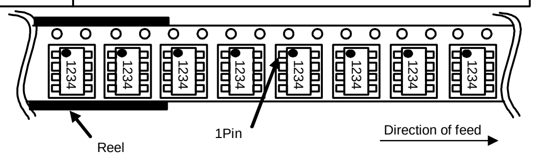


(Unit:mm)

SSOP-B16

〈Tape and Reel information〉

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the lower right when you hold reel on the left hand and you pull out the tape on the right hand)

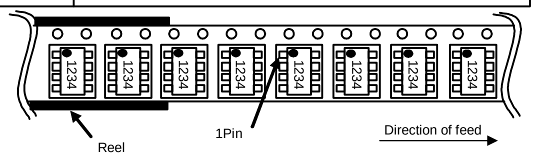


※When you order , please order in times the amount of package quantity.

SOP8/SOP16

〈Tape and Reel information〉

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the lower right when you hold reel on the left hand and you pull out the tape on the right hand)



※When you order , please order in times the amount of package quantity.

The products listed in this catalog are designed to be used with ordinary electronic equipment or devices (such as audio visual equipment, office-automation equipment, communications devices, electrical appliances and electronic toys).
Should you intend to use these products with equipment or devices which require an extremely high level of reliability and the malfunction of which would directly endanger human life (such as medical instruments, transportation equipment, aerospace machinery, nuclear-reactor controllers, fuel controllers and other safety devices), please be sure to consult with our sales representative in advance.

Excellence in Electronics

ROHM CO., LTD.

21, Saiin Mizosaki-cho, Ukyo-ku, Kyoto
615-8585, Japan
TEL: +81-75-311-2121 FAX: +81-75-315-0172
URL http: // www. rohm. com

Published by
LSI Business Promotion Dept.

Contact us for further information about the products.

Seoul	TEL: +82-2-8182-700	FAX: +82-2-8182-715
Masan	TEL: +82-55-240-6234	FAX: +82-55-240-6236
Dalian	TEL: +86-411-8230-8549	FAX: +86-411-8230-8537
Beijing	TEL: +86-10-8525-2483	FAX: +86-10-8525-2489
Tianjin	TEL: +86-22-23029181	FAX: +86-22-23029183
Shanghai	TEL: +86-21-6279-2727	FAX: +86-21-6247-2066
Hangzhou	TEL: +86-571-87658072	FAX: +86-571-87658071
Nanjing	TEL: +86-25-8689-0015	FAX: +86-25-8689-0393
Ningbo	TEL: +86-574-87654201	FAX: +86-574-87654208
Qingdao	TEL: +86-532-5779-312	FAX:+86-532-5779-653
Suzhou	TEL: +86-512-6807-1300	FAX: +86-512-6807-2300
Tianjin	TEL: +86-22-23029181	FAX: +86-22-23029183
Wuxi	TEL: +86-510-82702693	FAX: +86-510-82702992
Hong Kong	TEL: +852-2-740-6262	FAX: +852-2-375-8971
Dongguan	TEL: +86-769-393-3320	FAX: +86-769-398-4140
Fuzhou	TEL: +86-591-8801-8698	FAX: +86-591-8801-8690
Guangzhou	TEL: +86-20-8364-9796	FAX: +86-20-8364-9707
Shenzhen	TEL: +86-755-8307-3001	FAX: +86-755-8307-3003
Xiamen	TEL: +86-592-239-8382	FAX: +86-592-239-8380
Zhuhai	TEL: +86-756-3232-480	FAX: +86-756-3232-460
Taipei	TEL: +866-2-2500-6956	FAX: +866-2-2503-2869
Kaohsiung	TEL: +886-7-237-0881	FAX: +886-7-238-7332
Singapore	TEL: +65-6332-2322	FAX: +65-6332-5662
Manila	TEL: +63-2-807-6872	FAX: +63-2-809-1422
Bangkok	TEL: +66-2-254-4890	FAX: +66-2-256-6334
Kuala Lumpur	TEL: +60-3-7958-8355	FAX: +60-3-7958-8377
Penang	TEL: +60-4-6585084	FAX: +60-4-6585167
Dusseldorf	TEL: +49-2145-9210	FAX: +49-2154-921400
Munich	TEL: +49-8161-48310	FAX: +49-8161-483120
Stuttgart	TEL: +49-711-72723710	FAX: +49-711-72723720
France	TEL: +33-1-5697-3060	FAX: +33-1-5697-3080
United Kingdom	TEL: +44-1-908-306700	FAX: +44-1-908-235788
Denmark	TEL: +45-3694-4739	FAX: +45-3694-4789
Barcelona	TEL: +34-9375-24320	FAX: +34-9375-24410
Malaga	TEL: +34-9520-20263	FAX: +34-9520-20023
Hungary	TEL: +36-1-4719338	FAX: +36-1-4719339
Poland	TEL: +48-22-5757213	FAX: +48-22-5757001
Russia	TEL: +7-95-980-6755	FAX: +7-95-937-8290
San Diego	TEL: +1-858-625-3630	FAX: +1-858-625-3670
Atlanta	TEL: +1-770-754-5972	FAX: +1-770-754-0691
Boston	TEL: +1-978-371-0382	FAX: +1-928-438-7164
Chicago	TEL: +1-847-368-1006	FAX: +1-847-368-1008
Dallas	TEL: +1-972-312-8818	FAX: +1-972-312-0330
Denver	TEL: +1-303-708-0908	FAX: +1-303-708-0858
Nashville	TEL: +1-615-620-6700	FAX: +1-615-620-6702
Guadalajara	TEL: +52-33-3123-2001	FAX: +52-33-3123-2002

