Stepper Motor Driver series

Micro step 36V Stepper Motor Drivers

BD63847/BD63843EFV (CLK-IN type)

●Outline

BD6384□EFV series are stepper motor drivers of 1/16 micro step(sixteenth step) drive. As for its basic function, it is a low power consumption bipolar PWM constant current-drive driver with power supply rated voltage of 36V and rated output current (DC) of 1.0A, 2.0A. The input interface is CLK-IN type.
There are step modes of Full step & Half step, Eighth step, Sixteenth step mode by internal DAC (D-A converter), and for current decay mode, the ratio of FAST DECAY & SLOW DECAY can be freely set, so the optimum control conditions for every motor can be realized. In addition, being able to drive with one system of power supply makes contribution to the set design's getting easy.

●Feature

1) Single power supply input (rated voltage of 36V)
2) Rated output current:(DC) 1.0A, 2.0A
3) Low ON resistance DMOS output
4) CLK-IN drive mode
5) PWM constant current control (other oscillation)
6) Built-in spike noise cancel function (external noise filter is unnecessary)
7) Full step, Half step, Eighth step, Sixteenth step drive
8) Timing free for changing step modes
9) Current decay mode switching function (linearly variable FAST/SLOW DECAY ratio)
10) Normal rotation & reverse rotation switching function
11) Power save function
12) Built-in logic input pull-down resistor
13) Power-on reset function
14) Thermal shutdown circuit (TSD)
15) Over current protection circuit (OCP)
16) Under voltage lock out circuit (UVLO)
17) Over voltage lock out circuit (OVLO)
18) Ghost Supply Prevention (protects against malfunction when power supply is disconnected)
19) Electrostatic discharge: 8kV (HBM specification)
20) Adjacent pins short protection
21) Inverted mounting protection
22) Microminiature, ultra-thin and high heat-radiation (exposed metal type) HTSSOP-B28 package
23) Pin-compatible line-up (In addition, pin-compatible to BD6387□EFV series)

●Application

PPC, multi-function printer, laser beam printer, ink jet printer, monitoring camera, WEB camera, sewing machine, photo printer, FAX, scanner, mini printer, toy, and robot etc.

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●Absolute maximum ratings (Ta=25°C)

Item	Symbol	BD63847EFV	BD63843EFV	Unit
Supply voltage	$V_{CC1,2}$	-0.3~+36.0		V
Power dissipation	Pd	1.45※1		W
		4.70※2		W
Input voltage for control pin	V_{IN}	-0.3~+7.0		V
RNF voltage	V_{RNF}	0.7		V
Output current	I_{OUT}	2.0※3	1.0※3	A/phase
Output current (peak)※4	$I_{OUTPEAK}$	2.5※3	1.5※3	A/phase
Operating temperature range	T_{opr}	-25~+85		°C
Storage temperature range	T_{stg}	-55~+150		°C
Junction temperature	T_{jmax}	+150		°C

※1 70mm×70mm×1.6mm glass epoxy board. Derating in done at 11.6mW/°C for operating above Ta=25°C.
※2 4-layer recommended board. Derating in done at 37.6mW/°C for operating above Ta=25°C.
※3 Do not, however exceed Pd, ASO and Tjmax=150°C.
※4 Pulse width tw≦1ms, duty20%.

●Operating conditions (Ta= -25~+85°C)

Item	Symbol	BD63847EFV	BD63843EFV	Unit
Supply voltage	$V_{CC1,2}$	19~28		V
Input voltage for control pin	V_{IN}	0~5.5		V
Output current	I_{OUT}	1.7※5	0.7※5	A/相

※5 Do not, however exceed Pd, ASO.

●Electrical characteristics (Unless otherwise specified Ta=25°C, $V_{CC1,2}$=24V)

Item	Symbol	Limit			Unit	Condition
		Min.	Typ.	Max.		
Whole						
Circuit current at standby	I_{CCST}	-	1.0	2.5	mA	PS=L
Circuit current	I_{CC}	-	2.5	5.0	mA	PS=H, VREF=3V
Control input (CLK, CW_CCW, MODE0, MODE1, ENABLE, PS)						
H level input voltage	V_{INH}	2.0	-	-	V	
L level input voltage	V_{INL}	-	-	0.8	V	
H level input current	I_{INH}	35	50	100	μA	V_{IN}=5V
L level input current	I_{INL}	-10	0	-	μA	V_{IN}=0V
Output (OUT1A, OUT1B, OUT2A, OUT2B)						
Output ON resistance (BD63847EFV)	R_{ON}	-	0.85	1.10	Ω	I_{OUT}=1.5A, Sum of upper and lower
Output ON resistance (BD63843EFV)	R_{ON}	-	1.90	2.47	Ω	I_{OUT}=0.5A, Sum of upper and lower
Output leak current	I_{LEAK}	-	-	10	μA	
Current control						
RNFXS input current	I_{RNFS}	-2.0	-0.1	-	μA	RNFXS=0V
RNFX input current	I_{RNF}	-40	-20	-	μA	RNFX=0V
VREF input current	I_{VREF}	-2.0	-0.1	-	μA	VREF=0V
VREF input voltage range	V_{REF}	0	-	3.0	V	
MTH input current	I_{MTH}	-2.0	-0.1	-	μA	MTH=0V
MTH input voltage range	V_{MTH}	0	-	3.5	V	
Minimum on time (Blank time)	t_{ONMIN}	0.3	0.8	1.5	μs	C=1000pF, R=39kΩ
Comparator threshold 1	V_{CTH1}	0.570	0.600	0.630	V	VREF=3V, 100%
Comparator threshold 2	V_{CTH2}	0.403	0.424	0.445	V	VREF=3V, 70.71%
Comparator threshold 3	V_{CTH3}	0.196	0.230	0.264	V	VREF=3V, 38.27%

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●Input output equivalent circuit diagram

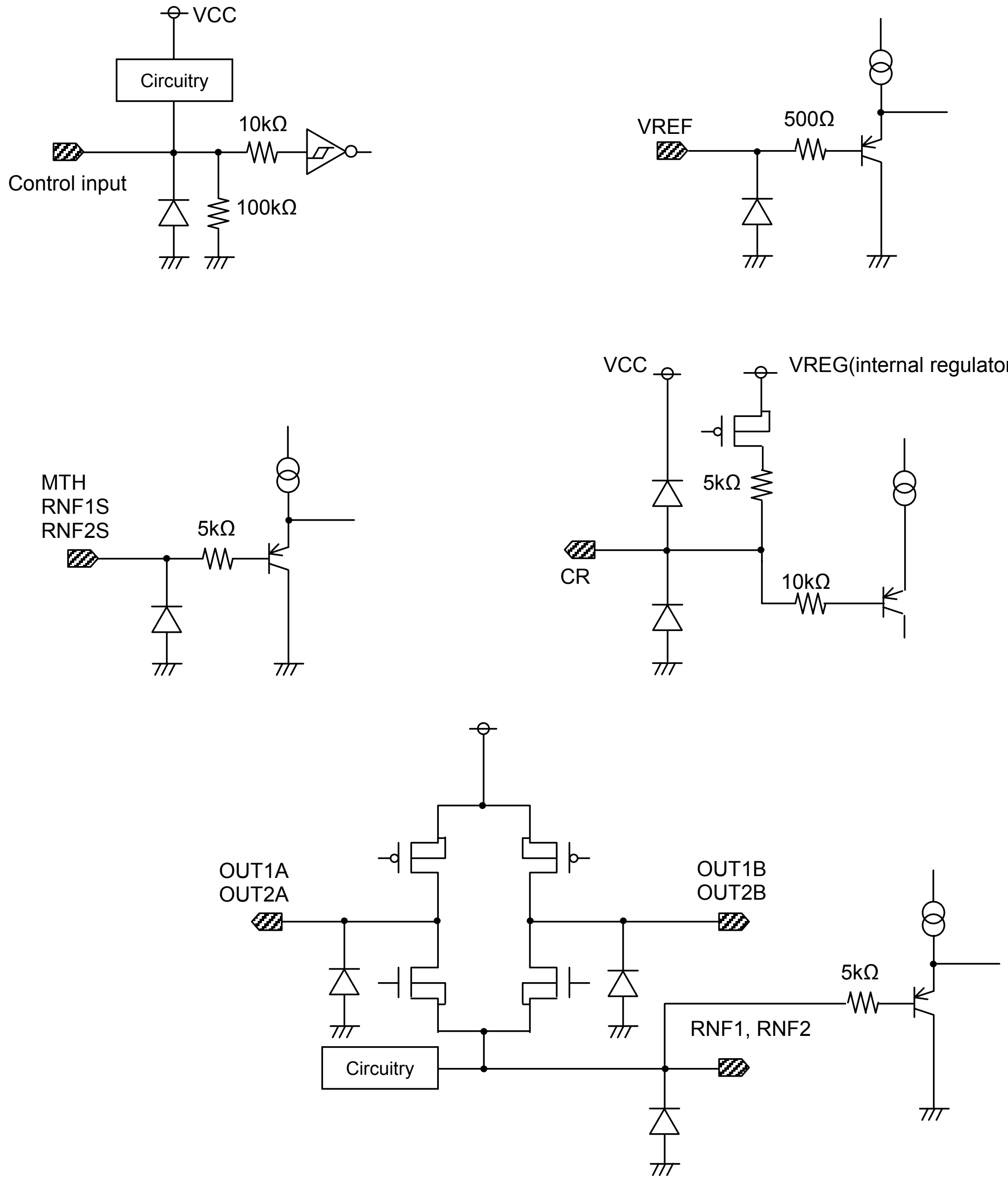

Fig.1 Input output equivalent circuit diagram

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● Terminal function and Application circuit diagram