Notes

- No technical content pages of this document may be reproduced in any form or transmitted by any means without prior permission of ROHM CO.,LTD.
- The contents described herein are subject to change without notice. The specifications for the product described in this document are for reference only. Upon actual use, therefore, please request that specifications to be separately delivered.
- Application circuit diagrams and circuit constants contained herein are shown as examples of standard use and operation. Please pay careful attention to the peripheral conditions when designing circuits and deciding upon circuit constants in the set.
- Any data, including, but not limited to application circuit diagrams information, described herein are intended only as illustrations of such devices and not as the specifications for such devices. ROHM CO.,LTD. disclaims any warranty that any use of such devices shall be free from infringement of any third party's intellectual property rights or other proprietary rights, and further, assumes no liability of whatsoever nature in the event of any such infringement, or arising from or connected with or related to the use of such devices.
- Upon the sale of any such devices, other than for buyer's right to use such devices itself, resell or otherwise dispose of the same, no express or implied right or license to practice or commercially exploit any intellectual property rights or other proprietary rights owned or controlled by
- ROHM CO., LTD. is granted to any such buyer.
- Products listed in this document are no antiradiation design.

The products listed in this document are designed to be used with ordinary electronic equipment or devices (such as audio visual equipment, office-automation equipment, communications devices, electrical appliances and electronic toys).
Should you intend to use these products with equipment or devices which require an extremely high level of reliability and the malfunction of which would directly endanger human life (such as medical instruments, transportation equipment, aerospace machinery, nuclear-reactor controllers, fuel controllers and other safety devices), please be sure to consult with our sales representative in advance.
It is our top priority to supply products with the utmost quality and reliability. However, there is always a chance of failure due to unexpected factors. Therefore, please take into account the derating characteristics and allow for sufficient safety features, such as extra margin, anti-flammability, and fail-safe measures when designing in order to prevent possible accidents that may result in bodily harm or fire caused by component failure. ROHM cannot be held responsible for any damages arising from the use of the products under conditions out of the range of the specifications or due to non-compliance with the NOTES specified in this catalog.

Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact your nearest sales office.

ROHM Customer Support System

THE AMERICAS / EUROPE / ASIA / JAPAN

www.rohm.com

Contact us : webmaster@ rohm.co.jp

ROHM CO., LTD. 21 Saiin Mizosaki-cho, Ukyo-ku, Kyoto 615-8585, Japan
TEL : +81-75-311-2121
FAX : +81-75-315-0172