Pin No.	Pin name	Function	Pin No.	Pin name	Function
1	GND	Ground terminal	15	CLK	Clock input terminal for advancing the electrical angle.
2	OUT1B	H bridge output terminal	16	CW_CCW	Motor rotating direction setting terminal
3	RNF1	Connection terminal of resistor for output current detection	17	TEST	Terminal for testing (Used by connecting with GND)
4	RNF1S	Input terminal of current limit comparator	18	MODE0	Motor excitation mode setting terminal
5	OUT1A	H bridge output terminal	19	MODE1	Motor excitation mode setting terminal
6	NC	Non connection	20	ENABLE	Output enable terminal
7	VCC1	Power supply terminal	21	NC	Non connection
8	NC	Non connection	22	VCC2	Power supply terminal
9	GND	Ground terminal	23	NC	Non connection
10	CR	Connection terminal of CR for setting chopping frequency	24	OUT2A	H bridge output terminal
11	NC	Non connection	25	RNF2S	Input terminal of current limit comparator
12	MTH	Current decay mode setting terminal	26	RNF2	Connection terminal of resistor for output current detection
13	VREF	Output current value setting terminal	27	OUT2B	H bridge output terminal
14	PS	Power save terminal	28	NC	Non connection

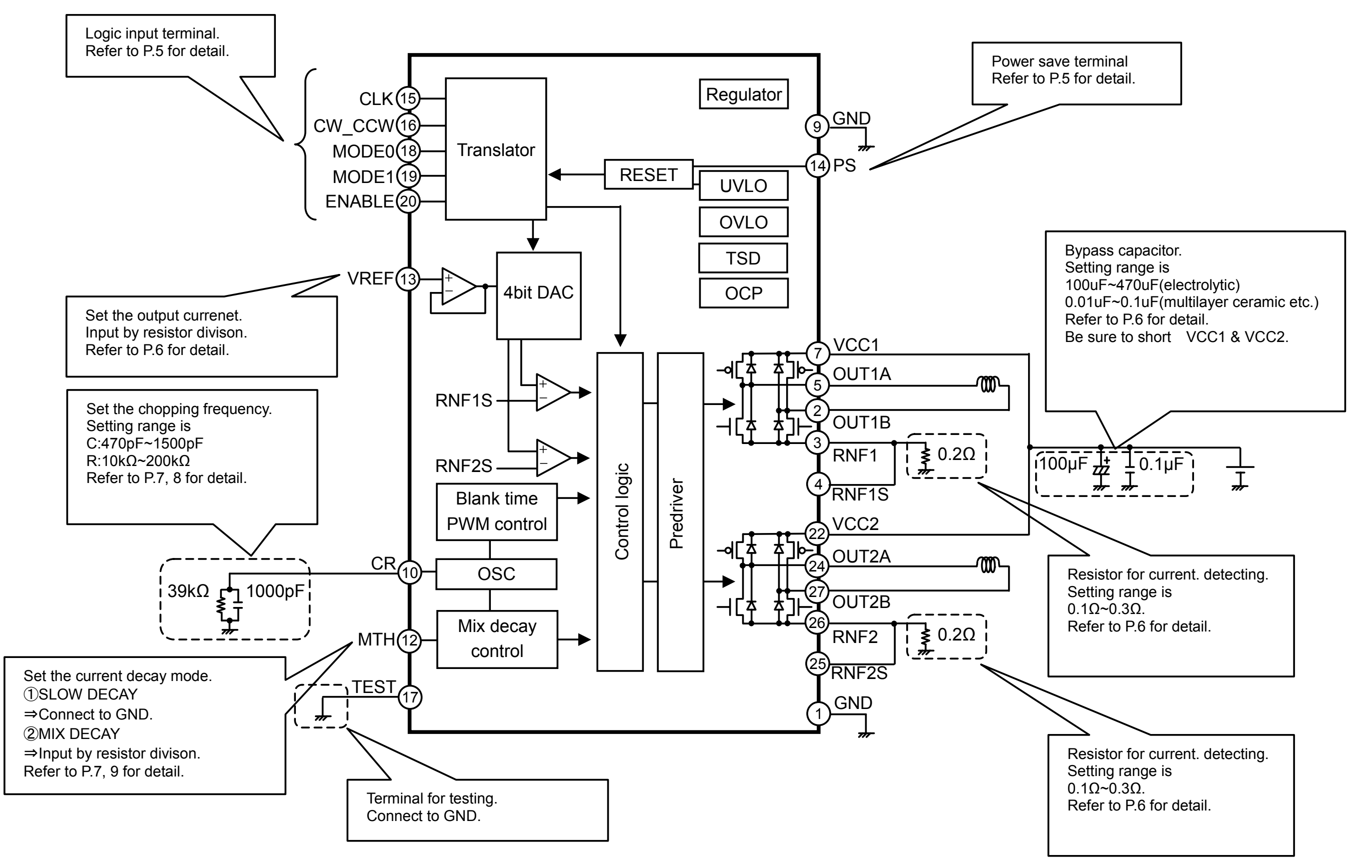

Fig.2 Block diagram & Application circuit diagram

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●Points to notice for terminal description and PCB layout

○CLK/Clock input terminal for advancing the electrical angle

CLK is reflected at rising edge. The Electrical angle advances by one for each CLK input.
Motor's misstep will occur if noise is picked up at the CLK terminal, so please design the pattern in such a way that there is no noise plunging.

○MODE0,MODE1/Motor excitation mode setting terminal

Set the step mode.

MODE0	MODE1	Step mode
L	L	Full step
H	L	Half step
L	H	1/8 step
H	H	1/16 step

Unrelated to CLK, change in setting is forcibly reflected (refer to P.13).

○CW_CCW /Motor rotating direction setting terminal

Set the motor's rotating direction. Change in setting is reflected at the CLK rising edge immediately after the change in setting (refer to P.12)

CW_CCW	Rotating direction
L	Clockwise (CH2's current is outputted with a phase lag of 90° in regard to CH1's current)
H	Counter Clockwise(CH2's current is outputted with a phase lead of 90° in regard to CH1's current)

○ENABLE/Output enable terminal

Turn off forcibly all the output transistors (motor output is open).
At ENABLE=L, electrical angle or operating mode is maintained even if CLK is inputted.
If step modes are changed during ENABLE=L, new step mode is carried out at ENABLE=L to H(refer to P.13).

ENABLE	Motor output
L	OPEN (electrical angle maintained)
H	ACTIVE

○PS/Power save terminal

PS can make circuit standby state and make motor output OPEN. In standby state, translator circuit is reset (initialized) and electrical angle is initialized.
Please be careful because there is a delay of 40μs(max.) before it is returned from standby state to normal state and the motor output becomes ACTIVE (refer to P.10).

PS	State
L	Standby state (RESET)
H	ACTIVE

The electrical angle (initial electrical angle) of each step mode immediately after RESET is as follows (refer to P.11).

Step mode	Initial electrical angle
Full step	45°
Half step	45°
1/8 step	45°
1/16 step	45°

○TEST/ Terminal for testing

This is the terminal used at the time of shipping test. Please connect to GND. Please be careful because there is a possibility of malfunction if GND unconnected.

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○VCC1,VCC2/Power supply terminal

Motor's drive current is flowing in it, so please wire in such a way that the wire is thick & short and has low impedance. Voltage VCC may have great fluctuation, so please arrange the bypass capacitor of about 100μ~470μF as close to the terminal as possible and adjust in such a way that the voltage VCC is stable. Please increase the capacity if needed especially when a large current is used or those motors that have great back electromotive force are used. In addition, for the purpose of reducing of power supply's impedance in wide frequency bandwidth, parallel connection of multi-layered ceramic capacitor of 0.01μ~0.1μF etc is recommended. Extreme care must be used to make sure that the voltage VCC does not exceed the rating even for a moment. VCC1 & VCC2 are shorted inside IC, so please be sure to short externally VCC1 & VCC2 when using. If used without shorting, malfunction or destruction may occur because of concentration of current routes etc., so please make sure that they are shorted when in use. Still more, in the power supply terminal, there is built-in clamp component for preventing of electrostatic destruction. If steep pulse or voltage of surge more that maximum absolute rating is applied, this clamp component operates, as a result there is the danger of destruction, so please be sure that the maximum absolute rating must not be exceeded. It is effective to mount a Zener diode of about the maximum absolute rating. Moreover, the diode for preventing of electrostatic destruction is inserted between VCC terminal and GND terminal, as a result there is the danger of IC destruction if reverse voltage is applied between VCC terminal and GND terminal, so please be careful.

○GND/Ground terminal

In order to reduce the noise caused by switching current and to stabilize the internal reference voltage of IC, please wire in such a way that the wiring impedance from this terminal is made as low as possible to achieve the lowest electrical potential no matter what operating state it may be.

○OUT1A,OUT1B,OUT2A,OUT2B/ H Bridge output terminal

Motor's drive current is flowing in it, so please wire in such a way that the wire is thick & short and has low impedance. It is also effective to add a Schottky diode if output has positive or negative great fluctuation when large current is used etc, for example, if counter electromotive voltage etc. is great. Moreover, in the output terminal, there is built-in clamp component for preventing of electrostatic destruction. If steep pulse or voltage of surge more that maximum absolute rating is applied, this clamp component operates, as a result there is the danger of even destruction, so please be sure that the maximum absolute rating must not be exceeded.

○RNF1,RNF2/ Connection terminal of resistor for detecting of output current

Please connect the resistor of 0.1Ω~0.3Ω for current detection between this terminal and GND. In view of the power consumption of the current-detecting resistor, please determine the resistor in such a way that $W=I_{OUT}^2 \cdot R$[W] does not exceed the power dissipation of the resistor. In addition, please wire in such a way that it has a low impedance and does not have a impedance in common with other GND patterns because motor's drive current flows in the pattern through RNF terminal~current-detecting resistor~GND. Please do not exceed the rating because there is the possibility of circuits' malfunction etc. if RNF voltage has exceeded the maximum rating (0.7V). Moreover, please be careful because if RNF terminal is shorted to GND, large current flows without normal PWM constant current control, then there is the danger that OCP or TSD will operate. If RNF terminal is open, then there is the possibility of such malfunction as output current does not flow either, so please do not let it open.

○RNF1S,RNF2S/ Input terminal of current limit comparator

In this series, RNFS terminal, which is the input terminal of current limit comparator, is independently arranged in order to decrease the lowering of current-detecting accuracy caused by the wire impedance inside the IC of RNF terminal. Therefore, please be sure to connect RNF terminal and RNFS terminal together when using in the case of PWM constant current control. In addition, because the wires from RNFS terminal is connected near the current-detecting resistor in the case of interconnection, the lowering of current-detecting accuracy, which is caused by the impedance of board pattern between RNF terminal and the current-detecting resistor, can be decreased. Moreover, please design the pattern in such a way that there is no noise plunging. In addition, please be careful because if terminals of RNF1S & RNF2S are shorted to GND, large current flows without normal PWM constant current control and, then there is the danger that OCP or TSD will operate.

○VREF/ Output current value-setting terminal

This is the terminal to set the output current value. The output current value can be set by VREF voltage and current-detecting resistor (RNF resistor).

Output current I_{OUT}[A] = {VREF[V] / 5} / RNF[Ω]・・・(Half step, 1/8step, 1/16step)

Output current I_{OUT}[A] = {VREF[V] / 5}∗0.7071 / RNF[Ω]・・・(Full step)

Please avoid using it with VREF terminal open because if VREF terminal is open, the input is unsettled, and the VREF voltage increases, and then there is the possibility of such malfunctions as the setting current increases and a large current flows etc. Please keep to the input voltage range because if the voltage of over 3V is applied on VREF terminal, then there is also the danger that a large current flows in the output and so OCP or TSD will operate. Besides, please take into consideration the outflow current (max.2μA) if inputted by resistance division when selecting the resistance value. The minimum current, which can be controlled by VREF voltage, is determined by motor coil's L & R values and minimum ON time because there is a minimum ON time in PWM drive.

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○CR/ Connection terminal of CR for setting chopping frequency

This is the terminal to set the chopping frequency of output. Please connect the external C(470p~1500pF) and R(10k~200kΩ) between this terminal and GND. Please refer to P8.
Please interconnect from external components to GND in such a way that the interconnection does not have impedance in common with other GND patterns. In addition, please carry out the pattern design in such ways as keeps such steep pulses as square wave etc. away and that there is no noise plunging. Please mount the two components of C and R if being used by PWM constant current control because normal PWM constant current control becomes impossible if CR terminal is open or it is biased externally.

○MTH/ Current decay mode-setting terminal

This is the terminal to set the current decay mode. Current decay mode can be optionally set according to input voltage.

MTH terminal input voltage [V]	Current decay mode
0~0.3	SLOW DECAY
0.4~1.0	MIX DECAY
1.5~3.5	FAST DECAY

Please connect to GND if using at SLOW DECAY mode.
Please avoid using with MTH terminal open because if MTH terminal is open, the input is unsettled, and then there is the danger that PWM operation becomes unstable. Besides, please take into consideration the outflow current (max.2μA) if inputted by resistance division when selecting the resistance value.

○NC terminal

This terminal is unconnected electrically with IC internal circuit.

○IC back metal

For HTSSOP-B28 package, the heat-radiating metal is mounted on IC's back side, and on the metal the heat-radiating treatment is performed when in use, which becomes the precondition to use, so please secure sufficiently the heat-radiating area by surely connecting by solder with the GND plane on the board and getting as wide GND pattern as possible. Please be careful because the allowable loss as shown in P.16 cannot be secured if not connected by solder. Moreover, the back side metal is shorted with IC chip's back side and becomes the GND potential, so there is the danger of malfunction and destruction if shorted with potentials other than GND, therefore please absolutely do not design patterns other than GND through the IC's back side.

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●PWM Constant current control

1) Current control operation

When the output transistor is turned on, the output current increases, raising the voltage over the current sense resistor. When the voltage on the RNF pin reaches the voltage value set by the internal 4-bit DAC and the VREF input voltage, the current limit comparator engages and enters current decay mode. The output is then held off for a period of time determined by the CR time constant connected to the CR pin. The process repeats itself constantly for PWM operation.

2) Noise-masking function

In order to avoid misdetection of output current due to RNF spikes that may occur when the output turns ON, the IC employs an automatic current detection-masking period (t_{ONMIN}), during which current detection is disabled immediately after the output transistor is turned on. This allows for constant-current drive without the need for an external filter. This noise-masking period defines the minimum ON-time for the motor output transistor.

3) CR Timer

The CR filter connected to the CR pin is repeatedly charged and discharged between the VCRH and VCRL levels. The output of the internal comparator is masked while charging from VCRL to VCRH in order to cancel noise. (As mentioned above, this period defines the minimum ON-time of the motor output transistor.) The CR terminal begins discharging once the voltage reaches VCRH. When the output current reaches the current limit during this period (i.e. RNF voltage reaches the decay trigger voltage), then the IC enters decay mode. The CR continues to discharge during this period until it reaches VCRL, at which point the IC output is switched back ON. The current output and CR pin begin charging simultaneously.

The CR charge time (t_{ONMIN}) and discharge time ($t_{discharge}$) are set by external components, according to the following formulas. The total of t_{ONMIN} and $t_{discharge}$ yield the chopping period, t_{chop}.

$t_{ONMIN}[s] \fallingdotseq C \cdot R' \cdot R / (R'+R) \cdot \ln[(VCR-0.4)/(VCR-1.0)]$

$VCR = V \cdot R/(R'+R)$

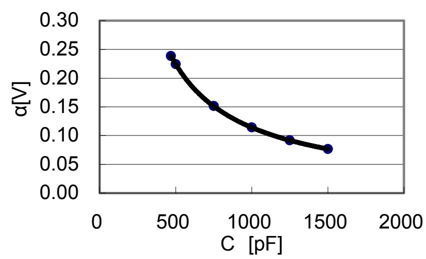
V: internal regulator voltage 5V(Typ.)

R': CR terminal internal impedance 5kΩ (Typ.)

$t_{discharge}[s] \fallingdotseq C \cdot R \cdot \ln[(1+\alpha)/0.4]$

α:See the right graph.

$t_{CHOP}[s] \fallingdotseq t_{ONMIN} + t_{discharge}$



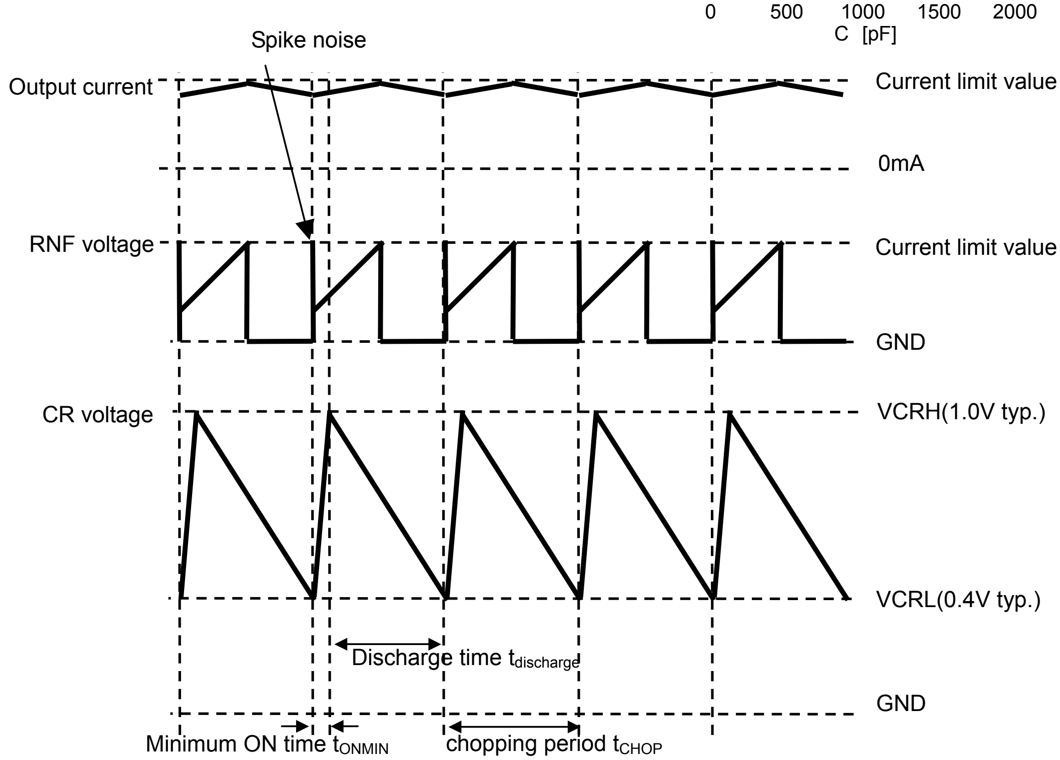


Fig.4 Timing chart of CR voltage, RNF voltage and output current

Attach a resistor of at least 10 kΩ to the CR terminal (10 kΩ~200 kΩ recommended) as lower values may keep the CR from reaching the VCRH voltage level. A capacitor in the range of 470 pF~1500 pF is also recommended. As the capacitance value is increased, however, the noise-masking period (t_{onmin}) also increases, and there is a risk that the output current may exceed the current limit threshold due to the internal L and R components of the output motor coil. Also, ensure that the chopping period (t_{chop}) is not set longer than necessary, as doing so will increase the output ripple, thereby decreasing the average output current and yielding lower output rotation efficiency. The optimal value should reduce the motor drive noise while keeping distortion of the output current waveform to a minimum.

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●Current decay mode

The IC allows for a mixed decay mode in which the ratio of fast and slow decay can be optionally set.
The following diagrams show the operating state of each transistor and the regenerative current path during attenuation for each decay mode:

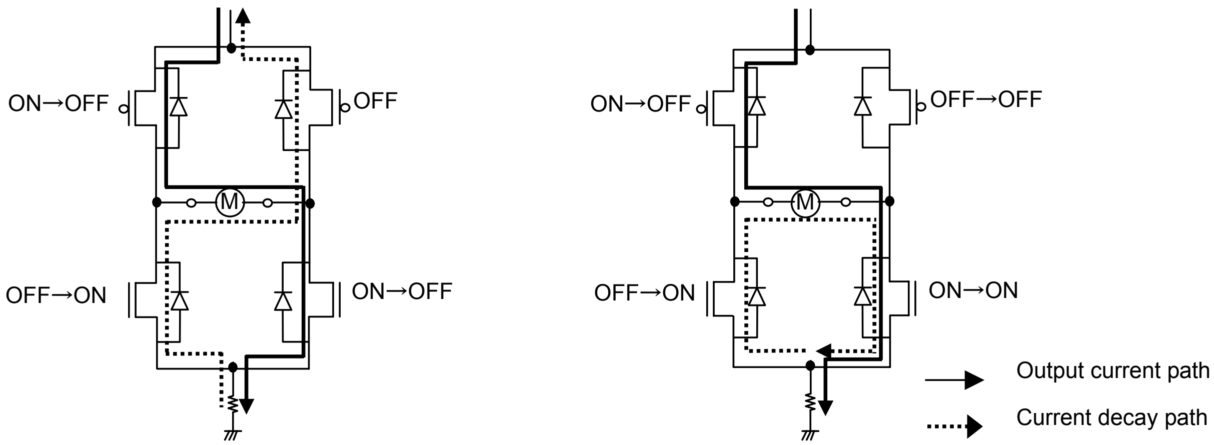


Fig.4 Route of regenerative current during current decay

The merits of each decay mode are as follows:

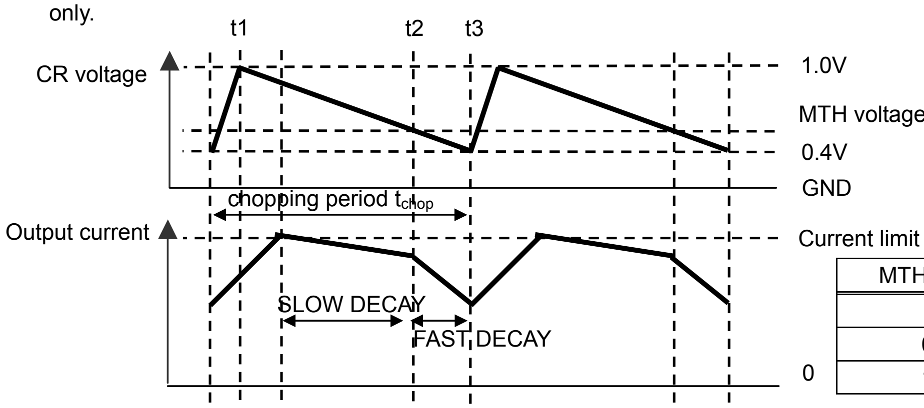
○SLOW DECAY

During current attenuation, the voltage between motor coils is small and the regeneration current decreases slowly, decreasing the output current ripple. This is favorable for keeping motor torque high. However, due to fall-off of current control characteristics in the low-current region, or due to reverse EMF of the output motors exhibited when using high-pulse-rate half-step, eighth-step or sixteenth-step modes, the output current increases, distorting the output current waveform and increasing motor vibration. Thus, this decay mode is most suited to full-step modes, or low-pulse-rate half-step, eighth-step or sixteenth-step modes.

○FAST DECAY

Fast decay decreases the regeneration current much more quickly than slow decay, greatly reducing distortion of the output current waveform. However, fast decay yields a much larger output current ripple, which decreases the overall average current running through the motor. This causes two problems: first, the motor torque decreases (increasing the current limit value can help eliminate this problem, but the rated output current must be taken into consideration); and second, the power loss within the motor increases and thereby radiates more heat. If neither of these problems is of concern, then fast decay can be used for high-pulse rate half-step, eighth-step or sixteenth-step drive.

Additionally, this IC allows for a mixed decay mode that can help improve upon problems that arise from using fast or slow decay alone. In this mode, the IC switches automatically between slow and fast decay, improving the current control characteristics without increasing the output current ripple. The ratio of fast to slow decay is set externally via the voltage input to the MTH pin; therefore, the optimal mix of slow and fast decay can be achieved for each application. Mixed decay mode operates by splitting the decay period into two sections, the first X%(t1-t2) of which operates the IC in slow decay mode, and the remainder(t2-t3) of which operates in fast decay mode. However, if the output current (i.e., the voltage on the RNF pin) does not reach the set current limit during the first X% (t1-t2) decay period, the IC operates in fast decay mode only.



MTH voltage [V]	Current decay mode
0~0.3	SLOW DECAY
0.4~1.0	MIX DECAY
1.5~3.5	FAST DECAY

Fig.5 Relation between CR terminal voltage, MTH voltage, and output current during mixed decay

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●Translator circuit

This series builds in translator circuit and can drive stepper motor in CLK-IN mode.
The operation of the translator circuit in CLK-IN drive mode is described as below.

○Reset operation

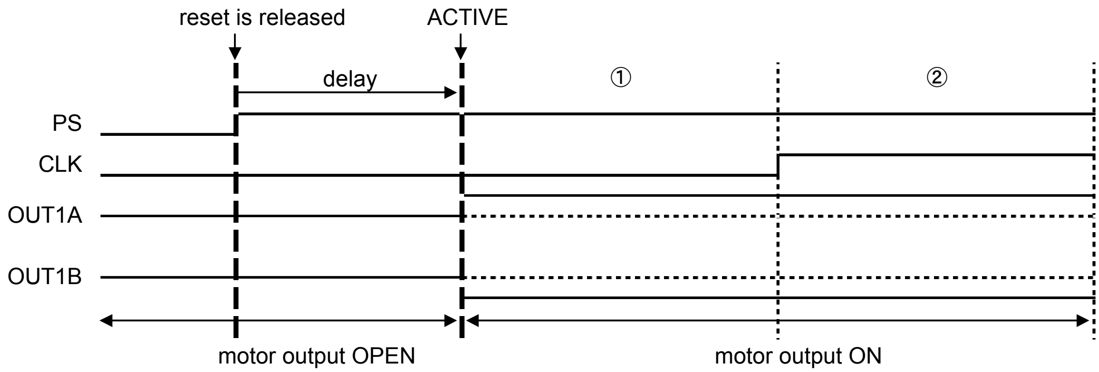
The translator circuit is initialized by power ON Reset function and PS terminal.

・Initializing operation when power supply is turned on

①If power supply is turned on at PS=L (Please use this sequence as a general rule)

When power supply is turned on, the power ON reset function operates in IC and initialized, but as long as it is PS=L, the motor output is the OPEN state. After power supply is turned on, because of the changing of PS=L⇒H, the motor output become the ACTIVE state, and the excitation is started at the initial electrical angle.

But at the time of PS=L⇒H, it returns from the standby state to the normal state and there is a delay of 40μs(max.) until the motor output has become the ACTIVE state.



②If power supply is turned on at PS=H

When power supply is turned on, the power ON function in IC operates, and initialized before the motor output become the ACTIVE state, and the excitation is started at the initial electrical angle.

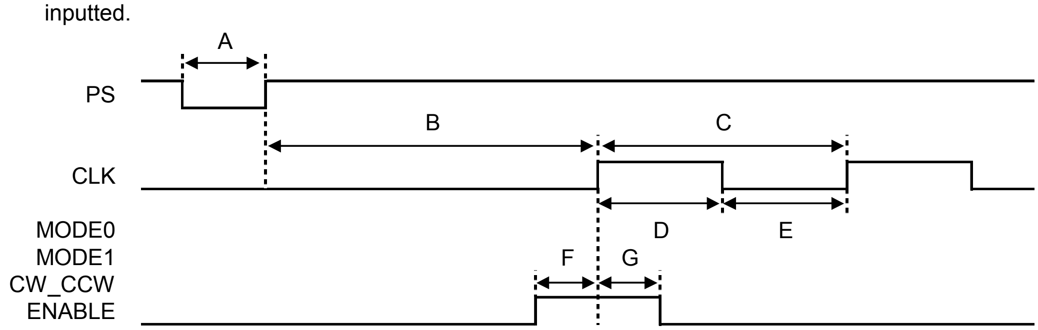
・Initializing operation during motor operating

Please input the reset signal to PS terminal when the translator circuit is initialized during motor operating. (Refer to P.12)

But at the time of PS=L⇒H, it returns from the standby state to the normal state and there is a delay of 40μs (max.) until the motor output has become the ACTIVE state, so please be careful.

○Control input timing

Please input as shown below because the translator circuit operates at the rising edge of CLK signal. If you disobey this timing and input, then there is the possibility that the translator circuit does not operate as expected. In addition, at the time of PS=L⇒H, it returns from the standby state to the normal state and there is a delay of 40μs (max.) until the motor output has become the ACTIVE state, so within this delay interval there is no phase advance operation even if CLK is inputted.



A: PS minimum input pulse width・・・・・・20μs
B: PS rising edge~CLK rising edge input possible maximum delay time・・・・・・40μs
C:CLK minimum period・・・・・・4μs
D:CLK minimum input H pulse width・・・・・・2μs
E:CLK minimum input L pulse width・・・・・・2μs
F:MODE0,MODE1,CW_CCW, ENABLE set-up time・・・・・・1μs
G:MODE0,MODE1,CW_CCW, ENABLE hold time・・・・・・1μs

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●Step sequence table(CW_CCW=L、Initial electrical angle=step angle 45°)

	Full step	Half step	1/8 step	1/16 step	ch1 current[%]	ch2 current[%]	step angle[°]
		1	1	1	100.00	0.00	0.0
				2	99.52	9.80	5.6
			2	3	98.08	19.51	11.3
				4	95.69	29.03	16.9
			3	5	92.39	38.27	22.5
				6	88.19	47.14	28.1
			4	7	83.15	55.56	33.8
				8	77.30	63.44	39.4
Initial position→	1	2	5	9	70.71	70.71	45.0
				10	63.44	77.30	50.6
			6	11	55.56	83.15	56.3
				12	47.14	88.19	61.9
			7	13	38.27	92.39	67.5
				14	29.03	95.69	73.1
			8	15	19.51	98.08	78.8
				16	9.80	99.52	84.4
		3	9	17	0.00	100.00	90.0
				18	-9.80	99.52	95.6
			10	19	-19.51	98.08	101.3
				20	-29.03	95.69	106.9
			11	21	-38.27	92.39	112.5
				22	-47.14	88.19	118.1
			12	23	-55.56	83.15	123.8
				24	-63.44	77.30	129.4
	2	4	13	25	-70.71	70.71	135.0
				26	-77.30	63.44	140.6
			14	27	-83.15	55.56	146.3
				28	-88.19	47.14	151.9
			15	29	-92.39	38.27	157.5
				30	-95.69	29.03	163.1
			16	31	-98.08	19.51	168.8
				32	-99.52	9.80	174.4
		5	17	33	-100.00	0.00	180.0
				34	-99.52	-9.80	185.6
			18	35	-98.08	-19.51	191.3
				36	-95.69	-29.03	196.9
			19	37	-92.39	-38.27	202.5
				38	-88.19	-47.14	208.1
			20	39	-83.15	-55.56	213.8
				40	-77.30	-63.44	219.4
	3	6	21	41	-70.71	-70.71	225.0
				42	-63.44	-77.30	230.6
			22	43	-55.56	-83.15	236.3
				44	-47.14	-88.19	241.9
			23	45	-38.27	-92.39	247.5
				46	-29.03	-95.69	253.1
			24	47	-19.51	-98.08	258.8
				48	-9.80	-99.52	264.4
		7	25	49	0.00	-100.00	270.0
				50	9.80	-99.52	275.6
			26	51	19.51	-98.08	281.3
				52	29.03	-95.69	286.9
			27	53	38.27	-92.39	292.5
				54	47.14	-88.19	298.1
			28	55	55.56	-83.15	303.8
				56	63.44	-77.30	309.4
	4	8	29	57	70.71	-70.71	315.0
				58	77.30	-63.44	320.6
			30	59	83.15	-55.56	326.3
				60	88.19	-47.14	331.9
			31	61	92.39	-38.27	337.5
				62	95.69	-29.03	343.1
			32	63	98.08	-19.51	348.8
				64	99.52	-9.80	354.4

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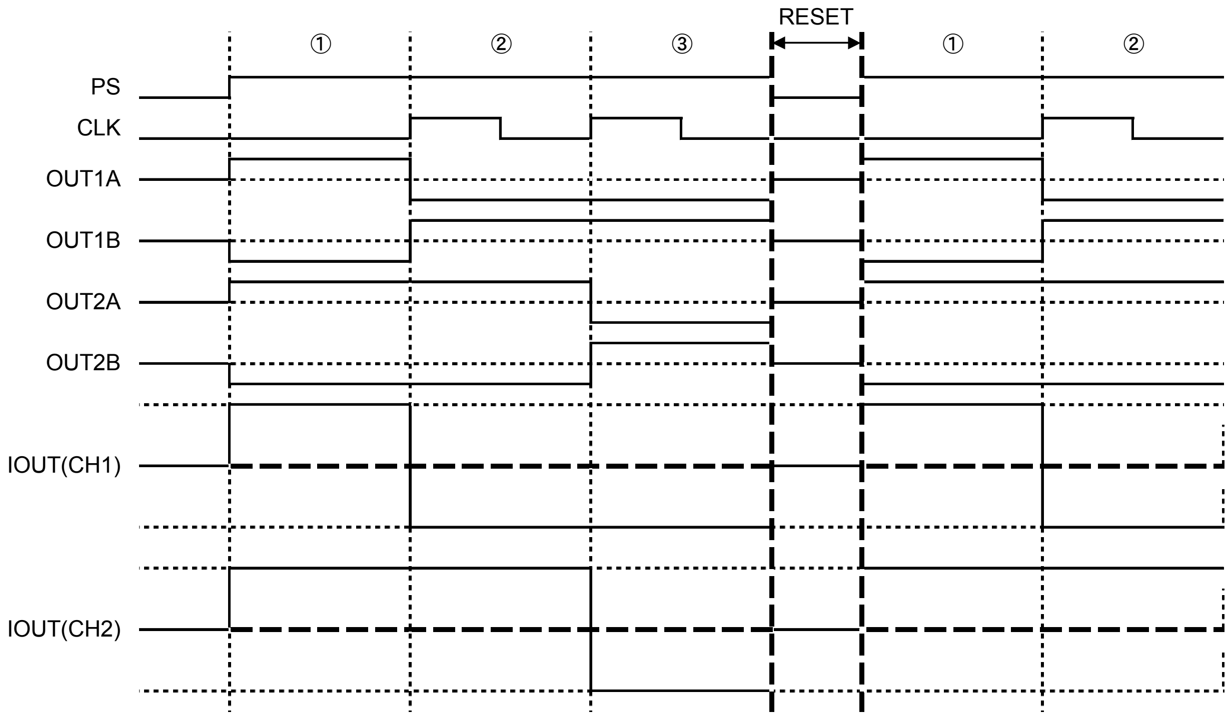
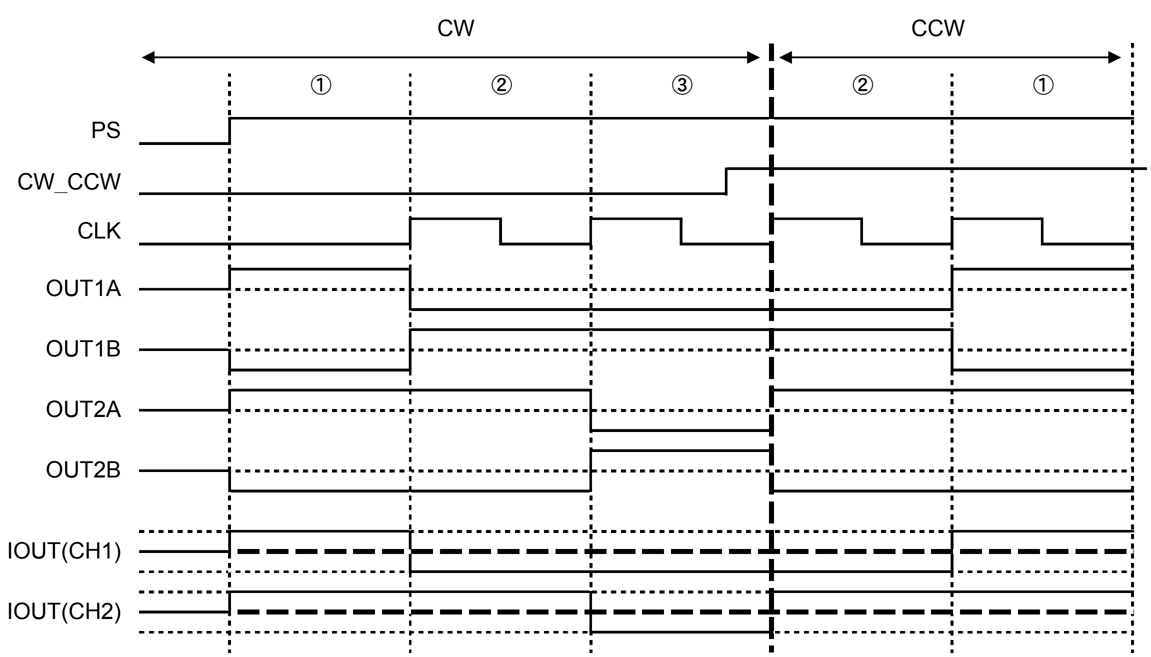
・Reset timing chart (FULL STEP, MODE0=L, MODE1=L, CW_CCW=L , ENABLE=H)

If the terminal PS is input to L, the reset operation is done with regardless of other input signals when reset the translator circuit while motor is working. At this time, IC internal circuit enters the standby mode, and makes the motor output OPEN.



・CW_CCW Switch timing chart (FULL STEP, MODE0=L, MODE1=L, ENABLE=H)

The switch of CW_CCW is reflected by the rising edge of CLK that comes immediately after the changes of the CW_CCW signal. However, depending on the state of operation of the motor at the switch the motor cannot follow even if the control on driver IC side is correspondent and there are possibilities of step-out and mistake step in motor, so please evaluate the sequence of the switch enough.



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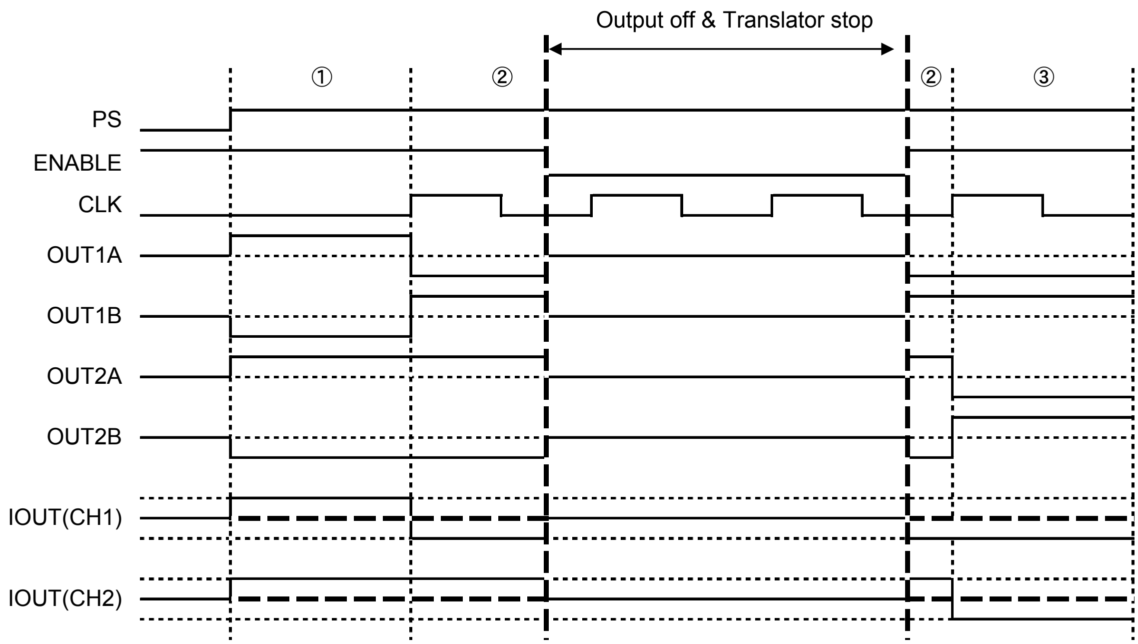
・ENABLE Switch timing chart (FULL STEP, MODE0=L, MODE1=L)

The switch of the ENABLE signal is reflected by the change in the ENABLE signal with regardless of other input signals. During ENABLE=L, the motor output becomes OPEN and the electrical angle doesn't advance. Because the translator circuit stop and CLK input is canceled. It returns at ENABLE=L to H in the same state as the state before ENABLE=L is input. But the change of step modes is reflected during ENABLE=L. Therefore, if step mode is changed during ENABLE=L, it returns at ENABLE=L to H in the different state (changed state) from the state before ENABLE=L is input.



It returns in the same state as the state before ENABLE=L is input.

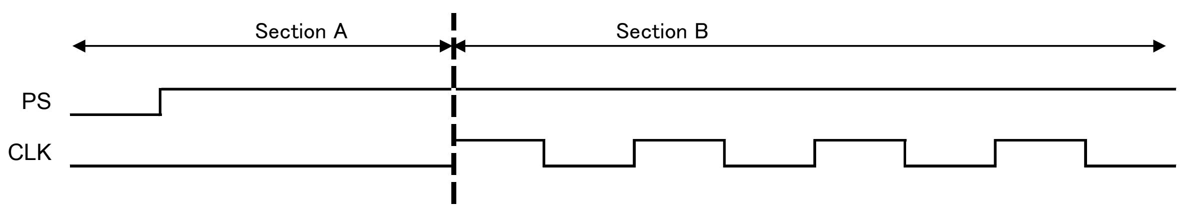
・Changing step modes

The switch of the step mode signals are reflected by the change in the MODE0, MODE1 signal with regardless of other input signals. This series can prevent the motor miss step(due to the inconsistency of motor electrical angle between step modes) happened at changing step modes.

・Changing both CW_CCW and step modes(MODE0, MODE1)

Section A: no restriction of control sequence

Section B: Please change only either CW_CCW or step modes (MODE0, MODE1).



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●Protection Circuits

○Thermal Shutdown (TSD)

This IC has a built-in thermal shutdown circuit for thermal protection. When the IC's chip temperature rises above 175°C (Typ.), the motor output becomes OPEN. Also, when the temperature returns to under 150°C (Typ.), it automatically returns to normal operation. However, even when TSD is in operation, if heat is continued to be added externally, heat overdrive can lead to destruction.

○Over Current Protection (OCP)

This IC has a built in over current protection circuit as a provision against destruction when the motor outputs are shorted each other or VCC-motor output or motor output-GND is shorted. This circuit latches the motor output to OPEN condition when the regulated threshold current flows for 4μs (Typ.). It returns with power reactivation or a reset of the PS terminal. The over current protection circuit's only aim is to prevent the destruction of the IC from irregular situations such as motor output shorts, and is not meant to be used as protection or security for the set. Therefore, sets should not be designed to take into account this circuit's functions. After OCP operating, if irregular situations continues and the return by power reactivation or a reset of the PS terminal is carried out repeatly, then OCP operates repeatly and the IC may generate heat or otherwise deteriorate. When the L value of the wiring is great due to the wiring being long, after the over current has flowed and the output terminal voltage jumps up and the absolute maximum values may be exceeded and as a result, there is a possibility of destruction. Also, when current which is over the output current rating and under the OCP detection current flows, the IC can heat up to over Tjmax=150°C and can deteriorate, so current which exceeds the output rating should not be applied.

○Under Voltage Lock Out (UVLO)

This IC has a built-in under voltage lock out function to prevent false operation such as IC output during power supply under voltage. When the applied voltage to the VCC terminal goes under 15V (Typ.), the motor output is set to OPEN. This switching voltage has a 1V (Typ.) hysteresis to prevent false operation by noise etc. Please be aware that this circuit does not operate during power save mode. Also, the electrical angle is reset when the UVLO circuit operates during CLK-IN drive mode.

○Over Voltage Lock Out (OVLO)

This IC has a built-in over voltage lock out function to protect the IC output and the motor during power supply over voltage. When the applied voltage to the VCC terminal goes over 32V (Typ.), the motor output is set to OPEN. This switching voltage has a 1V (Typ.) hysteresis and a 4μs (Typ.) mask time to prevent false operation by noise etc. Although this over voltage locked out circuit is built-in, there is a possibility of destruction if the absolute maximum value for power supply voltage is exceeded, therefore the absolute maximum value should not be exceeded. Please be aware that this circuit does not operate during power save mode.

○Ghost Supply Prevention (protects against malfunction when power supply is disconnected)

If a signal (logic input, VREF, MTH) is input when there is no power supplied to this IC, there is a function which prevents the false operation by voltage supplied via the electrostatic destruction prevention diode from these input terminals to the VCC to this IC or to another IC's power supply. Therefore, there is no malfunction of the circuit even when voltage is supplied to these input terminals while there is no power supply.

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●Power dissipation

Please confirm that the IC's chip temperature Tj is not over 150°C, while considering the IC's power consumption (W), package power (Pd) and ambient temperature (Ta). When Tj=150°C is exceeded the functions as a semiconductor do not operate and problems such as parasitism and leaks occur. Constant use under these circumstances leads to deterioration and eventually destruction of the IC. Tjmax=150°C must be strictly obeyed under all circumstances.

○Thermal Calculation

The IC's consumed power can be estimated roughly with the power supply voltage (V_{CC}), circuit current (I_{CC}), output ON resistance (R_{ONH}、R_{ONL}) and motor output current value (I_{OUT}).

The calculation method during FULL STEP drive, SLOW DECAY mode is shown here:

Consumed power of the Vcc [W] = V_{CC} [V]・I_{CC} [A] ・・・・・・①

Consumed power of the output DMOS [W] = $\underline{(R_{ONH}[\Omega] + R_{ONL}[\Omega]) \cdot I_{OUT}[A]^2 \cdot 2[ch] \cdot on\_duty}$ (During output ON)

$+ \underline{(2 \cdot R_{ONL}[\Omega]) \cdot I_{OUT}[A]^2 \cdot 2[ch] \cdot (1 - on\_duty)}$ (During current decay) ・・・・・・②

However, on duty: PWM on duty = t_{on} / (t_{chop})

t_{on} varies depending on the L and R values of the motor coil and the current set value. Please confirm by actual measurement, or make an approximate calculation.

t_{chop} is the chopping period, which depends on the external CR. See P.8 for details.

Model Number	Upper PchDMOS ON Resistance $R_{ONH}[\Omega]$ (Typ.)	Lower NchDMOS ON Resistance $R_{ONL}[\Omega]$ (Typ.)
BD63847EFV	0.50	0.35
BD63843EFV	1.25	0.65

Consumed power of total IC W_total [W] = ① + ②

Junction temperature Tj = Ta[°C] + θ_{ja}[°C/W]・W_total [W]

However, the thermal resistance value θ_{ja} [°C/W] differs greatly depending on circuit board conditions. Refer to the derating curve on P.16. Also, we are taking measurements of thermal resistance value θ_{ja} of boards actually in use. Please feel free to contact our salesman. The calculated values above are only theoretical. For actual thermal design, please perform sufficient thermal evaluation for the application board used, and create the thermal design with enough margin to not exceed Tjmax=150°C.Although unnecessary with normal use, if the IC is to be used under especially strict heat conditions, please consider externally attaching a Schottky diode between the motor output terminal and GND to abate heat from the IC.

○Temperature Monitoring

There is a way to directly measure the approximate chip temperature by using the TEST terminal. However, temperature monitor using this TEST terminal is only for evaluation and experimenting, and must not be used in actual usage conditions. TEST terminal has a protection diode for prevention from electrostatic discharge. The temperature may be monitored using this protection diode.

(1) Measure the terminal voltage when a current of Idiode=50μA flows from the TEST terminal to the GND, without supplying VCC to the IC. This measurement is of the Vf voltage inside the diode.

(2) Measure the temperature characteristics of this terminal voltage. (Vf has a linear negative temperature factor against the temperature.) With the results of these temperature characteristics, chip temperature may be calibrated from the TEST terminal voltage.

(3) Supply VCC, confirm the TEST terminal voltage while running the motor, and the chip temperature can be approximated from the results of (2).

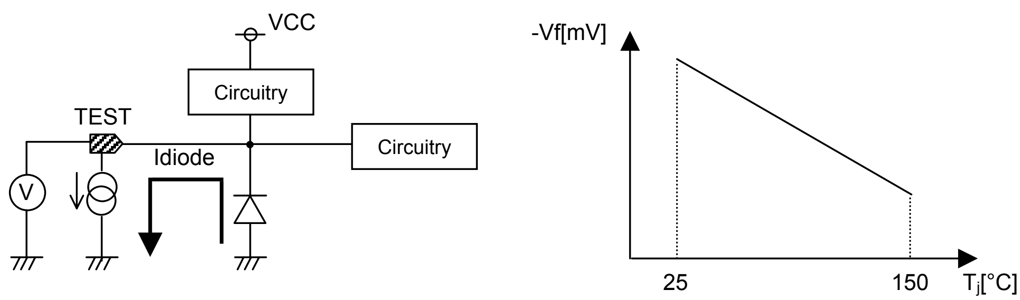

Fig.6 Model diagram for measuring chip temperature

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●Thermal derating curve

HTSSOP-B28 has exposed metal on the back, and it is possible to dissipate heat from a through hole in the back. Also, the back of board as well as the surfaces has large areas of copper foil heat dissipation patterns, greatly increasing power dissipation. The back metal is shorted with the back side of the IC chip, being a GND potential, therefore there is a possibility for malfunction if it is shorted with any potential other than GND, which should be avoided. Also, it is recommended that the back metal is soldered onto the GND to short. Please note that it has been assumed that this product will be used in the condition of this back metal performed heat dissipation treatment for increasing heat dissipation efficiency.

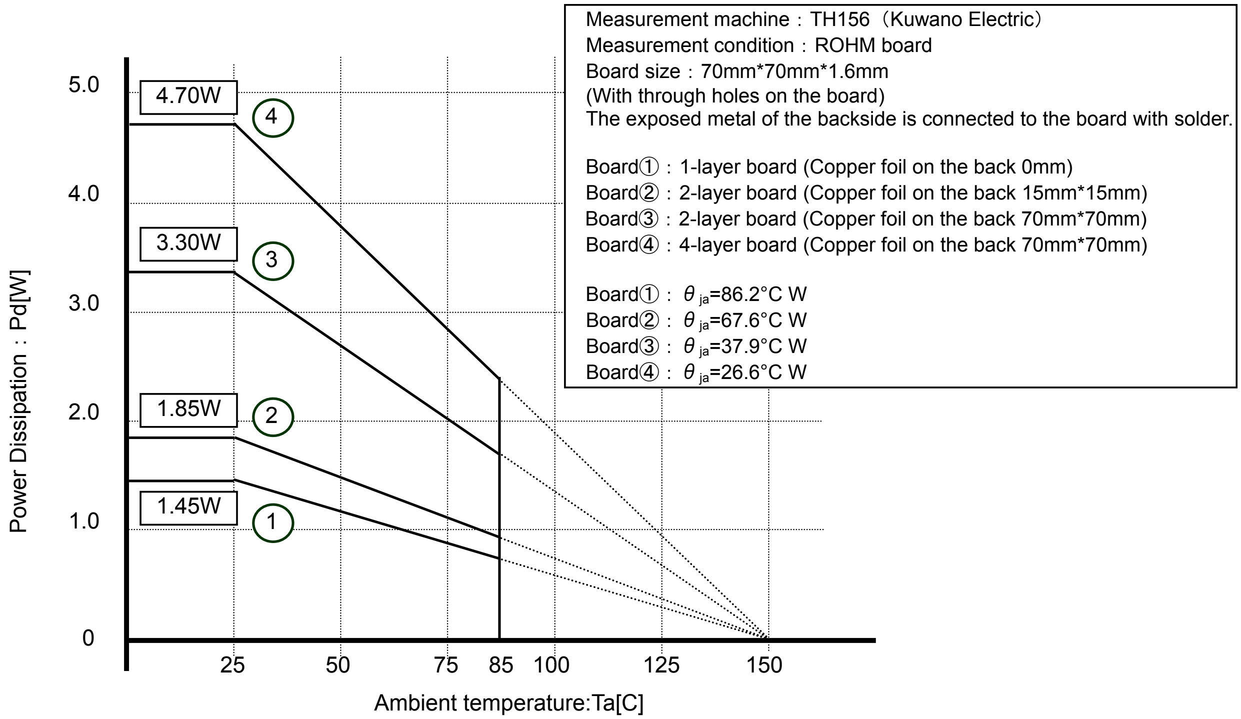

Fig.7 HTSSOP-B28 Thermal derating curve

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●Usage Notes

(1) Absolute maximum ratings
An excess in the absolute maximum ratings, 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 Lines
As return of current regenerated by back EMF of FET output happens, take steps such as putting capacitor between power supply and GND as an electric pathway for the regenerated current. Be sure that there is no problem with each property such as emptied capacity at lower temperature regarding electrolytic capacitor to decide capacity value. If the connected power supply does not have sufficient current absorption capacity, regenerative current will cause the voltage on the power supply line to rise, which combined with the product and its peripheral circuitry may exceed the absolute maximum ratings. It is recommended to implement a physical safety measure such as the insertion of a voltage clamp diode between the power supply and GND pins.

(4) GND Potential
The potential of GND pin must be minimum potential in all operating conditions.

(5) Metal on the backside (Define the side where product markings are printed as front)
The metal on the backside is shorted with the backside of IC chip therefore it should be connected to GND. Be aware that there is a possibility of malfunction or destruction if it is shorted with any potential other than GND.

(6) Thermal design
Use a thermal design that allows for a sufficient margin in light of the power dissipation (Pd) in actual operating conditions. This IC exposes the metal on the backside of package. Note that this part is assumed to use after providing heat dissipation treatment to improve heat dissipation efficiency. Try to occupy as wide as possible with heat dissipation pattern not only on the board surface but also the backside.

(7) Inter-pin shorts and mounting errors
When attaching to a printed circuit board, pay close attention to the direction of the IC and displacement. Improper attachment may lead to destruction of the IC. There is also possibility of destruction from short circuits which can be caused by foreign matter entering between outputs or an output and the power supply or GND.

(8) Operation in a strong electric field
Use caution when using the IC in the presence of a strong electromagnetic field as doing so may cause the IC to malfunction.

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

(10) Thermal shutdown circuit
The IC has a built-in thermal shutdown circuit (TSD circuit). If the chip temperature becomes Tjmax=150°C, and higher, coil output to the motor will be open. The TSD circuit is designed only to shut the IC off to prevent runaway thermal operation. It is not designed to protect or indemnify peripheral equipment. Do not use the TSD function to protect peripheral equipment.

TSD on temperature [°C] (Typ.)	Hysteresis temperature [°C] (Typ.)
175	25

(11) Inspection of the application board
During inspection of the application board, if a capacitor is connected to a pin with low impedance there is a possibility that it could cause stress to the IC, therefore an electrical discharge should be performed after each process. Also, as a measure again electrostatic discharge, it should be earthed during the assembly process and special care should be taken during transport or storage. Furthermore, when connecting to the jig during the inspection process, the power supply should first be turned off and then removed before the inspection.

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(12) Input terminal of IC

This IC is a monolithic IC, and between each element there is a P+ isolation for element partition and a P substrate. This P layer and each element's N layer make up the P-N junction, and various parasitic elements are made up. For example, when the resistance and transistor are connected to the terminal as shown in figure A,

○When GND＞(Terminal A) at the resistance and GND＞(Terminal B) at the transistor (NPN), the P-N junction operates as a parasitic diode.

○Also, when GND＞(Terminal B) at the transistor (NPN) The parasitic NPN transistor operates with the N layers of other elements close to the aforementioned parasitic diode.

Because of the IC's structure, the creation of parasitic elements is inevitable from the electrical potential relationship. The operation of parasitic elements causes interference in circuit operation, and can lead to malfunction and destruction. Therefore, be careful not to use it in a way which causes the parasitic elements to operate, such as by applying voltage that is lower than the GND (P substrate) to the input terminal.

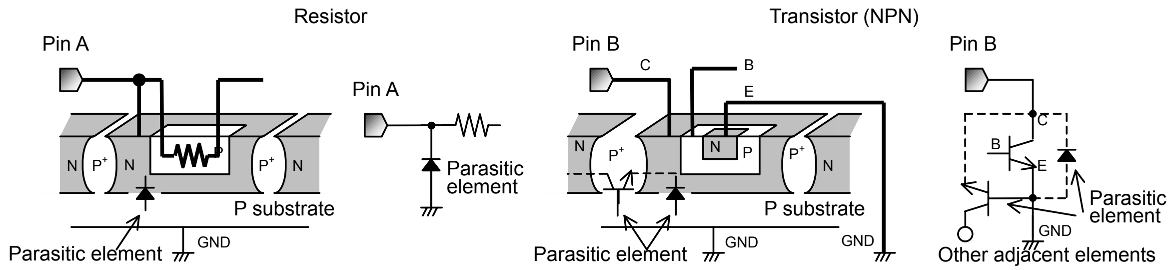


Fig. A Pattern diagram of parasitic element

(13) Ground Wiring Pattern

When using both large current and small signal 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.

(14) TEST pin

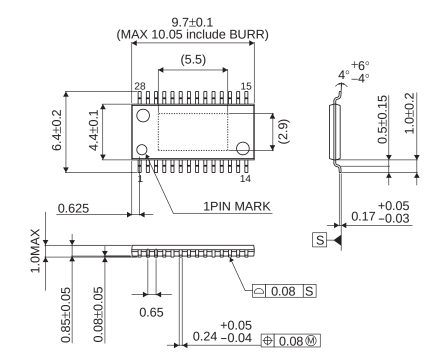
Be sure to connect TEST pin to GND.

●Selecting a model name when ordering

B	D	6	3	8	4	3	E	F	V	–	E	2

ROHM model: BD
Part number: 63843
Package type EFV=HTSSOP-B28
E2 = Reel-wound embossed taping

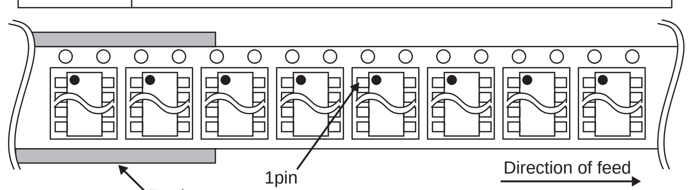
HTSSOP-B28



(Unit : mm)

<Tape and Reel information>

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



*Order quantity needs to be multiple of the minimum quantity.

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Nashville	+1-615-620-6700	**Poland**	+48-22-5757213	**Wuxi**	+86-510-82702693	**Thailand**	+66-2-254-4890
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Düsseldorf	+49-2154-9210	**Seoul**	+82-2-8182-700	**Huizhou**	+86-752-205-1054	**Penang**	+60-4-2286453
Munich	+49-8999-216168	**Masan**	+82-55-240-6234	**Fuzhou**	+86-591-8801-8698	**Kyoto**	+81-75-365-1218
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